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CLIMATE CHANGE AND PUBLIC LANDS: EXAMINING IMPACTS AND CONSIDERING ADAPTATION OPPORTUNITIES

OVERSIGHT HEARING

BEFORE THE

SUBCOMMITTEE ON NATIONAL PARKS, FORESTS, AND PUBLIC LANDS

OF THE

COMMITTEE ON NATURAL RESOURCES
U.S. HOUSE OF REPRESENTATIVES

ONE HUNDRED SIXTEENTH CONGRESS

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OVERSIGHT HEARING ON CLIMATE CHANGE AND PUBLIC LANDS: EXAMINING IMPACTS AND CONSIDERING ADAPTATION OPPORTUNITIES

Wednesday, February 13, 2019
U.S. House of Representatives
Subcommittee on National Parks, Forests, and Public Lands
Committee on Natural Resources
Washington, DC

The Subcommittee met, pursuant to notice, at 10:04 a.m., in room 1324, Longworth House Office Building, Hon. Deb Haaland [Chairwoman of the Subcommittee] presiding.

Present: Representatives Haaland, Neguse, DeGette, Horsford, Huffman, Lowenthal, Case, Grijalva; Young, Westerman, Hice, Curtis, Fulcher, and Bishop.

Ms. HAALAND. The Subcommittee on National Parks, Forests, and Public Lands will now come to order. The Subcommittee is meeting today to hear testimony on the impacts of climate change on public lands, and to consider adaptation opportunities.

Under Committee Rule 4(f), any oral opening statements at hearings are limited to the Chairman and Ranking Minority Member. Therefore, I ask unanimous consent that all other Members' opening statements be made part of the hearing record, if they are submitted to the Clerk by 5 p.m. today.

Hearing no objection, so ordered.

STATEMENT OF THE HON. DEBRA A. HAALAND, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF NEW MEXICO

Ms. HAALAND. Today is an exciting day. It will be the first of a new era for this Committee and for this Congress, an era of inclusion, where the diverse voices of the American people are clearly heard in these halls. We will uphold our public lands as a point of pride that all Americans can share and co-own. These special places will serve as refuge for our highest values, and as places of growth toward our Nation's future.

I want to start this hearing, the first of the 116th Congress for this Subcommittee, by thanking my fellow Members for joining me in this important work. I am grateful for the confidence you have expressed in selecting me to chair this Subcommittee. It is my sincere hope that we will find common ground on important issues, and I promise you that we will lead this Congress, the most diverse in history, toward bold policy solutions that benefit our Federal lands and our communities.

We begin that leadership today as we confront the most pressing issue facing our Nation, which is climate change. We will hear testimony from leading scientists about the disproportionate impact climate change is already having on our public lands.

Our national parks are warming twice as fast as the rest of the country. Parks in the Southwest, my home, and the home of many of my fellow Members here on this dais, are experiencing unprecedented aridity. That means less water for ecosystems, which, in turn, means less water for our homes and our farmers, because we live in a deeply inter-connected world, where changes to one system impact all others.

We rely on the natural world to provide us with many of the things we depend on each day, from clean water and clean air to flood control and coastal protection. At a time when these natural services are under threat from global climate change, Americans will require strong leadership to ensure that we are ready to adapt to these changes and to meet these challenges.

Unfortunately, the Trump administration has failed to provide this leadership. They see fit to pursue energy dominance at all costs, to push an extractive and destructive agenda that has left our public lands responsible for nearly one-quarter of all CO_2 emissions. At the same time, the Administration has suppressed science and prevented adaptation. They canceled executive orders outlining adaptation strategies on public lands, and even pulled back guidance on climate change and national security. They ignored the science of climate change, relying on outdated and inadequate mandates, and put Americans in harm's way.

If this Administration will not take the lead, this Committee will. Dr. Gonzalez will help us to understand the threat we face by explaining the impact climate change will have on our public lands. We will then hear from a top climate change adaptation scientist, Dr. Lara Hansen, because we can no longer afford to stand on the sidelines and do nothing.

It is time for America to act on climate change, and our public lands are one of the best resources for us to do so. Public lands protect biodiversity and the ecosystems on which our daily lives depend. They provide space for the natural world to adapt to the new climate we have created. And they form the backbone of nearly a $1 trillion outdoor recreation economy that can help us create good, clean jobs.

Climate change is an unprecedented challenge that will require big and bold solutions. Today, we take the first step toward meaningful action by hearing the risks we face, and by considering how we can prepare our communities, our country, and our public lands for the challenges climate change presents.

Thank you all for joining me here today. I look forward to our leadership on these issues.

Thank you again to the witnesses. I look forward to your testimony.

[The prepared statement of Ms. Haaland follows:]

PREPARED STATEMENT OF THE HON. DEBRA A. HAALAND, CHAIR, SUBCOMMITTEE ON NATIONAL PARKS, FORESTS, AND PUBLIC LANDS

Today is an exciting day. It will be the first of a new era for this Committee and for this Congress. An era of inclusion, where the diverse voices of the American people are clearly heard in these halls. We will hold up our public lands as a point of pride that all Americans share in and co-own. These special places will serve as refuge for our highest values and as places of growth toward our Nation's future.

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Unfortunately, the Trump administration has failed to provide this leadership. They see fit to pursue energy dominance at all costs; to push an extractive and destructive agenda that has left our public lands responsible for nearly one-quarter of all U.S. CO_2 emissions. At the same time, the Administration has suppressed science and prevented adaptation. They canceled Executive Orders outlining adaptation strategies on public lands and even pulled back guidance on climate change and national security. They ignore the science of climate change, relying on outdated and inadequate mandates, and put Americans in harm's way.

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Thank you all for joining me here today. I look forward to our leadership on these issues.

Thank you again to the witnesses. I look forward to your testimony.

Ms. HAALAND. I now recognize the Ranking Member, Mr. Curtis, for his opening statement.

Mr. CURTIS. Thank you very much. It is a pleasure to sit in for our Ranking Member, Don Young. And on his behalf and all of our behalf, I would like to congratulate Representative Haaland on her election to the House of Representatives, and for being selected as the new Chair of the National Parks, Forests, and Public Lands Subcommittee.

I will now read Mr. Young's statement.

STATEMENT OF THE HON. DON YOUNG, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF ALASKA

Mr. CURTIS. I look forward to working with her and this Congress on the many important land issues facing our country.

Today, we meet to discuss the impacts of climate change on our Federal lands and to examine adaptation opportunities. It is certainly my hope that we will use this time to discuss innovative land management solutions that fall under this Subcommittee's jurisdiction.

All too often this issue has been used as a vehicle to push a radically progressive agenda that would prove to be devastating for American families, and would offer minimal, at best, climate results. Among the policy goals that have been expressed includes calls for complete elimination of air travel, cows, and nuclear energy.

Fearmongering and unrealistic rhetoric should have no place in this debate. Instead, we should focus on pragmatic solutions that offer realistic environmental solutions.

And on that note, I would like to turn the microphone over to Ranking Member Don Young to finish his statement.

[Laughter.]

Mr. YOUNG. Madam Chair, I apologize.

Ms. HAALAND. No need to apologize.

Mr. YOUNG. I will say that those that live on the Hill have it made. Those that live 25 miles out, it is not good. I hate the traffic.

Ms. HAALAND. We are happy to see you.

Mr. YOUNG. I am here to—first, let me congratulate you for being Chairman, and I do apologize. This is a very important Committee.

I would say, seriously, we ought to start thinking about reducing carbon emissions, but we also ought to be talking about how do we address that in some of the areas which we have been working on.

I think we have to look at the forests, something I am very interested in, because we have the largest national forest in America in Alaska. And we have lost use of that: 16.8 million acres of the forest, only 4 percent has been managed for timber production. And consequently, we have very large forests that have dead trees. We have had that in other areas.

I can tell you that, in Alaska, because we did not manage, did not harvest some trees—I am not saying all—we have lost two pulp mills, five large sawmills, and a lot of small mills. But we also lost 6,000 good, high-paying, middle-class jobs. For what cause, I don't know. They say, we have to protect it. But what we don't manage, we lose the forest. This has happened in the Lower 48. People will talk to that, as we know. Tremendous forest fires. It is a loss. And it also contributes to the carbon, the gases in the air, and the particulate amount in the air.

So, I suggest, respectfully, one of our jobs is to see whether we can manage better, instead of saying no, ask what we can do. Other countries have done beautifully. If you go to Sweden, they have managed their forests for centuries, and they produce a lot of timber and they employ a lot of people. And it looks like a brand-new forest.

So, that is what we have to consider. And I do think this is a great hearing. We have good witnesses today. There are differences of opinion, but I just want us to adapt as part of this hearing, and I am happy with what we are proceeding here. I would submit the rest of my statement for the record and yield back the balance of my time.

[The prepared statement of Mr. Young follows:]

PREPARED STATEMENT OF THE HON. DON YOUNG, RANKING MEMBER, SUBCOMMITTEE ON NATIONAL PARKS, FORESTS, AND PUBLIC LANDS

I would first like to congratulate Representative Haaland on her election to the House of Representatives and for being selected as the new Chair of the National Parks, Forests, and Public Lands Subcommittee. I look forward to working with her this Congress on many of the important land management issues facing our country.

Today we meet to discuss the impacts of climate change on our Federal lands and to examine adaptation opportunities. It is certainly my hope that we use this time to discuss innovative land management solutions that fall under this Subcommittee's jurisdiction.

All too often, this issue has been used as a vehicle to push a radically progressive agenda that would prove to be devastating for American families and would offer minimal at best climate results. Among the ludicrous policy goals that have been expressed includes calls for the complete elimination of air travel, cows, and nuclear energy.

Fearmongering and unrealistic rhetoric should have no place in this debate. Instead we should focus on pragmatic solutions that offer realistic environmental benefits.

One area of policy actually under this Committee's jurisdiction is forestry. It's common knowledge that the poor health of our Nation's forests is has reached crisis levels.

If the Democrat Majority is truly serious about reducing vast amounts of Carbon Emissions into the atmosphere, they should be working more closely alongside Republicans in supporting common-sense forest management reforms which include the responsible cutting and replanting of trees, as well as grazing on public lands.

Before our own eyes, we've seen the Nation's once flourishing Federal forests transform into dead and burned out waste lands.

The sorry state of our Federal forests has become a national disgrace and national emergency. While climate change has certainly exacerbated the challenges facing our Federal forests, there is much that we can be doing to help our forests adapt and become more resilient in a time of changing climate.

With 16.8 million acres, the Tongass National Forest is the largest national forest in the United States. In the last 90 years, only 4 percent has been managed for timber production. To make matters worse, the Forest Service has been unwilling and unable to provide a reliable and sufficient supply of timber sales.

In my home state of Alaska, over the past 35 years we have seen the closure of two pulp mills, five large saw mills, and countless small mills due to misguided forest policy. This has cost Alaskans over 5,000 good paying-family wage jobs.

For decades we have failed to proactively manage our forests in order to reduce hazardous fuels buildup. As a result, the excessive fuel loads that have piled up are increasing the likelihood of explosive, unmanageable and costly megafires that wreak havoc on our rural communities and emit millions of metric tons of carbon dioxide into the air.

We cannot continue to ignore the forest health crisis. The Federal Government's current rate, treating a paltry 2 percent of the nearly 60 million acres identified as high risk to wildfire, is not acceptable.

To solve our Nation's forest health crisis, we must enact measures to increase the pace and scale of active management across our forestlands.

The American people want our forests returned to health. They want the growing scourge of wildfire brought back under control. They want the destruction of mountain habitats by fire, disease and pestilence arrested and reversed. They want the prosperity of their forest communities restored.

Our witness, Dr. Elaine Oneil, has spent her career specializing in forest health, climate change, and forest carbon accounting. Dr. Oneil's written testimony offers reasonable solutions that would be beneficial for our forests, for our climate, and for the American people.

I look forward to a robust discussion on the state of our Federal lands.

Ms. HAALAND. Thank you very much, Mr. Curtis and Mr. Young.

I would like to introduce our witnesses. Under our Committee Rules, oral statements are limited to 5 minutes, but your entire statement will appear in the hearing record.

The lights in front of you will turn yellow when there is 1 minute left, and then red when time has expired. After the witnesses have testified, Members will be given the opportunity to ask questions.

The Chair now recognizes Dr. Patrick Gonzalez for 5 minutes.

STATEMENT OF PATRICK GONZALEZ, ASSOCIATE ADJUNCT PROFESSOR, UNIVERSITY OF CALIFORNIA–BERKELEY, BERKELEY, CALIFORNIA

Dr. GONZALEZ. Chairwoman, Ranking Member, and members of the Committee, thank you for the invitation to speak on the science of human-caused climate change in the U.S. national parks.

I am Patrick Gonzalez, a forest ecologist and associate adjunct professor at the University of California, Berkeley. I am also the principal climate change scientist of the U.S. National Park Service. But today I speak under my Berkeley affiliation, not for the Park Service.

I have conducted and published field research on climate change for over 25 years. I have also served as a lead author on four reports of the Intergovernmental Panel on Climate Change, the science organization awarded a share of the 2007 Nobel Peace Prize.

Wildfires burning in Yosemite National Park in California, glaciers melting in Glacier Bay National Park in Alaska: published scientific research has detected these changes and others in U.S. national parks, and attributed them to human-caused climate change.

The human cause of climate change is an important scientific fact because it points us to the solutions to the problem. Measurements show that cars, power plants, deforestation, and other human sources have increased carbon dioxide to its highest levels in 800,000 years. This increase has intensified the greenhouse effect, and increased temperatures to their highest levels in over 800 years. Human activities have caused 97 percent of historical heating.

Colleagues and I published last year the first analysis of climate change trends across all 417 national parks. Our results revealed that climate change since 1895 has exposed the national parks to conditions hotter and dryer than the country, as a whole. Temperatures in the national parks increased at double the national rate. The temperature increase was 1 degree Celsius, or 2 degrees Fahrenheit per century.

That might not sound like a lot, but 1 degree is the equivalent of pushing a mountain down 170 meters, or 550 feet—that is the height of the Washington Monument—from cooler areas at higher elevations to warmer areas below.

Also, rain and snow decreased more in the national parks than in the country as a whole. Hotter and drier conditions occurred because many parks are located in the extreme environments: in the Arctic, in high mountains, and the arid Southwest.

As a result, in Glacier Bay National Park in Alaska, climate change has melted 640 meters of ice from Muir Glacier. That's 2,100 feet more than the height of One World Trade Center.

In Yosemite National Park and across the West, climate change has doubled wildfire, compared to the area of natural burning.

In Rocky Mountain National Park and across the West, climate change has doubled tree death, particularly from bark beetles.

In Noatak National Preserve in Alaska, climate change has shifted forests northward onto formerly treeless tundra.

Climate change has raised sea level halfway to your knee in Golden Gate National Recreation Area in San Francisco, and all the way to your knee in New York City, not far from the Statue of Liberty.

Climate change has killed coral reefs in Biscayne National Park, Florida.

Continued climate change under the worst scenario could substantially heat the parks and the future up to 9 degrees Celsius or 16 degrees Fahrenheit in Alaska.

Our research shows that cutting carbon pollution could reduce projected heating in national parks by up to two-thirds. The lowered heating would lower future risks.

The United States has demonstrated its ability to cut emissions. The United States cut emissions 8 percent from 2007 to 2015. The U.S. Climate Alliance of 19 states and 1 territory has cut its emissions 14 percent, on track to meet the Paris Agreement goals. We achieved this progress with energy conservation, energy efficiency, solar, public transit, and other sustainable actions.

In conclusion, the U.S. national parks protect some of the most irreplaceable natural areas and cultural sites in the world. Cutting carbon pollution would reduce human-caused climate change and help save our national parks for future generations. Thank you.

[The prepared statement of Dr. Gonzalez follows:]

PREPARED STATEMENT OF PATRICK GONZALEZ, PH.D., UNIVERSITY OF CALIFORNIA, BERKELEY

EXECUTIVE SUMMARY

From wildfires burning in Yosemite National Park, California, to glaciers melting in Glacier Bay National Park, Alaska, published scientific research has detected changes globally and in United States (U.S.) national parks and attributed them to human-caused climate change. These impacts are occurring because climate change since 1895 has exposed the national parks to twice the heating of the country as a whole and to more severe aridity. Without cuts to pollution from cars, power plants, deforestation, and other human sources, continued climate change could increase future temperatures up to six times faster than historical rates, threatening the unique landscapes, plants, and animals in parks. Adaptation of resource management could decrease some projected damage. Yet, cutting carbon pollution from human sources is the solution that targets the cause of climate change. Emissions reductions could lower projected heating in national parks by one-half to two-thirds. The lowered heating would reduce risks of severe wildfire, disappearances of plant and animal species, and other threats to our national parks.

INTRODUCTION

Chairwoman, Ranking Member, and members of the Committee, thank you for the invitation to speak on the science of human-caused climate change in the U.S. national parks. I am Patrick Gonzalez, a forest ecologist and Associate Adjunct Professor at the University of California, Berkeley, in the Department of Environmental Science, Policy, and Management. I am also the Principal Climate Change Scientist of the U.S. National Park Service, but today I am speaking under my Berkeley affiliation, not for the Park Service. I earned my Ph.D. at the University of California, Berkeley, and have conducted and published field research on climate change for 25 years. I have also served for over 8 years as the lead for climate change science in the U.S. National Park Service. I am a lead author on four reports of the Intergovernmental Panel on Climate Change (IPCC), the organization that

produces the authoritative scientific assessments of climate change, for which it was awarded a share of the 2007 Nobel Peace Prize.

HUMAN CAUSE OF CLIMATE CHANGE

The human cause of climate change (1) is an important scientific fact because it points us to solutions to the problem. Atmospheric measurements show that carbon dioxide has increased to its highest level in 800,000 years (Figure 1) (2–5). Measurements show that the increased carbon dioxide and other greenhouse gases in the atmosphere come from cars, power plants, deforestation, and other human sources (6). Chemical analyses show that the additional carbon dioxide bears the unique chemical signature of fossil fuels—coal, oil, and gas—not of natural emissions from volcanoes (7). Human sources now emit twice the amount of carbon dioxide that vegetation, soils, and the oceans can naturally absorb (6). This is the fundamental imbalance that causes climate change.

The increase in carbon dioxide has intensified the greenhouse effect, the trapping of heat close to the surface of the Earth. Consequently, the world has heated to its highest temperature in 800 years (8). Measurements of the potential causal factors—human and natural—show that carbon dioxide and other greenhouse gases from human activities caused 97 percent of historical heating (9). Solar cycles and other natural factors caused just the remaining 3 percent. Therefore, scientific evidence shows that human activities are causing climate change.

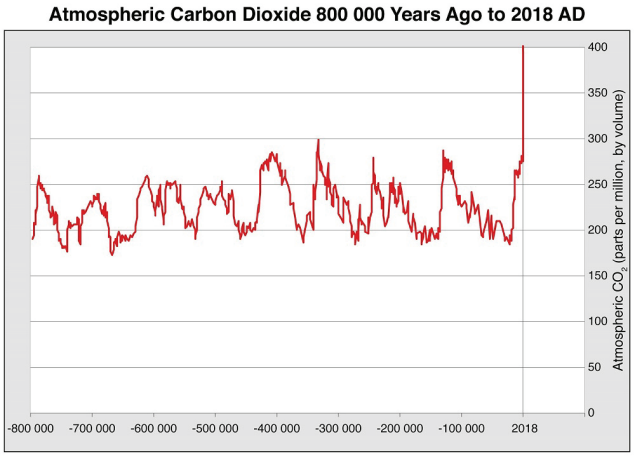

Figure 1. Atmospheric carbon dioxide 800,000 years ago to 2018 AD.

HISTORICAL IMPACTS IN U.S. NATIONAL PARKS

The magnitude of climate change across all the U.S. national parks was not known until recent research by colleagues and me. In 2018, we published the first spatial analyses of temperature and precipitation trends across all 417 U.S. national parks (10). Our analyses of historical data revealed that climate change has exposed the national parks to conditions hotter and drier than the country as a whole. This occurs because extensive parts of the parks are in extreme environments—the Arctic, high mountains, and the arid Southwest.

Our findings show that temperatures in the national park area increased at a rate of 1°C (approximately 2°F.) per century from 1895 to 2010, double the national rate. At the same time, precipitation decreased across a greater fraction of the national park area (12 percent) than the country as a whole (3 percent). Out of all 417 national parks, temperatures increased most in Denali National Preserve, Alaska (4.3°C [approximately 8°F.] per century) (Figure 2), and rainfall declined most in Honouliuli National Monument, Hawaii (85 percent decrease per century).

The implications of this increased heat and aridity in the national parks were not comprehensively known until recently. In 2017, I published the first comprehensive assessment of published research on climate change impacts and vulnerabilities in U.S. national parks (11). This section on historical impacts provides cases from that publication, only including research that has employed the research procedures of detection and attribution (1).

Detection is the finding of statistically significant changes over time that are different than natural variation. Attribution is the analysis of different potential causes, natural and human, to determine their relative importance. In many national parks, it is easier to tell if human-caused climate change is the main cause of changes in the field because many parks have been protected from urbanization, timber harvesting, grazing, and other non-climate disturbances.

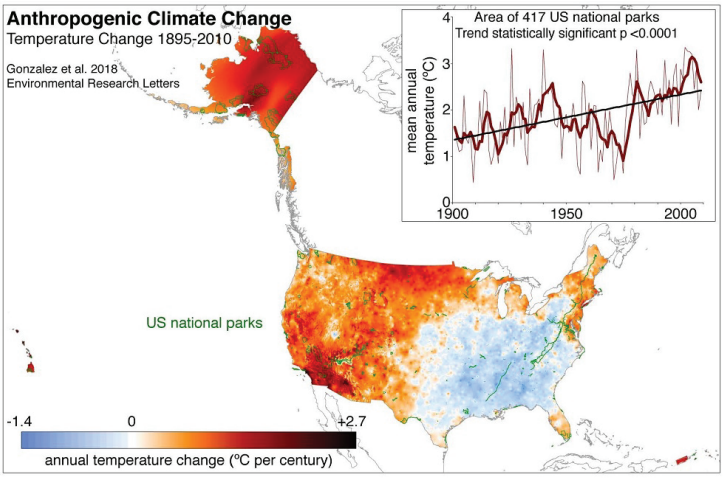

Figure 2. Temperature change from 1895 to 2010 due to human-caused climate change. Map: Trend in annual temperature in degrees Celsius per century, with park boundaries in green. Graph: Statistically significant trend for the area of the 417 U.S. national parks.

Historical impacts detected and attributed to human-caused climate change include:

- **Glaciers melting** In Glacier Bay National Park (NP), Alaska, climate change melted 640 meters (2100 ft.) of ice (depth) from Muir Glacier from 1948 to 2000 (Figure 3) (12,13). In Glacier NP, Montana, climate change melted 1.5 km (1 mi.) of ice (length) from Agassiz Glacier from 1926 to 1979 (13,14). In the North Cascades NP complex, Washington, climate change melted four glaciers away completely from 1984 to 2004 (13,15).

Figure 3. Melting of Muir Glacier, Glacier Bay National Park, Alaska. Top: August 13, 1941 (photo by William O. Field, U.S. Geological Survey). Bottom: August 31, 2004 (photo by Bruce F. Molnia, U.S. Geological Survey).

- **Snowpack decline** Across the western U.S., including North Cascades NP, Washington, and 10 other national parks, climate change has melted snowpack to its lowest level in eight centuries (16).
- **Wildfire increase** Across the western U.S., including Yellowstone NP, Wyoming, and Yosemite NP, California, climate change doubled the area burned by wildfire from 1984 to 2015, compared to the area of natural burning (17). Wildfire is a natural part of many ecosystems but excessive wildfire can damage ecosystem integrity and hurt people. Across the western U.S., climate was the dominant factor controlling burning from 1916 to 2003, even during periods of active fire suppression (18).
- **Tree death** Across the western U.S., including Kings Canyon NP, Lassen Volcanic NP, Sequoia NP, and Yosemite NP, California, Mount Rainier NP, Washington, and Rocky Mountain NP, Colorado, climate change doubled tree mortality from 1955 to 2007 (19), due to increased aridity (19,20), the most extensive bark beetle infestations in a century (19–22), and increased wildfire (20).
- **Vegetation shifts** In Yosemite NP, California, climate change shifted subalpine forest upslope into subalpine meadows between 1880 and 2002 (23). In Noatak National Preserve, Alaska, climate change shifted boreal conifer forest northward onto formerly treeless tundra between 1800 and 1990 (24). Climate change, by shifting warmer conditions upslope and farther north, has shifted major vegetation types (biomes) at sites around the world (25).

- **Wildlife shifts** In Yosemite NP, California, field research showed that climate change shifted the ranges of the American pika, a small alpine mammal, and other species 500 meters upslope (approximately 1600 ft.) from 1920 to 2006, when temperature increased 3°C (approximately 5°F) (26). Because the national park had protected the survey area, timber harvesting, grazing, and hunting were not major factors.

  Analyses of Audubon Christmas Bird Count data across the U.S., including sites in numerous national parks, found that climate change shifted the average winter range of 254 bird species northward 15 km (9 mi.) from 1975 to 2004 (27). Because of this, the evening grosbeak disappeared from counts in Sleeping Bear Dunes National Lakeshore, Michigan, and Shenandoah NP, Virginia.
- **Sea level rise** Climate change has raised sea level 22 cm (9 in.) since 1854 at Golden Gate National Recreation Area, San Francisco, California (28–30), 42 cm (17 in.) since 1856 at New York City (29–31), not far from the Statue of Liberty National Monument, and 30 cm (12 in.) since 1924 at Washington, DC (29,30,32), not far from the Jefferson Memorial and the White House, which is a national park.
- **Coral bleaching** Climate change bleached and killed up to 80 percent of coral reef area in 2005 at sites in Biscayne NP, Florida, and Buck Island Reef National Monument, Salt River Bay National Historical Park and Ecological Preserve, Virgin Islands National Park, and Virgin Islands Coral Reef National Monument (33,34). That year, climate change had caused the hottest sea surface temperatures recorded in the Caribbean Sea since 1855.

FUTURE VULNERABILITIES

To quantify potential future changes in national parks, colleagues and I analyzed all available climate projections from the Intergovernmental Panel on Climate Change, as part of the first spatial analysis of climate trends across all 417 U.S. national parks (10). Our results indicate that continued carbon emissions under the worst scenario could increase temperatures in the 21st century six times faster than occurred in the 20th century. Temperatures in national parks could increase up to 9°C (16°F.) by 2100, in the national parks of Alaska, and rainfall could decline by as much as 28 percent, in the national parks of the U.S. Virgin Islands. Aridity could also increase in Big Bend NP, Texas, Everglades NP, Florida, and other national parks at southern latitudes.

Published research on U.S. national park resources indicates that continued climate change could damage many of the globally unique ecosystems and resources that the parks protect. These vulnerabilities include:

- **Loss of glaciers** Climate change could cause, under the worst scenario, complete melting of glaciers from Glacier National Park, Montana, by the 2030s (35) and the disappearance of Sperry Glacier from Rocky Mountain NP by the 2040s (36).
- **Wildfire increase** The hotter temperatures of climate change could, under a high emissions scenario, increase wildfire frequencies in Yellowstone NP and Grand Teton NP, Wyoming, 300 percent to 1000 percent (37) and up to 300 percent in Yosemite NP, California, by 2100 (38).
- **Tree death** The more severe aridity of climate change could, under a high emissions scenario, reduce suitable habitat of the Joshua tree in the southwestern U.S. 90 percent by 2100, leading to extensive death of Joshua trees in Joshua Tree NP, California (39,40). The more severe aridity of climate change also increases the risk of higher mortality of foothills palo verde and ocotillo in Saguaro NP, Arizona (41), piñon pine in Bandelier National Monument, New Mexico (42), and coast redwoods, the tallest living things on Earth, in Muir Woods National Monument, California (43,44). Loss of snow under projected climate change increases the vulnerability of Alaska yellow cedar to increased mortality in Sitka National Historical Park, Alaska (45). Under projected climate change, 16 percent to 41 percent of total national park area is highly vulnerability to northward and upslope vegetation shifts (biome shifts) (25).
- **Loss of wildlife** Climate change may shift habitats upslope to such an extent that the American pika, a small alpine mammal that lives at the highest elevations, could disappear from Lassen Volcanic NP, California (46). Climate change could also exacerbate cheatgrass invasions in Craters of the Moon National Monument and Preserve, Idaho, leading to substantial decline of the

sage grouse (47,48). Numerous national parks could lose local bird species and be colonized by new migrants (49). At Canaveral National Seashore, Florida, green turtles are vulnerable to increased mortality from flooding of nests by increases in storms (50).

- **Inundation from sea level rise** Sea level rise due to climate change could inundate much of Everglades National Park, Florida (51), the center of Golden Gate National Recreation Area, California (52,53), the National Mall and other national parks in Washington, DC (54), one-third of the area of Assateague Island National Seashore, Maryland (55), and the Statue of Liberty National Monument, New York (56).
- **Ocean acidification** Corals and other marine life in Dry Tortugas National Park, Florida (57), and Channel Islands NP and Cabrillo National Monument, California (58), are vulnerable to dissolving in acidified waters under continued climate change.

ADAPTATION OF NATURAL RESOURCE MANAGEMENT

Adaptation to climate change is the adjustment of practices in a way that moderates future harm. One adaptation measure under implementation in a national park is the protection of refugia for the Joshua tree in Joshua Tree NP, California (40). Other adaptation measures under consideration for parks include conservation of refugia for mountain plants and animals (59,60), and conservation of cooler water refugia for fish (61). Prescribed burning is an adaptation measure that reduces future risks of catastrophic wildfire and tree death by removing an unnatural build-up of fuel and small trees where old policies suppressed natural wildfire (62,63). While adaptation measures are important to help maintain ecosystem integrity, they only treat symptoms of climate change, not the cause.

CARBON SOLUTIONS

Published research by colleagues and me concludes that reducing the cause of climate change—carbon pollution from cars, power plants, deforestation, and other human sources—can save national parks from the most extreme heat in the future (10). Compared to the worst scenario, reduced carbon emissions would lower projected heating in national parks by one-half to two-thirds by 2100.

The reduced heating could produce real benefits on the ground. While under the worst emissions scenario, 16 percent of plant and animal species globally could be at risk of extinction (64), the risk drops to 5 percent under the lowest emissions scenario of meeting the Paris Agreement goal (65). Similarly, global sea level could rise 74 cm (29 in.) under the worst emissions scenario, but rise 44 m (17 in.) under the Paris Agreement goal (29). In Yosemite NP, California, climate change under the worst emissions scenario could triple burned area by 2100, but a low emissions scenario could keep wildfires near to their current level (38).

A supplemental carbon solution is the conservation of forests, which naturally reduce climate change by removing carbon dioxide from the atmosphere and storing it in leaves and wood. Coast redwood forest near Redwood NP, California, contains more carbon per area on the ground than any other forest in the world (66). The 27 national parks in California together contain as much carbon as the annual emissions of 7.4 million Americans, or the combined population of the cities of Boston, Charlotte, Dallas, Kansas City, Los Angeles, and Miami (67). This is a substantial amount of carbon, but those millions of people can burn the equivalent of all the carbon in the coast redwoods and other vegetation in the national parks in California in just one year. Therefore, forest conservation is insufficient as a sole solution to climate change. This points to the need for reducing emissions from fossil fuel burning.

Analyses by the IPCC recently confirmed that it is still possible to limit future heating to the Paris Agreement goal of a temperature increase less than 2°C (approximately 4°F) (68). The U.S. has already demonstrated its ability to cut emissions. From 2007 to 2015, the U.S. cut emissions 8 percent (69). From 2005 to 2016, the U.S. Climate Alliance of 19 states and one territory cut its emissions 14 percent, on track to meet the Paris Agreement goal (70). We have achieved this progress through energy conservation, improved efficiency, renewable energy, public transit, and other available practices.

The U.S. national parks protect some of the most irreplaceable natural areas and cultural sites in the world. Cutting carbon pollution would reduce human-caused climate change and help save our national parks for future generations.

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Publications and information by Patrick Gonzalez at http://www.patrickgonzalez.net, https://ourenvironment.berkeley.edu/people/patrick-gonzalez, and https://twitter.com/pgonzaleztweet.

Ms. HAALAND. Thank you, Dr. Gonzalez.

The Chair now recognizes Dr. Lara Hansen.

STATEMENT OF LARA HANSEN, EXECUTIVE DIRECTOR AND CHIEF SCIENTIST, ECOADAPT, BAINBRIDGE ISLAND, WASHINGTON

Dr. HANSEN. Good morning, and thank you, Ms. Chairwoman, Ranking Member, and the Committee, for inviting me to speak about climate change and our public lands. I have had the honor to visit the Hill twice before to talk about climate change, first in 2004, when I was pregnant with my son. And I talked about the hopeful work I was conducting around the world to improve ecosystem management in the face of climate change: a discipline called adaptation. I urged the Senate to reduce greenhouse gas emissions and keep climate change to less than 2 degrees Celsius.

In 2007, I was invited back to testify on the effects of climate change on marine ecosystems. My son was now three. I applauded Congress for the existence of several bills to reduce greenhouse gas emissions. I repeated the need to keep climate change to less than 2 degrees Celsius, and I added a request for the creation of a national adaptation policy with an extension agency to provide technical support.

The following year, two colleagues and I co-founded EcoAdapt, in order to bring the skills we were supporting internationally to the United States, so our own country could become more durable to the insults of climate change.

A decade later EcoAdapt is now a team of 12 supporting the innovation of adaptation approaches across the United States. We see a growing number of people incorporating the realities of climate change into their work, but not nearly to the extent necessary.

We host the biennial National Adaptation Forum, and in 2017 we had over 1,000 attendees. We are a country of 325 million. Certainly, we need more than 1,000 people doing this work. Our country is utterly unprepared for the scale of this challenge.

In every one of your districts, there are decisions being made every day, not only on public lands, but also on private lands and in our communities that are vulnerable to climate change. Not considering the implications of climate change will result in investments in infrastructure, management, and protection that will not garner the anticipated outcomes. Instead, we will end up spending additional funds to rebuild, risking community members' lives and livelihoods, and doing damage to our environment. Explicit consideration of climate change and our actions today is vital for our lives tomorrow.

As lawmakers, you have the power to do something. For my 20 years of professional experience in the field of adaptation, I recommend the following.

One, create a national adaptation policy that requires the consideration of the impacts from and to climate change, and evaluation of funding and permitting for land use activities and, quite frankly, everything else.

Two, create a national climate change adaptation and mitigation extension agency. This would provide technical support to public and private land managers and everyone else at the Federal, state, and local level.

Three, require the protection and management of our public lands with an awareness that the climate is changing. This means the agencies entrusted to protect our public lands must evaluate the climate change vulnerability of ecosystems and the actions proposed on these lands such that they can act to reduce that risk. This needs to be part of how we do business.

We must ensure that we are protecting adequate and appropriate space for ecosystems to function under changing conditions, including protecting refugia, connectivity, functionality, and employing forward restoration.

We must support our land stewards with the staff and funding to monitor and evaluate the effectiveness of management, and give them the ability to make management decisions that prepare us for future conditions.

We must manage lands for the long term, to maximize our rate of return, which will be realized as access to clean air, clean and plentiful water, flood control, wildlife habitat, improved mental health, spiritual opportunities, recreational enjoyment, and long-term jobs. Our public lands must not be managed for quarterly profit margins.

Four, re-evaluate acceptable levels of non-climate stressors on our public lands. From roads or invasive species, to over-harvest or eutrophication, to industrial chemicals from gas extraction and mining, or chemical fire suppressants, the impact of these stressors can be compounded by the manifestations of climate change.

And, of course, since that child I spoke about at the beginning of my testimony is now a teenager, I know that I often have to repeat myself to get action, such as emptying the dish rack. So, here it goes.

Number 5, keep global climate change to well below 2 degrees Celsius. Actually, we now know that 1.5 degrees Celsius is the more prudent target. We need to reduce our national consumption and production of fossil fuels to stop making the problem worse. The cost of inaction is unaffordable for us and our children.

I am delighted that Congress and this Committee are again taking up the issue of climate change. This time let's do something to increase the likelihood of good outcomes. Let's act now. Thank you.

[The prepared statement of Dr. Hansen follows:]

PREPARED STATEMENT OF DR. LARA J. HANSEN, CHIEF SCIENTIST AND EXECUTIVE DIRECTOR, ECOADAPT

Protecting our public lands is a critical part of an adaptation strategy that not only safeguards these areas and the ecosystems that inhabit them, but also the ecosystem services upon which our citizens rely. Investment in the protection of public lands may be our best path to enduring access to clean air, clean and plentiful water, flood control, wildlife habitat, improved mental health, spiritual heritage, and recreational enjoyment. In my testimony I will introduce you to the ways by which we can increase the resilience of our public lands in the face of climate change and what we need to make this happen.

I would like to begin by providing some context. I am the head of a non-profit organization that is filling a very large gap—creating a climate-savvy society by innovating, facilitating and training practitioners in adaptation solutions. EcoAdapt's [1] sole focus is to "meet the challenges of climate change." That means helping everyone from foresters and marine protected area managers to city planners and public health officials apply a climate lens through which to evaluate their work and develop solutions that will allow them to succeed in meeting their mandate even as the world is changing around them. We do this through four programs. Our State of Adaptation program takes a research approach to assessing what activities people are undertaking, what is working and what is preventing success. Our Climate Adaptation Knowledge Exchange is the largest adaptation resource database. It is available via an online, open access portal (CAKEx.org) [2] that is accessed by thousands of people from around the world each month. Awareness to Action is our workshop methodology that has provided hands-on training in climate change adaptation to over 6,000 individuals representing hundreds of organizations and agencies across the country (and a few around the world). Finally, our National Adaptation Forum [3] is a biennial convening of adaptation professionals that affords the opportunity for the exchange of ideas and the innovation of the next generation of climate solutions.

In the past 10 years, my team at EcoAdapt has learned a lot about good adaptation practice—on the ground and through government support. I'd like to share some of that with you today. My hope is that you will see the importance of supporting this type of work in your own Districts and through the Federal mechanisms that can help to make all of our lands and communities climate savvy. Because the effects of climate change that are being felt today will continue and intensify for centuries or millennia to come, every day we are afforded the opportunity to make management and planning decisions that either help us prepare for these changes or leave us more and more vulnerable. Let's take the path that leads to a better future. A path on which we take both mitigation (reducing the greenhouse gases that cause climate change) and adaptation (preparing for and responding to the climate change impacts that are unavoidable due to past emissions) seriously. These are not choices to be played against each other—both are necessary responses to climate change. Doing one without the other will lead us to a false sense of failure.

Ignoring climate change in the management of National Parks, forests and other public lands is not an option. It was not an option the first time I testified before a congressional committee (Senate Committee on Commerce, Science and Transportation) in March 2004, almost exactly 15 years ago, when atmospheric CO_2 was 378 ppm and global temperature had increased 0.6 degrees Celsius. Yet we did not take action. It was not an option when I testified in 2007 to the Senate Committee on Commerce, Science and Transportation's Subcommittee on Oceans, Atmosphere,

[1] http://ecoadapt.org/.
[2] https://www.cakex.org/.
[3] https://www.nationaladaptationforum.org/.

Fisheries, and Coast Guard, when atmospheric CO_2 was 386 ppm. And still we did not change our trajectory. Today atmospheric CO_2 has reached 410 ppm and global temperature has risen 1 degree Celsius. I am back today hoping that we are ready to fully address this massive problem with the level of action it requires. The best place to start is somewhere, so let's start by taking action on our public lands.

HOW CAN WE INCREASE THE RESILIENCE OF PUBLIC LANDS IN THE FACE OF CLIMATE CHANGE?

Public lands are the places where plants and animals thrive, where they have the space to move and grow. They are vital for providing intact ecosystems and connectivity, supporting high biodiversity and healthy species. Public lands also provide critical ecosystem services upon which neighboring and non-neighboring communities, non-local visitors, and others have come to rely. In particular, public lands provide abundant fresh water for human and environmental uses; building materials and other wood products; forage for livestock; clean air; water filtration and maintenance of water quality; protection from wildfire, floods, and erosion; carbon sequestration; recreational opportunities; aesthetic values from scenery; spiritual and religious values; and cultural heritage.

Climate change presents a significant threat to our public lands and the services that they provide. Resilient public lands enable species and ecosystems and the services they provide to rebound in the face of rapid environmental change. We can increase the resilience of public lands by implementing a number of well-understood practices, including incorporating climate change impacts and adaptation into all planning efforts, improving regional coordination, assessing the effectiveness of adaptation actions and implementing those that represent the "best bets" under changing climate conditions, protecting adequate and appropriate space, reducing local and regional climate change and non-climate stressors, and reducing the rate and extent of climate change. **By implementing these practices, we are safeguarding the species, ecosystems, and services that we not only hold dear but are essential to our way of life.**

Incorporate climate change impacts and adaptation into all planning efforts. Incorporating climate change into planning efforts can take the form of discrete "climate action or adaptation plans" or the direct integration of climate change into existing planning processes. For example, through our vulnerability assessment and adaptation planning methodologies, EcoAdapt helps natural resource managers from state and Federal agencies evaluate how the species and habitats they manage are vulnerable to climate change, reassess and revise their current actions and projects to address vulnerabilities, and identify new actions to integrate into future projects. Some examples include work in California and the Hawaiian Islands.

EcoAdapt, in collaboration with numerous other partners, worked with the Greater Farallones National Marine Sanctuary (located along the north-central California coast and ocean) to evaluate vulnerability of their species, habitats, and ecosystem services to climate change and create a Climate Adaptation Plan.[4] The region's natural resources and the services they provide are vulnerable to increasing ocean temperatures, sea level rise, and extreme weather events (winds, waves, storms). The plan integrates climate adaptation into existing management frameworks and recommends over 75 adaptation strategies for regional management agencies to take to enhance coastal resilience, including implementing living shorelines, protecting and restoring habitat, limiting human disturbance, addressing invasive species, promoting education, and investing in science needs.

In Southern California, EcoAdapt worked with natural resource managers to reexamine the Ojai Community Defense Zone Project, which planned to restore and expand fuel-breaks in chaparral habitats adjacent to multiple human communities.[5] Chaparral habitats, as well as adjacent communities, are vulnerable to increased wildfire severity and increased extreme precipitation events projected under climate change. Increasing human populations may exacerbate these impacts, as fire ignitions in the region are primarily human-caused. While a number of existing management actions help to alleviate climate impacts, resource managers identified new

[4] Hutto, S. 2016. Climate-Smart Adaptation for the North-central California Coast and Ocean. Ed. Rachel M. Gregg [Case study on a project of the Greater Farallones National Marine Sanctuary]. Retrieved from CAKE: https://www.cakex.org/case-studies/climate-smart-adaptation-north-central-california-coast-and-ocean.

[5] Kershner, J.M., L.E. Hilberg, and W.A. Reynier. 2017. The Ojai Community Defense Zone Project: A Southern California Climate Change Adaptation Case Study. Retrieved from CAKE: https://www.cakex.org/case-studies/ojai-community-defense-zone-project-southern-california-climate-change-adaptation-case-study.

actions to integrate into future projects. For example, planting native perennial grasses within fuel-breaks to reduce invasive grass establishment (invasive grasses contribute to more severe wildfires) and establishing trigger points for recreation closures and restrictions (helps reduce the number of human-caused ignitions).

In Hawaii, after going through a vulnerability assessment-adaptation planning process[6] with EcoAdapt, managers from the Plant Extinction Prevention Program decided to shift the amount of seeds they plant vs. store in response to projected climate threats such as increased drought risk and altered precipitation amount and timing.

Improve regional coordination. Improving coordination helps increase the resilience of public lands and associated ecosystem services by providing opportunities to leverage resources (e.g., funding, data, people time), building buy-in and support for plans and on-the-ground projects, improving communication about planned and ongoing activities, and providing a shared understanding of threats, solutions, and priorities. For example, the Flagstaff Watershed Protection Project is a partnership effort between the state of Arizona, city of Flagstaff, and Coconino National Forest to help reduce the risk of devastating wildfire and post-fire flooding in neighboring watersheds.[7] In 2010, the Schultz Fire in Coconino National Forest severely burned thousands of acres of steep terrain; over 20 major flash flooding events occurred after the fire, destroying community drinking water and costing over $130 million in damages. Increased fire severity and extreme precipitation events are projected to continue with climate change, requiring targeted forest restoration work and collaboration to reduce the risk of fire and flooding and subsequent impacts on the community. This project is one of only a handful of examples where restoration work on a national forest is being funded primarily by a municipality.

The Northern California Climate Adaptation Project is a multi-stakeholder, collaborative effort to assess the impacts of climate change on and co-develop adaptation strategies and actions for habitats and species of northwestern California.[8] The USDA Forest Service and Bureau of Land Management manage over 6 million acres of public lands in the region, and plan to use findings from this project to inform revisions of their land management plans. Many tribes occur within or around these public lands and are affected by management decisions made by these two entities. Tribal input and participation have been critically important in this project, helping to identify potential conflicts with adaptation options. For example, increasing the use of prescribed burning reduces the likelihood of high-severity wildfires (a current and future threat to the region) however, increased burning in the spring has the potential to conflict with cultural values and site use during the season. Explicitly incorporating tribal considerations into adaptation planning can help build buy-in for management actions on public lands and enhance the resilience of neighboring tribal communities.

Assess adaptation effectiveness. The importance of making informed decisions to alleviate the environmental, financial, and emotional costs of climate change cannot be overstated. Climate change presents a variety of impacts to which managers and planners must respond, ranging from habitat restoration and designation of protected areas to increased public education and outreach and broad policy changes. Several adaptation case studies and guidebooks have been released in recent years with recommendations of suitable adaptation actions to address different climate impact concerns. However, determining when, where and how a particular action may be best implemented is more difficult to discern. Synthesizing what has worked and what has not worked, as well as why, can help identify potential modifications to current management practices and facilitate understanding of the consequences of decisions. Further, science- and evidence-based decision making supports better management outcomes, while reducing costs and lowering the risk of implementing policies that may be based on well-intentioned but insufficient research. In addition to improving overall practice, a better understanding of which actions can be most effectively applied in different settings helps managers identify and leverage funding opportunities and create new or enhance existing partnerships to advance climate adaptation. Evaluating the science behind management approaches of the past to determine their usefulness under changing climate conditions is an evolving area of research by EcoAdapt. We have embarked on an effort to evaluate the body of scientific knowledge supporting specific climate adaptation

[6] Gregg, R.M., editor. 2018. Hawaiian Islands Climate Vulnerability and Adaptation Synthesis. EcoAdapt, Bainbridge Island, WA. http://bit.ly/HawaiiClimate.

[7] Flagstaff Watershed Protection Project: http://flagstaffwatershedprotection.org.

[8] Northern California Climate Adaptation Project: http://ecoadapt.org/programs/adaptation-consultations/norcal.

actions to determine the conditions under which particular actions may be most effective for achieving management goals. Since 2014, we have assessed wildfire, sea level rise, and ecological drought adaptation options.

Protect open space. Protecting adequate and appropriate space, including identifying and protecting areas of climate refugia (places with more stable climatic conditions, current and/or future), connectivity and corridors, and/or the geophysical setting continues to be a critical strategy for increasing the resilience of public lands.[9,10] Protecting habitats and areas of refugia provide a safe haven that species can retreat to and/or persist in under climate change, and ensures that important ecosystem services continue to be available. For example, protecting habitats such as headwater streams or groundwater sources may be critical for maintaining water supply that human communities depend on. Similarly, protecting geophysical settings may help maintain regional biodiversity with climate change.

Reduce local and regional climate change, as well as non-climate stressors. Reducing local and regional climate change and minimizing non-climate stressors are key to increasing the resilience of public lands.[11] In some cases, it may be possible to reduce local or regional climate changes. For example, replanting riparian vegetation along streams can limit water temperature increases and help keep water in the system. Non-climate stressors have the potential to exacerbate (or be exacerbated by) climate impacts. For example, invasive grasses alter the availability and continuity of fire fuels, contributing to more severe wildfires.

Restoration of habitat structure, function, and processes continues to be one of the best ways to address both climate and non-climate stressors. However, it is not enough to engage in restoration activities as we have done in the past and, in fact, "restoring" ecosystems to some former state will likely make them ill-equipped to deal with the challenges of climate change. Instead, restoration activities now need to be designed with climate impacts integrated from the start. For example, planting drought-tolerant native species in areas projected to get drier rather than planting the species that have historically been there under wetter conditions, or implementing a landscape-scale approach that combines thinning, prescribed burning, and managed wildfire to reduce tree densities and understory vegetation in an area projected to see more high-severity fires, rather than relying only on forest thinning.

Wildfires, particularly in the West, are increasing in frequency and severity. With increasing air temperatures and decreasing summer soil moisture levels, the probability of widespread, catastrophic wildfires continues to rise, threatening habitats, species, and public health and safety.[12,13] Several approaches are used to manage wildfire risk, including prescribed fire, thinning, mechanical fuel treatments, and wildfire managed for multiple objectives. For example, prescribed fire has been used for decades to reduce fuel loads, promote more open and diverse forest structure, maintain or increase biodiversity, and preserve defensible space around infrastructure and human communities.[14] As a climate adaptation action, prescribed fire reduces the risk of catastrophic or stand-replacing fire by targeting and reducing surface and ladder fuels, allows for the re-introduction of natural fire regimes, and prepares the landscape for the re-establishment of fire-tolerant native species that may be better adapted to shifting fire regimes.[13,15] Managers are already modifying their use of prescribed fire in responses to changing conditions, such as earlier spring burn windows, although institutional and sociopolitical constraints, such as a lack of funding and trained staff, liability issues, and public acceptance of smoke, limit its application across the landscape.[13]

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[9] Hansen, L.J. and J.R. Hoffman. 2011. Climate Savvy: Adapting Conservation and Resource Management to a Changing World. Island Press, Washington, DC.

[10] Hansen, L.J., et al. 2010. Adapting conservation to climate change. Conservation Biology. 24:63–68.

[11] Hansen, L.J. and J.R. Hoffman. 2011. Climate Savvy: Adapting Conservation and Resource Management to a Changing World. Island Press, Washington, DC.

[12] Westerling, A., et al. 2006. Warming and earlier spring increase western U.S. forest wildfire activity. *Science* (313)5789: 940–943. DOI: 10.1126/science.1128834.

[13] Gregg, R.M., et al. 2016. Available Science Assessment Project: Prescribed Fire and Climate Change in Northwest National Forests. Report to the Department of the Interior's Northwest Climate Science Center.

[14] Scott, G., et al. 2013. Reforestation-Revegetation Climate Change Primer: Incorporating Climate Change Impacts into Reforestation and Revegetation Prescriptions. U.S. Department of Agriculture, Forest Service, Northern Region.

[15] Spies, T.A., et al. 2010. Climate change adaptation strategies for federal forests of the Pacific Northwest, USA: ecological, policy, and socio-economic perspectives. Landscape Ecology 25(8): 1185–1199.

In coastal systems, sea level rise is causing saltwater intrusion into freshwater ecosystems and aquifers, habitat conversion, infrastructure loss, and in some cases, forced relocation of coastal communities, such as in Alaska (e.g., Native Alaska Villages of Kivalina and Newtok) and Washington State (e.g., Hoh Tribe). The primary adaptation approaches employed to address sea level rise, flooding, and erosion issues include: engineered structures (rip rap, bulkheads, tide gates), natural and nature-based approaches (natural habitats such as wetlands or engineered natural features such as living shorelines), and policy and regulatory techniques (tools that either prevent infrastructure in at-risk areas, such as conservation easements, managed retreat; or modify how activities are implemented to reduce risk such as rolling easements, minimum development buffers, real estate disclosures).[16] Natural and nature-based approaches are being increasingly used throughout the United States, especially in lieu of structural approaches that are experiencing limited and declining use, largely due to their cost, lifetime, and the potential for negative ecological consequences.[16] New and novel approaches, including prioritizing, protecting and restoring coastal wetlands with room to migrate inland as sea levels rise, as well as purchasing inland/upland land to create new opportunities for coastal habitat migration, are also important.[16]

Reduce the rate and extent of climate change. Decreasing greenhouse gas emissions, planting trees, restoring vegetative cover, and preserving open space can help to reduce climate change. If we are looking for solutions to climate change, ending fossil fuel extraction from public lands is a fine place to start. For every barrel of oil not extracted from U.S. public lands, it has been estimated that global demand decreases by half a barrel, leading to a reduction in U.S. emissions of 280 million tons annually by 2030.[17] This is the essential climate change mitigation role for our public lands. Fossil fuels left in the ground will not be entering our atmosphere as greenhouse gases, however the carbon storage potential of biological carbon is not so certain. For example, the carbon storage of coastal wetlands decreases significantly as sea levels rise, drown existing wetlands, and release carbon back into the atmosphere.[18]

HOW ARE ADAPTATION EFFORTS ON PUBLIC LANDS THREATENED?

Despite the urgent need for climate-informed action, the science and practice of adaptation in the United States is at risk from recent intentional and systematic disruptive actions. Public lands are threatened by energy development interests, and Federal climate programs and regulations are being defunded and dismantled.

Energy development and mining interests—oil, gas, coal, uranium, vanadium, cobalt—have driven the reduction of boundaries of Bears Ears and Grand Staircase-Escalante National Monuments by 85 percent and 45 percent, respectively. Bears Ears in particular is rich with cultural significance for Native Americans, featuring over 100,000 well-preserved cultural and archaeological sites. It is an area that is more than tracts of land—it is a profoundly sacred place of spirituality and subsistence. Bears Ears is also home to forests, grasslands, and headwaters, and 18 species listed under the Endangered Species Act, including the California condor and greenback cutthroat trout.[19] A recent study found that this area provides unrivaled ecological connectivity, which is essential for species resilience as well as biodiversity and ecological function preservation in a changing climate.[19] The Navajo people describe such intact landscapes as *Nahodishgish* or "places to be left alone."[20]

In 2009, President Obama enacted Executive Order 13514, which mandated the evaluation and assessment of vulnerabilities that climate change may pose to Federal agency operations and missions, as well as the creation and implementation of agency-specific climate adaptation plans. During that administration's tenure,

[16] Gregg R.M., et al. 2018. Available Science Assessment Process (ASAP): Sea Level Rise in the Pacific Northwest and Northern California. Report to the Northwest Climate Adaptation Science Center. EcoAdapt (Bainbridge Island, WA) and the Institute for Natural Resources (Corvallis, OR).

[17] Erickson, P., and M. Lazarus. 2018. Would constraining US fossil fuel production affect global CO_2 emissions? A case study of US leasing policy. Climatic Change 150: 29–42.

[18] Thorne K, et al. 2018. U.S. Pacific coastal wetland resilience and vulnerability to sea-level rise. Science Advances 4:eaao3270.

[19] Dickson, B.G., M. McClure, and C.M. Albano. 2017. A landscape-level assessment of conservation values and potential threats in the Bears Ears National Monument. A report to The Center for American Progress. http://www.csp-inc.org/wp-content/uploads/2017/03/CSP-BENM_Landscape_Assessment_032717.pdf.

[20] Bears Ears Coalition. 2016. Bears Ears: A Native perspective on America's most significant unprotected cultural landscape. http://www.bearsearscoalition.org/wp-content/uploads/2016/03/Bears-Ears-bro.sm_.pdf.

many Federal agencies and departments developed individual plans and policies, and collaborated through interagency working groups to facilitate funding of climate science and adaptation projects, resources, and tools to support on-the-ground action by other governmental and non-governmental entities. Over the last 2 years, there has been a notable shift in the support for Federal action on climate change, largely due to a growing politicization of science by elected and appointed officials. Federal regulations have been dismantled, climate programs defunded, and critical climate resources and tools removed, altered, or obfuscated, all of which directly impacts the country's ability to prepare for, respond to and recover from the effects of climate change. In addition to the threatened withdrawal of the United States from the Paris Agreement under the United Nations Framework Convention on Climate Change, numerous Executive Orders have been enacted to roll back climate policies (e.g., reversal of the Federal Flood Risk Management Standard, requiring Federal agencies to account for sea level rise in building infrastructure; Executive Order 13693 on Planning for Federal Sustainability in the Next Decade was revoked in May 2018[21]). In 2017 alone, the current administration undertook 60 actions aimed at removing or altering environmental regulations, laws, policies and protections.[22]

Funding has also been stripped from most climate-related Federal programs, which limits not only our Federal partners' capacity to support or implement climate action, but that of by those tribal, state, and local governments and non-governmental entities that depend on resources and services produced at the Federal level. For example, the Landscape Conservation Cooperatives (LCCs), housed within the Department of the Interior, were established to provide capacity and technical expertise to 22 regional networks of Federal, tribal, state, and local governments, NGOs, universities, and private organizations. Today, most LCCs are in limbo without dedicated funding and some have been redesigned and renamed (i.e., Landscape Conservation Partnerships) in instances where there were non-Federal partners that could provide interim support. In addition, Federal advisory panels have been dismantled or simply not continued, including those for the National Climate Assessment, Interagency Land Management Adaptation Group, the Environmental Protection Agency's Board of Scientific Counselors, and the Department of the Interior's Advisory Committee on Climate Change and Natural Resource Science.[23,24] Finally, resources developed by Federal agencies and their partners are now vulnerable or have been altered or removed.[25,26] While action is being taken by many non-governmental groups to protect climate data, there is less attention being paid to protecting the tools, reports, and metadata that are the resources relied on by civil society.[27] And even where it has been "rescued" it become harder for users to find when it is no longer on a Federal website.

WHAT IS NEEDED TO ENSURE WE OPTIMIZE ADAPTATION?

When access to sound science and case studies, technical experts and peer networks, and funding streams is restricted, decision makers are severely limited in their ability to adequately engage in climate adaptation. Organizations such as EcoAdapt and our partners are working every day to prevent this stagnation. Crucial to advancing adaptation and the climate-informed management of public lands are:

1. Access to sound science and technical experts
2. Clear climate-informed mandates, laws, and policies
3. Accessible and sustained finance streams for adaptation initiatives
4. Increased capacity, coordination, and collaboration

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[21] Executive Order 13834 Regarding Efficient Federal Operations: https://www.whitehouse.gov/Presidential-actions/executive-order-regarding-efficient-Federal-operations/.

[22] Eilperin, J. and D. Cameron. 2017. "How Trump is rolling back Obama's legacy." The Washington Post, 24 March 2017.

[23] Eilperin, J. 2017. "The Trump administration just disbanded a federal advisory committee on climate change. The Washington Post, 20 August 2017.

[24] Doyle, M. and B. Patterson. 2017. "Climate advisory group died quietly." Climatewire, 17 August 2017.

[25] Kahn, B. 2017. "The EPA has started to remove Obama-era information." Climate Central, 2 February 2017.

[26] Sabin Center for Climate Change Law, Silencing Science Tracker: http://columbiaclimatelaw.com/resources/silencing-science-tracker.

[27] Varinsky, D. "Scientists are banding together to fight a looming threat from the Trump administration." Business Insider, 19 January 2017.

Access to sound science and technical experts. Natural and cultural resource managers are faced with various challenges on how to avoid, minimize and/or recover from the effects of climate change. Decision making can be complicated by uncertainty in the rate and extent of climate change impacts over time, as well as knowledge gaps in terms of which adaptation actions are best suited for different conditions, most effective in reducing climate change impacts, and supported by scientific evidence.[28-31] Numerous Federal statutes call for using the "best available science" to inform natural resource management (e.g., Magnuson-Stevens Fishery Conservation and Management Act, U.S. Endangered Species Act), and scientists and decision makers consistently agree that the best available science improves the quality of management decisions.[32]

Making climate-informed decisions requires the integration of science, including evidence of effectiveness. The presence of and access to high-quality research, including data collection, analysis, and synthesis, supports optimal decision-making conditions for managers and planners, particularly in light of climate change. Identifying what approaches are being implemented and to what degree of success expands the list of options for managers seeking to address climate change impacts. Part of this critical need for research is understanding and learning from past and ongoing efforts. Since 2009, EcoAdapt has engaged in a sustained research initiative—the State of Adaptation Program—to identify, evaluate, and assess climate adaptation activities in planning and underway. These projects have included identification and synthesis of best available science on historic, observed, and projected future climatic changes and impacts, extensive reviews of Federal, tribal, state, and local climate change planning documents, over 4,000 interviews with practitioners in order to identify trends and barriers to climate adaptation action, and over 400 case studies.

Knowledge transfer and sharing of lessons learned among managers is fundamental to ensuring effective, successful adaptation outcomes. Federal (Climate Resilience Toolkit[33]) and non-governmental (EcoAdapt, Climate Adaptation Knowledge Exchange[34]) knowledge brokers play central roles in gathering, synthesizing, and contextualizing science into digestible and actionable information sources. Action must be taken to preserve what credible Federal resources are still available and support non-Federal adaptation science providers and brokers. Over the past 2 years, as Federal websites were stripped of mentions of climate change and access to adaptation guidance and examples were moved, key boundary organizations stepped up to fill these gaps. To protect access to sound science, EcoAdapt implemented a multi-phased plan to ensure the public could continue to rely on Federal resources through the CAKE database. While other groups focused on basic climate data rescue, we prioritized adaptation resources including reports, guidance, tools, and records of projects and case studies.

Clear climate-informed mandates, laws, and policies. Through the State of Adaptation Program interviews, we have found that one of the leading motivations of adaptation action on public lands is clear agency mandates, laws and policies. To move agencies and departments beyond planning into needed implementation projects on public lands, bringing back agency mandates to intentionally address and incorporate climate change in all their management decisions is critical. These mandates and policies should require agencies to work across jurisdictions to increase the likelihood of success.

Accessible and sustained finance streams for adaptation initiatives. One of the biggest barriers to adaptation action is a lack of funding,[35] inability to apply funding to adaptation efforts, or a lack of access to sustained funding. Adaptation

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[28] Bayliss, H.R., et al. 2012. Does research information meet the needs of stakeholders? Exploring evidence selection in the global management of invasive species. Evidence and Policy 8(1): 37–56.

[29] Cook, C.N., M. Hockings, and R.W. Carter. 2009. Conservation in the dark? The information used to support management decisions. Frontiers in Ecology and the Environment 8(4): 181–18.

[30] Eriksen, S., et al. 2011. When not every response to climate change is a good one: Identifying principles for sustainable adaptation. Climate and Development 3(1).

[31] Sutherland, W.J., et al. 2004. The need for evidence-based conservation. Trends in Ecology & Evolution 19(6):305–308.

[32] Sullivan, P.J., et al. Defining and Implementing Best Available Science for Fisheries and Environmental Science, Policy, and Management. Marine Sciences Faculty Scholarship. Paper 30.

[33] Climate Resilience Toolkit: https://toolkit.climate.gov/.

[34] Climate Adaptation Knowledge Exchange: http://www.CAKEx.org.

[35] Archie, K.M., et al. 2012. Climate change and western public lands: a survey of U.S. federal land managers on the status of adaptation efforts. Ecology and Society 17(4).

is a multi-phased process that includes scientific assessments, planning, implementation, and monitoring and evaluation. Funding directed to just one of these phases will not deliver the results needed to comprehensively address climate change. Therefore, it is imperative that the Federal Government increase its capacity to provide sustained funding to all stages of the adaptation process, particularly to implementation where upfront costs tend to be higher. Emphasis must also focus on increasing the capacity of boundary organizations, such as non-governmental partners, to execute climate adaptation work. These organizations are sources of highly specialized and locally relevant expertise, and execute on-the-ground work from technical decision support to facilitating community discourse through workshops. Additional funding sources include foundations and local and state governments. However, many of these initiatives have resulted in piecemeal, fragmented, and disparate approaches, as well as a lack of movement beyond assessment and planning into implementation and evaluation. Federal finance plays a key role in funding all phases of the climate adaptation process. In fact Federal funding that is used to support projects that are not inherently taking climate change into account is likely to be money misspent—unable to create the benefits it was intended to achieve when the effects of climate change erode the target efforts.

Increased capacity, coordination, and collaboration. One the greatest resources we have to address climate change is the collective capacity of scientists and managers in our Federal, tribal, and state agencies and non-governmental institutions. The knowledge, experience, and ingenuity brought by our Federal partners cannot be undervalued as a key part of the solution to climate change. To capitalize on this asset, we need increased capacity, coordination, and collaboration among and between Federal agencies and their non-Federal partners, including tribal nations, non-profits, small businesses, frontline communities, and academic institutions.

CONCLUDING THOUGHTS

The problems presented by climate change are vast and the solutions are innumerable and already overdue. With a challenge as urgent and pervasive as climate change, any delay in action is harmful. We have been underachieving for decades. Further prevention of progress will result in backsliding with irreversible and in some cases deadly consequences. What we need is someone to step forward. As a co-equal branch of government, this Congress has the ability to right the ship and advance climate action like never before—at a rate appropriate for the scale and speed of this problem. Key items for prioritization include:

- Continued protection and restoration of existing public lands and, where possible, expansion of these areas to maintain ecological functions, ecosystem services, and overall resilience. These efforts should include prioritizing areas that may serve as refugia—places that are likely to maintain more stable conditions over time—for plant, fish, and wildlife species, and eliminating energy development.
- Increased investments in science- and evidence-based approaches to climate adaptation while allowing for flexibility to identify, develop, and test promising, novel approaches. This includes not just funding for modeling and data collection, but also increased funding for implementation of activities with requirements for the evaluation of effectiveness, and capturing and sharing lessons learned.
- Increased coordination and collaboration between Federal entities and non-Federal partners (including international partners) to advance climate adaptation objectives. For example, the majority of Federal dollars goes toward fire suppression rather than prevention activities. Getting fire back onto the landscape (both natural and prescribed burns) to support ecological functions is critical, especially as a means to reduce wildfire risk. This includes supporting tribal cultural burning practices across the landscape.
- Discontinue (and certainly do not expand) the extraction of fossil fuels from Federal lands for use in energy generation. Not only does the practice of fuel extraction cause environmental degradation that reduces resilience, but the burning of those fuels literally adds insult to injury causing the changes that require even greater resilience. Simply put, we need to stop increasing the rate and extent of climate change in order to protect our public lands and the services they provide to us.

Congress' power to appropriate funds can be wielded as one of the most effective tools to ensure the protection of public lands and the prioritization of climate adaptation overall. Appropriations should be viewed through a climate lens to ensure

that the agencies, departments, and research programs most qualified and poised to meet the climate challenge are adequately funded, and that any investments of tax payer dollars are not mis-spent on efforts that are likely to be undermined by the effects of climate change. We need simultaneous action at the scale required to solve the problem on climate change mitigation and adaptation. Approaches like the Green New Deal present the types of opportunities we need to seize to take action on mitigation, while working to integrate investments in climate adaptation across all agencies to address the effects of climate change we are and will experience due to the past emissions we did not curb.

I invite the current Congress to have the fortitude your predecessors have lacked. The time to take meaningful action on climate change to protect not only our public lands but our citizens and our neighbors around the globe is upon us. It is your job as elected officials to recognize the scope of this crisis and make the changes that are needed. Be brave. Be bold. Take action today for a better tomorrow.

QUESTIONS SUBMITTED FOR THE RECORD BY REP. HAALAND TO DR. LARA HANSEN, EXECUTIVE DIRECTOR AND CHIEF SCIENTIST, ECOADAPT

Question 1. Both your and Dr. Gonzalez's work and testimony suggests the need to protect more places from the dangers of climate change.

1a. As policy makers, are there any places that we should prioritize for protection?

Answer. Climate change is already affecting natural and cultural resources and the human communities that depend on them, and is projected to continue for centuries to come. Impacts include loss of habitats and connectivity, shifts in animal and plant species distribution and abundance, alteration of natural communities, and significant changes in water availability and supply. Places to prioritize for protection in terrestrial systems include areas of climate refugia, wildlife corridors, enduring features, and headwater and groundwater sources. In particular, it is essential that we implement a portfolio of prioritization approaches to better cope with climate-related uncertainty. Protecting these places will help maintain habitat and species diversity, as well as the services they provide to people, over the long term.

Climate refugia, or areas relatively buffered from contemporary climate change over time, provide locations that species can retreat to, persist in, and potentially expand from under changing climate conditions.[1] Protecting areas of climate refugia can include identifying places that have remained relatively stable from historic to current conditions or places that are projected to remain stable with future climate change. For example, identifying places that have effectively maintained soil moisture levels over the last 100 years, even in the face of episodic droughts, or identifying places that are likely to continue to maintain adequate soil moisture levels even under hot and dry future climate conditions. Protecting wildlife corridors (both current and potential future routes) as well as habitat linkage areas (i.e. those places that connect intact or core habitats to one another) allows species to move across the landscape in response to changing conditions, helping to facilitate gene flow and decrease extinction risk. This could also include planning along latitudinal and elevational gradients. Enduring geophysical features (e.g., topography, soils, geology) seem to be the factors that help create species diversity in the first place.[2] Protecting areas with a diversity of geophysical features provides species and communities with the space to move and reorganize in response to climate change. Last, given the inherent uncertainty associated with precipitation projections (amount, timing, type), it is critical to prioritize the protection of our headwater and groundwater sources as it will help minimize the impacts of other non-climate stressors. Because the locations of many groundwater sources are currently unknown, an important first step will be providing the resources necessary to find and map these locations. It is also important to protect the area around these sites such that they are buffered and connected to the greater landscape.

1b. How might we work with the Federal land management agencies to identify and prioritize the protection of these places?

Answer. It is important to note that effective natural resources management includes a balance between "hands off" preservation of some natural areas and the

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[1] Morelli TL, et al. 2017. Climate change refugia and habitat connectivity promote species persistence. Climate Change Responses 4(8).

[2] Lawler JJ, et al. 2015. The theory behind, and the challenges of, conserving nature's stage in a time of rapid change. Conservation Biology 29(3): 618–629.

conservation of natural areas for continued and sustainable use. While preservation efforts may be appropriate in protecting specific sites to eliminate all human activity, the vast majority of conservation efforts require some active management of natural lands to ensure the continued availability and use of ecosystem services, such as food, timber, water supply, and cultural heritage. This is particularly true for climate adaptation practices wherein reducing vulnerability to both climate and non-climate stresses (e.g., pollution, water and oil withdrawals) is key. Congress has several tools at its disposal to support natural resources management in a changing climate—legislation, appropriations, oversight, and public hearings.

Legislation. Congress can support climate-informed action by passing climate change legislation, creating amendments to existing legislation, integrating climate change into National Environmental Policy Act (NEPA) processes, and designating public lands that support climate change mitigation and adaptation goals. For example, Congress could create an amendment to the Coastal Zone Management Act, calling for the Coastal and Estuarine Land Conservation Program to not only protect coastal areas with "significant conservation, recreation, ecological, historical, or aesthetic values" (16 U.S.C. § 1456–1), but also to explicitly protect areas of climate adaptation significance (e.g., refugia, corridors). Congress should encourage all NEPA-related environmental analyses to consider both the effects of climate change on projects and the effects of projects on climate change (e.g., how a proposed project may exacerbate greenhouse gas emissions). A tool like the Climate Change Adaptation Certification[3] could be employed. In addition, Congress may designate public lands and review designations made by Executive Order to ensure that public lands maintain ecological functions and services in a changing climate. For example, Congress can create national monuments on public lands (e.g., Tule Springs Fossil Beds in Nevada) or review and reverse national monument decisions (e.g., Mount Olympus National Monument was re-designated as Olympic National Park in 1938[4]). Congress can establish other public lands—national parks, national conservation areas, wilderness areas—to support climate mitigation and adaptation efforts. These decisions may be made in consultation with Federal land management agencies to ensure protection of sites that include climate refugia, wildlife corridors, enduring features, and headwater and groundwater sources.

Appropriations. Congressional appropriations should be viewed through a climate lens to ensure that the agencies, departments, and research programs most qualified and poised to meet the challenges of climate change are adequately funded. Sufficient budgets and staffing of Federal agencies are needed to facilitate institutional capacity for climate action. Adequate funds also need to be available to support on-the-ground climate action by other governmental and non-governmental entities. Congress can also eliminate riders that are contrary to climate mitigation and adaptation and conservation goals (e.g., blocking consideration of the economic costs of carbon pollution, repealing clean water rules). Congressional appropriations can be used to fund the scientific research, data collection, mapping, modeling, and staff time necessary to identify climate refugia, wildlife corridors and linkage areas, enduring features, and headwater and groundwater sources. Appropriations also allow Federal land managers to manage the best they can; for example, while the majority of Federal dollars goes toward fire suppression rather than prevention activities, most land managers recommend getting fire back onto the landscape through both natural and prescribed burns to better support ecological functions and reduce wildfire risk.[5]

Oversight. Congress can use its oversight powers to review, monitor, and otherwise supervise Federal agencies, programs, and activities to ensure that climate change mitigation and adaptation are adequately integrated. For example, Congress can hold polluters accountable for carbon emissions and other sources of pollution. Reducing these non-climate stresses, many of which can exacerbate the effects of climate change (e.g., temperature affects the toxicity of various chemicals[6]), increases overall resilience.

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[3] Justus Nordgren, S. and L.J.Hansen. 2018. Climate Change Adaptation Certification. EcoAdapt. https://www.cakex.org/adaptation-certification.

[4] National Park Service. 2018. Monuments List. National Park Service Archaeology Program, https://www.nps.gov/archeology/sites/antiquities/MonumentsList.htm.

[5] Gregg RM, et al. 2016. Available Science Assessment Project: Prescribed Fire and Climate Change in Northwest National Forests. Report to the Department of the Interior's Northwest Climate Science Center.

[6] Gregg RM, et al. 2011. The State of Marine and Coastal Adaptation in North America: A Synthesis of Emerging Ideas. EcoAdapt, Bainbridge Island, WA.

Public Hearings. Congress can give a voice to the land managers and everyday Americans experiencing climate change on the ground. In addition to inviting scientists to present their findings, we would encourage you to amplify the voices of the managers of these public lands who are making the everyday decisions in light of climate change as well as the administrative restrictions they are under. Part of EcoAdapt's role as climate adaptation facilitators is to identify the ways in which managers can make modifications to current practices and co-produce (with the relevant stakeholder communities) new, innovative strategies to address the climate challenge. No one is more passionate about protecting public lands than the people who work on them every day. Giving them the space to share their challenges, needs, and successes will be critical to informing Federal action.

Question 2. Dr. Hansen, when you say "protecting adequate and appropriate space for ecosystems to function under changing conditions," what kind of actions would that include?

Answer.

- This means protecting ample space for **ecosystem services** such as hydrological function under changing precipitation patterns. For example, what are the new requirements the recharge of groundwater or flow of surface water.
- This means protecting locations that appear to be climate **refugia**, meaning those locations that are changing less quickly and may afford natural systems the ability to respond on their own.
- This means supporting **connectivity** across landscapes so species (animal and plant) can move in response to changing climatic conditions. This includes thinking about latitudinal and elevational gradients.
- This means keeping systems as **intact** as possible so natural diversity can allow for the greatest number of potential response avenues.
- This means designing **restoration** efforts for not only current and future conditions, not reach for a past that cannot exist again given the elevated levels of carbon dioxide in our atmosphere.

Question 3. Dr. Hansen, in your testimony you mentioned that we need to provide our agencies with clear, informed mandates to begin preparing for climate change.

3a. Has this Administration provided these?

Answer. In short, no. The Administration has intentionally and systematically worked to eliminate or repeal climate-informed mandates, policies, and regulations. Furthermore, Federal climate programs have been defunded or dismantled, and scientific advisory groups dedicated to advising the Federal Government on best approaches to prepare for and respond to climate change have been disbanded.[7]

This Administration has taken more than 70 actions aimed at removing or altering environmental and climate mandates, regulations, and policies.[8] From international actions, such as announcing the withdrawal from the Paris Climate Accord, to revoking an Obama-era Executive Order setting Federal Flood Risk Management Standards, climate mandates put in place by previous administrations are under attack. Under the explanation of streamlining the approval process for building infrastructure, the current administration signed an Executive Order eliminating Obama-era planning step to make roads, bridges and buildings more resilient to climate and flood dangers. The current administration has also dissolved the Federal advisory panel for the National Climate Assessment, a group that helps policy makers and private-sector officials incorporate the government's climate analysis into long-term planning. In addition, the EPA and Department of the Interior have followed suit, with the EPA dismissing dozens of scientists from their Board of Scientific Counselors and Interior is not renewing the charters of numerous scientific advisory panels. Beyond these actions, the agencies are failing to enforce existing regulations and limiting enforcement mechanisms by others.

The loss of adaptation resources (and government services in general) is further exacerbated by recent changes in funding streams through changing tax law. Reduced Federal tax revenue will result in further cuts to Federal programs, and changes in state tax deductions will likely erode local tax revenue streams. With

[7] https://www.washingtonpost.com/news/energy-environment/wp/2017/08/20/the-trump-administration-just-disbanded-a-federal-advisory-committee-on-climate-change/?utm_term=.5d89df6ed69d.

[8] https://www.washingtonpost.com/graphics/politics/trump-rolling-back-obama-rules/?utm_term=.0aec397d6676.

state and local programs being touted as the backstop to lost Federal action this may undermine that potential. Should charitable contribution tax deductions be changed that would also undermine NGO adaptation activities, leaving American society with little access to information or support as it faces the perils of climate change.

3b. What type of mandates might we give to help the Government begin to address the impacts of climate change?

Answer. Through EcoAdapt's State of Adaptation Program, we have found that the leading motivations for adaptation action on public lands is clear agency mandates, laws, and policies.

We recommend mandates focus on:

1. Changing goal of public land management from short-term, multi-use industry concerns to a focus on the maintenance of the long-term health of our public lands for ecosystem services (which themselves have strong fiscal value) and public health. This shift in focus will enable agencies to embrace and prioritize planning for long-term uses including insurance against the effects of climate change, over short-term uses that often exacerbate climate change. We should definitely ensure that our public lands are not being used to make climate change worse by increase greenhouse gas emissions either through fossil fuel extraction or unmitigated use.
2. Focus on science, research, and technical experts
   - Prioritization of science and research is crucial because most agencies current mandates direct them to use the best available science. This science needs to reflect current and up to date understanding of current and future climate conditions and the implications of those conditions.
   - Technical experts are crucial to moving beyond research and planning into implementation. Without specific and clear direction from technical experts, Federal mandates will not translate into effective on-the-ground actions.
3. Require agencies to capture, share, and translate climate adaptation knowledge
   - Capture and Share: Most crucial to on-the-ground adaptation success are lessons learned from practitioners around the field. Given the scope of the lands managed by Federal agencies, these managers play a key role in building and advancing the field of adaptation.
   - Translation and synthesis: Managers often cite relevance, scale, and context as a barrier to the usability of climate science. Translation, or knowledge brokers, of climate science and adaptation research such as the Climate Adaptation Knowledge Exchange (CAKE), are vital to ensure on the ground managers have access to digestable and actionable information.
4. Require all phases of the adaptation process (assessment, planning, implementation, monitoring and evaluation) as well as thorough reporting on progress (including successes, failures, and modified approaches or lessons learned).
   - Include thorough reporting/oversight processes on progress including successes and failures, and modified approaches.
   - Reported progress should be tied to previous planning phase (e.g. planning should be tied to reducing vulnerability identified in assessment phase).
   - Mandate needs to identify accountability for progress, as well as highlight champions and leadership.

Finally, mandates need to be coupled with climate adaptation capacity at the agency and external partner level, appropriations and funding, and accountability and oversight. This means that Federal staff need appropriate training in climate change adaptation, which is often required through professional continuing education opportunities as much of the Federal work force has no formal training in this area of science and management practice. This should be supported through the National Conservation Training Center, Sea Grant, a national adaptation extension service, and other venues such as the National Adaptation Forum. Congress must ensure that there is sufficient funding to not only support training of Federal staff, but the funding for sufficient staff and the inclusion of funds to design, implement, monitor and share adaptation actions.

Question 4. Dr. Hansen, you suggest in your testimony that Federal funding for projects that don't account for climate change is often money misspent.

4a. Can you please elaborate on this claim?

Answer. When climate change is not recognized, and a project (or policy) is design or implemented without explicitly considering the implications of climate change, the project (or policy) is vulnerable to the effects of climate change. When those vulnerabilities become realities the climate uninformed project (or policy) will no longer be effective. It will then need to be repaired, replaced, removed or repeated elsewhere. This means that the initial projected or policy was taxpayer dollars not delivering the outcome they paid for.

Additionally, citizens, businesses, communities and ecosystems may incur harm from the project (or policy) that did not deliver on its intended and advertised outcome.

There are at least two major categories in by which this can happen.

1. Funds (or Federal employee effort) are expended in a manner that assumes conditions today are the same as they were in the past and will not change in the future. As a result, the work will not garner the desired effects given the reality that climate change will mean that today is different from yesterday and tomorrow will be different than today. For example, consider a coastal infrastructure investment such as a road, an estuary restoration project, or a coastal sewage treatment plant that are designed without taking sea level rise projections (relevant to the project lifetime) into account. You could also consider building standards or land use management in increasingly fire prone regions that does not take into account the increasing risk therefore putting new structures, communities and associated ecosystems at risk. You could also consider changing frequencies of flood events, wherein older flood projection maps continue to be used to make land use decisions or allow for the use of FEMA funds to rebuild in harm's way—again putting people, property, business and government function at risk.

   Uninformed decisions such as all of these (and many more) may result in either the need to spend additional funds to redesign the project when the vulnerability becomes an "event" that renders the project ineffective. For example, the restoration project fails because the site is inundated or the species used for the project has moved out of the region as temperatures change. Similarly, if a road is inundated it may require a sea wall, drains or pumps; or it may require that the road is moved to an entirely new location. In all cases there is an additional expenditure of funds to provide the same service as the initial outlay before the lifetime of the project should have ended.

2. Funds are not spent to address the challenges of climate change leaving existing efforts vulnerable to the impacts of climate change. Often there are existing investments or resources that need new actions to protect them. This can include creating living shorelines to protected coastal infrastructure, funding the application of prescribed fire to protect our forestlands, upgrading culverts and bridges to avoid flood and erosion damage, funding enforcement to protect natural habitats and species from illegal poaching and destruction.

4b. How do we best ensure we're getting a fair return on taxpayer funded infrastructure projects?

Answer. First of all, it is not just infrastructure projects that may be vulnerable to these issues. The simplest path to this is to both build the capacity of Federal agency staff and Congress about climate science and adaptation, and to create explicit review mechanisms that require evaluation of the implications of climate change on any Federal expenditure, project or other action. Using a tool such as the Climate Change Adaptation Certification,[9] provides a structure for how to do this, along with direction to readily available climate science to use in the evaluation, and a structure around how to make decisions based on what this analysis indicates. This is very similar to how current analyses are done to the financial or environmental impact of a project (or policy).

[9] Justus Nordgren, S. and L.J. Hansen. 2018. Climate Change Adaptation Certification. EcoAdapt. Bainbridge Island, WA. www.CAKEx.org/Adaptation-Certification.

Ms. HAALAND. Thank you, Dr. Hansen.

The Chair now recognizes Mr. Hans Cole.

STATEMENT OF HANS COLE, DIRECTOR OF ENVIRONMENTAL CAMPAIGNS AND ADVOCACY, PATAGONIA, INC., VENTURA, CALIFORNIA

Mr. COLE. Chairman Haaland, Ranking Member Young, thank you for the opportunity to testify today. My name is Hans Cole, and I am the Director of Campaigns and Advocacy for Patagonia.

At Patagonia, we are in business to save the home planet. On behalf of our 3,000 employees and their families and communities across America and around the world, I commend the Committee for tackling this issue, and I strongly urge you to take bold action to address our planet's climate crisis before it is too late.

The science reflects what we are seeing with our own eyes, and the voices of the American people and responsible businesses on the topic are clear. If we fail to change course, global temperatures will continue to rise and environmental emergencies, wildfires, deadly heat waves, hurricanes, flooding, and growing food shortages will grow worse.

At Patagonia, we believe that clean, renewable energy, regenerative organic farming, and public land and water protection should play critical roles in addressing the climate crisis. My testimony today will focus on our public lands.

America's public lands are one of our greatest collective assets, but they are also the source of substantial greenhouse gas emissions. Almost a quarter of all greenhouse gas emissions in the United States come from fossil fuels extracted from public lands or offshore waters. This will get much worse, as the Trump administration continues its assault on land and water protections, despite outcries from outdoor enthusiasts and companies of all political stripes who, together, represent a nearly $900 billion industry.

We oppose the Administration's proposed offshore leasing and drilling. It would make more than 90 percent of U.S. waters available to oil and gas companies.

We oppose an attack on Alaska's Arctic National Wildlife Refuge that would open one of our planet's truly wild places for drilling.

And we oppose the slashing size of Utah's Bears Ears and Grand Staircase-Escalante National Monuments, and any reduction in size of other monuments, as well.

The Administration's actions not only rob native people and all Americans of their natural and cultural heritage, threaten communities that depend on the outdoor economy, poison our water and air, and damage vulnerable species, they also make the climate crisis worse.

Opening up public lands to more extraction will increase emissions and destroy ecosystems that help mitigate climate change by storing carbon. Instead, Congress should impose a moratorium on oil and gas drilling in Federal waters, and bar drilling in Alaska's remaining wild places.

We urge you to restore Bears Ears and Grand Staircase-Escalante National Monuments, and support measures like Representative Haaland, yours, and Senator Udall's bill to make it

clear that no president has the authority to undermine the protection of America's national monuments.

Congress should also permanently re-authorize and fully fund the Land and Water Conservation Fund, which has used a small percentage of revenues from existing offshore drilling leases to protect 5 million acres of public parks, wildlife habitats, and recreation areas.

Instead of further slicing up our landscapes and waterways, we should build wildlife overpasses and underpasses, invest in communities eager to remove unsafe and damaging dams, and strengthen large-scale wildlife corridors for migratory species. These are all bipartisan solutions that address climate issues and appeal to outdoor enthusiasts and businesses in every single state.

Patagonia supports proposals to transition to 100 percent clean, renewable energy by 2050. We need to focus on the cleanest available technology, including wind, solar, and geothermal, and not rely on the false promise of outdated technologies like hydroelectric dams and nuclear power that have catastrophic consequences for our public lands and waters by producing toxic waste and driving species to extinction.

If Congress takes bold action to address this crisis, it will challenge the private sector to step up, as well, and Patagonia will continue to do our part. We are reinvesting $10 million from the 2017 irresponsible corporate tax cuts to groups working to solve the causes of the climate crisis. And Patagonia is committed to becoming carbon neutral across our entire business, including across our supply chain, by 2025.

Please make 2019 the year that the United States finally takes decisive action to fight the climate crisis. Please reclaim our public lands and waters from the polluters and give them back to the people.

Thank you, and I look forward to any questions you may have for me.

[The prepared statement of Mr. Cole follows:]

PREPARED STATEMENT OF HANS COLE, DIRECTOR OF ENVIRONMENTAL CAMPAIGNS & ADVOCACY, PATAGONIA, INC

Chairman Haaland, Ranking Member Young. Thank you for the opportunity to testify today. My name is Hans Cole, and I am director of Campaigns and Advocacy for Patagonia. At Patagonia, we are in business to save our home planet. On behalf of our 3,000 employees, and their families and communities across America and around the world, I commend the Committee for tackling this issue, and I strongly urge you to take bold action to address our planet's climate crisis head-on before it is too late.

The science reflects what we see with our own eyes, and the voices of the American people and responsible businesses on the topic are clear. If we fail to change course, global temperatures will continue to rise and environmental emergencies—massive wildfires, deadly heat waves, disastrous hurricanes, major flooding, growing food shortages—will grow worse.

The U.S. Government's 2018 National Climate Assessment noted that ecological catastrophe will lead to an economic catastrophe, wiping out up to 10 percent of the American economy by 2100. That is not good for business, but it's even worse for our employees, our customers and your constituents who could see wages drop and unemployment rise.

We believe that clean renewable energy, regenerative organic farming, and purposeful public lands protection should play critical roles in addressing the climate crisis. Consistent with this Committee's interest in public lands, my testimony today

will focus on purposeful protection of these important places and the need to transition to a more sustainable future.

America's public lands are one of our greatest collective assets but they are also the source of substantial greenhouse gas emissions. According to the U.S. Geological Survey, almost a quarter of all greenhouse gas emissions in the United States come from fossil fuels extracted from public lands or offshore waters. Oil, gas, and mining corporations are damaging our public lands and waters and worsening the climate crisis. This will get much worse as the Trump administration continues an assault on land and water protections, despite outcries from outdoor enthusiasts and companies of all political stripes who together represent a nearly $900 billion industry. We oppose:

- The Administration's proposed offshore leasing and drilling that would make more than 90 percent of U.S. waters available to oil and gas companies, including the entire Atlantic and Pacific coasts, the entire Gulf of Mexico, and most of Alaska's available coastal waters.
- An attack on Alaska's Arctic National Wildlife Refuge that would open one of our planet's last truly wild places to drilling and accelerate the destruction of the Western Arctic.
- Slashing the size of Utah's Bears Ears and Grand Staircase-Escalante National Monuments, in violation of the Antiquities Act.

The Administration's actions not only rob Native people and all Americans of their natural and cultural heritage, threaten communities that depend on the outdoor industry for economic survival, poison our water and air, and wreak untold damage on vulnerable species—they also exacerbate the climate crisis. Opening up public lands to more extraction will increase emissions and destroy ecosystems that help mitigate climate change by storing carbon.

Instead, Congress should impose a moratorium on oil and gas drilling in Federal waters and bar drilling in Alaska's remaining wild places. We urge you to restore Bears Ears and Grand Staircase-Escalante National Monuments, and support measures like Senator Udall and Representative Haaland's bill to make it clear that the President has no authority to undermine the protection of America's National Monuments.

Congress should also permanently reauthorize and fully fund the Land and Water Conservation Fund, which has used a small percentage of revenues from existing offshore drilling leases to protect 5 million acres of public parks, wildlife habitats, and recreation areas across the country. Instead of further slicing up our important landscapes and waterways, we should build wildlife overpasses and underpasses, invest in communities eager to remove unsafe and damaging dams and diversions, and strengthen large-scale wildlife corridors for migratory species. These are all bipartisan solutions that address climate issues and appeal to the outdoor enthusiasts in every single state, as well as the small and big businesses that rely on tourism and protected natural resources for their livelihood.

Along with protecting our public lands as one of our greatest resources to combat climate change, we must also transition our economy to rely on clean, renewable energy. Congress should stop spending taxpayer dollars subsidizing large oil and gas companies and approving destructive projects like the Keystone XL and Dakota Access pipelines, and reverse the drive to loosen restrictions on coal-fired power plants, inefficient cars and trucks, and polluters of all kinds.

Patagonia supports proposals to transition to 100 percent clean, renewable energy by 2050. We need to invest in transformative research and green infrastructure like a smart electric grid. Congress should provide incentives to encourage American consumers and businesses to install solar panels, build wind turbines, buy electric vehicles, and retrofit buildings to make them more energy efficient.

The traditional "all-of-the-above" approach has unfortunately relied on the false promise of outdated technologies like nuclear plants and hydroelectric dams that have catastrophic consequences for our environment by producing toxic waste and driving species to extinction. The only viable path for the planet's survival is to embrace wind, solar, geothermal, and other truly clean and renewable sources of energy.

This transition toward a less-polluting economy must account for how American's food is grown and distributed. Agriculture is a significant part of the American economy, contributing billions to GDP, and is also a source of substantial greenhouse gas emissions, emitting about 650 million metric tons of CO_2 equivalent annually. But how we grow our food also holds great promise in combatting climate change. At Patagonia we have helped develop a new standard—the Regenerative Organic Certification—that builds on current organic practices to improve soil health.

Regenerative organic farming has the potential to remove carbon from the atmosphere, storing it in the soil. Studies indicate that if we moved from current industrial farming to regenerative organic practices we could sequester enough carbon to slow, if not completely halt, the growing amount of CO_2 in our atmosphere. And experts agree we could feed our growing population using regenerative organic farming.

If Congress takes bold action in all these areas—protecting public lands and waters and promoting a change to clean, renewable energy along with encouraging regenerative organic agriculture—it will challenge the private sector to step up as well. Patagonia will continue to do our part.

We are re-investing $10 million we received from the 2017 irresponsible corporate tax cuts by donating to groups that are fighting to protect our air, land, and water to save our planet. Patagonia is committed to becoming carbon neutral across our entire business—including across our supply chain—by 2025. That means we will reduce, capture or otherwise mitigate all of the carbon emissions we create, including the emissions from the factories that make our textiles and finished clothing. We will use only renewable or recycled materials in our products, and by 2020 we will use only renewable electricity in our stores and offices. We are similarly piloting products made and built compliant with the new Regenerative Organic Certification to show the world that products can be built using these practices.

Patagonia will continue to encourage our community and customers to participate in the democratic process. As long as polluters wield power, Patagonia will speak out and fight back. We will proudly and transparently support candidates and causes we believe in.

Please make 2019 the year that the United States finally takes decisive action to fight the climate crisis. Please reclaim our public lands and water from the polluters and give them back to the people.

Thank you for the opportunity to testify here today. I look forward to any questions you may have for me.

QUESTIONS SUBMITTED FOR THE RECORD BY REP. HAALAND TO HANS COLE, DIRECTOR OF ENVIRONMENTAL CAMPAIGNS AND ADVOCACY, PATAGONIA, INC.

Question 1. Mr. Cole, some conservatives, especially those from the West, often cast our public lands as a burden. They claim that public lands hurt economies and ruin development potential. Do you at Patagonia think that public lands harm communities?

Answer. At Patagonia, we do not think of public lands as a burden, and in fact just the opposite: as a business that relies on protected public lands for our very existence, we know that public lands, particularly protected public lands, contribute immensely to the health and economic vitality of local communities. Looking first at the data, Headwaters Economics, an independent, non-partisan research firm, has shown that from the early 1970s to the early 2010s, ". . . rural counties in the West with more federal lands or protected federal lands [perform] better on average than their peers with less federal lands." This was shown to be true for four key economic measures: population, employment, personal income, and to a smaller extent, per capita income growth. Public lands also bring value across numerous different areas: from the ecosystem services of clean water and air (for example, National Forests provide as much as 33 percent of our water in the West), to the more community-based values of healthy opportunities for kids and families, to the recreation sector and economy that Patagonia is a part of. This sector, which brings economic opportunity for many "gateway" communities that sit at the doorstep of our public lands, now provides $887 billion in annual consumer spending and 7.6 million jobs (as compared with about 180,000 jobs from oil and gas extraction). National parks, national wildlife refuges, national monuments and other public lands and waters account for $45 billion in economic output and about 396,000 jobs nationwide—many of which are in communities with close proximity to public lands.

It's equally clear when you ask the public: a clear majority of people from across the political spectrum love our protected public lands and recognize the importance of the outdoor economy they support. For example, in the 2019 Colorado College "Conservation in the West" poll, results indicate that ". . . there is almost no partisan distinction in perceptions of outdoor recreation's importance to the economic future of the West." Whether it was Republicans, Independents or Democrats responding, over 85 percent indicated that outdoor recreation is important to their state's economic future.

Finally, coming out of the hearing on February 13, it's critical to note that our public lands are an important and often overlooked component of community-level efforts to address climate change. Protected public lands (where forests, wetlands, grasslands and other ecosystems are intact) have increased carbon storage capacity that will be needed to reduce greenhouse gases in the long term, and in the short term, provide the ecosystem services and resilience that communities will require as precipitation patterns and temperatures change, and as we face increasing fires, floods and other challenges. Intact and protected public lands provide a refuge for biodiversity and connectivity for migrating species that will need to move and adapt in response to a changing climate. And, with care given to smart and ecologically sensitive citing, we can even consider renewable energy development opportunities on our public lands. In summary, protected public lands are one of our greatest assets in the fight to protect our communities and ecosystems in the face of climate change.

Question 2. Mr. Cole, this Administration has prioritized extraction on our public lands over other uses, exposing us to the dangers of climate change and to the local impacts associated with methane leakage and groundwater depletion and contamination. This prioritization includes the alteration of our national monuments, seemingly for the benefit of fossil fuel interests.

2a. Why is it important that we protect our public lands from unbridled extraction and depletion?

2b. What benefits do national monuments provide that supersede the benefits of short-term and short-sighted extraction?

Answer. Public lands provide a diverse array of values to local communities, and they are critical to maintaining a life-sustaining climate and biosphere on a macro level. However, when we prioritize using these lands for resource extraction—particularly without any sense of balance or attention to sensitive ecosystems—we quickly lose access to many of the values that protected public lands offer. Unbridled resource extraction creates serious and long-lasting impacts (for example: pollution, disturbance, aesthetic impacts, barriers such as dams and fences, and carbon emissions), that permanently damage natural ecosystems, threaten biodiversity, exacerbate climate change, and exclude, often permanently, other more sustainable activities. While sometimes touted as part of a "multi-use" agenda on our public lands, the truth is that unwise resource extraction can turn our public lands into a single-use landscape, one where corporate interests are favored over those of citizens who rely on the place to support a more diverse, sustainable economy, or to recreate and spend time with family and community. Intensive resource extraction can also damage cultural resources and uses of the land important to native communities, who in many cases live closest to these landscapes and have a connection with them that stretches back hundreds, even thousands of years.

By contrast, National Monument designation can prevent unwise resource extraction on sensitive landscapes that hold incredible natural and cultural value. Whether we're talking about the sensitive cultural and ecological landscape of Bears Ears, the forests of Katahdin Woods and Waters, or the still largely unknown depths of the Northeast Canyon and Seamounts—National Monument status can quickly and effectively provide significant immediate protection, allowing for more thoughtful management planning to take place and giving Congress the time and opportunity to consider greater protection down the road if needed. It should be no surprise that almost half of our treasured National Parks started as National Monuments, including many of our most popular parks: Teton, Grand Canyon, Acadia, Zion, Olympic, and Arches. National Monument management plans offer an opportunity for diverse stakeholders to come to the table together, to discuss and plan for truly sustainable use of the landscape—allowing sensitive areas to have a rest, while simultaneously enabling a greater swath of the public to access, enjoy, and gain benefit from the area. The beauty of thoughtful management is that long-standing uses of the landscape can be grandfathered in where appropriate—for example, ranching, hunting, firewood gathering, and similar activities. Thus, a National Monument, while off limits to corporate oil and gas development, is not an exclusive model at all, but instead can host a variety of activities and groups of people, many of whom have had life-long and multi-generational connection to the place. Finally, in terms of long-term impact vs. short-term gain, there is no more convincing argument than the fact that National Monument protection can keep more fossil fuels in the ground, preventing further impact to our climate.

Ms. HAALAND. Thank you, Mr. Cole.

The Chair now recognizes Dr. Elaine Oneil.

STATEMENT OF ELAINE ONEIL, ONEIL FOREST RESEARCH AND MANAGEMENT, TENINO, WASHINGTON

Dr. ONEIL. Thank you, Chairman Haaland and Committee members. I am Dr. Elaine Oneil, a forest scientist and management consultant specializing in forest health, climate change, and forest carbon accounting.

Today, I will be providing comments on research I conducted at the University of Washington that examined the impacts of climate change on forest carbon in the 11 western states. That is contiguous states; we didn't look at Alaska. These results speak to the heart of the question before you today: What climate impacts are occurring on our public lands, and what adaptation opportunities exist?

I am going to place that research into context using examples from Washington State, my home state.

First, some easy math. Trees take up carbon dioxide out of the atmosphere and use it to make wood, roots, needles, leaves, and branches, ending up at about 50 percent carbon by dry weight. Superficial analysis suggests that the more trees we have, the more carbon dioxide they can suck out of the atmosphere.

That is only true if you ignore biological principles that dictate forest growth and death related to site carrying capacity. And in our western forest landscapes—and we have a lot of Members here representing them, and it is also where most of our public lands are located—that is only true if we ignore fire, which would be a mistake.

What we are seeing in the western United States is an epidemic of insects and disease and wildfires brought on, in large part, by what one of your Federal scientists calls an "epidemic of too many trees." He talked about that epidemic of too many trees at a recent TEDx talk called "The Era of Mega-Fires," and I have to say we are in an era of megafires.

When we first began the analysis of climate impacts on forest carbon in these 11 western states we used both historical fire rates for the region, and fire rates that were predicted to occur by 2050. A look at the wildfire statistics since 2000 is sobering. We have doubled the average acres burned since 2000, with 10 of the worst fire years on record occurring since that time, and that doesn't even count last year. The statistics aren't in on that date.

That means that the climate science published as late as 2004 was wildly optimistic. We are seeing future expected fire rates 30 years earlier than anticipated.

So, what do we do about these climate impacts? It is a bit counter-intuitive, but we cut more trees. This wildly unpopular idea has been the recommendation of fire scientists who have studied the fire ecology of these systems for decades. This is not new information. It is completely in line with our fire and carbon analysis that examined nine management alternatives across 25,000 forest inventory plots in the West. In other words, we didn't cherry-pick the data; we looked at every plot and said what would happen here.

In most cases, managing forests creates a more favorable forest outcome than letting nature take its course. Like any other potential natural disaster, whether driven by climate change or not, wildfire mitigation demands a response.

[Slide.]

Dr. ONEIL. Forest inventory data already show that two-thirds of the Federal forest growth is lost to wildfire, insects, and disease, as shown on this chart on the wall. In some states, mortality already exceeds growth, meaning the forests are now carbon sources and not sinks. In other words, they are emitting more than they are absorbing.

So, while forests do store carbon, when they are left without care the results are usually not what we want. Clearly, letting nature take its course did not provide much carbon benefit, especially since the climate impacts we are seeing are real, current, and often devastating.

We know how to mitigate these climate impacts at both the stand and landscape level. It starts with greatly reducing the number of trees, keeping fire-resistant species, and interrupting fuel ladders so the fires don't spread as easily. Across the West, this treatment has been proven to keep forests alive when wildfires hit, and they will hit. That is inevitable. It is part of the fire ecology of the system. They can be easily replicated across the landscape using a systematic approach that considers adjacent landowners in order to create a patchwork of defensible space that is actually more akin to what our natural forests looked like than they do now.

Coordination across landowners is required, so is infrastructure that can handle the harvested material. Even with the best of intentions, we will not be successful unless efforts are made to ensure milling infrastructure remains viable. Shared stewardship approaches like we have in Washington State, including the Good Neighbor Authority and local forests collaboratives, should continue to be supported and encouraged as a fundamental mechanism to move forward with keeping our public lands and adjacent forestlands healthy, fire resilient, and green.

Thank you.

[The prepared statement of Ms. Oneil follows:]

PREPARED STATEMENT OF DR. ELAINE ONEIL, ONEIL FOREST RESEARCH AND MANAGEMENT

I am Dr. Elaine Oneil, a forest scientist and management consultant specializing in forest health, climate change, and forest carbon accounting. My comments are focused on research I conducted while at the University of Washington that examined the impacts of climate change on forest carbon in the 11 western states. Key results from that research, combined with data on wildfire impacts, forest management, and regional forest health strategies will be used to provide context for the comments.

Commentary can be categorized into four main themes:

1. Forests are suffering from too many trees for the site and extant climate conditions. Overstocking creates conditions that kill trees. That mortality combined with wildfire has changed the calculus for defining the optimal strategies for climate mitigation and adaptation in forests.
2. Management provides for improved firefighting capability and improved forest carbon outcomes in nearly every forest type across the 11 western states.
3. Wildfire ignition is random, but the consequences of wildfires are driven by forest cover conditions, climate, and prevailing weather patterns. Forests that

have too many trees, and which contain large amounts of dead trees, produce conditions for wildfires that are uncontrollable, with devastating consequences to the forest, the adjacent landowners and communities, and the budgets of land management agencies.

4. Like any other potential natural disaster, wildfire mitigation demands a response. Letting nature take its course is not supported by the science of forest carbon dynamics.

FOREST CARBON PRIMER

Trees remove carbon dioxide from the atmosphere using photosynthesis to produce wood, roots, needles, leaves, and branches. Carbon is also released via respiration, either directly from the plant, or indirectly via decomposition or combustion pathways. Growth, and therefore carbon accumulation in forests is constrained by limiting factors that range from climatic parameters driving growing season, moisture and temperature conditions, to nutrient availability, competition, and species growth habit and longevity. There is some variability in carbon content between tree components and species but on average trees are about 50 percent carbon by dry weight. This has led some to suggest that leaving forests to grow without management or interruption would be a sound climate solution. That is only true if you ignore biological principles that dictate forest growth and death, including site carrying capacity. And in our western forest landscapes where most of our public lands are located, that is only true if you ignore fire.

1. Forests are suffering from having too many trees for the site and extant climate conditions. Overstocking creates conditions that kill trees. That mortality combined with wildfire has changed the calculus for defining the optimal strategies for climate mitigation and adaptation in forests.

What we are seeing in the western United States is an epidemic—of insects and disease and wildfires—brought on in large part by An Epidemic of Too Many Trees. That epidemic is summarized in a TED talk called the Era of Megafires and is described it in much greater detail in a hour long multimedia presentation that is available here. Wildfire data from the National Interagency Fire Center supports the idea that we are in an Era of Megafires. Their wildfire statistics show that the average acres burned since 2000 has doubled relative to the prior four decades, with 10 of the worst fire years on record occurring since 2000 (excluding 2018 data which is not available yet).

Every 10 years a U.S. forest inventory report (Resource Planning Assessment or RPA) is published that summarizes growth, harvest, and mortality by region, forest landowner, and forest type. Data are collected over a 10-year period, so the final numbers are more representative of an average for the 10-year period than a summary of the endpoint. These data show a fourfold increase in mortality on National Forests in the 40-year period from 1976–2016. Of total forest growth on National Forests about two-thirds is lost to wildfires, insects and disease (Figure 1). Wildfire is not the only mortality agent that is on the rise on Federal lands. Insects and diseases are prevalent and their threat is growing (Littell et al. 2010).

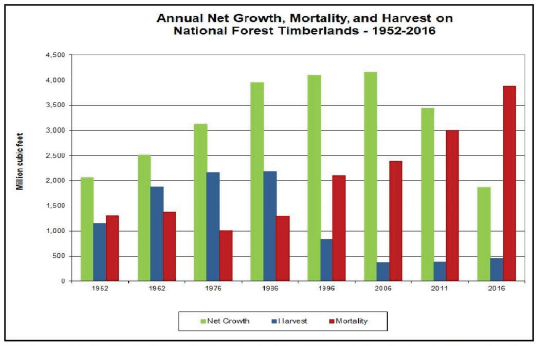

Figure 1. Growth, Mortality, and Harvest on National Forest Timberlands 1952–2016. Data provided by Oswalt et al. 2018.

The current rate of mortality is unsustainable. This may well lead to a tipping point wherein additional uncontrolled damage can be expected. It is doubtful that any one scientist or group of scientists has any idea where that tipping point is and what reaching it might cause. With policies and management approaches that pull us back from that brink by reducing risk and building resilience we can ensure that these forests remain a part of our heritage and serve a vital role as carbon sinks into the future.

2. Management provides for improved firefighting capability and improved forest carbon outcomes in nearly every forest type across the 11 western states.

Fire scientists who have studied the fire ecology of these systems for decades have long advocated for management action to mitigate fire risk and bring the forest condition into alignment with the fire ecology of the west (Agee and Skinner 2005, Skinner et al. 2004). Fire impacts can be substantially reduced by thinning treatments that restore densities more like those observed before fire suppression was introduced. Multiple studies have shown that thinning reduces fire severity, sufficient for firefighters to gain control and maintain forest structure, tree seed source, and other values (e.g. Agee and Skinner 2005, Moghaddas 2006, Skinner et al. 2004). General principles of fire management based on long-term research have been integrated into tools that can assess the impacts of fire and management for any combination of site, stand and climate conditions. These tools were used to model nine different forest management treatments on over 25,000 forest inventory plots in Arizona, California, Colorado, Idaho, Montana, New Mexico, Nevada, Oregon, Utah, Washington, and Wyoming. Results show that in most cases, managing forests created a more favorable forest carbon outcome (Figure 2b) than letting nature take its course (Figure 2a).

Figure 2a. Unmanaged forest with 100% mortality from wildfire.
Figure 2b. Managed forest with jackpot burns to reduce fuel loads.

Even better carbon outcomes are possible if harvested material is large enough to be used for solid wood products as the wood also stores carbon during its use phase (Oneil and Lippke 2010).

Research identifies how to mitigate climate impacts at both the stand and landscape level. In dry forests it starts with greatly reducing the number of trees, keeping fire resistant species, and interrupting fuel ladders so that fires don't spread as easily (Moghaddas 2006). Across the West, this treatment method has been proven to keep forests alive when wildfires hit. It can be easily replicated across the landscape using a systematic approach that considers adjacent landowners, in order to create a patchwork of defensible space that is more akin to historical natural conditions on our forests.

Under future climate conditions which predict longer, drier, hotter, summers (Littell et al. 2010, McKenzie et al. 2004) we can expect regeneration failure in burned forests, which will push these forests toward being a net carbon source. Mitigation measures include thinning the forests to prevent the loss of all trees and to reduce the fire impacts on soils somewhat so that successful regeneration is more likely. By thinning we also are building resilience into the existing trees, and ideally choosing the specimens and species that we think can survive and perpetuate on these landscapes.

3. Wildfire ignition is random, but the consequences of wildfires are driven by forest cover conditions, climate, and prevailing weather patterns. Forests that have too many trees, and which contain large amounts of dead trees, produce conditions for wildfires that are uncontrollable, with

devastating consequences to the forest, the adjacent landowners (Figure 3) and communities, and the budgets of land management agencies.

Coordination across landowners is required. So is infrastructure that can handle the harvested material. Shared stewardship approaches like we have in Washington State, including use of the Good Neighbor Authority and local Forest Collaboratives, should continue to be supported and encouraged as a fundamental mechanism to move forward with keeping our public lands, and adjacent forest lands, healthy, fire resilient, and green.

Figure 3. Wildfire impacts on adjacent state and private forest land from ignition on public forestland.

4. Like any other potential natural disaster, wildfire mitigation demands a response. Letting nature take its course is not supported by the science of forest carbon dynamics.

Jerry Franklin (ecologist) and Jim Agee (fire scientist) from the University of Washington offer their perspective on the need for a rationale national forest policy that incorporates ecology, fire science, known benefits of treatment and social benefits. Their perspective is that "Letting nature take its course in the current landscape is certain to result in losses of native biodiversity and ecosystem functions and other social benefits . . ." (Franklin and Agee 2003).

Other social benefits include smoke free summers. Emissions from wildfires are not inconsequential. In addition to the large amounts of carbon dioxide released, there are also releases of methane, nitrous oxides, and volatile organic carbons which are all potent greenhouse gases that have a greater atmospheric impact than the release of carbon dioxide alone (Wiedinmyer and Neff 2007). The net result is that emissions from wildfires can produce higher carbon dioxide equivalent values than the total equivalent carbon dioxide equivalent (CO_2e) content of the biomass that is consumed (data analysis of factors in Wiedinmyer et al. 2006). This means that a 20 percent reduction in forest carbon stocks from wildfire generates more than a 20 percent increase in CO_2e in the atmosphere.

SUMMARY

We have experienced two decades of unprecedented mortality in our western forests, and much of that mortality is concentrated on Federal lands. In some states, mortality on public forests has reached a point where they are now emitting carbon rather than sequestering it thus exacerbating our current greenhouse gas emissions profile. Forest health treatments that reduce tree density, create canopy discontinuities, and open patches will become both the climate mitigation and adaptation strategy on these forests. They will also more closely replicate historical forest conditions. Letting forests die and burn in anticipation that the past will replicate itself in a future with large uncertainties around climate conditions is a high-risk approach.

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Ms. HAALAND. Thank you very much, Dr. Oneil. Thank you for the valuable testimony that you have given this morning.

The Chair will now recognize Members for questions. Under Committee Rule 3(d), each Member will be recognized for 5 minutes. And I would like to recognize myself first for 5 minutes.

My question to each of you—and if you could just each answer this one after the other, that would be great—thank you all again for being here and for your testimony.

As I mentioned in my statement, I am excited for this Subcommittee to take the lead on these issues. To fill that role, we need to recognize that now is the time to act on climate change. We can't wait any longer. While some response efforts may be beyond this Committee's purview, the impacts of climate change affect the resources, lands, and communities we are here to protect. So, it is our responsibility to consider all options.

My first question for each of you is, can we prevent the worst impacts of climate change by land management strategies alone?

Dr. GONZALEZ. Land management strategies and adaptation are important for improving ecosystem integrity. But our research shows that, compared to the worst emission scenario, cutting carbon pollution could reduce projected heating in the national parks by up to two-thirds. And clearly, that attacks the cause of climate change.

Ms. HAALAND. Thank you. Dr. Hansen?

Dr. HANSEN. I agree that one of the most important things we can do is adjust our land use. And in reality, almost everything in the United States is affected by land use. Our transportation habits are affected by land use. Our energy consumption habits, both transportation and our homes, are affected by land use. However, at the end of the day, the core component that we have to take care of is addressing the root cause of climate change. We need to stop emitting greenhouse gases into the atmosphere from the combustion of fossil fuels.

Ms. HAALAND. Thank you.

Mr. COLE. I would say, from our perspective, we need to use all the techniques at our disposal. Land management is certainly one of them. We need to look at the types of land management. Protected public lands can help us make space for renewable energy and reduce our emphasis on fossil fuel extraction across the country, which can provide a massive impact on the amount of carbon in the atmosphere.

But we also need to think about other ways of addressing the climate crisis, including regenerative organic agriculture and looking at our entire energy mix across the board. Thank you.

Ms. HAALAND. Thank you.

Dr. ONEIL. I think that land management alone cannot address or prevent the worst impacts. But if you look at the way within the wheelhouse of forests and forest management, part of the way we look at that and we think about it is if you are able to maintain that sort of average forest carbon in your landscape, and then use those products to substitute for other products that have a higher greenhouse gas footprint, like steel and concrete, then you do have an opportunity to have an additive effect, based on how you use any kind of material that would be removed if you were removing those trees.

There are some complicated processes in there, but there is a possibility to actually leverage land management and land use activities where they are allowed—obviously, not in parks, but where they are allowed—to achieve additional benefits in terms of greenhouse gas mitigation.

Ms. HAALAND. Thank you, Dr. Oneil. I am glad we largely agree on that point.

Now, Dr. Hansen, can you please explain why adaptation, particularly on public lands, can help us fight the impacts of climate change?

Dr. HANSEN. I would be happy to. Adaptation offers you the opportunity to try to maintain the function of whatever it is you are trying to do. In this case, it is the function of public lands, which are vitally important to all of our lives, whether we live in a city or we live in more rural parts of the country.

Adaptation allows us to reflect directly on what are the implications that we anticipate happening from climate change, and how do we change management to respond to that. That will affect our ability to access water, for example.

In the Sierra Nevada of California, the way that those forests are managed provides water for most of the largest places in the state. Water is, obviously, a big issue there. But if we continue to manage the water resource and the forest resource, as we always have, ignoring the facts that precipitation patterns are changing, ignoring the fact that human use rates are changing because of increasing temperatures, we will not have the rate of return that we expect on those resources. And public lands are probably one of the best insurance investments we have in maintaining all those ecosystem services for our country.

Ms. HAALAND. Thank you, Dr. Hansen. And now the Chair recognizes Ranking Member Young for 5 minutes of questions.

Mr. YOUNG. Thank you, Madam Chairman.

Mr. Cole, Patagonia, what do they sell?

Mr. COLE. We are an outdoor clothing and gear company.

Mr. YOUNG. OK. And where are most of those products made?

Mr. COLE. We have a supply chain that is global in nature. We manufacture——

Mr. YOUNG. Where are they mostly made?

Mr. COLE. Across about 20 different countries, from the United States to China and——

Mr. YOUNG. Most of them are made in China. I happened to go to your store. And the ironic part about it is most of your products are a result of fossil fuels. They are made by fossil fuels, the material is fossil fuels. They are made in China. The biggest polluter we have is China. And I often think it is hypocrisy to talk about we cannot use fossil fuels when the product they sell and advocate against is made by fossil fuels—in China, not with American labor. I just wanted to bring that up.

Dr. Oneil, some environmental activists argue that fuel loads or too many trees are not a problem. However, in your testimony you argue the epidemic of insects and disease in our western forests have been brought down in a large measure by an epidemic of too many trees. How does that work, too many trees?

Dr. ONEIL. The work that myself and other scientists in that space—as opposed to activists, we work as scientists. We look at the numbers, and we look at the data.

If you are wanting to mitigate fire impacts, you have to think about it within the framework of how does fire actually work, and it is real simple. It is what is called a fire triangle. You have fuels, oxygen, and heat. The only thing we can affect in the fire triangle is the fuels. The more fuel you have, and the drier it is—which that will be exacerbated with warmer weather, drier weather, longer seasons—the more fuel you have, the more chance that when you get that lightning strike, when you get that ignition source, that you are going to end up with a catastrophic event.

Fire ecologists have been talking about this for 40 years, that this is a problem. And it is continuing to be a problem. And now we are seeing that it is a problem.

Mr. YOUNG. You bring up a very valid point. For those members on the Committee from California, when I was 5 years old we were pasturing sheep in Paradise. My father and I had 5,000 ewes. And we didn't have any fires of any consequence because there was no over-burden, no volatility that was left on the ground.

And what I see now, when there is a fire, there is so much heat that it destroys the tree and actually destroys a lot of the ground, which probably would add later on with more trash timber than real timber. And I just—I watch that fire.

By the way, how many acres did you burn? Anybody know? Anybody ever put a pencil to it?

[No response.]

Mr. YOUNG. I want to get the science, how much pollution was put in the air by that fire. A lot.

I think if they had managed it to begin with, you wouldn't have that fire. There is the big argument. Are we going to let the trees still be natural, or are we going to manage the timber? We have to manage the timber. But you even mention cutting the tree and,

"Oh, we can't do that," including those people who sell goods made in China. You can't do it.

But in reality, if we don't do it, we will never address this issue. That is called adapting. That is all I ask, is think about adapt. Just don't automatically say no.

I yield back the balance of my time.

Ms. HAALAND. Thank you, Mr. Young. The Chair now recognizes Mr. Grijalva.

Mr. GRIJALVA. Thank you, Madam Chair. And to you and to the members of this Committee, thank you very much for the hearing.

I want to associate myself with some of your comments at the outset, Madam Chair, and that was climate change isn't just in our jurisdiction. I think it falls under the shared responsibility for all Members, all decision makers. And I think this Subcommittee and the Committee as a whole plays a big role, a very expansive role, in addressing climate change. And within that jurisdiction, a very large nexus to be able to address those issues. So, I appreciate you mentioning that, because I think it is important to keep that in mind.

Dr. Hansen, let me ask you, both your and Dr. Gonzalez's work suggest that we need to protect more places from the dangers of climate change. An example that you could respond to, Dr. Hansen, is the Sky Islands along the southern border region in Arizona as a place for further protection. Can you speak about that, specifically, in terms of those Sky Islands being potential adaptation tools on the issue of climate change?

Dr. HANSEN. One of the effects of climate change that was alluded to in testimony today is about the movement of ecosystems and species in response to climate change. In order for that movement to happen, there has to be a place for that to happen.

The Sky Islands Region offers a unique suite of opportunity because, not only does it involve space that moves up in latitude to some degree, but it also creates elevational refugia, places that stay a little bit cooler, perhaps, as the overall landscape is changing, and places for things to move.

Thinking about how we use the space we have to allow natural systems to respond to the extent they can by themselves in conditions like that is a vital component of adaptation. We do not have the money to hand-manage all of the systems. We do not have the ability to move species manually. We need to come up with how do we create an intact landscape across which things can move on their own.

Mr. GRIJALVA. Thank you very much.

Mr. Cole, based partly on Dr. Hansen's response and the testimony today, we talk about these efforts at adaptation. The Land and Water Conservation Fund, of which your organization and your business have been large supporters of, what role do you believe that plays in the discussion?

Mr. COLE. I think the Land and Water Conservation Fund is one of our most important conservation measures in the United States. It has impacts in every single state, almost every single county across the country. And it takes a small amount of money from revenues from offshore drilling and leasing, and puts that into conservation. And I think that, whether you are living in a community

that has city parks, or whether you are living in a community that is close to wilderness area, you could be helped by the Land and Water Conservation Fund.

And with climate change, we need more of those protected spaces to allow for resilience, to allow for protection of biodiversity, to allow for carbon storage, all those things. The Land and Water Conservation Fund can contribute to all those benefits in the face of climate change.

Mr. GRIJALVA. And last, Dr. Hansen, you served on the Advisory Committee on Climate Change and Natural Resources Science under the previous administration. Let's take a snapshot of where we are right now, in the last 2 years, under this Administration.

Dr. HANSEN. Unfortunately, that committee no longer exists.

Mr. GRIJALVA. Any action on the findings?

Dr. HANSEN. No. In fact, most of the suggestions that were made by that committee, the structures that were part of that set of ideas, that set of principles no longer exists, or are quite vestigial with no funding.

Mr. GRIJALVA. If you could respond, there was a beginning effort of utilizing public lands as an adaptation vehicle going forward. And that has stopped, as well. The issue now becomes, are we contributing to the overall negative effect of climate change as public lands, or retreating from any commitment to adaptation. Are we part of the problem now, as opposed to being part of the solution?

Dr. HANSEN. Yes. I mean, unfortunately, the dominant contribution of greenhouse gases to the atmosphere from public lands is our use of them for the extraction of fossil fuels. And increasing that increases the problem not only for all of us, but for public lands themselves. We need to be stopping climate change to save our public lands, not using our public lands to stop climate change, as a friend of mine would be paraphrased to say.

Mr. GRIJALVA. Thank you very much.

Madam Chair, I yield back. Thank you.

Ms. HAALAND. Thank you, Mr. Grijalva. The Chair now recognizes Mr. Westerman.

Mr. WESTERMAN. Thank you, Madam Chair. Thank you to the witnesses for being here today. I have read all of your testimonies last night, plus listened to your testimonies today.

Dr. Gonzalez, I would like to commend you on the written testimony and the research behind the data that you presented. And Dr. Oneil, as well, I appreciate you bringing to the forefront things that need to be talked about, as far as the benefits of healthy forests to helping our environment.

Dr. Gonzalez, part of your testimony, you said prescribed burning is an adaptation measure that reduces future risk of catastrophic wildfire and tree death by removing an unnatural buildup of fuel and small trees, where old policies suppressed natural wildfire. I agree with that.

Can you elaborate on that a little bit more about carrying capacity of land and how many trees per acre? Is it just small trees, or are there places where larger trees need to be removed and then do the controlled burning?

Dr. GONZALEZ. Well, the published scientific research shows that two major factors have caused the catastrophic wildfires that we

are seeing. It is the old policies that have led to this unnatural accumulation of small trees and, of course, woody debris. And then human-caused climate change has ignited that and doubled the wildfire since 1984.

Mr. WESTERMAN. All right, I agree——

Dr. GONZALEZ. It is mainly the small trees and the coarse, woody debris.

Mr. WESTERMAN. Right. And I agree the suppression tactics over the decades have increased fire potential.

Dr. Oneil, would you like to talk about the carrying capacity, stems per acre, or biomass per acre, and how that contributes to more fires?

Dr. ONEIL. Thank you. What we are dealing with in the western United States in particular, we have done some research looking at carrying capacity under these various alternative scenarios of a warmer and drier region.

In 2010, we published this over-arching document that looked at this carrying capacity issue, and realized that, going forward, we might end up losing two, three, or more species in particular areas because of increasing aridity.

What that really means is that there isn't enough water there to sustain forests. As most people who live in the West know, you have forests in places where you have a little bit more moisture, and as soon as you leave those places and go into more arid regions, it turns into grassland. So, we are seeing that——

Mr. WESTERMAN. I am going to have to move on, but I appreciate you highlighting that part about the water. And I know there were questions about the role of land management and the role of adaptation management, which gets into water and how important our healthy forests are for providing good water.

But there is one thing that I think is confusing out there, and that is how managed forests helped to sequester more carbon over the long run. I have a slide I would like to put up.

[Slide.]

Mr. WESTERMAN. It is very hard to see, especially at that scale. But basically, the top chart shows an unmanaged forest over 160 years. The bottom chart shows a managed forest. And those curved lines are the amount of carbon stored over that time frame. That is a logarithmic scale, so that is actually 10 times more carbon on the bottom than on the top.

And when you use these wood products, you are storing the wood in buildings. If you look at not managing the forest, the top chart, and the one in the middle is where you do harvest every 70 years, the one on the top does store more carbon. But the one on the bottom, because you are storing the carbon in buildings—plus, the amount of energy that it takes to produce wood versus other building materials, which that was alluded to.

And if you will, put the next slide up there.

[Slide.]

Mr. WESTERMAN. This is another very-hard-to-see chart. But the black line there in the middle, the large black line, that is the amount of cement—on the first column—that China used in 2017. The very top one is how much the United States used.

So, China used 2.4 billion tons of cement in 2017. That is three times more than the United States used in the previous 10 years combined. And then we look at using wood in a building as—it takes 1.9 times more energy, more fossil fuels to produce concrete than it does to produce wood. So, you get this huge cumulative effect, globally, when you substitute wood for other materials.

I wish we had more time to talk about this. I am out.

Ms. HAALAND. Thank you, Mr. Westerman.

The Chair now recognizes Ms. DeGette.

Ms. DEGETTE. Thank you very much, Madam Chair, and congratulations on your new position. I want to congratulate the Chair on having her very first hearing as a hearing on climate change, which is so important for our public lands and for our country.

I also sit on the Energy and Commerce Committee, and we had a hearing last week on climate change. I asked the panel a question that I am going to also ask this panel here today, vis-à-vis public lands. And it will require only a yes or no answer, so we will start with you, Dr. Gonzalez.

And the question is, is climate change real, largely due to human activity, a source of profound risk to the health, safety, and welfare of our country, including to our public lands, and something we urgently need to address? Yes or no?

Dr. GONZALEZ. Yes.

Ms. DEGETTE. Dr. Hansen?

Dr. HANSEN. Yes.

Ms. DEGETTE. Mr. Cole?

Mr. COLE. Yes.

Ms. DEGETTE. Dr. Oneil?

Dr. ONEIL. Yes.

Ms. DEGETTE. Thank you very much. And as I said last week in Energy and Commerce, the very fact that we have a bipartisan panel here who all agree with the basic foundation of what we need to address is actually a big step forward for Congress. And it gives me great hope that we can work in a bipartisan way on really addressing these issues.

As a westerner, I see the impacts on our public lands for myself. And I just have a few follow-up questions.

Dr. Gonzalez, you testified that temperatures have increased in national parks more than other places. Could you briefly tell us why that is?

Dr. GONZALEZ. National parks are located in our most extreme environments: in the Arctic, in high elevation mountains, and in the arid Southwest. And those are the areas that climate change is exposing more. And that is where we have placed——

Ms. DEGETTE. They are the most vulnerable areas. Would that be——

Dr. GONZALEZ. Yes, they are the most exposed. And America's most special places, the national parks, happen to be located in those extreme environments.

Ms. DEGETTE. Dr. Oneil, I wanted to talk with you about some issues, because I think we agree on a lot, which is when you would have a forest, normally that would help offset carbon emissions. But as you accurately point out in your testimony, when you have

massive forest fires, that increases carbon emissions. Would that be a fair assessment of your testimony?

Dr. ONEIL. That is a fair assessment.

Ms. DEGETTE. Thank you.

Dr. ONEIL. The difficulty is that the global carbon budgets don't actually count emissions from public lands as something that is human caused, so they get excluded.

Ms. DEGETTE. We should probably fix that.

But one of the things that you testified about is the increased vulnerability of our forests from issues of aridity and also things like insects, which we have seen in Colorado and throughout the rest of the Rocky Mountain West very dramatically the last few years.

Scientists say that the reason why we have had the devastating pine beetle kill, for example, in our western forests is in large part because of climate change, because it doesn't get cold enough in the winters any more to kill the insects. Would you agree with that statement about pine beetles?

Dr. ONEIL. No.

Ms. DEGETTE. You don't?

Dr. ONEIL. No, because that is the focus of my Ph.D. And, in fact, in Colorado and the southern states, it is not colder winters, it is hotter summers that is causing——

Ms. DEGETTE. But in any event, the hotter summers are due to climate impacts, correct?

Dr. ONEIL. When you see these changes——

Ms. DEGETTE. You know what? I only have a minute left. Can you answer that yes or no?

Dr. ONEIL. There is that pattern that is in that system——

Ms. DEGETTE. Right. So, I will say if we address the climate issues as Dr. Hansen was talking about, if we can keep climate change down below 2 degrees, that will help with the initial causes of the devastating forest fires that we have, as well as other issues. And that is what I think we need to look at.

And one last thing I will say. I was just telling Congressman Huffman forest management is really important in a lot of these areas. And to my view, one of the reasons why we have had such devastating fires is previous forest management plans where we didn't let naturally occurring fires burn. But now we have millions of acres in the West, millions of acres of public lands. The idea that we would harvest wood from these areas in order to have better forest management is just simply not tenable. We have to work on a lot of other issues, and we have to be practicable.

Thank you, Madam Chair.

Ms. HAALAND. Thank you, Ms. DeGette. The Chair now recognizes Mr. Hice.

Dr. HICE. Thank you, Madam Chair.

Today, we are engaging in—from my count, at least—this Committee's fifth hearing on anthropogenic climate change and the horrible consequences that will occur unless, of course—and this is my concern—unless we take action which includes massively expanding government, ultimately destroying federalism, and restricting individual liberties.

And I go back and look at the first five hearings of the 115th Congress that this Committee had, and it included modernizing water and power infrastructure, improving infrastructure for tribal and insular communities, examining management of marine sanctuaries, improving infrastructure for National Park Service and Forest Service, and how best to use our natural raw materials for national security.

But today, again, if my count is correct, we have the fifth hearing—this time in the National Parks, Forests, and Public Lands Subcommittee, in what amounts to me as a publicity stage for the Green New Deal, which is championed by many of my colleagues across the aisle. And this resolution—which, of course, was named, at least recalls the name from FDR's New Deal, which, arguably, intended to put Americans back to work—this resolution does just the opposite.

In fact, one really has to wonder, in looking at the details of this, whether or not there will actually be new regulations that would be created regarding the manner in which we breathe because of the carbon dioxide that we ourselves produce.

This deal calls for a massive mobilization of resources, resources that could be more appropriately used to pay down $11.6 billion in Park Service maintenance backlog, which, of course, Chairman Grijalva and Republican Leader Bishop in a bipartisan manner put forth last Congress in the Restore Our Parks Act.

And I can't recall the number of times that I have heard from my colleagues across the aisle talking and complaining about how offshore oil rigs so far off they can't even be seen, and yet they ruin our environment. But this Democratic plan would now call for hundreds of thousands of square miles of wind turbines and solar panels. More precisely, a 2015 study by Stanford engineers noted that to meet the Nation's power needs entirely with clean energy would require almost 500,000 on- and off-shore wind turbines and over 75 million solar panels, and would cost roughly $7 trillion.

All of this new infrastructure would somehow, amazingly, not run into any problems with the Endangered Species Act or Clean Waters Act, and environmental impact studies would apparently just sail right through the approval process, although in this Committee we have had countless witnesses testify that oftentimes we are looking at a 7- to 10-year average of getting some of these permits.

This is potentially, I would say, the Green New Deal's only winning strategy, which I would assume supporters on the other side would aggressively help to overhaul, some of the ridiculous burdensome hoops that must be jumped through. And I would certainly welcome that conversation.

But overall, I am extremely disappointed with the direction of this Committee and the Subcommittees in these first few weeks of business. It seems to have taken the very important issue we have of managing the American people's natural resources and disguise the Committee as one focused on climate alarmism.

No doubt clean air, clean water, and healthy environment are important issues, one that I certainly want to help pass on to my children and my grandchildren. But so is the business of managing our Federal lands and parks, and making sure that we are focused

on the issues like the national parks' maintenance backlog and a host of other issues. This is an immediate concern to the function of these parks, so that they continue to be enjoyed.

My hope is that in the near future we will come back to this Committee's agenda to match more closely the mission and our jurisdiction, and that we would get away from these continued rainbow and unicorn promises of the fairyland Green New Deal.

With that, Madam Chairman, I yield back.

Ms. HAALAND. Thank you so much, Mr. Hice. The Chair now recognizes Mr. Neguse.

Mr. NEGUSE. Thank you, Madam Chair. And also, congratulations to you on your election. And I appreciate the opportunity to participate in this hearing, and the fact that this first hearing of the Subcommittee is on such an important issue, and as existential an issue as climate change.

I would just say, with respect to my colleague on the other side of the aisle, I respectfully disagree in the framing of this hearing as a publicity stage or publicity stunt, something to that effect. I think this hearing is an opportunity for members of this Committee to hear from some world-renowned experts and scientists in their respective fields, both witnesses from the Majority and the Minority. And I have appreciated, actually, the give and take and some of the thoughtful questions with respect to forest management, and so forth.

So, I think that this could hardly be described as a publicity stage, that this is, in fact, an important Subcommittee hearing on the defining issue of our time, which is the planetary crisis that we find ourselves in.

Dr. Hansen, I found your testimony very compelling with respect to your comment to testifying in 2004. As I mentioned at the last Full Committee meeting, my wife and I are new parents. I have a 6-month-old. Or she is 5 months, 2 weeks old, Natalie, our daughter. And I think a lot about the work that we do here in the context of the world that she will inherit.

When some of the most catastrophic consequences of climate change are set to occur at the IPCC report and, of course, we have several members of the IPCC here with us today, my daughter will be 12 years old, 13 years old. So, it really brings into clarity just how important the work is that this Committee is undertaking. I appreciate the Chairwoman holding the hearing, and the Members participating, and, of course, the witnesses, for joining us today.

I want to ask a question of Dr. Gonzalez. And you referenced Rocky Mountain National Park. I happen to represent the great state of Colorado, Northern Colorado, Boulder, Fort Collins, and Rocky Mountain National Park. I have spent my life as a child and a young adult and, of course, now, as a father, going to the park and enjoying the park as so many countless Americans do. You talked a lot about the consequences, just in terms of how our national parks are faring as a result of climate change, including Rocky Mountain National Park. I guess I am wondering if you can put a finer point on what we are to expect in the coming years if we don't take decisive action.

I agree with Dr. Hansen, that inaction is just simply not an option, but I am curious if you could provide sort of some additional

details about just how dire the consequences will be for our national parks.

Dr. GONZALEZ. Yes. Rocky Mountain actually has experienced, historically, some of the more severe impacts of climate change: the increased wildfire; the bark beetle kill, which, across the western United States has been the most severe in 125 years; and the reduction of snow cover. If we don't reduce carbon emissions from human activities, wildfire could substantially increase—published research estimates in Yellowstone an increase of 300 to 1,000 percent. And with the increased aridity and the increase in bark beetles, more massive tree death, tree mortality across the western United States.

In addition, the wildlife right now in Yosemite National Park, historically, wildlife have been shifting up-slope, following the cooler temperatures. That shifting might go off the top of mountains.

And in Lassen Volcanic National Park, the American pika, small mammal, might completely lose its habitat and locally disappear.

Mr. NEGUSE. Thank you, Dr. Gonzalez. My next question is for Mr. Cole.

I want to thank you for your testimony, and certainly for your leadership. I want to give you an opportunity to respond, to the extent that you would like to, to the Ranking Member of this Subcommittee's comments with respect to your company and manufacturing and so forth. My understanding is Patagonia was a founding member of the Sustainable Apparel Coalition, and does quite a bit in that regard. So, I just want to make sure you have an opportunity to respond to the extent you would like to.

Mr. COLE. Thank you. I appreciate that. In regards to our company's activities and our approach to this problem, we have a goal of being carbon neutral by 2025. This is in alignment with 40 years of our work around sustainability, as you note. And we are working hard across our entire supply chain to make that happen.

We do make products around the world, in about 20 different countries. We also are proud to make products in the United States, and we support about 1,500 to 2,000 jobs in the United States, depending on the season. We are proud of those employees and that contribution to our economy here.

We are also a part of an $887 billion industry, the outdoor recreation economy, that is present in the United States and supports about 7.6 million U.S. jobs, direct jobs, that derive directly from the protection of our public lands and from having a climate that supports the kind of lifestyle and economy that we are used to.

So, I would say, internationally, that having a global supply chain is an advantage for us, in understanding this global problem. And we are working with our suppliers in China, frankly, and other places around the world to also address these key issues. Climate is not just a problem for our country, but it is a global problem, as well. Thank you.

Ms. HAALAND. Thank you, Mr. Cole.

Thank you, Mr. Neguse.

Mr. NEGUSE. Thank you, I yield back.

Ms. HAALAND. The Chair now recognizes Mr. Curtis.

Mr. CURTIS. Thank you, Madam Chairman. I, with my colleagues, would like to express my appreciation for the opportunity

to talk about this important topic. If any of you have been to Utah, you will understand why I believe Utahans have it in their DNA to be good stewards of this earth. It comes quite naturally.

As a Boy Scout, I was taught to leave my campground cleaner than I found it. And I actually believe that both Republicans and Democrats believe that to be true. I regret the stereotypes that are often formed around this issue. Somehow all Republicans hate the environment and all Democrats are alarmist. And I don't believe either of those stereotypes are true. I hope we can find common ground as we talk.

You have heard from a lot of my colleagues today how important the forests are. I would like to add to that. Clean air and natural disaster resiliency, I think it is a mistake not to be talking about resiliency to these natural disasters.

There has been, interestingly, something that, in my opinion, has been totally missed in our dialogue today, and is almost always missed in this dialogue in Washington, DC, and that is the impact of local and state governments and elected officials. I believe, personally, having been a former mayor, that if you want to reduce it by 2 degrees, mayors know how to solve this. And I think it is a mistake when we feel like there is somehow one magic fix at the Federal level that we can mandate in a one-size-fits-all to solve this problem.

And I want to give you a quick example. In Utah, in Salt Lake City in Utah County, we have a unique problem, that we are surrounded by mountains on all sides. And particularly in the winter months, we get what is called an inversion, where a high-pressure system comes in and traps there in those valleys. And, therefore, if you ask Utahans what the largest environmental crisis is, they will say clean air. And they will say it about 15 times a year. Otherwise, we enjoy beautiful mountain, clean air.

In response to this, our governor, in his last State of the Union just several weeks ago, increased the money in his budget not 2 times, not 3 times, but 117 times for clean air, introducing initiatives with transit. And we have a big issue with wood-burning stoves, and that was a big part of it, electrical vehicles charging stations, things like that were part of his plan.

I mentioned that I was mayor before I came here, and our city recognized the need to take responsibility, and we produced something called the Provo Clean Air Toolkit. The name of the city is Provo. I would also invite all of you to Provo. And I would hope that you would all search on the Internet for the Provo Clean Air Toolkit. In it, I think you will see a masterful plan for cities about what individuals can do, what municipal government can do, what colleges can do, what businesses can do to improve air quality.

We also introduced transit. We worked on walking and biking. As the mayor, I committed to ride my bike to work 100 times in a given year to try to inspire my residents to do the same.

We introduced renewables, we are a municipal power city. We were 70 percent coal when I took over. We introduced renewables and gave our residents a chance to buy as much as 100 percent of their energy from renewables.

And one fun thing that we did is, we also recognized no matter what we did as a government, unless the hearts and minds of our

residents were in tune with this need, that we could accomplish nothing. So, we came up with what we called the Provo Clean Air Challenge pledge, and we had several points that we challenged our residents to do. We asked them to carpool as much as possible.

We have a unique situation in Utah, where you can find a church house on almost every corner. And most of us live within walking distance of that church. Embarrassingly, the Curtis family sometimes will take three cars to that church three or four blocks away. And we are not the only ones, so challenging my residents to carpool when it was appropriate.

Park and ride, instead of going into a drive-up restaurant was on the list, not letting your vehicle idle for more than 30 seconds, and ride or bike or carpool and use public transit wherever possible.

So, today I invite all of my colleagues to take this challenge. And I have for you a pin that we wear on our lapel in Provo, if any of you feel so inclined to take that personal responsibility.

Thank you, Madam Chairman. The very first one I have given out in Washington, DC.

But before my time expires, I would just like to really emphasize how important it is that, first of all, as a Member of Congress, we personally are doing what we can do before we ask other people to do it. Are we changing our light bulbs? Are we not using plastic bags, and all of those things?

And the second thing is to remember the power of local government in solving this problem, and make sure that we are empowering them and not ignoring them.

Thank you very much. I yield my time. Thank you.

Ms. HAALAND. Yes, thank you, Mr. Curtis. I walk to work every day. Just letting you know that. And I haven't used a plastic disposable water bottle since I have been here on Capitol Hill. So, thank you so much.

The Chair now recognizes Mr. Case.

Mr. CASE. Thank you, Chair.

Dr. Oneil and Dr. Gonzalez, I have two questions, one for each of you, both sides of the same coin. I will give them to you both up front.

Dr. Oneil, I will start with kind of a very abbreviated story from my own home state of Hawaii, where the indigenous peoples of Hawaii, the native Hawaiians, lived for generations and generations in isolation, no contact, a very ecologically and environmentally balanced and sustainable society.

And then what happened was the first western ships brought with them rats, and the rats wreaked havoc on the local wildlife, and also on human beings. Therefore, we imported the mongoose from India to take care of the rats. Well, the mongoose started killing off the foul population, and they went from hero to enemy. So, we brought in something else to take care of the mongoose, et cetera, et cetera. You can see that sometimes the best intentions of humans are not as good as what nature wrote to start with.

And I say that by way of asking you this question. When I hear your testimony, what I hear you saying is that, hey, we have a climate change problem, we have incredible risk to our public lands, to include our forests. And, obviously, that is creating a

number of problems, whether it be wildfires or whether it be the lack of a natural solution to climate change and CO_2 emissions. But the way to do that is to harvest the forest. And I just pause on that when I think about it, from a science perspective, because you are asking me to really say that my solution to the problem I had in Hawaii was to introduce another human solution, when the problem was the rat coming in to start with. The problem was climate change to start with.

So, I just ask you to comment on—are you saying that the out, in terms of the impact of climate change on our public lands, is to enhance harvesting, or is there a human solution? I am just having—I am not a scientist, I am not a climate scientist, but I am a skeptic of that position. As opposed to just going back to a more natural cycle.

I am sorry. And, Dr. Gonzalez, the flip side is, is there a way to manage our forests that helps climate change?

Dr. ONEIL. I think that the challenge is do nothing or log it to the beach. And that is not actually an alternative that you would look at, in terms of the national forests, which is where I have done a lot of this analysis and work. Those are areas that are available, they are considered timberlands. And there are a lot of different alternatives of the way that you would treat those forests to get to a condition that was more fire resilient.

Like the example that you just explained—I was just in Hawaii at Christmas, so I got the story of the errors of the mongoose way—but the idea that if we just leave it to nature everything would be wonderful would suggest that we haven't spent 40 or 50 years doing fire suppression and, therefore, that historic fire return interval would be such that we would get back to a natural condition. And because we are so far out of synch, that is not actually possible.

Mr. CASE. So, are you saying that we are out of synch because of human-caused management, and we have to get back into synch by human ways, as opposed to——

Dr. ONEIL. It is a combination of all of those things. It is a combination of the management decisions that were made in the last 100 years, including stopping all fires by 10 a.m.

Mr. CASE. OK.

Dr. ONEIL. And the recognition of that probably—like I said, for the past 30 or 40 years, fire ecologists are saying we are going to have a problem, we are going to have a problem. And now we have a problem.

Mr. CASE. OK, I get it. I appreciate your answer. That was an honest answer.

Dr. Gonzalez, what do you think? Can we handle climate change in some forest management way to include continued harvesting? What does that do?

Dr. GONZALEZ. Well, published scientific research by my colleagues at the University of California-Berkeley in Yosemite National Park and elsewhere shows that prescribed burning and the use of wildland fire can effectively restore ecosystem function to our forests, and that it reduces risks of high-severity fire in the future, improves their resilience to drought, and improves soil moisture.

Also, fire is more efficient, cost effective, and environmentally sound than timber harvesting or thinning.

I would underline also that prescribed burning also results in long-term accumulation of carbon, which naturally reduces climate change. And the way it does that is you remove the small trees and the large trees get larger. And over the long term, the research shows that the large trees will store more carbon than you release in the short-term burn.

Mr. CASE. OK, I am out of time.

So, you are saying, just briefly, yes, there are appropriate forest management techniques that actually help climate change?

Dr. GONZALEZ. Yes, prescribed burn and wildland fire.

Mr. CASE. OK, thank you.

Ms. HAALAND. Thank you, Mr. Case. The Chair recognizes Mr. Bishop.

Mr. BISHOP. Thank you.

Dr. Oneil, I appreciate you not speaking in glittering generalities. But I have 1 minute to ask this question and have it answered.

Traditionally, forests are thought of as carbon sinks to suck up carbon. Instead, they are now emitting it. Are there, in your opinion, some creative ways of forest resiliency that we could use for these extreme events that we have had? Forty-one seconds, go for it.

Dr. ONEIL. There are a number of examples that are occurring here. There is an example in Arizona, where they are looking at forest restoration. They removed the trees, they have to find a market for them. Unfortunately, there are no markets to be found.

And part of their requirement is actually to do the fire risk reduction and get rid of all the biomass before they can move on to the next area. And I think this is important. When you harvest, you also have to treat those residues, usually through some kind of a fire effort.

Now, the challenge is——

Mr. BISHOP. I am sorry. Let me go on with this. So, you are talking about there are practices, but they also have to have some private-sector economy to make them functional at the same time?

Dr. ONEIL. Absolutely.

Mr. BISHOP. All right. Mr. Cole, I appreciate the fact that you are here when none of your company actually was going to attend last year. So, thank you for accepting a Democrat invitation. I think it clearly illustrates how crony capitalism is working very well in the last administration, and may do it again in the future.

I have been reading in Matthew about how Christ and John talked about the hypocrites, except the word "hypocrite" comes from a Greek word, which actually is better translated as a play actor. There are roles people are playing. And I think we have roles that people are playing here.

Now, the slur against Patagonia is, is Patagonia made in China? Because that is what all the labels say. I want everyone to know that is not true. I cleaned out my closet and found a vest that was purchased from Patagonia, so I looked at the label. And it was not made in China, it was made in Sri Lanka.

So, the $900 billion industry you are talking about—which is a slight exaggeration—is basically there to improve the bottom line, not necessarily improve the planet.

So, for example, the stuff that is made in China by your company, your company clearly put out the statement that, "We made the choice not to disengage with countries on the basis of their policies." I wish you would do that in the United States, as well.

But amongst those policies which the company now wishes to ignore is the internment, re-education of over a million Uighur Muslims; routine jailing of environmental activists and civil rights campaigners; destroying over 3,000 acres of coral reefs in the South China Sea with ports and military facilities; subsidizing long-range commercial fishing fleets that threaten the viability of fishing around the world; providing $36 billion in financing to developing countries for the construction of over 102 gigawatts of coal-fired power plants.

In addition, just the Patagonia businesses in China, 65 percent of all those businesses are run on coal. If you had actually done your work in America, the average in the United States is only 37 percent, which would be a lot nicer.

Now, in addition to that, the testimony you have given here has a whole bunch of false narratives in there. If I read the paragraph you said simply about Bears Ears and Grand Staircase, but specifically Bears Ears, "The Administration's actions not only robbed Native Americans," which is false, "and all Americans of their natural and cultural heritage," false, "threatened communities that depend on outdoor industries for economic survival," false, "poison our air and water," false, "wreaked untold damage on vulnerable species," false, "exacerbate climate change," false, "and open up public lands to more extraction."

Mr. Curtis, if I can yield to you for a second, you had a bill to actually legalize the Bears Ears situation and create it the proper way. Did you open up extraction in the area that was no longer part of the Bears Ears Monument that was done, unfortunately, by President Obama in Hawaii?

Mr. CURTIS. I regret that, because of the anger in that area, nobody realized that my bill did more to protect the land than President Obama's designation. There was a mineral withdrawal throughout the entire area that President Obama had designated.

Mr. BISHOP. All right. Well, get this in 40 seconds, 50 seconds or less: Did you ban extraction?

Mr. CURTIS. Yes.

Mr. BISHOP. Why?

Mr. CURTIS. It is the right thing to do.

Mr. BISHOP. And was there any potential of extraction in that entire area?

Mr. CURTIS. No.

Mr. BISHOP. So, that is why we were able to do it. Actually, the association Patagonia leads was organized to avoid paying taxes so that you can get the taxpayer to fund all these programs to exist with your bottom line.

I am pleased that on the tax break that you got, you got $10 million and you decided to put that into politics. Had you done that into something actually enhancing the backlog problem we have in

maintenance, that could have been real, and that could have been something specific, and that could have been happily there.

Madam Chairman, I have 15 seconds. I want to congratulate you. You are the only member on your side that has not gone over the 5-minute limit. In fact, so far, everyone totals 2 minutes and 44 seconds. We should get another speaker on our side, just to do that. But I appreciate the fact there is a 5-minute limit. I am quitting.

Ms. HAALAND. You are amazing. Thank you very much, Mr. Bishop.

The Chair now recognizes Mr. Horsford.

Mr. BISHOP. For 5 minutes.

Mr. HORSFORD. Thank you, Madam Chair. And it gives me great honor to say that, and I am very pleased to be on this Committee.

Not to belabor the comments that were just made, I would like to divert back to the interest from my home state of Nevada, which depends heavily on public lands, and has a long-standing partnership with government agencies, that we work to both manage and protect the public lands in partnership together.

In fact, my district, Nevada's 4th Congressional District, is home to Great Basin National Park, Death Valley National Park, Lake Mead National Recreation Area, as well as Gold Butte, Basin and Range, and Tule Springs National Monument, something that I am proud to have worked with Ranking Member Bishop in prior congressional sessions.

Nevada's 4th Congressional District is also home to three national forests, which span more than 3.5 million acres. In total, Nevada has more than 59 million acres of public lands. Eighty-six percent of our state is made up of public land managed by the Bureau of Land Management, the National Park Service, the U.S. Forest Service, and other Federal agencies.

Nevada's public lands provide unparalleled outdoor recreational opportunities for the people of Nevada and the visitors to our state. In 2017 alone, the National Park Service accommodated more than 6 million visits to Nevada's parks. And in 2017, visitors to land managed by the National Park Service spent more than $250 million supporting 3,281 jobs.

Sadly, due to the impacts of climate change, Nevada's public lands face an ever-increasing list of threats. In recent years, rising temperatures have allowed the bark beetle to multiply faster, putting more forest area at risk of infestation. Now, the bark beetle may not sound too threatening to some. But as it continues to infest our forest, it will substantially increase the forest fires and threaten the health of Nevada's national forests.

Climate change continues to contribute to longer wildfire seasons in Nevada. And we have also seen a decline in our water rates at the Lake Mead National Recreational Area.

All the impacts of climate change increase in scope and severity. Managers of public lands will continue to face increased challenges.

Dr. Gonzalez, your research spoke to the disproportional impacts of climate change on national parks in the Southwest. And I would like to ask, if you could, if we allow climate change to continue unabated, what will this mean for districts like mine?

Dr. GONZALEZ. Already in Lake Mead National Recreation Area, in your district, climate change has combined with increased water

withdrawals from cities and agriculture to lower the level of the lake to its lowest level since it was filled in the 1930s. That is in part due to a drought in the southwestern United States that published research has shown has been caused by human-caused climate change since 2000, and is ongoing.

Continued climate change could continue to reduce water flow in the Colorado River, which threatens the level of the lake, which not only provides for the ecosystems in the area, but sustains the people of southern Nevada.

Mr. HORSFORD. Thank you. And Mr. Cole, can you explain how the threats outlined by Mr. Gonzalez might impact outdoor recreation on our public lands?

Mr. COLE. Absolutely. And first off, Nevada is a very important state for us. We will have upwards of 1,000 employees as of the end of this year.

Mr. HORSFORD. We appreciate your contribution to our state and the creation of those jobs.

Mr. COLE. Thank you, and thanks for your leadership. And those employees—for a business, we need to attract employees like that to our locations, to places like our distribution center in Reno, Nevada. And we can't do that without an attractive state to bring them into. And part of the attraction, as you have just noted, about Nevada are its public lands. It has incredible places for people to come and recreate, spend time outdoors.

It is an attractive thing for a business like ours. I think that is the case for businesses across the spectrum in outdoor recreation, whether it is small mom-and-pop businesses on a local level that rely on protected places for their business and to bring people in, or large ones like ours. It was a huge economic impact, for sure.

Ms. HAALAND. Thank you, Mr. Cole.

Thank you, Mr. Horsford. The Chair recognizes Mr. Fulcher.

Mr. FULCHER. Thank you, Madam Chairman and panel, thank you for being here. I have a question for Dr. Oneil, but I need to set the stage for that because I think, from what I am hearing, the situation in our state of Idaho is different than what I am hearing from my colleagues.

But in our state, approximately two-thirds of our land is Federal land, so we are really tenants there, instead of landlords in that sense. And the problem is that our landlord is about $22 trillion in debt, and they don't have the ability to manage what is theirs, so they don't.

So, in a given year, we will burn up—just in the forest areas—about a half-a-million acres, if you want to average it out over time. And that has kind of turned into a worse-of-all-worlds scenario, because the wildlife gets decimated in that circumstance, tons of carbon emissions get kicked up into the air. We will collectively, state and Federal, spend six-digit millions in trying to suppress it. But when it is not managed at all, there is this fuel load that builds up so much that a lightning strike, boom, hits it and then it is decimated for our wildlife, our sportsmen, our timber industry, all of that.

So, what is left of our timber industry, what is left of our sportsmen, our recreationalists, and our farmers, our ranchers, they would just like to engage in some fashion to try to put some

wisdom—and that is all, just that, just wisdom—into how that land is managed, the land that is within our state borders.

From your perspective and your homework, what are the biggest obstacles and some of the things we might be able to do, just simply to take the stakeholders who live there, who want to take care of it, to have a little bit more say in how that is done?

Dr. ONEIL. In Washington State, we have adopted an all-lands, all-hands approach, where you systematically—looking at these very high-risk areas, including state, private, and Federal land, and tribal lands, and looking at how it is that we could create these large areas that have some resilience in them. That is sort of a shared stewardship model. They work very closely with the U.S. Forest Service to try to accomplish that kind of effort.

But it wouldn't happen without on-the-ground forest collaboratives. In Washington State, we have a large number of forest collaboratives that very much speak to that local input and local outcomes. I would suggest that is a model that is usable in almost every area. They use it in Arizona, they use it in Washington State, where they are actually looking at ways that the local people can get their needs addressed well.

And also public-private relationships because, obviously, the Forest Service or any other public agency is not in the business of marketing any kind of material that they remove. And you do need markets to be able to sustain this stuff. We have had stewardship contracts for years, and the difficulty is being able to actually market the material and, therefore, nobody bids on it, or they don't bid enough to do the work to actually create this really significant change.

So, it is a systemic challenge, especially if you lose your infrastructure.

Mr. FULCHER. Thank you, Dr. Oneil.

And Madam Chair, just a closing statement. And I really do appreciate the perspective of the panelists. And I would just invite you, if you really believe that fires in their natural state and just leaving things alone is the best thing to do for the environment, then I would just encourage you during fire season, when we are pumping tons of carbon into the air and spending hundreds of millions to try to suppress it, I would encourage you just to come visit. We live there. It is our home. And we just want to take care of it. Thank you.

Ms. HAALAND. Thank you, Mr. Fulcher. The Chair now recognizes Mr. Lowenthal.

Dr. LOWENTHAL. Thank you, Madam Chair and the witnesses for being here. I have sat here through this, listening to this, and I really think it reflects the fact that—later on we are going to be voting about a package to keep the government open or not. And we may have some issues later on around the President thinking about a national emergency. What we are talking about here is the national emergency that the Nation confronts, and the planet confronts. So, I am really glad to be part of this hearing and listen to it.

Yesterday, we held hearings in the Natural Resources Committee on the Energy and Mineral Resources Subcommittee, and again, as witnesses have pointed out, 25 percent of our Nation's energy

sources—oil, gas, coal, and then also renewables—come from Federal lands. That is all the offshore, all the onshore that are under the control of the Federal Government, about 25 percent. So, I think that is a great discussion.

And we have heard from some of the witnesses. I am going to ask all the witnesses to really answer three questions.

Should we now be placing a moratorium on issuing any new permits or any new leases for onshore and offshore oil, gas, and coal? Should we be?

Should we also look at, on existing extraction, to place a fee or a tax on fossil fuel extraction to fund some of the impacts of climate change? Should those that are contributing now, should we be looking at that?

And if we are going to fund some of the impacts, what would you set up as our priorities from some kind of fee on oil extraction, or carbon fee, but from Federal lands? How would you spend, as your highest priority, in terms of some of the impacts?

I am going to go right across, start with Dr. Gonzalez. First question, should we place a moratorium on all now new development on Federal lands?

Dr. GONZALEZ. The scientific research clearly shows that we need to reduce greenhouse gas emissions from fossil fuels. And moving to renewable, solar, wind, and energy conservation, and energy efficiency is the way to do that.

Many policy mechanisms to do that, and the one that you have identified is one of them, it is not in my particular area of expertise to judge that moratorium, but anything that moves us away from fossil fuels is good.

Dr. LOWENTHAL. OK, Dr. Hansen. Should we be placing a moratorium on all new development, permits, leases?

Dr. HANSEN. If our bottom-line goal is to stop making this problem worse, I would say that would be a prudent course of action, especially when the injury from the action affects the very place from which that energy is being extracted.

Dr. LOWENTHAL. Thank you.

Mr. Cole?

Mr. COLE. Yes, we have already been pretty public in stating that, for offshore drilling, we believe very firmly the moratorium should be in place. And similarly, for onshore, I think it is a prudent action to proceed that way.

Dr. LOWENTHAL. And Dr. Oneil?

Dr. ONEIL. Offshore oil and gas is outside of my realm of expertise, as a scientist. I am going to decline that one.

Dr. LOWENTHAL. OK. On existing oil extraction, which is approximately 25 percent of the Nation's oil, gas, and coal, should we be having some kind of fee or extraction to really begin to pay for some of the both short-term and long-term impacts?

And if it is so, what other kinds of impacts, whether environmental, whether it is economic development, transitions, labor, disruptions, if we begin to do this, how should we begin to use some of the resources?

And anybody can jump in. Because we are going to have to prioritize.

First of all, should we be—is there a cost to carbon extraction? And should they be part of the solution by helping to fund impacts?

Dr. GONZALEZ. Again, clearly, the research shows that the real cost of fossil fuels, the social cost of carbon, has not been reflected in the price, the environmental impacts and the social costs. So, any policy that can integrate that real social cost of carbon into fossil fuel use would be a good advance.

Dr. LOWENTHAL. Anybody else? I think I am running out of time.

Dr. HANSEN. I would just like to quickly say that solving the problem of climate change is addressing the need for fiscal prudence. The cost of the impacts of climate change is already upon us. We have already talked about a lot of the effects that have been seen in everybody's home states.

What that will mean if it continues unchecked for our economy is catastrophic. Coming up with ways that we create market incentives to move us away from that and toward the economy of the future, I think, is vital. I am not an economist, so I don't know what the best mechanisms are, but we certainly do need to account for those costs.

Dr. LOWENTHAL. All right. Thank you, Mr. Chair, and I yield back.

Mr. HUFFMAN [presiding]. Thank you, Mr. Lowenthal. The Chair now recognizes the acting Chair. And I allowed a little extra time there, unlike Ranking Member Bishop, who did a great job bringing his comments in precisely within the time limit.

However, I think he may have exceeded the limit of reasonable credibility with some of that anger and sanctimony directed at Patagonia. It seems that all of this anger and passion about doing business with China and other countries for clothing is reserved for companies that want to protect public lands and national monuments, and do something about climate change and be good corporate citizens.

I wish we had more even-handed sanctimony that applied to the Trump family. After all, these are the biggest hypocrites of all. They attend their MAGA rallies, they whip people into a nationalist fervor, railing against doing business and trade with China, and then they turn around and do exactly that. So, I hope we cannot only honor time limits, but also honor even-handedness in our sanctimony, as we go forward.

I was pleased by the other side's calling a witness to this hearing—the first time, I believe, in any of our Natural Resource Subcommittee hearings—Dr. Oneil, who firmly reflects the mainstream of the global scientific community in acknowledging climate change. I am getting a little whiplash, because we have heard previous witnesses that tell us no big deal, nothing to see here.

But Dr. Oneil, I found your testimony refreshing and welcome. The only piece that I wanted to push back on a little is the notion that we might be able to log ourselves out of this problem, or log ourselves even to fire resilience. I represent a lot of forestland and a lot of public land that has much in common with some of my Republican colleagues. And I am glad you clarified a little bit that you are not talking about logging all the way to the beach, so I appreciate that comment very much that you made.

But I think it is important to acknowledge—because I live this reality, too—that the 2017 North Bay Fires and last year's Mendocino Complex Fire, which devastated parts of my district, burned primarily in chaparral. These were not large-standing merchantable trees. Sixty percent of wildfires occur on chaparral and grasslands, so they are not going to be stopped by logging, they are not going to be stopped even by many conventional fuels reduction projects. And these fires also are exceptional because of weather events: high winds, dry ground, all of these factors, not simply this simplistic notion that we don't cut enough trees.

That is why many of us want to prioritize mitigation projects in and around at-risk communities, ensuring that those communities have the resources and guidance that they need to establish fire-safe neighborhoods. That is smart fire resiliency.

But you might be surprised, Dr. Oneil. I think if you and I sat in a room, we would agree on a lot of things where we can do more cutting of trees and more harvesting. And we can do it thoughtfully, with shaded fuel breaks. We can do thinning of some of these second and third-growth plantation stands that are extreme risks for catastrophic fires.

So, I don't want to suggest that we are totally on opposite pages, or that the choice is to discontinue all harvesting and just open the doors to unlimited harvesting with impunity. I think there is a lot of common ground that we can work on together.

Now, Dr. Gonzalez, we have heard at length about logging to reduce fuel loads, and I want to ask you. Does the best available science suggest that commercial logging in this fashion is a silver bullet to reduce fire risk?

Dr. GONZALEZ. Published scientific research shows the opposite. It is that pre-emptively using fire management, prescribed burning, and wildland fire is the way to restore ecosystem integrity to our forests, and to reduce high-severity fire in the future.

Mr. HUFFMAN. OK. Mr. Cole, I know Patagonia is based in Ventura, close to where the devastating Thomas Fire burned hundreds of thousands of acres around Ventura. Was this the fire in an unthinned tree stand?

Mr. COLE. No, those fires which did impact us heavily—we had over half of our employees evacuated at given times over the past couple of years—that was in exactly the kind of habitat you described, which is chaparral. It is coastal scrub.

A policy to log more would not have helped that area at all.

Mr. HUFFMAN. OK. Moving to a different subject, we have talked a lot about our public lands being a great asset for this country, and a contributor to emissions. But they can also be part of the solution through carbon sequestration, soil health, and other factors. Can you speak very briefly about regenerative agriculture, and healthy soils on our public lands, as a strategy to reduce emissions?

Mr. COLE. Yes, this is another sort of pillar of our policy and approach around addressing the climate crisis, is regenerative organic agriculture. The concept is one that goes back, literally, thousands of years. It is a sort of low-till, no-till crop rotation orientation to agriculture that has huge benefits in storing carbon in the soil. And we know that simply cutting back on fossil fuels and shifting to renewables is not enough. We have to store carbon.

Mr. HUFFMAN. Thank you——

Mr. COLE. So, this is a great approach——

Mr. HUFFMAN. I apologize that I don't have more time, because we deserve to have a longer conversation about that subject, but we are out of time.

Mr. Westerman.

Mr. WESTERMAN. Thank you, Mr. Chairman, I appreciate——

Mr. HUFFMAN. I think we have reached the end.

Mr. WESTERMAN. Yes, OK, I thought we were doing a second round.

Mr. HUFFMAN. Are we going to do a second round? Oh, the Chair is here.

Mr. WESTERMAN. We still have time on the clock.

Mr. HUFFMAN. I am happy to—let me leave that tough decision to the Chair, though.

Ms. HAALAND [presiding]. Thank you so much. I wanted to go until noon. We have 10 minutes. So, we have time for two more questions, one on your side and one on ours. How is that? If you would like to go over your time, I am more than happy to accommodate you. Thank you.

Mr. WESTERMAN. We are burning them now.

Ms. HAALAND. Exactly. Mr. Westerman.

Mr. WESTERMAN. Thank you, Madam Chair. I appreciate you doing a second round. I think southerners should be given more minutes. I think we are being discriminated against because of our slow cadence in speaking, but we will try to get more questions in this time.

I would like to make a bit of a clarification. I think we have to distinguish between public lands and Federal lands. We have the national parks and we have the Forest Service, which I think are two land bases that should be managed differently.

Dr. Gonzalez, I know you talked about Yellowstone. I got to spend some time in Yellowstone. I never realized before going out there just how much of a lodgepole pine cohort is in Yellowstone, which we know has about a 100-year life expectancy, until you get a stand-replacing fire. I think the one in the 1980s took out about half of Yellowstone. It is going to burn. I don't think we need to manage on Yellowstone, we can let nature manage Yellowstone. That is what has been going on there. And there are other places on our national parks where I have never promoted doing intensive management on those parks. There could be stuff in the wildland-urban interface.

But the Forest Service is a different story. And I would like to just go back briefly to my previous testimony, where I had the chart up that showed that active management plus using wood materials, overall, is a bigger carbon synch, better for the environment than just a hands-off approach to management. And I want to ask the scientist this.

Dr. Gonzalez, do you agree with that assessment, that management plus using wood materials is better than non-management?

Dr. GONZALEZ. Prescribed burning, again, has been shown to increase carbon storage in forests more than mechanical thinning.

Mr. WESTERMAN. Dr.——

Mr. HUFFMAN. Could I ask if Mr. Westerman would yield just for a clarification of his question? And I will give you all of my time, as far as——

Mr. WESTERMAN. I will yield to the gentleman.

Mr. HUFFMAN. I am just wondering if you are asking categorically, across the board. Because sometimes we talk as if all forests and all fires are the same, and they are just——

Mr. WESTERMAN. No, I am not talking across the board.

Mr. HUFFMAN. OK.

Mr. WESTERMAN. But in areas where we can actively manage, where we produce wood products, we build wood buildings, build furniture, the research shows that that, overall, is better for the environment than no management at all. And I am just asking if you agree with that research, or do you disagree with it.

Dr. GONZALEZ. Storage and harvested wood products can, yes, increase carbon storage. But the point I was making was the difference between prescribed burning, proactive fire management, versus logging and thinning. And it is the proactive fire management that has been shown——

Mr. WESTERMAN. I need to move on. Dr. Hansen?

Dr. HANSEN. My area of expertise is not forest dynamics. However, what I do know is that if, in fact, you want to have forest products in order to be harvested, we need to start managing our forest systems for future conditions. Otherwise, we will end up with not——

Mr. WESTERMAN. Agreed, that the adaptive management——

Dr. HANSEN. We need to undertake adaptation principles, yes.

Mr. WESTERMAN. And Dr. Oneil?

Dr. ONEIL. I have worked extensively in this area. In fact, some of the published research quantifies those differences in just leaving the forests alone or managing it for wood products to both store the carbon in the wood and offset the use of other materials like steel and concrete. So, yes, I do agree with that.

Mr. WESTERMAN. OK. And Madam Chair, I would like to submit for the record the charts that I have put up that were so hard to read. They did come from this graduate-level textbook called Global Resources and the Environment, by Chad Oliver, who is a professor at Yale University. I would like to submit those for the record, that show that managing forests and using wood products are better for the environment.

Ms. HAALAND. Without objection, so ordered.

Mr. WESTERMAN. Thank you.

Dr. Oneil, you also supplied this chart that shows forests on the Federal lands have a higher mortality rate than a growth rate, which is very concerning.

Contrary to that, in my state of Arkansas we produce 16 million more tons of wood per year every year. And with your data of 50 percent of that is carbon, we are actually synching 8 million more tons of carbon per year in the state of Arkansas. The state of Georgia, it is 9½ million tons of carbon more per year that is going into synch.

Should states like Arkansas, who have a healthy forest, be rewarded for that, versus states who have—or the Federal Govern-

ment, that have forests that have higher mortality and are emitting more carbon, storing less carbon? Should they be punished?

Dr. ONEIL. I am not into the punishment and reward thing here.

Mr. WESTERMAN. Well, maybe that wasn't the right word. Should there be more incentives for states like Arkansas, that are sequestering more carbon?

Dr. ONEIL. I think the incentive is to promote and support a sector, for a sector that will encourage that investment in growing forests and using them for harvested wood products, and then using those harvested wood products, as many of them as possible and long-lived products.

Certainly in the Southeast we have a really vibrant forest industry. And actually, that same report that looked at the national forests and the level of mortality also speaks to the fact that in the southeast United States there are more acres under management, and they are harvesting more than they ever have, but yet they are carrying more than they ever had because there is investment, because there is a market. And that market promotes the reinvestment in forestry.

We also see that in the Pacific Northwest in the coastal areas, where you have a lot of private forestland, and the investment supports the idea of continued forest management.

When we lose that market, we lose the investment potential, we lose the potential to use those lands to sequester carbon and then produce wood products. It is a different calculus.

Ms. HAALAND. Thank you, Dr. Oneil.

Thank you, Mr. Westerman. And I would like to make note that we did yield to your southern cadence, so thank you for bringing that up.

Mr. HUFFMAN. Madam Chair, would you please deduct Mr. Westerman's extra time from mine? And I will yield back.

[Laughter.]

Ms. HAALAND. Thank you. I will ask the last question of this hearing, and my question goes to Dr. Hansen. The first is a yes-no question, the second one I will ask you to expand on the answer.

In your testimony, you mentioned that we need to provide our agencies with clear, informed mandates to begin preparing for climate change. In your opinion, has this Administration provided these?

Dr. HANSEN. No.

Ms. HAALAND. And what should we be requiring our agencies to do?

Dr. HANSEN. It should be a required part of how they do business. And I am going to preface this by saying this isn't just because of environmental interests. This should also be an interest by every taxpayer in this country.

We should not be allowing decisions to be made that are not going to be effective for what we want our government to be doing for us, because they will be undermined by the effects of climate change. So, the need would be for all decisions made, all actions taken by Federal agencies to be evaluated for their vulnerability to climate change, and designed to maximize the reduction of that risk so that we can deliver on the promises that we are making to

the American people, to future generations, and to the environment that we are stewards of.

Ms. HAALAND. Thank you very much, Dr. Hansen. And that concludes our hearing on this climate change and public lands.

I want to thank you all again for being here today, and for helping us start this important conversation. It is imperative that we hear the best science, and that we understand the impacts so that we can begin to act on climate change.

Unfortunately, our colleagues across the aisle have chosen to focus on land use scenarios and outdated rhetoric, but these claims will not slow us down.

To our witnesses, your insights and policy recommendations have been helpful, and will help us craft bold and impactful legislation around climate change adaptation. Let us not forget how momentous it is that we are once again hosting these important conversations in the halls of Congress.

And this is the end of the hearing.

That is right. The members of the Committee may have some additional questions for the witnesses, and we will ask you to respond to these in writing.

Under Committee Rule 3(o), members of the Committee must submit witness questions within 3 business days following the hearing, and the hearing record will be held open for 10 business days for these responses.

If there is no further business, without objection, the Committee stands adjourned.

[Whereupon, at 12 p.m., the Subcommittee was adjourned.]

[ADDITIONAL MATERIALS SUBMITTED FOR THE RECORD]

PREPARED STATEMENT OF THE HON. DEBBIE DINGELL, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF MICHIGAN

Thank you, Chairman Haaland and Ranking Member Young, for convening this hearing to discuss the threat of climate change and the unique challenges it poses to our Nation's public lands.

Public lands are key to the economic and ecological health of Michigan. As they comprise almost 10 percent of Michigan's total land area, these areas drive tens of millions of dollars in tourism and support thousands of jobs.

From the iconic Sleeping Bear Dunes National Lakeshore to Isle Royale National Park, these areas are fundamental to Michigan's identity and the state's outdoor recreation economy.

Given the integral role that public lands play in Michigan, I am highly concerned about the effects of climate change that these areas face. We know that public lands will face disproportionate impacts as a result of climate change.

Over the last century, the mean annual temperature experienced across the United States' national park system increased at double the rate of the United States as a whole.

As a result of reduced winter ice and snow cover caused by climate change, the Sleeping Bear Dunes National Lakeshore will face accelerated loss from increased erosion. Additionally, other national parks both in Michigan and across the United States face potentially existential risks.

The need for action is clear—we must work to address climate change without delay by taking strong and decisive action at the Federal level.

Protections for public lands are critical for not only mitigating the impact of climate change on sensitive ecosystems, but also, properly managed, can serve as a climate adaption solution.

Unfortunately, the Trump administration has elected to ignore the numerous economic, public health, and ecological benefits that public land preservation

provides. Instead, they have prioritized oil drilling, mining and resource extraction at all costs.

The Administration's actions include rescinding Department of the Interior guidance to prepare for the impacts of climate change on public lands, as well as unprecedented actions to put public lands in private hands.

These actions are highly misguided. Instead, we should be renewing our commitment to preserving America's public lands for future generations.

It is my hope that today's witnesses will provide context on the importance of public land protections in addressing climate change, and the key role that they will play as we examine solutions to this pressing issue.

DR. MARK E. HARMON, PROFESSOR EMERITUS, OREGON STATE UNIVERSITY

STATEMENT SUBMITTED FOR THE RECORD CONCERNING COMMITTEE HEARING DATED FEBRUARY 13, 2019 ON CLIMATE CHANGE AND PUBLIC LANDS: EXAMINING IMPACTS AND CONSIDERING ADAPTATION OPPORTUNITIES

My name is Dr. Mark E. Harmon and I am currently a professor emeritus at Oregon State University. I wish to offer the Subcommittee my personal comments and opinions on the issue you are considering. These are based on my 33 years of professional experience examining these and related issues. Over my career I have received a large number of grants (78 in total), published numerous peer-reviewed journal articles (over 140), been an author of three major reviews (one cited over 3,900 times), reviewed about 175 research proposals for agencies such as NASA, NSF, and USDA, served as a referee on many scientific manuscripts (over 450 for a total of 100 different journals), taught several graduate level courses on the topic of forest ecosystems and forest carbon dynamics and well as made dozens of scientific and outreach presentations on these topics, and served as a scientific expert to Oregon's and Federal agencies including the US EPA (biogenic carbon). To give more details I am providing my abbreviated curriculum vitae, but I believe most scientists in this field would consider me a leading expert particularly in the field of forest carbon.

I have a general concern about both the written and transcribed testimony from Dr. Oneil (the Minority witness) that I have recently read regarding the examination of climate change impacts on public lands and adaptation opportunities. To sum up the basic logic that appears to have been presented: (1) a warming climate coupled with increased tree density has lead increased disturbance caused by fire, insects, and disease in forests; (2) therefore more trees must be harvested to reduce tree density; (3) these management actions will reduce the amount of disturbance; and (4) will result in greater stores of carbon thus reducing one of the key drivers of climate change, atmospheric carbon dioxide. I find this analysis to be overly simplified, lacking context, and incomplete as it leaves out many key concepts that need to be part of any practical and credible solution. In the following sections I elaborate.

SELECTING A MANAGEMENT SOLUTION

The choice presented in the testimony seemed to have been that one can either let nature take its course or institute management involving deliberate campaign of widespread tree harvesting. I believe that is a false choice that does not reflect the diversity of forest management objectives present in the United States, nor does it reflect the range of forest conditions and responses; nor does it reflect the practical and economic limitations that will undoubtedly shape management choices. One can envision a wide diversity of potentially effective management options that go far beyond what was offered:

> In some remote wilderness/park/reserve areas the best choice might be to allow nature take its course given lack of access, expense, and management objectives (which might include allowing nature to dominate);
>
> In other such areas it might make sense to reintroduce disturbances such as fires to achieve objectives;
>
> In yet other areas it might make sense to suppress fires aggressively under certain weather conditions, but not others;
>
> In the interfaces between forests and human communities it might make sense to not only reduce tree density, but to remove trees altogether.

This not an exhaustive list, but the point is that the management solution must match the specific management objectives, have a strong chance of achieving the objectives, and be realistic regarding economic and logistical limitations. Using forest harvest such as thinning in all situations would mean roads would have to be built into parks and wilderness areas often at extreme financial and environmental cost, but it would also mean that areas where complete tree removal is needed, such as for fire breaks and defensible spaces, would not be managed appropriately either. In plain terms we need to match specific solutions to specific conditions, not find a general problem to impose the single solution that we desire to implement.

In deciding which management actions to take, the primary objective of management for a particular forest needs to be recognized. Despite studying forest carbon for decades, I do not believe that carbon sequestration is the primary reason why most forests are managed today. While certainly important, carbon is a secondary objective/concern that should be managed to maximize stores (in the forest, in products, and substitutions) within the constraints of the primary management objective. One of my concerns with the testimony I read is that it seems to suggest that management actions will be taken to increase carbon stores and that other benefits such as economic, housing, energy benefits will follow. I would encourage everyone to stop dropping "the carbon bomb" to convince others of the validity of their desired management objective. There is a wide range of valid forest management objectives that have little to do with carbon. A more productive pathway would involve accepting the wide range of forest management objectives that exist and within those consider how carbon can be managed effectively.

MORTALITY CONSIDERED

Increased mortality beyond the historic range of this process is a concern, and I have no doubt some aspects of these changes need to be managed and mitigated through adaptation. However, it is overly simplistic and counterproductive to imply that mortality is always undesirable or that it automatically degrades forest ecosystem function. Mortality has always occurred in forests and that is why there are numerous species of animals, plants, and fungi that have evolved to take advantage of dead trees. Moreover, mortality is how forests thin themselves and coupled with decomposition is how forests recycle the nutrients they need to grow. Preventing mortality in forests or removing dead trees, as in the very intensive management best seen in 1980s northern Europe, has reduced the abundance of many species by removing their habitat and limiting the structural development/diversification of forests. That is why current forest management in many parts of northern Europe is trying to restore dead tree habitat. It should be noted that mortality does not equate with the loss of carbon or any other general function of forest ecosystems. The concept that carbon is completely lost or habitat is completely lost because of mortality is mistaken at best. When trees die in a forest from natural causes, a substantial part of the carbon remains (even in the case of severe fires more than 90 percent remains) and this carbon is gradually lost through the process of decomposition (which takes decades to centuries). While live tree habitat is lost during mortality, dead tree habitat is gained. What occurs in mortality is that the form of carbon and type of habitat changes. The only known process to immediately remove live and/or dead tree carbon and habitat at a large scale from a forest is timber harvest. We know this because trees, at least the aboveground part, are deliberately removed from the forest in a harvest!

Mortality is a natural process and ranges from the death of scattered individual trees to small patches of trees all the way up to major episodes covering broad areas. These forms of mortality have occurred in forests as long as forests have existed. None of these scales is more natural than another and over a broad area about as many trees die as scattered individuals as in major episodes. In and of itself these forms of mortality are not cause for concern. What is a concern is the degree that these forms of mortality change forests in ways that prevent specific management objectives from being achieved. This means that we cannot assume that the level of mortality tolerated in an intensively managed forest (very little) is the same as expected in a wilderness area where the creation of open habitats might be an important management objective (a great deal).

If maintaining forests is the management objective, then widespread mortality coupled with low tree regeneration success is the key concern, not mortality on its own. Mortality need not lead to a permanent loss of desired forest conditions, especially when a disturbed forest retains and regenerates the elements needed to restore these conditions. In many cases, disturbance-related mortality is a temporary reorganizer of forests and there are natural processes that allow forests to "recover" the conditions that are desired. The recovery process can begin quickly (years) or

slowly (decades), but one must bear in mind that the perceived speed of successful recovery is strongly influenced by management objectives: 5 years may be too long for tree regeneration in a short rotation production forest, but 50 years or more may be appropriate in a remote wilderness. If management actions such as seeding and planting are needed to speed forest regeneration, then these actions need to be targeted to specific locations and situations as they may be neither needed (moist soils) nor effective (persistently very dry soils) in all locations. Moreover, if regeneration is assisted, the approach should be to introduce a wide range of genetic stock and species to cover the possible spectrum of future conditions. This acknowledges our uncertainty in predicting future conditions and increases changes of success because it allows natural processes to find the most successful "players" in the future forest.

To understand how to solve a problem one must understand what the problem is. Much was made in the testimony of the observation that mortality has increased fourfold in National Forest timberlands over the 1976–2016 period. While the data support this observation, it is misleading if taken at face value. The implication is that if mortality has increased fourfold, it must be solely due to increases in disturbance. This is misleading because, as noted above, about half of all tree mortality occurs at the individual level (which is not generally considered a disturbance), but also because mortality as it was expressed (that is a volume dying per year) depends on two items: (1) the proportion dying each year and (2) the volume of trees that can potentially die. Mortality can increase if either term increases. As Figure 1 in Dr. Oneil's written statement makes clear, net growth (the amount forest live volume/biomass/carbon increases) has been positive throughout the 1952–2016 period. This means, despite the occurrence of mortality, that live tree volume has increased over this time period. Based on the values presented in Dr. Oneil's testimony I estimate that tree volume may have roughly doubled over this period.[1] Thus, one would expect half of the fourfold mortality increase evoking concern to have been caused simply by the fact that today's forest has substantially more volume than earlier forests. By analogy if one plans to buy a house at 4 percent annual mortgage interest then do not be surprised if the $100,000 house has one-half the interest payment of the $200,000 house. This not to say that there has not been an increase in the proportion of tree volume dying. Using the mortality rate reported by Dr. Oneil, it does appear that the proportion of tree volume dying has increased by about a factor of two between 1972 and 2016 with much of this increase occurring in the past two decades. However, in addition to knowing what level of reduction is required one must also understand the specific mechanisms behind the changes: one has to ask why the proportion of tree volume dying has increased. The suggestion in the testimony seems to be that it is related to fire and bark beetles; while I suspect this is partially true and there is evidence to support this hypothesis, there are other substantial sources of tree mortality that have increased over this period such as those related to wind and invasive species that are not related to either tree density or drought. Therefore, it is hard to envision how forest thinning, the proposed solution to reducing fires, disease, and insect attacks, would decrease the impact of wind disturbance, or that related to invasive insects such as the woolly adelgids attacking eastern hemlocks and Fraser fir or the emerald ash borer attacking green ash much less diseases such as sudden oak death. In fact, in some cases thinning might exacerbate these forms of mortality.

While an increase in the proportion of trees dying each year is of concern, the idea that the proportion of gross growth (NPP) allocated to mortality is indicative of a problem is misguided. Specifically, concern was expressed that two-thirds of gross growth (equivalent to net primary production or NPP) is currently being "lost" to mortality. The suggestion is that this "large" proportion is unnatural, but that ignores the fact that, absent harvests (which are after all forms of human induced mortality), forests allocate gross growth (NPP) into either net growth or mortality and this allocation changes as forests age. In young forests the majority of gross growth is allocated toward net growth (leading to a rapid increase in volume) and in older forests an increasing share of gross growth (up to 100 percent) is allocated toward mortality. This change is why forest volume does not increase forever and

[1] Unfortunately the data used in this figure is not publicly available as far as I could determine and a full citation was not provided limiting my ability to find it. I have no doubt that the data presented are relatively accurate, however, without knowing the starting volume it is difficult to precisely estimate the degree volume has increased in a relative sense. The data presented suggest that cubic volume has increased by 212,150 million cubic feet over the 1952–2016 period. However, we know that cubic volume was not zero in 1952. Based on the likely fraction of live tree volume dying in 1952–1976, something in the range of 0.3–0.6 percent per year, it is likely the volume in 1952 was in the range of 250,000 cubic feet. If provided the 1952 volume from this dataset I could easily make a more precise estimate of the relative increase in live tree volume between 1952 and 2016.

tends to saturate as forests age. This is a fundamental relationship found in all forests, documented in the forestry literature for more than a century, and is observed even those in management systems in which harvest mortality replaces natural mortality as a source of live tree removal. In fact when a sustainable harvest system is implemented, the expectation is that harvest and mortality comprise 100 percent of gross growth, hence the volume over a large area remains constant. As a specific example of how the allocation of mortality changes as forest age, we can examine the case when tree maximum life span is about 500 years. For this kind of forest, mortality would comprise 63 percent of the gross growth of an even-aged stand at about 100 years. In a stand that is 200 years of age one would anticipate that mortality would comprise 85 percent of gross growth and for a stand of 300 years age mortality would comprise 95 percent. Returning to the National Forest timberlands data we find that between 1952 and 2019 all forms of mortality (harvest included) have increased as a share of gross growth from 53 to 69 percent. But much of this is related to the fact that these forests have become older, a fact consistent with the observed twofold increase in volume over this period. The only alternative explanation for increased live mass is that National Forest timberland acreages have increased twofold, whereas we know these acreages have remained relatively constant.

WHERE AND WHEN IS HIGH TREE DENSITY A PROBLEM?

The idea that high tree density (that is number of stems) is the primary cause of recent unnatural mortality levels is overly simplistic. This is because it ignores the natural variation in space and time that one expects of tree density. In closed forest ecosystems, tree density is highest once forest stands have regenerated. As trees grow and start to compete for resources, mortality is expected to increase. Harvest thinning in these forests is a way to mimic and control this expected natural mortality process.

While some forests have higher tree density because of management actions such as fire suppression, others have climates and reproductive strategies that lead to high tree density. Those most influenced by fire suppression in the West include ponderosa pine and mixed conifer types where tree density has greatly increased over the period of fire suppression. One could argue that harvest thinning in these types would be appropriate. However, in many other forest types tree density is naturally high and is unlikely the direct cause of recent widespread mortality. A prime example would be the recent massive beetle-kill in lodgepole pine forests. The cause of these outbreaks was not high tree density. Tree densities in these types are naturally very high because of this species' reproductive strategy and tree densities in these forests have not noticeably increased substantially due to fire suppression. Rather, warmer conditions allowed bark beetle populations to increase and coupled with a long-term drought widespread mortality occurred. Ironically, the lodgepole pine stands least susceptible to beetle-kill were those with small diameter and high tree density, the conditions where drought conditions should have had the highest impact due to high levels of competition. The ecology of these species tells us why: this beetle species cannot reproduce when bark falls below a certain thickness and adult beetles will not attack trees if the beetles cannot reproduce within them, regardless of the tree's drought stress. It is therefore important to apply basic ecological knowledge in developing an effective solution and not impose a one-size-fits-all solution unrelated to addressing actual mechanisms.

EFFECTIVE MANAGEMENT SOLUTIONS WITH A RESPONSIVE SYSTEM

While it tempting to assume that once a management treatment is imposed from "above" that the problem is solved, this is a mistake when applied to forests.[2] This is because forests do not stay the way one leaves them, and they often respond in ways that counter treatment objectives. Perhaps the best example of this is fire suppression and its effects on fuels: suppressing fires initially leads to a decrease in fire impacts, but as fuels increase (because of the lack of fire) the impacts (at least in some forests) eventually increase. A similar response behavior is quite possible for the management actions being proposed. Specifically, reducing tree density or carbon in the form of fuel is a temporary solution because, unless the underlying controls are changed, forests will respond to these actions by increasing tree density and carbon. Hence, the solution will have to be repeated frequently raising long-term logistical, environmental, and economic concerns. This repeated treatment also leads to permanent carbon debts: if high fuel/carbon level is the cause of undesired

[2] A mistake that I might add which has been repeated to the degree that an alternative to top down control management approaches has recently been developed.

levels of disturbance, then to solve the problem one must reduce fuel/carbon permanently, hence a carbon permanent debt develops. I should add that the argument that carbon debts cannot occur in forests because forests are renewable resources is completely erroneous: if high fuel/carbon is causing a problem then why would be want this high level to renew?

Even if the goal of reducing tree density is permanently achieved, forests may react in ways that counter the expected goal. Suppose the goal is to greatly reduce the occurrence of crown fires; then tree density would have to be greatly reduced because average tree distance has to be increased beyond that needed to spread these types of fires. This degree of opening in turn would allow smaller forms of vegetation (fine fuels associated with fire spread) to greatly increase and these openings would also greatly increase the rate of fuel drying. So while crown fires might be reduced, fires would continue to be widespread and challenge control efforts. In other words, one would replace one problem with a slightly different one.

To avoid these problems, one cannot think of forests as static systems that do what they are "told." Instead forests are adaptive, responsive systems than need to be persistently "persuaded" to move in the directions consistent with our management objectives.

THE FATE OF HARVESTED TREES

In the testimony harvest removal is viewed as not only solving the problem, but having major benefits in terms of goods and economic gain as well as major carbon benefits that would exceed carbon losses incurred in the forest. The carbon benefits would come in two forms: (1) carbon stores related to forest products and (2) substitutions that would reduce the use of fossil carbon. While there is an element of truth to these statements, they are misleading if accepted at face value.

Let us consider the statement that harvested carbon is stored in products. A more accurate statement would be that **some** harvested carbon is stored in products for **some** time. Although these sound similar, they are profoundly different in their effects. Specifically, when carbon is removed from forests through harvest, not all of the carbon ends up as solid products. If the harvested carbon is used for lumber/plywood/OSB production then somewhere between 30–40 percent is lost to the atmosphere in the manufacturing process. If the harvested carbon is used to make paper, then the amount lost to the atmosphere is around 50 percent and if used as fuel then it is 100 percent. Contrast these amounts to the range of live carbon lost to the atmosphere during natural disturbances: somewhere between zero and 10 percent. Moreover, consider the fact that wood products have varying life spans in use and after they are disposed, that these time frames can be quite short, and are roughly comparable to those found for wood decomposing naturally. While is it often assumed that the carbon related to mortality is lost to the atmosphere, that process can take 3 to 50 decades to complete. Taken together, the initial losses in manufacture and the losses in use and disposal means that removing carbon by harvest have roughly the same carbon storages effects as leaving the wood in the forest to decompose. Granted harvesting produces items that humans can use and generates wealth, but that should not be conflated with carbon effects.

Perhaps the biggest misconception is that using harvested wood will lead to large amounts of fossil carbon not being used through the process of substitution. While this is theoretically possible, there are several considerations that must be acknowledged to determine the degree this actually will happen. For example, in the case of product substitution (that is substituting wood for concrete and steel in construction), the preferences for materials has to be considered. In North America wood is the preferred material for residential homes, with about a 95 percent preference for wood. That would mean that one could try to replace the 5 percent of buildings not utilizing wood and gain a substitution benefit, but it is not possible to substitute wood for wood and gain a substitution benefit for the other 95 percent. The situation for taller buildings would differ as concrete and steel are currently preferred, but this raises a different problem: to build taller buildings using wood one need to engineer laminated materials, a process that involves more energy. It is highly unlikely that concrete and steel manufacturers will increase their fossil carbon use to keep the product-related displacement factor the same. Hence, it is possible that amount of fossil carbon displaced by wood use could decrease substantially in the case of taller buildings. Finally, for both substitutions related to products and energy one must recognize that the fossil carbon not used by the building sector today will likely be used by other sectors in the future. Consider the estimates of the times that fossil fuel carbon is likely to be depleted: 50–250 years depending on the form of fossil carbon. Unless this substitution-related carbon is protected by some actual mechanism, the assumption that unused fossil carbon today will never be used in

the future is completely naïve. Taken together it is highly likely that actual substitution benefits will be far lower than most expect and, in some cases, will not fully counter carbon losses related to forest harvest.

A STRATEGY THAT ACKNOWLEDGES ODDS OF SUCCESS AND FAILURE

As described in the testimony, the suggested management treatments appear to assure complete success. Conversely, the path of allowing nature to take its course appears to assure complete failure. That may be, but this view seems overly deterministic given the system we are actually dealing with: critical conditions such as drought and temperature that vary greatly from place to place, season to season and year to year; different historical pathways creating varying forest structures that react to climate and other stressors in different ways; and species that not only have different characteristics, but that do not interact in consistent ways.[3] In other words, the system we have to deal with is not deterministic, it is highly stochastic (seemingly random). Like it or not, we are forced to play games of chance in our management.

There are several ways to increase the odds of success when playing games of chance including: (1) know the rules and the possibilities, (2) understand the odds regarding outcomes, (3) use a range of strategies, (4) recognize that while there is a chance of winning, there is also a chance of losing, and (5) decide where and when it is best to not play at all. This general strategy is applied to everything from poker to investments to medicine. I am not sure why we would not apply it to climate change adaptation.

SUMMARY

I believe that it is a mistake to apply a single solution (such as more tree harvest) to a problem with the complexity of forest adaptation to climate change. A more appropriate and productive approach would be the development of a broad strategy that considers the likelihood of climate change-related phenomena modifying forests in ways that do not meet the very wide range of management objectives related to forests. To work, this strategy would have to be applied a local level given the wide variation at multiple scales from landscapes to regions to the Nation in terms of management objectives as well as the conditions present in forests. Moreover, it would have to assess the range of negative responses possible, their magnitude, and likelihood so that efforts can be prioritized. Management solutions would have to be tied to the actual mechanisms causing the undesired changes and the possible negative side effects (environmental, economic, ecosystem) and potential countervailing processes would have to be considered to evaluate the chances of success once the solution is implemented. Finally, given the inherently stochastic nature of this problem it would make sense to use a diversity of approaches (even at the local scale) until more information can be gathered as to the most effective and efficient solutions.

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[3] The case of bark beetles illustrates this point. When bark beetle populations are low, many of these species attack recently killed trees, but not living ones. When bark beetle populations are high many species attack weakened living trees, and when very high they attack even vigorously growing trees. This behavior is related to the ability to mass attack trees which is in turn a function of the beetles' population size.

[LIST OF DOCUMENTS SUBMITTED FOR THE RECORD RETAINED IN THE COMMITTEE'S OFFICIAL FILES]

Submission for the Record by Rep. Westerman

—Two graphs from Global Resources and the Environment, published by Cambridge University Press.

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