

CREATING A CLIMATE RESILIENT AMERICA

HEARING BEFORE THE SELECT COMMITTEE ON THE CLIMATE CRISIS HOUSE OF REPRESENTATIVES ONE HUNDRED SIXTEENTH CONGRESS

FIRST SESSION

HEARING HELD
MAY 23, 2019

Serial No. 116-4



www.govinfo.gov

Printed for the use of the Select Committee on the Climate Crisis

U.S. GOVERNMENT PUBLISHING OFFICE

37-407

WASHINGTON : 2019

SELECT COMMITTEE ON THE CLIMATE CRISIS

ONE HUNDRED SIXTEENTH CONGRESS

KATHY CASTOR, Florida, *Chair*

BEN RAY LUJÁN, New Mexico
SUZANNE BONAMICI, Oregon
JULIA BROWNLEY, California
JARED HUFFMAN, California
A. DONALD McEACHIN, Virginia
MIKE LEVIN, California
SEAN CASTEN, Illinois
JOE NEGUSE, Colorado

GARRET GRAVES, Louisiana,
Ranking Member
MORGAN GRIFFITH, Virginia
GARY PALMER, Alabama
BUDDY CARTER, Georgia
CAROL MILLER, West Virginia
KELLY ARMSTRONG, North Dakota

ANA UNRUH COHEN, *Majority Staff Director*
MARTY HALL, *Minority Staff Director*
climatecrisis.house.gov

CONTENTS

STATEMENTS OF MEMBERS OF CONGRESS

	Page
Hon. Kathy Castor, a Representative in Congress from the State of Florida, and Chair, Select Committee on the Climate Crisis:	
Opening Statement	1
Prepared Statement	3
Hon. Garrett Graves, a Representative in Congress from the State of Lou- isiana, and Ranking Member, Select Committee on the Climate Crisis:	
Opening Statement	3
Hon. Robert Scott, a Representative in Congress from the State of Virginia, prepared statement, submitted for the record by Ms. Castor	56

WITNESSES

Noah Diffenbaugh, Kara J Foundation Professor and Kimmelman Family Senior Fellow, Stanford Woods Institute for the Environment	
Oral Statement	6
Prepared Statement	7
Rachel Cleetus, Policy Director, Climate and Energy Program, Union of Con- cerned Scientists	
Oral Statement	11
Prepared Statement	13
Hon. Keith Hodges, Virginia State Delegate, 98th District of Virginia	
Oral Statement	26
Prepared Statement	28
Matthew Russell, Executive Director, Iowa Interfaith Power and Light	
Oral Statement	29
Prepared Statement	31

SUBMISSIONS FOR THE RECORD

Speech by Sarah Braden, Avoiding the storm: <i>Climate change and the finan- cial system</i> , submitted for the record by Mr. Casten	52
Report, <i>Unprecedented climate events: Historical changes, aspirational targets, and national commitments</i> , submitted for the record by Mr. Luján	55
Article from <i>The Hill</i> , “Paris Agreement goals could save trillions in avoided climate damages,” submitted for the record by Mr. Luján	55

APPENDIX

Question for the Record from Hon. Kathy Castor for Noah Diffenbaugh	57
Question for the Record from Hon. Suzanne Bonamici for Noah Diffenbaugh ..	59
Questions for the Record from Hon. Mike Levin for Noah Diffenbaugh	61
Questions for the Record from Hon. Kathy Castor for Rachel Cleetus	63
Question for the Record from Hon. Suzanne Bonamici for Rachel Cleetus	66

CREATING A CLIMATE RESILIENT AMERICA

THURSDAY, MAY 23, 2019

HOUSE OF REPRESENTATIVES,
SELECT COMMITTEE ON THE CLIMATE CRISIS,
WASHINGTON, DC.

The committee met, pursuant to call, at 9:03 a.m., in Room 2247, Rayburn House Office Building, Hon. Kathy Castor [chairwoman of the committee] presiding.

Present: Representatives Castor, Luján, Brownley, Huffman, McEachin, Levin, Casten, Neguse, Graves, Griffith, Palmer, Carter, and Miller.

Ms. CASTOR. The committee will come to order.

And welcome to the May 23, 2019, committee meeting for the House Select Committee on the Climate Crisis. Without objection, the chair is authorized to declare a recess of the committee at any time. And I invite everyone to follow the witness testimony or read it at climatecrisis.house.gov. That is our website. There are some very impressive graphics contained in witness testimony and I encourage you all to review it. Again, that is climatecrisis.house.gov.

Today, we are going to examine the largest consequences and costs of climate change and set the table for how communities' ecosystems and the food system can be more resilient in the face of a changing climate.

I now recognize myself for 5 minutes to give an opening statement.

Our last hearing focused on drawing down carbon pollution while building up the American economy. Today, we are examining another component of climate action, preparing for the consequences of the climate crisis, consequences that are here already and what is to come.

We need to create a climate resilient America. Floodwaters, extreme heat, wildfires, they do not care if we live in a red district or a blue district. In my home State of Florida, Republicans and Democrats at the local level are working together to protect the places that we know and love. And we can do the same thing here in Washington, D.C.

The climate crisis isn't somebody else's problem; it is everybody's problem. There are more than 300,000 coastal homes worth a total value of almost \$120 billion that are expected to face chronic flooding in the next 30 years. When the seas rise, so does the cost to American families on our coast. When brutal heat waves hit our communities, people get sick and agricultural crops and animals suffer.

If we fail to take action, the cost of extreme heat and poor air quality from the climate crisis could add up to \$167 billion a year. And we could lose another \$155 billion a year simply from days when it is too hot for people to work outside, according to the National Climate Assessment.

And then there are the disasters. The number of billion dollar weather disasters in the United States has more than doubled in recent years. In 2017, we set a record with more than \$300 billion worth of damage. And 2018 was close behind with nearly \$100 billion. Many of these disasters are worse because of the climate crisis, including wildfires, dramatic swings in rainfall, and coastal storm surge.

When these disasters happen, we have a moral obligation to help. It is frustrating that so many Americans in Puerto Rico and Florida and across the country are still waiting for help in the aftermath of disasters. Because solving the climate crisis also requires a commitment to climate justice, that means correcting the injustices that leave so many people, especially people of color, vulnerable to flooding, heat waves, and wildfires.

These are daunting problems, but the good news is we have solutions. We can protect our communities from the climate crisis, while we cut the carbon pollution that is causing the climate to change in the first place. For instance, energy efficiency and smarter grids help keep power flowing and air-conditioning moving during dangerous heat waves. That saves life. And when we restore wetlands on our coast, those trees and plants can absorb the devastating power of coastal storms. And they absorb something else as they grow: carbon.

And increasingly, farmers are adjusting their practices to increase soil health, which makes farms more resilient to the impacts of extreme weather, and increases carbon stored in the soil. As we continue our work, we are looking forward to solutions to the climate crisis that provide multiple benefits: that reduce carbon pollution, that protect communities, and produce good jobs.

The costs of the climate crisis are already adding up, and it is time that we invest in climate solutions instead. But it is more than just dollars. It is about leaving our children a cleaner, safer, and healthier world. The millions of young people who are joining climate strikes tomorrow, Fridays for the Future, never lived in a normal climate, and they know it. That is why they are demanding climate action now, because we need to start baking the climate crisis into every decision we make, on energy, on transportation, on agriculture and infrastructure.

The climate crisis is here, and we need to act like it. This is personal. This is happening to our neighbors, this is happening to all of us. When disasters happen, we should put the politics of the day aside, come together, and solve problems. Our expert witnesses will recommend policies to do so, because we need to come together and take climate action now. We are all in this together.

At this time, I yield 5 minutes to the Ranking Member Graves for an opening statement.

[The statement of Ms. Castor follows:]

Opening Statement (As Prepared for Delivery)

Rep. Kathy Castor (D-FL)
U.S. House Select Committee on the Climate Crisis

Creating a Climate Resilient America
May 23, 2019

Good morning. Our last hearing focused on drawing down carbon pollution while building up the American economy. Today we are examining another important component of climate action: preparing for the *consequences* of the climate crisis—consequences that are here already and what is to come. We need to create a climate resilient America. Floodwaters, extreme heat, wildfires: they do not care if we live in a red district or a blue district. In Florida, Republicans and Democrats at the local level are working together to protect the places we know and love. We can do the same in Washington, DC.

The climate crisis isn't somebody else's problem. It's everyone's problem.

There are more than 300,000 coastal homes worth a total value of almost \$120 billion that are expected to face chronic flooding in the next 30 years. When the seas rise, so does the cost to American families on our coasts.

When brutal heat waves hit our communities, people get sick and agricultural crops and animals suffer. If we fail to take action, the cost of extreme heat and poor air quality from the climate crisis could add up to \$167 billion a year. And we could lose another \$155 billion a year simply from days when it is too hot for people to work outside, according to the National Climate Assessment.

And then there are the disasters. The number of billion-dollar weather disasters in the United States has more than doubled in recent years. 2017 set a record with more than \$300 billion worth of damage. 2018 was close behind with nearly \$100 billion. Many of these disasters are worse because of the climate crisis, including wildfires, dramatic swings in rainfall, and coastal storm surge.

When these disasters happen, we have a moral obligation to help. It's frustrating that so many Americans in Puerto Rico, Florida and across the country are still waiting for help in the aftermath of disasters. Because solving the climate crisis also requires a commitment to climate justice. That means correcting the injustices that leave so many people, especially people of color, vulnerable to flooding, heat waves and wildfires.

These are daunting problems, but the good news is we have solutions. We can protect our communities from the climate crisis, while we cut the carbon pollution that is causing the climate to change in the first place.

For instance, energy efficiency and a smarter grid helps keeps power flowing and air conditioning going during dangerous heat waves. That saves lives.

And when we restore wetlands on our coast, those trees and plants can absorb the devastating power of coastal storms. And they absorb something else as they grow: carbon.

And increasingly farmers are adjusting their practices to increase soil health which makes farms more resilient to the impacts of extreme weather and increases carbon stored in the soil.

As we continue our work, we are looking for solutions to the climate crisis that provide multiple benefits—that reduce carbon pollution, that protect communities and create good jobs. The costs of the climate crisis are already adding up. It's time to invest in climate solutions.

But it more than just dollars. It's about leaving our children a cleaner, safer and healthier world.

The millions of young people who are joining climate strikes tomorrow have never lived in a normal climate—and they know it. That's why they're demanding climate action now, because we need to start baking the climate crisis into every decision we make—on energy, on transportation, on agriculture, on infrastructure.

The climate crisis is here. And we need to act like it. This is personal. This is happening to our neighbors. This is happening to us. When disasters happen, we should put the politics of the day aside, come together, and solve problems. Our expert witnesses will recommend policies to do so, because we need to come together to take climate action now. We are all in this together.

Mr. GRAVES. Thank you, Madam Chair.

And I want to thank all the witnesses for taking the time to be here today and for the appropriation of your testimony.

I asked the chair to focus on this topic first, and there is a very good reason for that. As we heard during the last hearing, when Congressman Palmer asked a question of some of our witnesses, he basically said, what happens if we cut all emissions from the United States today? Are we still going to see this momentum continue moving forward in terms of temperature changes and seas rising? And the answer was yes.

And I am doing this from memory, so there is an excellent chance I am going to get this somewhat wrong. But I think you then went on to ask, what happens if all countries cut emissions? Would we see a stopping of this sea rise increase and temperature changes? And I think the answer was no.

What that means is that there is effectively nothing we can do right now, based on our current understanding of science and technology. There is nothing we can do to stop this momentum of temperatures changing and seas rising in the immediate term. And I want to distinguish that, in the immediate term. I am not saying long term; in the immediate term.

So if things are changing, if we are—if we have this momentum built up and we have seas rising and we have temperatures changing. And as the chair just covered, we are seeing these disasters occurring, and they are occurring for a few reasons in terms of the cost. They are occurring because of development. They are occurring because in the coastal counties, parishes, and boroughs that the chair and I represent and others, while that only represents 10 percent of the land area of the United States, it is where 40 percent of our population lives, and it is growing. More people want to live on the water where we are having these greater vulnerabilities with sea rise storms and other challenges.

This is an area where we absolutely need to focus, and there is zero reason why this should even be a remotely partisan issue. And that is why we did work and, I think, were able to make unprecedented advances in the last Congress in helping to move toward an adaptation or mitigation type strategy.

Number one, we actually incentivized parishes, counties, and States to be proactive, to lean forward. And they will get a reduced cost share on disasters. Number two, between some of the funds through the Corps of Engineers and through HUD—and I want to make note, HUD, who can't think their way out of a wet paper bag to get this money out on the street—we have provided record levels of funding for flood mitigation, again, through the Corps of Engineers and through HUD. And I am going to beat HUD again. We appropriated this money in February of last year, and they still haven't even figured out how to write the Federal Register guidance on how the States can access these dollars. It is inexcusable.

We were able to come in and look at this \$100 billion of backlog of water resource projects to the U.S. Army Corps of Engineers, enabled to carry out some expedited features to move those projects forward faster. We were able to define a resiliency standard within the Disaster Recovery and Reform Act last year, whereby we are not building back to how things were; we are building for the future, providing additional flexibility of this 428 authority in the aftermath of disasters.

We have more flexibility in how you build back. A lot of advancements last year and many others but some really important progress.

Now, the other thing that is really important, because I want to emphasize once again, I am not saying that just if we adapt, we just stop and say, okay, we are done. We do need to make sure that we expand the access and portfolio of clean energy solutions and opportunities for our citizens. We do need to continue, continue on this trajectory of reducing emissions in the United States. And while many people like to demonize this country, both Americans and people from other countries like to demonize the United States. I am once again going to go on a victory lap and say that the United States, since 2000, has had the greatest absolute reduction of emissions in the world, period.

So we need to recognize that we are actually doing a pretty good job and we can continue on this trajectory without wrecking the U.S. economy. And we can make progress in terms of options, energy options for our citizens. And we can help to bend this curve of growing emissions that we are seeing around the world, not from the United States, but from other countries like China, India, and others, to ensure that we can provide a future for these next generations that is sustainable, that is resilient.

I yield back.

Ms. CASTOR. Without objection, members who wish to enter opening statements into the record may have 5 business days to do so.

Now I want to welcome our witnesses. First, we have Dr. Noah Diffenbaugh, who is a professor of Earth, energy, and environmental sciences at Stanford University. Dr. Diffenbaugh studies the climate system, including the processes by which climate change could impact agriculture, water resources, and human health. He served as a lead author for Working Group II of the Intergovernmental Panel on Climate Change, and has provided testimony in scientific expertise to Federal and State policymakers.

Dr. Rachel Cleetus is the policy director with the Climate and Energy Program at the Union of Concerned Scientists. Her research focuses on the risks and costs of climate impact. She is an expert on policies to promote climate resilience. She has coauthored numerous reports, including the recent Union of Concerned Scientists' report, *Underwater: Rising Seas, Chronic Floods, and the Implications for U.S. Coastal Real Estate*.

Mr. Keith Hodges represents the 98th District in the Virginia State House of Delegates, where he has worked on flooding and coastal resiliency and has produced legislation on those. Mr. Hodges is a lifelong resident of the 98th District of Virginia and was elected in 2011.

Mr. Matt Russell is the executive director of Iowa Interfaith Power and Light, as well as a fifth generation Iowa farmer. He is a leader and expert on sustainable agriculture and finding solutions to climate change. Prior to joining Iowa Interfaith Power and Light, Mr. Russell worked at the Drake University Agricultural Law Center focusing on issues concerning retail agriculture, conservation, climate change, rural development, and Federal farm policy.

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

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

STATEMENTS OF NOAH DIFFENBAUGH, SENIOR FELLOW, STANFORD WOODS INSTITUTE FOR THE ENVIRONMENT; RACHEL CLEETUS, POLICY DIRECTOR, CLIMATE AND ENERGY PROGRAM, UNION OF CONCERNED SCIENTISTS; KEITH HODGES, VIRGINIA STATE DELEGATE, 98TH DISTRICT OF VIRGINIA; AND MATT RUSSELL, EXECUTIVE DIRECTOR, IOWA INTERFAITH POWER AND LIGHT

STATEMENT OF NOAH DIFFENBAUGH

Mr. DIFFENBAUGH. Thank you.

Thank you, Chairwoman Castor and Ranking Member Graves and the committee, for the invitation to testify.

My name is Noah Diffenbaugh. I am a professor and senior fellow at Stanford University. I am appearing today in my personal capacity.

The subject of today's hearing is creating a climate resilient America. The good news for our country is that although climate change is already impacting Americans, there are many opportunities for us to become more resilient, and in doing so build a more vibrant, secure, and equitable Nation.

My testimony will focus on the scientific evidence for the changing risks posed by global warming. You have already heard testimony summarizing the IPCC reports and the National Climate Assessment. So I would like to start by summarizing an assessment that my colleagues and I recently published evaluating the scientific evidence from the perspective of EPA's endangerment finding.

As you know, EPA issued the endangerment finding for greenhouse gases in 2009. This followed the 2007 Supreme Court ruling that EPA must regulate greenhouse gases under the Clean Air Act if those gases are found to, quote, "endanger the public health and welfare," end quote.

The finding evaluated risks in eight areas: public health; air quality; food production and agriculture, forestry; water resources; sea level rise and coastal areas; energy, infrastructure and settlements; and ecosystems and wildlife.

Drawing on more than 280 studies, our multidisciplinary team found that, not only was the evidence for endangerment strong in 2009, but also that the evidence has increased in all eight areas of the original finding.

We also found that there is now strong evidence of entirely new kinds of impacts that weren't featured in the finding. These include ocean acidification, interpersonal violence, national security, and economic well-being.

Economic well-being represents a particular area of increased understanding. Recent analysis shows that should global warming continue along the current trajectory, the majority of U.S. counties are likely to suffer economic damages arising from impacts in areas such as labor productivity, agricultural yields, and coastal damage.

Integrating across these sectors suggests that each 1 degree Celsius of warming is likely to result in damages exceeding 1 percent of U.S. GDP, with poorer counties suffering the most.

Further, in my research with Professor Marshall Burke, also at Stanford, we found that holding global warming to 1.5 degrees Celsius could reduce cumulative economic damages in the United States by \$6 trillion, relative to the 2 degree C target.

Across the country, we are already experiencing rising economic costs from extreme events. In my home State of California, we have experienced a remarkably costly series of extremes over the past 7 years, from drought and heat waves, to flooding and mudslides, to wildfires and smoke plumes. These events have caused billions of dollars in damage, killed tens of millions of trees, cost tens of thousands of jobs, left thousands of residents without running water, and claimed hundreds of lives. And many other parts of the country have experienced similar impacts.

One reason that the evidence for endangerment has increased over the past decade is that we have made tremendous strides in understanding the influence of global warming on individual extremes. My research shows that global warming has already increased the odds of record-setting hot and wet events for around 75 percent of North America, and record-setting dry spells for more than 50 percent of North America.

The influence of global warming has also been detected in many specific events, from the extremely hot, dry summer that devastated crops in the Midwest in 2012, to the prolonged California drought, to the storm surge flooding during Hurricane Sandy, and the record-setting rainfall delivered to Houston by Hurricane Harvey.

In the aftermath of these extremes, we are seeing inspiring examples of how communities, companies, and State and local governments can work together to build climate resilience. In California, the State's climate efforts offered a roadmap that integrates mitigation, adaptation and, quote, "an integral commitment to remedying past injustice," end quote.

In California and across the country, we are seeing examples of how to simultaneously reduce greenhouse gas emissions, sustain economic growth, address environmental injustice, and invest in climate resilience for all citizens.

I applaud the committee for working to create a climate resilient America. And I am happy to answer any questions.

[The statement of Mr. Diffenbaugh follows:]

**Written Testimony of Dr. Noah S. Diffenbaugh
Kara J Foundation Professor and Kimmelman Family Senior Fellow
Stanford University**

**Hearing on "Creating a Climate Resilient America"
United States House Select Committee on the Climate Crisis**

May 23, 2019

Good morning. Thank you Chairwoman Castor, Ranking Member Graves, and the members of the Committee for the invitation to testify today.

My name is Noah Diffenbaugh. I am a Professor in the School of Earth, Energy and Environmental Sciences at Stanford University, and a Senior Fellow at Stan-

ford's Woods Institute for the Environment. I am appearing today in my personal capacity, not on behalf of Stanford University.

I study Earth's climate, including how changes in regional and local conditions—such as extreme weather events—affect people and ecosystems. I have just completed a 4-year term as Editor-in-Chief of *Geophysical Research Letters*, one of the leading peer-reviewed journals publishing climate science research. I have been a lead author for a number of scientific assessments, including the IPCC Fifth Assessment Report and the California Climate-Safe Infrastructure Working Group.

The subject of this hearing of the Select Committee on the Climate Crisis is “Creating a Climate Resilient America”. The good news for our country is that, although climate change is already impacting Americans, there are many opportunities for us to become more resilient, and in doing so build a more vibrant, secure, and equitable nation.

To create a more climate resilient America, we must understand the changing risks posed by global warming. My testimony today will focus on the scientific evidence of those risks, including how they have changed in response to the warming that has already happened, and how they are likely to change in the future in response to different greenhouse gas trajectories.

There have been many reports synthesizing the scientific knowledge of climate change. In addition to the IPCC reports and the National Climate Assessment—which have been summarized during previous testimony—my colleagues and I recently evaluated the scientific evidence¹ from the perspective of EPA's “Endangerment Finding” for greenhouse gases.

As you know, EPA issued the Endangerment Finding in 2009, following the 2007 Supreme Court ruling that EPA must regulate carbon dioxide and other greenhouse gases under the Clean Air Act if those gases are found to “endanger the public health and welfare.” The Finding evaluated climate risks in eight areas: (1) public health; (2) air quality; (3) food production and agriculture; (4) forestry; (5) water resources; (6) sea level rise and coastal areas; (7) energy, infrastructure and settlements; and (8) ecosystems and wildlife.

Summary of New Evidence Since the Endangerment Finding
new evidence for impacts in areas included in and emergent beyond the EF

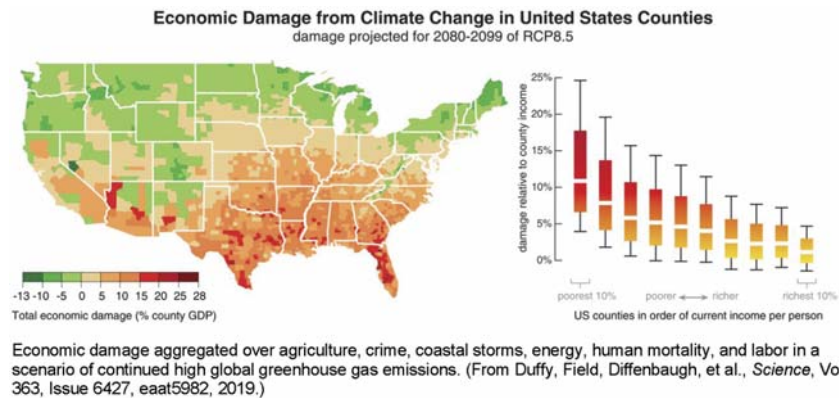
	Impacts Areas Included in EF		
	Confidence in Impacts	Evidence of More Severe or Pervasive Impacts	Emergent Impacts Beyond the EF
Public Health	↑	↑	↑
Air Quality	↑	↑	↑
Food Production and Agriculture	↑	↑	↑
Forestry	↑	↑	
Water Resources	↑	↑	↑
Sea Level Rise and Coastal Areas	↑	↑	
Energy, Infrastructure and Settlements	↑		
Ecosystems and Wildlife	↑	↑	
Ocean Acidification			↑
Violence			↑
National Security			↑
Economic Wellbeing			↑

Summary of new evidence since the 2009 EPA Endangerment Finding. Upward arrows indicate that the evidence has increased, with the size of the arrow indicating the strength of the new evidence. (From Duffy, Field, Diffenbaugh, et al., *Science*, Vol. 363, Issue 6427, eaat5982, 2019.)

¹Duffy, P.B., Field, C.B., Diffenbaugh, N.S., et al., 2019. Strengthened scientific support for the Endangerment Finding for atmospheric greenhouse gases. *Science*, 363(6427), eaat5982.

For each of these areas, our multidisciplinary team assessed (i) strength of evidence for a link with anthropogenic climate change, (ii) severity of observed and projected impacts, and (iii) new risks beyond those considered in the original Finding. Drawing upon more than 280 studies, we found that not only was the evidence for endangerment strong in 2009, but also that the evidence has increased in all eight of the areas considered in the Finding. Further, we found that there is now strong evidence of entirely new kinds of impacts that were not featured in the original Finding. These include ocean acidification, interpersonal violence, national security, and economic wellbeing.

Economic wellbeing represents a particular area of increased understanding. For example, recent analysis² shows that should global greenhouse gas emissions continue along the current trajectory, the majority of US counties are likely to suffer negative economic impacts. These include decreased labor productivity and increased crime throughout most of the US, along with impacts from mortality, energy expenditures, coastal damage, and/or crop yields across large swaths of the country. Integrating across these sectors suggests that each 1°C of warming is likely to result in damages exceeding 1% of US GDP, with poorer counties suffering the most.



Work that I have published with Prof. Marshall Burke³ has used a different approach, but yielded similar results: Analyzing aggregate GDP, we found that holding global warming to 1.5°C could reduce global economic damages by more than \$20 trillion (relative to the 2°C target), with cumulative savings to the US economy potentially totaling \$6 trillion. Further, in a new study published last month,⁴ we found that historical global warming has negatively impacted per capita GDP in most countries in the tropics and sub-tropics, including reductions of as much as 25% in Central and South America (relative to a world without global warming). Our estimates suggest that these southern neighbors are likely to experience increased economic damages in response to continued warming.

Here in the US, we are already experiencing rising economic costs from extreme events. As American citizens suffer through heatwaves, droughts, floods, hurricanes and wildfires, there is now clear evidence that the frequency of extremes is increasing, and that the costs are rising. In particular, the past decade has witnessed tremendous strides in understanding the influence of global warming on individual extreme events, such as the recent California Drought⁵ and the record-setting Hous-

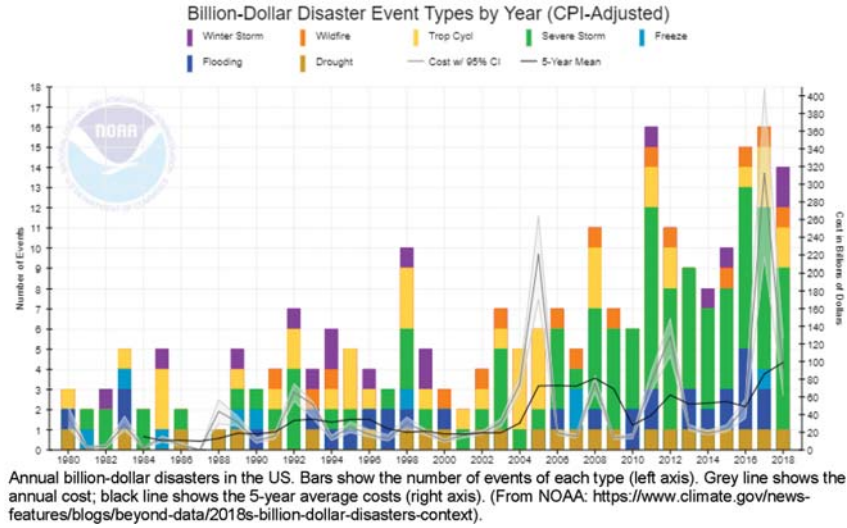
² Hsiang, S., Kopp, R., Jina, A., Rising, J., Delgado, M., Mohan, S., Rasmussen, D.J., Muir-Wood, R., Wilson, P., Oppenheimer, M. and Larsen, K., 2017. Estimating economic damage from climate change in the United States. *Science*, 356(6345), pp.1362–1369.

³ Burke, M., Davis, W.M. and Diffenbaugh, N.S., 2018. Large potential reduction in economic damages under UN mitigation targets. *Nature*, 557(7706), p.549–553.

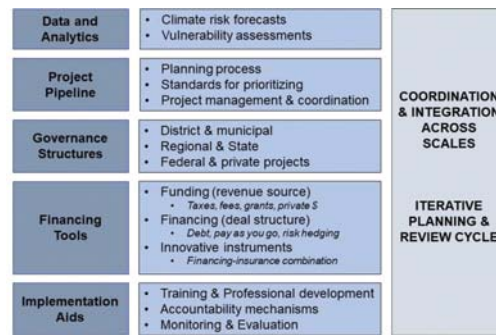
⁴ Diffenbaugh, N.S. and Burke, M., 2019. Global warming has increased global economic inequality. *Proceedings of the National Academy of Sciences*, 116(20), pp.9808–9813.

⁵ Diffenbaugh, N.S., Swain, D.L. and Touma, D., 2015. Anthropogenic warming has increased drought risk in California. *Proceedings of the National Academy of Sciences*, 112(13), pp.3931–3936.

ton rainfall that occurred during Hurricane Harvey.⁶ My research⁷ shows that global warming has already increased the odds of record-setting hot and wet events for around 75% of North America, and record-setting dry spells for more than 50% of North America. In addition, the influence of global warming has now been detected in many specific events, including heatwaves, cold snaps, heavy rainfall, floods, droughts, and the precipitation and storm surge delivered by tropical cyclones.



In my home state of California, we have experienced an extremely costly series of such events over the past 7 years, from drought and heatwaves, to flooding and mudslides, to wildfires and smoke plumes. These events have caused billions of dollars in damage, killed tens of millions of trees, cost tens of thousands of jobs, left thousands of residents without running water, claimed hundreds of lives, and created public health emergencies throughout the state.



A framework for action to ensure climate-safe infrastructure for all. (From *Paying It Forward: The Path Toward Climate-Safe Infrastructure in California*, Report of the Climate-Safe Infrastructure Working Group to the California State Legislature and the Strategic Growth Council, 2018.)

Many other parts of the country have experienced similar events in recent years, from the Northeast to the Southwest, and the Gulf to the Great Plains. In the aftermath, we are seeing inspiring examples of how communities, companies, and state and local governments can work together to build climate resilience. The California

⁶ Emanuel, K., 2017. Assessing the present and future probability of Hurricane Harvey's rainfall. *Proceedings of the National Academy of Sciences*, 114(48), pp.12681–12684.

⁷ Diffenbaugh, N.S., Singh, D. and Mankin, J.S., 2018. Unprecedented climate events: Historical changes, aspirational targets, and national commitments. *Science advances*, 4(2), eaao3354.

Climate-Safe Infrastructure Working Group's recent report⁸ is a prime example of a roadmap that integrates mitigation, adaptation and "an integral commitment to remedying past injustice". This commitment is emerging across California's climate efforts, which include the recently renewed cap-and-trade policy, the Sustainable Groundwater Management Act, and the Safeguarding California Plan.

Although our nation faces serious risks from climate change, and income inequality and environmental justice remain critical concerns, we are seeing many examples around the country of how it is possible to simultaneously reduce greenhouse gas emissions, sustain economic growth, and invest in climate resilience for all citizens.

Climate change presents imposing challenges, but there are also many opportunities to build a more climate resilient America. I applaud the Committee for working on this critical issue, and I look forward to discussing any questions that you may have.

Ms. CASTOR. Thank you very much.

Dr. Cleetus, you are recognized for 5 minutes.

STATEMENT OF RACHEL CLEETUS

Ms. CLEETUS. Thank you.

Good morning, and thank you, Chairwoman Castor, Ranking Member Graves, and members of the select committee. Thank you for providing me the opportunity to testify here today.

My name is Rachel Cleetus, and I am the policy director and the lead economist for the Climate and Energy Program at the Union of Concerned Scientists.

I would like to start today with some research that we released last year on the impacts of worsening tidal flooding on coastal property in the United States. What our studies showed is that by the end of the century, approximately 2.5 million U.S. coastal homes and commercial properties currently worth more than \$1 trillion would be at risk from chronic flooding. And by 2045, within the lifetime of a typical mortgage issued today, about 325,000 coastal properties worth \$136 billion are at risk. The properties at risk by 2045 contribute nearly \$1.5 billion to today's property tax base, and those numbers jump to \$12 billion by 2100. States with the most homes at risk include Florida, with 1 million homes at risk by the end of the century; New Jersey with 250,000; and New York with 143,000.

And the declining value of these homes, while it will be devastating for individual homeowners, also has broad implications for other parts of our economy, including the affected communities, lenders, investors, and taxpayers. And we know that communities that have fewer resources to begin with will be the hardest hit. These include communities in Louisiana, North Carolina, New Jersey, and Maryland, that our research shows will be highly exposed to chronic flooding and have higher than average poverty rates.

UCS has also developed an interactive mapping tool that allows you to explore these risks in your congressional districts, and we have fact sheets to go along with that.

Our research points to a choice we face: If the global community adheres to the primary goals the Paris Agreement of keeping warming to below 2 degrees Celsius and its land-based ice loss is

⁸ Climate-Safe Infrastructure Working Group (CSIWG). 2018. Paying it forward: The Path Toward Climate-Safe Infrastructure in California. Report of the Climate-Safe Infrastructure Working Group to the California State Legislature and the Strategic Growth Council. Sacramento, CA: CNRA, Publication number: CNRA-CCA4-CSI-001.

limited, the U.S. could avoid up to 85 percent of these coastal property losses.

UCS has also analyzed the exposure of 18 military installations along the eastern Gulf Coast to sea level rise. In the absence of preventive measures, these sites, including bases in Virginia, Georgia, and Florida, face major risks. By 2050, most of the installations we analyzed will see more than 10 times the number of floods they experience today. By 2100, eight bases are at risk of losing 25 to 50 percent of their land to rising seas. Four installations, Naval Air Station Key West, Joint Base Langley-Eustis, Dam Neck Annex, and Parris Island, are at risk of losing between 75 and 95 percent of their land by the end of the century.

As Dr. Diffenbaugh pointed out, scientists have linked Hurricane Harvey's unprecedented levels of rainfall to warmer air and oceans caused by climate change. We did analysis in the wake of that storm showing that more than 650 energy and industrial facilities may have been exposed to Hurricane Harvey's floodwaters.

In the Houston area, low-income communities and communities of color have long been disproportionately exposed to toxic chemicals, as local environmental justice groups like TEJAS have pointed out. And in the hurricane's wake, we saw floodwaters contaminated with toxic chemicals and potent bacteria, compromised industrial facilities, toxins released into the air, all of which magnified the public health burden on these communities.

Climate change is making heavy rains heavier and more frequent in many parts of the country, with human alteration of the land, including engineering of rivers, and increased construction in flood plains. Many parts of the U.S. are at greater risk of destructive and costly floods. This spring alone has brought terrible flooding to many parts of the country, including Louisiana, Texas, the Midwest, and all along the Mississippi and Missouri Rivers. NOAA data confirmed that at the end of April 2019, the U.S. has just experienced the wettest 12 months on record.

Climate projections show that these conditions are likely to grow worse in many parts of the country in the decades ahead. The Fourth National Climate Assessment also highlights many ways in which climate change is going to contribute to worsening health risks, including through extreme heat events, flooding, wildfires, intensifying storms, and other events, which can contribute to poor air quality, heat-related illnesses, water and vector-borne diseases, mental illnesses associated with stress and trauma.

And in many cases, socioeconomic and environmental factors can exacerbate the vulnerability of specific populations, including the elderly, the very young, outdoor workers and athletes, many tribal communities and communities of color, and people who live in poverty.

These grave risks require an urgent response from the Federal, State, and local policymakers, as well as the private sector, to better protect communities and build resilience. Broadly, we need to make sure that these risks are being better communicated and taken into account in our policies and programs, everything from FEMA and HUD programs to what is happening at the local level in terms of building codes and zoning codes. We need to make sure that robust expeditious funding of disaster assistance flows quickly

to hard-hit communities in a way that builds resilience to future events.

We need bold and visionary leadership. We need resources for adaptation, investments and coordination, governance, stakeholder engagement. And our Nation's resilience efforts must prioritize the needs of those who will be disproportionately exposed to these risks.

Most importantly, we must make deep cuts in heat-trapping emissions and contribute to global efforts to limit climate change. Every fraction of a degree we can avoid matters in terms of the climate impacts we will face.

Adaptation is costly, and there are limits to how much change we can adapt to. Transitioning to a low-carbon economy by investing in renewables and efficiency and other low and zero carbon options reaching that zero carbon emissions by mid century will not only help address climate change, it will deliver tremendous near-term public health and economic benefits.

Ms. CASTOR. Dr. Cleetus—

Ms. CLEETUS. In closing, I am here today both as a climate expert and as a mom. I have two young children aged 11 and 13, and like many of you with young people in your lives, I am acutely aware that the choices we make today, choices that you and Congress are uniquely empowered to help make, will be deeply consequential to their future. I hope we will seize this opportunity to make their future generations prosper without fear of runaway climate change.

Thank you for the opportunity to testify.

[The statement of Ms. Cleetus follows:]

**Written Testimony of Dr. Rachel Cleetus, Policy Director, Climate and
Energy Program
Union of Concerned Scientists**

“Creating a Climate Resilient America”

House Select Committee on the Climate Crisis

May 23, 2019

Hello and thank you, Chairwoman Castor, Ranking Member Graves, and Members of the Select Committee, for providing me the opportunity to testify here today. My name is Rachel Cleetus. I am the policy director and lead economist for the climate and energy program at the Union of Concerned Scientists. I am here today to share my perspectives on the impacts of climate change, particularly on coastal communities, and some vital, urgent steps our nation must take to limit the harms coming our way.

IMPACTS OF SEA LEVEL RISE ON COASTAL PROPERTY

I'd like to start with some research my colleagues and I have been doing on the impacts of sea level rise to coastal communities. Our research shows that long before rising seas permanently submerge properties, millions of Americans living in coastal communities will face more frequent and disruptive high-tide flooding. Last year we released a report showing that, by the end of the century, under a high sea level rise scenario (which I will use throughout this testimony unless otherwise indicated),¹ approximately 2.5 million US coastal homes and commercial properties

¹The high scenario, which is drawn from the 2014 National Climate Assessment, assumes rapid ice sheet loss and projects a global average sea level rise of 6.6 feet (2.0 m) above 1992 levels by the end of this century. This scenario is considered most applicable in situations with

Continued

currently worth more than \$1 trillion would be at risk from chronic flooding—a threshold we defined as flooding that occurs 26 times per year or more. By 2045, within the lifetime of a typical mortgage issued today, about 325,000 coastal properties worth \$136 billion will be at risk of chronic flooding (see figures 1 and 2).

Figure 1: Homes at risk of chronic inundation



Credit: Union of Concerned Scientists. Data provided by third parties through the Zillow Transaction and Assessment Dataset (ZTRAX).

Figure 2: Value of homes at risk from chronic inundation



Credit: Union of Concerned Scientists. Data provided by third parties through the Zillow Transaction and Assessment Dataset (ZTRAX).

The properties at risk by 2045 currently house 550,000 people and contribute nearly \$1.5 billion toward today's property tax base. Those numbers jump to about 4.7 million people and \$12 billion by 2100 (see figure 3).

Figure 3: Property tax base at risk from chronic inundation



Credit: Union of Concerned Scientists. Data provided by third parties through the Zillow Transaction and Assessment Dataset (ZTRAX).

States with the most homes at risk by the end of the century are Florida, with about 1 million homes (more than 10% of the state's current residential properties); New Jersey, with 250,000 homes; and New York with 143,000 homes.

The declining value of coastal homes will be damaging, even devastating, to individual homeowners. It will also have more widespread consequences, including for affected communities, lenders, investors, and taxpayers. Falling property values mean reduced local tax revenue from those properties. Our calculations show that

a low tolerance for risk. This makes it most suitable for estimating the scale of risk to residential properties, which typically represent a homeowner's greatest single asset. For more on our data and methodology, please see: <https://www.ucsusa.org/sites/default/files/attach/2018/06/underwater-analysis-full-report.pdf> and <https://www.ucsusa.org/sites/default/files/attach/2018/06/underwater-analysis-technical-background.pdf>.

in about 120 communities along US coasts, the properties that would be at-risk in 2045 currently represent a full 20 percent or more of the local property tax base. Many coastal residents, whether they own homes or not, would be affected as property tax bases shrink, which typically leads to reduced services or tax hikes for remaining taxpayers. This could prevent cities and towns from fully funding schools, emergency services, and the maintenance and new construction of infrastructure—including critical adaptation measures that could help protect homes, businesses, and infrastructure itself from chronic flooding. Access to additional capital for such projects depends on a municipality's credit rating; its credit rating depends on its financial health and degree of risk exposure, both of which are compromised as chronic flooding worsens. Mortgages on homes that could be chronically flooded during the term of the loan are inherently riskier, exposing lenders to losses.

Communities with fewer resources to start with, or that are otherwise disadvantaged, will likely be most heavily affected by chronic flooding and its accompanying financial losses. Nearly 175 communities nationwide can expect significant chronic flooding by 2045, with 10 percent or more of their housing stock at risk. Of those, nearly 40 percent—or 67 communities—currently have poverty levels above the national average. The largest share of these is in Louisiana, where there are 25 communities with above-average poverty rates and with 10 percent or more of the homes at risk by 2045. Louisiana is not the only state where poverty and exposure to chronic inundation intersect to create a hotspot of heightened risk. North Carolina, New Jersey, and Maryland also have significant numbers of highly exposed communities with above-average rates of poverty (see Figure 4). Within the next 30 years, about a dozen such communities along Maryland's eastern shore are projected to have one-third or more of their property tax base at risk.

Figure 4: Communities with high poverty rates at risk of chronic inundation in Louisiana and Maryland



These results do not include future development or new homes, nor do they include the impacts on critical infrastructure such as roads, bridges, power plants, airports, ports, public buildings, and military bases that will also be in harm's way. When all of these are taken together, the effects of chronic flooding could have staggering economic impacts.

UCS also developed an interactive map tool that lets you explore the risk sea level rise poses to homes in your congressional district and provides district-specific fact sheets about those risks.² What our maps show is that rising seas will begin to reshape many coastal communities in the coming decades, in some cases quite drastically. Communities need representatives in Congress who will advocate for the research, funding, and policies needed to help them cope with sea level rise and coastal flooding head-on. In some cases, that will include help with relocation to safer ground.

Our research also points to the choices we face: If the global community adheres to the primary goal of the Paris Agreement of capping warming below 2°C, and with limited loss of land-based ice, by the end of the century the United States could avoid losing residential properties that are currently valued at \$780 billion, contribute \$10 billion annually in property tax revenue, and house 4.1 million people.

IMPACTS OF SEA LEVEL RISE ON RAIL INFRASTRUCTURE

We also used our data and methodology to assess the risks of chronic flooding to Amtrak's Northeast corridor route between Boston and Washington, one of the most

²Interactive map, data and fact sheets for all coastal Congressional districts in the lower 48 states available here: <https://ucsusa.maps.arcgis.com/apps/MapJournal/index.html?appid=b53e9dd7a85a44488466e1a38de87601>.

heavily travelled rail routes in our nation. Our maps were used in a Bloomberg story on this subject, *Rising Waters Are Drowning Amtrak's Northeast Corridor*.³

Figure 5: Amtrak rail lines in Newark, NJ exposed to chronic flooding



Chronic flooding in the vicinity of Newark Liberty Airport in Newark, NJ, in 2060 (left) and 2100 (right). Chronically flooded areas are defined as flooding 26 times per year or more and are shown in orange. The Amtrak rail line, shown in black, cuts through the area exposed to chronic inundation highlighted by the green oval.

Many parts of the Northeast Corridor rail route are at risk of chronic flooding starting by 2060, including sections near Wilmington, Delaware, and throughout Connecticut, New Jersey, and New York (see figure 5). Current preparation efforts fall far short of these realities.

IMPACTS OF SEA LEVEL RISE ON U.S. MILITARY BASES

UCS has also analyzed the exposure of 18 military installations along the East and Gulf coasts to more frequent and extensive tidal flooding, land loss as some areas flood with daily high tides, and deeper and more extensive storm surge inundation.⁴ In the absence of preventive measures, these sites, including bases in Virginia, Georgia and Florida face major risks:

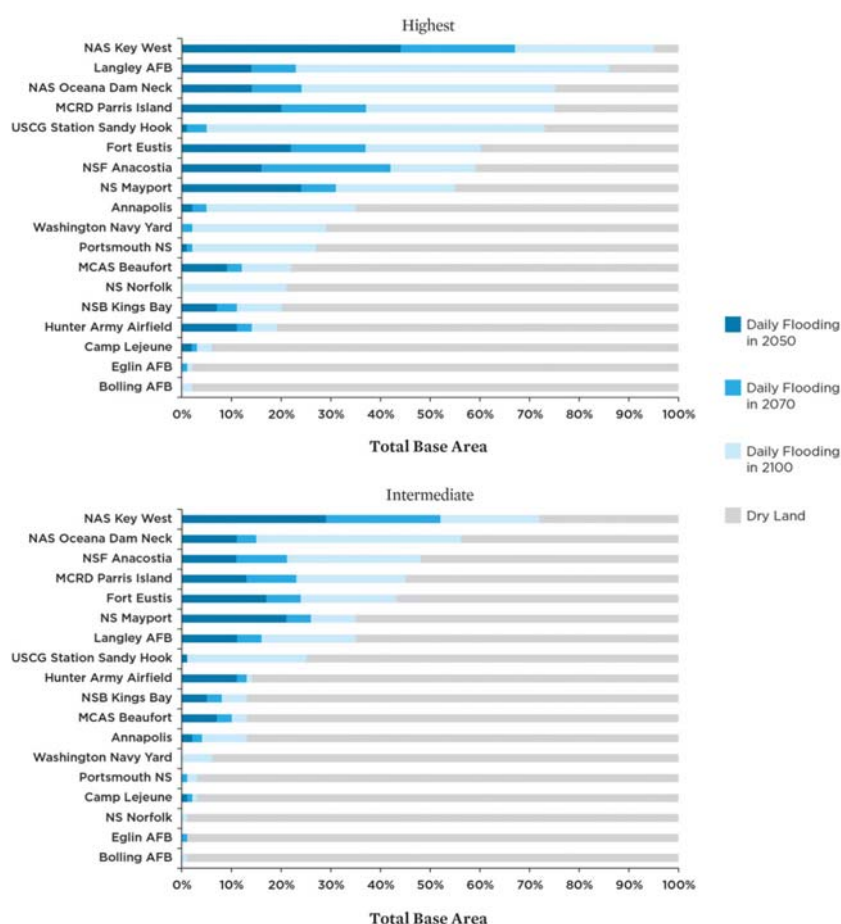
- By 2050, most of the installations we analyzed will see more than 10 times the number of floods they experience today.
- By 2070, half of the sites could experience 520 or more flood events annually—the equivalent of more than one flood daily.
- By 2100, eight bases are at risk of losing 25 percent to 50 percent or more of their land to rising seas.
- Four installations—Naval Air Station Key West, Joint Base Langley-Eustis, Dam Neck Annex, and Parris Island—are at risk of losing between 75 and 95 percent of their land by the end of this century (see figure 6).

³ <https://www.bloomberg.com/graphics/2018-amtrak-sea-level/>.

⁴ <https://www.ucsusa.org/global-warming/science-and-impacts/impacts/sea-level-rise-flooding-us-military-bases>.

Figure 6: US military bases exposed to chronic inundation and land loss

Land Loss across Bases



As high tide reaches farther inland, significant land loss is possible, in both the intermediate and highest scenarios, at many of the installations analyzed. Dark blue represents the percentage of total base area that floods with daily high tides in 2050; such land is conservatively considered a loss in this analysis. Medium blue represents the additional area that is inundated with high tide by 2070; light blue represents additional area inundated by 2100. Gray represents the percentage of the total base area that remains above the high tide line at the end of the century. Affected land can include developed and undeveloped areas and even wetlands that reside above the current high tide mark. This analysis finds that installations projected to see major land loss will also see substantial loss of currently developed and utilized areas.

© Union of Concerned Scientists 2016; www.ucsusa.org/MilitarySeasRising

FLOODING AND EXPOSURE TO TOXICS DURING HURRICANE HARVEY

Hurricane Harvey's unprecedented levels of rainfall—which scientists have linked to warmer air and oceans caused by climate change⁵—exact a huge toll on the

⁵ Risser, M.D. and M. F. Wehner. 2017. Attributable Human-Induced Changes in the Likelihood and Magnitude of the Observed Extreme Precipitation during Hurricane Harvey. *Geophysical Research Letters*. Volume 44, Issue 24 28 December 2017 Pages 12,457–12,464. <https://doi.org/10.1002/2017GL075888>. Trenberth, K. E., Cheng, L., Jacobs, P., Zhang, Y., & Fasullo, J.

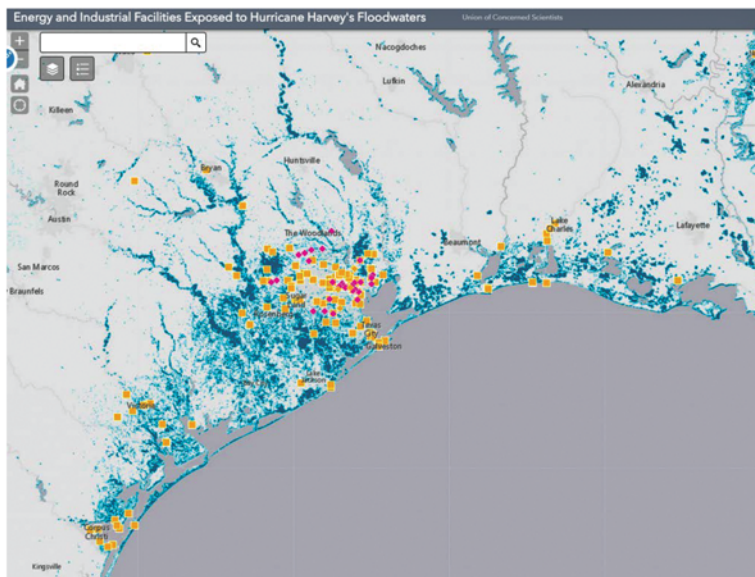
Continued

residents of Texas and Louisiana. In the wake of this storm, UCS analysis showed that more than 650 energy and industrial facilities may have been exposed to Hurricane Harvey's floodwaters.⁶

To highlight these facilities, the Union of Concerned Scientists developed an interactive tool showing affected sites. The tool relies on satellite data analyzed by the Dartmouth Flood Observatory to map the extent of Harvey's floodwaters, and facility-level data from the US Energy Information Administration and the Environmental Protection Agency.

The tool includes several types of energy infrastructure (refineries, LNG import/export and petroleum product terminals, power plants, and natural gas processing plants), as well as wastewater treatment plants and three types of chemical facilities identified by the EPA (Toxic Release Inventory sites, Risk Management Plan sites, and Superfund sites).

Figure 7: Chemical facilities potentially exposed to flooding from Hurricane Harvey



Hurricane Harvey may have exposed to flooding more than 160 of EPA's Toxic Release Inventory sites, 7 Superfund sites, and 30 facilities registered with EPA's Risk Management Program.

The Gulf Coast is home to a vast chemical industry. The EPA's Toxic Release Inventory (TRI) program lists over 4,500 facilities in Texas and Louisiana alone that are required to report chemical releases to the environment.

Before the storm hit, many facilities shut down preemptively, releasing toxic chemicals in the process. In the wake of the storm, explosions at Arkema's Crosby facility highlighted the risks that flooding and power failures pose to the region's chemical facilities and, by extension, the health of the surrounding population.

In the Houston area, low-income communities and communities of color are disproportionately exposed to toxic chemicals. Our analysis shows that over 160 TRI facilities, at least seven Superfund sites, and over 30 facilities registered with EPA's Risk Management Program were potentially exposed to floodwaters. The number of flooded Superfund sites may be even higher than the map shows, as indicated by preliminary reports from the EPA and other sources.

(2018). Hurricane Harvey links to ocean heat content and climate change adaptation. *Earth's Future*, 6. <https://doi.org/10.1029/2018EF000825>.

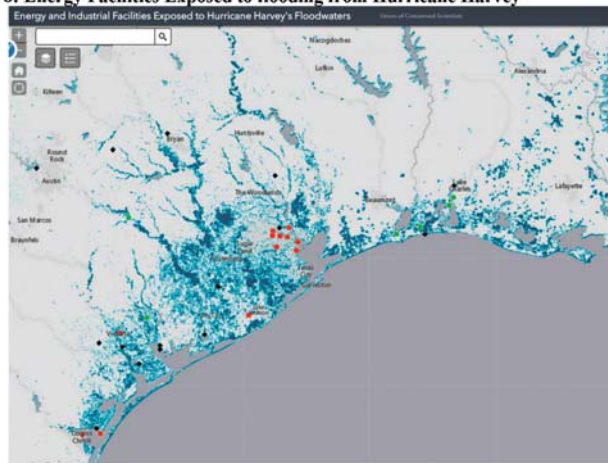
⁶<https://blog.ucsusa.org/kristy-dahl/flooded-by-hurricane-harvey-new-map-shows-energy-industrial-and-superfund-sites>.

Though most of the impacts from this exposure remain unknown, the risks include compromised facilities and the release of toxins into the air and receding floodwaters.

Energy infrastructure

In the week after Hurricane Harvey reached the Texas coast, disruptions to the region's energy infrastructure caused gas prices to rise nationally by more than 20 percent. Our analysis found that more than 40 energy facilities may have been exposed to flooding, potentially contributing to disruptions in operations.

Figure 8: Energy Facilities Exposed to flooding from Hurricane Harvey



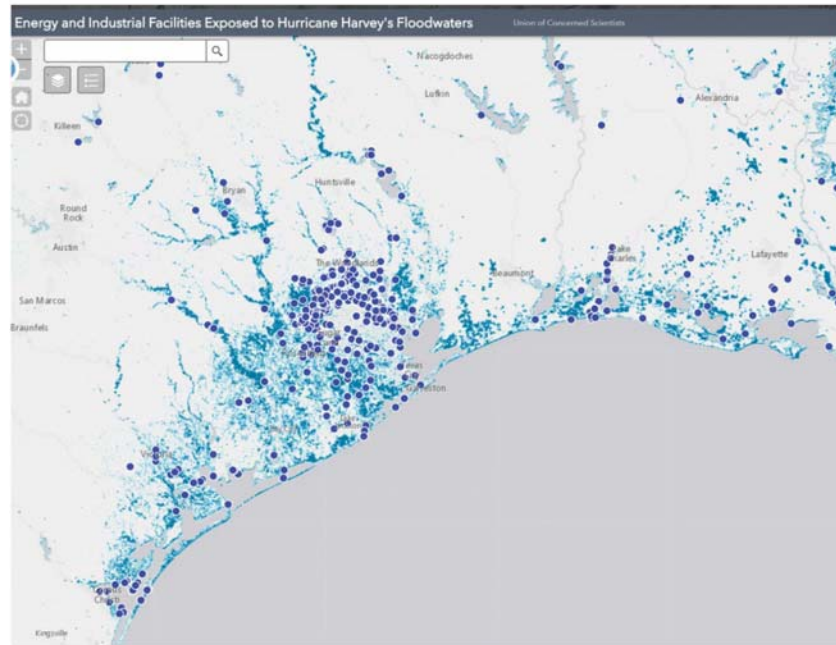
More than 40 energy facilities—including power plants and refineries—may have been exposed to Hurricane Harvey's floodwaters.

Wastewater treatment infrastructure

Wastewater treatment facilities comprised the bulk of the facilities (nearly 430) that we identified as potentially exposed to flooding. The EPA monitored the quality and functionality of water systems throughout the region and reported that more than half of the wastewater treatment plants in the area were fully operational as of September 3, roughly nine days after the storm made landfall.

With floodwaters widely reported as being contaminated with toxic chemicals and potent bacteria, wastewater treatment facilities were likely contending with both facility-level flooding and a heightened need to ensure the potability of treated water.

Figure 9: Wastewater Facilities Exposed to Flooding from Hurricane Harvey



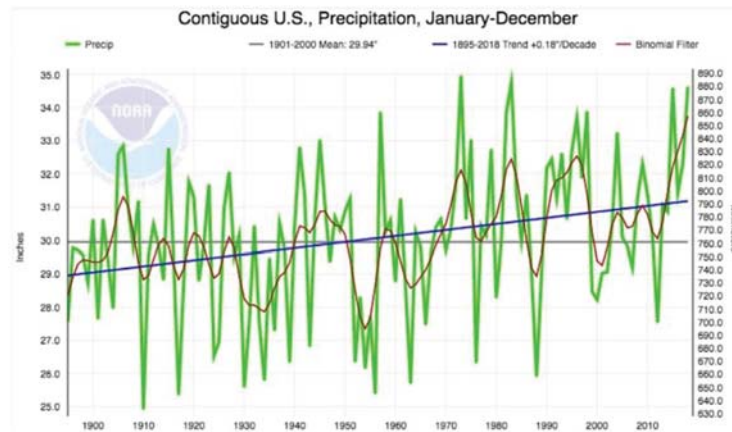
Nearly 430 wastewater treatment facilities may have been exposed to flooding during Hurricane Harvey.

GROWING RISKS FROM INLAND FLOODING

Climate change is also shifting rainfall patterns, making heavy rain heavier and more frequent in many areas of the country. With human alteration of the land—like the engineering of rivers, the destruction of natural protective systems, increased construction on floodplains, and increased area of impermeable surface—many parts of the United States are at greater risk of experiencing destructive and costly floods.⁷

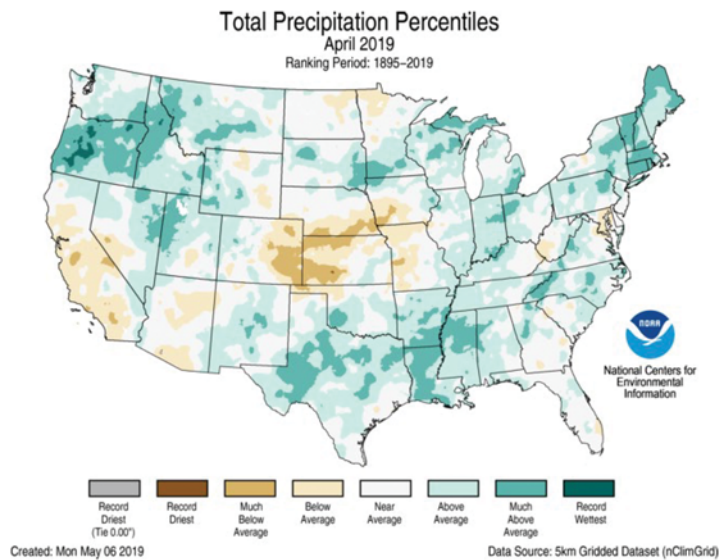
This spring alone has brought extended flooding to many parts of the country, including Louisiana, Texas, the Midwest and the central part of the country along the Mississippi and Missouri rivers. NOAA data confirm that (at the end of April 2019) the US has just experienced the wettest 12 months on record.

⁷ <https://www.ucsusa.org/sites/default/files/attach/2018/07/gw-fact-sheet-epif.pdf>.

Figure 10: Precipitation in the Contiguous U.S.

While there is considerable variability from year to year and from decade to decade, total annual precipitation for the contiguous US as a whole has increased since 1900.

(NOAA data via https://www.wunderground.com/cat6/Wettest-12-Months-US-History?cm_ven=cat6-widget)

Figure 11: April 2019 Precipitation Relative to a Historical Baseline

April 2019 capped the wettest 12-months on record for the contiguous US. Above normal precipitation and the subsequent flooding across the central US lead to widespread disruption of transportation by road and rail.

Source: NOAA⁸

This record-breaking flooding has washed out roads and bridges in many places, sometimes for days on end, making it difficult for people to travel safely to work and school.⁹ In Nebraska alone, the flooding caused an estimated \$100 million in damage to the state's highway system.¹⁰

Rail lines in Nebraska and Missouri were shut down for weeks.¹¹ Businesses that rely on safe and reliable transportation have also been affected.¹²

A growing body of evidence has linked specific extreme rainfall events to human-caused climate change. The record-breaking rainfall during Hurricane Harvey that brought devastating flooding to Houston, for example, was made about three (1.5–5) times more likely and around 15% (8–19%) more intense because of human-caused climate change.¹³ Human-caused climate change also made the devastating rains in Louisiana in 2016—in which more than two feet of rain fell in a two-day period—more likely. A study of that particular event concluded that such downpours are expected to occur 40 percent more often and be 10 percent more intense now than they were before the Industrial Revolution.¹⁴ Projections of future climate suggest that the frequency and intensity of extreme precipitation events will continue to increase across much of the United States in the coming decades.¹⁵

WATER, WASTEWATER AND SEPTIC SYSTEMS AT RISK FROM CLIMATE CHANGE

Rising sea levels and extreme storms are also making water, wastewater and septic tank systems more prone to damage or failure, including in coastal Florida, North Carolina, South Carolina and Maryland. Studies show that tidal flooding, storm surges, heavy rainfall, and saltwater intrusion pose risks to coastal infrastructure, human health and the environment, and efforts to address these challenges could cost billions of dollars.^{16,17,18,19}

⁸ <https://www.ncdc.noaa.gov/temp-and-precip/us-maps/1/201904#us-maps-select>.

⁹ https://www.washingtonpost.com/nation/2019/05/10/really-genuinely-scary-torrential-rain-houston-strands-cars-leaves-thousands-without-power/?utm_term=.9612e14621c9.

¹⁰ <https://kfor.com/2019/05/08/odot-several-highways-closed-due-to-flooding-across-the-state/>.
¹¹ <https://www.wxyz.com/getting-around-metro-detroit/flooding-across-metro-detroit-closes-several-roads-highways>.

¹² <https://dot.nebraska.gov/news-media/nebraska-flood-2019/>.

¹³ <https://www.grainnet.com/article/166508/transportation-impacts-of-midwest-flooding>.

¹⁴ <https://www.freightwaves.com/news/railroad/rail-volumes-drop-for-march-30>.

¹⁵ <https://www.mprnews.org/story/2019/04/21/flooding-roundup-communities-weary>.

¹⁶ van Oldenborgh, G.J., K. van der Wiel, A. Sebastian, R. Singh, J. Arrighi, F. Otto, K. Haustein, S. Li, G. Vecchi, and H. Cullen. 2017a. Attribution of extreme rainfall from Hurricane Harvey, August 2017. *Environmental Research Letters* 12(12):1–11. doi:10.1088/1748-9326/aa9ef2.

¹⁷ van der Weil, K., S.B. Kapnick, G.J. van Oldenborgh, K. Whan, S. Philip, G.A. Vecchi, R.K. Singh, J. Arrighi, and H. Cullen. 2017. Rapid attribution of the August 2016 flood-inducing extreme precipitation in south Louisiana to climate change. *Hydrol. Earth Syst. Sci.*, 21, 897–921. 2017 www.hydrol-earth-syst-sci.net/21/897/2017/ doi:10.5194/hess-21-897-2017. Online at <https://www.hydrol-earth-syst-sci.net/21/897/2017/hess-21-897-2017.pdf>.

¹⁸ Easterling, D.R., K.E. Kunkel, J.R. Arnold, T. Knutson, A.N. LeGrande, L.R. Leung, R.S. Vose, D.E. Waliser, and M.F. Wehner. 2017. Precipitation change in the United States. In *Climate science special report: Fourth national climate assessment, volume 1, fourth edition*, edited by D.J. Wuebbles, D.W. Fahey, K.A. Hibbard, D.J. Dokken, B.C. Stewart, and T.K. Maycock. Washington, DC: US Global Change Research Program, 207–230. doi:10.7930/J0H993CC.

¹⁹ Intergovernmental Panel on Climate Change (IPCC). 2012. Summary for policymakers. In *Managing the risks of extreme events and disasters to advance climate change adaptation: Summary for policymakers*, edited by C.B. Field, V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley. Cambridge, UK, 1–19. Online at http://www.ipcc.ch/pdf/special-reports/srex/SREX_FD_SPM_final.pdf.

²⁰ T.R. Allen, T. Crawford, B. Montz. 2018. Linking Water Infrastructure, Public Health, and Sea Level Rise: Integrated Assessment of Flood Resilience in Coastal Cities. *Public works management and policy*. Vol 24, Issue 1, 2019. <https://doi.org/10.1177/1087724X18798380>.

²¹ Septic systems vulnerable to sea level rise. November 2018. Final Report in support of Resolution No. R-911–16. By the Miami-Dade County Department of Regulatory & Economic Resources, Miami-Dade County Water and Sewer Department & Florida Department of Health in Miami-Dade County.

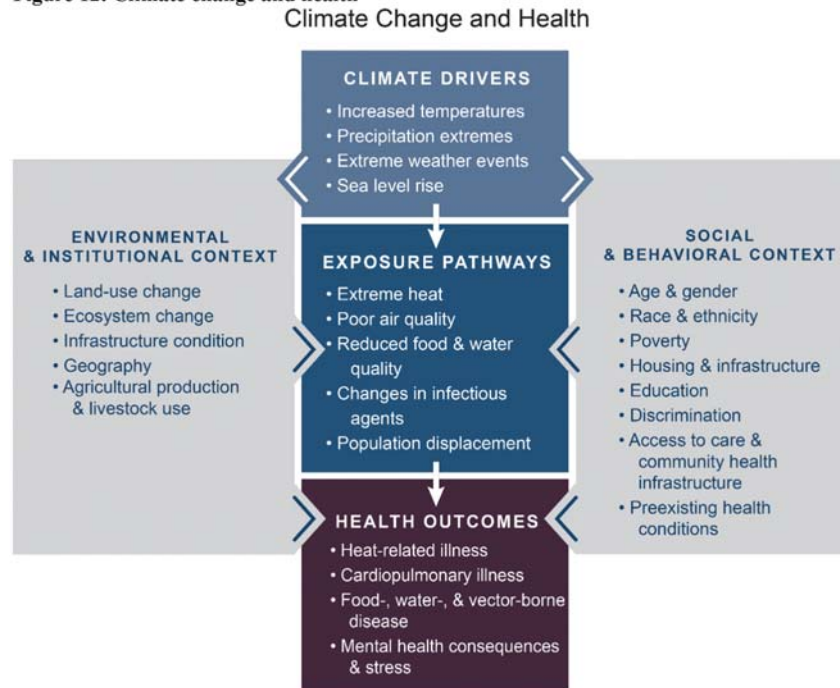
²² Mihaly, E. 2018. *Avoiding Septic Shock: How Climate Change Can Cause Septic System Failure and Whether New England States are Prepared*. *Ocean and Coastal Law Journal* Volume 23, Number 1 Article 2 January 2018. <https://digitalcommons.maine.gov/cgi/viewcontent.cgi?article=1359&context=oclj>

²³ Harris, A. A \$3 billion problem: Miami—Dade's septic tanks are already failing due to sea rise. *Miami Herald*, January 10, 2019. <https://www.miamiherald.com/news/local/environment/article224132115.html>.

PUBLIC HEALTH IMPACTS OF CLIMATE CHANGE

Climate change will have profound effects on human health. See Figure 8 for a conceptual diagram from the National Climate Assessment illustrating the exposure pathways by which climate change could effect human health.

Figure 12: Climate change and health



Source: <https://nca2018.globalchange.gov/chapter/14/>

Drawing from the National Climate Assessment, I highlight here some major health implications of climate change:²⁰

- *High temperatures in the summer are conclusively linked to an increased risk of a range of illnesses and death, particularly among older adults, pregnant women, and children.* Studies show that other vulnerable populations include low-income households especially those in urban areas, outdoor workers, athletes, those with pre-existing health conditions, the homeless and the incarcerated.²¹

- *Climate change is expected to alter the geographic range, seasonal distribution, and abundance of disease vectors, exposing more people in North America to ticks that carry Lyme disease or other bacterial and viral agents, and to mosquitoes that transmit West Nile, chikungunya, dengue, and Zika viruses.*

- *Increasing water temperatures associated with climate change are projected to alter the seasonality of growth and the geographic range of harmful algae and coastal pathogens, and runoff from more frequent and intense rainfall is projected to increasingly compromise recreational waters and sources of drinking water through increased introductions of pathogens and toxic algal blooms.* Research has shown that a combination of warming waters and increased rainfall bringing excess nutrients into freshwater lakes and rivers could lead to an increase in algal blooms that pose

²⁰ See Chapter 14: Human Health in the Fourth National Climate Assessment, and references therein. Online at <https://nca2018.globalchange.gov/chapter/14/>.

²¹ See Union of Concerned Scientists. 2018. Heat Waves and Climate Change: What the Science Tells us about extreme heat Events. Online at <https://www.ucsusa.org/sites/default/files/attach/2018/08/extreme-heat-science-fact-sheet.pdf>; Union of Concerned Scientists. 2018. Health Risks and Impacts of Extreme Heat. Online at <https://www.ucsusa.org/sites/default/files/attach/2018/08/extreme-heat-impacts-fact-sheet.pdf>.

threats to humans and marine life, as well as affect water supplies and recreational activities.²² In the summer of 2018, a massive algal bloom affected over 100 miles along the Gulf Coast in southwestern Florida, and the widespread release of associated neurotoxins led to massive die offs of fish and other marine species. Algal blooms have also affected the Great Lakes.²³

- *Projected increases in extreme precipitation and flooding, combined with inadequate water and sewer infrastructure, can contribute to viral and bacterial contamination from combined sewage overflows and a lack of access to potable drinking water, increasing exposure to pathogens that lead to gastrointestinal illness.*

- *Climate change, including rising temperatures and changes in some extreme weather and climate events, can adversely affect global and U.S. food security by, for example, threatening food safety (by altering exposures to certain pathogens and toxins), disrupting food availability, decreasing access to food, and increasing food prices. Food quality also is expected to be affected by rising CO2 concentrations that decrease dietary iron, zinc, protein, and other macro- and micronutrients in crops and seafood.*

- *Mental health consequences, ranging from minimal stress and distress symptoms to clinical disorders, such as anxiety, depression, post-traumatic stress, and suicidality, can result from exposures to short-lived or prolonged climate- or weather-related events and their health consequences. These mental health impacts can interact with other health, social, and environmental stressors to diminish an individual's well-being. Some groups are more vulnerable than others, including the elderly, pregnant women, people with preexisting mental illness, the economically disadvantaged, tribal and Indigenous communities, and first responders.*

Additionally, the Lancet Countdown on health and climate change provides an independent, global monitoring system dedicated to tracking the health dimensions of the impacts of, and the response to, climate change and includes a special brief for the United States.^{24,25}

RESPONDING TO CLIMATE CHANGE

The grave risks climate change poses to our nation require an urgent response from federal, state and local policymakers, as well as market actors, to help protect communities and build resilience. Important priorities for resilience include:

- The federal government must play a lead role in communicating risks to the public and incorporating those risks into its own policies and actions. Flood-risk disclosure in the marketplace is also vital to help individuals and businesses understand the risks to their investments and drive more resilient outcomes.

- We must fund post-disaster recovery adequately and in an expeditious way so that aid can flow to hard-hit communities quickly and equitably, and in a way that helps build resilience to future events.

- Post-disaster investments should be made with a view to reducing future risks through a range of protective measures, including home buyouts and investments in flood-proofing measures, particularly in low to middle income communities and as appropriate, a requirement for adequate insurance coverage.

- We have to get out ahead of risks and not just respond in the aftermath of disasters, by ramping up investments in FEMA's pre-disaster hazard mitigation grants—including the Building Resilient Infrastructure and Communities (BRIC) program²⁶—and flood mitigation assistance programs, and the community development block grant program administered by the US Department of Housing and

²² <https://www.climate.gov/news-features/event-tracker/harmful-algal-blooms-linger-parts-southern-florida-july-and-august-2018>. Chapra, S.C.; Boehlert, B.; Fant, C.; Bierman Jr., V.J.; Henderson, J.; Mills, D.; Mas, D.M.L.; Rennels, L.; Jantarasami, L.; Martinich, J.; Strzepek, K.M.; & Paerl, H.W. (2017). "Climate change impacts on harmful algal blooms in U.S. freshwaters: a screening level assessment." *Environmental Science and Technology* 51, 8933-8943 (2016). Paerl, Hans W., and Valerie J. Paul. "Climate change: Links to global expansion of harmful cyanobacteria." *Water res.* 46, 1349-1363 (2012).

²³ See, for example: https://www.washingtonpost.com/news/capital-weather-gang/wp/2018/08/14/how-climate-change-is-making-red-tide-algal-blooms-even-worse/?utm_term=.820a42b60d02.

²⁴ Watts, N. et al. 2018. The 2018 report of the Lancet Countdown on Health and Climate Change: Shaping the health of nations for centuries to come. Online at [https://www.thelancet.com/journals/lancet/article/PIIS0140-6736\(18\)32594-7/fulltext](https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(18)32594-7/fulltext).

²⁵ Lancet Countdown, 2018: 2018 Lancet Countdown on Health and Climate Change Brief for the United State of America. Salas RN, Knappenberger P, Hess JJ. Lancet Countdown U.S. Brief, London, United Kingdom, 32 pp Online at <http://www.lancetcountdown.org/media/1426/2018-lancet-countdown-policy-brief-usa.pdf>.

²⁶ Under the recently passed Disaster Recovery Reform Act (DRRA), this grant program will be funded through the Disaster Relief Fund as a six percent set aside from estimated disaster grant expenditures.

Urban Development (HUD). Research shows that every \$1 invested can save the nation \$6 in future disaster costs.²⁷

- The National Flood Insurance Program requires commonsense reforms to the program to ensure that it more effectively maps and communicates all types of current and future flood risks, protects and insures communities in an equitable way, and promotes better floodplain management.²⁸

- A robust federal flood risk management standard would help protect vital federally funded infrastructure, ensure wise use of taxpayer dollars, and set a valuable guidepost for communities.

- Federal, state and local resources will be necessary to cope with and prepare for the health impacts of climate change.

- Congress should set up a diverse and inclusive expert advisory body to provide guidance on infrastructure that not only accounts for climate change but historic injustices as well, by targeting investments in underserved and marginalized communities.²⁹

- Strengthened state and local building and zoning regulations—as well as coastal zone management regulations that protect wetlands, barrier islands, and other natural systems that reduce flood impacts—are needed to ensure flood-smart development

- Increased funding for voluntary home buyout programs administered by FEMA and HUD can also help homeowners move to safer locations. Communities in high-risk areas may also increasingly need relocation grants and technical assistance. Correspondingly, communities receiving an influx of new residents may need financial resources.

- Banks, insurers, real estate investors, developers, and other major financial actors in coastal areas should establish guidelines and standards to incorporate the risks of sea level rise in their business models, thus better serving the long-term economic interests of their clients.

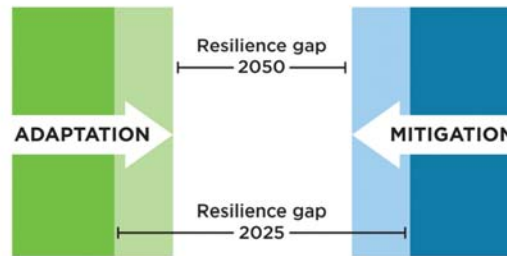
Most importantly, we must make deep cuts in heat-trapping emissions to contribute to global efforts to limit climate change. Adaptation is costly, and there are limits to how much change we can adapt to, so we need to do our utmost to also mitigate carbon emissions with the goal of limiting the resilience gap for communities (see figure 13). Transitioning to a low-carbon economy—by investing in renewable energy, energy efficiency and other low-and zero-carbon energy options—and reaching net zero carbon emissions by mid-century would not only help address climate change, it will deliver tremendous near-term public health and economic benefits.³⁰ Contributing to global efforts, including by helping developing countries make a low-carbon energy transition and cope with and build resilience to the impacts of climate change, is also vital.

²⁷ Multihazard Mitigation Council. 2018. Natural Hazard Mitigation Saves: 2018 Interim Report. Principal Investigator Porter, K.; co-Principal Investigators Scawthorn, C.; Huyck, C.; Investigators: Eguchi, R., Hu, Z.; Reeder, A; Schneider, P., Director, MMC. National Institute of Building Sciences, Washington, D.C. www.nibs.org.

²⁸ <https://blog.ucsusa.org/rachel-cleetus/congress-must-extend-and-reform-the-national-flood-insurance-program>.

²⁹ Union of Concerned Scientists. 2019. Building Equitable, Clean, and Climate-Safe Infrastructure. Online at <https://www.ucsusa.org/sites/default/files/attach/2019/03/climate-resilient-infrastructure-fact-sheet.pdf>.

³⁰ Watts, N. et al. 2018. The 2018 report of the Lancet Countdown on Health and Climate Change: Shaping the health of nations for centuries to come. Online at [https://www.thelancet.com/journals/lancet/article/PIIS0140-6736\(18\)32594-7/fulltext](https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(18)32594-7/fulltext).

Figure 13: Closing the Resilience Gap**The Resilience Gap**

The “resilience gap” represents the degree to which a community or nation is unprepared for damaging climate effects—and therefore the degree to which people will suffer from climate-related events. The arrows show the two ways to narrow the gap. We can adapt (left arrow) by preparing for climate impacts, and mitigate carbon emissions (right arrow) to slow the pace at which climate risks grow more severe or more common over time. The changing size of the resilience gap in 2025 versus 2050 conveys the potential for society’s resilience gap to be narrowed, though not eliminated, through concerted effort on both fronts.

© Union of Concerned Scientists 2016; www.ucsusa.org/Resilience_Principles

CLOSING

In closing, I am here today both as an expert who has studied these issues for a long time, and as a Mom. I have two young children who are 11 and 13 years old. Like many of you with young people in your lives, I am acutely aware that the choices we make today—choices that you in Congress are uniquely empowered to help make—will be deeply consequential to their future. I hope we will seize the opportunity to leave our children and grandchildren a world where they can prosper without fear of runaway climate change. Thank you for this opportunity to testify and for your leadership on climate action.

Ms. CASTOR. Thank you.

Mr. Hodges, you are recognized for 5 minutes.

STATEMENT OF KEITH HODGES

Mr. HODGES. Thank you.

Good morning, Chairwoman Castor, Ranking Member Graves, and members of the select committee. My name is Keith Hodges, and I represent the 98th District in the Virginia House of Delegates, located in the heart of Virginia’s rural coastal region. I also have the distinct pleasure of serving as the co-chair for the Virginia General Assembly Joint Commission on Coastal Flooding, and serve as a member of the General Assembly State Water Commission.

I am here today to paint a picture, a picture of the real impacts coastal flooding is having on our rural suburban and urban areas of the commonwealth. My constituents are already feeling the impacts. One of the smallest localities in my district and in the Commonwealth, Mathews County, has just 9,000 people, but has already suffered \$65 million loss of land value directly and indirectly

due to flooding. The loss of land impacts—not only impacts the property owners, but means less tax revenue is available for critical public services such as police, fire, and schools.

I will also outline the challenges we face in mitigating the effect of water, the layers of government regulations that stand in between property owners and their ability to protect themselves, and the innovative solutions being developed to address it; solutions that ultimately could be applied in any coastal region in the Nation.

We can all agree that the Commonwealth's signature water quality protection legislation, the Chesapeake Bay Preservation Act, dating back to the late 1980s, was needed and is responsible for the significant improvements that have made over time, the cleanup of our most important waterways on the East Coast.

A large portion of the Preservation Act regulated the riparian areas, generally where the tidal wetlands and the upland areas converge. It was written to protect the natural spaces around the waterways, preventing overdevelopment, and protecting water quality. That was on paper. But in reality, a great deal of those areas are peoples' yards. It is where peoples' lives are. It is where they grill out. It is their homes. It is their sense of place. That is where we are seeing the flooding. And that is where we are seeing layer upon layer of additional government regulations.

There is a disconnect between where the laws are, laws that prevents any sort of resiliency efforts being done, and where the people live. It is important to note here that many of these laws were intended to manage water running off from a higher elevation, the land, and into the lower elevation, the sea. It never realized that we could be facing water coming from a lower elevation to a higher elevation, bringing the river into people's yards. It doesn't make it right. It doesn't make it wrong. It is just reality.

We have identified 23 laws and regulations that protect water quality. While well intended, they are also holding us back. In the Commonwealth of Virginia, specifically in the rural coastal Virginia, we have been studying ways to both adhere to the spirit of the Preservation Act and other regulations and the goals to maintain water quality, while also helping property owners protect their homes, localities protect their tax base and promote resiliency.

It started with looking at legislation and regulations in a more wholistic and innovative way. We found ways to help property owners, residential and commercial, installing living shorelines, proven to help water quality, resiliency, and providing the funding and insurance to bring them to reality. We are building shorelines that are bigger, that are wider, and that are taller.

We have addressed storm water legislation and equalized the cost for developers building in rural versus urban areas. We have created ways through the Virginia Waterway Maintenance Fund to give localities more options to use dredge materials for resiliency efforts. We are looking at how to ensure risk more properly and creatively; that is, ensuring nature-based flood mitigation strategies.

And we are fighting the flood with a new campaign set to launch this year where we are bringing together a consumer need for solu-

tions with the marketplace. We are connecting them together and making it cheaper for property owners to protect themselves.

Perhaps most innovatively, we are also leveraging intellectual capital around the issue. Thanks to the GO Virginia legislation, we have funded a project to study ways to harness and focus that intellectual capital. Water goes everywhere. It doesn't discriminate whether you are rural, suburban, or urban. We have opted to look at it as an asset, not a liability. We are looking at it as a relationship versus something that is detrimental. We are reframing the way we approach water management.

When you reframe the way you approach water management, you can come at it from a more wholistic, economic perspective. You can create jobs and you can protect livelihoods. We are not sitting back and complaining about the problem. We are looking at it as something that is not going away. We are creating an opportunity. The opportunity requires us all to work together to address the challenges, to find the innovative solutions from here in Washington, to Richmond, and the localities where constituents live, where they work, and where they play.

Thank you for the opportunity to discuss this important issue here today and for helping us all see that working together will benefit us all. As they say, a rising tide lifts all ships.

Thank you, Madam Chair.

[The statement of Mr. Hodges follows:]

**Testimony of Delegate Keith Hodges
Virginia House of Delegates, 98th District
House Select Committee on the Climate Crisis
"Creating a Climate Resilient America"
May 23, 2019**

Good Morning Chairwoman Castor, Ranking Member Graves, and the members of the Select Committee. My name is Keith Hodges and I represent the 98th District, located in the heart of rural coastal Virginia, in the Virginia House of Delegates. I also have the distinct pleasure of serving as the Co-Chair for the Virginia General Assembly Joint Subcommittee on Coastal Flooding and serve as a member of the General Assembly State Water Commission.

I am here today to paint a picture of the real impacts coastal flooding is having on our rural, suburban and urban areas of the Commonwealth. My constituents are already feeling the impacts. One of the smallest localities in my district—Mathews County—has just 9,000 people but has already suffered a \$65 million dollar loss of land value directly and indirectly due to flooding. The loss of land value impacts not only property owners, but means less tax revenue is available for critical public services such as police, fire, and schools.

I will also outline the challenges we face in mitigating the effect of water, the layers of government regulations that stand in between property owners and their ability to protect themselves, and the innovative solutions being developed to address it—solutions that ultimately could be applied in any coastal region of the nation.

We can all agree that the Commonwealth's signature water quality protection legislation—the Chesapeake Bay Preservation Act, dating back to the late 1980s—was needed and is responsible for the significant improvements that have been made over time to the clean-up of our most important waterways on the East Coast.

A large part of the preservation part of the act regulated the riparian areas, generally where the tidal wetlands and the uplands converge.

It was written to protect the natural spaces around the waterways, preventing over development and protecting water quality.

That was on paper.

But in reality, a great deal of those areas are people's yards. It's where people's lives are. Where they grill out. It's their homes. Their sense of place.

That's where we're seeing flooding. And that's where we're seeing layers upon layers of additional government regulations.

There is a disconnect between where the laws are—laws that prevents any sort of resiliency efforts being done—and where people live.

It's important to note here, that many of these laws were intended to manage water running off from a higher elevation—land—and into a lower elevation—the sea. It never realized that we would be facing water coming from a lower elevation to a higher elevation—bringing the rivers into people's yards.

Doesn't make it right. Doesn't make it wrong. It's just reality.

But these 23 laws and regulations that protect water quality, while well intended, are also holding us back.

In the Commonwealth of Virginia—specifically in rural coastal Virginia—we have been studying ways to both adhere to the spirit of the Preservation Act and other regulations and the goals to maintain water quality, while also helping property owners protect their homes, localities protect their tax base and promote resiliency.

It's started with looking at legislation and regulations in a more holistic and innovative way.

We've found ways to help property owners—residential and commercial—install Living Shorelines, proven to help with water quality and resiliency, and provided the funding and insurance to bring them to reality. We're building shorelines that are more robust—bigger, wider, taller.

We've addressed stormwater legislation, and equalized the cost for developers building in rural vs urban areas.

We've created ways—through the Virginia Waterway Maintenance Fund—to give localities more options to use dredged materials for resiliency efforts.

We are looking at how you insure risk more properly, and creatively—that is, insuring nature based flood mitigation strategies.

And we are fighting the flood with a new campaign set to launch this year, where we are bringing together the consumer need for solutions with the marketplace. We're connecting them together and making it cheaper for property owners to protect themselves.

Perhaps most innovatively, we're also leveraging intellectual capital around this issue. Thanks to the Virginia Growth and Opportunity Fund, we have funded a project to study ways to harness and focus that intellectual capital.

Water goes everywhere.

It doesn't discriminate whether you are rural, suburban or urban.

We have opted to look at it as an asset, not a liability.

We are looking at it as a relationship verses something that is detrimental.

We are reframing the way we approach water management.

When you reframe the way you approach water management, you can come at it from a more holistic economic perspective. You can create jobs. You can protect livelihoods.

We're not sitting back and complaining about the problem.

We're looking at it as something that's not going away.

We're creating opportunity.

That opportunity requires us all to work together to address the challenges, to find the innovative solutions, from here in Washington, to Richmond and all the localities where our constituents live, work and play.

Thank you for the opportunity to discuss this important issue here today, and for helping us all see that working together will benefit us all.

As they say, a rising tide lifts all ships.

Ms. CASTOR. Thank you.

Mr. Russell, you are recognized for 5 minutes.

STATEMENT OF MATT RUSSELL

Mr. RUSSELL. Good morning. Chair Castor, Ranking Member Graves, members of the committee, thank you for the opportunity to talk about the opportunities and challenges for American farmers in our climate crisis. I am a fifth generation Iowa farmer, executive director of the Iowa Interfaith Power and Light, and we are an organization who works with Iowans to find and implement faith-based solutions to climate change. It is an honor to testify this morning on behalf of American farmers.

A partial solution to the global climate crisis is right in front of us, if we just have the courage to embrace it. This solution will also

help us clean our air and water, save our soils, stabilize our rural communities and our food system. That solution is to pay farmers for environmental services when we sequester carbon. Doing so will revolutionize both agriculture and environmental policy. These policies should no longer be in opposition. They should complement each other in strategic ways. Costs will be pennies per meal in the short run, but actually, this is not a cost at all. It is an investment in our children and grandchildren's future.

We can help solve global warming by unleashing the power of American farmers to solve problems. It is what we do. Regardless where you are in America, if you are a farmer, on a daily basis you solve problems. When the rain is coming and the hay is down and the bailer is broken, you are underneath of it fixing it. If you are in the orchard and you are dealing with disease, we solve problems.

The question today isn't do you believe in climate change. The question is, do you believe in American farmers, in our ability to innovate when confronted with major challenges. By including agriculture in this hearing, it is clear this committee wants to start investing in American farmers.

Paying farmers to capture carbon is an effective way to slow climate change and make our farmers more resilient to extreme weather. Carbon farming will also increase productivity, build soil, improve air and water quality, and increase economic opportunity in our rural communities.

At Iowa Interfaith Power and Light, we are gathering farmers in church basements to talk about climate action. These farmers are ready to help solve climate change. They point out the current combination of public policy and markets creates a situation where farmers investing in better conservation and stewardship actually carry a greater burden of risk than farmers who are willing to shortchange long-term stewardship for short-term profits.

In the face of these distorted policy and market signals, more and more farmers are ready to help tackle this climate crisis. Last century, the population bomb was the greatest challenge facing humanity. American farmers led the revolution that helped solve this problem. Our parents and grandparents partnered with researchers and agri-business to increase productivity that, not only delivered enough food, but lowered the cost of that food.

The green revolution not only prevented a global disaster, it unleashed global growth that dramatically increased the quality and length of life for every human all throughout the world.

We are at a similar pivotal moment in history. We are facing a catastrophic crisis. American farmers can again lead the world into a future that is even more abundant than our past. We have a mountain of research, powerful technological tools, and pioneering farmers across the country already starting to manage their farms to not only produce the goods the world demands, but to provide the environmental services this crisis requires.

To do this, we must partner with the rest of America to leverage smart public policy and develop effective markets to reward innovation on our farms. Here are some ways you can help farmers lead the next agricultural revolution.

Work with farmers to develop public policy that encourages farmer and market-led solutions to—for climate action. American farm-

ers, we are at our best when we yoke smart public policy and the power of capitalism. As the world begins to put a price on carbon, let's make sure American farmers can claim some of the value of what we do on our farms when providing climate change mitigation services.

Embrace the opportunities climate action holds for rural development. Rural America is where energy is produced and agricultural products are grown. Every farmer in every part of this country can benefit from helping solve the climate crisis.

Rethink the politics of climate. If resources remain focused on the politics, we all lose. But if we bring the very best Democratic ideas and the very best Republican ideas together, we can—our rural communities will be more resilient to extreme weather, can hold onto the value of capturing carbon, and can generate clean energy.

Everyone says we need bipartisan solutions; incentivizing farmers to lead on climate action is an opportunity to make that happen. Investing in American farmers is hands down one of the fastest and most effective ways for climate action.

Thank you for your time.

[The statement of Mr. Russell follows:]

Written Testimony of Matt Russell

Executive Director, Iowa Interfaith Power & Light

Hearing on “Creating a Climate Resilient America”

United States House Select Committee on the Climate Crisis

May 23, 2019

Chair Castor, Ranking Member Graves, and members of this committee, thank you for the opportunity to speak about the challenges and opportunities for American farmers in the midst of our climate crisis. As a 5th generation Iowa farmer, member of multiple farm organizations, and the executive director of Iowa Interfaith Power and Light, an organization working to help Iowans find and implement faith-based solutions to climate change, it's a tremendous honor and great responsibility to testify on behalf of American farmers.

A partial solution to the global climate crisis is right in front of us—we just have to have the courage to embrace it. This solution to rising CO2 levels will also help us clean our water and air, save our soils, and stabilize our food system and rural economies. That solution is to pay farmers for environmental services they render in building soil health and sequestering carbon. Doing so will revolutionize both agricultural and environmental policy. Unlike the current configuration, these policies should no longer be in opposition—they should complement each other in strategic ways. Costs will be pennies per meal for the short term—but actually, it isn't a cost at all. It's an investment. It's an investment in our children and grandchildren's future.

We must start believing in American farmers. We can solve global warming by unleashing the power of American farmers to solve problems. It's what we do on a daily basis. Regardless what we're producing on our own farms, we're all managing complex systems. We survive because we're masters at solving problems. The question today isn't “do you believe in climate change.” The question is do you believe in American farmers and their ability to innovate when confronted with major challenges?

This committee is answering that question with a profound yes! By the very nature of including agriculture in this hearing, it's clear this committee wants to start investing in and empowering American farmers.

On American farms, being more resilient to extreme weather and mitigating global warming by reducing greenhouse gas pollution and capturing carbon, can be the same thing, two sides of the same coin. Paying farmers to capture carbon, to develop carbon farming, is an effective way to slow climate change and make our farms more resilient to increasingly extreme weather.

Carbon farming can increase productivity, build soil, improve air and water quality, and increase economic opportunities in our rural communities. This committee can help American farmers lead on climate action and to work with us to develop the incentives that reward us when we do.

At Iowa Interfaith Power and Light, we're gathering farmers in church basements to talk about how their faith calls them to embrace climate action on their farms. These farmers, mostly conventional commodity and livestock farmers, are ready to act on climate change. They point out the current combination of public policy and markets creates a situation where farmers investing in better conservation and environmental stewardship carry a greater burden of risk than farmers who are willing to shortchange long term stewardship for short term profit. Despite these current distorted policy and market signals, and contrary to conventional wisdom, we're proving more and more farmers are ready to help solve this climate crisis. We farmers recognize that like our parents and grandparents before us, we must innovate on our farms to provide what the world demands.

Last century, the population bomb was one of the greatest challenges facing humanity. American farmers led the revolution that helped solve this problem. Our parents and grandparents innovated and partnered with researchers and agri-business to unleash increased productivity that not only delivered enough food, but lowered the cost of that food. The Green Revolution not only prevented a global disaster, it unleashed global growth that dramatically increased the quality and length of human life touching every corner of the world.

We're at a similar, pivotal moment in human history. We are facing a catastrophic crisis; the greatest crisis humans have ever faced. American farmers can again lead the world through this crisis and into a future that is even more abundant than our past. We have a mountain of scientific research, powerful technological tools, and pioneering and innovative farmers across the country already starting to manage their farms to not only produce the goods the world demands, but to provide the environmental services this crisis requires.

There are no silver bullets for adapting to or mitigating climate change. American farmers understand complex systems and how to produce multiple benefits. We're ready to embrace the call to innovate on our farms to not only capture carbon and reduce emissions but to also increase productivity, build soil, improve air and water quality, and increase economic opportunities in our rural communities. What's missing is the call for our leadership and an investment in our innovation. That's what this committee can do. Call American farmers to lead on climate action and to work with us to develop the incentives that reward us when we do. If American farmers are going to lead the next agricultural revolution, we must partner with the rest of America to leverage smart public policy and develop effective markets to reward innovation on our farms.

As a committee, here are some ways you can help farmers and rural Americans lead the next agricultural revolution.

Work with farmers to develop smart public policy for farmer and market led climate action. American farmers are at our best when we yoke smart public policy with the power of capitalism. As the world begins to put a price on carbon, let's make sure American farmers can claim some of the value of what we do on our farms when providing climate change mitigation services.

Embrace the opportunities climate action holds for rural development. One of the greatest strengths of American agriculture is that it's still made up of families managing small businesses. One reason American agriculture can move faster and more effectively than agriculture in some other parts of the world, is that the vast majority of land is still owned by individual Americans. Help unleash the power of capitalism to reward these entrepreneurs for developing the small businesses that can help defeat the climate crisis. Every farmer and every rural landowner in every state in the country can potentially benefit from helping solve the climate crisis. Rural America is where energy is generated and agricultural products are grown. That won't change as we transition into a clean energy economy. Let's make sure we empower farmers and rural Americans to reap the rewards as we make this transition.

Rethink the politics of climate action. If resources remain focused on the politics, we all lose. But if we encourage farmers and rural Americans to bring the very best Democratic ideas and the very best Republican ideas together, our rural communities will be more resilient to extreme weather and can hold onto the value of capturing carbon. Everyone says we need bipartisan solutions. Incentivizing farmers and rural communities to lead on climate action is an opportunity to make that happen.

The things farmers need to do to adapt to extreme weather are the very same things they need to do to develop carbon farming to help mitigate the climate crisis.

The world has a limited time for climate action. America has to invest in expedient and cost-effective efforts to reduce emissions and capture carbon. Investing in American farmers is hands down one of the fastest and most effective ways for climate action. No other group of Americans is more threatened by climate change than farmers and at the same time more capable of providing solutions to help solve this climate crisis. We need your courage, and your leadership to fashion climate legislation that includes a robust section to pay farmers for performance-based agriculture and ecosystem services. American farmers, rural communities, our country, and the entire world is depending on your leadership.

Ms. CASTOR. Well, thanks to all of our witnesses for your very compelling testimony.

I recognize myself for 5 minutes for questions.

Well, Mr. Russell, you caught my attention when you were talking about the dual benefits of climate action when it comes to our farmers across this country. And you highlighted some ways that we can reduce carbon pollution while supporting our agricultural economy, dual benefits, because we don't have time to go backwards. And we have to do these things, yes, in the short term, because while America, we have made progress on reducing carbon pollution, unfortunately, in 2018 our emissions went up. And as we have heard in our previous hearing, the U.S. and the world need to achieve net zero carbon emissions by 2050 to avoid catastrophic climate impacts.

So get a little more specific even than what you highlighted there at the end of your testimony on what we can do to encourage, incentivize farmers to help us reduce carbon pollution. And then talk about how this translates to American consumers and our food system here in the United States.

Mr. RUSSELL. Yeah. I will try to be brief in a general overview. Essentially, in the fossil fuel economy, we have used fossil fuels to do amazing things, and the green revolution was one of those. And we have used that to kind of force nature to do some particular things, and that was very successful. But in this new economy that we are moving into as a response to climate change, we have to think about how we farm differently.

So instead of forcing nature to do particular things, we have to work with nature to come up with the benefits that we need. And this doesn't mean throwing out our agriculture systems. It means leaning into what we already have. So we have the policy tools to do this. Our farmers understand this and are already trying to—and our land grant universities are diving into this. But we have to unleash the power for them to do that and signal to them that we are going to support this more. Essentially, it means taking agricultural systems and stacking a number of environmental services.

There are really five things that farmers can do across the country. It doesn't matter what kind of farm you are on. It is conservation tillage. How do we till the land as least as possible? Permaculture, how do we have something growing all the time? Cover crops is a big thing in the Midwest, is a category there. Integrating livestock into our agricultural systems. Managed grazing is a big piece of that, but it is all kinds of integrating, pork, poultry, dairy, all the livestock. How do we integrate that so that we are increasing the biological activity in the soil. We need to extend our crop rotations. So we have to add new crops into the mix.

I think I got all four of them there. And the fifth thing then is renewable energy.

And so when you stack all of those things together, it makes our rural economy, our farmers more resilient to the extreme weather, because soils can hold water when it rains and have water stored when it is dry. But it also then captures carbon and provides a service. So we can't do one or the other—I mean, we can, but we are not going to get the benefits. We do it at the same time, and we incentivize farmers and we partner with the research scientists. We can lead this like no other place on the planet. And if we don't, other farm—other agricultural systems in other parts of the world are going to do this in the next decade. It is ours to lose if we don't.

Ms. CASTOR. Thank you very much.

Dr. Cleetus, the Union of Concerned Scientists has done fantastic work on measuring the impacts of climate on our coastal communities. I am very sensitive to this, representing a coastal district in Florida. And I see the cost burden going up and up and up for the folks I represent in my State, whether it is flood insurance, property insurance, what local communities are having to do with fixing storm water and wastewater. I mean, the list goes on and on.

But I want to shift here. One of the things we don't talk about are the rising costs relating to public health due to climate. Could you go into greater detail there on solutions for us moving forward?

Ms. CLEETUS. Sure. As I mentioned, the National Climate Assessment has pointed out the multiple ways in which climate change is already affecting health and will do so in the future. To take just one example, extreme heat events, which are getting worse, and they are now affecting parts of country that weren't affected before.

So what is really important in this moment is, first of all, that we need to understand what the climate trends are already showing and what the risks are coming our way. We need to identify vulnerable populations. I mentioned several in my testimony, including the elderly, the very young, people with preexisting medical conditions, outdoor workers, homeless people, incarcerated people, first responders. We need to identify these vulnerable populations and where they are in the country and make sure that we have got early warning systems in place, that our healthcare systems have the resources to deal with the consequences of these extreme events and the health outcomes that they will have.

That means actually having a holistic picture. We are dealing with climate change, but we are also talking about healthcare systems, and doing these things together, mainstreaming climate resilience across the board is the call of the hour.

We need better coordination from the Federal to the local level, Health and Human Services, CDC, EPA, NOAA, agencies working together at the Federal level helping at the local level. We have also got to understand that in some of these coastal places, we will have displaced population—

Ms. CASTOR. I may need you to continue when you are answering another question, because I have got to recognize the ranking member for 5 minutes.

Ms. CLEETUS. Sure.

Mr. GRAVES. Thank you.

I want to thank you again for your testimony.

Mr. Russell, fifth generation farmer. Certainly, lots of history there. Would you agree that over those generations with improvements in fertilizers and other techniques, that there has been an increase in yield per acre of different agricultural products?

Mr. RUSSELL. Absolutely. That is why I was talking about the green revolution. We did that immensely.

Mr. GRAVES. And which has helped out the United States, but countries all over the world. And so what is your—your recommendation is, which I think makes a lot of sense, is to basically incentivize farmers to innovate to help improve sort of the biogenic environment or the natural environment's ability to sync. And Delegate Hodges actually mentioned the engineered oyster reefs, which is another sink for greenhouse gases.

There is a tax provision that was included called 45Q that does provide a tax credit under certain circumstances for carbon sequestration. And, basically, what you are saying is that should also apply to farmers and to incentivize them to carry out practices that does increase the uptake of greenhouse gases or sequestration. Is that—

Mr. RUSSELL. Yeah. And I am not extremely familiar with that tax credit, but that is exactly the type of solutions that we need for farmers to have access to.

Mr. GRAVES. That is great. And I think that there is a role for incentivizing, again, the biogenic environment, whether it be through farmers or finding other techniques, but also recognizing that the use of fertilizers, which is very natural gas heavy, there is a complementary relationship. You can find ways to sink while still increasing yield and you kind of get a win-win.

Dr. Diffenbaugh—did I get that right? Thank you.—I want to make sure that I understand a few things. Number one, based on earlier opening statement and comments from previous expert witnesses, you do agree that there is momentum built up in the greenhouse gas concentrations to where if we cut all emissions from the United States today, we would still see increases in temperature and sea rise and things along those lines?

Mr. DIFFENBAUGH. Yeah. I actually published a paper in 2012 running exactly that thought experiment of what if, not only the U.S., but all of the OECD countries, cut emissions instantaneously.

Mr. GRAVES. So there is no regrets for us carrying out resiliency activities right now. I mean, those are things that no matter what we do with our emissions profile, those are no regrets investments in helping to improve the resiliency of our coastal communities and communities all over the United States. Is that accurate?

Mr. DIFFENBAUGH. Yes. I think there are two key points. One is that resilience can be a win-win, as we have heard throughout the morning, that there are opportunities both to manage climate risks, both by managing our greenhouse gas trajectory and by becoming—catching up with the climate change that is already happened and becoming more prepared for the climate change that will happen in the future.

Mr. GRAVES. So if you look back between 2005 and 2017, the United States has reduced emissions by somewhere just under 1 gigaton; whereas during a similar period of time, and I think mov-

ing forward toward—during a similar period of time, I think, and I need to go back and check this, but I think China increased their emissions by, I want to say, maybe four or five times what the U.S. reduced theirs by. Under Paris, by 2030, they are expected to increase another 5 gigatons.

So the U.S. is taking these aggressive efforts to cut emissions while other countries are increasing emissions multiple times, we are not headed in the right direction, are we, in regard to trying to head off this mitigation challenge that we are experiencing, meaning that we are going to end up with net temperature increases, with net sea rise, and things along those lines, if the U.S. is reducing and other countries are significantly increasing emissions? Is that accurate?

Mr. DIFFENBAUGH. So we know because of the fundamental physics of planet Earth, the basic energy balance of planet Earth, that in order to stabilize the global temperature at any level, that essentially requires reaching net zero emissions. And as was mentioned earlier, reaching net zero by mid century gives about a 50 percent chance of staying below 2 degrees C.

Mr. GRAVES. Net zero means everybody, though, is my point; is that we can't just come to the United States and stop all emissions and have other countries more than offset the emissions we are reducing by increasing their emissions and having any type of environmental—positive environmental outcome.

Mr. DIFFENBAUGH. So net zero is a global requirement for the global energy balance. It is important to keep in mind that we have had about 1 degree Celsius of global warming already. The U.S. has contributed about a quarter of the emissions that have, you know, led to that warming historically. And, in fact—

Mr. GRAVES. But if China is increasing fivefold what we are reducing, where—

Mr. DIFFENBAUGH. But if we look—if we look at the total—if we look at the total cumulative emissions historically, the U.S.—

Mr. GRAVES. Is there something we can do about historic emissions or can we only do things about prospective emissions? We can carry out some of the activities, like Mr. Russell indicated and Delegate Hodges indicated, to sequester carbon, but in terms of—we can't do things about—otherwise about emissions that have already been released. We have got to look forward.

So having China on a trajectory of quadrupling what we are reducing isn't the right direction that we need to be heading in.

Mr. DIFFENBAUGH. So we are dealing now with the emissions that have already been released in that we are paying out year after year in the cost of climate change that we are living with right now. And as I said in my opening statement, we have opportunities to manage those risks by simultaneously managing our emissions and increasing our resilience.

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

Mr. LUJÁN. Thank you very much, Madam Chair. And I want to thank our chair and our ranking member for holding this hearing.

Dr. Diffenbaugh, yes or no, should the United States take action to reduce emissions?

Mr. DIFFENBAUGH. The question of should is a question for elected officials such as yourself.

Mr. LUJÁN. Dr. Diffenbaugh, must the United States take action to reduce emissions?

Mr. DIFFENBAUGH. In order to stabilize the global temperature, the global——

Mr. LUJÁN. That is not a yes or no.

Let's move on to the next one. I will submit it to you in writing, that way we can get a thorough response.

Dr. Cleetus, should the United States take action to reduce emissions?

Ms. CLEETUS. Yes. As part of the global effort to limit climate change, the United States and the——

Mr. LUJÁN. Yes or no is fine. Thank you.

Delegate Hodges, yes or no, should the United States take action to reduce emissions?

Mr. HODGES. In a market-based approach.

Mr. LUJÁN. Is that a yes?

Mr. HODGES. Yes. In a market-based approach.

Mr. LUJÁN. At least you qualified it, but that is a yes. I appreciate that.

Mr. Russell, should the United States take action to reduce emissions?

Mr. RUSSELL. Absolutely.

Mr. LUJÁN. I was getting lost on that last exchange of should we or shouldn't we or where should we go. I think that we must take action on resiliency and that the United States must take immediate action to reduce emissions. The two go hand in hand. If any of you are concerned about rising sea levels, it is not just about the action we take now; it is about the actions we take forward. This is not a complicated question. And so I hope that that provides a little bit of content and context to at least where I stand on the issue. I appreciate the testimony today.

In New Mexico, we are experiencing extreme weather as a result of climate change as well. For generations, summer monsoons and winter snowpack provided New Mexico communities with the water they needed to thrive, even during times of drought.

This last year, we had a flood in Santa Fe, New Mexico, that some described as a 1,000-year episode. The year before, a flood that was described as a 500-year episode. And when we talk about the importance of resiliency, and also for all my colleagues that represent coastal communities, there weren't programs to help those families that experienced those episodes as well.

I think that as we talk about resiliency and making sure that we are able to work with families, that we take into consideration areas like New Mexico, where we sit in the high desert and are drought-prone, where wildfire may be more likely than a flood, but 2 years in a row of 500-year and 1,000-year episodes are very concerning.

To Mr. Russell, you said that every farmer in every part of the country should have access to these programs. Does that include farmers who maybe farm on an acre or two?

Mr. RUSSELL. Yeah. To be clear, when we are bringing farmers into basements in churches and we are leading with what is your faith calling you to respond with your farm, most of those farms are conventional commodity and livestock farms, 6,000, 6,500 acres.

But we have had a few farmers in that room that do have like a couple of acres of produce. So that is the mix in Iowa. But it is in every part of this country.

If you are managing your farm so that at the end of the day—or at end of the year you have a net balance of less—like more carbon on your farm and less emissions, your balance is negative, we as taxpayers should be paying you for those services because that is what the world is demanding. And so every farmer in the country is going to manage their own system with that metric.

Mr. LUJÁN. Mr. Russell, let me ask the question a little differently. In Iowa, you have some of the largest farms in America.

Mr. RUSSELL. Yeah.

Mr. LUJÁN. There are a lot of programs that help the largest producers in the country where most food is produced. You also have farmers that raise in a basement or on an acre of land. Should those farmers that raise crops in their basement or, in my case, in New Mexico, most farmers raise crops on an acre of land, should those farmers also be included in the programs as we talk about the goals associated with carbon capture and what farmers can achieve?

Mr. RUSSELL. Right now, a lot of our programs are practice based. So if you follow the—we need to shift to a performance base, so if on my farm I can show, it doesn't matter what size my farm is, that I am delivering, I should qualify.

Mr. LUJÁN. I am interpreting that as a yes.

Mr. RUSSELL. Absolutely, yes.

Mr. LUJÁN. Just a straight answer. We have only got 5 minutes here.

Dr. Diffenbaugh, does the Stanford Woods Institute for the Environment have any papers that you published on the importance of reducing emissions in America, even though you are here in your personal capacity?

Mr. DIFFENBAUGH. I have published a number of papers quantifying the differential impacts at different levels of emissions.

Mr. LUJÁN. And do any of those documents include the need to call for action on reducing emissions?

Mr. DIFFENBAUGH. I am unaware in my peer-reviewed scientific writings or in my public op-ed writings of any time in which I have stated that—

Mr. LUJÁN. I will go back and read them.

Thank you, Madam Chair. I yield back.

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

Mr. PALMER. Thank you, Madam Chairman.

Just to clarify the record, we are not suggesting that the United States not reduce its carbon emissions. We are leading the world in that area. The fact of the matter is, and some of you may disagree—Madam Chairman, the clock is not on, not that I don't mind talking as long as I can—

Ms. CASTOR. Got it.

Mr. PALMER. All right. Time change.

What was my point? Oh, that we are leading the world in reducing carbon emissions. There are also other factors that impact the weather. I mean, I know you are all expert scientists, but what

about the shift in the magnetic poles and the potential for impacting weather. Anyone want to comment on that? Probably not.

Mr. RUSSELL. No, I am happy to comment on that.

Mr. PALMER. Alright.

Mr. RUSSELL. I mean, we have seen across the State talking to farmers over the last decade, 15 years, that—you know, we first started talking about extreme weather, we wouldn't talk about climate change, but we talked about extreme weather. And then we came up with a lot of natural cycles to lean into. And we are now believing increasingly that those natural cycles exist, but that something else is happening that is really radically different. And we are ready to start leaning into fixing those things we can fix. We can't fix the magnetic field, but we can fix carbon, and it does have a profound effect on our farms.

Mr. PALMER. Well, I am glad you mentioned the natural cycles, because I think it is becoming more and more apparent that natural variation is having a greater impact on climate change than carbon emissions. That doesn't mean that carbon emissions don't have an impact. They do, they certainly do.

But in terms of resiliency, and I thought that is what we were here to talk about, adaptation and mitigation, we need to be preparing for what we know we cannot stop. I mean, they shut down the Tampa airport not too long ago because of the shift in the magnetic fields, and they are shifting at an unprecedented rate. I think it is, like, 30 miles per day. You have that, combined with the solar activity, and our magnetic fields protect the Earth from those cosmic rays which impact our weather, as do ocean currents, changes in ocean currents. And we need to be focused on how do we protect ourselves from that.

These events will cause sea level rise. We heard someone mention 500-year floods, 1,000-year floods. There is a reason we talk about 500-year floods and 1,000-year floods, is that we have had massive floods throughout the history of the world. Climate has a history.

So I think when you talk about this, if you put all of your focus just on reducing carbon emissions and we don't take into account these other events that are taking place, we are going to find ourselves in a really bad place.

You want to comment on that, Doctor.

Mr. DIFFENBAUGH. Yeah. So I think, as you may have gathered from my recent exchange with Congressman Luján, I am pretty conservative in my statements. In this question of whether the contribution of natural variability, the contribution of solar forcing, the contribution of human forcing, my work is extremely conservative. The work in my community is extremely conservative. Our null hypothesis is that when an extreme event happens, it was due to random chance and that global warming had no role. We are extremely conservative, both in terms of our intellectual framework and in terms of our statistical treatment.

So our statistical treatment is beyond a reasonable doubt, statistically, and we need very, very, very high confidence in order to reject a null hypothesis that it wasn't—the null hypothesis being that it was random chance.

It is very difficult to move us off of that position, and the reality is that even with that level of conservatism, we still find that for severe heat events, as I mentioned earlier, more than 75 percent of North America, the scales have already been tipped towards record-breaking heat events, record-breaking wet events, at half of North America, record-breaking dry events. And that is even within the framework of being extremely conservative.

Mr. PALMER. I find that interesting. You are in California, right?

Mr. DIFFENBAUGH. Correct.

Mr. PALMER. And our temperature records only go back so far, but yet we have record evidence of major droughts that far exceed the droughts that California has experienced in the last 75 to 100 years. The same thing of the southwestern part of the United States. And again, climate has a history. And my point is, is that we know that climate is changing. It always changes. We are in an interglacial period.

Mr. DIFFENBAUGH. So for California, there have been—and the broader western U.S.—there have been many, many, many studies analyzing, not only the instrumental record that goes back around a century, but these geologic proxy records that you are mentioning. And, in fact, the California drought actually was an unprecedented event in those proxy records that we have available to us, in terms of the combination of low precipitation and high temperature.

Mr. PALMER. Just one last point. In terms of mitigation/adaptation, California had the opportunity to expand their reservoirs and didn't, and you got about 40 million people using water, which I think really makes a drought situation much more difficult.

I thank you, Madam Chairman. I yield back.

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

Ms. BROWNLEY. Thank you, Madam Chair.

Dr. Diffenbaugh, I wanted to also ask you, you talked about wildfires in California. I am from California. I represent Ventura County. Over the last 14 months, the entire county has burned through two very significant fires, Thomas Fire and Woolsey Fire. If we do nothing, everything stays the same and we move forward. Can you describe what wildfires look like if nothing changes?

Mr. DIFFENBAUGH. Yes. We have very strong evidence that global warming has already increased the risk of wildfire in the western United States. And, in fact, about half of the increase in area burned has been attributed to that drying of the vegetation from the rising temperature. And we certainly are seeing, as you know very, very well, and your constituents, clearly, sadly know very well, we are experiencing the impacts of that global warming that has already happened. We also have very strong evidence that if emissions continue, we will continue to experience intensification of that wildfire risk.

Ms. BROWNLEY. Does that mean more fires, more frequent fires? What does that mean exactly?

Mr. DIFFENBAUGH. Well, so I think we can expect continuation of the trends in areas burned. So what we are hearing very clearly from Cal Fire is that, one, they no longer consider there to be a wildfire season. It is a year-round phenomenon. Two, they are experiencing fires that expand faster and are more difficult to control.

And those are key contributors to the increase in the area burned. Three, the—because of the elevated risk across the State and across the region, our old systems of deployment, the planning, the resource allocation throughout the year and in different geographic regions is no longer durable. And we certainly saw that very tragically this last autumn season where having both, you know, those severe fires in both northern California and southern California simultaneously that late in the year made it, frankly, impossible to contain those fires until they were very, very large.

So I think that we have very strong evidence that, at a minimum, we can expect continuation of the recent trends, which have been very steep. And, you know, our current research is focused on understanding whether there could be processes that accelerate those trends even further.

Ms. BROWNLEY. Thank you.

Dr. Cleetus, you talked about, in your testimony, with regards to coastal flooding will exacerbate income inequality. If you could talk a little bit more about that.

Ms. CLEETUS. Well, as I pointed out, our research is showing there is a lot of coastal property at risk from chronic flooding, but it is not just property, right. There is a lot of things in the way, including infrastructure, critical infrastructure that people depend on. For many people, their home is their single biggest asset, and this matters even more for low-income and fixed-income folks if they lose property. Local property tax bases getting eroded has a tremendous effect on the ability to fund local services that people depend on, emergency services, social services.

So there is a spiraling effect. As properties get affected, other things start to—the domino effect starts to play in. And in some places, like in coastal Louisiana and Maryland, many people are going to be displaced by this flooding. They already are being displaced as land gets lost. So especially for low-income folks, communities of color that have had historic burdens, this means that the effect will be even more magnified on them.

Ms. BROWNLEY. I have a very large Naval base in my district, it is coastal, very important to our national security. Could you speak to impacts on national security?

Ms. CLEETUS. Absolutely. Our research is showing that there are a lot of military installations around the country that are at risk from flooding, coastal installations. And we know that the U.S. military takes this threat seriously. They understand that, both here in the U.S. and around the world, their mission critical readiness depends on preparing for these impacts. For example, naval station Norfolk is doing a lot to help prepare for these impacts. We have seen reports from DOD on climate resilience. They are also investing heavily in renewable energy, because they understand that that is also critical for their mission.

And the community surrounding the bases are also being affected. And we have seen that with the hurricanes that we have seen with Michael and Florence last year, terrible hurricanes, terrible impacts on U.S. military installations.

Ms. BROWNLEY. Thank you, Madam Chair. I yield back.

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

Mr. GRIFFITH. Thank you very much. And I appreciate our witnesses being here today.

Delegate Hodges, good to see you. And greetings from Congress to the oldest legislative body to have continuously met and have been elected in the world, the Virginia House of Delegates, formerly the House of Burgesses. And while Virginia hasn't always gotten it right and there is certainly some really large, bad things we have done, one of things we did was to bring elected representative government to the new world. And would you please tell the members of the committee, with the exception of former delegate and State senator Don McEachin, who already knows, exactly how old is the Virginia legislature?

Mr. HODGES. Let's see. Well, actually, it dates back to the House of Burgesses. And let's see, 1689, I believe.

Mr. GRIFFITH. 1619, so this is the 400th year of its celebration.

Mr. HODGES. Oh, I should know. That is right across the river too.

Mr. GRIFFITH. You talked about Gwynn's Island.

Mr. HODGES. Yes, sir.

Mr. GRIFFITH. And, of course, it is an interesting—Mathews County in Gwynn's Island is an interesting area. And there was a book recently written about the men who fought in World War II, because they all knew the water so well because the roads weren't as good as the waterways to get around.

You talked about regulations that were affecting the ability of Virginia to respond to the water rise and the increased water rising. Can you give us some more detail on that, because you only had 5 minutes?

Mr. HODGES. Yes, sir. Thank you, Mr. Chairman. And the Hodges man in Mathews County, no relation that I know of, but that is who it was about.

We have identified 23 laws and regulations passed 50 years going back to the Clean Water Act through ENS, storm water, the Chesapeake Bay Act; septic. All of these programs had a well-intended purpose: protect our waterways and protect our water quality. But what we found is, over the years, we didn't intend for sea level rise and things changing.

And everything that we are working on flooding and chairing that flood commission, those barriers are in place to get results. We can study everything, but unless you can get that wall that government has put in place—government is here looking at solutions today, but also, government is our largest barrier.

Mr. GRIFFITH. So are you saying, Delegate, that in order to protect some of these areas from flooding, you need to build a wall, but first you have to tear down the wall of regulation that prevents you from protecting land from being flooded?

Mr. HODGES. Yes, sir.

Mr. GRIFFITH. So what we need to do is—are you asking us to do a comprehensive review of the laws to make sure that what we thought was going to be water flowing into the waterways is now water flowing onto the land, and to make sure that we haven't created any improper barriers that would prevent you as a State legislator from protecting the people in your district?

Mr. HODGES. Yes, sir. I like to say, if we had an eraser and could start from scratch, how would you build this program that still protects water quality, that protects our property owners, and looks at long-term effects of the flooding? All of these laws and regulations are intertwined. And, unfortunately, our government, they think in silos and it creates a huge barrier and permitting process, and headaches for landowners. And we have to find a way to tear down that wall and do a comprehensive review. We can build a better mousetrap at a lower cost and help business and property owners.

Mr. GRIFFITH. So no matter why the seas are rising, they are rising, and you want to make sure you can protect your people that you represent in the coast of Virginia.

Mr. HODGES. Yes, sir, definitely. Number one priority.

Mr. GRIFFITH. All right. Appreciate it. And then, you know, one of the big concerns, and we have heard several of the folks already mention, is that a lot of the pollutants that we are worried about, you know, coming in the future are coming from overseas. And we all share the air. In fact, there is a wonderful study that NASA did. They followed a sandstorm from the middle of the Gobi Desert, and it took 10 days to get to the eastern shore of Virginia.

So what they are doing with, you know, carbon emissions in Asia only takes 10 days, maybe India is 11 or 12, to get to the United States. And so if we are not careful, we are going to ship all of our jobs off to Asia because we said you can't do anything here. And we are going to end up with the air pollution and the CO₂ anyway. Isn't that correct?

Mr. HODGES. Yes, sir. Yes, sir.

Mr. GRIFFITH. And so we need to look at things in creative ways. Mr. Russell brought up the farming, and some organic farming folks in my district say that a lot of the practices they use help capture more carbon than the more industrialized farming. I think that is probably true, and we should find ways to encourage that.

Mr. HODGES. And if I may, Mr. Congressman.

Mr. GRIFFITH. Yes, sir.

Mr. HODGES. We are all actually at a market-based approach. Chairing the Rappahannock River Basin Commission, we have been able to quantify the value of forestry as a water quality initiative, and forestry also helps protect with flooding. And through a market-based approach in quantifying that, we had 4.3 billion metric tons of carbon sequestration in Virginia forestry, but it was unable to get it to the marketplace so we have come up with a solution.

Mr. GRIFFITH. All right. Thank you. I yield back.

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

Mr. MCEACHIN. Thank you, Madam Chair.

And, again, I want to echo Congressman Griffith's sentiments and welcome Delegate Hodges to the other side of the Potomac.

Mr. HODGES. Good to see you.

Mr. MCEACHIN. I hope you will take a moment to come to the House floor and see the joke of a mace that we have. Only those of us who have served in the Virginia legislature can understand what we are talking about, but I hope you will take a moment to do that.

On a more serious note, though, to the extent that you have identified regulations that are not allowing you to, or us in Virginia,

to combat sea level rise, I invite you to send to my office suggested changes. And I mean that sincerely and seriously. Get your executive director to jot down some notes and let us take a peek at it and, copy Morgan on it too so he will keep me honest.

Mr. Russell, I would like to ask you—I know we have gone over this a couple of times through different members, but I think we are all struggling for us to try to see, for you to put clothes on this notion of paying farmers to sequester carbon. I think it is a great idea, sounds great. I am a big believer in creation care. I want to invite you to share with us with more specificity what that looks like. Are we talking about a tax credit or are we talking literally a payment? What does it look like to you at least?

Mr. RUSSELL. Well, thank you for the question. We have the most robust toolkit in this country around agriculture than any other place on the planet, any other country. The history of our land grants, the USDA programs. So I am not going to advocate a specific thing today but more a directional approach. We already have the tools in place, so how do we complement good public policy that creates incentives with markets?

And so in terms of capturing carbon, right now, we have in our farm programs a lot of practice-based programs. If you do this, check, you get a cost share. But in the future, it looks like the signals are that there is going to be a monetization of carbon. There is going to be some kind of market. Congratulations to California for already moving in that direction and for inviting farmers to participate in that market. That is where we are headed.

So how do we position American farmers to lead that and then participate in it?

And so when Secretary Northey left Iowa as Secretary of Agriculture and went to become Under Secretary of programs, I was talking with him and talking about this opportunity. And he said, Matt, how could we pilot something like this in the farm bill? Right. So an example would be, if I can show on my whole farm that I am essentially a negative carbon balance, I am pulling more carbon out than I am releasing, then can I get a higher crop insurance subsidy? In other words, can the taxpayers reward me for that performance-based effort? That is just one example. The farm bill is loaded with opportunities.

And collectively and creatively, when we put farmers in a leadership position helping drive and understand that policy, what we can do is the same kind of transformation that happened from horses to tractors. And I live on a farm that was built in the 1930s, and we have got a barn with five stalls for draft horses. That farm bet on horses in the future, and they were wrong. We went to tractors.

Right now, when we keep everything the same, we are betting on horses, when the future is telling us we are headed to tractors. And tractors are monetized carbon, carbon markets, paying people for solutions to solve this problem.

And to Representative Palmer's point, excellent; I agree 100 percent. We can't just do resiliency and we can't just do carbon cap; we have to do both together. And the fortunate thing for agriculture is when we capture carbon, we actually become more resilient. It is a twofer. And we have the tools in our farm programs

already to adjust and develop. And we have farmers who are so capable of solving problems if we invite them in to do this, in the next decade, we can—it is not a transformation of agriculture that throws out everything we have got. It is a transformation of agriculture that builds on everything we have.

When we increase the organic matter in our soils from 2 percent in Iowa up to 5 percent, we go from 200 bushel corn to 300 bushel corn with half the added nitrogen. That is the future, that is the promise.

Mr. MCEACHIN. Thank you. Madam Chair, I yield back.

Ms. CASTOR. Thank you.

Mrs. Miller, you are recognized for 5 minutes.

Mrs. MILLER. Thank you, Madam Chair. Thank you all for being here today.

Mr. Russell, in 1992, we bought a farm. In 1994, we bought five female and one bull American bison. I as a legislator learned how to deal with chicken litter. As a farmer, I learned how to deal with buffalo litter. And I agree with many of the things you say, because farmers do solve problems. One of the problems was when the government thought multiflora roses would be a wonderful fence, and they have been a terrible thing to deal with.

Delegate Hodges, welcome, from the other Virginia. I represent West Virginia. And we are geographically challenged in an entirely different way than you are. Our folks, as they moved west, settled along the rivers. Some of them did go to the top of the mountains, but most of the population was along the rivers. And we have had to deal with a lot of flooding.

Dr. Cleetus, I am a mother and a grandmother and very concerned with our climate and the environment that we give to our children and our grandchildren. The policies and the programs you talk about make us realize that this issue is multipronged. It isn't just one area. It encompasses many people, many areas. And I know what bad policy and what unintended consequences can do to devastate whole communities.

Dr. Diffenbaugh, I recently read an article in The New York Times that states that China, in their northern province, Shandong, is releasing CFC-11, which is really bad for the ozone. And from the Montreal Protocol, all of that was supposed to be finished; maybe mid century, there would be nothing left. And this is really a bad thing for our climate.

So I want you to know that we are dealing with many different types of problems, as some of the other Congress people have mentioned, in dealing with the ozone and with our environments. So I just want people to realize that things are happening out there in the world that directly affect all of us.

But we are here to talk about resilience, and so I want to talk about what happened in my area recently. We have been having a lot of flooding. In 2016, it devastated several different counties in my district. There were three schools in Nicholas County, West Virginia, which, in my district, totally were destroyed. The flood damage was terrible, the impact on these three schools.

When you think about schools in rural America, they are your community. They are the center of everything that happens. It is not only a place of learning, but it is a community hub. And it is

now 2019, and we are still trying to find out what went wrong and review the assessment needed to replace these schools. This incident has illuminated the fact that our communities need to be equipped to handle disasters and what to do once that they receive the Federal assistance. That is where the slip is between the cup and the lip.

Last year, President Trump signed the Disaster Recovery Reform Act, DRRRA, which enacted many provisions to help build up our capacity for our—any catastrophic event. This is an action, it is not just talk.

Delegate Hodges, given your position on the State level, how can we better equip our States, counties, and cities to best utilize disaster funding and prepare for the next disaster?

Mr. HODGES. Thank you for the question. As an answer to that, we—and as Congressman Griffith had asked, the regulatory burdens actually tie our hands to be able to utilize these funds sometimes. They are not always used in the most effective way. We actually have created a living shores revolving loan program that helps to build living shorelines and incentivize landowners to do that. We have created, through a septic loan program, to repair our failed septic systems that are contaminating our waters when flooded. But I do believe that the funding challenge is real. We need to better utilize those funds.

Mrs. MILLER. What you are saying to me with those answers is it really is the State and the counties that best know how to handle—

Mr. HODGES. They do. And from the top down is not the solution. It needs to come from the bottom up. And as you said, each area of the country is different and, you know, how we are dealing with flooding. So we are the ones that know best how to utilize those funds to get them to our homeowners, to get them to our farmers, and to utilize those funds in the best way.

So it really should come from the ground up, but the regulations and laws have gone from the top down. So we need to look at tearing down those walls. The pie is only so big. You know, there is only so much money, and we need to better utilize those funds and get them into the right hands.

Mrs. MILLER. Thank you. I yield back my time.

Ms. CASTOR. Thank you.

Mr. Levin you are recognized for 5 minutes.

Mr. LEVIN. Thank you, Chair Castor.

I appreciate everyone's testimony today. It reinforced a fact that we know well in southern California where I live, and that is that our sea levels are rising and that means serious consequences for our public health, our communities, and our property. In my district, we are seeing decades-old structures falling into the Pacific Ocean. Literally, things like basketball courts and parking lots and public restrooms that are no longer able to operate. And that might sound trivial, but this is just the beginning of much worse to come, based on much of the research that you have done.

The U.S. Geological Survey last year projected higher levels of climate change in my communities in Orange and San Diego counties over the next century. A lot of the best work being done in this area is being done at the Scripps Institute of Oceanography, which

is in my district, as is the University of California in San Diego. And researchers at Scripps have created a network that measures wave characteristics, tide heights, water levels. And it is used to do wave modeling and predictions, as well as flood forecasting.

Using that network, the folks at Scripps can predict when the city of Imperial Beach is going to be at greatest risk. And if you have heard about Imperial Beach, they have had significant concerns with flooding.

Dr. Cleetus, I wanted to ask you a question. I certainly share your belief that we need to cap warming in order to limit sea level rise. But do you see a benefit in expanding the types of things that Imperial Beach and the Scripps institute are working on, perhaps to other cities to be able to forecast flooding? And do you think it could help us avoid some of the costs of climate change that you outline in your testimony?

Ms. CLEETUS. Absolutely. I think this kind of scientific data and research is critical to help local communities understand the risks that are coming their way, and kind of measures that will work and the kinds that may not work in light of the risks that are coming. So absolutely, sharing that information, cities and towns are often the laboratory of innovation in this space, and I fully encourage that kind of sharing.

Mr. LEVIN. I wanted to turn to a different topic, which is one that you have probably been hearing about in the news, infrastructure. I think we probably here all want a great infrastructure bill, but we seem to be moving further away from one. But I think it is really important that, with you here, we talk about how to build sustainable infrastructure that is really forward looking and thinking about climate change.

So to Dr. Cleetus and Dr. Diffenbaugh, what types of projects and programs would you like to see in a discussion of a climate change resilient infrastructure bill?

Ms. CLEETUS. So the first thing is we have to make sure that the infrastructure we are building is going to be climate resilient, and it is taking into account these projections that we are seeing around extreme precipitation, heat, and other kinds of extreme events. We can also simultaneously be building low carbon climate resilient infrastructure. So get some twofers out of this, renewable energy, energy storage, other things that cut emissions that also keep the grid online and secure during extreme weather events.

Mr. DIFFENBAUGH. I appreciate that question. And I would point you to the California Safe—Climate-Safe Infrastructure Working Group AB 2800 and our report that was released last summer.

A couple of highlights. One is creating climate-safe infrastructure starts with an acknowledgment that the climate is changing. There were many engineers on that working group, and a lot of the discussion was focused on the ways in which the historical data no longer accurately predicts the frequency of extreme events. We have heard already about 1,000-year events and 500-year events happening in quick succession and that is because of the nonstationarity of the climate. And so acknowledging those changes and updating the way in which planning is done is critical.

And then I would echo the point about win-wins between resilience and emissions. One proposal that a colleague of mine, Mi-

chael Wara, at Stanford has made in an op-ed in the Los Angeles Times with regard to wildfires. One of the big risks of wildfires, as you know, are the electric lines and PG&E has been in the news a lot about that. So my colleague, Dr. Wara, has proposed having solar and storage, battery storage and solar capability as a way of providing electricity when those lines are decommissioned. So this will provide both resilience by reducing the wildfire risk, but also low carbon energy and maintaining electricity availability to vulnerable populations when those lines are deenergized.

Mr. LEVIN. So I am out of time, but I would love to make sure that we follow up with you and the appropriate people in our Transportation and Infrastructure Committee so that they can get that study.

Mr. DIFFENBAUGH. I would be very happy.

Mr. LEVIN. I yield back.

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

Mr. CARTER. Thank you, Madam Chair. And I thank all of you for being here. Interesting discussion today, and appreciate all of you.

Delegate Hodges, thank you for being here. Appreciate you coming and testifying. You know, in another life, I was a mayor. And I remember when I was a mayor, you know, there are all these projects you want to do and you just can't afford to do them. And it is challenging. In fact, we had the mayor of Los Angeles here yesterday that we met with to talk about these specific issues. And even he expressed the frustration, you know, with not being able to do all the projects that he wanted to do.

But I wanted to mention a project that is being done down in Georgia. In fact, it is being led by Georgia Tech, the Georgia Institute of Technology. It is a program that installs sensors. And let me back up for just a second. I represent the entire coast of Georgia, over 100 miles of pristine coastline. So rising sea levels are important to us, obviously, and we are very concerned.

But the program at Georgia Tech, they have installed sensors that help the coastal areas to pinpoint the specific areas that might be impacted and that we need to build up resiliency and roads, bridges. And this is a great program.

And I just wanted to ask you, Delegate Hodges, how important do you think it is that we use metrics that can help us show these type of events and the impact that they could have?

Mr. HODGES. Sure. Actually, thank you, Congressman, for the question. Metrics are very important. It is important to have the science and the data. As we are, you know, also looking at sea level rise, where I live, we also have land subsidence with groundwater withdrawal. So just a very small lowering of the land can have a tremendous effect on the sea level. So the metrics are very important, the science is very important. And I am fortunate enough to have the Virginia Institute of Marine Science in my district that I work very closely with that provides data that works with me very closely. So a world-renowned center.

Mr. CARTER. How do you think the Federal Government can help in this?

Mr. HODGES. Funding and any access, you know, any assistance with GIS. And also, as I mentioned earlier, to get out of the way.

Mr. CARTER. Exactly. The permitting process.

Mr. HODGES. The permitting process is number one, especially with dredge material, dredge spoils. You know, the funding for dredging is no longer there from the Federal Government. We have identified a backlog of the permitting at VMRC with dredging. And we kind of streamlined that in legislation, but there is still a problem to having access to those dredge spoils that can be used for living shorelines of resiliency.

Mr. CARTER. Absolutely. Absolutely. And speaking of which, the University of Georgia, my alma mater, where I graduated from pharmacy school at, that is—they have got a project that is a very interesting project as well. And they are using—and it is—working in conjunction with the Corps of Engineers and with private businesses. So I am really proud of that. But it uses natural material like dredge spoils to build up resiliency. An example is they are building wetlands along the river. You know, I have always said, look, we have got to do all these things. We have got to have mitigation, adaptation, and innovation, and we do in order to address the situation.

But do you think this is something, this example of using light dredge spoils? I mean, commonsense things like this, is this something the Federal Government ought to be pursuing?

Mr. HODGES. Yes, sir. Dredge spoils can be of assistance, and you mentioned—you know, living shorelines. They can be used in living shorelines, which not only helps water quality, but resiliency and flooding. We are working on ways to incentivize landowners through tax relief at the local level, a loan program. But we need to build them bigger, we need to build them better. And these natural assets are also—they are assets, other like sometimes hardening structures are a liability.

Mr. CARTER. Right, right. And, you know, this is such an important issue for us along the coast of Georgia because we got like one-third of all the world's marsh land right in Georgia on the Georgia coast. So making sure we protect that marsh land is extremely important. Thank you, Delegate Hodges.

I wanted to ask before I go, Mr. Russell, I thought it was in your testimony you mentioned using smart public policy combined with capitalism. And I found that to be quite interesting and quite encouraging, to be quite honest with you. I just wanted to ask you, do you agree that private investment and robust markets are necessary to improve resiliency for us?

Mr. RUSSELL. Absolutely. Our wind energy in Iowa is a perfect example of smart public policy. And shout-out to Senator Grassley, standing up, granddaddy of those tax credits, and defending them still. Smart public policy and markets built on top of it, we have a whole wind industry in our State. We are going to be 40 percent of one calculation of our energy, electricity renewable from wind. Absolutely, that is the key to the future.

Mr. CARTER. Thank you very much. And I yield back.

Ms. CASTOR. Thank you.

Mr. HUFFMAN, you are recognized for 5 minutes.

Mr. HUFFMAN. Well, thank you, Madam Chair.

And I am once again reminded how nice it would be to take this committee on the road to California so that we could educate our

colleagues across the aisle, and we continue to hear assertions about what is going on in California, things that have many Pinocchios attached to them. I know that we have got work to do.

So thank you, Dr. Diffenbaugh, for pointing out that the 5-year drought that California just recently came through is actually not consistent with anything we have experienced in modern history and even going back to the proxy record, whether you want to look at tree rings or any other proxy records. This was different. It was deep, it was hot, and it was climate change related.

And the other assertion that we heard, of course, was that California has not been expanding water storage. Factually incorrect. California has expanded water storage, as well as invested in all sorts of other resiliency strategies, which is why we came through that drought of record without our economy skipping a beat, including the agricultural economy. So I think this committee could learn a thing or two about resiliency. California is not perfect, but this sport of California bashing at some point needs to give way to some fact-based conversation.

I enjoyed the conversation about these twofers that several of our witnesses and my colleagues have referred to. And so I wanted to follow up on that a little bit.

Dr. Cleetus, in your research, have you identified other examples that we haven't talked about, strategies that can be twofers, that can provide resiliency while also drawing down greenhouse gas emissions at the same time?

Ms. CLEETUS. I think there are tremendous opportunities across the economy too. I work on a power sector in particular, and in that sector there, is no question that investing in energy efficiency, low carbon energy, twinned with storage, not only helps us get affordable energy, low carbon energy, but also will help us build resilience through extreme events and extreme heat that are coming our way. And making sure that these are targeted at communities that are being disproportionately affected by these climate impacts is really, really important.

So, for example, having these in public housing, upgrading public housing to have energy efficiency weatherization investments, investments in cooling because of the extreme heat coming our way that is putting people at risk.

Mr. HUFFMAN. All right. And let me ask you, Mr. Russell, about your testimony on this subject. You talked about some ways in which agriculture can be part of the solution. Talk a little bit more about how climate smart farming practices like planting cover crops, crop rotation, no-till farming can help sequester carbon as we mitigate for climate change.

And also, the question I had as I was listening to your testimony is, I know that right now the agricultural sector is a part of the problem in terms of greenhouse gas emissions. We have a lot of chemical inputs, fertilizers, et cetera. Do these climate smart farming practices actually reduce those chemical inputs in other beneficial ways?

Mr. RUSSELL. I will try to be brief. I promise I will be brief.

Essentially, when we look at managing living systems to develop the services needed that humans need, that is what agricultural is; historically, it has been food, and now going forward, it is going to

be less about food. Still about food, but a lot of other things. And we have seen that over the last few decades, biofuels and other things, and now climate services.

So with that in mind, as we lean into that, what we do is we increase the biological activity in the soil. The green revolution created productivity, but it didn't pay attention to the biology of the soil. The future is going to be about the biology of the soil, so photosynthesis, getting the biological activity. And when you do that, you get that carbon out of the atmosphere, through the plants, through the roots, through the biological activity, and stored working in the soil. So that is kind of how that happens.

The result of that is that you increase organic matter tremendously, which holds more water when it is raining, has more water stored when its dry. So we get carbon sequestration and we get more resiliency. So that has happened, and that is the twofer that is happening at the same time.

We have not managed our agricultural systems. We don't have agricultural industry invested in that model. But we know that farmers are able to develop that model. And so it is disruptive, but it is not necessarily disruptive to rural communities and farmers in the same way that it is disruptive to agriculture in general. So that is part of the rub.

Mr. HUFFMAN. Well, thank you for that.

And finally, Delegate Hodges, I was intrigued by a number of the strategies that you talked about. I am a big believer in beneficial reuse of dredge spoils and the oyster reef restoration. Those both sound like great strategies. But I do think we know we have to be careful about how we do coastal resiliency strategies.

And I would just note that the Virginia Institute of Marine Science that you referred to, coupled with Virginia Tech, did a study on at least a prior version of your bill and found some unintended consequences that still need some more work. So I would urge you to keep working on it.

I was grateful for your statement that you would support greenhouse gas reduction through market-based strategies. However, I note that you voted against efforts to include Virginia in RGGI and TCI. So if the existing market-based strategies aren't good enough, I hope you will find some that you can put forward and support, because we have got to work on greenhouse gas reduction and not just resiliency.

With that, I yield back.

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

We are going to try to finish before votes, so if you all could be brief. Thank you.

Mr. CASTEN. Thank you, Chair Castor.

Mr. Russell, in your work with religious leaders and people of faith in Iowa, do you ever come across the argument that as a species, our moral behavior should be predicated on other people being moral first?

Mr. RUSSELL. I would say no.

Mr. CASTEN. Okay. Thank you.

Dr. Cleetus, you mentioned in your testimony, I think you said that \$136 billion of property is at risk from coastal flooding. That is, of course, a small fraction of the total economic loss from some

of the wildfires and floods and droughts that Dr. Diffenbaugh has talked about, expansion of tropical diseases, crop failures. If we fail to get all the way to net zero, but we make a meaningful reduction in carbon, can we assume that we will avoid some of those economic losses?

Ms. CLEETUS. We have to reach net zero by mid century to really limit some of these losses. And the burden will fall to our children and grandchildren.

Mr. CASTEN. I am not asking the moral question. I am just asking, do we save that money only if we get to net zero or do we save a portion of that money if we get part—

Ms. CLEETUS. Every fraction of a degree we can avoid matters. So we have got to go all in on mitigation and adaptation right now.

Mr. CASTEN. Thank you.

I would conclude from the two comments that we have both a moral obligation and an economic incentive to reduce CO2 as quickly as we can. And I would hope all of my colleagues will stop with this nonsensical argument that we have to wait for China.

I want to stay with you, Dr. Cleetus, and specifically on the flooding issue. If we eliminated CO2 emissions today, how much sea level rise is already baked into the system?

Ms. CLEETUS. Unfortunately, we have a couple of feet of sea level rise already baked in. And what is really worrisome is that we are starting to see that land-based ice sheets are getting more and more unstable. So we may have set off a feedback loop that will have consequences for hundreds of years. And that land-based ice, once it starts to go, cutting emissions will unfortunately not be able to cut that feedback loop. So this is the moment to really dig in and cut emissions as fast as possible.

Mr. CASTEN. So if we are looking at a couple of feet, talk to me about the major population centers in the United States that are below sea level with that level of rise, just the top ones off the top of your head.

Ms. CLEETUS. Everywhere along the eastern Gulf Coast, Boston, New York City, Miami, all around the eastern Gulf Coast, and many, many small communities that are not in the headlines but are going to be hit really, really hard with this.

Mr. CASTEN. So I sit on the Financial Services Committee, and we recently had Fed Chairman Powell before us. And one of the questions that I asked him was that as he looks at the tests we do to evaluate the integrity of banks, does the Federal Reserve consider the exposure that banks have with 30-year mortgages in these communities. And the answer was essentially no. We are somewhat unique in that.

And, Chair Castor, I would like unanimous consent to enter into the record “Avoiding the storm: Climate change and the financial system.” It is a report by the Bank of England.

Ms. CASTOR. Without objection.

[The information follows:]

ATTACHMENT: Breeden, S. (2019, April). *Avoiding the storm: Climate change and the financial system*. Official Monetary & Financial Institutions Forum. London.

The speech is retained in the committee files and available at:

<https://www.bankofengland.co.uk/-/media/boe/files/speech/2019/avoiding-the-storm-climate-change-and-the-financial-system-speech-by-sarah-breeden.pdf?la=en&hash=AC28DFEFED7B14A197E6B0CB48044D06F4E38E84>

Mr. CASTEN. The Bank of England has asked their banking system to factor this in. You spoke a bit about that. Can you speak a little bit about what we should be doing on the other committees here to try to make sure that we evaluate those risks to our financial system?

Ms. CLEETUS. The private sector and the financial sector have a huge role to play. And when we did this research, we actually reached out to a number of private sector actors, bankers, lenders, investors. And what we heard from all of them was, yes, the science is real. Yes, the risk is real. And, no, the market is not pricing it accurately right now.

The risk is flying below the radar. And, unfortunately, this is very, very risky for coastal communities, because should the market suddenly start to price the risk, the impact will be very harsh especially on low-income and fixed-income folks.

So, absolutely, I think there is a responsibility from the Federal Government to ensure that our economic system, including our banking system, is taking these risks into account.

Mr. CASTEN. Okay. Last thing, and again, this is from our purview on the Financial Services Committee, that the flood insurance program is up for renewal. You mentioned some commonsense reforms. We have to decide that pretty quickly. Can you help us understand a couple of those reforms that you would like to see in the flood insurance program?

Ms. CLEETUS. We need better flood mapping and money for it to accurately access these risks. We need to make sure that we are investing ahead of time, not just after disaster. So flood mitigation measures, including voluntary home buyouts, have to be funded well. We have to do this equitably so that we are not hitting low- and fixed-income folks in an inequitable way. So building in affordability measures as we do these things is very, very important. We have to get more people insured because these events are getting worse.

Mr. CASTEN. When you mention voluntary home buyouts, just help me to understand, because we have—what should we do with that land once we have got it bought out?

Ms. CLEETUS. Turn it over into green space. That is land that should not be developed. But developing in these risky areas is only increasing the risk to people, property, and the taxpayer.

Mr. CASTEN. Thank you. And I yield back the balance of my time.

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

Mr. NEGUSE. Thank you, Madam Chair.

In September of 2013, the State of Colorado experienced what is known as a 100-year flood. Over the course of 1 week, an entire year's worth of rain fell along Colorado's front range. Over 18,000 people were evacuated from their communities, including my own. They returned to find thousands of homes and hundreds of roads and bridges destroyed. In total, the flood cost more than \$4 billion in damages and tragically claimed 9 lives.

Despite the devastation of this disaster, I am proud that Colorado has worked to repair and replace the affected roads with flood zones and the communities. And, ultimately, I believe these communities are smarter and stronger than before. But it is important

to note, as we have rebuilt, ultimately, resiliency was not a choice; it was a necessity. The increase in extreme weather events means that our communities must be quick to respond, repair, and recover. And in the face of increasing climate disasters and uncertainty, my district is taking action on developing climate resiliency. So that is why I believe today's topic is so important. I appreciate the witnesses and their testimony. We absolutely need to have infrastructure in place to address the impacts of climate change, and we must do it soon.

But I would be remiss if I did not agree and associate myself with the remarks of my colleague from California, Representative Huffman, which is to say that all of this work means nothing if we don't take real concrete action to address the cause of climate change and reduce our greenhouse gas emissions. Because if we don't, 100-year events like the catastrophic flooding in my State could become much more common.

I want to ask you, Dr. Cleetus, in your testimony, you emphasized the kind of local communities and the ability of local communities to make recommendations for responding to climate change. In Colorado, as you might be familiar, I represent northern Colorado, so Boulder, Fort Collins, the Central Mountains. We have a number of communities that have developed these plans. I believe per capita the front range has more of these communities that have developed such plans than anywhere else in the United States. And yet there are many communities elsewhere in the State that have not.

I am wondering if you could perhaps offer a bit more detail in terms of why you believe these plans are so important and how Congress and the Federal Government can help incentivize and motivate local communities to step forward.

Ms. CLEETUS. Yeah. We need action from the Federal to the local, so we need Federal resources and know-how on data and capacity building. The local communities understand best how adaptation is going to work in their geographies and their environments and the risks that are coming their way. For example, the wildfire risks that are coming and getting worse in the area of Colorado that you describe.

And those wildfire risks affect forestry, they affect watersheds. They have all kinds of now gone effects. In the seasons after them, you start getting flooding events in the denuded landscapes. So we need to have more and more communities that are in power that have the resources and the tools and know how to develop these plans, to develop them in a well-resourced way, and to be able to take actions to protect themselves.

So we are really looking now for the Federal Government to step up with the resources so that communities can do these plans better in an inclusive way with the stakeholder process that includes a wide variety of perspectives.

Mr. NEGUSE. Thank you, Dr. Cleetus.

And finally, Mr. Russell, thank you for your testimony. There are some exciting things happening back in my district around regenerative agriculture and so forth. I am curious, though, and I want to go back to a comment you made in reference to one of the questions that was posed with respect to the burgeoning growing wind

industry in your State, in your home State of Iowa. You know, I believe you attributed that in part to the private sector, private markets. And of course, I agree that the private sector, of course, has a role. But I also am curious if you believe that there are any government investments that played a significant or substantive role in the wind industry becoming what it is in the State of Iowa.

Mr. RUSSELL. Absolutely. I mean, you first have the renewable portfolio standard as a starter and then the tax credits and continuing. So that is the foundation, good smart public policy, and then we have grown a tremendous economy on top of it. And that is really the future that is being presented to us, a future of abundance if we are willing to use smart public policy to move in and use capitalism to get the future we need, which is, you know, clean renewable energy and managing living systems.

Mr. NEGUSE. Thank you, Dr. Russell.

And with that, I guess I would only hope that our colleagues on this committee from both sides of the aisle, that we could join together to help build and refine and expand the foundation that you just described. I think that is the role of this committee and ultimately the Congress from a Federal policymaking standpoint.

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

Ms. CASTOR. Thank you.

Mr. Luján for a UC request.

Mr. LUJÁN. Madam Chair, I would ask unanimous consent to submit two articles into the record. The first is from Science Advances, "Unprecedented climate events: Historical changes, aspirational targets, and national commitments." And the other is from The Hill, titled, "Paris Agreement goals could save trillions in avoided climate damages."

I think I was asking the question in the wrong way to Dr. Diefenbach. So I appreciate the few pieces that I was able to identify. Thank you.

Ms. CASTOR. Without objection.

[The information follows:]

ATTACHMENT: Diefenbach, N. S., Singh, D., & Mankin, J. S. (2018). Unprecedented climate events: Historical changes, aspirational targets, and national commitments. *Science Advances*, 4(2).

The report is retained in the committee files and available at:

<https://advances.sciencemag.org/content/advances/4/2/eaao3354.full.pdf>

ATTACHMENT: Diefenbach, N. S., & Burke, M. (2018, May 27). Paris Agreement goals could save trillions in avoided climate damages. *The Hill*.

The article is retained in the committee files and available at:

<https://thehill.com/opinion/energy-environment/389550-paris-agreement-goals-could-save-trillions-in-avoided-climate>

Ms. CASTOR. I also ask unanimous consent to have a statement for the record from Representative Bobby Scott of Virginia.

Without objection, so ordered.

[The information follows:]

Statement for the Record
Congressman Robert C. “Bobby” Scott
Select Committee on the Climate Crisis
Creating a Climate Resilient America
May 23, 2019

Thank you, Chairwoman Castor, Ranking Member Graves and members of the Select Committee on the Climate Crisis for holding this hearing on creating a climate resilient nation.

I represent the 3rd congressional district of Virginia where the Chesapeake Bay meets the James, Nansemond, and Elizabeth Rivers, which presents both challenges and opportunities. The U.S. Army Corps of Engineers has worked closely with our communities to ensure that they can continue to live with the water that surrounds our community.

Unfortunately, due to sea level rise, both attributable to climate change as well as historic subsidence, these waterways also pose a serious risk. Some studies estimate that sea level rise to be as much as 7 feet by the year 2100, which makes the Hampton Roads region the second largest population center at risk from sea level rise in the nation, behind only New Orleans. The City of Norfolk is specifically at risk from flooding due to high tides, nor'easters, and hurricanes. As the home of Naval Station Norfolk and numerous other federal and military facilities, this recurrent flooding also poses a severe national security risk.

State and local elected officials in Virginia already appreciate the significant threat sea level rise poses to Hampton Roads. Unfortunately, the cost to proactively and aggressively address this problem head-on is far too great for any city to bear by itself. While Norfolk has already spent considerable sums of money to study its recurrent flooding issues and implement resilient infrastructure where feasible, the scope of the entire project to actually address the problem is expected to total in the billions of dollars.

As this committee considers ways to make our nation more resilient, I urge you to make flood mitigation a priority. I encourage you to look at the Building Up Infrastructure and Limiting Disasters through Resilience (BUILD Resilience) Act, legislation that I introduced last Congress with Senators Mark Warner and Tim Kaine and that I intend to introduce again soon. The BUILD Resilience Act would establish a competitive grant program for resilient infrastructure investment to bolster the ability of regions, such as Hampton Roads and New Orleans, to implement projects and strategies to reduce regional vulnerability to threats like sea level rise and recurrent flooding. Analyses by the Congressional Budget Office and the Multi-hazard Mitigation Council of the National Institute of Building Sciences estimate that every \$1 invested in resilient infrastructure upfront saves \$3 to \$4 in future losses on the back-end after a major disaster strikes. Investing upfront in resilient solutions can potentially help save taxpayers and impacted communities billions of dollars in avoided costs.

Madam Chairwoman, thank you for allowing me the opportunity to share my concerns creating a climate resilient America with the select committee.

Ms. CASTOR. Thank you all. Thank you to our witnesses for being here today. We are interested in building a more resilient America.

Without objection, all members will have 10 business days within which to submit additional written questions for the witnesses. I ask our witnesses to please respond as promptly as possible.

We are adjourned.

[Whereupon, at 10:50 a.m., the committee was adjourned.]

United States House of Representatives Select Committee on the Climate Crisis

Hearing on May 23, 2019 “Creating a Climate Resilient America”

Questions for the Record

Dr. Noah Diffenbaugh
Kara J Foundation Professor and Kimmelman Family Senior Fellow
Stanford University

THE HONORABLE KATHY CASTOR

1. China’s increasing emissions were raised in the hearing. Can you provide additional perspective on China’s emissions and what impact they should or should not have on U.S. climate policies?

While it is true that China’s emissions have been increasing (along with those of many other countries, and the global total), there are a number of important aspects to consider as Congress deliberates US climate policies. Many of the relevant datasets are provided by the Global Carbon Project. In addition to the information below, I refer you to their most recent *Global Carbon Budget*.¹

We know from the fundamental physics of Earth’s energy balance that the warming of the planet is approximately proportional to the total cumulative greenhouse gas emissions.² As a result, stabilizing the global temperature—and thus the global climate system—very likely requires reaching net-zero emissions.^{3,4} As the figures on the following page illustrate, the US has contributed the largest share (25%) of the world’s total cumulative fossil fuel emissions, meaning that we are the largest contributor to the global warming that has already occurred. (And, as I articulated during my testimony on May 23, 2019, US citizens are already experiencing acute impacts from that global warming.)

In addition to being the largest historical emitter, according to the Global Carbon Project the US remains the largest emitter per capita, with annual per capita emissions that are more than twice as large as China or the EU, and almost 10 times as high as India.¹ Further, it is also important to consider that, in addition to having much larger per capita emissions than China, the US also consumes products that are produced in China, and in other countries around the world. When the emissions that are embodied in these products are also considered, the total emissions associated with consumption in the US (and in the EU) are even greater than the respective territorial emissions, while the total emissions associated with consumption in China (and in India) are lower than the respective territorial emissions.

Further, it is also important to consider the emissions intensity of the economy of each country. As is illustrated in the chart published by *The Economist* in May 2019 (reproduced below), China—and India and Indonesia—are curbing their emissions much earlier in their respective economic developments than the US and other OECD countries. For example, as the chart shows, China’s per capita GDP is currently similar to the per capita GDP of the US and large European economies during the mid-20th century. However, China’s emissions are currently approximately half of what the emissions of the US and large European economies were during the mid-20th century. As a result, in addition to having lower per capita emissions, China is much more economically efficient in its emissions than the US, and is in fact curbing its emissions much earlier in its long-term economic trajectory.

A final point of context is that, because greenhouse gases are well-mixed throughout the global atmosphere, they affect the global energy balance, and thus climate around the world. As a result, US citizens are exposed to the climate change caused by all global emissions. As stated above, the US has accounted for 25% of the total global emissions to date, and we remain the largest per capita emitter. The future trajectory of US emissions will thus contribute very strongly to the climate risks that Americans experience in the future, with greater US emissions contributing to greater risks. (For a summary of these risks, please refer to my testimony on May

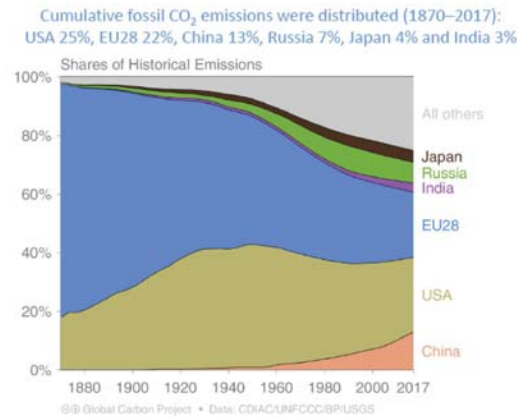
¹Global Carbon Project, 2018 *Global Carbon Budget*: <https://www.globalcarbonproject.org/carbonbudget/18/presentation.htm>.

²Matthews, H.D., Gillett, N.P., Stott, P.A. and Zickfeld, K., 2009. The proportionality of global warming to cumulative carbon emissions. *Nature*, 459(7248), 829-832.

³Matthews, H.D. and Caldeira, K., 2008. Stabilizing climate requires near-zero emissions. *Geophysical research letters*, 35(4), <https://doi.org/10.1029/2007GL032388>.

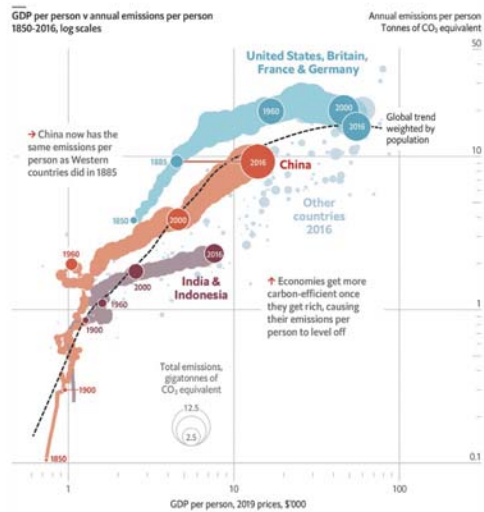
⁴Stocker, T.F., Qin, D., Plattner, G.K., Tignor, M., Allen, S.K., Boschung, J., Nauels, A., Xia, Y., Bex, V. and Midgley, P.M., 2013. *Climate Change 2013: The physical science basis. Fifth Assessment Report of the Intergovernmental Panel on Climate Change*.

23, 2019.) Further, in addition to being exposed to the climate change caused by future US emissions, Americans are also exposed to the climate change caused by the emissions of all other countries. Put simply, the greater the total global emissions, the greater the climate change that will occur in the US, and the greater the risks to US citizens.⁵ As a result, even if one views the Chairwoman's question of US climate policies only from the perspective of risks in the US, there is clear evidence that policies that reduce the total global emissions will reduce the future risks to Americans.



Historical cumulative emissions for different economic regions of the world. The US has been responsible for a quarter of all of the historical emissions, which is almost double China's cumulative total. (Global Carbon Project 2018 Carbon Budget)

China emits far less greenhouse gas per person than Western countries did at the same stage of economic development



Level of emissions at different stages of economic development. China emits less per person than the US, and also emits less than the US did at a similar level of per capita GDP. (*The Economist*, May 25, 2019)

⁵ Diffenbaugh, N.S., 2013. Human well-being, the global emissions debt, and climate change commitment. *Sustainability Science*, 8(1), pp.135–141.

THE HONORABLE SUZANNE BONAMICI

1. Like California, Oregon has faced horrific wildfires over the last few years and, unfortunately, it is becoming the norm. Last summer, our region known for its damp and green landscapes was suppressed by an orange blanket of haze. Surrounded by plumes of smoke moving south from British Columbia, north from Southern Oregon and California, and east from the Cascades, air quality in the Portland metropolitan area was recorded at levels unhealthier than Mumbai, Jakarta, and every major industrial city in China.

Dr. Diffenbaugh, what are the economic and health consequences of wildfires?

During my testimony on May 23, 2019, I summarized results of a recent review that my colleagues and I conducted evaluating the scientific evidence underpinning the EPA's "Endangerment Finding" for greenhouse gases.⁶ As is summarized in that peer-reviewed paper, the area burned in the western United States has increased approximately tenfold since the mid-1980s (see attached figure). Further, evidence shows that "human-caused climate change caused over half of the documented increases in fuel aridity since the 1970s and doubled the cumulative forest fire area since 1984."⁷

These wildfires have proved very costly. For example, according to the National Oceanic and Atmospheric Administration (NOAA), the 2018 western wildfires had a CPI-adjusted cost of \$24.5 billion, while the 2017 western wildfires had a CPI-adjusted cost of \$18.7 billion.⁸

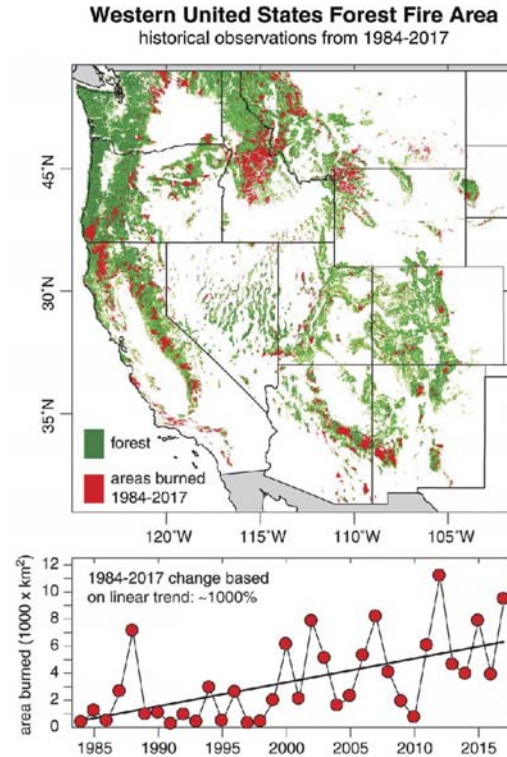
In addition to the high financial losses caused by of catastrophic wildfires, we also know that the historical increases in area burned have been accompanied by rising costs of fire suppression. For example, as reported in the National Climate Assessment, both the total US burned area and federal spending on fire suppression have increased fourfold over the past 30 years, with suppression costs rising reaching approximately \$2 billion/year in recent years (see attached figure).⁹

⁶Duffy, P.B., Field, C.B., Diffenbaugh, N.S., et al., 2019. Strengthened scientific support for the Endangerment Finding for atmospheric greenhouse gases. *Science*, 363(6427), eaat5982.

⁷Abatzoglou, J.T. and Williams, A.P., 2016. Impact of anthropogenic climate change on wild-fire across western US forests. *Proceedings of the National Academy of Sciences*, 113(42), pp.11770–11775.

⁸NOAA *Billion Dollar Weather and Climate Disasters*, Table of Events: <https://www.ncdc.noaa.gov/billions/events/US/1980-2019>.

⁹*Fourth National Climate Assessment*, Chapter 6 "Forests": <https://nca2018.globalchange.gov/chapter/6#fig-6-4>.

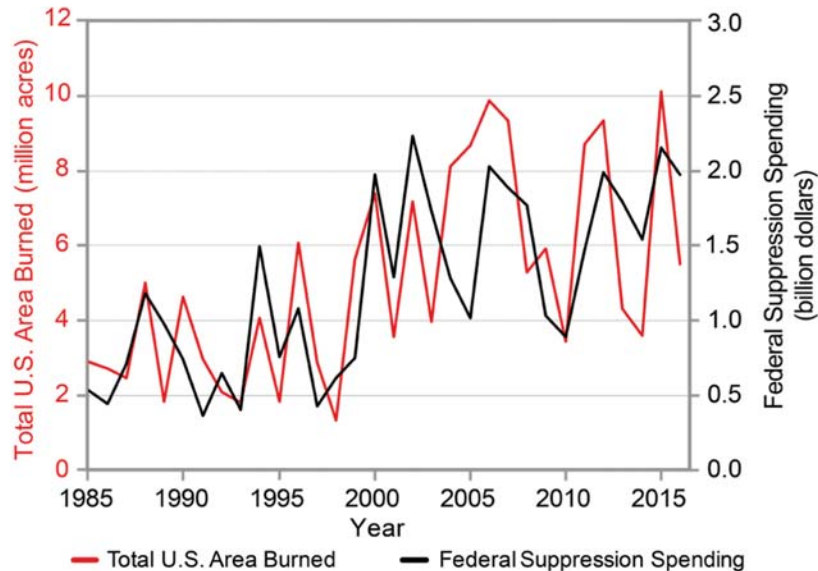


Area burned by wildfires in the western United States since the mid-1980s. (From Duffy, Field, Diffenbaugh, et al., *Science*, Vol. 363, Issue 6427, eaat5982, 2019.)

Beyond the direct financial costs, it is also clear that wildfires have substantial health consequences. A recent review concluded that, “Consistent evidence from a large number of studies indicates that wildfire smoke exposure is associated with respiratory morbidity with growing evidence supporting an association with all-cause mortality.”¹⁰ This finding confirms what so many US citizens have experienced first-hand in recent years: that wildfires can have far-reaching health consequences beyond the geographic area where the fires occur. In addition, of relevance for decisions about the management of wildfire risks, evidence is now emerging that health impacts of wildfires are greater than health impacts of prescribed burns.¹¹

¹⁰Reid CE, Brauer M, Johnston FH, Jerrett M, Balmes JR, Elliott CT. 2016. Critical review of health impacts of wildfire smoke exposure. *Environmental Health Perspectives* 124:1334–1343; <http://dx.doi.org/10.1289/ehp.1409277>.

¹¹Prunicki, M., Kelsey, R., Lee, J., Zhou, X., Smith, E., Haddad, F., Wu, J. and Nadeau, K., 2019. The impact of prescribed fire versus wildfire on the immune and cardiovascular systems of children. *Allergy*. DOI: 10.1111/all.13825.



Historical federal suppression spending (constant 2016 dollars) and total US area burned. (From the Fourth National Climate Assessment)

Although further research is needed to quantify and project the full costs of rising wildfire frequency in different areas of the US, we already have very strong evidence that wildfires are increasing, and anthropogenic climate change is contributing to that increase, and that costs associated with wildfires are increasing.

THE HONORABLE MIKE LEVIN

1. Dr. Diffenbaugh, you responded to Representative Brownley saying that recently half the wildfire area burned in California is due to the rising temperature, and you expect this trend to continue.

Many Members on this committee are concerned about the cost of inaction on climate, and I believe it is important to understand the degree to which wildfire costs should be included in that cost of inaction. Have you or your colleagues quantified the financial costs associated with the greater burned area driven by climate change?

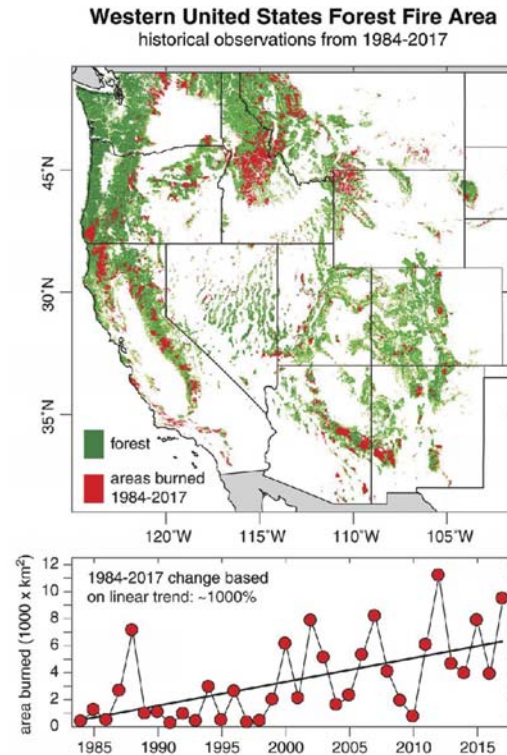
During my testimony on May 23, 2019, I summarized results of a recent review that my colleagues and I conducted evaluating the scientific evidence underpinning the EPA's "Endangerment Finding" for greenhouse gases.¹² As is summarized in that peer-reviewed paper, the area burned in the western United States has increased approximately tenfold since the mid-1980s (see attached figure). Further, evidence shows that "human-caused climate change caused over half of the documented increases in fuel aridity since the 1970s and doubled the cumulative forest fire area since 1984."¹³

These wildfires have proved very costly. For example, according to the National Oceanic and Atmospheric Administration (NOAA), the 2018 western wildfires had a CPI-adjusted cost of \$24.5 billion, while the 2017 western wildfires had a CPI-adjusted cost of \$18.7 billion.¹⁴

¹²Duffy, P.B., Field, C.B., Diffenbaugh, N.S., et al., 2019. Strengthened scientific support for the Endangerment Finding for atmospheric greenhouse gases. *Science*, 363(6427), eaat5982.

¹³Abatzoglou, J.T. and Williams, A.P., 2016. Impact of anthropogenic climate change on wildfire across western US forests. *Proceedings of the National Academy of Sciences*, 113(42), pp.11770–11775.

¹⁴NOAA Billion Dollar Weather and Climate Disasters, Table of Events: <https://www.ncdc.noaa.gov/billions/events/US/1980-2019>.



Area burned by wildfires in the western United States since the mid-1980s. (From Duffy, Field, Diffenbaugh, et al., *Science*, Vol. 363, Issue 6427, eaat5982, 2019.)

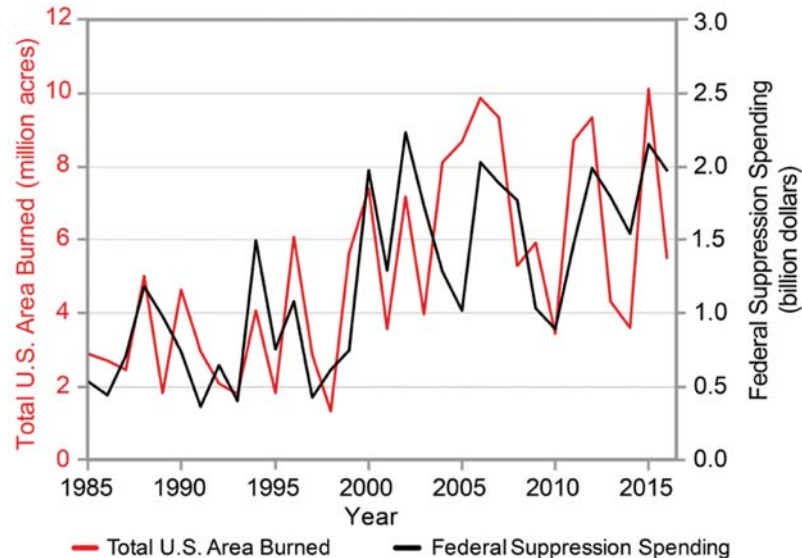
In addition to the high financial losses caused by catastrophic wildfires, we also know that the historical increases in area burned have been accompanied by rising costs of fire suppression. For example, as reported in the National Climate Assessment, both the total US burned area and federal spending on fire suppression have increased fourfold over the past 30 years, with suppression costs rising reaching approximately \$2 billion/year in recent years (see attached figure).¹⁵

Beyond the direct financial costs, it is also clear that wildfires have substantial health consequences. A recent review concluded that, “Consistent evidence from a large number of studies indicates that wildfire smoke exposure is associated with respiratory morbidity with growing evidence supporting an association with all-cause mortality.”¹⁶ This finding confirms what so many US citizens have experienced first-hand in recent years: that wildfires can have far-reaching health consequences beyond the geographic area where the fires occur. In addition, of relevance for decisions about the management of wildfire risks, evidence is now emerging that health impacts of wildfires are greater than health impacts of prescribed burns.¹⁷

¹⁵ *Fourth National Climate Assessment*, Chapter 6 “Forests”: <https://nca2018.globalchange.gov/chapter/6#fig-6-4>.

¹⁶ Reid CE, Brauer M, Johnston FH, Jerrett M, Balmes JR, Elliott CT. 2016. Critical review of health impacts of wildfire smoke exposure. *Environmental Health Perspectives* 124:1334-1343; <http://dx.doi.org/10.1289/ehp.1409277>.

¹⁷ Prunicki, M., Kelsey, R., Lee, J., Zhou, X., Smith, E., Haddad, F., Wu, J. and Nadeau, K., 2019. The impact of prescribed fire versus wildfire on the immune and cardiovascular systems of children. *Allergy*. DOI: 10.1111/all.13825.



Historical federal suppression spending (constant 2016 dollars) and total US area burned. (From the Fourth National Climate Assessment)

Although further research is needed to quantify and project the full costs of rising wildfire frequency in different areas of the US, we already have very strong evidence that wildfires are increasing, and anthropogenic climate change is contributing to that increase, and that costs associated with wildfires are increasing.

2. During the hearing, Rep. Levin asked the following question: "What types of projects and programs would you like to see in a discussion of a climate change resilient infrastructure bill?" You responded: "I would point you to the California Climate Safe Infrastructure Working Group, AB 2800, and our report that was released last summer." Please provide that report.

The reference for the report is:

Climate-Safe Infrastructure Working Group (CSIWG). 2018. Paying it forward: The Path Toward Climate-Safe Infrastructure in California. Report of the Climate-Safe Infrastructure Working Group to the California State Legislature and the Strategic Growth Council. Sacramento, CA: CNRA, Publication number: CNRA-CCA4-CSI-001.

The report is available from the California Natural Resources Agency at this website: <http://resources.ca.gov/climate/climate-safe-infrastructure-working-group/>.

Questions for the Record

Dr. Rachel Cleetus
Policy Director, Climate and Energy Program
Union of Concerned Scientists (UCS)

THE HONORABLE KATHY CASTOR

1. There was discussion in the hearing about the potential for the shift in magnetic poles to impact weather and whether natural variations have a greater or smaller impact on climate change than carbon emissions. What impact does the shift in magnetic poles have on weather and how does that compare to both natural variations and carbon emissions have on climate change?

The science is clear: human-caused emissions of heat-trapping gases are the dominant contributor to observed climate change since the mid-20th century, and natural variations cannot account for more than a marginal contribution.

The Fourth National Climate Assessment (NCA) is an authoritative summary of the latest climate science conducted by the US Global Change Research Program (USGCRP), which produces these reports on a regular basis under Congressional mandate.¹ Volume 1 of the Fourth NCA, the Climate Science Special Report, provides a clear answer to the question, and I quote below:

Many lines of evidence demonstrate that human activities, especially emissions of greenhouse gases, are primarily responsible for the observed climate changes in the industrial era, especially over the last six decades. Formal detection and attribution studies for the period 1951 to 2010 find that the observed global mean surface temperature warming lies in the middle of the range of likely human contributions to warming over that same period. The Intergovernmental Panel on Climate Change concluded that it is extremely likely that human influence has been the dominant cause of the observed warming since the mid-20th century. Over the last century, there are no alternative explanations supported by the evidence that are either credible or that can contribute more than marginally to the observed patterns. There is no convincing evidence that natural variability can account for the amount of and the pattern of global warming observed over the industrial era. Solar flux variations over the last six decades have been too small to explain the observed changes in climate. There are no apparent natural cycles in the observational record that can explain the recent changes in climate.

The US National Academy of Sciences and the UK Royal Society have put together a short reference document, *Climate Change: Evidence and Causes*, that also clearly lays out the current state of climate science for policymakers, decisionmakers and the public.² As the document notes:

"Scientists know that recent climate change is largely caused by human activities from an understanding of basic physics, comparing observations with models, and fingerprinting the detailed patterns of climate change caused by different human and natural influences. . . ."

The expected changes in climate are based on our understanding of how greenhouse gases trap heat. Both this fundamental understanding of the physics of greenhouse gases and fingerprint studies show that natural causes alone are inadequate to explain the recent observed changes in climate. Natural causes include variations in the Sun's output and in Earth's orbit around the Sun, volcanic eruptions, and internal fluctuations in the climate system (such as El Niño and La Niña). Calculations using climate models have been used to simulate what would have happened to global temperatures if only natural factors were influencing the climate system. These simulations yield little warming, or even a slight cooling, over the 20th century. Only when models include human influences on the composition of the atmosphere are the resulting temperature changes consistent with observed changes."

2. China's increasing emissions were raised in the hearing. Can you provide additional perspective on China's emissions and what impact they should or should not have on U.S. emissions targets or other U.S. climate policies?

Climate change is a global problem and it will require a concerted effort by the entire global community—especially the major emitting nations—to help address it. No one nation, whether it be the US or China, can tackle this on its own.

The reality is global emissions are still rising, at a time when they need to fall sharply. According to the IEA, in 2018 global energy-related carbon dioxide emissions were up 1.7% and hit a record high of 33.1 GtCO₂.³ China's emissions grew by 2.5% and US emissions by 3.1%. According to the EIA, US energy-related CO₂ emissions were up 2.8% in 2018, the largest increase since 2010.⁴

Clearly, both the US and China—and all major emitting countries—will need to cut emissions significantly if we are to meet our climate goals of limiting global temperature increase to well below 2°C, aiming for 1.5°C. The US can and must play a leadership role. One of the most impactful things we can do is stay committed to the Paris Agreement and work hard to implement it in a robust way, in cooperation with other countries including China. Unless we act boldly together, we will fail to meet our climate goals and future generations everywhere will suffer as a

¹ See <https://www.globalchange.gov/about> for the mandate of the USGCRP.

² See <http://dels.nas.edu/resources/static-assets/exec-office-other/climate-change-full.pdf>

³ See <https://www.iea.org/geco/>.

⁴ See <https://www.eia.gov/todayinenergy/detail.php?id=38133>.

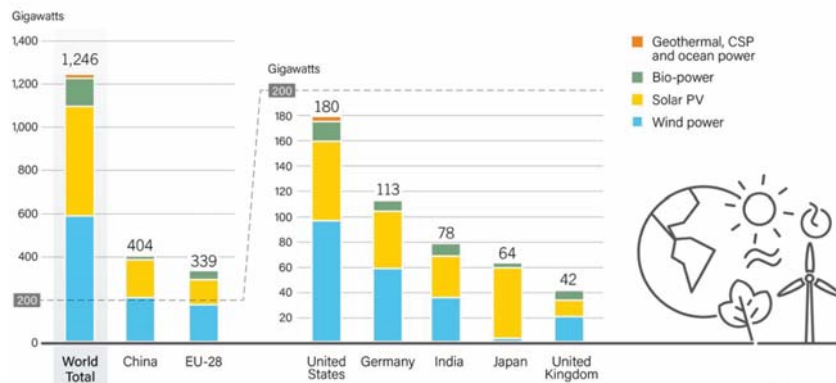
result. The urgency of the climate crisis requires that we face this challenge head-on and not retreat to insular ways of thinking.

The US and China are both global leaders in renewable energy and there is a huge opportunity to expand the global market in these technologies and create new jobs and economic opportunities in the process. Right now, the policy environment in the US is lagging and putting our nation at a competitive disadvantage. Now is the time to set ambitious targets for transitioning to a low-carbon economy and reaping all the economic, health and environmental benefits of doing so.

China is both a global leader in renewable energy deployment and, unfortunately, in coal consumption. The US similarly has seen a big surge in renewable energy over the last decade but 2018 also saw the nation reach new records in the production, consumptions and export of fossil fuels.⁵

In 2018, China was responsible for 32% of all new renewable power investments (see figure 1).

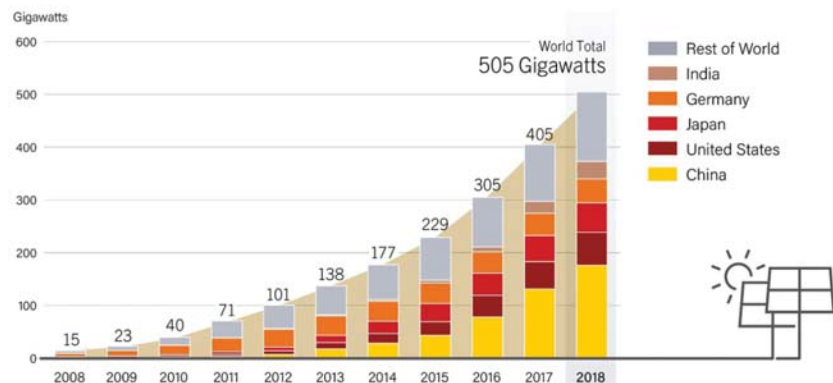
Renewable Power Capacities in World, EU-28 and Top 6 Countries, 2018



Source: REN21⁶

It also led in solar PV installations (see figure 2)

Solar PV Global Capacity, by Country and Region, 2008-2018



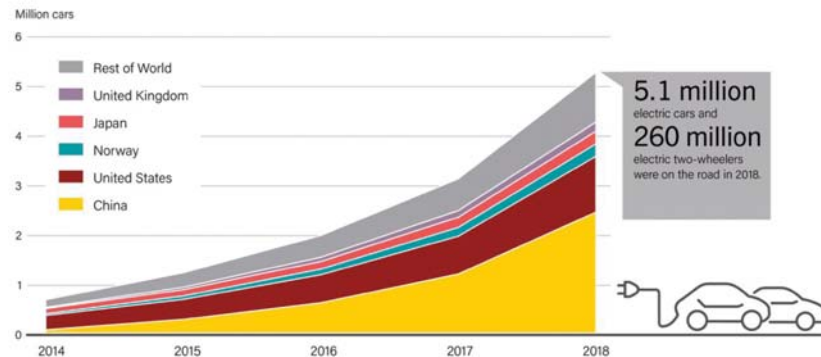
Source: REN21

China is also leading the world in electric vehicle deployment (see figure 3)

⁵ See <https://www.eia.gov/todayinenergy/detail.php?id=39392>.

⁶ See <http://www.ren21.net/gsr-2019/>.

Figure 3:
Electric Car Global Stock, Top 5 Countries and Rest of World, 2014-2018



Source: REN21

3. The minority witness, Mr. Keith Hodges, testified that government regulations promulgated under the Clean Water Act and other environmental protections are a barrier to creating communities that are resilient to flooding. Are environmental regulations barriers to protecting communities from the impacts of climate change?

In short: no. In fact, environmental standards that help preserve natural ecosystems like wetlands, mangroves, barrier islands and vegetation can help reduce the harms and costs of flooding to communities in a very cost-effective and sustainable way. It would be very misguided to try to address flooding—which is worsening due to sea level rise and extreme precipitation driven by climate change—by eroding environmental protections. For more on the value of green infrastructure in protecting against flooding, please see resources from the EPA and NOAA.⁷

THE HONORABLE SUZANNE BONAMICI

1. According to the Oregon Climate Change Research Institute's Fourth Climate Assessment, in 2015 the Northwest experienced its warmest year on record. Temperatures were about 3.4 degrees Fahrenheit above normal. Snowpack in Oregon was the lowest on record, at more than 89 percent below average. Precipitation from January to June 2015 was nearly five inches below average. In addition to producing the largest harmful algal bloom recorded on the West Coast, these conditions also led to low water levels and warmer water temperatures. As a result, there were widespread losses for our fisheries, including hundreds of thousands of sockeye salmon in the Columbia River.

Dr. Cleetus, can you discuss the effects of warming temperatures and decreased snowpack and precipitation on the larger ecosystem, particularly our endangered fisheries, in the Northwest? How will climate change affect species in the future?

As with the rest of the nation and the world, Oregon residents are experiencing impacts from global warming, resulting from the buildup of heat-trapping emissions in the atmosphere. The average annual temperature in the Pacific Northwest has risen by at least 1.5°F since the first half of the 20th century, and winter minimum temperatures have increased by more than 4.5°F.

Forest mortality is rising in Oregon.⁸ Wildfires are becoming more frequent and intense, and the costs to fight them are growing. In 2018, the price tag reached more than \$514 million. More than 132,000 Oregon homes were at high or extreme risk of damage from wildfire in 2018.⁹

⁷ See <https://www.epa.gov/green-infrastructure/manage-flood-risk> and <https://coast.noaa.gov/digitalcoast/training/gi-cost-benefit.html>.

⁸ Abatzoglou, J.T., and A.P. Williams. 2016. Impact of anthropogenic climate change on wildfire across western US forests. *Proceedings of the National Academy of Sciences* 113(42):11770–11775. Online at <http://doi.org/10.1073/pnas.1607171113>, accessed December 18, 2018.

⁹ CoreLogic. 2018. CoreLogic wildfire risk data. Irvine, CA.

Higher temperatures and changes in precipitation already significantly affect water resources in the Northwest. Since 1955, parts of Oregon have experienced a decrease in average snowpack on April 1 of more than 70 percent.¹⁰ Winter snow accumulation in the mountains is a natural water storage system on which Oregon relies during its drier summer months, most critically for agriculture. Snowpack decline is projected to continue as more winter precipitation falls as rain rather than snow throughout much of the Pacific Northwest.¹¹ Snow already melts as much as 30 days earlier than in the mid-20th century, reducing summer stream flows in many of the Northwest's snow-fed rivers.

The increasing acidity of ocean surface waters is also damaging marine life. About 40 percent of the human-produced carbon dioxide released to the atmosphere over the last 250 years is now dissolved in the oceans, where it reacts chemically to make seawater more acidic and corrosive.¹² Many types of shellfish are very sensitive to the effects of ocean acidification, posing potential risks to the fishing industry. For example, altered ocean chemistry contributed to declines in hatchery production near Oregon's Netarts Bay due to the softening of oyster shells at the largest independent producer of seed oysters in the Pacific Northwest.¹³ Increased ocean acidification is projected to continue altering the marine food web by decreasing the abundance of shell-forming species, which in turn threatens Pacific salmon and other culturally and commercially significant marine species.¹⁴

According to the Fourth National Climate Assessment:¹⁵

- *The negative impacts on Northwest fisheries associated with ocean warming, acidification, and harmful algal blooms are expected to increase. This could lead to extensive fisheries closures across all of the region's coastal fisheries, with severe economic and cultural effects on commercial and subsistence shellfish industries.*
- *Projections for increased stream temperature indicate a 22% reduction in salmon habitat in Washington by late century under a high emissions future.*

For more on the risks and solutions for climate change in Oregon, please see a recent UCS factsheet, *Confronting Climate Change in Oregon*.¹⁶ See also the Fourth National Climate Assessment, Volume II, Chapter 24 which is focused on the Northwest.¹⁷



¹⁰ Mote, P.W., S. Li, D.P. Lettenmaier, M. Xiao, and R. Engel. 2018. Dramatic declines in snowpack in the western US. *npj Climate and Atmospheric Science* 1(1):2. Online at <http://doi.org/10.1038/s41612-018-0012-1>, accessed December 18, 2018.

¹¹ Wehner, M.F., J.R. Arnold, T. Knutson, K.E. Kunkel, and A.N. LeGrande. 2017. Droughts, floods, and wildfires. In *Climate science special report: Fourth National Climate Assessment*, volume I, edited by D.J. Wuebbles, D.W. Fahey, K.A. Hibbard, D.J. Dokken, B.C. Stewart, and T.K. Maycock. Washington, DC: US Global Change Research Program. Online at <http://doi.org/10.7930/J0CJ8BNN>, accessed December 18, 2018.

¹² DeVries, T., M. Holzer, and F. Primeau. 2017. Recent increase in oceanic carbon uptake driven by weaker upper-ocean overturning. *Nature* 542(7640):215-218. Online at www.nature.com/articles/nature21068, accessed January 2, 2019. doi:10.1038/nature21068.

¹³ Barton, A., G.G. Waldbusser, R.A. Feely, S.B. Weisberg, J.A. Newton, B. Hales, S. Cudd, B. Eudeline, C.J. Langdon, I. Jefferds, T. King, A. Suhrbier, and K. McLaughlin. 2015. Impacts of coastal acidification on the Pacific Northwest shellfish industry and adaptation strategies implemented in response. *Oceanography* 28(2):146-159. Online at <http://dx.doi.org/10.5670/oceanog.2015.38>, accessed December 18, 2018.

¹⁴ Dalton, M.M., K.D. Dello, L. Hawkins, P.W. Mote, and D.E. Rupp. 2017. The third Oregon climate assessment report. Corvallis, OR: Oregon Climate Change Research Institute. Online at https://pnwcirc.org/sites/pnwcirc.org/files/ocar3_finalweb.pdf, accessed December 13, 2018.

¹⁵ <https://nca2018.globalchange.gov/chapter/24/>.

¹⁶ See <https://www.ucsusa.org/sites/default/files/attach/2019/01/Confronting-Climate-Change-Oregon-2019-final.pdf>.

¹⁷ See <https://nca2018.globalchange.gov/chapter/24/>.