NO TIME TO WASTE.

The Intergovernmental Panel on Climate Change's Special Report on Global Warming of 1.5°C and Implications for Washington State.

CLIMATE IMPACTS GROUP
UNIVERSITY *of* WASHINGTON
An EarthLab Member Organization

In October 2018, the Intergovernmental Panel on Climate Change released the Special Report on Global Warming of 1.5°C, describing the expected impacts of 1.5°C and 2°C of warming and outlining global greenhouse gas emission reduction pathways that could limit warming to those levels.

This brief summarizes the Special Report and related consequences for Washington state. It addresses these questions:

- How much warming has already occurred, compared to the 1.5°C threshold?
- What are the anticipated global consequences of additional warming?
- What are the implications for Washington state?
- How much more warming is likely to occur, given current emissions patterns and policies?
- What are the options for limiting warming to 1.5°C or 2°C?

WHAT'S SO IMPORTANT ABOUT 1.5°C?

Under the 1992 United Nations Framework Convention on Climate Change, nations around the world agreed to "stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic [human-caused] interference with the climate system." In 2015, 195 countries endorsed the Paris Agreement, committing to limit global temperature rise to "well below 2°C" (3.6°F) and "pursuing efforts to limit the temperature increase to 1.5°C" (2.7°F) above pre-industrial levels.

Humans have changed the atmosphere, already causing global warming of about 1°C (1.8°F) and impacts on people, economies and ecosystems around the world.

Human activities have caused current levels of atmospheric greenhouse gases to exceed any level measured for at least the past 800,000 years.

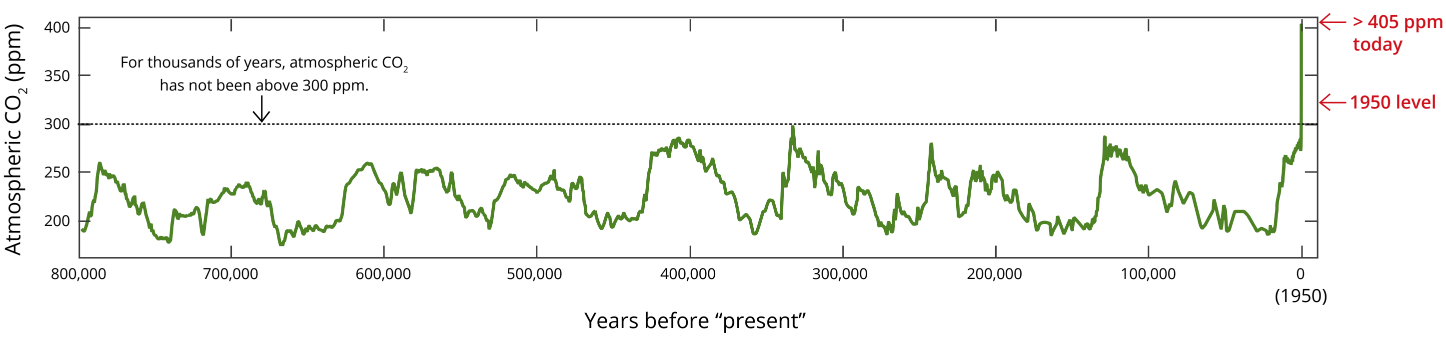


Figure 1. Measurements of air trapped in Antarctic ice and direct measurements of the atmosphere show that atmospheric CO_2 concentrations were less than 300 parts per million (ppm) for at least 800,000 years prior to "present" (1950). Because of human activities, such as fossil fuel combustion and land-use change, atmospheric CO_2 levels are now above 405 ppm. *Data from: Lüthi et al. 2008 (Nature 453:379-82); NOAA (www.esrl.noaa.gov/gmd/ccgg/trends).*

The world has already warmed as a result of human activity.

Global average temperatures have increased about 1°C (0.8°C to 1.2°C) since pre-industrial times (1850-1900). Warming in many regions has already exceeded 1.5°C above pre-industrial levels. According to the IPCC, close to 100% of this warming is the result of human activity.

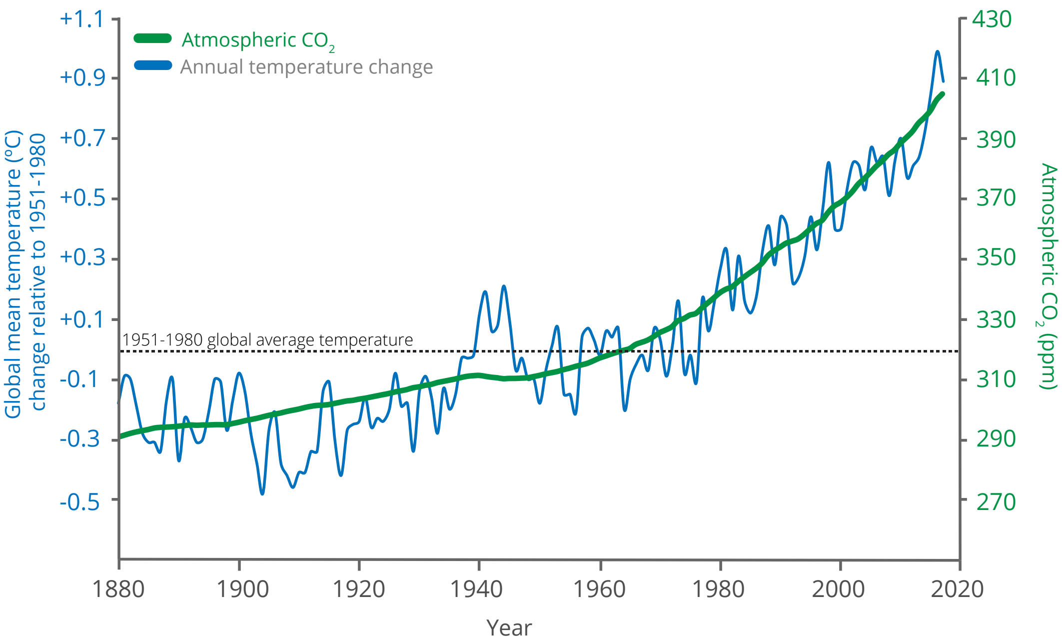


Figure 2. Since the industrial revolution, atmospheric concentrations of CO_2 and global temperatures have increased significantly as a result of human activities. Atmospheric CO_2 increased from about 290 ppm in 1880 to over 405 ppm today, as shown by the green line. Over the same period, global temperatures increased approximately 1°C (1.8°F) – the blue line shows global annual temperature compared to the average global temperature for the period 1951-1980. *Data from: NASA (data.giss.nasa.gov), NOAA (www.ncei.noaa.gov/access & www.esrl.noaa.gov/gmd/ccgg/trends).*

If current rates of warming continue, global warming could reach 1.5°C as soon as 2030.

Human-caused warming resulting from continuing emissions of greenhouse gases is adding around 0.2°C (0.4°F) to global average temperatures every decade. If this continues, global average warming is likely to reach 1.5°C between 2030 and 2052, which is within the lifetime of most people on Earth.

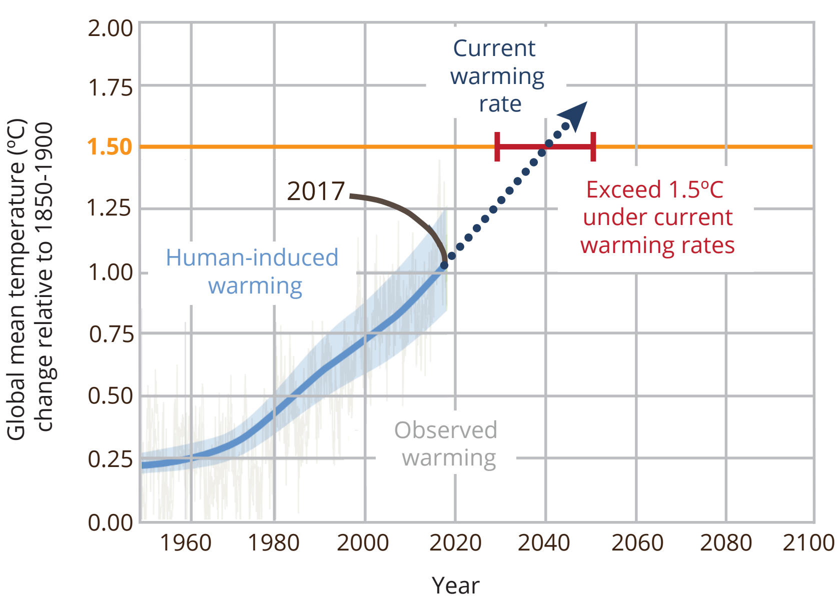


Figure 3. Human activities have caused approximately 1°C of global warming since pre-industrial times (1850-1900). If current rates of warming continue, global warming could reach 1.5°C as soon as 2030 (2030-2052). *Figure modified from IPCC Special Report on 1.5°C (Chapter 1, FAQ 1.2, Figure 1).*

Global costs and challenges from climate change will worsen with any additional warming.

Warming of 1.5°C will increase global poverty; expose more people to life-threatening extreme events (heatwaves, droughts, floods and tropical storms), reduce crop yields and cause economic losses. More severe impacts are projected at 2°C of warming.

Global warming impacts will increase stresses associated with global instability, such as by increasing the severity of extreme declines in water availability in Southern Europe, northern Africa, the Near-East and Southern Africa, and increasing vulnerability to food availability, especially in already vulnerable regions.

Unique and threatened ecosystems and biodiversity in general are even more sensitive to warming of 1.5°C and 2°C than previously thought.

Evidence of present-day impacts and new science on the limits of ecosystem adaptability have shown that low levels of additional warming would severely damage threatened systems, such as coral reefs and the Arctic. Increased risks of wildfires, extreme weather events, and spread of invasive species, pests and diseases would further stress ecosystem services. The United States was noted as one of the regions of the world most at risk from increasing wildfire.

		1.5°C	2.0°C	Impacts of 2.0°C
Extreme Heat	Global population exposed to heatwaves	~4 billion	~6 billion	~2 billion more people
Agriculture & Fisheries	Reduction in global corn harvests	10%	15%	1.5x worse
Agriculture & Fisheries	Decline in marine fisheries	4.5 million metric tons	6.0 million metric tons	1.3x worse
Plants & Animals	Further decline in coral reefs	70-90%	99%	up to 1.4x worse
Plants & Animals	Vertebrates, plants & insects losing at least 1/2 of their range	7%	15%	2x worse
Water Resources	Global population exposed to new or aggravated water scarcity	4%	8%	2x worse
Water Resources	People exposed to drought each month	114.3 million	190.4 million	76.1 million more people
Water Resources	Additional global population affected by river floods	108.4 million	146.3 million	37.9 million more people
Economy	Global costs of warming	$54 trillion	$69 trillion	$15 trillion more
Economy	U.S. Gross Domestic Product (GDP) losses	0.6%	1.2%	2x worse

Figure 4. Half a degree of warming makes a big difference, as shown in this summary of the global impacts of 1.5°C and 2°C warming. *Figure adapted from World Resources Institute. Data from: IPCC Special Report on 1.5°C.*

Continued global warming will challenge the health of Washington's communities, economy and ecosystems.

This section draws from the Fourth National Climate Assessment and two Climate Impacts Group Special Reports: Climate Change Impacts and Adaptation in Washington State and State of Knowledge: Climate Change in Puget Sound.

By mid-century, if greenhouse gas emissions continue on their current pathway, the average year in Washington will be warmer than the hottest year of the 20th century.

Warming is expected to increase the number of very hot days and the chance of both droughts and floods, bring larger and more frequent wildfires to both sides of the Cascades and challenge agriculture through stresses on irrigation supplies and changing pests and diseases. More very hot days are likely to increase hospitalizations, deaths and demand for emergency medical services. Increases in ground-level ozone associated with higher summer temperatures are also expected to increase deaths. Reductions in summer water supply will reduce summer hydropower production and may affect public health through impacts on drinking water quality. More frequent wildfires would reduce air quality, increase hospitalizations related to respiratory conditions and reduce opportunities for outdoor summer recreation.

Warming, sea level rise and ocean acidification are expected to stress Washington's coastal communities and fisheries critical to the state's economy and Northwest tribes.

Rising seas will increase coastal flooding, inundation and bluff erosion. Coldwater fish across the state are expected to be harmed by warmer streams and streamflow changes: higher peak flows and lower low flows.

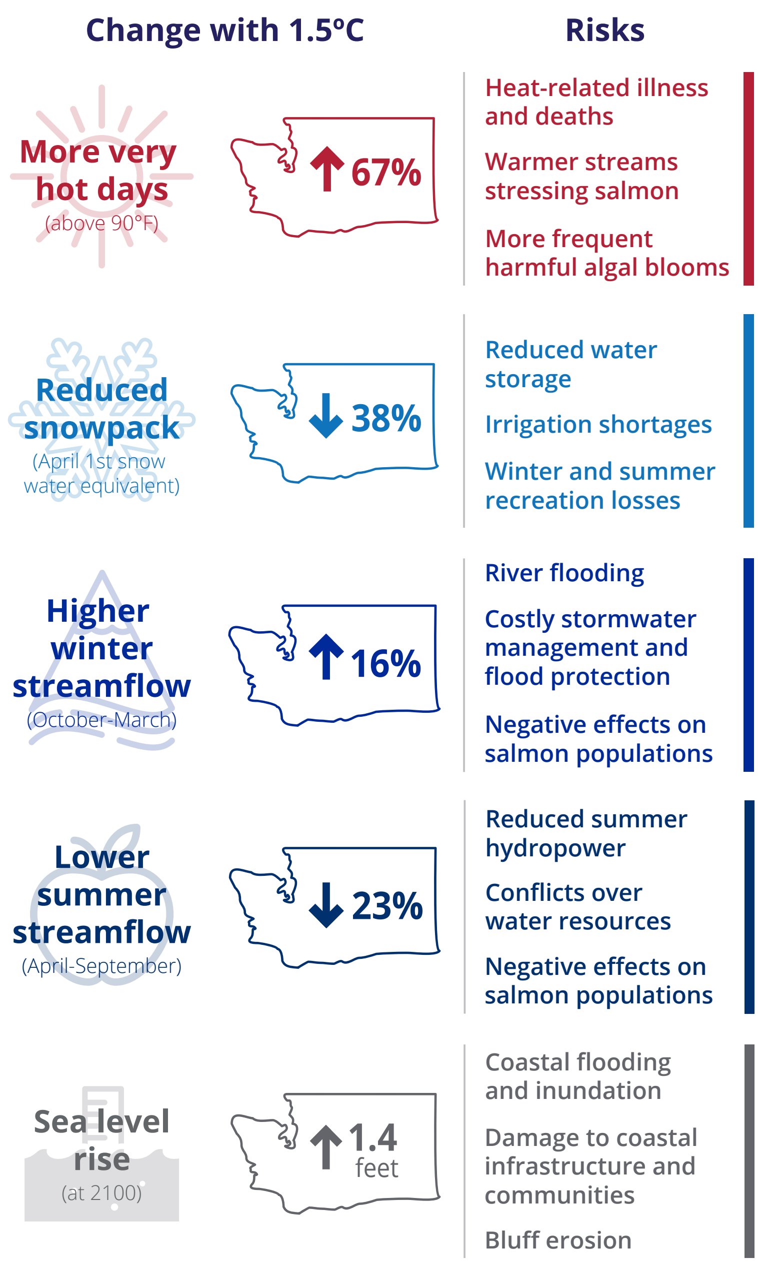


Figure 5. Warming of 1.5°C will bring increasing challenges to Washington. (The figure shows projected changes in hot days relative to 1976-2005, changes in sea level rise relative to 1991-2010; all others relative to 1970-1999.) *Data from: Fourth National Climate Assessment; Climate Change Impacts and Adaptation in Washington State; State of Knowledge: Climate Change in Puget Sound; Projected Sea Level Rise for Washington State – A 2018 Assessment.*

Ocean acidification will harm species with calcium-based shells, such as oysters, clams, mussels and crabs. Warming and ocean acidification may worsen harmful algal blooms, a public health concern due to associated toxins in shellfish. The negative effects of climate change and ocean acidification could lead to more fisheries closures with substantial economic and cultural consequences for commercial and subsistence fisheries.

Washington's built environment (transportation, water, wastewater and energy systems) will face increasing climate-related hazards.

Rising seas, more intense heavy rains, river floods and increasing temperatures are likely to cause transportation closures, delays or detours, especially for facilities and transportation lines located in or near coastal and low-lying areas. Coastal wastewater and stormwater collection systems are likely to experience more problems with saltwater intrusion, corrosion, flooding and inundation, increasing maintenance costs. Port operations and infrastructure, including access to port facilities, are likely to be affected by sea level rise and increased coastal flooding. Increased wildfires could interrupt or damage power generation facilities and energy transmission and distribution infrastructure.

Our natural resource-dependent communities and economies are especially at risk.

In 2015, the agriculture, forestry and fisheries sectors of Washington had $58.8B in sales revenue and collectively employed 303,321 people. Those on the front lines of climate change – tribes, economically disadvantaged communities and those dependent on natural resource economies -- are expected to experience impacts first and most severely. Actions taken today to reduce climate risks will play an important role in determining future consequences of climate change.

The impacts of 2015's extreme climate foreshadow expected local impacts of warming.

During 2015, Northwest average temperatures were about 2.7°C (4.8°F) warmer than pre-industrial (1.9°C (3.4°F) above the 1970-1999 average) and Washington state snowpack was 70% below normal (1970-1999 average). These conditions caused irrigation shortages, agricultural losses, fish die-offs, challenging mismatches between hydropower supply and demand and degraded water- and air-quality.

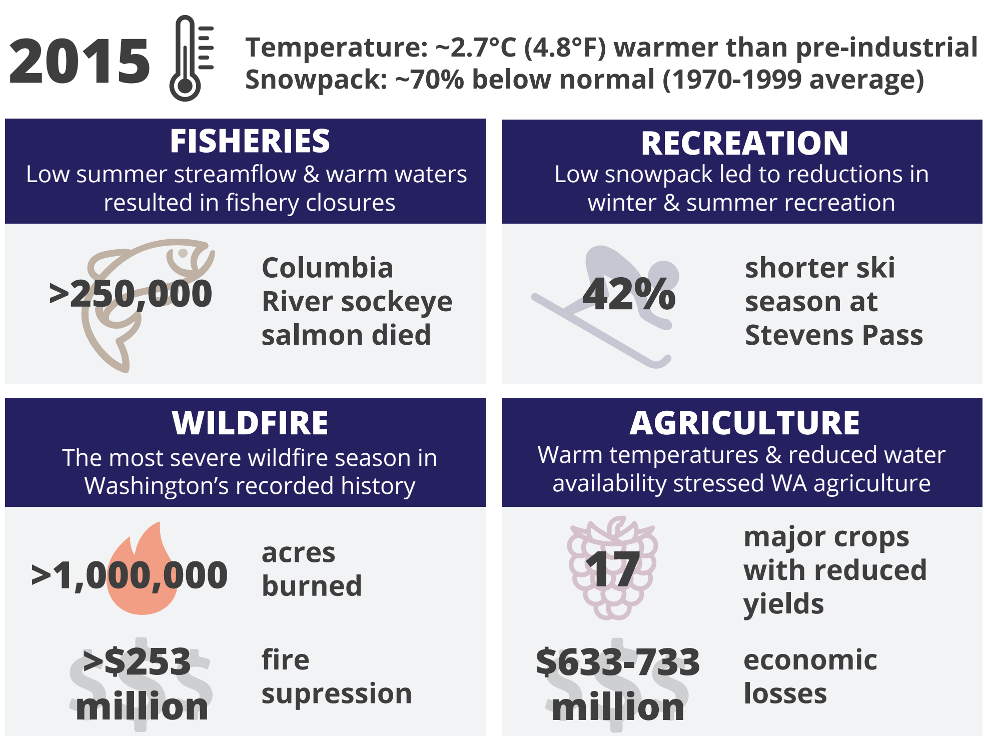


Figure 6. The extreme climate of 2015 provided a preview of impacts likely to become more frequent in Washington state if greenhouse gas emissions are not dramatically reduced. Regional temperatures were about 2.7°C (4.8°F) warmer than pre-industrial and Washington state snowpack was about 70% below normal. *Data from: Fourth National Climate Assessment.*

The costs and challenges of coping with the impacts of climate change will be higher at higher levels of warming.

The extent of harm from global warming depends on both how much warming occurs and how well communities prepare for the impacts of that warming.

Faster reductions in greenhouse gas emissions and slower rates of warming will allow for greater opportunities to address the negative impacts of warming, such as by changing agricultural practices to deal with increasing drought stress, updating local zoning to reduce flooding damages due to sea level rise or preparing public health systems to cope with new health risks. However, even if warming is limited to 1.5°C, it will not be possible to prepare for all of the consequences of climate change.

We're close to locking in 1.5°C of warming

If current emission rates continue, the Earth's carbon budget for limiting warming to 1.5°C will be used up in about 10 years.

After about ten more years of global greenhouse gas emissions at the current rate, net global emissions would immediately have to drop to zero in order for the world to have a 66% chance of limiting warming to 1.5°C. If emissions stopped today, the 1.5°C limit would not be breached.

Even if countries around the world limit their near-term emissions to the amounts pledged under the Paris Agreement, global warming is expected to surpass 1.5°C, at least for a period of time.

In order to seek to return to warming of 1.5°C at a later date, society would have to develop and implement practices and technologies to remove CO_2 from the atmosphere at a global scale. Without this additional effort, expected emissions under the Paris agreement would result in a global warming of 2.9-3.4°C (5.2-6.1°F) by 2100, with additional warming into the 22nd century.

LIMITING WARMING TO A SPECIFIC LEVEL REQUIRES SETTING A GLOBAL CARBON BUDGET

The amount of global warming that will occur depends on the total amount of greenhouse gases emitted due to human activities: more emissions = more warming. The carbon budget is the maximum total amount of CO_2 and other greenhouse gases that can be emitted before causing warming above a specific level.

There is a limited amount of time left in which it is feasible to limit warming to 1.5°C, but society has options.

Avoiding global warming of 1.5°C is only possible if global CO_2 emissions start to decline well before 2030.

Limiting warming to 1.5°C can only be achieved if action is taken to reduce global CO_2 emissions by about 45% from 2010 levels by 2030 and to 'net zero' by around 2050. Limiting warming to 2°C requires net global CO2 emissions to decrease by about 25% from 2010 levels by 2030 and reach 'net zero' by around 2070. Similar deep reductions in non-CO_2 emissions of greenhouse gases, such as methane and nitrous oxide, would also be required in both cases.

STABILIZING GLOBAL TEMPERATURE AT ANY LEVEL REQUIRES REDUCING GLOBAL GREENHOUSE EMISSIONS TO 'NET ZERO'

'Net zero' emissions occur when the amount of CO_2 entering the atmosphere is matched by the amount removed (through, for example, reforestation or carbon capture and storage). As long as more CO_2 is added to the atmosphere than is removed, as is currently the case, global temperatures will continue to increase.

Global CO_2 emission reduction pathways to limit warming to 1.5ºC (2.7ºF)

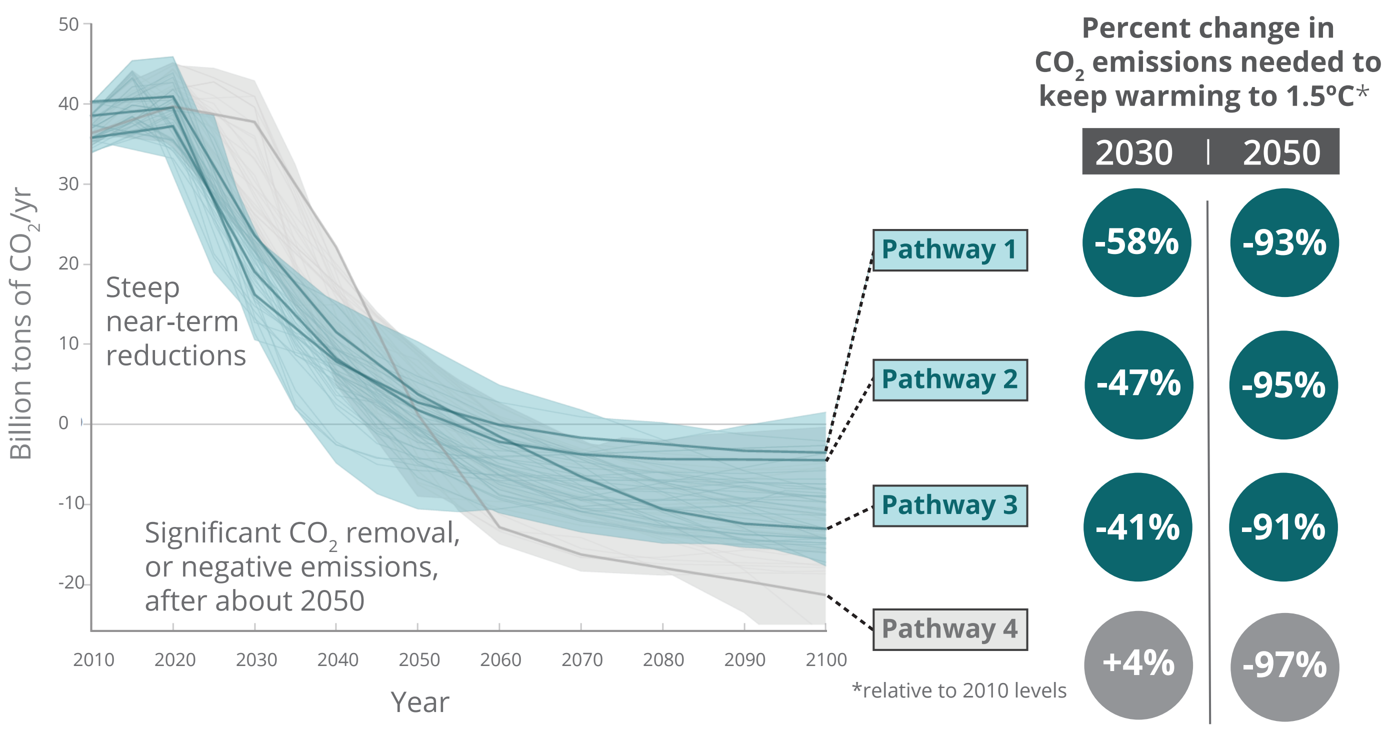


Figure 7. Limiting warming to 1.5°C can only be achieved if action is taken to significantly reduce global CO_2 emissions well before 2030 and if global emissions are decreased to 'net zero' by around 2050, as shown in the blue shaded area and by Example Pathways 1-3. The gray shaded area and Pathway 4 show CO_2 emission pathways that would lead to global temperatures "overshooting" 1.5°C for a few decades and returning to below 1.5°C before 2100. All pathways require "rapid and profound near-term decarbonization of energy supply" and some amount of atmospheric CO_2 removal. *Figure modified from IPCC Special Report on 1.5°C (Summary for Policymakers, Figures SPM.3a & SPM.3b).*

The sooner CO_2 emissions are reduced, the less-drastic those reductions will need to be, and the easier it will be to stay below 1.5°C of warming.

Slower emission reductions decrease the chance that warming can be limited to 1.5°C. Even greater emission reductions would then be needed in order to meet the 1.5°C target, resulting in increased costs, greater likelihood of stranded assets and increased reliance on large-scale, currently unproven, deployment of technologies for atmospheric CO_2 removal.

There are many different ways to stay under the 1.5°C limit, but all alternatives share certain features.

The IPCC provides many alternative global greenhouse gas emission reduction pathways that would limit global warming to 1.5°C (or 2°C) – each represents a portfolio of reductions in emissions of CO_2, methane, black carbon, nitrous oxide and hydrofluorocarbons. All pathways require "rapid and profound near-term decarbonization of energy supply," including steep near-term emission reductions, 'net zero' emissions around 2050 and developing and using technologies, which have not yet been proven at scale, to remove CO_2 from the atmosphere.

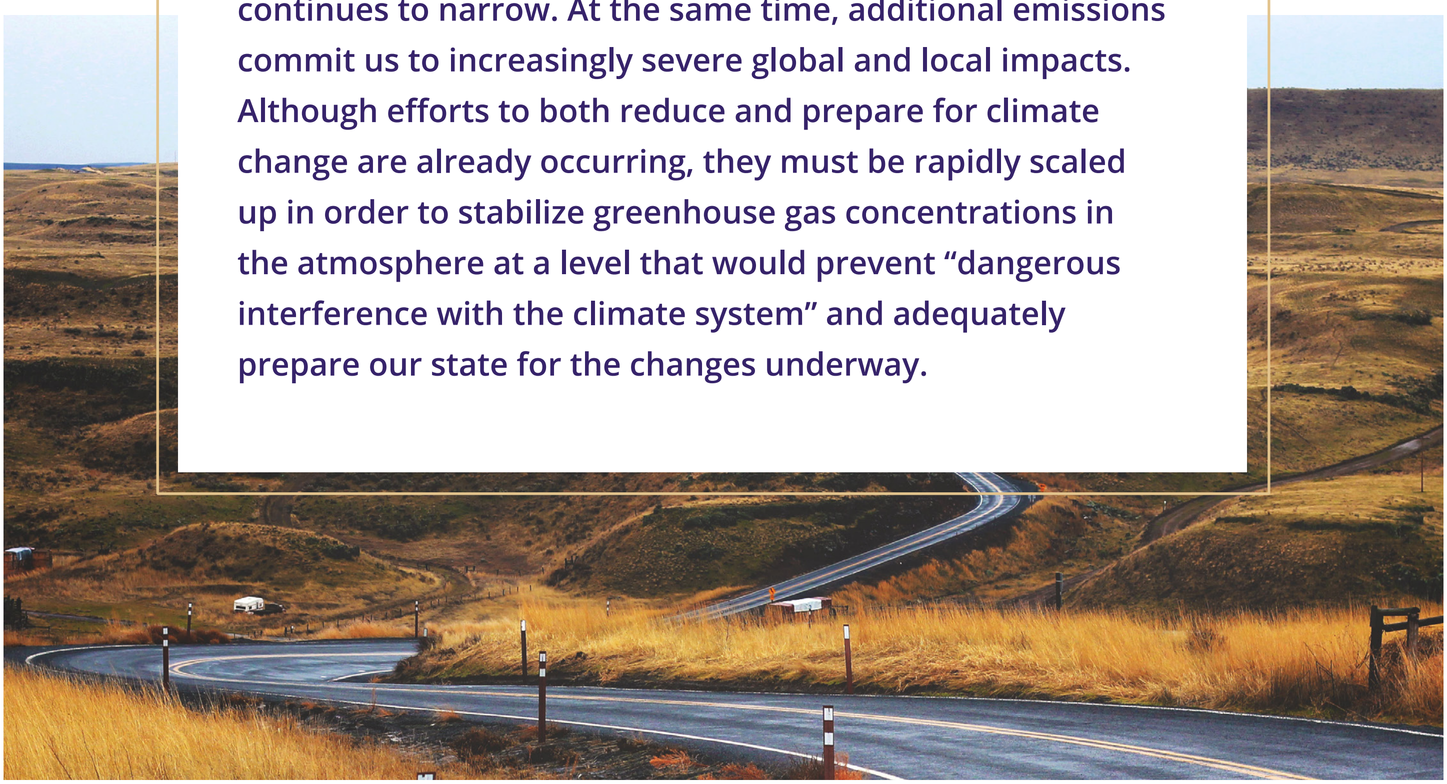
Limiting warming to 1.5°C or 2°C requires rapid transformations in every economic sector, including buildings, industry, transport, energy, agriculture and forestry.

No single sector or fuel type can provide the needed emission reductions. Limiting warming to 1.5°C requires largely phasing out coal use by mid-century, reducing CO_2 emissions from industry by 75–90% by 2050 (relative to 2010), supplying most electricity from renewables and significantly enhancing energy efficiency. According to the IPCC, although "the energy system transition that would be required to limit global warming to 1.5°C is underway in many sectors and regions around the world," "limiting warming to 1.5°C would require a rapid escalation in the scale and pace of transition, particularly in the next 10-20 years."

In conclusion:

Climate change impacts have been observed around the globe, across the United States and here in Washington. Communities around the state are increasingly facing climate-related challenges that stress important natural systems and the economic and ecosystem services that they provide, threaten public health and increase costs of maintaining critical infrastructure. These challenges are expected to become even more likely as warming continues. Climate-related risks are higher for global warming of 1.5°C than at present, and even higher at 2°C warming.

The urgency to reduce emissions and prepare for global warming's inevitable impacts has never been greater. The window of time for limiting warming to 1.5°C and 2°C continues to narrow. At the same time, additional emissions commit us to increasingly severe global and local impacts. Although efforts to both reduce and prepare for climate change are already occurring, they must be rapidly scaled up in order to stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent "dangerous interference with the climate system" and adequately prepare our state for the changes underway.



FOR MORE INFORMATION

The IPCC Special Report on Global Warming of 1.5°C highlights the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission reduction pathways.
Link: ipcc.ch/sr15/

The Fourth National Climate Assessment, Volume Two describes the effects of climate change on the United State, including for 10 regions and 18 national topics.
Link: nca2018.globalchange.gov

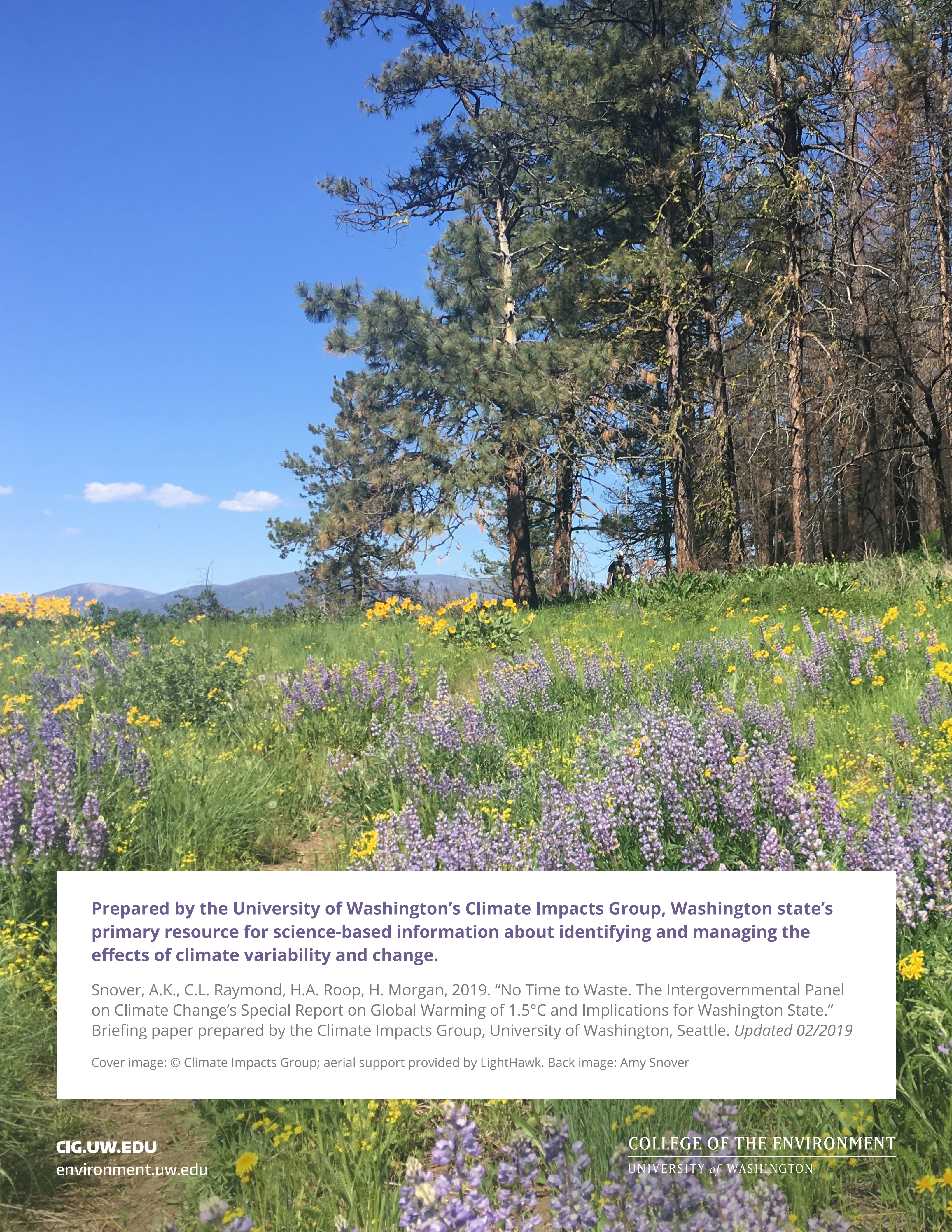
> **Chapter 2** highlights observed and projected changes in U.S. climate.
> Link: nca2018.globalchange.gov/chapter/2/
>
> **Chapter 24** highlights the interconnected risks within the Northwest Region. Impacts are evaluated by sector, including natural resources, cultural heritage, infrastructure, health, and communities.
> Link: nca2018.globalchange.gov/chapter/24/

Climate Change Impacts and Adaptation in Washington State: Technical Summaries for Decision Makers summarizes knowledge about the likely effects of climate change on Washington State and the Pacific Northwest.
Link: cig.uw.edu/resources/special-reports/wa-sok/

State of Knowledge: Climate Change in Puget Sound summarizes the current state of knowledge concerning observed and likely future climate trends and their effects on the lands, waters, and people of the Puget Sound region.
Link: cig.uw.edu/resources/special-reports/ps-sok/

Projected Sea Level Rise for Washington State – A 2018 Assessment provides community-scale sea level rise projections for 171 different locations around coastal Washington.
Link: cig.uw.edu/resources/special-reports/

An interactive climate trends analysis tool for Washington, Idaho, Oregon and western Montana shows observed changes in temperature, snowpack, and rainfall.
Link: climate.washington.edu/trends/



Prepared by the University of Washington's Climate Impacts Group, Washington state's primary resource for science-based information about identifying and managing the effects of climate variability and change.

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