Written Testimony of Diana M Liverman
Regents Professor of Geography and Development
University of Arizona

Hearing on "Solving the Climate Crisis: Drawing Down Carbon and Building Up the American Economy"
United States House Select Committee on the Climate Crisis

April 30th 2019

Good morning. Chairwoman Castor, Ranking Member Graves, and members of the committee, thank you for the invitation to testify at today's hearing.

My name is Diana Liverman and I am a Regents Professor of Geography and Development at the University of Arizona. I have studied climate for 4 decades beginning with my graduate work on climate change and food security at UCLA and the National Center for Atmospheric Research in Colorado, and in faculty positions at the University of Wisconsin, Penn State, Oxford University, and the University of Arizona. I am an expert on the impacts of climate on society and on climate adaptation.

Although I have been a US citizen for decades, I have retained my British accent because my students tell me it helps them pay more attention in lectures.

When 40 years ago, as a student, I first heard that human activities were increasing greenhouse gases, CO_2 was around 335ppm, 25% above a baseline prior to the Industrial Revolution[1]. I learned that if we continued to emit CO_2 and doubled concentrations, global temperatures could warm more than 3°C.

My graduate work at UCLA showed that this could have serious impacts on food security and on crop yields in the US and across the world.

Since then, the rise in CO_2 has continued. Now, 4 decades later, the increase in greenhouse gas concentrations, has brought us to almost 410ppm, a 50% increase over the baseline. We have already seen the onset of warming of more than 1°C global average (1.8°F) and we are headed for more than 3°C (5.4°F) if trends continue.

In my hometown of Tucson, I have observed how warming is increasing extreme heat and fire risks, bringing more intense storms, threatening water supplies from the Colorado River and altering ecosystems. Climate change is affecting our most vulnerable or historically disadvantaged citizens – the poor, the elderly, and children, tribal members, farm and construction workers who labor outside – who cannot escape the heat or afford the increased air conditioning and water costs.

I welcome the interest of this committee in what can be done to reduce the risks of dangerous climate changes.

[1] *Climate.gov*

The IPCC SR1.5°C

I have been asked to speak to the committee about the recent special report of the Intergovernmental Panel on Climate Change (IPCC) on Global Warming of 1.5°C[2]. I was a lead author, nominated by the US government, of Chapter 5 of the main report and I also contributed substantially to the Summary for Policy Makers. I have also contributed to the US National Climate Assessment (NCA). I include the IPCC Summary for Policy Makers and the Southwest chapter of the US National Climate Assessment as appendices to my testimony.

In its decision on the adoption of the Paris Agreement in 2015, the Conference of Parties (COP) to the United Nations Framework Convention on Climate Change invited the IPCC to provide a special report on the impacts of global warming of 1.5°C. The IPCC accepted this invitation and released this special report in October 2018. 1.5C converts to 2.7°F. I will use 1.5°C in referring to the report.

The report is the product of a team of 91 authors and editors from 40 countries. We assessed more than 6,000 scientific studies and received over 40,000 comments from governments, scientists, and expert reviewers that helped us improve the report.

The IPCC special report responds to the government approved outline that asks several key questions:

> *What are the warming trends and impacts and how close are we to 1.5°C already?*
> *Is there a significant difference between a global average warming of 1.5°C and one of 2°C?*
> *What would it take in terms of emission cuts to limit warming to 1.5°C?*
> *What are the implications for sustainable development?*

The full report is more than 250 pages and has a 31-page Summary for Policy Makers, which was approved by the 195-member governments of the IPCC Panel as an accurate summary of the underlying scientific report, which is included as part of my written testimony. Below, I summarize some of the key findings of the report that may be of interest to this committee.

---

[2] IPCC, 2018: Summary for Policymakers. In: *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty* [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, Maycock, M. Tignor, and T. Waterfield (eds.)]. *World Meteorological Organization, Geneva, Switzerland, 32 pp.*

IPCC, 2018. Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. In Press.

The earth has already warmed on average by 1°C (1.8°F) and we are already seeing impacts and losses from this warming

Warming is greater over land regions, especially the Arctic. In the US warming has been greatest in Alaska, New Mexico, and Arizona (Figure 1). In the Southwest US and California, the annual average temperature has increased by 1.6°F between 1901 and 2016, with parts of southern California and Arizona warming more than 4°F[3]. In the Colorado River Basin, drought, high temperatures due mainly to climate change have contributed to lower runoff and to 17%–50% of the record-setting streamflow reductions between 2000 and 2014 (Figure 2).

These changes are detectable in how we feel out of doors, how much water we use to irrigate farms and gardens and in our air conditioning bills. Tucson now has almost 17 more days above 105°F and 25 days above 100°F than in 1970. This warming has increased the risk of drought and wild fires (Figure 3) and is especially tough on those who work outdoors, occupy poor quality housing, or who find it hard to pay their utility bills. There is stress on the electrical grid from increased demand, from wildfire risk, and from operating inefficiencies at high temperature.

The IPCC and the 4th US National Climate Assessment (NCA4) provide comprehensive assessments of the scientific literature. The Special Report on warming of 1.5°C and the National Climate Assessment concluded that scientific studies show that warming so far has increased the risks of species extinction, shifted agricultural zones and risks, affected human health, and increased the risks and intensity of some natural disasters.

Figure 1: Warming since 1901 in SWUSA (source Fig 25.1)

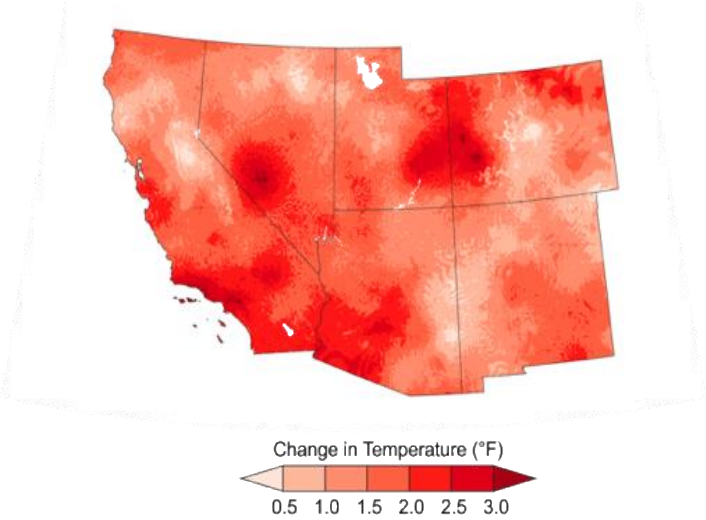
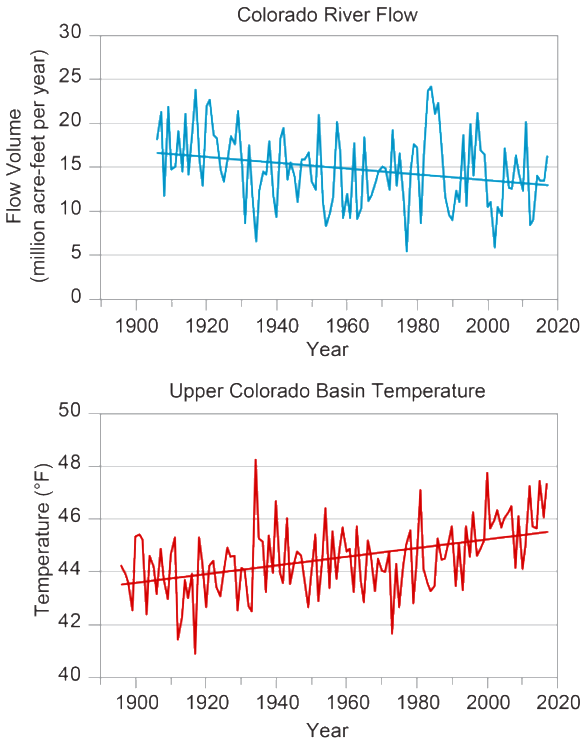


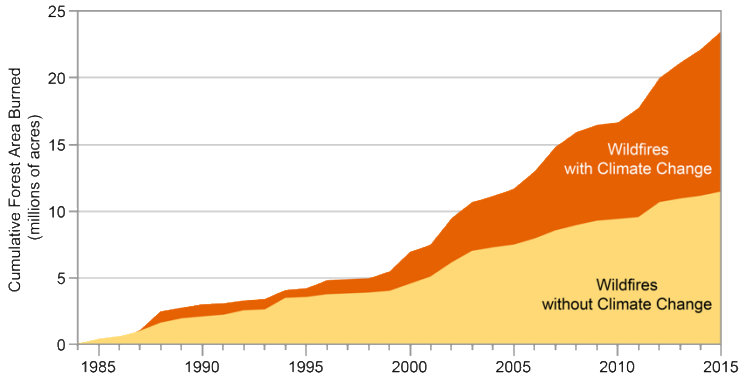
Figure 2: Changes in flow of Colorado and temperature change since 1900 (Source NATOINAL CLIMATE ASSESSMENT4, Fig 25.3)



[3] Gonzalez, P., G.M. Garfin, D.D. Breshears, K.M. Brooks, H.E. Brown, E.H. Elias, A. Gunasekara, N. Huntly, J.K. Maldonado, N.J. Mantua, H.G. Margolis, S. McAfee, B.R. Middleton, and B.H. Udall, 2018: Southwest. In Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment (**NCA4**), Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 1101–1184. doi: 10.7930/NCA4.2018.CH25

US communities and businesses are already making costly adaptations to cope with observed warming, including relocating away from coasts, reinforcing infrastructure, and increasing overall resilience to climatic extremes[4]. Internationally, warming is undermining decades of investment in economic development, and these international impacts are disrupting supply chains for US business and are of concern to national security.

Figure 3: Area burned by wildfires across Western US 1984-2015 (Source: Fig 25.4 NCA4)

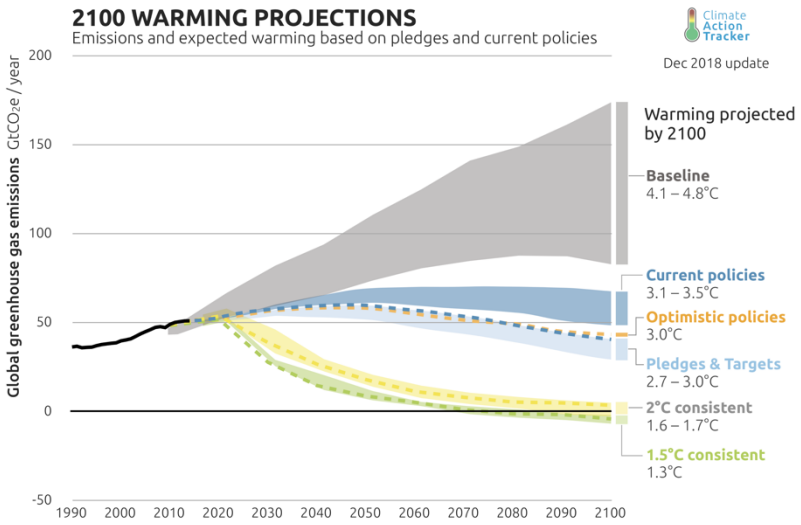


We are not on track if we want to limit warming to 1.5°C

Global warming is likely to reach 1.5°C between 2030 and 2052 if the current warming rate continues. Because greenhouse gases remain in the atmosphere for decades or more, and oceans store heat for many decades, additional warming is guaranteed. But as the IPCC report states, if we stopped emissions today, we could limit climate change to under 1.5°C.

The Paris Agreement provides an international framework for collective commitments to reduce and monitor emissions and adapt to climate change. The IPCC concluded that the voluntary commitments pledged only limit warming to 3°C (5.4°F), much warmer than 1.5°C (Figure 4). The Paris agreement does assume commitments to reductions will increase and provides the framework for taking stock and ratcheting up commitments over time.

*Figure 4: Projected emissions and temperatures based on current policies and pledges (Source: Climate Action Tracker, Dec 2018)_*



[4] Lempert, R., J. Arnold, R. Pulwarty, K. Gordon, K. Greig, C. Hawkins Hoffman, D. Sands, and C. Werrell, 2018: Reducing Risks Through Adaptation Actions. In Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 1309–1345. doi: 10.7930/NCA4.2018.CH28

Every bit of warming matters

The IPCC was asked whether there was a difference between 1.5°C and 2°C warming (2.7°F and 3.6°F). We concluded that every bit of warming matters. There are higher risks for natural and human systems at 1.5°C compared to the present, and those risks increase if warming rises above 1.5°C to 2°C. A half a degree extra global average warming from 1.5°C to 2°C would mean greater increases in temperature for most land and ocean regions, increases in heat extremes, and increases in the risk of droughts in some regions.

Sea level rise by 2100 would be between 10 and 30 inches at 1.5°C and 4-6 inches more at 2°C with added risk if ice sheets become unstable. Even a few inches of sea level rise increase the risks of coastal flooding, saltwater intrusion, and damage to infrastructure. The Arctic would be ice free in summer once per century at 1.5°C compared to once per decade at 2°C.

The impacts on ecosystems and natural resources are projected to be higher at 2°C than 1.5°C. The IPCC cites studies suggesting that the loss of habitat for many insects, plants, and animals doubles from 1.5°C to 2°C. Fire risk is lower at 1.5°C and fisheries are less disturbed. At 1.5°C we lose about 70% of corals, at 2°C they disappear.

2°C compared to 1.5°C increases the people who are poor and vulnerable by several hundred million, increases the risks of heat related deaths and disease, and increases the incidence and geographic shifts in malaria and dengue in some regions. Water stress is higher by up to 50% in many regions at 2°C. In many regions, including the southern parts of the US, warming reduces crop yields and stresses livestock, with greater stress on agriculture at 1.5°C than 2°C. Warming shifts some crop zones to higher latitudes and lengthens the growing season but these increases in crop production do not balance the agricultural losses at either 1.5°C or 2°C.

Adaptation is an important option – it can reduce losses now and at 1.5°C, but may reach some limits at higher temperatures

We are already seeing adaptation to a warmer climate across the world, and the US, in response to the warming climate. In the Southwest of the US, the University of Arizona is working with water managers, conservation scientists, farmers and communities to develop and implement solutions that reduce the risks of climate change. Both the IPCC report and the 4th US National Climate Assessment identify a broad range of ongoing and feasible adaptations that include reinforcing infrastructure such as coastal protection and energy systems, increasing water use efficiency in cities and farms, designing cities and buildings for warmer temperatures, improving disaster warning and insurance, and protecting natural ecosystems.

Limiting warming to 1.5°C makes adaptation easier and less costly than if we warm to 2°C or higher. At 2°C risks from rising seas, drought, and heatwaves are higher and would require more investment, innovation, and even relocation to avoid losses than at warming of 1.5°C.

If temperatures rise higher than 2°C we can encounter limits to adaptation when, for example, heat stress means that crops, livestock and wildlife can no longer survive in a particular location or when sea level rise and severe storms mean that facilities and communities must relocate away from coast. The loss when families lose their farms, a species becomes extinct, or a community abandons their land, is immeasurable and irreparable.

It is possible to effectively link reducing emissions to adapting to warming. There are response options, such as building design for lower emissions and higher temperatures, or farming for carbon sequestration and water conservation, that are wins for both adaptation and emission reductions. Research suggests that the synergies - the possibilities for win-win solutions - are greater when adaptation and mitigation are considered together.

Limiting warming to 1.5°C is possible

The IPCC report finds that it is possible to limit warming to 1.5°C if we make steep cuts in emissions and make a transition to a lower carbon energy system. For a good chance to stay under 1.5°C, emissions would need to be cut in half by 2030 and be net zero by 2050 (Figure 5).

The IPCC report suggests that these emission cuts can be achieved through an ambitious and exciting portfolio that increases energy efficiency and investment in renewables, reduces dependence on fossil fuels, supports forestry and land uses that sequester carbon, and develops bioenergy and carbon sequestration and storage. We looked at a range of possible trajectories for reducing warming with more or less immediate, or steep, declines in emissions and different levels of reliance on technologies to remove carbon dioxide from the atmosphere. These technologies include bioenergy and carbon capture and storage (BECCS/CCS) which, the IPCC, concludes are not yet viable for rapid deployment.

Figure 5: Illustrative pathway P2 that limits global warming to 1.5C with no or limited overshoot. Percent change is relative to 2010 (based on Fig SPM3b, IPCC SR1.5, 2018)

Action	2030	2050
Emissions	-47%	-95%
Energy Demand	-5%	2%
Energy from Coal	-61%	-77%
Energy from Oil	-13%	-50%
Energy from Gas	-20%	-53%
Energy from Nuclear	+83%	+98%
Energy from renewables (wind, solar, hydro, geothermal)	+470%	+1327%
Forests, CCS+Bioenergy	+348 GT	+151 GT

All scenarios include a decline in other greenhouse gas emissions, including methane, black carbon and nitrous oxide emissions. The pathways that provide the best chance of limiting global warming to 1.5°C are those that cut CO_2 emissions by 41% to 58% between 2010 and 2030. The amount of CO_2 we need to reduce depends on how much we reduce other greenhouse gases, such as methane and nitrous oxides, and how much we improve our carbon capture, through bioenergy or carbon capture and storage. Reducing our emissions dramatically by 2030 is a necessary step in order to reach the net zero CO_2 emissions needed by 2050 to meet the 1.5°C target. Net zero emissions are when remaining CO_2 emissions are balanced by removing CO_2 from the air with vegetation uptake or carbon capture.

The IPCC report evaluated the feasibility and impacts of a full range of response options to reach the 1.5°C target and the tradeoffs that occur with each scenario. For example, the expansion of bioenergy and forests would reduce emissions, but it would also reduce land available for crops and pasture.

To reach these reductions in CO_2, rapid and far-reaching transitions in energy, land, urban and infrastructure, and industrial systems will be needed. Many of these changes are already underway. These transformations can be achieved through a range of actions and policies, such as a carbon price combined with a shift and increase in investment. Current global energy investment is estimated at $2.3 trillion, about 1/3 in renewables and energy efficiency, and would need to increase to about $3 trillion, with 2/3 in renewables and efficiency, to limit warming to 1.5°C. These extra costs are balanced by the significant reduction in impacts and losses if we make the investments.

The IPCC economic impact projections show that limiting warming to 1.5°C rather than 2°C would avoid $15-38 trillion in damages by the end of the century (IPCC SR1.5 Section 3.5.2.4 and Box 6) with more serious impacts in developing countries. The report cites papers finding that economic damages in the US will be 0.2%-0.6% higher at 2° than 1.5°C. According to the 4th National Climate Assessment, the US could lose 2.3% of GDP per degree of warming (Figure 6).

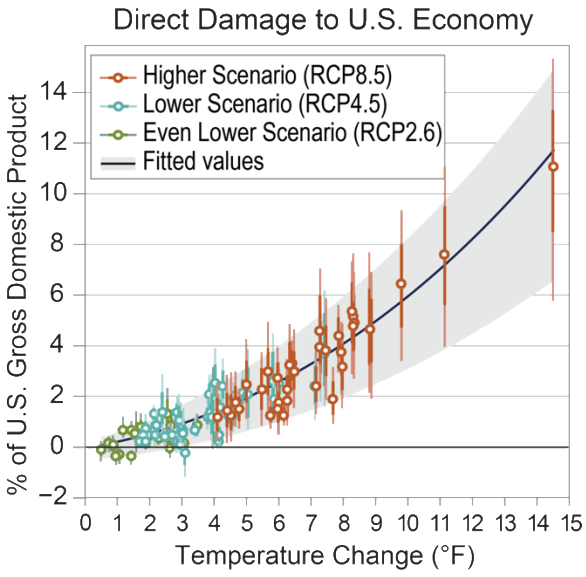


Figure 6: Projections of direct damage to the US economy as a function of global average temperature change from multiple models. The RCP2.6 scenario is closest to a pathway limiting warming to 1.5°C. The dots are the median damages and the whiskers show the range of results (NCA4 2018, Figure 29.3).

The US is already showing momentum through historic transformations in the power sector with growth in renewables, electric vehicles, and efficiency, and our potential for technology innovation.

There are additional opportunities for the US to capture emissions in well managed forest and agricultural systems which store carbon. The 4th National Climate Assessment highlights the role of increasing forest area and increasing soil carbon storage in reducing greenhouse gas emissions (Chapter 5) supported by the Second State of the Carbon Cycle in North America report[5].

The IPCC report focuses on the global scale of emission cuts needed to limit warming to 1.5°C and the options for changes across different sectors, such as energy, land and technology, but it does not specify the country by country reductions needed. For example, one scenario suggests a 47% cut in CO_2 emissions is needed between 2010 and 2030 (20 years). Since we are in 2019 that translates into at least halving emissions in the next 11 years. But IPCC does not suggest who should make those cuts in emissions. Various options are examined in the research literature including equal percent, absolute allocations according to current shares of emissions, per capita emissions, historical emissions, consumption-based emissions, and capabilities. Many of these options place an even steeper emission cut on the US.

Delaying emission reductions could be costly

To summarize the key messages from the IPCC Special Report on 1.5°C: The world has already warmed by an average of 1°C with significant impacts and every bit of extra warming will bring greater losses. To have a chance of limiting warming to 1.5°C, we need to halve emissions by 2030 in order to reach net zero emissions by 2050. And to respond to the negative impacts of warming already underway and anticipated, we need to devote considerable thought and resources to adaptation.

The IPCC report recommends that the best change of limiting climate change to 1.5°C requires dramatic action now. If we choose to delay the emission reductions we may lose the chance to stay under 1.5°C, or will have to make deeper and more expensive cuts in emissions, rely on untested technologies, experience greater losses, or adapt to higher temperatures.

Halving emissions by 2030, starting now, sets us on the path to success. While the world itself will not end if we do not make these emission cuts by 2030, that world will be much harder for us to live in.

[5] USGCRP, 2018: Second State of the Carbon Cycle Report (SOCCR2): A Sustained Assessment Report [Cavallaro, N., G. Shrestha, R. Birdsey, M. A. Mayes, R. G. Najjar, S. C. Reed, P. Romero Lankao, and Z. Zhu (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, 878 pp., https://doi.org/10.7930/SOCCR2.2018.