

**Written Testimony of Dr. Noah S. Diffenbaugh
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**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 Stanford’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

¹ Duffy, 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.

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.)

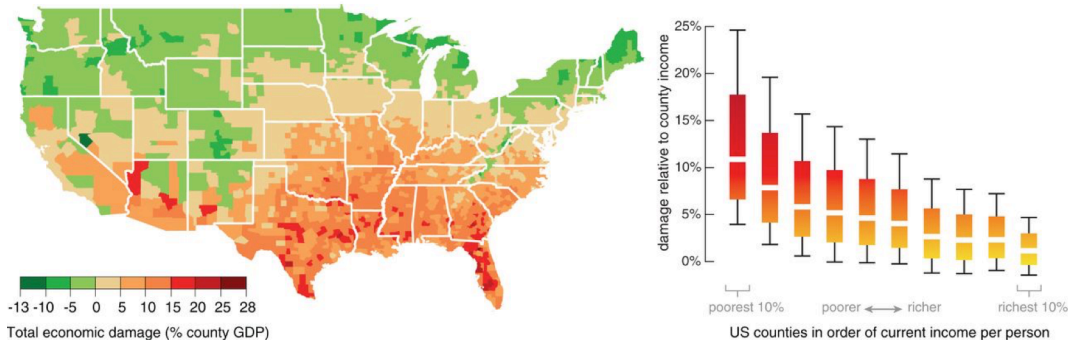
level rise and coastal areas; (7) energy, infrastructure and settlements; and (8) ecosystems and wildlife.

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

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.

Economic Damage from Climate Change in United States Counties
 damage projected for 2080-2099 of RCP8.5



Economic damage aggregated over agriculture, crime, coastal storms, energy, human mortality, and labor in a scenario of continued high global greenhouse gas emissions. (From Duffy, Field, Diffenbaugh, et al., *Science*, Vol. 363, Issue 6427, eaat5982, 2019.)

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.

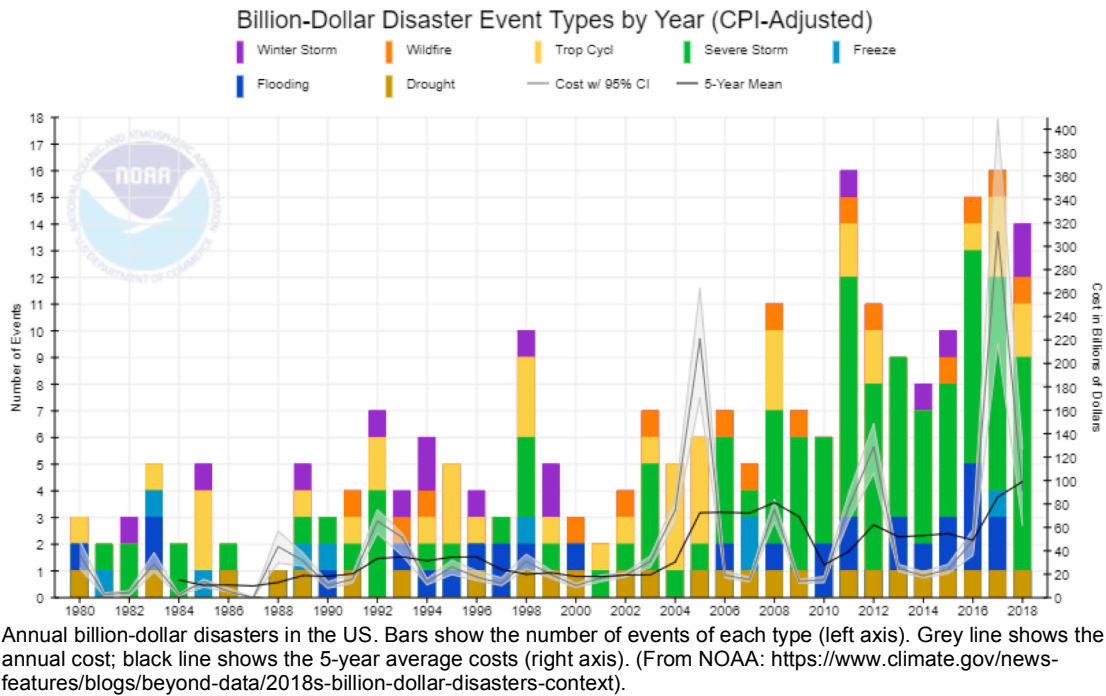
Here in the US, we are already experiencing rising economic costs from extreme events. As American citizens suffer through heatwaves, droughts, floods, hurricanes and wildfires, there is now clear evidence that the frequency of extremes is increasing, and that the costs are rising. In particular, the 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 Houston rainfall that occurred during Hurricane Harvey⁶. My research⁷ shows that global warming has already increased the

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.

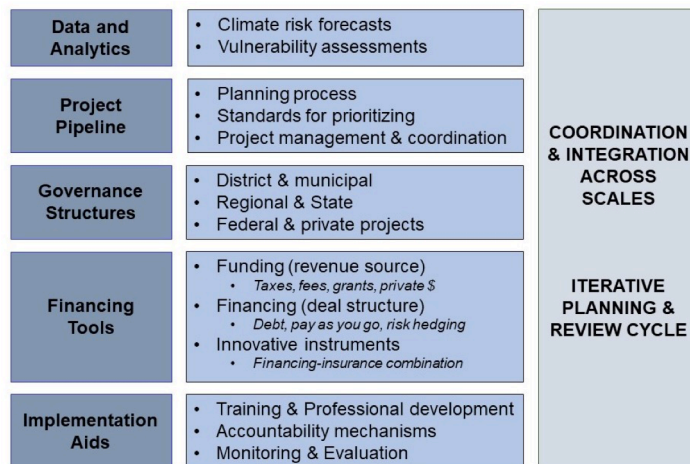
⁵ Diffenbaugh, N.S., Swain, D.L. and Touma, D., 2015. Anthropogenic warming has increased drought risk in California. *Proceedings of the National Academy of Sciences*, 112(13), pp.3931-3936.

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.



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



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.)

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.

throughout the state.

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 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.

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.