Government Climate & Energy Policies Must Target <350 ppm Atmospheric CO_2 by 2100 to Protect Children & Future Generations

INTRODUCTION

Human laws can adapt to nature's laws, but the laws of nature will not bend for human laws. Government climate and energy policies **must** be based on the best available science to protect our climate system and vital natural resources on which human survival and welfare depend, and to ensure the fundamental rights of young people and future generations are protected.

Because carbon dioxide (CO_2) is the primary driver of Earth energy imbalance (EEI), climate destabilization, and ocean warming and acidification, all government policies regarding CO_2 emissions and CO_2 sequestration should be aimed at reducing global CO_2 concentrations **below 350 parts per million (ppm) by 2100**. Earth's atmospheric CO_2 level, as of 2022, was approximately 419 ppm and rising.[1] With timely action, an emission reductions and sequestration pathway back to <350 ppm could stabilize long-term heating this century at ~1°C above pre-industrial temperatures with further reductions next century.[2] The temperature of the Earth, much like sea-level rise,[3] is a measurable indicator of the CO_2 problem, but it is not a good metric for solving it. EEI and atmospheric CO_2 levels provide measurable standards, with CO_2 emission reductions and sequestration the measurable means to meet those standards.

The current situation highlights the need to reduce carbon dioxide concentrations below 350 ppm, not solely limit future emissions. Emissions must be eliminated in the coming decades. And our carbon sinks must be protected to drawdown more atmospheric CO_2. The world is already too hot to sustain much of the cryosphere. This is akin to taking an ice cube out of the refrigerator. Going above 350 ppm carbon dioxide in the atmosphere was the action that took the ice cube out of the refrigerator; the ice will now inevitably melt. The question then is how warm is our kitchen? Will the ice cube melt in 5 or 20 minutes? But melt it will unless we put the ice cube back in the freezer by reducing carbon dioxide below 350 ppm.

As explained in more detail below, there are numerous scientific bases and lines of evidence supporting setting <350 ppm by 2100 as the uppermost safe limit for atmospheric CO_2 concentrations and global warming. Beyond 2100, atmospheric CO_2 will need to return to well below 350 ppm and closer to the preindustrial level of ~280 ppm to prevent the complete melting of Earth's ice sheets and protect coastal cities from sea-level rise.[4] Fortunately, it is still not only technically and economically

[1] Ed Dlugokencky & Pieter Tans, NOAA/GML, www.esrl.noaa.gov/gmd/ccgg/trends/.
[2] In February 2022, the Working Group (WG) II of the Intergovernmental Panel on Climate Change (IPCC) reported that only less than 1.1°C of warming above preindustrial temperatures could be considered a "safe climate" with "dignified living standards for all." IPCC, *Technical Summary*, *in* Climate Change 2022: Impacts, Adaptation and Vulnerability, 79 (2022).
[3] Peter U. Clark et al., *Sea-Level Commitment as a Gauge for Climate Policy*, 8 Nature Climate Change 653 (2018).
[4] Peter U. Clark et al., *Consequences of Twenty-First-Century Policy for Multi-Millennial Climate and Sea-Level Change*, 6 Nature Climate Change 360 (2016).

feasible to return to <350 ppm by 2100 but also transitioning to clean energy sources will provide significant economic and public health benefits and improve quality-of-life.

WHY GOVERNMENTS MUST AIM FOR <350 PPM AND RESTORING EARTH ENERGY BALANCE

Three lines of robust and conclusive scientific evidence, based on the paleoclimate record and real-world observations, show that above an atmospheric CO_2 concentration of 350 ppm there is: 1) significant EEI; 2) massive ice-sheet destabilization and sea-level rise; and 3) ocean warming and acidification resulting in the bleaching death of coral reefs and other marine life.

1) Earth Energy Imbalance

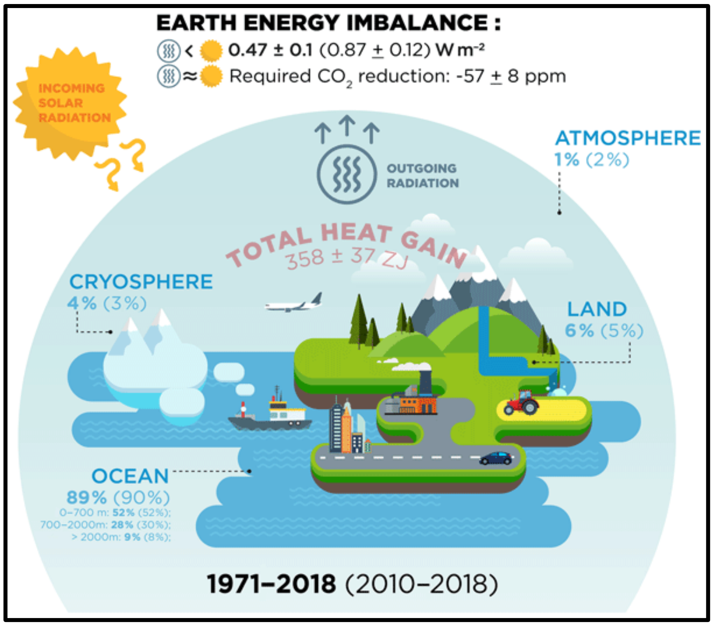

Figure 1: Earth heat inventory for Earth energy imbalance at the top of the atmosphere.

Scientists say the "Earth energy imbalance (EEI) is the most critical number defining the prospects for continued global warming and climate change,"[5] which is echoed in the 2021 WGI IPCC 6th assessment report.[6] "Stabilization of climate, the goal of the universally agreed United Nations Framework Convention on Climate Change (UNFCCC) in 1992 and the Paris Agreement in 2015, requires that EEI be reduced to approximately zero to achieve Earth's system quasi-equilibrium."[7] Earth's energy flow is significantly out of balance. Because of a buildup of CO_2 (and to a lesser extent other greenhouse gases) in our atmosphere, due to human activities, primarily the burning of fossil fuels and deforestation,[8] more solar energy is retained in our atmosphere and less energy is released back into space.[9] (Figure 1.)[10] The measured imbalance from 2010 to 2018 (0.87 ± 0.12 Wm^{-2}) was approximately double the imbalance from 1971 to 2018.[11]

Returning CO_2 concentrations to below 350 ppm would restore the energy balance of Earth by allowing as much heat to escape into space as Earth receives from the Sun, an important historic balance that has kept our planet in the sweet spot for the past 7,000 years, supporting stable sea level

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[5] Karina von Schuckmann et al., *Heat Stored in the Earth System: Where Does the Energy Go?*, 12 Earth Sys. Sci. Data. 2013 (2020) [hereinafter *Heat Stored in the Earth System*] (written by 38 international experts, including lead IPCC authors).
[6] Piers Forster et al., *The Earth's Energy Budget, Climate Feedbacks, and Climate Sensitivity*, *in* Climate Change 2021: The Physical Science Basis 14 (2021).
[7] von Schuckmann, *Heat Stored in the Earth System.*
[8] IPCC, *Summary for Policymakers, in* Climate Change 2014: Synthesis Report (2014).
[9] James Hansen et al., *Assessing "Dangerous Climate Change": Required Reduction of Carbon Emissions to Protect Young People, Future Generations and Nature*, 8 PLOS ONE e81648 (2013) [hereinafter *Assessing* "*Dangerous Climate Change*"].
[10] von Schuckmann, *Heat Stored in the Earth System*.
[11] *Id.*

and coastlines, enabling productive agriculture, and allowing humans and other species to thrive.[12] The paleoclimate record shows that CO_2 levels, temperature, and sea level all move together (Figure 2).[13] Humans have caused CO_2 levels to rise to levels unprecedented in human existence[14] and the past 3 million years, causing the EEI.[15] The last time atmospheric CO_2 levels were this high, the Hominin "Lucy" (*Australopithecus*) inhabited what is today Ethiopia.[16] The current anthropogenic rate of CO_2 emissions eclipses all prehistoric rates of carbon emissions that nevertheless resulted in global hyperthermal periods and contributed to mass extinctions of 90% of life on the planet and the end of the dinosaurs.[17]

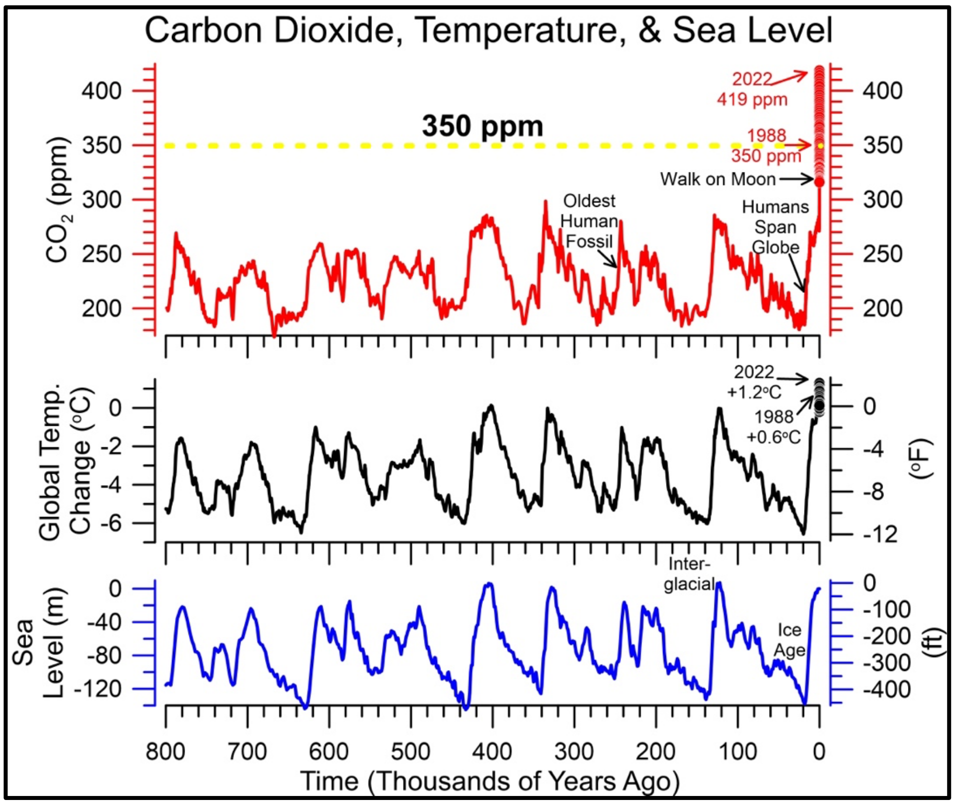

Figure 2: Carbon dioxide, global temperature and sea level for the last 800,000 years.

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[12] James Hansen, *Storms of My Grandchildren* 166 (2009).

[13] Eelco J. Rohling et al., *Sea Surface and High Latitude Temperature Sensitivity to Radiative Forcing of Climate over Several Glacial Cycles*, 25 J. Climate 1635 (2012); James Hansen et al., *Climate Sensitivity, Sea Level and Atmospheric Carbon Dioxide*, 371 Philosophical Transactions Royal Society 21020294 (2013); Eelco J. Rohling et al., *Sea Level and Deep-Sea Temperature Reconstructions Suggest Quasi-Stable States and Critical Transitions Over the Past 40 Million Years*, 7 Science Advances eabf5326 (2021).

[14] Céline M Vidal et al., *Age of the Oldest Known* Homo sapiens *from Eastern Africa*, 601 Nature 579 (2022).

[15] Gavin L. Foster et al., *Future Climate Forcing Potentially Without Precedent in the Last 420 Million Years*, 8 Nature Communications 14845 (2017).

[16] Robert C. Walter, *Age of Lucy and the First Family: Single-Crystal $^{40}Ar/^{39}Ar$ Dating of the Denen Dora and Lower Kada Hadar Members of the Hadar Formation, Ethiopia*, 22 Geology 6 (1994).

[17] Sierra V. Petersen et al., *End-Cretaceous Extinction in Antarctica Linked to Both Deccan Volcanism and Meteorite Impact Via Climate Change*, 7 Nature Communications 12079 (2016); Philip D. Gingerich, *Temporal Scaling of Carbon Emission and Accumulation Rates: Modern Anthropogenic Emissions Compared to Estimates of PETM Onset Accumulation*, 34 Paleoceanography Paleoclimatology 329 (2019); Ying Cui et al., *Massive and Rapid Predominately Volcanic CO_2 Emission During the End-Permian Mass Extinction*, 118 Proc. Nat'l Acad. Sci. e201470118 (2021); Jack Longman et al., *Assessing Volcanic Controls in Miocene Climate Change*, 49 Geophysical Rsch. Letters e2021GL096519 (2022).

2) **Ice Sheets, Glaciers and Sea-Level Rise**

Figure 3: Antarctic melt water from the Nansen ice shelf.

The last time the ice sheets appeared stable in the modern era was in the 1980s when the atmospheric CO_2 concentration was <350 ppm (Figure 2). The consequences of >350 ppm and >1°C of warming are already visible, significant, and dangerous for humanity. With just over a global average 1°C of warming, glaciers in all regions of the world are shrinking in response to this human-caused climate change, and the rate at which they are melting is accelerating.[18] In fact, >1/3 of the world's glacier mass outside of its ice sheets is are predicted to disappear at the current level of global warming.[19] With 1.5°C of warming, the IPCC predicts that "[m]any low elevation and small glaciers around the world will lose their total mass."[20] Large parts of the Greenland and Antarctic ice sheets, which required millennia to grow, are teetering on the edge of irreversible disintegration (Figure 3), a point that, if reached, would lock-in major ice-sheet mass loss, sea-level rise of many meters, and worldwide loss of coastal cities – a consequence that would be irreversible on any timescale relevant to humanity.[21]

Greenland ice-sheet melt is currently occurring faster than anytime during the last three and a half centuries, with a 33% increase alone since the 20th century.[22] From 1994 to 2017, the Earth lost 28 trillion tonnes of ice; the rate of mass loss from the Greenland and Antarctic ice sheets was seven and four times higher, respectively, for 2010-2016 relative to 1992-1999.[23] The paleoclimate record shows the last time atmospheric CO_2 levels were >400 ppm, the seas were **60 feet higher** than they are today and heating consistent with CO_2 concentrations as low as 400 ppm may have been enough to melt the marine portions of the Antarctica ice sheets.[24] Indeed, the current level of global heating may already be sufficient to destabilize the Greenland and West Antarctic ice sheets.[25] While many

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[18] Jan Oerlemans, *Holocene Glacier Fluctuations: Is the Current Rate of Retreat Exceptional?*, 31 Annals Glaciology 39 (2000); Ben Marzeion et al., *Attribution of Global Glacier Mass Loss to Anthropogenic and Natural Causes*, 345 Science 919 (2014); Gerard H. Roe et al., *Centennial Glacier Retreat as Categorical Evidence of Regional Climate Change*, 10 Nature Geoscience 95 (2017); M. Zemp et al., *Global Glacier Mass Changes and their Contributions to Sea-Level Rise from 1961-2016*, 568 Nature 382 (2019); Romain Hugonnet et al., *Accelerated Global Glacier Mass Loss in the Early Twenty-First Century*, 592 Nature 726 (2021).

[19] Ben Marzeion et al., *Limited Influence of Climate Change Mitigation on Short-Term Glacier Mass Loss*, 8 Nature Climate Change 305 (2018).

[20] IPCC, *Technical Summary*, *in* Climate Change 2022: Impacts, Adaptation and Vulnerability, 30 (2022).

[21] Hansen, *Assessing "Dangerous Climate Change*," at 13; *see also* James Hansen et al., *Ice Melt, Sea Level Rise and Superstorms; Evidence from Paleoclimate Data, Climate Modeling, and Modern Observations that 2 °C Global Warming Could be Dangerous*, 16 Atmos. Chem. & Phys. 3761 (2016) [hereinafter *Ice Melt, Sea Level Rise and Superstorms*].

[22] Luke D. Trusel et al., *Nonlinear Rise in Greenland Runoff in Response to Post-industrial Arctic Warming*, 564 Nature 104 (2018).

[23] Thomas Slater et al., *Earth's Ice Imbalance*, 15 The Cryosphere 233 (2021); IPCC, *Technical Summary*, *in* Climate Change 2022: Impacts, Adaptation and Vulnerability, 42 (2022).

[24] Andrea Dutton et al., *Sea-Level Rise Due to Polar Ice-Sheet Mass Loss During Past Warm Periods*, 349 Science aaa4019 (2015); Oana A. Dumitru et al., *Constraints on Global Mean Sea Level During Pliocene Warmth*, 574 Nature 233 (2019).

[25] Ian Joughin et al., *Marine Ice Sheet Collapse Potentially Under Way for the Thwaites Glacier Basin, West Antarctica*,

experts are predicting multi-meter sea-level rise this century[26], even NOAA's modest estimate of 2.0-7.2 feet (0.6-2.2 m) global mean rise by 2100[27] would impact millions of Americans (Figure 4).[28]

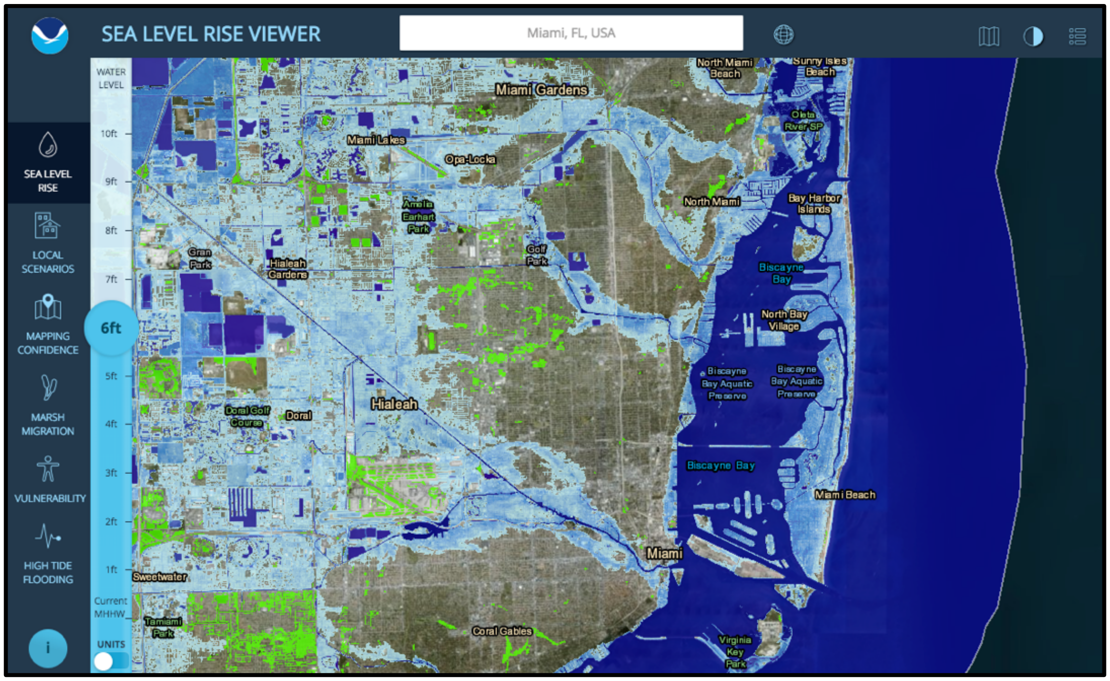

Figure 4: South Florida, including Miami, will face significant inundation with 6 feet of sea-level rise.

The geologic record shows that terrestrial ice sheets retreat and raise sea level at a more linear rate, while marine portions of ice sheets can collapse, rapidly raising sea level in pulses.[29] Scientists believe we still have a chance to preserve the large Greenland and Antarctic ice sheets and most of our shorelines and ecosystems if we restore Earth's energy balance and return to below 350 ppm, thereby limiting longer-term warming by the end of the century to no more than 1°C above pre-industrial levels (short-term warming will inevitably exceed 1°C but must not exceed 1°C for more than a short span of years rather than multiple decades or centuries).

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344 Science 735 (2014); Alberto V. Reyes et al., *South Greenland Ice-Sheet Collapse During Marine Isotope Stage 11*, 510 Nature 525 (2014); Anders E. Carlson et al., *Earliest Holocene South Greenland Ice-Sheet Retreat Within Its Late-Holocene Extent*, 41 Geophysical Rsch. Letters 5514 (2014); Nicholas R. Golledge et al., *Retreat of the Antarctic Ice Sheet During the Last Interglaciation and Implications for Future Change*, 48 Geophysical Rsch. Letters e2021GL094513 (2021).

[26] Jonathan L. Bamber et al., *Ice Sheet Contributions to Future Sea-Level Rise from Structured Expert Judgement*, 116 Proc. Nat'l Acad. Sci. 11195 (2019); Benjamin P. Horton et al., *Estimating Global Mean Sea-Level Rise and Its Uncertainties by 2100 and 2300 from an Expert Survey*, 3 npj Climate Atmospheric Sci. 10.1038/s41612-020-0121-5 (2020).

[27] William V. Sweet et al., *Global and Regional Sea Level Rise Scenarios for the United States: Updated Mean Projections and Extreme Water Level Probabilities Along U.S. Coastlines*, NOAA Technical Report NOS 01, xiii (2022).

[28] NOAA, Examining Sea Level Rise Exposure for Future Populations, https://coast.noaa.gov/digitalcoast/stories/population-risk.html.

[29] H.R. Wanless, et al., *Dynamics and Historical Evolution of the Mangrove/Marsh Fringe Belt of Southwest Florida, in Response to Sea-level History, Biogenic Processes, Storm Influences and Climatic Fluctuations*. Semi-annual Research Report (June 1993 to February 1994); Hansen, *Ice Melt, Sea Level Rise and Superstorms*, at 3761; Hansen, *Assessing "Dangerous Climate Change,"* at 20; Anders E. Carlson & Peter U. Clark, *Ice Sheet Sources of Sea Level Rise and Freshwater Discharge During the Last Deglaciation*, 50 Reviews Geophysics RG00371; Anders E. Carlson & Kelsey Winsor, *Northern Hemisphere Ice-Sheet Responses to Past Climate Warming*, 5 Nature Geoscience 607 (2012); Jo Brendryen et al., *Eurasian Ice Sheet Collapse Was a Major Source of Meltwater Pulse 1A 14,600 years ago*, 13 Nature Geoscience 363 (2020).

The recent WGII IPCC report noted that ice-sheet disintegration risk increases from "moderate" to "high" risk with warming from the current 1.1°C to 1.5°C and above.[30] Indeed, the IPCC WGI 6th assessment report identified the tipping point for Greenland ice-sheet loss to be as low as 1.0°C of warming above the pre-industrial period,[31] in line with the above referenced evidence for its instability at current levels of global warming and further highlighting the need to reduce global temperature below 1.0°C as soon as possible, as opposed to pursuing policies that target 1.5°C of warming.

3) <u>Ocean Warming and Acidification</u>

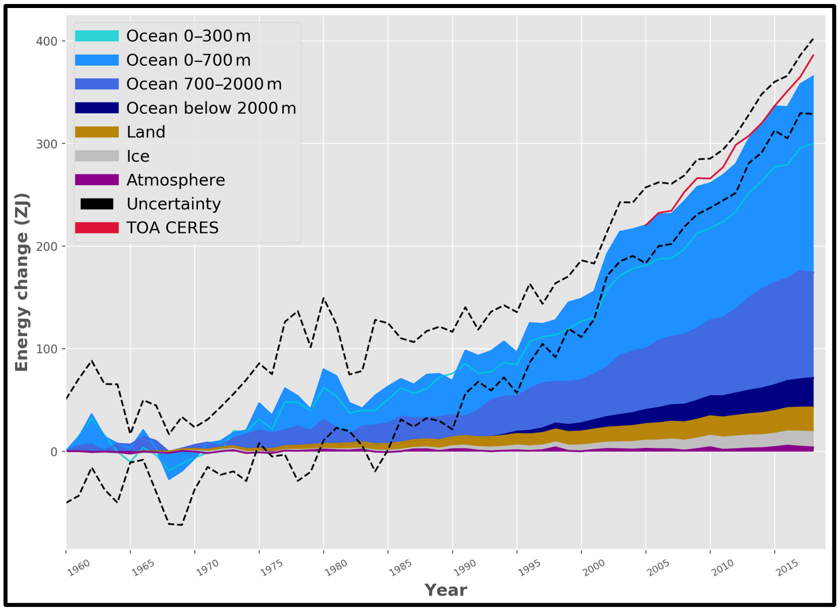

Figure 5 . Earth energy accumulation relative to 1960.

Less than 350 ppm is the best scientific standard to protect oceans and marine life. Our oceans have absorbed about 90% of the excess heat in the atmosphere trapped by greenhouse gases (Figure 5) as well as approximately 30% of CO_2 emitted into the atmosphere, causing ocean temperatures to surge and the ocean to become more acidic.[32] Indeed, our oceans are warming much more rapidly than previously-thought.[33] In 2020, the oceans absorbed 20 sextillion joules of heat due to climate change and warmed to record levels. The quantity of warming, 20,000,000,000,000,000,000,000 joules, is equivalent to the amount of energy from 10 Hiroshima atomic bombs being released every second of the year or to heat 1.3 billion kettles of water.[34] Many marine ecosystems, and particularly coral reef ecosystems, cannot tolerate the increased warming and acidity of ocean waters that result from increased CO_2 levels.[35] At today's global atmospheric CO_2 concentration, ~419 ppm, critically important ocean ecosystems, such as coral reefs, are rapidly declining and will be irreversibly damaged from high ocean temperatures and repeated mass bleaching events if we do not quickly curtail emissions and then achieve negative emissions through sequestration (Figures 6 and 7).[36]

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[30] IPCC, *Technical Summary*, *in* Climate Change 2022: Impacts, Adaptation and Vulnerability, 42 (2022).

[31] Baylor Fox-Kemper et al., *Ocean, Cryosphere and Sea Level Change*, *in* Climate Change 2021: The Physical Science Basis 61 (2021).

[32] von Schuckmann, *Heat Stored in the Earth System*; Hansen, *Assessing "Dangerous Climate Change*," at 1; IPCC, *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* (Cambridge University Press, 2013); Lijing Cheng et al., *How Fast are the Oceans Warming?*, 363 Science 128 (2019) (as of 2019, about 93% of the energy balance accumulates in the ocean); NOAA, *What is Ocean Acidification?,* https://oceanservice.noaa.gov/facts/acidification.html.

[33] Lijing Cheng et al., *How Fast are the Oceans Warming?*, 363 Science 128 (2019).

[34] https://www.abc.net.au/news/2021-01-18/ocean-temperatures-reached-record-high-in-2020-study-finds/13062628; https://www.cambridgenetwork.co.uk/news/world-continued-warm-2020.

[35] Terry P. Hughes et al., *Global Warming Impairs Stock-Recruitment Dynamics of Corals*, 568 Nature 387 (2019).

[36] K. Frieler et al., *Limiting Global Warming to 2 ℃ is Unlikely to Save Most Coral Reefs*, 3 Nature Climate Change 165

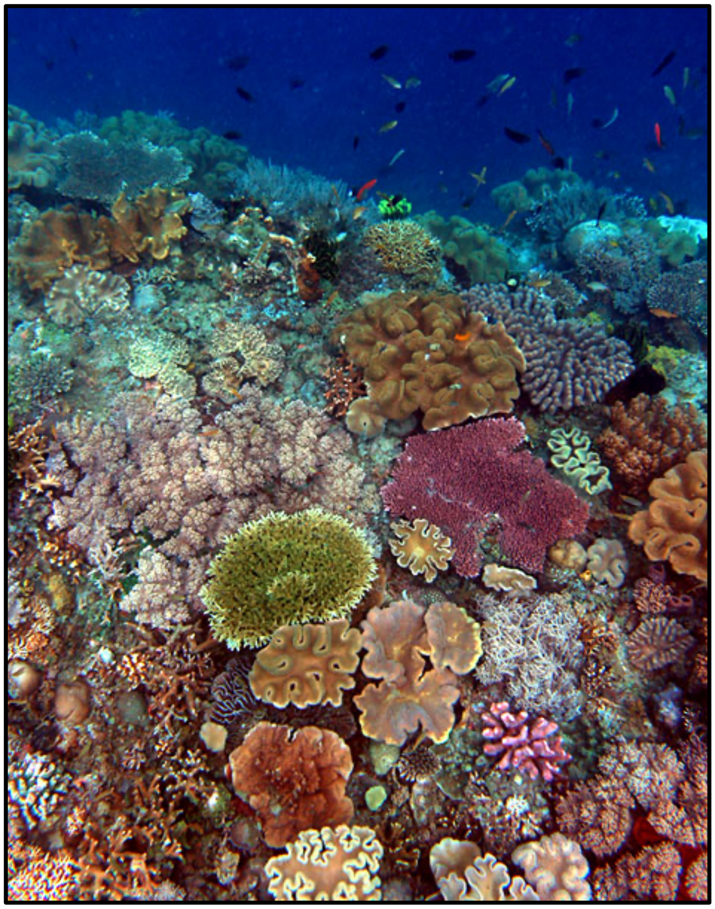

Figure 6: Healthy coral like this are already gravely threatened and will likely die with warming of 1.5°C.

Figure 7: Bleached coral from warmer ocean temperatures.

According to the IPCC, bleaching events are occurring more frequently than the IPCC previously projected and 70-90% of the world's coral reefs could disappear as soon as 2030 (the IPCC also predicts >99% of coral reefs will die with 2°C warming).[37] The 2018 National Climate Assessment acknowledged that coral reefs in Florida, Hawaii, Puerto Rico, and the U.S. Virgin Islands have been harmed by mass bleaching and coral diseases and could disappear by mid-century as a result of warming waters.[38] The 2022 IPCC WGII 6th assessment report attributed "warm-water coral bleaching and mortality" to "human-induced climate change".[39] Scientists have concluded we can protect marine life and prevent massive bleaching and die-off of coral reefs only by rapidly returning CO_2 levels to below 350 ppm.[40]

No scientific institution, including the IPCC, has ever concluded that the EEI that exists with >350 ppm CO_2 and 1.5-2.0°C warming would be safe for ocean life. According to Dr. Ove Hoegh-Guldberg, one of the world's leading experts on ocean warming and acidification, and a Coordinating Lead Author on the "The Ocean" chapter of the IPCC's 5th Assessment Report and on the "Impacts

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(2013); J.E.N. Veron et al; *The Coral Reef Crisis: The Critical Importance of <350ppm CO_2*, 58 Marine Pollution Bulletin 1428 (2009); Terry P. Hughes et al., *Spatial and Temporal Patterns of Mass Bleaching of Corals in the Anthropocene*, 359 Science 80 (2018); Terry P. Hughes et al., *Global Warming Impairs Stock–Recruitment Dynamics of Corals*, 568 Nature 387 (2019).

[37] Ove Hoegh-Guldberg et al., *Impacts of 1.5ºC Global Warming on Natural and Human Systems, 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, at 225-226 (2018); IPCC, *Summary for Policymakers, in* Global Warming of 1.5°C (2018).

[38] A.J. Pershing et al., *Oceans and Marine Resources, in* Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Vol. II (USGCRP, 2018).

[39] IPCC, *Summary for Policy Makers*, *in* Climate Change 2022: Impacts, Adaptation and Vulnerability, 8 (2022).

[40] J.E.N. Veron et al., *The Coral Reef Crisis: The Critical Importance of <350 ppm CO_2*, 58 Marine Pollution Bulletin 1428 (2009).

of 1.5ºC Global Warming on Natural and Human Systems" of the IPCC's Special Report on Global Warming of 1.5°C:

> *"Allowing a temperature rise of up to 2°C would seriously jeopardize ocean life, and the income and livelihoods of those who depend on healthy marine ecosystems. Indeed, the best science available suggests that coral dominated reefs will completely disappear if carbon dioxide concentrations exceed much more than today's concentrations. Failing to restrict further increases in atmospheric carbon dioxide will eliminate coral reefs as we know them and will deny future generations of children from enjoying these wonderful ecosystems."*[41]

IPCC's Special Report on Global Warming of 1.5° stated that "[w]arming of 1.5ºC is not considered 'safe' for most nations, communities, ecosystems and sectors and poses significant risks to natural and human systems as compared to the current warming of 1°C (*high confidence*)."[42] Going further, IPCC WGII stated in their 6th assessment report that "Without urgent and deep emissions reductions, some species and ecosystems, especially those in polar and already-warm areas, face temperatures beyond their historical experience in the next decades (e.g. >20% of species on some tropical landscapes and coastlines at 1.5°C global warming). Unique and threatened ecosystems are expected to be at high risk in the very near term at 1.2°C global warming levels (*very high confidence*) due to… coral reef bleaching..."[43] Another recent study found that "warming of 1.5°C relative to pre-industrial levels will be catastrophic for coral reefs."[44] With 1.5°C of warming, only 0.2% of the world's coral reefs would have climate refugia from heating events that drive bleaching (Figure 8).

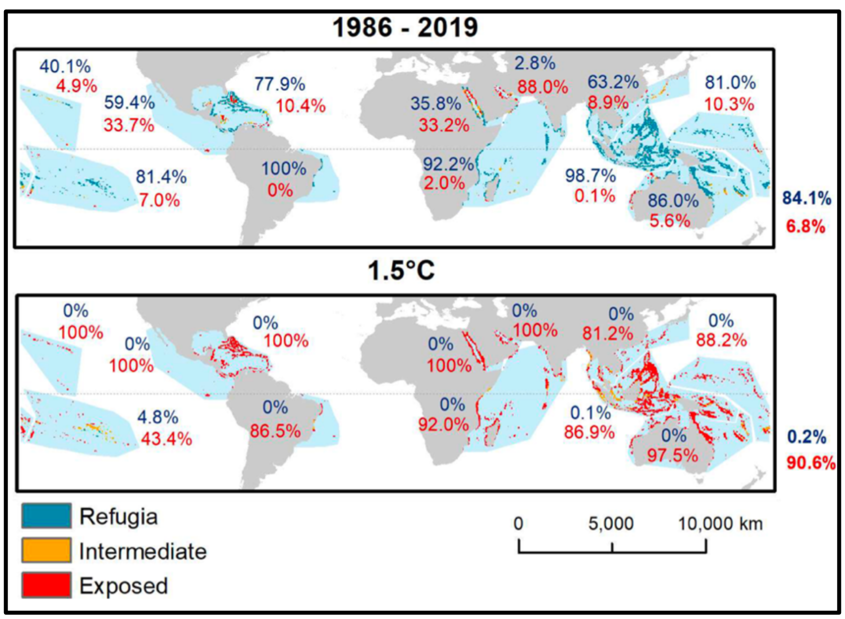

Figure 8: Coral reef refugia (blue symbols and numbers) for 1986-2019 (top) and in a 1.5ºC world bottom with exposed reefs indicated by red symbols and numbers.

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[41] Ove Hoegh-Guldberg, *Declaration in Support of Petitioners, Foster v. Wash. Dep't of Ecology*, No. 14-2-25295-1 SEA (Wash. Super. Ct. Aug. 24, 2015).
[42] M.R. Allen et al., *Technical Summary, in* Global Warming of 1.5°C, at 44 (2018).
[43] IPCC, *Technical Summary*, *in* Climate Change 2022: Impacts, Adaptation and Vulnerability, 24 (2022).
[44] Adele M. Dixon et al., *Future Loss of Local-Scale Thermal Refugia in Coral Reef Ecosystems*, 1 PLOS Climate e0000004, 1 (2022).

ADDITIONAL OBSERVATIONS ILLUSTRATE THE DANGERS OF INCREASED WARMING

In addition to the evidence discussed above that illustrates the necessity of ensuring that the atmospheric CO_2 concentration returns to no more than 350 ppm, based on current observations about climate impacts occurring **now**, it is clear that the present level of 419 ppm and attendant 1.2°C of global warming and 260 mm of sea-level rise since the late 1800s[45] is already causing significant climate impacts; additional warming will exacerbate these already dangerous impacts (Figure 9).

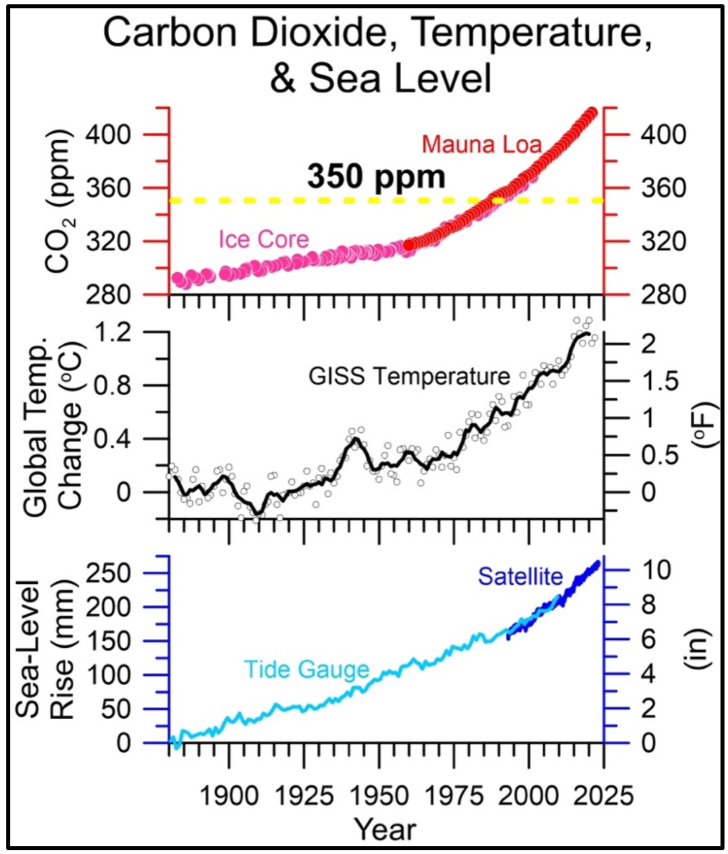

Figure 9: Historical carbon dioxide, global temperature and sea level.

Climate impacts that are already being experienced today include:

- Declining snowpack and rising temperatures are increasing the length and severity of drought conditions, especially in the western United States, causing problems for agriculture, forcing some people to relocate, and leading to water restrictions.[46]
- In addition to causing sea-level rise, glacier retreat adds to the growing water crisis. Glacier loss is impacting reliant ecosystems, including economically important Pacific salmon, and increasing landslide and flood hazards.[47] In the western United States, glaciers are completely vanishing from mountain ranges, removing a reliable water source in a region already experiencing unprecedented drought.[48]

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[45] John A. Church & Neil J. White, *Sea-Level Rise from the Late 19th to the Early 21st Century*, 32 Survey Geophysics 585 (2011); https://data.giss.nasa.gov/gistemp/; https://sealevel.colorado.edu.

[46] John T. Abatzoglou & A. Park Williams, *Impact of Anthropogenic Climate Change on Wildfire Across Western US Forests*, 113 Proc. Nat'l Acad. Sci. 11770 (2016); Philip W. Mote et al., *Dramatic Declines in Snowpack in the Western US*, 1 npj Climate Atmospheric Science s41612-018-0012-1 (2018); Steven W. Running, *Declaration in Support of Plaintiffs, Juliana v. United States*, No. 18-36082, Doc. 21-12 (9th Cir. Feb. 7, 2019); Marshall Burke et al., *The Changing Risk and Burden of Wildfire in the United States*, 118 Proc. Nat'l Acad. Sci. e2011048118 (2021); A. Park Williams et al., *Rapid Intensification of the Emerging Southwestern North American Megadrought in 2020-2021*, 12 Nature Climate Change 232 (2022).

[47] Matthias Huss et al., *Toward Mountains Without Permanent Snow and Ice*, 5 Earth's Future 2016EF000514 (2017); Alexander M. Milner et al., *Glacier Shrinkage Driving Global Changes in Downstream Systems*, 114 Proc. Nat'l Acad. Sci. 9770 (2017); Kara J. Pitman et al., *Glacier Retreat and Pacific Salmon*, 70 Bioscience 220 (2020); Dan H. Shugar et al., *Rapid Worldwide Growth of Glacial Lakes Since 1990*, 10 Nature Climate Change 939 (2020); Jordyn B. Miller et al., *Recharge from Glacial Meltwater is Critical for Alpine Springs and their Microbiomes*, 16 Env't Rsch. Letters 064012 (2021).

[48] J.-B. Bosson et al., *Disappearing World Heritage Glaciers as a Keystone of Nature Conservation in a Changing Climate*, 7 Earth's Future 469 (2019); Chelsea J. Martin-Mikle & Daniel B. Fagre, *Glacier Recession Since the Little Ice*

- In the western United States, the wildfire season is now almost three months longer (87 days) than it was in the 1980s.[49] 10.3 million acres burned in 2020, well above the 2011-2020 average of 7.5 million acres.[50]
- Extreme weather events, such as intense rainfall events that cause flooding, are increasing in frequency and severity because a warmer atmosphere holds more moisture.[51] What are supposedly 1-in-1000-year rainfall events are now occurring with alarming frequency – in 2018 there were at least five such events.[52] The 2021 U.S. Pacific Northwest heatwave, which broke numerous records, was "virtually impossible" without human-greenhouse gas emissions; at +2.0ºC of global warming, such events will occur once to twice a decade.[53]
- Tropical storms and hurricanes are increasing in frequency and intensity, both in terms of rainfall and windspeed, as warmer oceans provide more energy for the storms (e.g., Hurricanes Harvey, Irma, and Maria in 2017)[54] (Figure 10).
- Terrestrial ecosystems are experiencing compositional and structural changes, with major adverse consequences for ecosystem services.[55]
- Terrestrial, freshwater, and marine species are experiencing a significant decrease in population size and geographic range, with some going extinct and others are facing the very real prospect of extinction – the rapid rate of extinctions has been called the sixth mass extinction.[56]

Figure 10: Port Arthur, TX flooding August 13, 2018 after Hurricane Harvey.

Age: Implications for Water Storage in a Rocky Mountain Landscape, 51 Arctic, Antarctic, Alpine Rsch. 280 (2019); Justin M. Garwood et al., *20th Century Retreat and Recent Drought Accelerated Extinction of Mountain Glaciers and Perennial Snowfields in the Trinity Alps, California*, 94 Northwest Sci. 44 (2020); Anders E. Carlson et al., *Farewell to Oregon's Central Cascade Glaciers?*, 104 Mazama Bulletin 15 (2022).

[49] Steven W. Running, *Declaration in Support of Plaintiffs, Juliana v. United States*, No. 18-36082, Doc. 21-12 (9th Cir. Feb. 7, 2019); Anthony LeRoy Westerling, *Increasing Western US Forest Wildfire Activity: Sensitivity to Changes in the Timing of Spring*, 371 Phil. Trans. R. Soc. B 20150178 (2016).

[50] Congressional Research Service, *Wildfire Statistics* (updated Jan. 4, 2021).

[51] Kevin E. Trenberth, *Declaration in Support of Plaintiffs, Juliana v. United States*, No. 18-36082, Doc. 21-3 (9th Cir. Feb. 7, 2019).

[52] F. Belles, *America's 'One-in-1,000-Year' Rainfall Events in 2018*, The Weather Channel (Sept. 27, 2018).

[53] https://www.worldweatherattribution.org/western-north-american-extreme-heat-virtually-impossible-without-human-caused-climate-change/.

[54] Kevin E. Trenberth, *Declaration in Support of Plaintiffs, Juliana v. United States*, No. 18-36082, Doc. 21-3 (9th Cir. Feb. 7, 2019); Kerry Emanuel, *Atlantic Tropical Cyclones Downscaled from Climate Reanalyses Show Increasing Activity over Past 150 Years*, 12 Nature Communications 7027 (2021); Justin T. Maxwell et al., *Recent Increases in Tropical Cyclone Precipitation Extremes over the US East Coast*, 118 Proc. Nat'l Acad. Sci. e2105636118 (2021).

[55] Connor Nolan et al., *Past and Future Global Transformation of Terrestrial Ecosystems Under Climate Change*, 361 Science 920 (2018).

[56] Gerardo Ceballos et al., *Accelerated Modern Human–Induced Species Losses: Entering the Sixth Mass Extinction*, 1 Sci. Advances e1400253 (2015); Steven W. Running, *Expert Report, Juliana v. United States*, No. 6:15-cv-01517-TC, Doc. 264-1 (D. Or. June 28, 2018).

- Arctic permafrost thresholds in Canada and Scandinavia may already be surpassed, leading to landscape degradation, infrastructure destruction (Figure 11) and release of greenhouse gases, furthering the climate crisis.[57] At least 534 settlements will lose their underlying frozen ground and 3.3 million people will be affected (even displaced) from the loss of permafrost that could occur much faster than originally thought due to feedbacks in the Arctic climate system.[58]

Figure 11: House sinking due to permafrost melting near Fairbanks, Alaska.

- Human health and well-being are already being affected by heat waves, floods, droughts, and extreme events; infectious diseases; and quality of air, food, and water.[59] Doctors and leading medical institutions are calling climate change a "health emergency."[60] Human greenhouse gas emissions have already caused up to 84% of the North American pollen allergy and asthma season lengthening.[61] Children are uniquely vulnerable to climate change health effects due to their higher respiratory rate, lung growth and development, immature immune system, higher metabolic demands, and immature central nervous system.[62]
- In addition to physical harm, climate change is causing mental health impacts, ranging from stress to clinical disorders such as anxiety, depression, and suicidality, due to exposure to climate events, displacement, loss of income, chronic stress, other impacts of climate change and the belief that their government is not protecting them from climate change.[63]

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[57] Andrew H. MacDougall et al., *Significant Contribution to Climate Warming from the Permafrost Carbon Feedback*, 5 Nature Geoscience 719 (2012); April M. Melvin et al., *Climate Change Damages to Alaska Public Infrastructure and the Economics of Proactive Adaptation*, 114 Proc. Nat'l Acad. Sci. E122 (2016); Trevor J. Porter et al., *Recent Summer Warming in Northwestern Canada Exceeds the Holocene Thermal Maximum*, 10 Nature Communications 1631 (2019); Merritt R. Turetsky et al., *Carbon Release Through Abrupt Permafrost Thaw*, 13 Nature Geoscience 138 (2020); Richard E. Fewster et al., *Imminent Loss of Climate Space for Permafrost Peatlands in Europe and Western Siberia*, Nature Climate Change s41558-022-01296-7 (2022).

[58] Justine Ramage et al., *Population Living on Permafrost in the Arctic*, 43 Population Env't 22 (2021); Rúna Magnússon et al., *Extremely Wet Summer Events Enhance Permafrost Thaw for Multiple Years in Siberian Tundra*, 13 Nature Communications 1556 (2022).

[59] K.L. Ebi et al., *Human Health, in* Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Vol. II (USGCRP, 2018); IPCC, *Summary for Policy Makers*, *in* Climate Change 2022: Impacts, Adaptation and Vulnerability (2022).

[60] Caren G. Solomon & Regina C. LaRocque, *Climate Change – A Health Emergency*, 380 N. Engl. J. Med. 209 (2019).

[61] William R.L. Anderegg et al., *Anthropogenic Climate Change is Worsening North American Pollen Seasons*, 118 Proc. Nat'l Acad. Sci. e2013284118 (2021).

[62] Susan E. Pacheco, *Catastrophic Effects of Climate Change on Children's Health Start before Birth*, 130 J. Clinical Investigation 562 (2020); C. May et al., *Northwest, in* Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Vol. II (USGCRP, 2018); Nick Watts et al., *The 2019 Report of The Lancet Countdown on Health and Climate Change: Ensuring that the Health of a Child Born Today is not Defined by a Changing Climate*, 394 The Lancet 1836 (2019); *Brief of Amici Curiae Public Health Experts, Public Health Organizations, and Doctors in Support of Plaintiffs*, No. 18-36082, Doc. 47 (9th Cir. Mar. 1, 2019).

[63] Lise Van Susteren, *Expert Report, Juliana v. United States*, No. 6:15-cv-01517-TC, Doc. 271-1 (D. Or. June 28, 2018). K.L. Ebi et al., *Human Health, in* Impacts, Risks, and Adaptation in the United States: Fourth National Climate

Figure 12: Offutt Air Force Base was impacted by flood waters during flooding in Nebraska during spring 2019.

- As Congress has recognized, "climate change is a direct threat to the national security of the United States and is impacting stability in areas of the world both where the United States Armed Forces are operating today, and where strategic implications for future conflict exist."[64] Senior military leaders have called climate change "*the* most serious national security threat facing our Nation today,"[65] a conclusion similarly recognized by our Nation's intelligence community.[66] Climate change is increasing food and water shortages, pandemic disease, conflicts over refugees and resources, and destruction to homes, land, infrastructure, and military assets, directly threatening our military personnel and the "Department of Defense's ability to defend the Nation" (Figure 12).[67]
- Climate change is already causing vast economic harm in the United States. Since 1980 the United States has experienced 310 climate and weather disasters that each caused damages in excess of $1 billion, for a total cost of $2.160 trillion and 15,180 deaths.[68] In 2021 alone, weather and climate related disasters cost the United States in excess of $145 billion, which was ranked only third in terms of cost.[69]

These already serious impacts will grow in severity and will impact increasingly large numbers of people and parts of the world if CO_2 concentrations continue to rise, which is what would happen if climate policies are targeted to achieving 1.5ºC of warming or net zero emissions, as opposed to negative emissions. If we want our children and grandchildren to have a safe planet to live on, full of health and biodiversity rather than chaos and conflict, we must follow the best scientific prescription to restore Earth's energy balance and avoid the destruction of our planet's atmosphere, climate, and oceans.

Assessment, Vol. II (USGCRP, 2018); Caroline Hickman et al., *Climate Anxiety in Children and Young People and Their Beliefs About Government Responses to Climate Change: A Global Survey*, 5 The Lancet e863 (2021); IPCC, *Summary for Policy Makers*, *in* Climate Change 2022: Impacts, Adaptation and Vulnerability (2022).

[64] *National Defense Authorization Act for Fiscal Year 2018*, Pub. L. No. 115-91, 131 Stat. 1358.

[65] Vice Admiral Lee Gunn, USN (Ret.), *Declaration in Support of Plaintiffs, Juliana v. United States*, No. 18-36082, Doc. 21-17 (9th Cir. Feb. 7, 2019) (emphasis in original); *see also* CNA Military Advisory Board, *National Security and the Accelerating Risks of Climate Change* (2014).

[66] National Intelligence Council, *Implications for US National Security of Anticipated Climate Change* (Sept. 2016).

[67] U.S. Dep't of Defense, *2014 Climate Change Adaptation Roadmap* (2014).

[68] NOAA, *Billion Dollar U.S. Weather/Climate Disasters 1980-2021* (2022), https://www.ncdc.noaa.gov/billions/.

[69] https://www.climate.gov/news-features/blogs/beyond-data/2021-us-billion-dollar-weather-and-climate-disasters-historical.

INTERNATIONAL POLITICAL TARGETS OF 1.5°C OR 2.0°C ARE NOT SCIENCE-BASED AND ARE NOT SAFE

International treaties require the stabilization of the climate system to avoid dangerous anthropogenic climate change. As described above, EEI and CO_2 concentrations should be the measurable scientific metrics, adopted as legal standards, for setting emission reduction and sequestration targets to stabilize our climate, avoid danger, and protect children and future generations. Temperature targets, set higher than today's already-too-hot planet that would mean even greater and more dangerous EEI and greater instability, are incompatible with fundamental human rights. International, politically-established temperature targets like 1.5°C or "well below" 2.0°C – which are commonly associated with long-term atmospheric CO_2 concentrations of 425 and 450 ppm, respectively and "net zero emissions" – have not been and are not presently considered safe or scientifically-sound targets for present or future generations.

Neither 1.5°C nor 2.0°C warming above pre-industrial levels has ever been considered "safe" from either a political or scientific point of view. The 2.0°C figure was originally adopted in the political arena "from a set of heuristics," and it has retained predominantly political character ever since.[70] One review of climate economics noted that the 2.0°C figure was actually proposed by policy makers, not scientists.[71] The 2.0°C figure has been all-but-abandoned as a credible policy goal, in light of the findings in IPCC's 1.5°C Special Report, and the mounting evidence leading up to its publication, that 2.0°C would be catastrophic relative to lower, still-achievable levels of warming.[72]

On the other hand, the idea of a 1.5°C target was first raised by the Alliance of Small Island States (AOSIS) in the negotiations leading up to the ill-fated 2009 UNFCCC Conference of Parties in Copenhagen.[73] AOSIS, however, was explicitly advocating a *well below* 1.5°C and *well below* 350 ppm target, on the basis of the research of Dr. James Hansen and his colleagues.[74] Political compromise, including pressure from the fossil fuel industry, on this target then led to the adoption of a goal of "pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels" in Article 2 of the Paris Agreement. Yet the 2018 IPCC Special Report on 1.5°C has made clear that allowing a temperature rise of 1.5°C:

> is **not considered 'safe'** for most nations, communities, ecosystems and sectors and poses significant risks to natural and human systems as compared to the current warming of 1°C (*high confidence*).[75]

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[70] Samuel Randalls, *History of the 2°C Climate Target*, 1 WIREs Climate Change 598, 603 (2010); Carlo C. Jaeger & Julia Jaeger, *Three Views of Two Degrees*, 11 (Suppl 1) Reg. Env't Change S15 (2011).

[71] Eva Lövbrand, *Co-Producing European Climate Science and Policy: A Cautionary Note on the Making of Useful Knowledge*, 38 Science Public Policy 225, 233 (2011).

[72] IPCC, *Summary for Policymakers, in* Climate Change 2014: Impacts, Adaptation, and Vulnerability, 13-14 (2014); UNFCCC, *Report on the Structured Expert Dialogue on the 2013–2015 Review*, 18 (2015), http://unfccc.int/resource/docs/2015/sb/eng/inf01.pdf; Petra Tschakert, *1.5°C or 2°C: A Conduit's View from the Science-Policy Interface at COP20 in Lima, Peru*, 2 Climate Change Responses 8 (2015); IPCC, *Global Warming of 1.5°C* (2018).

[73] *See* Robin Webster, *A Brief History of the 1.5C Target*. Climate Change News (Dec. 10, 2015), http://www.climatechangenews.com/2015/12/10/a-brief-history-of-the-1-5c-target/.

[74] *Submission from Grenada on behalf of AOISIS to the Ad Hoc Working Group on Further Commitments for Annex I Parties Under the Kyoto Protocol*, U.N. Doc. FCCC/KP/AWG/2009/MISC.1/Add.1 (25 March 2009), https://unfccc.int/sites/default/files/resource/docs/2009/awg7/eng/misc01a01.pdf, citing James Hansen et al. *Target Atmospheric CO_2: Where Should Humanity Aim?* 2 The Open Atmospheric Science Journal 217 (2008).

[75] M.R. Allen et al., *Technical Summary, in* Global Warming of 1.5°C, at 44 (2018) (emphasis added).

Creating climate policies that allow heating of 1.5°C-2.0°C legalizes and locks in greater dangers than we have already witnessed. It is a death sentence for young people. In fact, Sir David King, former Special Envoy for Climate Change and Chief Scientific Advisor for the United Kingdom, elaborated on the importance of 350 ppm and limiting global heating to 1.0°C:

> *"As a key negotiator for the United Kingdom government during discussions leading up to the Paris Agreement, I advocated that 1.5°C was an acceptable level of global warming. However, I was wrong. In 2020, our planet experienced an average of 1.1°C of warming — much higher in some places like the Arctic -- and we experienced catastrophic weather events and climate-related disasters. These will only become more frequent, and more severe, as our emissions continue to rise. We cannot afford to negotiate what we now know is the safest level for stabilizing our climate systems: We must limit warming to less than 1.0°C as fast as possible. The 350 ppm pathways findings in studies by Jim Williams and Evolved Energy Research successfully demonstrate that the United States has clear pathways available to significantly reduce emissions, protecting the health and livelihood of their citizens while also boosting their national economies. This will crucially enable the USA to join leading nations in managing this severe challenge to humanity."*[76]

Sir David King also stated:

> *"We need to get ourselves back down to 350 parts per million or less carbon dioxide equivalent."*[77]

Importantly, the IPCC has never established nor endorsed a target of 1.5°C or 2.0°C warming as a limit below which the climate system will be stable, and the energy balance restored. It is beyond the IPCC's declared mandate to endorse a particular threshold of warming as "safe" or "dangerous." As the IPCC makes clear, "each major IPCC assessment has examined the impacts of [a] multiplicity of temperature changes but has left [it to the] political processes to make decisions on which thresholds may be appropriate."[78] Unfortunately, one flaw in the IPCC's work is that it has always looked at pathways to higher levels of planetary heating, not lower levels, and it has not focused its analysis on restoring Earth's Energy Imbalance. Nonetheless, the IPCC has evaluated and published the extensive harms of even 1°C of heating on children and the planet.

The 2022 IPCC WGII 6th assessment report found that: "In terrestrial ecosystems, 3 to 14% of species assessed will *likely* face very high risk of extinction at global warming levels of 1.5°C" and "[i]n ocean and coastal ecosystems, risk of biodiversity loss ranges between moderate and very high by 1.5°C global warming level . . . ."[79] They also stated: "Projections suggest that 350 million (± 158.8 million) more people in urban areas will be exposed to water scarcity from severe droughts at 1.5°C warming . . . ."[80] Similarly, "[a]daptation to address risks of heat stress, heat mortality and reduced capacities for outdoor work for humans, face soft and hard limits across regions become significantly

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[76] Correspondence from Sir David King to Julia Olson (Jan. 2021) (notes on file with Julia Olson); The Do One Better! Podcast, Interview with Sir David King, https://www.lidji.org/sir-david-king.
[77] https://www.lidji.org/sir-david-king.
[78] IPCC, *Climate Change 2014: Mitigation of Climate Change, Contribution of Working Group III to the Fifth Assessment Report* 125 (Cambridge University Press, 2014).
[79] IPCC, *Summary for Policy Makers*, *in* Climate Change 2022: Impacts, Adaptation and Vulnerability 15-6 (2022).
[80] IPCC, *Technical Summary*, *in* Climate Change 2022: Impacts, Adaptation and Vulnerability 37 (2022).

more severe at 1.5°C…”[81] Such extinction, ecosystem losses, thirst, droughts, stress and death fly in the face of any claim that 1.5°C of global warming is somehow “safe”.

Dr. James Hansen warns that “distinctions between pathways aimed at ~1°C and 2°C warming are much greater and more fundamental than the numbers 1°C and 2°C themselves might suggest. These fundamental distinctions make scenarios with 2°C or more global warming far more dangerous; so dangerous, we [James Hansen et al.] suggest, that aiming for the 2°C pathway would be foolhardy.”[82] This target is at best the equivalent of “flip[ping] a coin in the hopes that future generations are not left with few choices beyond mere survival. This is not risk management, it is recklessness and we must do better.”[83]

Tellingly, more than 80 eminent scientists from over 50 different institutions have been co-authors on publications in peer-reviewed journals finding that the maximum level of atmospheric CO_2 consistent with restoring the EEI, protecting humanity and other species is 350 ppm, and no one, including the IPCC, has published any scientific evidence to counter that 350 ppm is the maximum safe concentration of CO_2.[84]

A 1.5°C OR 2.0°C TARGET RISKS LOCKING-IN DANGEROUS FEEDBACKS

The longer the length of time atmospheric CO_2 concentrations remain at dangerous levels (i.e., above 350 ppm) and there is an EEI, the risk of triggering, and locking-in, dangerous warming-driven feedback loops increases. The 1.5°C or 2.0°C target (linked to 425-450 ppm) reduces the likelihood that the biosphere will be able to sequester CO_2 due to carbon cycle feedbacks and shifting climate zones.[85] As Earth surface temperatures increase, forests burn and soils warm, releasing their carbon. These natural carbon “sinks” become carbon “sources” and a portion of the natural carbon sequestration necessary to drawdown excess CO_2 simply disappear. Another dangerous feedback includes the release of methane (along with CO_2), a potent greenhouse gas, as the global permafrost thaws.[86] These feedbacks might show little change in the short-term (with the exception of permafrost melting, which may already be triggered in parts of the Arctic[87]), but can hit a point of no return, even

[81] IPCC, *Technical Summary*, *in* Climate Change 2022: Impacts, Adaptation and Vulnerability 57 (2022).
[82] Hansen, *Assessing "Dangerous Climate Change*," at 15.
[83] Matt Vespa, *Why 350? Climate Policy Must Aim to Stabilize Greenhouse Gases at the Level Necessary to Minimize the Risk of Catastrophic Outcomes*, 36 Ecology Law Currents 185, 186 (2009).
[84] James Hansen, et al., *Target Atmospheric CO_2: Where Should Humanity Aim?* 2 The Open Atmospheric Science Journal 217 (2008); Hansen, *Assessing "Dangerous Climate Change"*; Hansen, *Ice Melt, Sea Level Rise and Superstorms*; James Hansen, et al., *Young People's Burden: Requirement of Negative CO_2 Emissions*, 8 Earth Syst. Dynamics 577 (2017); J.E.N. Veron, et al., *The Coral Reef Crisis: The Critical Importance of <350 ppm CO_2* 58 Marine Pollution Bulletin 1428 (2009); K. Frieler, et al., *Limiting Global Warming to 2 ℃ is Unlikely to Save Most Coral Reefs* 3 Nature Climate Change 165 (2013); von Schuckmann, *Heat Stored in the Earth System*; Communication from James Hansen, Karina von Shuckmann to Julia Olson (2021) (notes on file with Julia Olson).
[85] Hansen, *Assessing "Dangerous Climate Change,"* at 15, 20.
[86] *Id.*; Andrew H. MacDougall et al., *Significant Contribution to Climate Warming from the Permafrost Carbon Feedback*, 5 Nature Geoscience 719 (2012); Gustaf Hugelius et al., *Large Stocks of Peatland Carbon and Nitrogen are Vulnerable to Permafrost Thaw*, 117 Proc. Nat'l Acad. Sci. 20438 (2020).
[87] Trevor J. Porter et al., *Recent Summer Warming in Northwestern Canada Exceeds the Holocene Thermal Maximum*, 10 Nature Communications 1631 (2019); Richard E. Fewster et al., *Imminent Loss of Climate Space for Permafrost*

at a 1.5°C or 2.0°C temperature increase, which will trigger accelerated heating and sudden *and irreversible* catastrophic impacts. Moreover, an emission reduction target aimed at 2.0°C would "yield a larger eventual warming because of slow feedbacks, probably at least 3°C."[88] Once global warming of 2.0°C is reached, there will already be "additional climate change 'in the pipeline' even without further change of atmospheric composition."[89] This is evidenced by committed ice-sheet retreat and attendant sea-level rise. At our current 1.2°C of warming, the committed rise in sea level is at least 30 feet (9 m) over the coming centuries and millennia; at 1.5°C, more than 45 feet (14 m) of sea-level rise is committed that increases to greater than 70 feet (21 m) at 2.0°C.[90] In short, even at our current level of global warming, the seas will not stop rising for thousands of years; additional warming will only increase the rate and amount that the seas rise. Because the IPCC projects Earth reaching 1.5°C of global warming by 2035,[91] the time to stop greenhouse gas emissions and reduce already to high atmospheric CO_2 concentration is now.

THE BEST AVAILABLE SCIENCE REQUIRES US TO REDUCE CO_2 LEVELS TO <350 PPM BY 2100

There are two steps to reducing CO_2 levels to <350 ppm by the end of the century: 1) reducing CO_2 emissions to near zero by 2050; and separately 2) sequestering excess CO_2 already in the atmosphere, which can be accomplished primarily by protecting and enhancing our natural carbon sinks (carbon drawdown). Politically-motivated emission reduction targets that seek to reduce CO_2 emissions by only 80% by 2050 are consistent with an atmospheric CO_2 concentration of 450 ppm and long-term warming of 2.0°C, which, as described above, would result in catastrophic and irreversible impacts for the climate system and oceans and an eventual Earth temperature of >3.0°C.

The politically popular concept of "net zero," associated with achieving 1.5°C of warming, allows governments to zero out a percentage of ongoing fossil fuel emissions by counting them as "sequestered" through removal processes, such as biogenic or natural sequestration in carbon sinks, leaving a smaller amount of source "net emissions" to be reduced.[92] However, in order to align emissions and sequestration with a <350 ppm standard, carbon removed through natural sequestration in sinks must be used to draw down the excess CO_2 already in the atmosphere from cumulative historic emissions, not to provide a negative credit or offset for ongoing emissions. Emissions and sequestration must be accounted and inventoried separately with separate standards for each category.[93] A "net zero" emissions target is a shell game with little accountability,[94] detached from a precise standard for protection of fundamental rights and restoration of Earth's energy balance.

Peatlands in Europe and Western Siberia, Nature Climate Change s41558-022-01296-7 (2022); Charles K. Paull et al., *Rapid Seafloor Changes Associated with the Degradation of Arctic Submarine Permafrost*, 119 Proceedings Nat'l Academy Sciences e2119105119 (2022).

[88] Hansen, *Assessing "Dangerous Climate Change,"* at 15.

[89] *Id*. at 19.

[90] Peter U. Clark et al., *Consequences of Twenty-First-Century Policy for Multi-Millennial Climate and Sea-Level Change*, 6 Nature Climate Change 360 (2016); Peter U. Clark et al., *Sea-Level Commitment as a Gauge for Climate Policy*, 8 Nature Climate Change 653 (2018).

[91] IPCC, *Technical Summary*, *in* Climate Change 2022: Impacts, Adaptation and Vulnerability, 8 (2022).

[92] Sam Fankhauser et al., *The Meaning of Net Zero and How to Get It Right*, 12 Nature Climate Change 15 (2022).

[93] Duncan P. McLaren et al., *Beyond "Net-Zero": A Case for Separate Targets for Emissions Reduction and Negative Emissions*, Frontiers in Climate (2019).

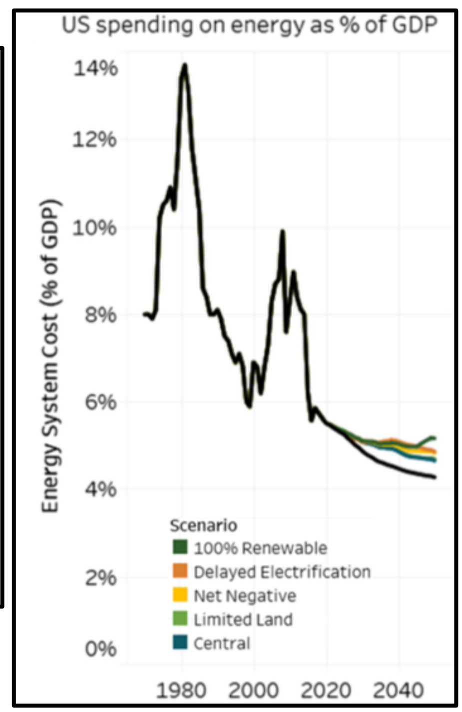
[94] Sam Fankhauser et al., *The Meaning of Net Zero and How to Get It Right* , 12 Nature Climate Change 15, 17 (2022).

IT IS TECHNOLOGICALLY AND ECONOMICALLY FEASIBLE TO REDUCE EMISSIONS IN LINE WITH 350 PPM BY 2100

Importantly, it is economically and technologically feasible to transition the entire U.S. energy system to a zero-CO_2 energy system by 2050 and to drawdown the excess CO_2 in the atmosphere through reforestation and carbon sequestration in soils and other geological reservoirs.[95]

Deep Decarbonization Pathways Project and Evolved Energy Research recently completed research and very sophisticated modeling describing a near complete phase out of fossil fuels in the U.S. by 2050.[96] They describe six different technologically feasible pathways to drastically, and quickly, cut our reliance on fossil fuels and achieve the requisite level of emissions reductions in the U.S. while meeting our nation's forecasted energy needs. All of the 350 ppm pathways rely on four pillars of action: a) investment in energy efficiency; b) electrification of everything that can be electrified; c) shifting to very low-carbon and primarily renewable electricity generation; and d) CO_2 capture as fossil fuels are phased out. The six scenarios are used to evaluate the ability to meet the targets even absent one key technology. For example, one scenario describes a route to 350 ppm absent construction of new nuclear facilities; another illustrates achieving 350 ppm with extremely limited biomass technology; still another describes a means to 350 ppm without any carbon capture and storage. Even absent a key technology, each of these six routes are viable and cost effective.

Figure 13: Historic and projected costs of energy in the U.S. as percentage of GDP.



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[95] *See* Mark Z. Jacobson et al., *100% Clean and Renewable Wind, Water, and Sunlight (WWS) All-Sector Energy Roadmaps for the 50 United States,* 8 Energy & Env't Sci. 2093 (2015) (for plans on how the United States and over 100 other countries can transition to a 100% renewable energy economy see www.thesolutionsproject.org); *see also* Arjun Makhijani, *Carbon-Free, Nuclear-Free: A Roadmap for U.S. Energy Policy* (2007); B. Haley et al., Evolved Energy Research, *350 PPM Pathways for the United States* (2019); James Williams et al., *Carbon-Neutral Pathways for the United States*, 2 AGU Advances e2020AV000284 (2021).

[96] B. Haley et al., Evolved Energy Research, *350 PPM Pathways for the United States* (2019).

A related 2021 study concludes that emissions reductions consistent with a 350 ppm trajectory by 2100 can be done at low net cost, substantially lower than estimates for less ambitious 80% by 2050 scenarios a few years ago due to recent declines in solar, wind, and vehicle battery prices.[97] The cost would be well below the 9.5% of GDP spent on the energy system in 2009 (not to mention well below the harm to the economy caused by climate change). (Figure 13)[98] Once the transition is complete, the cost of energy will remain low and stable because we will no longer be dependent on volatile global fossil fuel markets for our energy supplies. As Nobel Laureate Economist Dr. Joseph Stiglitz has stated: "[t]he benefits of making choices today that limit the economic costs of climate change far outweigh any economic costs associated with limiting our use of fossil fuels."[99]

Other experts have already prepared plans for all 50 U.S. states as well as for over 139 countries that demonstrate the technological and economic feasibility of transitioning off fossil fuels toward 100% of energy, for all energy sectors, from clean and renewable energy sources: wind, water, and sunlight by 2050 (with 80% reductions in fossil fuels by 2030).[100]

Products already exist that enable new construction or retrofits that result in zero greenhouse gas buildings. We have the technology to meet all electricity needs with zero-emission electric generation. We know how to achieve zero-emission transportation, including aviation. These actions result in other benefits, such as improved health, job creation, and savings on energy costs.

The amount of natural carbon sequestration required is also proven to be feasible. Researchers have evaluated the potential to drawdown excess carbon dioxide in the atmosphere by increasing the carbon stored in forests, soils, and wetlands, and have found significant potential for these natural systems to support a return to 350 ppm by the end of the century.[101] We know the agricultural, rangeland, wetland, and forest management practices that decrease greenhouse gas emissions and increase sequestration.

There is no scientific, technological, or economic reason to *not* adopt a target of <350 ppm atmospheric CO_2 and 1.0°C by 2100. There are abundant reasons for doing so, not the least of which is to do our best through human laws to respect the laws of nature and create a safe and healthy world for children and future generations.

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97 James Williams et al., *Carbon-Neutral Pathways for the United States*, 2 AGU Advances e2020AV000284 (2021).
98 *Id*., Ben Haley et al., Evolved Energy Research, *350 PPM Pathways for Florida, Technical Supplement* (2020).
99 Joseph E. Stiglitz, Ph.D., *Declaration in Support of Plaintiffs, Juliana v. United States*, No. 18-36082, Doc. 21-14 (9th Cir. Feb. 7, 2019).
100 Mark Z. Jacobson et al., *100% Clean and Renewable Wind, Water, and Sunlight (WWS) All-Sector Energy Roadmaps for the 50 United States,* 8 Energy & Env't Sci. 2093 (2015); Mark Z. Jacobson et al., *Zero Air Pollution and Zero Carbon from all Energy at Low Cost and Without Blackouts in Variable Weather Throughout the U.S. with 100% Wind-Water-Solar and Storage*, 184 Renewable Energy 430 (2022). For a graphic depicting the overview of the plan for the United States see: https://thesolutionsproject.org/why-clean-energy/#/map/countries/location/USA.
101 Benson W. Griscom et al., *Natural Climate Solutions,* 114 Proc. Nat'l Acad. Sci. 11645 (2017); Joseph E. Fargione et al., *Natural Climate Solutions for the United States,* 4 Science Advances eaat1869 (2018); C. Ronnie Drever et al., *Natural Climate Solutions for Canada*, 7 Sci. Advances eabd6034 (2021).