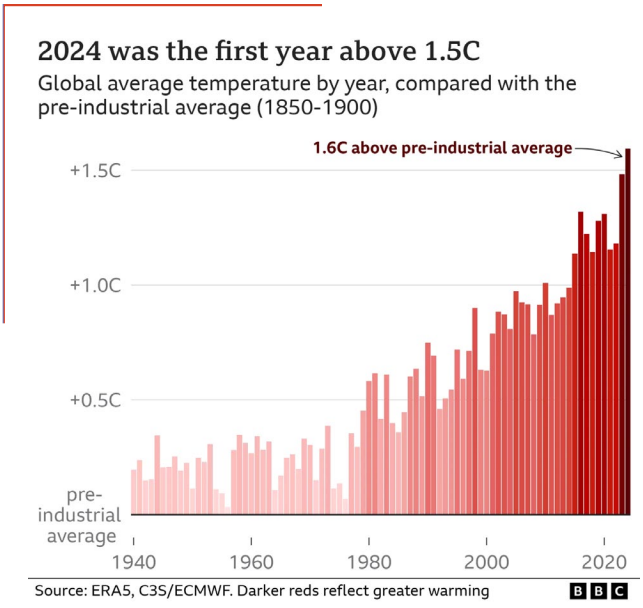
Oregon Climate Impacts and Costs

Climate change poses many costly risks to Oregon residents, including hotter air and water temperatures, extreme drought and wildfires, changes in precipitation, and sea level rise.[1] A recent report on the cost of climate change in Oregon states that "The science is undeniable: Every day, carbon dioxide and other pollutants in the atmosphere cause changes in climate that damage the economic well-being of workers, families, businesses, and communities in Oregon and around the globe."[2] Even if fossil fuel emissions and atmospheric concentrations of greenhouse gasses eventually stabilize through aggressive climate action, the severity of these events will continue to rise as we adjust to the new climate reality. Below we outline the impacts of climate change Oregon faces and some of the potential costs associated with adapting to these impacts. This list is not exhaustive and other costs may be incurred as a result of additional necessary climate change adaptations.

Hotter Temperatures – Air and Water

In 2024, the global average temperature was almost 3°F warmer than the average temperature during the pre-industrial period (1850-1900) due to anthropogenic greenhouse gas emissions,[3] and the rate of warming has been increasing over the past 30 years.[4] In Oregon, the average temperature has increased 2.2°F per century since 1895.[5]



1 EPA, "What Climate Change Means for Oregon" (Environmental Protection Agency, 2016), https://19january2017snapshot.epa.gov/sites/production/files/2016-09/documents/climate-change-or.pdf.

2 Keaton Miller et al., "The Economic Costs of Climate Change for Oregonians: A First Look" (Forum on Oregon Climate Economics, October 2024), https://irp.cdn-website.com/0358d1eb/files/uploaded/economic-cost-of-climate-change-oregonians.pdf.

3 "The 2024 Annual Climate Summary: Global Climate Highlights 2024," Copernicus, January 10, 2025, https://datawrapper.dwcdn.net/oiTWA/40/.

4 Ibid.

5 Erica Fleishman and Oregon Climate Change Research Institute, "Seventh Oregon Climate Assessment," Technical Report (Oregon State University, 2025), https://doi.org/10.5399/osu/1181.

In the next 50 years, the mean annual temperature is expected to be about 5°F warmer in Oregon, with the summer season seeing the highest increase — up to 7.0°F warmer — in projected mean temperature rise.[6]

Not only are average temperatures increasing, but Oregon is now being subjected to intense heatwaves. Week long heatwaves are expected to be 2 to 7 times more likely during the period 2021-2050, relative to 1986-2005.[7] In June 2021, the Pacific Northwest (PNW) experienced a heat dome that wreaked havoc on the region.[8] During the heatwave, much of Oregon experienced three days over 105°F, which is unprecedented for the state, reaching a record high of 119°F at the Pelton Dam COOP and Moody Farms Agrimet weather stations in Jefferson County and Wasco County, respectively.[9] While it is hard to quantify exactly how many people died from the PNW heat dome, the U.S. Department of Health and Human Services reported that 119 people died from heat related causes in Oregon from June 26 - July 10, 2021. The previous year, no one in Oregon died from the heat during that same time period.[10] This heatwave is estimated to have cost Oregonians at least $1.3 billion dollars.[11]

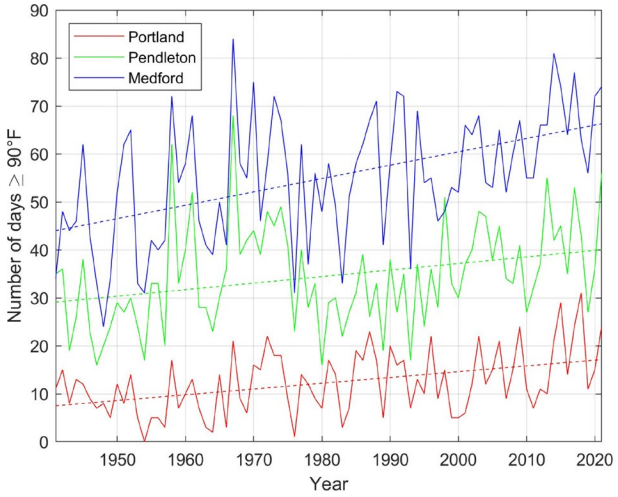


Figure 1 Taken from Oregon's Sixth Climate Assessment[12] showing the number of days over 90°F from 1940-2022 for three cities in Oregon. Each city shows a statistically significant increase in the number of days over 90°F during 2010-2022 as compared to the 1950's.

Public services are already being disrupted by heat. Only 15 out of the 81 schools in Oregon's largest school district have air conditioning, so rising temperatures pose

6 Fleishman and Oregon Climate Change Research Institute.

7 E. M. Fischer, S. Sippel, and R. Knutti, "Increasing Probability of Record-Shattering Climate Extremes," *Nature Climate Change* 11, no. 8 (August 2021): 689–95, https://doi.org/10.1038/s41558-021-01092-9.

8 Sjoukje Y. Philip et al., "Rapid Attribution Analysis of the Extraordinary Heat Wave on the Pacific Coast of the US and Canada in June 2021," *Earth System Dynamics* 13, no. 4 (December 8, 2022): 1689–1713, https://doi.org/10.5194/esd-13-1689-2022.

9 Paul Loikith, "The 2021 Pacific Northwest Heatwave (Heat Dome)," *Oregon Encyclopedia*, April 20, 2023, https://www.oregonencyclopedia.org/articles/heat-dome-2021/.

10 U.S. Department of Health and Human Services, "Extreme Heat," Page, U.S. Department of Health and Human Services, December 12, 2022, https://www.hhs.gov/climate-change-health-equity-environmental-justice/climate-change-health-equity/climate-health-outlook/extreme-heat/index.html.

11 Miller et al., "The Economic Costs of Climate Change for Oregonians: A First Look."

12 Erica Fleishman and Oregon Climate Change Research Institute, "Sixth Oregon climate assessment" ([Corvallis, Oregon] : Oregon Climate Change Research Institute, Oregon State University, 2023).

a threat to students across the state.[13] In September 2024, schools around Portland, Oregon, had to send students home early, with one school even cancelling classes altogether.[14] The Center for Climate Integrity estimates that it would cost approximately $173 million to install and maintain air conditioning in public schools throughout Oregon to cope with hotter temperatures experienced by 2040.[15] In 2020, voters approved a $75 million bond to install air conditioning in Oregon schools.[16]

Hotter temperatures also lead to many other adverse impacts, like increasing mosquito and tick populations, both of which spread vector-borne illnesses, such as West Nile Virus and Lyme disease.[17] Lyme disease infection rates have been increasing across the state in recent years. Oregon had an average of 18 cases of Lyme diseases per year from 2003-2012, and an average of 46 cases per year from 2013-2022.[18]

Ocean temperatures are also rising. Oregon's coastal ocean waters have warmed about 0.5°F per decade since the 1950's and will continue to rise throughout this century.[19] In recent years, the northeast Pacific Ocean has experienced a series of marine heatwaves and sea surface temperature anomalies.[20]

The Pacific Ocean along the coast of Oregon has historically supported productive, multi-million dollar fisheries, as upwelling, a process that brings cold, bottom ocean waters to the surface, leads to cooler surface water temperature in estuary mouths.[21] Rising ocean temperatures have disrupted this cycle, leading to lower oxygen levels, ocean acidification, and increased harmful algal blooms, threatening this ecosystem and the industry it supports.[22] Some marine

13 Monica Samayoa, "As Extreme Heat Cancels Classes, Climate Change Prompts Oregon Schools to Consider AC Upgrades," *OPB*, September 6, 2024, https://www.opb.org/article/2024/09/06/extreme-weather-heat-schools-education-climate-change-air-conditioning-temperatures/.

14 Ibid.

15 Sverre LeRoy, "Oregon - Hotter Days, Higher Costs: The Cooling Crisis in America's Classrooms" (The Center for Climate Integrity, 2021), https://coolingcrisis.org/states/oregon.

16 Samayoa, "As Extreme Heat Cancels Classes, Climate Change Prompts Oregon Schools to Consider AC Upgrades."

17 Pien Huang, "The U.S. Is Unprepared for the Growing Threat of Mosquito- and Tick-Borne Viruses," *NPR*, December 15, 2023, sec. Public Health, https://www.npr.org/sections/health-shots/2023/12/15/1219478835/arboviruses-mosquito-tick-borne-viruses-tropical-disease.

18 Oregon Health Authority, "Lyme Disease in Oregon," 2017, https://www.oregon.gov/oha/PH/DISEASESCONDITIONS/COMMUNICABLEDISEASE/VETERINARIANS/Documents/DiseaseFactsheets/lyme.pdf.

19 Fleishman and Institute, "Sixth Oregon climate assessment."

20 NOAA, "Large Marine Heatwave Reaches Oregon and Washington Coasts," NOAA Fisheries, June 6, 2024, West Coast, https://www.fisheries.noaa.gov/feature-story/large-marine-heatwave-reaches-oregon-and-washington-coasts.

21 Cheryl A. Brown, Darrin Sharp, and T. Chris Mochon Collura, "Effect of Climate Change on Water Temperature and Attainment of Water Temperature Criteria in the Yaquina Estuary, Oregon (USA)," *Estuarine, Coastal and Shelf Science* 169 (February 5, 2016): 136–46, https://doi.org/10.1016/j.ecss.2015.11.006.

22 John A. Barth et al., "Widespread and Increasing Near-Bottom Hypoxia in the Coastal Ocean off the United States Pacific Northwest," *Scientific Reports* 14, no. 1 (February 15, 2024): 3798, https://doi.org/10.1038/s41598-024-54476-0.

species failed to recover after a 2014-2016 marine heatwave[23] with one of the authors of a study assessing the event remarking that "a warming climate will make restoring baseline conditions more difficult."[24] Oregon has a valuable Dungeness crab and Pacific oyster fishing industry and both species are extremely susceptible to ocean acidification. In 2015, an ocean heatwave cost the West Coast Dungeness crab fishery about $150 million.[25]

Potential Costs Related to Hotter Temperatures

Structure and Infrastructure Projects

- Energy efficiency retrofits in public and private buildings and housing, including costs for the design and development of standards.
- Increased cooling costs for all public buildings, including green roofs or cool roofing systems on public buildings and new AC installation or upgrade costs for schools.
- Increased road damage due to more frequent extreme heat events.
- Plan for and increase capacity for increased energy demands due to both increased daytime and nighttime temperature.
- Increase high-albedo surfaces on buildings, roads, and other locations where feasible.

Public Health Projects

- Build and manage more cooling centers, including staffing and tracking of high-risk individuals.
- Increased demand for publicly-financed air conditioning targeted to low-income families and public housing.
- Control the increase of vector borne illness using education and physical and chemical controls for ticks and mosquitoes.
- Treat victims of vector borne illness.
- Treat an increase in asthma attacks requiring hospitalization (resulting from increased heat and ground level ozone, and the increase in airborne allergens).
- Reduce the urban heat island effect by planting trees.
- Protect drinking water supplies from hazardous algae blooms.

23 Zechariah D. Meunier, Sally D. Hacker, and Bruce A. Menge, "Regime Shifts in Rocky Intertidal Communities Associated with a Marine Heatwave and Disease Outbreak," *Nature Ecology & Evolution* 8, no. 7 (July 2024): 1285–97, https://doi.org/10.1038/s41559-024-02425-5.

24 Lynne Terry, "Climate Change Devastating to Some Marine Species, OSU Study Indicates • Oregon Capital Chronicle," *Oregon Capital Chronicle*, June 10, 2024, https://oregoncapitalchronicle.com/2024/06/10/climate-change-devastating-to-some-marine-species-osu-study-indicates/.

25 Fleishman and Institute, "Sixth Oregon climate assessment."

Economic Losses

- Damage to the fishing industry as species migrate to cooler waters and become more susceptible to disease.

Drought and Wildfires

Climate change is making climate extremes more pronounced, including drought. Despite a projected average increase in precipitation in the coming decades, hotter temperatures will increase the rate of evapotranspiration, making soil more dry.[26] Across the state, the number of abnormally dry years has increased.[27] A recent global analysis predicts that Oregon will experience more frequent and severe drought conditions due to climate change.[28] This is especially problematic for Oregon's already vulnerable water supply, as most of it comes from winter snowpack.[29] The water supply is vulnerable to drought, changing precipitation patterns, and hotter temperatures. All of these climate variables will lead to decreased snowpack, meaning there will be less water available to melt in the springtime, limiting water recharge in the local aquifers .[30] Because the springtime will be warmer in Oregon, the snowpack will melt more quickly, potentially overwhelming reservoirs in the spring and leaving less water available throughout the summer and fall.[31] This change in water availability is extremely problematic for Oregon's $5.7 billion dollar agricultural industry, as 85% of Oregon's water is used for irrigation.[32]

Prolonged drought combined with hotter summer temperatures puts Oregon's 30 million acres of forest at risk of wildfires,[33]releasing substantial amounts of carbon emissions and impacting human health and air quality. The Environmental Protection Agency estimates the cost to treat long-term exposures to wildfire is $450 billion, and calculated that short-term exposure from 2008 to 2012 led to premature death and hospitalizations totaling $63 billion.[34]

26 Fleishman and Oregon Climate Change Research Institute, "Seventh Oregon Climate Assessment."

27 Ibid.

28 Lei Gu et al., "Projected Increases in Magnitude and Socioeconomic Exposure of Global Droughts in 1.5 and 2 °C Warmer Climates," *Hydrology and Earth System Sciences* 24, no. 1 (January 28, 2020): 451–72, https://doi.org/10.5194/hess-24-451-2020.

29 Miller et al., "The Economic Costs of Climate Change for Oregonians: A First Look."

30 Hyman-Rabeler, K. A., & Loheide II, S. P. (2023). Drivers of Variation in Winter and Spring Groundwater Recharge: Impacts of Midwinter Melt Events and Subsequent Freezeback. Water Resources Research, 59(1), e2022WR032733. https://doi.org/10.1029/2022WR032733.

31 bid.

32 Miller et al., "The Economic Costs of Climate Change for Oregonians: A First Look."

33 Mike Cloughesy, "Oregon Forest Facts: 2019-2020 Edition" (Oregon Forest Resources Institute, 2020), https://site.oregonforests.org/sites/default/files/2019-01/OFRI_2019-20_ForestFacts_WEB.pdf.

34 Jesse Roman, Angelo Verzoni, and Scott Sutherland, "The Wildfire Crisis: Greetings from the 2020 Wildfire Season," *National Fire Protection Association Journal*, 2020. http://www.nfpa.org/News-and-Research/Publications-and-media/NFPA-Journal/2020/November-December-2020/Features/Wildfire.

The number of large wildfires in Oregon — wildfires that have burned more than 5,000 acres — has increased significantly since the 1970s.[35] The mean size of all wildfires greater than 5 acres in size has also increased significantly from a mean of 79 acres burned in the 1970s to a mean of 6,769 acres burned from 2020-2023.[36] The total acres burned from 2020-2023 was 2,233,743, which is greater than the 2,078,419 total acres burned in the previous decade (2010-2019).[37] In September 2020, wildfires in the PNW killed at least nine people and burned over 5 million acres of land.[38] The 2021 PNW heat dome caused an increase in extreme fire weather conditions for a prolonged period of time.[39] In July 2024, with 22 wildfires already burning and the threat of more to come, over 500,000 people were under fire danger warnings in Oregon and Washington due to a heatwave blanketing the area.[40] Wildfires have become so severe in California that some major insurance companies have pulled out of the home insurance market,[41] which could become a reality in Oregon as wildfire frequency and severity increase.

Wildfires are also costly to fight and control. Fire suppression — which includes expenditure on aviation, vehicles, and fire crew — cost the U.S. $3.7 billion in 2022.[42] Since 1980, the U.S. has experienced an increasing number of wildfires that cost over $1 billion per event. These large wildfires cost the U.S. $13.2 billion per year from 2018-2022, significantly more money than in the 1980s where, when adjusted for inflation, there were no billion dollar wildfires in the U.S.[43] A recent report states that "the federal government spent over $500 million on fire suppression efforts in Oregon in 2018" and estimates that the 2018 fire season may have cost over $6.8 billion to Oregon, or about $3,900 per household.[44] The 2020 wildfire season in Oregon was especially destructive, burning more than 1.2 million acres of land, destroying more than 5,000 homes, and killing nine people.[45] Impacted individuals also incur personal expenses.

35 Stuart Borduin, "How Oregon Wildfires Have Changed over the Decades," ArcGIS Story Map, March 20, 2024, https://storymaps.arcgis.com/stories/14a7d191ff3f41798855adc9535c1733.

36 Ibid.

37 Ibid.

38 Johnny Diaz, "Utility Must Pay $85 Million to People Affected by Oregon Wildfires, Jury Rules," *The New York Times*, January 24, 2024, sec. U.S., https://www.nytimes.com/2024/01/24/us/oregon-wildfires-award.html.

39 Piyush Jain et al., "Record-Breaking Fire Weather in North America in 2021 Was Initiated by the Pacific Northwest Heat Dome," *Communications Earth & Environment* 5, no. 1 (April 22, 2024): 1–10, https://doi.org/10.1038/s43247-024-01346-2.

40 Yan Zhuang and Amanda Holpuch, "Pacific Northwest Faces Critical Fire Risk as Wildfires Burn," *The New York Times*, July 21, 2024, sec. U.S., https://www.nytimes.com/2024/07/21/us/wildfires-lightning-oregon-washington.html.

41 The Associated Press, "Surge in U.S. Thunderstorms" https://www.cbc.ca/news/business/swiss-re-insurance-damage-1.6932920.

42 Jennifer L, "Wildfires Cost Over $148B and 30% of Emissions," Carbon Credits, January 30, 2023. https://carboncredits.com/wildfires-cost-emissions/; Western Fire Chiefs Association, "What Is the Financial Cost of a Wildfire?," December 7, 2022. https://wfca.com/articles/cost-of-wildfires/.

43 NOAA, "U.S. Billion-Dollar Weather and Climate Disasters" https://www.ncei.noaa.gov/access/billions/.

44 Miller et al., "The Economic Costs of Climate Change for Oregonians: A First Look."

45 Ibid.

Recent research estimates that it costs around $5,000 per family to evacuate during severe weather events, like hurricanes and wildfires.[46]

Wildfires also change the landscape of an area and make it more susceptible to debris flows, mudslides, and flash flooding during extreme rainfall events.[47] A recent study estimated that by 2100, the frequency of extreme rainfall occurring within one year after a wildfire will increase by 700% in the Pacific Northwest.[48]

Potential Costs Related to Drought and Wildfires

Water Management

- Purchase of water during water-scarce times.[49]
- Local farmers may need to install or upgrade irrigation systems to mitigate crop loss during drought.
- Public health costs related to increased exposure to water-borne illnesses.[50]
- Replace old pipelines and related infrastructure that have water leak issues.[51]
- Building water conservation infrastructure.
- Upgrading water treatment, wastewater treatment, and other energy infrastructure.[52]
- "Maintain and expand urban and community tree canopy and support ongoing efforts to expand drought-tolerant trees."[53]

Wildfires

- Increase fire suppression, including staffing, equipment, and aviation.
- Prioritize creating fire-adapted communities, restore and maintain resilient landscapes,

46 Jade Scipioni, "Hurricane Irma's Coming: What an Average Family Spends and Does to Prepare," Text.Article, FOXBusiness (Fox Business, September 6, 2017), https://www.foxbusiness.com/markets/hurricane-irmas-coming-what-an-average-family-spends-and-does-to-prepare.

47 Susan H. Cannon and Jerry DeGraff, "The Increasing Wildfire and Post-Fire Debris-Flow Threat in Western USA, and Implications for Consequences of Climate Change," in *Landslides – Disaster Risk Reduction*, ed. Kyoji Sassa and Paolo Canuti (Berlin, Heidelberg: Springer, 2009), 177–90, https://doi.org/10.1007/978-3-540-69970-5_9.

48 Danielle Touma et al., "Climate Change Increases Risk of Extreme Rainfall Following Wildfire in the Western United States," *Science Advances* 8, no. 13 (April 2022): eabm0320, https://doi.org/10.1126/sciadv.abm0320.

49 Zoë Roller et al., "Closing the Water Access Gap in the United States: A National Action Plan," Dig Deep and US Water Alliance, 2022. https://static1.squarespace.com/static/5e80f1a64ed7dc3408525fb9/t/6092ddcc499e1b6a6a07ba3a/1620237782228/Dig-Deep_Closing-the-Water-Access-Gap-in-the-United-States_DIGITAL_compressed.pdf.

50 Ibid.

51 CISA, "Drought and Infrastructure - A Planning Guide" https://www.cisa.gov/sites/default/files/publications/Drought_and_Infrastructure_A_Planning_Guide_508c.pdf.

52 Ibid.

53 Gibson and Jones, "Clark County, Nevada: Climate Vulnerability Assessment."

and create a safe and effective response plan, per the Oregon's Governor's Council on Wildfire Response's requirements.[54]

- Rebuild or relocate damaged properties and public infrastructure, such as homes and utility lines.
- Relocate public infrastructure where necessary.
- Update power lines to withstand dust from wildfires.
- Implement fire mitigation strategies for the future like burying utility lines underground.
- Plan for and disburse community aid after wildfires.
- Implement fire detection strategies, like solar-powered sensors.[55]
- Rehabilitate the landscape post-fire to reduce the risk of erosion and invasive species and mitigate future fire risk.
- Increased hospitalization costs for asthma attacks and other chronic health conditions (resulting from decreased air quality due to wildfire smoke) from both local fires and wildfire smoke traveling from other places like Canada.
- Increased public health costs related to long-term exposure to poor air quality.

Local Planning and Regulation

- Organize public participation and staffing in the creation of water scarcity management plans.[56]
- Develop tools for monitoring ground and surface water resources for public use.[57]

Education and Awareness Programs

- Public education, outreach, and awareness campaigns about water conservation.[58]
- Increase public outreach to encourage wildfire risk management; educate residents in wildfire safety, technical assistance availability, funding sources, and best practices.

Economic Losses

- Agricultural losses due to lost crop and/or infertile topsoil.

54 Kate Brown, "Governor's Council on Wildfire Response: November 2019 Report and Recommendations," 2019, https://www.oregon.gov/osfm/Documents/GovWildfireCouncilRpt-FinalRecs.pdf.

55 Jennifer L, "Wildfires Cost Over $148B" https://carboncredits.com/wildfires-cost-emissions/.

56 CISA, "Drought and Infrastructure - A Planning Guide".

57 Ibid.

58 Ibid.

- Loss of natural services, such as rain providing farmers with free irrigation and infiltration of rainwater through soil being in a state ready.
- Winter recreation and tourism industry losses due to shorter winters and less snowpack.

Increased Precipitation and Severe Storms

Climate change has led to a warmer atmosphere that can hold more water causing a more intense hydrologic cycle. Globally, this leads to changes in precipitation patterns. Oregon's climate naturally has variable precipitation rates and average annual precipitation amounts have not changed significantly from 1977-2016. However, many locations in Oregon have shown significant changes to seasonal precipitation patterns. For example, Portland, Oregon, shows increased precipitation rates from 1977-2016 for January, March, June, October, and November.[59] Further, certain regions in Oregon historically experience more precipitation than others. From 2045-2074, precipitation in Oregon is projected to increase by up to 10% compared to 2015-2044.[60] Extreme precipitation days — days experiencing the 99th percentile of precipitation or more — during the period 2045-2074 are expected to experience up to 20% more rain than the extreme precipitation days in the historical period (1950-2014).[61] Recent national trends in extreme precipitation suggest that, in the coming decades, the most extreme precipitation events may experience substantially more rain in a short amount of time than projections predict.

Increased precipitation has already had severe impacts on Oregon. As extreme precipitation events get worse, the unhoused population in Oregon becomes more susceptible to bacterial gastroenteritis.[62] Eastern Oregon is expected to experience more heavy precipitation after wildfires in the coming century due to climate change, which will trigger flash flooding and mudslides.[63] Calamitous "rain on snow" events, such as the 1996 floods, have the potential to become worse over time.[64]

59 Alexis Kirsten Cooley and Heejun Chang, "Detecting Change in Precipitation Indices Using Observed (1977–2016) and Modeled Future Climate Data in Portland, Oregon, USA," *Journal of Water and Climate Change* 12, no. 4 (June 11, 2020): 1135–53, https://doi.org/10.2166/wcc.2020.043.

60 Fleishman and Oregon Climate Change Research Institute, "Seventh Oregon Climate Assessment."

61 Fleishman and Oregon Climate Change Research Institute.

62 Jonas Z. Hines et al., "Heavy Precipitation as a Risk Factor for Shigellosis among Homeless Persons during an Outbreak — Oregon, 2015–2016," *Journal of Infection* 76, no. 3 (March 1, 2018): 280–85, https://doi.org/10.1016/j.jinf.2017.11.010.

63 Alex Baumhardt, Oregon Capital Chronicle April 5, and 2022, "More Flooding, Mudslides in Oregon as Extreme Fires to Be Followed by Extreme Rains," *Oregon Capital Chronicle*, accessed February 7, 2025, https://oregoncapitalchronicle.com/briefs/more-flooding-mudslides-in-oregon-as-extreme-fires-to-be-followed-by-extreme-rains/; Touma et al., "Climate Change Increases Risk of Extreme Rainfall Following Wildfire in the Western United States."

64 George H. Taylor, "The Great Flood of 1996," 2018, https://www.weather.gov/media/pqr/The_Great_Flood_of_96.pdf.

According to NOAA, extreme weather events that cost over a billion dollars, or "billion-dollar events," have been increasing when adjusted for inflation. A recent analysis by Swiss Re, a reinsurance company, found that severe thunderstorms alone in the U.S. incurred $60 billion in insured losses during 2023 — a record high.[65] Billion-dollar flooding events cost an average of $4.6 billion per event and billion-dollar severe storms cost an average of $2.4 billion per event.[66] In the first half of 2024, severe thunderstorms accounted for 70% of insured losses globally.[67]

Potential Costs Related to Increased Precipitation

Structure and Infrastructure Projects

- Remove, relocate, acquire, or demolish structures to minimize future flood losses.
- Install, reroute, increase capacity, or implement a routine cleaning plan of the storm drainage system.
- Add extra culverts, increase dimensions of existing culverts, or implement routine cleaning and repairing.
- Install detention or retention basins, relief drains, spillways, drain widening/dredging or rerouting, etc.
- Inspect and maintain drainage systems and flood control structures (dams, levees, etc.).
- Inspect bridges in order to identify and/or implement repairs or retrofits or clean under low bridges.
- Resurface roads with more permeable pavement and concrete and/or pavement able to withstand heavier precipitation.
- Stabilizing bridges against scour by hardening abutments and piers.
- Protect rural communities from flooding by installing flood control structures.
- Elevate roads and bridges above the base flood elevation (BFE)[68] to maintain dry access.
- Elevate structures above the BFE, or relocate utilities, water heaters, etc. above BFE.

65 "Insured Losses from Severe Thunderstorms Reach New All-Time High of USD 60 Billion in 2023, Swiss Re Institute Estimates," *Swiss Re*, December 7, 2023, https://www.swissre.com/press-release/Insured-losses-from-severe-thunderstorms-reach-new-all-time-high-of-USD-60-billion-in-2023-Swiss-Re-Institute-estimates/4a15acf7-64b4-4766-8662-1c35d268ab12.

66 National Atmospheric and Oceanic Administration (NOAA), "NOAA National Centers for Environmental Information (NCEI) U.S. Billion-Dollar Weather and Climate Disasters," 2023. https://doi.org/10.25921/stkw-7w73.

67 Swiss Re, "Severe Thunderstorms Drive Insured Losses to USD 60 Billion in First Half of 2024, Swiss Re Institute Estimates," August 7, 2024, https://www.swissre.com/press-release/Severe-thunderstorms-drive-insured-losses-to-USD-60-billion-in-first-half-of-2024-Swiss-Re-Institute-estimates/fdefcc81-c403-4ce8-ab2c-37ca6d98cf4a.

68 Base flood elevation (BFE), as defined by FEMA, is "the elevation of surface water resulting from a flood that has a 1% chance of equaling or exceeding that level in any given year."

- Floodproof inside of municipal buildings, for example by installing check valves, sump pumps, or backflow prevention devices.
- Floodproof or relocate wastewater treatment facilities located in flood hazard areas.
- Floodproof or relocate water treatment facilities located in flood hazard areas.
- Protect emergency operations by requiring or moving all emergency operations centers, police stations, and fire department facilities outside of flood-prone areas.
- Protect critical and emergency facilities by requiring all critical facilities be built 1 foot above the 500-year flood elevation (to meet requirements of FEMA Executive Order 11988).[69]
- Protect critical and emergency facilities from floods using any other technique, for example, raising components above BFE, installing pumping systems or back-up generators for pumping, building dikes, or stabilizing banks.
- Construct floodwalls, small berms, revetments, bioengineered bank stabilization, or other small structural mitigants.
- Implement severe storm strategies for the future like burying utility lines underground.

Natural Flood Mitigation

- Protect and enhance natural floodplain mitigation features (such as wetlands, dunes, and vegetative buffers) to help prevent flooding in other areas and increase water quality.

Public Health

- Protect public water supplies from pollutants transported by runoff.
- Increased hospitalizations related to water-borne illness.

Local Planning and Regulation

- Update flood risk maps and flood zones.
- Develop a floodplain management plan.
- Adopt a stormwater management or drainage plan.
- Adopt, apply, and enforce building codes to ensure buildings can withstand flooding.
- Obtain easements to use privately-owned land for temporary water retention and drainage.

69 Federal Emergency Management Agency, "Executive Order 11988: Floodplain Management," www.fema.gov/executive-order-11988-floodplain-management.

- Join or improve compliance with the National Flood Insurance Program (NFIP) if needed.[70]
- Preserve floodplains as open space using any of several land use planning tools: develop a plan that targets hazard areas for acquisition, reuse, and preservation, a land banking program, use of transfer of development rights to keep floodplains vacant, easements to prevent development, or acquiring properties in the floodplain and turning them into open space.

Education and Awareness Programs

- Increase public outreach to encourage flood insurance purchase; educate residents in flood safety, flood mitigation, technical assistance availability, funding sources, and best practices.
- Increase public outreach to provide awareness of harmful algal blooms and their health impacts.
- Locate new utilities and critical facilities outside of susceptible areas.

Sea Level Rise

Globally, sea levels are rising,[71] as glaciers melt and ocean waters expand.[72] Sea level is estimated to increase on average by 1 to 4 feet by the end of the century.[73] During the last century, sea level has not risen much in the Pacific Northwest due to upward vertical land motion, however, this region, which includes Oregon, is expected to experience up to 1 foot of sea level rise by 2050, as compared to the sea level in 2000.[74]

Oregon is also expected to experience an increase in the number of high tide flooding events. From 1990-2020, the number of these events has tripled across the United States and are expected to triple again by 2050. In 1990, the Pacific Northwest experienced three minor flood

70 U.S. Federal Emergency Management Agency (FEMA), The National Flood Insurance Program (NFIP), at www.fema.gov/national-flood-insurance-program Policy Information by State (https://nfipservices.floodsmart.gov//reports-flood-insurance-data), accessed March 31, 2024; Oregon has over $6.5 billion in total coverage and over 23,700 policies, but local governments should make sure they comply.

71 Ekwurzel et al., "The Rise in Global Atmospheric CO2, Surface Temperature, and Sea Level from Emissions Traced to Major Carbon Producers." https://doi.org/10.1007/s10584-017-1978-0.

72 Miller et al., "A Geological Perspective on Sea-Level Rise and Its Impacts along the U.S. Mid-Atlantic Coast." https://onlinelibrary.wiley.com/doi/abs/10.1002/2013EF000135.

73 Runkle, J., K.E. Kunkel, S.M. Champion, R. Frankson, B.C. Stewart, A.T DeGaetano, and J. Spaccio, 2022: Maine State Climate Summary 2022. NOAA Technical Report NESDIS 150-ME. NOAA/NESDIS, Silver Spring, MD, 4 pp.

74 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" (National Ocean Service, Silver Spring, MD: National Atmospheric and Oceanic Administration, 2022), https://oceanservice.noaa.gov/hazards/sealevelrise/noaa-nos- techrpt01-global-regional-SLR-scenarios-US.pdf.

events, in 2020 that number grew to four events, and by 2050, that number is expected to be over 10 events.[75]

A report from the Union of Concerned Scientists estimates that by 2050, there will be about 26 critical sites, such as waste water treatment plants and industrial contamination sites, along the Oregon coast that could flood twice per year due to increased sea level rise. By 2100, that number will increase to about 86 sites.[76] To protect critical sites, the Center for Climate Integrity estimates that the State of Oregon will need to spend about $7.6 billion by 2040 to mitigate rising sea levels along its coast.[77] Relat-edly, a recent report found that Oregonians could lose more than $450 million in ecosystem services from the loss of salt marshes due to sea level rise.[78]

Potential Costs Related to Sea Level Rise

Structure and Infrastructure Projects

- Stabilize susceptible coastal slopes and cliffs and shorelines using grading techniques, planting vegetation, riprap or geotextile fabric, or bioengineering.
- Remove, relocate, acquire, or demolish structures to minimize future flood losses.
- Install, reroute, increase capacity, or implement a routine cleaning plan of the storm drainage system.
- Add extra culverts, increase dimensions of existing culverts, or implement routine cleaning and repairing to divert high-tide flood water.
- Install detention or retention basins, relief drains, spillways, drain widening/dredging or rerouting, green infrastructure, etc.[79]
- Inspect and maintain drainage systems and flood control structures (dams, levees, etc.).
- Elevate structures above BFE, or relocate utilities, water heaters, etc. above BFE.
- Floodproof inside of municipal buildings, for example by installing check valves, sump pumps, or backflow prevention devices.
- Floodproof or relocate wastewater treatment facilities located in coastal areas.

75 Ibid.

76 Union of Concerned Scientists et al., "Looming Deadlines for Coastal Resilience: Rising Seas, Disruptive Tides, and Risks to Coastal Infrastructure" (Union of Concerned Scientists, June 25, 2024), https://doi.org/10.47923/2024.15502.

77 Sverre LeRoy et al., "High Tide Tax: The Price to Protect Coastal Communities from Rising Seas" (Center for Climate Integrity and Resilient Analytics, 2019), https://climatecosts2040.org/files/ClimateCosts2040_Report.pdf.

78 Miller et al., "The Economic Costs of Climate Change for Oregonians: A First Look."

79 Giese et al., "Assessing Watershed-Scale Stormwater Green Infrastructure Response to Climate Change in Clarksburg, Maryland." https://ascelibrary.org/doi/full/10.1061/%28ASCE%29WR.1943-5452.0001099

- Floodproof or relocate water treatment facilities located in coastal areas.
- Protect emergency operations by requiring or moving all emergency operations centers, police stations, and fire department facilities outside of coastal, flood-prone areas.
- Protect critical and emergency facilities from floods using any other technique, for example, raising components above BFE, installing pumping systems or back-up generators for pumping, building dikes, or stabilizing banks.

Coastal Protection

- Protect critical infrastructure using techniques like beach nourishment, jetties, berms, and seawalls.
- Restore natural wetland areas.

Local Planning and Regulation

- Identify, map, and track coastal erosion and flood hazards.
- Develop and enforce a coastal zone management plan.
- Develop site and building standards.
- Maintain and update existing laws on development.

Education and Awareness Programs

- Increase awareness by disclosing location of high-risk areas to current and future property owners; offer mitigation technique information.
- Locate new utilities and critical facilities outside of susceptible areas.
- Identify, map, or track erosion hazard areas.
- Other education and awareness programs.

Other Potential Costs

Other plausible impacts from climate change that would incur public health costs are increased allergen levels, food- and water-borne infections, and zoonotic diseases.[80]

80 Carmen Milanes et al., "Indicators of Climate Change in California" (Office of Environmental Health Hazard Assessment, 2022), https://oehha.ca.gov/media/downloads/climate-change/document/2022caindicatorsreport.pdf.