OREGON Climate and HEALTH Profile Report

Oregon Health Authority
PUBLIC HEALTH DIVISION
Climate and Health Program

> "As President, and as a parent, I refuse to condemn our children to a planet that's beyond fixing."
>
> -(Barack Obama, June 2, 2014)

In June of this year, President Obama introduced his Clean Power proposal at the Children's National Medical Center in Washington DC. This proposal, together with doubling auto fuel efficiency standards, represents our country's most substantial commitment to cutting carbon dioxide and other greenhouse gas emissions that are disrupting our climate.

It is no accident that the President chose children's health as his lead argument for taking action on climate change. The health of our children and grandchildren are at risk if we fail, from deteriorating air quality, heat exposure, vector-borne diseases, and displacement and trauma due to extreme weather events. Even if we take the most aggressive actions to reduce greenhouse gas emissions, in Oregon and nationally, we must prepare to cope with the serious adverse efforts of climate change for decades to come. This report, from the Oregon Health Authority's Public Health Division, describes the health risks associated with climate change and lays the groundwork for action to address these health impacts.

The Public Health Division is charged with promoting and protecting safe, healthy and resilient environments where Oregonians can achieve lifelong health. This challenge is magnified by growing uncertainties and instabilities in our environments. We know that changing climate conditions will lead to more extreme weather events in Oregon, but we cannot predict exactly where the next wildfire will strike or where the next landslide will occur. The impacts are complex and many of the health effects are long-lasting.

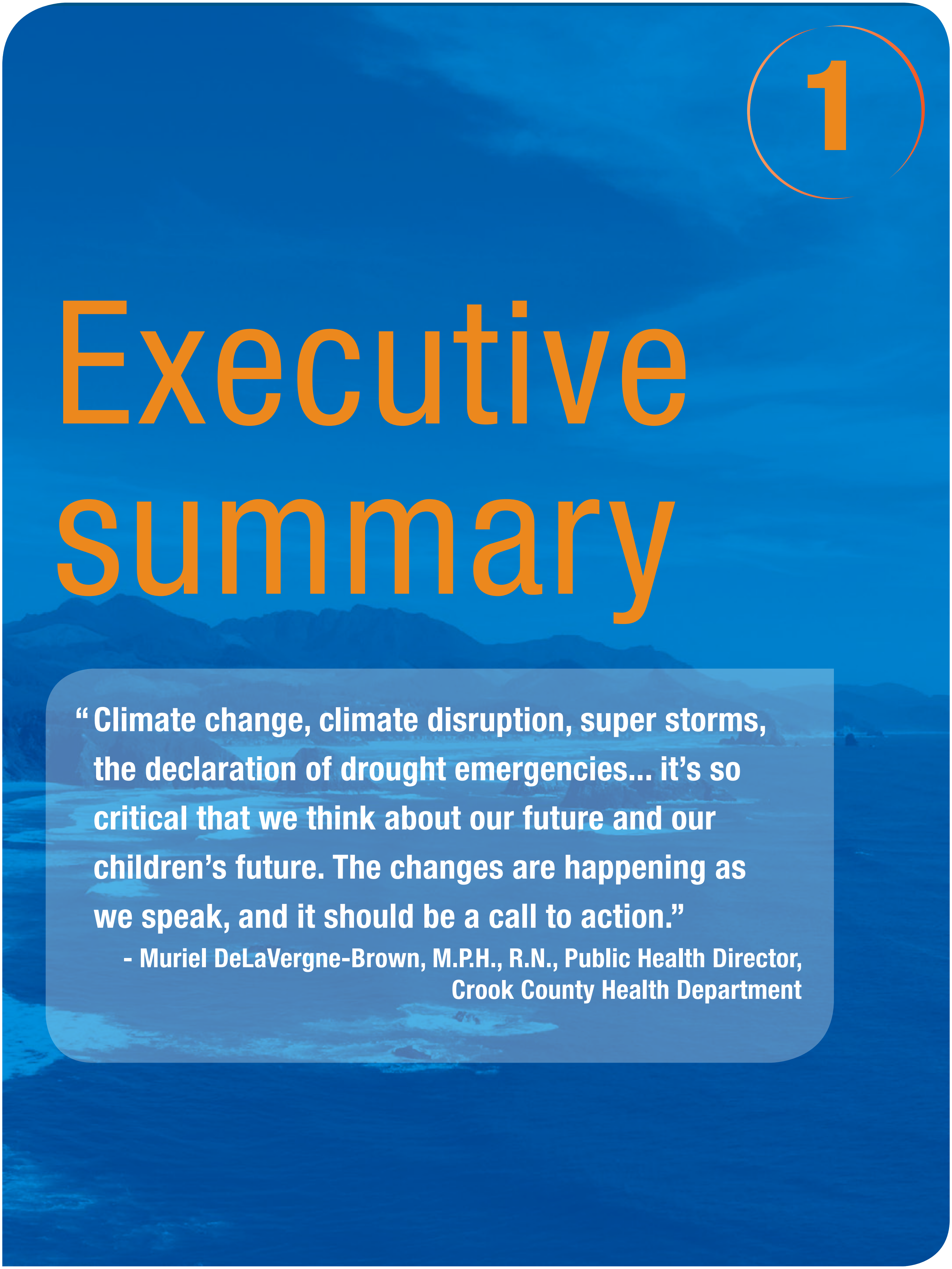
This report defines a problem that we need to come together to solve; the next step is to find the solutions. We must plan and prepare for the health effects of climate change. We need to implement early warning systems, monitor climate-related health impacts, train our health care workers, and more. It's time to make changes that prepare us for the challenges ahead. It's time to make the choices that our children and grandchildren might someday thank us for. When it comes to the many decisions that shape our lives and our world, it's time to put human health first.

Lillian Shirley

Lillian Shirley, BSN, MPH, MPA
Oregon Public Health Division Director

Angus Duncan
Chair of the Oregon Global Warming Commission

Contents



1

Executive summary

" Climate change, climate disruption, super storms, the declaration of drought emergencies... it's so critical that we think about our future and our children's future. The changes are happening as we speak, and it should be a call to action."

- Muriel DeLaVergne-Brown, M.P.H., R.N., Public Health Director, Crook County Health Department

EXECUTIVE SUMMARY

Climate change is happening in Oregon.

Oregon's climate is changing and will continue to change in the years to come.

- Summers are getting hotter and drier.
- The last freeze of winter is occurring earlier, while the first freeze of fall is starting later. By mid-century, much of Oregon is projected to have 20 fewer days below freezing per year.
- More precipitation will fall as rain rather than snow, increasing the risk of floods and landslides.
- Oregon is likely to experience more extreme events like heat waves, wildfires and storms.
- Sea level rise and ocean acidification are expected to continue.

Our health and safety are at risk.

Climate change affects our health in many ways.

- Changes are likely to lead to health impacts from drought, deteriorating air quality, wildfires, heat waves, water-borne disease, increased allergens and diseases spread by ticks and mosquitoes
- Climate change could also increase and worsen chronic diseases such as asthma and mental health issues such as depression and anxiety.

Climate change threatens our access to clean air, clean water and healthy food.

- Air pollution from increased ground-level ozone and wildfire smoke could worsen respiratory illness.
- Water sources can become contaminated from drought or flooding.
- Drought in Oregon or elsewhere could cause food insecurity, especially among vulnerable populations.

Climate already affects health in Oregon.

- Hospitalizations increase during extreme heat events.
- Wildfire smoke is a problem in many communities.
- In many rural communities, drought threatens family incomes and quality of life.

Some communities will be affected more than others.

Climate change is likely to make health disparities worse.

- Some populations, like communities of color and low-income households, already bear a disproportionate burden of disease.
- These groups face more exposures to hazards and have fewer resources to recover from climate change related impacts.

Risk is higher among certain groups.

- American Indians risk further loss of cultural traditions, sustenance and way of life.
- Older adults are more at risk of heat-related illness and death.
- People in low-income urban neighborhoods are at greater risk of heat-related illness due to the urban heat island effect.
- People living on steep slopes are at risk of landslides and those living at the interface of wildlands are more at risk of wildfire.
- Residents on the coast are more at risk from extreme storms.
- Private well users may be at greater risk of water insecurity.
- People working outside, such as farmworkers and construction workers, are more at risk of negative health effects
- People working on the front lines of emergencies, including firefighters and first responders, are more at risk of injury and death.
- Children face cumulative impacts over their lifetime, which will be greater than those of earlier generations

We can work together to protect our families and communities.

Oregon's Public Health Division is taking action to reduce risks.

- Oregon's Public Health Division recognizes that climate affects health in many ways. We are working to further understand our risks and what we can do to prepare for the changes ahead.
- Addressing health disparities and prioritizing the needs of our most vulnerable communities will build Oregon's overall resilience.

Collaboration is essential to building our resilience.

- Taking action requires collaboration across agencies, sectors and cultures.
- Innovative solutions come from our many diverse communities.
- Adapting to climate change includes building local capacity and leadership in traditionally underrepresented communities.

Everyone has a role to play.

- Everyone has a role to play in protecting and improving our quality of life in Oregon.
- Learn more at: **www.healthoregon.org/climatechange**

2

Introduction

"We are trying to preserve and restore traditional foods as they become further threatened by climate change. The salmon provide complete nutrition, and they nourish our forests. Salmon is not just a food source, but a spiritual part of us and this place."

- Delia Sanchez, Grande Ronde Tribe

SECTION II: INTRODUCTION

Oregon is one of many states studying and planning for the health impacts of climate change. As a participant in the Centers for Disease Control and Prevention's (CDC) Climate Ready States and Cities Initiative, the Oregon Health Authority's Public Health Division (OHA) is undertaking a climate and health adaptation planning process known as BRACE (Building Resilience Against Climate Effects). The Oregon Climate and Health Profile Report is a principal component in the BRACE framework.

The BRACE framework is consistent with other planning processes such as basic policy analysis (1) and evidence-based public health practice (2). This report is intended to define and quantify the problem as a first step toward effective intervention.

BRACE FRAMEWORK

STEP 1: Forecast climate impacts and assess vulnerabilities

STEP 2: Project the burden of disease

STEP 3: Assess interventions

STEP 4: Develop and implement a climate and health adaptation plan

STEP 5: Evaluate impact

Rationale

The Oregon Climate and Health Profile Report describes likely impacts of climate change and its influence on health outcomes in Oregon. The report presents a broad, statewide assessment of demographic, geographic and occupational vulnerability to climate change risks. This report will be used in a subsequent, more detailed assessment analyzing social vulnerability, projecting the burden of disease resulting from climate change and identifying interventions likely to reduce negative health impacts. This information will be used to create the Oregon Climate and Health Adaptation Plan to guide climate adaptation activities within OHA and partner agencies.

REPORT GOALS

1. Inform subsequent steps of the BRACE framework.
2. Set direction for the Oregon Climate and Health Adaptation Plan
3. Serve as a tool to communicate likely impacts and a platform for future outreach.
4. Be a resource for local health departments and other sections within OHA.
5. Inform best practices within Oregon and among CDC Climate Ready States and Cities grantees.

The OHA Climate and Health Program envisions a future in which Oregon communities are well-equipped to adapt and thrive in a changing climate. This vision includes building our understanding of the impacts of climate change and developing innovative and collaborative ways to prepare and respond to emerging community needs. The program aims to achieve the following long-term outcomes:

- Reduce or prevent injuries, illness and death that could result from climate change;
- Improve the quality of life in Oregon;
- Decrease health disparities; and
- Advance the practice of climate and health adaptation planning.

Oregon Health Authority's Climate and Health Program

The OHA Climate and Health Program was established in 2010 at the outset of the CDC Climate Ready States and Cities Initiative. The program's first task was to provide training and funding for five local health jurisdictions to pilot the BRACE climate and health adaptation planning process. The participating counties, shown in the adjacent map, represent the diversity of Oregon ecosystems and land use patterns. The health jurisdictions included populated areas in the wet and temperate Willamette Valley, and also included rural eastern counties characteristic of the natural resource-oriented economies found in many parts of the state.

The Climate and Health Program and the jurisdictions identified climate-related health risks of statewide concern. These include injury and mortality, water and vector-borne diseases, respiratory diseases, malnutrition, food insecurity and mental health impacts. We based this on climate projections that anticipate increases in temperature, extreme weather, insect and pest outbreaks, wildfires, sea level, droughts and economic stress.

In the summer of 2013, each of the jurisdictions completed local adaptation plans and are now moving forward with those implementation activities. Best practices will be compiled and shared through an evolving online toolbox that will serve as a resource for other local health jurisdictions across the state.

In 2010, OHA was one of several state agencies that participated in the development of The Oregon Climate Change Adaptation Framework. The framework outlined the beginning of a climate change adaptation strategy for Oregon, setting the stage for further research and development. OHA continues to participate in the adaptation framework work group.

In addition to the core work of the Climate and Health Program, related OHA programs are engaged in several initiatives that inform current efforts:

The Environmental Public Health Tracking Program analyzed heat-related morbidity and mortality in 2012 (3). Researchers found significant increases in hospitalizations associated with extreme heat. Notably, the threshold was lower in areas with more temperate climates. For example, increased health impacts were observed when temperatures were more than 90° F at the coast, whereas the threshold was 105° in southwest Oregon. The Environmental Public Health Tracking Program continues to collect data on climate-related indicators.

"Climate change is a reality we all must face. Yet, the most impacted communities are those who are least responsible. We must collectively arrive at a moment of decision, **where we fully acknowledge the science and start supporting the communities who are most affected"**

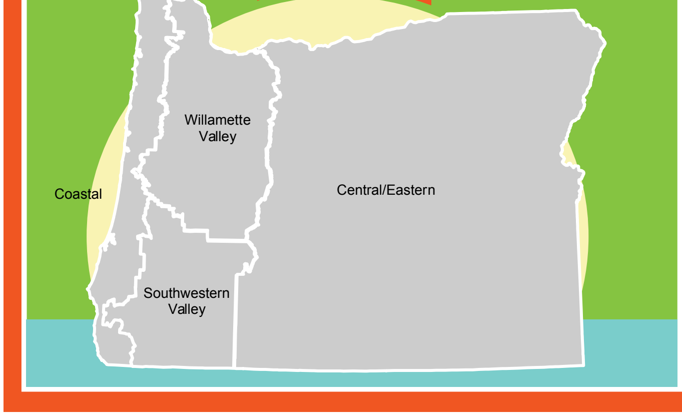
The Health Impact Assessment (HIA) Program has conducted two HIAs on a regional plan focused on reducing carbon emissions from transportation. Using the Integrated Transport and Health Impact Modeling tool, the HIA program estimated health benefits of transportation investments that would reduce reliance on light-duty vehicles. Their findings, quantified primarily in disability-adjusted life years, indicate dramatic health benefits from physical activity under the proposed scenarios, with smaller gains from improved air quality.

The Preparedness Surveillance and Epidemiology Team developed two toolkits for use during natural hazards; one focused on flooding and one on wildfires. These toolkits provide easy access to lessons learned, key information and communication guidance based on past experiences with each hazard. The toolkits have integrated basic messages about climate change and the likelihood of increased natural hazard events.

Geographic scope

The scope of this report is limited to the state of Oregon. In some cases, climate projections are generalized to the Pacific Northwest, a region that includes Washington, Oregon and Idaho. Climate scientists often refer to region-wide impacts, citing a lack of differentiation in climate impacts across the region (4). We have applied regional projections to Oregon in some cases.

MAP 2.2



Oregon shares borders with Washington, Idaho, Nevada and California. While the Climate and Health Program collaborates with similar programs in neighboring states, this report is specific to impacts and vulnerabilities within Oregon.

We have sought to distinguish impacts by region within the state. Oregonians experience vastly different climates in four main zones displayed in the adjacent map: Coastal, Willamette Valley (including Portland and Eugene), Southwestern Valley (including Medford and Roseburg), and Central/Eastern Oregon (including Bend, Burns, and Pendleton). Generally, cooler and wetter weather is found in the western part of the state, with desert-like conditions east of the Cascade Mountains.

References

1. Patton CV, Sawicki DS. Basic methods of policy analysis and planning. 3rd ed. Englewood Cliffs, NJ: Prentice Hall; 2012.

2. Brownson RC, Fielding JE, Maylahn CM. Evidence-based public health: A fundamental concept for public health practice. Annual Review of Public Health. 2009;30:175–201.

3. Oregon Health Authority. Health Burden of Extreme Heat Events (unpublished report). 2012.

4. Dello KD. Associate Director-Oregon Climate Change Research Institute. Phone conversation. (November 18, 2013).

"The wine industry in Oregon is part of an **interconnected tapestry of businesses, industries, and livelihoods that are being threatened by climate change.** We need to work together to find the unique solutions to the challenges that lie ahead."

3

Climate projections

"As a public health preparedness planner it became very clear to me that if the climate models are true, we all need to work together to come up with ways to lessen the impacts."

- Brian Cooke, Benton County Health Department

SECTION III: CLIMATE PROJECTIONS

This section compares the climate we have known and documented in the past to what we may expect based on models of climate change. Using patterns of temperature, precipitation and extreme events based on historical data, the report examines how these conditions might apply to three future climate scenarios.

Baseline: Oregon's climate history and trends

Overview

Oregon's climate is similar to other parts of the Northwest. Weather patterns are shaped by west-to-east progression of weather from the Pacific Ocean over the state's two large mountain ranges. The Coast Range and the Cascades cause heavier precipitation in the west of the state, where proximity to the Pacific Ocean keeps temperatures generally mild year round. East of the Cascades, precipitation is generally lower, summers are warmer and winters are cooler. The strong winds that funnel through the Columbia River Gorge influence the climate along the state's northern border. Oregon's climate is affected by climate variability, most often caused by the El Niño-Southern Oscillation (ENSO), which produces warmer, drier winters and springs during El Niño years (1).

Summers in Oregon tend to be very dry, with low precipitation levels in July, August and September. Thunderstorms are comparatively rare in the Northwest (the lowest frequency in the U.S.), and summer heat is not usually accompanied by high humidity (2). The fall, winter and spring months are typically wet, with many areas of western Oregon receiving rain on more than half the days of the year.

Temperature

As displayed in Table 3.1, normal temperatures during the period of 1981–2010 were relatively mild, with most of the state experiencing mean temperatures in the middle to low 50s. The columns on the right side of the table list mean January minimum and mean July maximum temperatures to give a sense of temperature variation by season. Summer temperatures are generally cooler in the coastal and mountainous areas and warmer in southern valleys and eastern regions (Map 3.1) (4). The eastern region of the state has a greater daily range than the west and typically has lower winter temperatures (Map 3.2) (4).

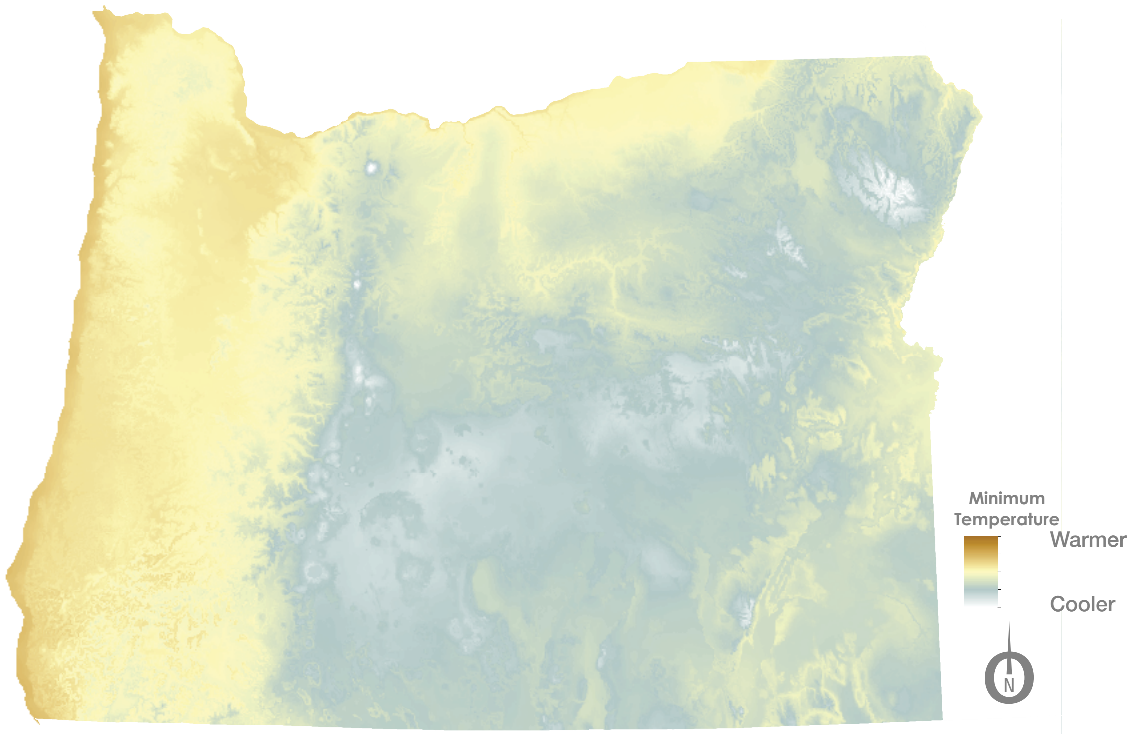
TABLE 3.1.

SELECTED WEATHER STATION NORMALS, 1981–2010

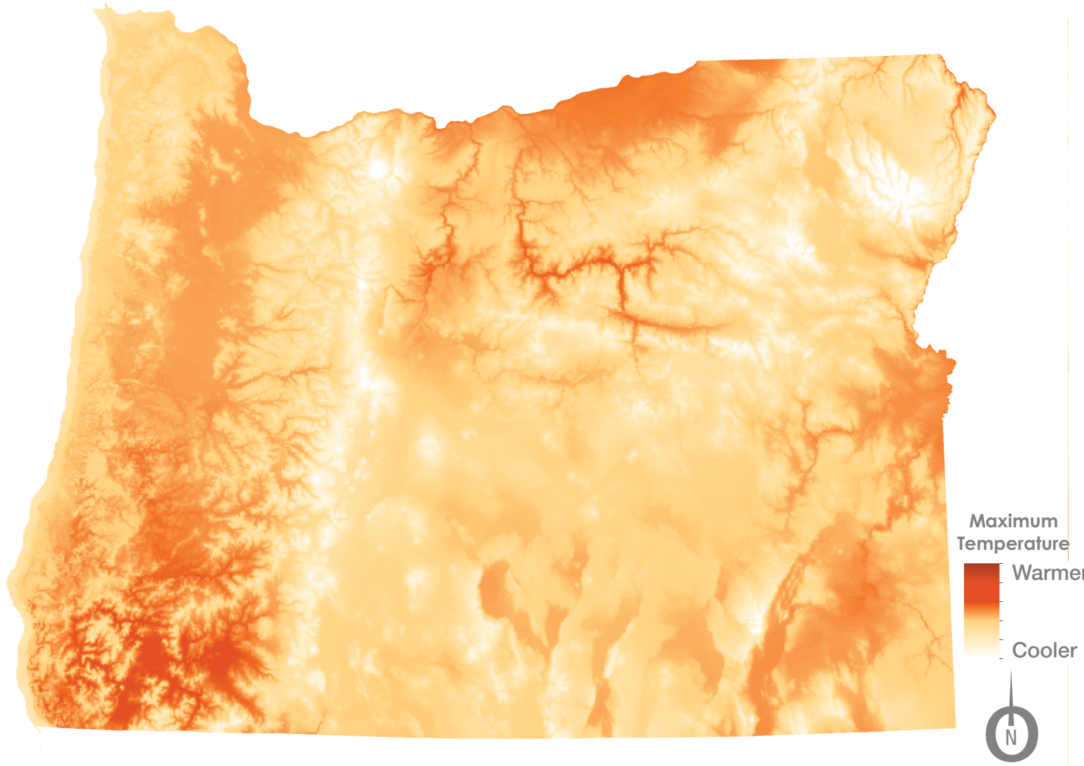
	Mean precipitation (in.)	Mean temperature (deg. F)		
City	**Annual**	**Annual**	**Jan min**	**Jul max**
Bend	11.4	46.6	24.3	81.5
Eugene	46.1	52.5	34.2	82.3
Medford	18.4	55.6	32.8	90.7
Pendleton	17.3	50.8	27.2	89.0
Portland	42.9	54.5	37.5	79.6
Tillamook	88.0	51.3	37.3	68.0

Source: Western Regional Climate Center, 2014(3)

Map 3.1. Average annual minimum temperature 1981–2010



Map 3.2. Average annual maximum temperature 1981–2010



Temperatures throughout the Northwest have risen approximately 0.8°C (1.5°F) since 1895, with significant upward trends in all seasons except spring. Winter temperatures have risen approximately 0.1°C (0.2°F) per decade since 1895, much faster than those in fall or summer. The last freeze in spring is occurring earlier while the first of fall has been later. On average, the freeze-free season was 11 days longer during 1991–2010 compared to 1961–1990 (2).

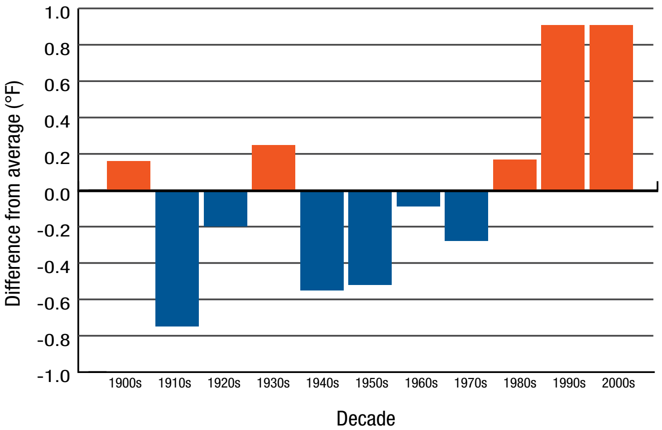


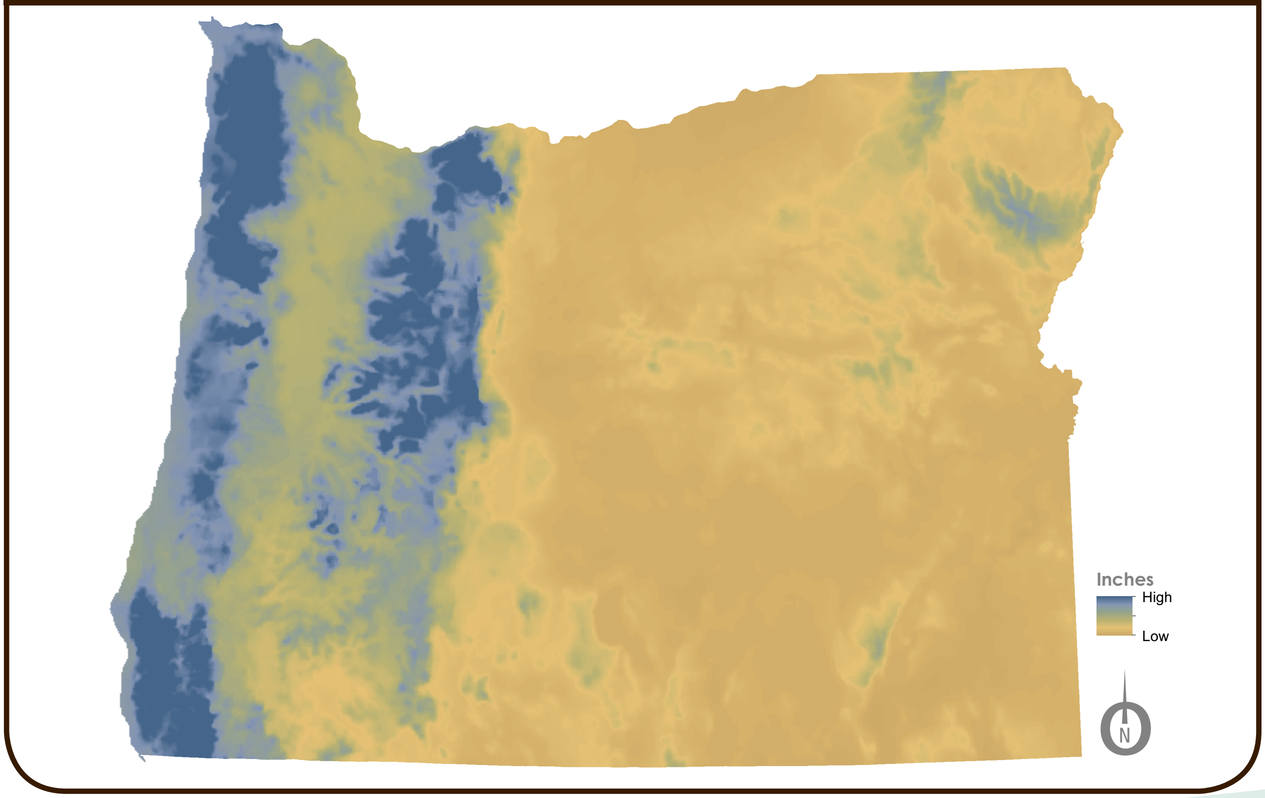
Figure 3.1. Decadal mean temperature
Source: David Rupp, OCCRI

The warming trend is visible in Figure 3.1, which displays the difference from the 20th century average temperature by decade. Temperatures have been above the 20th century average for the past 30 years (1).

Precipitation

During the period of 1981–2010, mean annual precipitation varied widely. Some areas of the state received less than 10 inches of total precipitation while others registered well over 100 inches (Map 3.3) (4). Parts of the Oregon coast are considered rain forests, contrasting with desert conditions

Map 3.3. 30-year annual average precipitation: 1981–2010



Jeff Stone • ED, Oregon Association of Nurseries

"Warmer temperatures could change our growing season and alter types of plants grown in the state. **More alarming is the exposure to new pests and diseases.** This is a significant issue and could have major impacts on what we grow and the cost of production."

in the east. While snowfall is relatively infrequent in the western valleys, it is more common in eastern Oregon and is often heavy in the Cascades. Table 3.1 provides an overview of precipitation in selected cities, illustrating the difference between coastal environments (Tillamook), Willamette Valley population centers (Portland, Eugene) and eastern regions (Bend, Pendleton)(5).

Annual mean precipitation has been somewhat more variable since 1970 than in the distant past (6). Some of the wettest and driest years on record occurred in the last 40 years. While there has been more precipitation variability in recent years, data do not show a clear overall increase or decrease.

Extreme events

Oregon experiences relatively few extreme precipitation events (2). Winter storms occasionally bring significant precipitation and strong winds. The 1962 Columbus Day Storm was one of the most powerful storms in the U.S. since the 1800s (7). As expected, these storms can cause major flooding, especially when combined with melting snow. Major cities in the Northwest are poorly adapted to extreme winter storms and such events tend to have substantial economic impacts. However, many areas of Oregon are accustomed to spring flooding from snowmelt, especially in western river valleys (2).

Drought affects much of Oregon, particularly in the east. With much of the state dependent on mountain snowpack for water during the summer, low precipitation in winter months is a prominent contributor to drought conditions. Drought conditions are more common in eastern areas and often exacerbate wildfires. Wildfires caused by drought can also damage western regions, as with the Tillamook Burns of 1933–1951, the Biscuit Fire of 2002 and the Douglas Complex Fire of 2013.

Detecting trends in cold and heat waves depends on the period studied and the metric used. A 2013 study found that nighttime heat events have increased since 1980 (8). By other measures, the trends in both cold and heat waves have not changed significantly (2). To date, changes in extreme precipitation have generally been modest or insignificant in the Northwest (1).

Coastal trends

Study of sea-level rise in Oregon incorporates the combined effects of ENSO, increased precipitation and ice melt, coastal storms and tectonic motion. Active subduction zones have resulted in the southern Oregon coast rising, while the northern coast is sinking (2). The regional mean sea level rise rate is 2.3 mm/year, less than the global mean of 3.1mm/year (9). Regional sea levels have risen up to a foot during strong ENSO events (10).

Climate projection scenarios

TABLE 3.2.

SCENARIO TIME PERIODS		
Scenario	Reference periods	Projected periods
Medium: CMIP5 RCP4.5	1950–1999, 1980–2004	2041–2070, 2050–2074
Medium–high: CMIP3 A2	1971–2000, 1971–2000, 1980–2000	2021–2050, 2041–2070, 2070–2099
High: CMIP5 RCP8.5	1950–1999, 1980–2004	2041–2070, 2050–2074

Climate scientists use a range of scenarios to model climate changes in part because future human activity is difficult to predict and will have a substantial impact on climate outcomes.

The International Panel on Climate Change (IPCC) uses models from climate scientists around the world, which are synthesized through the Coupled Model Intercomparison Project (CMIP). CMIP 5 scenarios are known as Representative Concentration Pathways, hence the "RCP" prefix. The numeric identifier refers to the amount of radiative forcing (global energy imbalance) associated with each pathway in the year 2100.

We selected scenarios based on available data and to be consistent with other products of the Climate Ready States and Cities Initiative. The time periods available for each model are compared in Table 3.2. Unless otherwise noted, the same time periods are used in our analysis. We also apply projections for the entire Northwest region to the state of Oregon. Based on discussions with experts and the similarities between Oregon, Washington and Idaho, we believe this to be a defensible approach. NOAA and the Oregon Climate Change Research Institute have provided documentation and expert guidance on the use of these projections.

Projections of coastal impacts such as sea level rise, ocean acidification and harmful algal blooms are not readily available using the same timeframe and scenarios. We therefore summarize research from a variety of sources to describe coastal impacts based on the most recent available studies.

Medium emissions: CMIP5 RCP4.5

This is a scenario in which global energy imbalances are stabilized shortly after 2100 (11). This represents substantial emissions reductions and is associated with approximately 2.4°C (4.3°F) warming by 2100 compared to pre-industrial temperatures (12,13). This scenario is reflected in a key source document, Climate Change in the Northwest (1), which is an input into the National Climate Assessment. It provides an optimistic contrast to the medium-high and high emissions scenarios, helping us understand how the health impacts of climate change might differ if mitigating actions are taken. Importantly, this scenario suggests the minimum projected health impacts that could occur in Oregon.

Medium-high emissions: CMIP3 A2

This scenario represents regionally-oriented economic development and relatively high population growth. The scenario is based on medium-to-high emissions and predicts warming of about 2.0–5.4°C (3.6–10.8°F) by the end of this century compared to 1980–1999 (14). A key source document, Regional Climate Trends and Scenarios for the U.S. National Climate Assessment, Part 6 Climate of the Northwest U.S. is based on this scenario. Unlike the other two scenarios selected for this report, extreme temperature and precipitation projections are available.

High emissions: CMIP5 RCP8.5

This third scenario represents the high end of possible impacts, with greenhouse gas emissions continuing to increase over time. It approximates a 4.9°C (8.8°F) warming in 2100 compared to pre-industrial temperatures(13). Like the medium emissions scenario, relevant data and climate outlooks were included and available in Climate Change in the Northwest.

Climate projections in Oregon

Medium emissions scenario: CMIP5 RCP4.5

Mean temperature

Under this scenario, the mean temperature in the Northwest in the period of 2041–2070 is projected to increase by 2.4°C (4.3°F) compared with 1950–1999. At least 0.5°C (0.9°F) of warming is expected in every season, with somewhat more warming in summer (1.3–4.1°C; 2.3–7.4°F).

Projected maximum temperature is an indicator of how much warming can be expected on the warmest days of the year. Geographic models of the period 2050–2074 show annual mean maximum temperatures increasing the most in southeast Oregon (2.8°C; 5.0°F), and the least along the coast (2.0°C; 3.6°F). Maximum temperatures in the Willamette Valley and central Oregon are expected to increase 2.1–2.7°C (4.0–4.9°F)(15).

Data on extreme temperature under RCP4.5 are not available.

Richard Leman MD • Epidemologist

"Rising temperatures will likely result in changes in the distribution of disease—carrying insects. Some we don't see now may gain a foothold, and they will potentially promote the spread of illnesses we currently see only in people who have traveled from other areas."

Mean precipitation

There is uncertainty about the amount and direction of change in precipitation. All projected changes are relatively small compared with normal year-to-year variation. As noted by Dalton et al. (1), "a majority of models project increases in the winter, spring and fall and a majority project decreases in summer." The mean projected decrease in summertime precipitation is -5.6%, but this estimate ranges from a 34% decrease to a 2% increase.

The amount of projected change in annual mean precipitation is similar for all regions in the state of Oregon. More differentiation can be seen when broken down by month or season. For example, springtime decreases in precipitation are projected in western areas, whereas simulations show increases in eastern areas (15).

Data on extreme precipitation under RCP4.5 are not available.

Medium-high emissions scenario: CMIP3 A2

Mean temperature

In this scenario, significant warming is expected in the Northwest, with greater changes expected in southeastern areas of Oregon and Idaho. Smaller changes are projected along the coast. Compared with the period of 1971–1999, annual mean temperatures during the period of 2041–2070 are projected to increase 1.4–3.4°C (2.5 to 6.1°F). A geographic distribution of changes in mean temperature can be seen in Map 3.4.

Springtime changes in temperature are projected to be less than in other seasons, and the greatest warming is expected in summer. Table 3.3 displays the increases expected by season across the region under scenario A2.

Similar to annual means, less warming is expected along the coast in all seasons.

TABLE 3.3.

SEASONAL AVERAGE TEMPERATURE INCREASES (2041–2070), SCENARIO A2

Winter	1.7–2.8°C (3.0–5.0°F)
Spring	1.4–2.5°C (2.5–4.5°F)
Summer	1.9–3.3°C (3.5–6.0°F)
Fall	1.7–3.0°C (3.0–5.5°F)

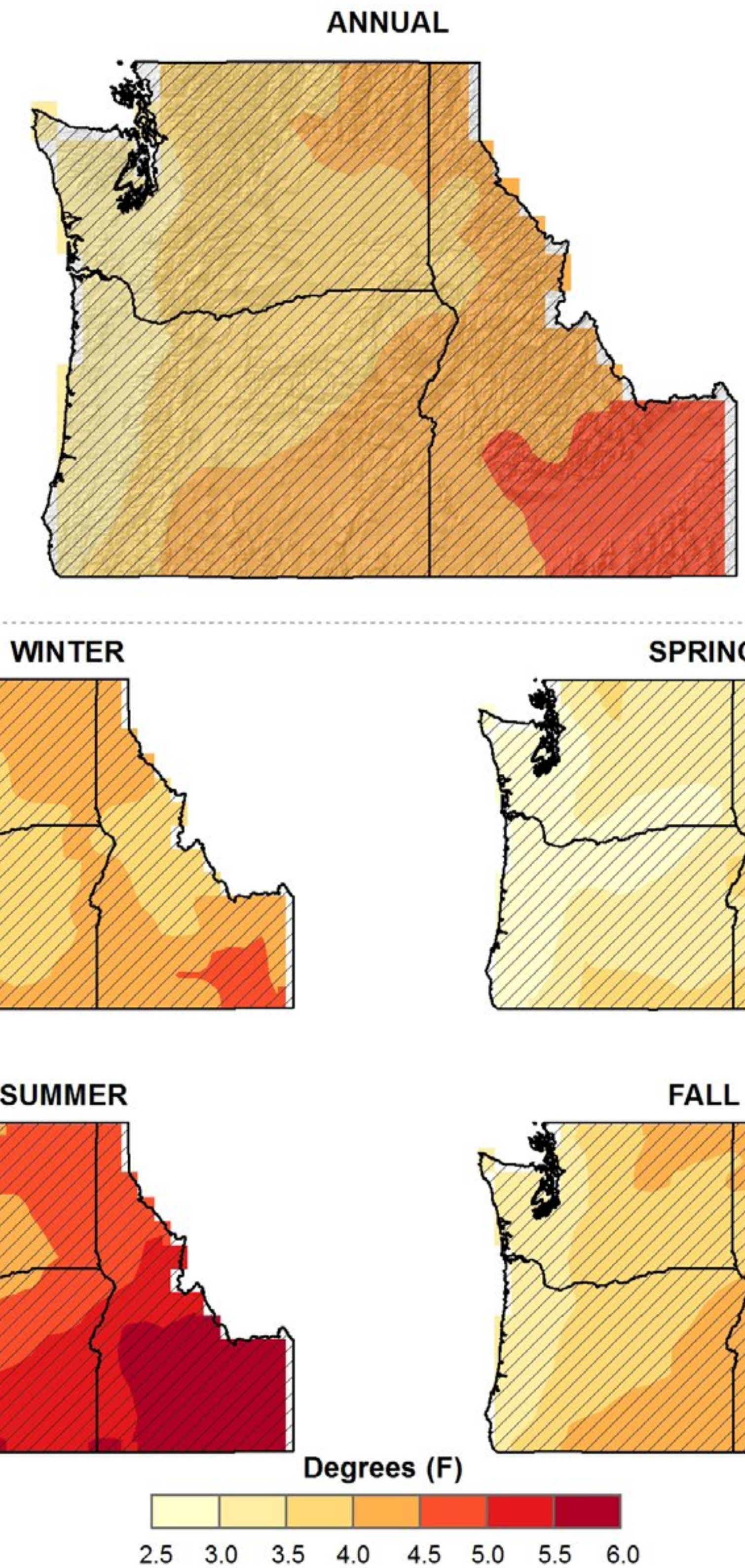
Extreme temperature

This scenario projects a significant increase in high heat days above 35°C (95°F) throughout the Northwest. During the period of 1980–2000, simulations show that nearly all of Oregon had fewer than five days per year above the 35°C (95°F) threshold. Projections for 2041–2070 estimate an increase of three to six more days per year, with more than six additional high heat days expected in the southwest and southeast portions of the state.

Extreme cold <-12.2°C (<10°F) is expected to diminish. While western parts of Oregon will experience little change, much of southeastern Oregon will experience 10 to 15 fewer days of extreme cold per year during the period of 2041–2070.

A large decrease in the annual number of freezing days <0°C (<32°F) is expected throughout most of the Northwest. The Northwest is projected to have a decrease of 35 freezing days. Except for coastal areas, most of Oregon is projected to experience at least 20 fewer days below freezing, with higher elevation areas in the Cascades experiencing more than 40 fewer freezing days. Similarly, the freeze-free season is expected to lengthen throughout the region. The largest changes are projected in northwest Oregon and the southern coast, both of which are expected to see an increase of more than 40 freeze-free days.

MAP 3.4
Simulated difference in annual and seasonal mean temperature (2041–2070 compared to 1971–2000)



Source: Regional Climate Trends and Scenarios for the U.S. National Climate Assessment 2013

Mean precipitation

Compared with 1971–1999, the period of 2041–2070 is projected to see a precipitation increase of approximately 3% in northern and eastern Oregon. According to models, this will likely be indistinguishable from normal year-to-year variation in some areas. For much of central and southwest Oregon, there is uncertainty about precipitation trends, with some models estimating a decrease and others estimating an increase.

There is slightly more certainty about seasonal change, in contrast to changes in annual means. The majority of models for scenario A2 show increases in precipitation during winter, spring and fall, although the distribution within Oregon is a mix of increases and decreases. There is somewhat more confidence in summer projections, which consistently show decreases in precipitation during 2041–2070 compared with 1971–2000. The most consistent modeling results show parts of southern Oregon experiencing summertime precipitation decreases of up to 20%.

Extreme precipitation

One measure of extreme precipitation is the number of days per year with precipitation exceeding 1 inch. For most of Oregon, models of scenario A2 indicate that changes in days with more than 1 inch of precipitation will be less than normal year-to-year variation. There is greater confidence in projections for central and northeastern Oregon, which show an increase of more than 40% in the number of days per year with precipitation exceeding 1 inch. Findings suggest that southeastern Oregon will experience an increase of approximately 15% days per year with precipitation of more than 1 inch.

Kunkel et al. (2) measure lack of precipitation expressed as the mean maximum number of consecutive days within a year with <0.1 inches of precipitation. An increase in the number of consecutive days with <0.1 inches of precipitation is projected for the entire Northwest. In western Oregon, the mean maximum number of days is simulated to increase by 12–15 days per year and 3–9 days in eastern Oregon.

Lyf Gildersleeve • Flying Fish Seafood

"We are changing and evolving as we learn more. Every year there is more to know and more opportunity to participate in sustainable practices. **The opportunities will lie in the hands of those who figure out how to navigate the changes."**

High emissions scenario: CMIP5 RCP8.5

Mean temperature

Greater warming is projected under this scenario. During the period of 2041–2070, the modeled increase in annual average temperature for the Northwest is 3.2°C (5.8°F) compared to 1950–1999, with a range of 1.7–4.7°C (3.1–8.5°F). The greatest warming is projected in summer (1.9–5.2°C; 3.4–9.4°F) and winter (1.3–5.1°C; 2.3–9.2°F). Fall and spring are both projected to warm at least 1°C (1.8°F), and as much as 4.6°C (8.3°F).

The warmest days of the year will become warmer across the state, with some regional variation. Maps of annual mean maximum temperature show less warming at the coast (2.7°C; 5.0°F) and greatest warming along the eastern border (3.8°C; 6.8°F). (15)

Data on extreme precipitation under RCP8.5 are not available.

Mean precipitation

Annual mean precipitation is projected to increase 3.2%, with a range of -4.7–13.5%. The projections of summer precipitation show a decrease. In this case the mean projection is -7.5%, with a range of -27.8–12.4%. There is no difference across Oregon in annual mean precipitation change. Projections for specific months show the greatest variability in the Cascades and on the northern and southern coasts.(15)

Data on extreme precipitation under RCP8.5 are not available.

Projected coastal impacts

In addition to the projections described above, there is evidence of specific coastal impacts in Oregon. These include sea-level rise, storm surges and ocean acidification. Projections of sea level rise are available from a 2012 National Research Council report (10) and study by Mote et al. (16).

Sea levels along the Northwest coast are projected to rise 4–56" by 2100. In the Northwest, non-uniform vertical land motion caused by seismic activity is likely to result in local variation, with some areas experiencing a net increase in sea level and some seeing little change.

Beyond sea level rise, Northwest coastal waters will be affected by climate change in other ways. Carbon emissions are projected to continue affecting acidification in the Northwest. As discussed in Section 4, acidification upsets the ecosystems that many communities depend on for natural resources such as shellfish. A 2012 NOAA report found that the average acidity will increase 100–150% over pre-industrial levels at the current rate of emissions (17).

TABLE 3.4.

CHANGES IN MEAN ANNUAL TEMPERATURE AND PRECIPITATION BY SCENARIO, 2041–2070

Scenario	Temperature	Precipitation
Meduim: CMIP3 A2	+ 1.4–3.4°C (2.5–6.1°F)	+ 3%
Meduim-High: CMIP5 RCP4.5	+ 1.1–3.7°C (2.0–6.7°F)	-4.3%–+10.1%
High: CMIP5 RCP8.5	+ 1.7–4.7°C (3.0–8.5°F)	-4.7%–+13.5%

Summary

All scenarios project higher mean temperatures and slightly increased precipitation (see Table 3.4.)

- Winters are projected to be warmer and wetter and summers will be hotter and drier.
- The mean maximum number of consecutive days with little or no precipitation annually is expected to increase across Oregon, especially in western Oregon.
- Extreme heat days/nights will likely increase while extreme cold days will decrease.
- Sea level will continue to rise, which will be moderated or exacerbated by El Niño, storms and tectonic motion.
- Northwest coastal waters will continue to acidify.

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4

Causal pathways

"Warmer, drier climate conditions will impact the Rogue Valley immensely since much of our domestic water comes from precipitation (mainly snowpack) and if we continue to experience major fires every summer, our health and economic livelihood are in jeopardy."

- Larry Koster, Outdoor Recreation Business Owner

SECTION IV: CAUSAL PATHWAYS

This section identifies health impacts that may result from the projected changes in Oregon's climate. The effects of climate change are complex and a single causal pathway can lead to many health outcomes. For example, exposure to a wildfire or wildfire smoke could exacerbate respiratory illness, result in injury or cause acute stress. Outcomes will vary greatly depending on how we limit the amount of warming and prepare our communities.

Climate change has the potential to affect economic, social, physical and mental well-being through many pathways. Climate change impacts can be interrelated in that one event may increase the probability that another occurs. Drought can increase the risk of wildfire while drought and wildfire can both increase the severity of floods and landslides (1).

CAUSAL PATHWAY: the relationship between determinants (e.g., diet) and health outcomes (e.g., diabetes).

HEALTH DETERMINANT: a causal influence on health, such as smoke exposure

HEALTH OUTCOME: a health endpoint, usually a type of illness or death, such as lung cancer.

CLIMATE IMPACT: changes in temperature, precipitation or ocean acidification including drought, storms and heat waves.

In this section, we treat each climate impact separately to simplify causal relationships, but recognize that climate impacts are often interrelated. Complex pathways caused by events that are especially difficult to project, such as the potential for global climate-caused migration, are not included in this report.

While there may be positive outcomes associated with climate change, such as temporary increases in crop yields in some regions, current climate science concludes that the potential negative effects outweigh those that are positive (2). However, there are ways to minimize health impacts.

Many of the pathways described below are already present in Oregon. For example, hospitalizations increase during extreme heat events. Based on the projected increase in frequency and/or intensity of climate conditions, morbidity and mortality could rise (3). Adaptation to many changes in climate could happen over time, but when abrupt events occur, communities can be caught off-guard. Five consecutive days of temperatures above 95º F would be manageable for residents of Arizona, yet this would be considered a heat wave in Oregon, especially in coastal areas (4). Many Oregonians are less able to adapt because they may not have air conditioning or are unfamiliar with the dangers of prolonged heat exposure (5).

We provide examples of evidence from research literature supporting each pathway. However, this does not constitute a full scientific review of the literature. We have relied on reviews conducted by others, especially the health section of Climate Change in the Northwest (2). For each pathway, we describe possible causal mechanisms, summarize relevant literature and list examples of associated morbidity, mortality and vulnerability. In Section V, vulnerable populations are discussed in greater detail.

Figure 4.1 displays the pathways from greenhouse gas emissions to injury, illness and death. Greenhouse gas emissions cause changes in temperature, precipitation and ocean chemistry, leading to changes in many determinants of health. This section is organized according to eight key pathways: heat, drought, wildfire, floods and storms, sea level, allergens, infectious disease and indirect impacts.

Figure 4.1. Causal pathways


HEAT
HEAT RELATED ILLNESS
DEATH
VIOLENCE
AIR POLLUTION
HARMFUL ALGAL BLOOMS
RECREATIONAL RISK
DROUGHT
FOOD INSECURITY
WATER INSECURITY
MENTAL HEALTH
INCOME LOSS
WILDFIRE
AIR QUALITY
WATER QUALITY
OCCUPATIONAL RISK
INCOME LOSS
DISPLACEMENT
FLOODS, STORMS
WIND
LANDSLIDES
FLOODING
DISPLACEMENT
MENTAL HEALTH
SEA LEVEL
INCOME LOSS
DISPLACEMENT
MENTAL HEALTH
ALLERGENS
ALLERGIC REACTIONS
INFECTIOUS DISEASE
VECTOR-BORNE DISEASE
FOOD-BORNE DISEASE
FUNGAL DISEASE
INDIRECT IMPACTS
ECONOMIC INSTABILITY
OCEAN ACIDIFICATION
CHRONIC STRESS
MIGRATION
RISK
INJURY • ILLNESS • DEATH
TIME TO PREPARE
Oregon Health Authority
PUBLIC HEALTH DIVISON
Climate and Health Program

HEAT

HEAT-RELATED ILLNESS

Morbidity: Examples: heat rash, heat cramps, heat exhaustion, heat syncope (fainting), heat stroke

Vulnerable groups: Examples: people with chronic diseases, pregnant women, young children, older adults, low-income, socially isolated, outdoor workers, unacclimatized, urban residents, communities of color

"Heat-related illness" refers to a variety of conditions resulting from elevated body temperatures such as heat stroke, heat syncope (fainting), heat exhaustion, heat cramps and heat rash (6,7). Heat stroke is defined by a body temperature greater than 104°F, and can include disorientation, convulsions, unconsciousness and potentially death. Average temperatures and heat waves are expected to increase in the Northwest, which could cause an increase in heat related illness (8). Persons who are not acclimatized are at greater risk of heat-related illness (7) but there are many groups vulnerable to extreme heat. A 2008 study by Basu and Ostro found a higher risk of mortality on high heat days for Blacks in California (9).

HEAT-RELATED DEATH

See also: recreational risk

Mortality: Examples: cardiovascular disease, renal failure, heart attack, stroke, heat stroke, deaths from respiratory illness

Vulnerable groups: Examples: people with chronic diseases, infants, children, older adults, low-income, socially isolated, urban, outdoor workers

Extreme heat events result in deaths, especially among older adults (10–15). In the U.S., extreme heat causes more deaths each year than all other weather events combined (11). Existing chronic health conditions are exacerbated by extreme heat. Studies have found extreme heat to be a contributing factor in deaths from respiratory illness, cardiovascular disease, renal failure, heart attacks and strokes (16–18).

VIOLENCE

Morbidity and mortality: Examples: intentional injury, homicide

Vulnerable groups: Examples: children and young adults

The well-documented seasonal variation in crime has led researchers to investigate the relationship between heat and violent behavior. Heat can increase heart rate, blood circulation and sweating, and metabolic changes associated with sympathetic nervous system activity linked to the fight or flight response (19–21). In a study of murder rates and temperature in the U.S., Anderson (2001) estimates an increase of nine murders or assaults per 100,000 people for every 2° F increase in average temperature.

AIR POLLUTION

Morbidity and mortality: Examples: chest pain, coughing, throat irritation, congestion, reduced lung function, exacerbation of emphysema, bronchitis and asthma, cancer deaths, cardiopulmonary deaths

Vulnerable groups: Examples: people living near heavy traffic, people with existing chronic respiratory illness, children

Two harmful components of air pollution are ground-level ozone (smog) and particulate matter. Particulate matter and ozone aggravate asthma (26,27) and increase the risk of cardiovascular disease (28,29). Particulate matter has been identified by the World Health Organization as a leading cause of cancer deaths (30).

Ground-level ozone and particulate matter are expected to increase as a result of climate change. Ozone formation increases with temperature (3,22). Higher summer temperatures and air stagnation events due to climate change are expected to cause modest increases in particulate air pollution and ground-level ozone in the Northwest (23). Decreasing precipitation and more frequent air stagnation events are projected in the Western U.S. (24,25).

HARMFUL ALGAL BLOOMS

See also: infectious disease

Morbidity and mortality: Examples: rash, paralytic shellfish poisoning, gastrointestinal illness, neurotoxic shellfish poisoning, food insecurity, death

Vulnerable groups: Examples: people who eat shellfish, those who are economically dependent on seafood or coastal tourism, American Indians

Harmful algal blooms (HABs) occur when certain types of microscopic organisms grow quickly in water, often in response to higher nutrient levels. The association of HABs and climate change is not thoroughly understood (22). Since HABs are less likely to develop in cold water, it is reasonable to expect that warmer temperatures could increase frequency and range (Dalton et al. 2013).

HABs (cyanobacteria) can lead to exposure to natural toxins through direct skin contact, swallowing, inhalation or by eating shellfish harvested from affected areas (22). HABs can cause neurotoxic and paralytic shellfish poisoning when humans consume shellfish that have accumulated biotoxins from ingesting microorganisms that produce toxins (23). In coastal communities and among some American Indians, shellfish are an important source of food and income (2).

Many cyanobacteria can produce neurotoxic, hepatotoxic, dermatotoxic or other bioactive compounds that pose a threat if they occur in drinking water sources (24). The presence of high levels of cyanotoxins in drinking water can cause gastrointestinal complications, liver damage, neurological symptoms, and potentially but rarely, death (25). Recreational exposure to toxic HABs through direct skin contact, inhalation or ingestion of water can cause rashes, allergies and gastrointestinal problems for people working or engaged in recreation on the water (26). If contaminated water is used for irrigation, farm workers can be at risk of inhalation or direct contact. Contact with HABs can result in deaths among dogs and livestock, and several such cases have been recorded in Oregon (27). Some HABs can become airborne and cause or worsen asthma symptoms (28).

Safina Koreishi MD MPH • Neighborhood Health Center

"Building resilience is vital for all stakeholders including medical providers, patients, health care leaders, organizations and communities, since a true health system transformation cannot simply occur within an exam room."

RECREATIONAL RISK

Morbidity and mortality: Example: drowning

Vulnerable groups: Examples: children, males

Recreational swimming in Oregon is not without risk for those seeking relief from heat. Most drowning deaths occur during the heat of summer months and drowning deaths in cold-running rivers fed by snow melt can be frequent (29,30). Cold shock from entering water below 70 °F can cause involuntary gasping, severe hyperventilation and severe cardiac stress (31). Increased heat events could lead to more people entering hazardously cold waters that contribute to drowning deaths.

DROUGHT

FOOD INSECURITY

Morbidity and mortality: Examples: malnutrition, obesity, chronic diseases

Vulnerable groups: Examples: communities of color, American Indians, low-income households, pregnant women, children, rural residents

Agricultural production depends on water availability, and drought can bring large losses of crops and livestock (32–34). Global climate change could result in food shortages and an additional 5 to 170 million people at risk of hunger by 2080 (34–36). Losses in food crops and livestock can cause increased food prices, leading to food insecurity. Food insecurity is the lack of access to a sufficient amount of nutritious food and can impact health in ways ranging from increased obesity rates to chronic malnutrition. If food insecurity increases the consumption of calorie-dense, processed foods, it can contribute to obesity and lead to chronic disease such as diabetes (37). Conversely, food insecurity may cause chronic malnutrition when supplies are inadequate to meet caloric and other nutrient needs over a long period of time (38). Food insecurity is also associated with negative health outcomes among children that have lasting effects on learning and productivity into adulthood (39–41).

WATER INSECURITY

Morbidity and mortality: Examples: water-borne disease (microorganisms, biotoxins and toxic contaminants), dehydration

Vulnerable groups: Examples: rural residents, low-income, private well users, infants, American Indians

Water insecurity refers to a lack of access to water of sufficient quantity and quality for basic needs and livelihoods. Drought is primarily an issue of water quantity. Low water levels can result in decreased food production, energy production and diminished wildlife habitat, all of which can lead to negative effects on health associated with food insecurity or interruptions in health care resulting from lack of clean water (38,42). Water scarcity can lead to poor hygiene or improper washing of fruits and vegetables (38).

Decreased water quantity and flow can lead to higher levels of drinking water contaminants. Viruses, protozoa, bacteria, nitrates and arsenic contaminants increase the likelihood of water-borne disease or toxic exposure (38,43–46). As a result, communities with small drinking water systems may need alternate water sources or increased treatment. These conditions have been observed during the ongoing drought in California (47).

MENTAL AND BEHAVIORAL HEALTH

See also: storms and flooding, sea level rise, other indirect impacts

Morbidity and mortality: Examples: stress, depression, anxiety, suicide

Vulnerable groups: Examples: farmers and ranchers, rural residents, low-income

Drought can cause stress from financial concerns, loss of security and displacement (48). Uncertainty and loss of control from drought events can lead to depression and mental distress (49–51). Distress and suicide among farmers and ranchers is associated with drought (52,53). The adverse mental health effects of drought increase the likelihood of risk behaviors such as tobacco and alcohol use, and poor dietary habits (54,55).

INCOME LOSS

See also: wildfire, sea level rise

Morbidity and mortality: Examples: stress, chronic disease, premature death

Vulnerable groups: Examples: economically dependent on agriculture, rural residents, American Indians

Drought threatens the livelihood of farming and ranching communities. Citing observations in Brazil and Australia, Berry et al. (2010) suggest that drought can result in chronically lower socioeconomic status and educational attainment in rural areas. Since income and educational attainment are strong predictors of chronic disease and premature death, such changes could have effects on public health (56,57).

WILDFIRE

AIR QUALITY

Morbidity and mortality: Examples: cardiopulmonary disease, ischemic heart disease, asthma, bronchitis, pneumonia, cancer, motor vehicle crash injury

Vulnerable groups: Examples: people with existing chronic illness, children, older adults

Particulate matter (PM) in smoke from wildfires is associated with cancer, cardiopulmonary disease and respiratory illness (58–60). As a result of projected increases in wildfire, Spracklen et al. (2009) anticipate an increase in aerosol organic carbon of up to 40% and an increase in elemental carbon in the western U.S. of up to 20% in 2046–2055 compared to 1996–2005. Organic and elemental carbon are major parts of ambient PM (61). PM associated with wildfires in California has been shown to be more toxic to the lungs than normal ambient PM (62). PM exposure from wildfire smoke is a risk beyond the immediate area of the fire, since high winds can carry the PM long distances (2). Increases in smoke are associated with hospital admissions for respiratory complaints, and long-term exposure worsens existing cardiopulmonary disease (58,63), bronchitis and pneumonia (64).

Decreased visibility from wildfire smoke can be a contributing factor to motor vehicle crashes (65,66).

WATER QUALITY

See also: drought

Morbidity and mortality: Examples: gastrointestinal illness, methemoglobinemia

Vulnerable groups: Examples: infants, private well users

After wildfire, watersheds can experience increased flows of sediment and nutrients and elevated temperatures (67,68). This can increase treatment requirements and damage infrastructures in drinking water systems. As described by the EPA (2013), turbidity in drinking water is a marker for harmful viruses, parasites and bacteria. Drinking water with nitrate concentrations above 10 mg/L can cause methemoglobinemia (blue baby syndrome) (69). Nitrates can increase after wildfire, but specific studies of wildfire and risk of methemoglobinemia are lacking (70).

OCCUPATIONAL RISKS

Morbidity and mortality: Examples: heat stress, heat-related illness, unintentional injury, hearing loss, rhabdomyolysis, death

Vulnerable groups: Example: wildland firefighters

Wildland firefighters are at risk of illness, death and injuries from falls, equipment and burns (71). Among the exposures common among firefighters is equipment noise, which can lead to hearing loss (72). Wildland firefighters are at greater risk of rhabdomyolysis, a condition resulting from the breakdown of muscle tissue after physical exertion (73). Deaths can be related to vehicle crashes, heat exposure, burns and heart attacks (73). There were over 200 fatalities among wildland firefighters from 2001 to 2012 (73). The 2013 wildfire season in Oregon resulted in the loss of three firefighters (74).

INCOME LOSS

See also: drought, sea level rise

Morbidity and mortality: Examples: chronic disease, premature death

Vulnerable groups: Examples: rural residents, American Indians, those economically dependent on tourism or forestry

There are at least two pathways by which wildfires have potential to reduce income. The first is by reducing forest industry productivity, which represents an estimated 76,000 jobs in Oregon (75). The second is the impact to recreation in areas vulnerable to wildfire (2). Studies from other regions have shown a drop in tourism demand due to wildfire (76), and anecdotal evidence from Oregon indicates that tourism revenue and employment decreases during wildfires (77). Fisheries and agriculture are also dependent on healthy forest systems and vulnerable to economic impacts. Loss of income, especially over the long term, can have lasting health effects. Socioeconomic status is a powerful predictor of leading causes of death, especially chronic disease (57).

DISPLACEMENT

See also: storms and flooding, sea-level rise

Morbidity and mortality: Examples: anxiety, depression, suicide

Vulnerable groups: Examples: low-income, wildland/urban interface residents

"As climate change brings more severe weather to Oregon, volunteers are called upon to ensure that everyone has a safe place to go. **Homelessness is dangerous every night and this danger is only heightened when severe weather strikes.**"

Displacement after a wildfire can cause acute and chronic mental health issues such as anxiety, depression and disruption of social networks (21). A University of Oregon study estimated that up to one third of residents in the West who live near wildland areas lack incomes to meet basic needs and are unable to afford the cost of fire protection, increasing the risk of displacement (78).

WIND

Morbidity and mortality: Examples: injury, death

Vulnerable groups: Examples: residents of forested areas

Wind storms can cause injuries from falling trees, electrical hazards, unsafe structures and flying debris (79). In part due to Hurricane Sandy, there were 104 wind-related deaths in the U.S. in 2012, more than double the 10-year average of 51 (80). Like other extreme weather events, high wind can cause disruption of critical services like electricity and reduce access to healthy sources of food and water (81). During power failures associated with major storms, carbon monoxide poisoning resulting from indoor use of charcoal stoves or gas generators has been observed (82).

LANDSLIDES

Morbidity and mortality: Examples: stress, injury, death,

Vulnerable groups: Examples: responders, buildings near steep slopes

Heavy precipitation and saturated soils increase the risk of landslides (83,84). The most direct health impact of landslides is injury and death from the slide itself. Landslides cause an average of 25 to 50 deaths per year in the U.S. (85). Landslides can damage or block transportation infrastructure, creating barriers between residents and critical resources such as health care (86). Other infrastructure, such as drinking water and sewer services, also can be disrupted (87). Isolated communities can experience economic impacts from landslides (88). Landslides present hazards to responders. After the 2014 landslide in Oso, Washington, rescue workers used protective gear to avoid toxic chemicals and were vaccinated for tetanus and hepatitis B (89).

FLOODING

Morbidity and mortality: Examples: injury, water-borne disease, respiratory illness, exposure to toxins, death

Vulnerable groups: Examples: coastal communities, low-lying areas

Flooding causes injury and death from many hazards, including debris, electrocution and drowning. From 1959 to 2005, flooding caused approximately 44 deaths and 31 recorded injuries in Oregon (90). Increases in storms, sea level rise and the intensity of El Niño/Southern Oscillation could result in coastal flooding and erosion hazards (2,91), increasing exposure to these risks in coastal areas.

Some hazards persist after a flood, increasing the risk of illness and injury. Mold can develop in structures after a flood, leading to respiratory illness (92,93). Flooding has been associated carbon monoxide poisoning among people using gas-powered clean-up equipment indoors (94).

Drinking water contamination is a concern during and after floods. Extreme rainfall has been linked to outbreaks of multiple water-borne diseases (95). Flooding increases the likelihood of contamination from sewage and toxic substances, leading to exposure to Cryptosporidium and gastrointestinal illness (87,95). Illness can be caused by direct contact with water, water sources or watersheds that have been contaminated or through compromised drinking water infrastructure (95). Private well users may be especially at risk (87).

DISPLACEMENT

See also: wildfire, sea level rise

Morbidity and mortality: Examples: communicable disease, anxiety, depression, suicide

Vulnerable groups: Examples: low-income, low-lying areas, coastal areas, high-risk landslide areas, American Indians

Storms and flooding can cause property damage, forcing residents to relocate temporarily or permanently. Crowding and challenges in maintaining hygiene in evacuation centers during and after storms can increase exposure to communicable disease (96). Displacement after disasters can cause acute and chronic mental health issues such as stress, grief, anxiety, sense of loss and disruption of social networks (21). Displacement related to disasters, such as Hurricane Katrina, has been associated with suicide rates several times the baseline rates (97).

MENTAL AND BEHAVIORAL HEALTH

See also: drought, sea level rise

Morbidity and mortality: Examples: anxiety, depression, suicide

Vulnerable groups: Examples: existing mental illness, low income

Storms and flooding can cause distress both from the threat of destruction and the actual loss of property (21,98,99). As discussed above, the mental health effects of displacement can be severe. Natural disasters have been associated with post-traumatic stress disorder, depression and suicide (21,100,101). These stresses can lead to unhealthy coping behaviors such as drug use and poor dietary habits, which may elevate the risk of other diseases (49,55).

SEA LEVEL

INCOME LOSS

See also: drought, wildfire

Morbidity and mortality: Examples: food insecurity (malnutrition and obesity), chronic disease

Vulnerable groups: Examples: coastal communities

Sea-level rise threatens to inundate coastal areas, damage infrastructure and alter coastal habitats (102,103). Some culturally and economically significant tribal lands are located in vulnerable low-lying areas, particularly those of the Coquille and the Coos, Lower Umpqua and Siuslaw tribes. Sea-level rise may destabilize habitats that support fisheries (2). Lasting effects of diminished socioeconomic status resulting from sea level rise could lead to food insecurity and higher risk for chronic disease (49).

DISPLACEMENT

See also: wildfire, storms and flooding

Morbidity and mortality: Examples: anxiety, depression, suicide

Vulnerable groups: Examples: coastal communities, American Indians

Erosion and storm surges associated with sea-level rise could isolate entire communities or destroy previously habitable space (102). Coastal tribal communities could lose tribal land (2). As discussed above, displacement after disasters can result in an array of mental health issues and can increase the risk of suicide (21,97).

MENTAL AND BEHAVIORAL HEALTH

See also: wildfire, storms and flooding

Morbidity and mortality: Examples: anxiety, depression, suicide

Vulnerable groups: Examples: coastal communities, American Indians

Damage to culturally and economically significant places can lead to a sense of distress termed solastalgia (21,104). American Indians may lose access to important places like burial grounds and traditional fishing grounds (105). Disruption of social ties may have negative mental health effects (106).

ALLERGIC REACTIONS

Morbidity and mortality: Examples: allergic rhinitis, asthma attacks

Vulnerable groups: Examples: people with existing asthma, urban residents

Ragweed, a common allergen, is an indicator of climate-driven changes because higher levels of carbon dioxide increase its growth (107,108). Ragweed and other plants also have been shown to produce more pollen with increased carbon dioxide concentrations. Research shows that pollen from ragweed exposed to high concentrations of carbon dioxide is more potent and carries higher levels of the protein associated with allergies (109,110). Approximately 26% of the U.S. population is allergic to ragweed (111). There is evidence that ragweed produces more pollen in urban areas than in rural areas, attributed to higher concentrations of carbon dioxide and warmer temperatures (108). Temperature changes can lead to longer pollination seasons and greater concentrations of allergy-causing proteins in other plants (112), increasing allergic reactions and triggering asthma attacks (110)

VECTOR-BORNE DISEASE

Morbidity and mortality: Examples: West Nile virus, Lyme disease

Vulnerable groups: Examples: outdoor workers, people in routine contact with animals, people living in areas with ticks

Stagnant water bodies caused by heat or drought provide habitats for mosquitoes that transmit West Nile virus (113–115). Because of greater exposure to mosquitoes, outdoor workers are considered to be at higher risk of infection (116). Temperature and humidity may influence the spread of Lyme disease by affecting the survival of nymphs and active tick hosts (117). OHA regularly tracks cases of West Nile virus and Lyme disease in Oregon (116,118,119).

FOOD-BORNE DISEASE

Morbidity and mortality: Examples: gastroenteritis, campylobacteriosis, salmonellosis, V. parahaemolyticus

Vulnerable groups: Examples: consuming shellfish

Rising temperatures could increase harmful algal blooms and risk of exposure to toxins from shellfish consumption (22). Climate change is expected to impact other types of food-borne illness through multiple pathways (120). Researchers hypothesize that improper food storage and handling during warmer than usual weather contributes to a rise in Salmonella (121).

FUNGAL DISEASE

Morbidity and mortality: Examples: Cryptococcus gattii cryptococcosis

Vulnerable groups: Examples: unknown

Changes in the climate could make environments more hospitable to fungi or cause organisms to spread by adapting to new environments. It is often difficult to determine how climate change may affect the distribution of fungal disease. A prominent example is Cryptococcus gattii, an emerging disease in the Pacific Northwest, which was first detected in the region in 1999 (122). Epidemiologists suspect links to climate change because this species had previously been known only in subtropical and tropical locations (123). Between 2004 and 2011, 61 cases of Cryptococcus gattii infection were reported in Oregon, representing about 64% of all cases reported in the U.S. during that period (124).

INDIRECT IMPACTS

ECONOMIC INSTABILITY

Morbidity and mortality: Examples: food insecurity, chronic disease

Vulnerable groups: Examples: low-income, communities of color, American Indians, coastal communities

Oregon forestry, fisheries, agriculture and tourism industries depend on a stable climate and may be particularly vulnerable after extreme events. Each of these industries could face economic damage because of changes to the climate (2).

There is significant risk of economic instability from climate change in the U.S. and around the world. Crop failures or disruption in energy supplies elsewhere could cause volatility in the prices of these goods in Oregon. Price increases could especially impact low-income households, exacerbating the negative health effects of poverty (49).

OCEAN ACIDIFICATION

Morbidity and mortality: Examples: food insecurity, chronic disease

Vulnerable groups: Examples: American Indians, people who are economically dependent on fisheries

Acidification inhibits the growth of shellfish that some communities depend on for food or economic livelihood (125). Some Northwest tribes rely on shellfish harvesting for economic livelihood and could be affected by acidification (2). Negative impacts on diet and economic circumstances could lead to food insecurity or increased risk of chronic disease.

Jim Phelps MD • Psychologist

"The worst thing on the horizon for mental health care is climate change and the economic stresses it will cause, falling disproportionately on those already close to poverty, where the vulnerabilities are greatest."

CHRONIC STRESS

Morbidity and mortality: Examples: chronic disease, mental illness

Vulnerable groups: Examples: low-income, people who are economically dependent on climate stability, parents, youth

Stress related to climate change could come from decreased access to nature, species extinction, traumatic events, displacement, financial uncertainty and anxiety over future threats (21,48). Coping with the stress and uncertainties related to climate change could lead to unhealthy behaviors such as smoking, alcohol use and poor dietary habits (55,126), increasing the risk of chronic disease (127).

MIGRATION

Morbidity and mortality: Examples: infectious disease

Vulnerable groups: Examples: unknown

Human migration can result in epidemics of infectious disease (35,128). There is substantial uncertainty about how climate change could affect domestic and international migration patterns, but significant shifts in population could occur (129). An influx of climate refugees in Oregon could stress infrastructure and services.

CONCLUSION

The causal pathways described in this section are summarized in Table 4.1. The health outcomes associated with these pathways are existing public health concerns in Oregon, but the magnitude of their effects is likely to increase with climate change.

TABLE 4.1.

SUMMARY OF CAUSAL PATHWAYS	
Heat	Heat-related illness, heat-related death, violence, air pollution, harmful algal blooms, recreational risks
Drought	Food insecurity, water insecurity, mental and behavioral health, income loss
Wildfire	Air quality, water quality, occupational risks, income loss, displacement
Storms and floods	Wind, landslides, floods, displacement, mental and behavioral health
Sea-level rise	Income loss, displacement, mental and behavioral health
Aero allergens	Allergic rhinitis, asthma attacks
Infectious disease	Vector-borne disease, food-borne disease, fungal disease,
Other impacts	Economic instability, ocean acidification, chronic stress, migration,

These pathways do not capture the entire range of potential health impacts of climate change, but they are among the possibilities supported by existing research. Our understanding of these relationships and the strength of evidence supporting them will evolve. As described in Section VI, subsequent steps of the BRACE framework will add to our understanding of the likely impacts of climate change in Oregon.

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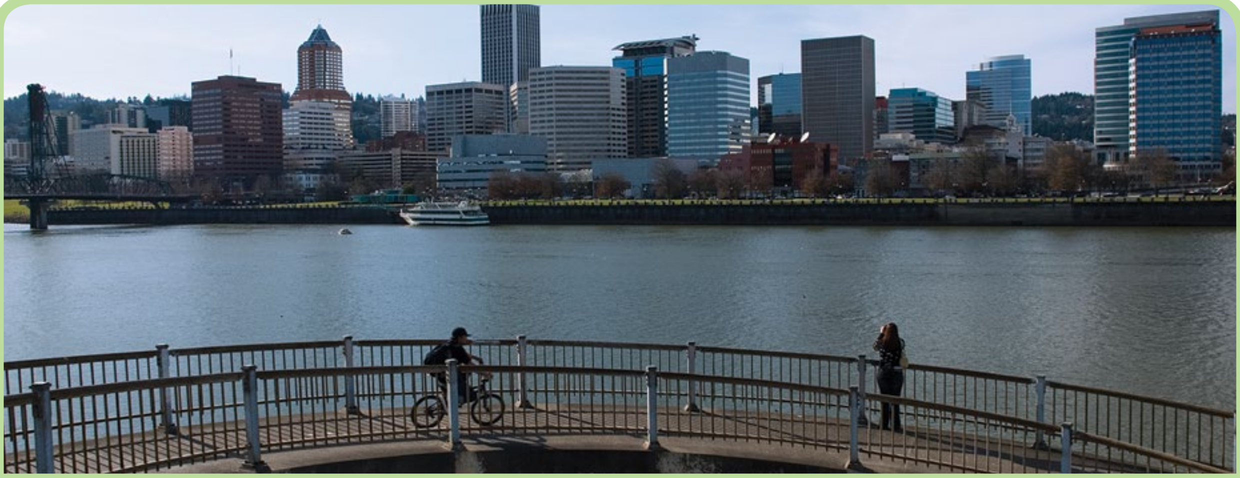

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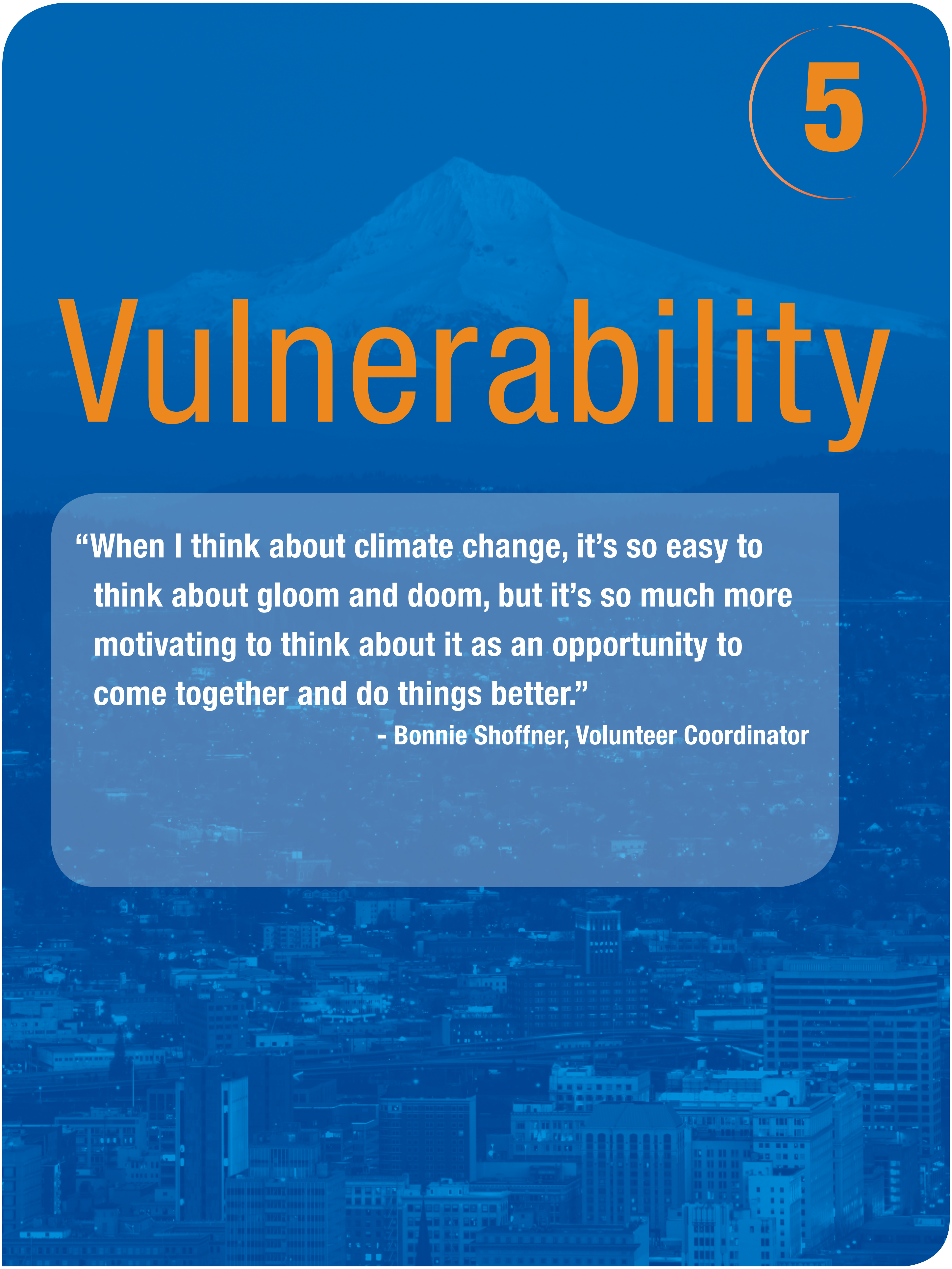


5

Vulnerability

"When I think about climate change, it's so easy to think about gloom and doom, but it's so much more motivating to think about it as an opportunity to come together and do things better."

- Bonnie Shoffner, Volunteer Coordinator

SECTION V: VULNERABILITY

The health risks described in this report vary from place to place and person to person. Some communities are more vulnerable to climate risks than others, depending on factors such as location, current health conditions and access to resources. Low-income and minority populations in Oregon have existing environmental exposures and burdens of disease that place them at higher risk. These systemic inequities cause many of Oregon's vulnerable people to fall into more than one category of vulnerability. For example, communities of color have higher rates of existing illness and have lower socioeconomic status, compounding their vulnerability. Older adults may also have low socioeconomic status, live in social isolation or with existing illnesses.

This section broadly describes populations that could be most vulnerable to health impacts from climate change. This section is organized by population group with examples of climate impacts to which they are especially vulnerable, and ways morbidity and mortality might disproportionately affect them. A more in-depth assessment of vulnerability, including a vulnerability index, will be completed in the coming year.

Demographic vulnerability

People with existing illnesses

Climate change may exacerbate existing illness, especially mental illness, asthma and other chronic diseases. Higher temperatures or heat events can increase the risk of heat-related mortality for those with diabetes (1). Disruptions in care can arise from climate impacts after extreme events. For example, people may be unable to access or afford necessary medication after major storms. After Hurricane Katrina, about one in five survivors with chronic conditions reduced or terminated their treatment because of the event (2). Disrupted care may result from lack of access to doctors, medication or transportation, or financial problems (2).

The Behavioral Risk Factor Surveillance System provides basic measures of self-reported mental and physical health. About 64% of Oregon adults report good physical health (2006–2009), and 66% report good mental health (2006–2009) (3).

Oregonians have a higher burden of asthma than many states (4). In Oregon, about 11% of adults and 8% of children have asthma, leading to hospitalizations that cost more than $28 million in 2011 (4). Asthma rates are higher among Oregonians who are American Indian or Alaska Natives, African Americans or those without a college education (4).

Climate change will be a driver of increased asthma. Heat can increase ground-level ozone, wildfires produce particulate pollution and harmful algal blooms can aerosolize, all causing problems for people with asthma (5,6).

People with disabilities

Emergencies, such as fires and floods, present additional challenges for people with disabilities who may have difficulties evacuating a dangerous area and relocating to a safe place. People with disabilities may rely on assistance, personal care equipment, and transportation services — all of which can be disrupted during a natural disaster.

"When food prices rise, the effects on Oregonians experiencing hunger can be crippling. Already forced to make tough choices between paying for food, rent, utilities or medical care, rising food prices make these decisions even tougher."

The Behavioral Risk Factor Surveillance System provides basic measures of self-reported disability. About 27% of Oregon adults report having a disability and 37% of 8th and 11th graders report the same (7). In addition to physical/mobility disabilities, other disabilities include sensory (such as hearing loss or visual impairment) and cognitive (such as dementia or autism).

People with disabilities are more likely to live with other risk factors, such as low-income or poor physical health (7), compounding their vulnerability to climate change.

Older adults

Older adults are especially vulnerable to a range of climate impacts, particularly heat-related illness and death (1,8). People aged 65 years and older are not able to adjust as well as younger people to changes in temperature and are more likely to have chronic medical conditions further decrease their ability to adjust. Heat waves put older adults at greater risk of mortality (9). In addition to heat, Gamble et al. (2013) identify at least two other primary climate stressors that disproportionately affect older adults: air pollution and infectious disease. Older adults are more likely to have compromised immune systems, increasing vulnerability to disease. Higher ambient ozone concentrations are also associated with mortality among older adults (10,11).

The most recent census estimates that over half a million Oregonians are age 65 and older, or about 14% of the population. This is slightly more than the national figure of 13%. In rural areas of Oregon, about 19% of the population is age 65 years and older, compared to only 13% of urban Oregonians (12).

Mothers, infants, and children

Infants and children are vulnerable because they must rely on others to protect them from harm. One study estimated that 88% of the additional global burden of disease due to climate change falls upon children (13).

Extreme heat is associated with preterm births and pregnant women are especially vulnerable after extreme weather events (14,15). Children younger than 15 years of age are also at increased risk of mortality from high temperature, although the causal mechanisms are not well understood (9).

Infants and children can be disproportionately affected by exposures to toxins because they eat, drink and breathe more in proportion to their body size (5,16,17). In an analysis of emergency department visits in Wisconsin, Drayna et al. (2007) found that gastrointestinal illness increases among children after extreme rain events, suggesting waterborne disease (18).

Researchers have also found an association between fungal spores, aeroallergens and wheezing in early childhood (19). Increases in ground-level ozone are expected to raise pediatric asthma hospitalizations (13).

Perhaps the most important consideration for children is the cumulative health effects of climate change during their lifetimes. In Oregon, about 6% of the population is younger than 5-years-old, and about 23% is less than 18 years of age (12). These proportions are similar to national figures.

Low socioeconomic status

Low-income households face challenges in dealing with climate change because they have fewer resources to cope with it (20,21). Disasters have a greater impact on low-income populations as a result of geographic isolation, type of residence and social exclusion (22). Low-income households are more likely to be displaced after a disaster (22) and eviction or loss of a home was a factor in 75 suicide deaths in Oregon between 2009–2010 (23).

Low-income populations are more likely to live in urban heat islands with higher exposure to air pollutants, and less likely to be able to afford protective measures such as air conditioning (1,24,25). Youth from low-income households show greater risk of psychiatric impairment resulting from extreme weather events (26). Food insecurity associated with poverty can lead to consumption of calorie-rich but nutrient-poor food, contributing to obesity (27,28). Measures of socioeconomic status in Oregon are displayed in Table 5.1.

TABLE 5.1.

MEASURES OF SOCIOECONOMIC STATUS (2008–2012 AMERICAN COMMUNITY SURVEY ESTIMATES)

Indicator	Oregon	U.S.
Income in the past 12 months below the poverty level	15.5%	14.9%
Receiving SNAP (food stamp) benefits in the last 12 months	11.4%	16.6%
Receiving Supplemental Security Income	3.8%	4.6%
Unemployed	10.8%	9.3%
Population 25 years and over without a BA or higher	70.8%	71.5%

Linguistically or socially-isolated populations

Linguistically or socially-isolated populations may lack information or services that can aid in coping with climate impacts. If warning systems aren't capable of matching language needs of linguistically-isolated communities, they are more likely to experience negative impacts (29). Isolation can contribute to disruption in care for chronic conditions during and after extreme events (2). Studies have found that linguistically and socially-isolated residents made more distress calls during extreme heat events (30).

"Our community recognizes the devastating impacts of trauma, chronic stress and adversity. **Together we are building resilience and rescripting our future."**

In Oregon, about 6% of the population speaks English less than very well (12). Nearly 9% of Oregon residents speak Spanish at home and an additional 3% speak Asian and Pacific Island languages (12). Living alone is another form of isolation and risk factor for older adults. About 10% of all households in Oregon are adults aged 65 years or older living alone (12).

Immigrants and refugees

Climate change has the potential to displace millions of people globally (31). Although first generation immigrants tend to have better health outcomes than their native counterparts in the U.S., this advantage rapidly erodes (32). Poverty is higher and educational attainment is lower among immigrants, influencing their access to health-promoting resources (33). In Oregon, about 10% of the population was born abroad, a smaller proportion than the U.S. as a whole (13%) (12).

Communities of color

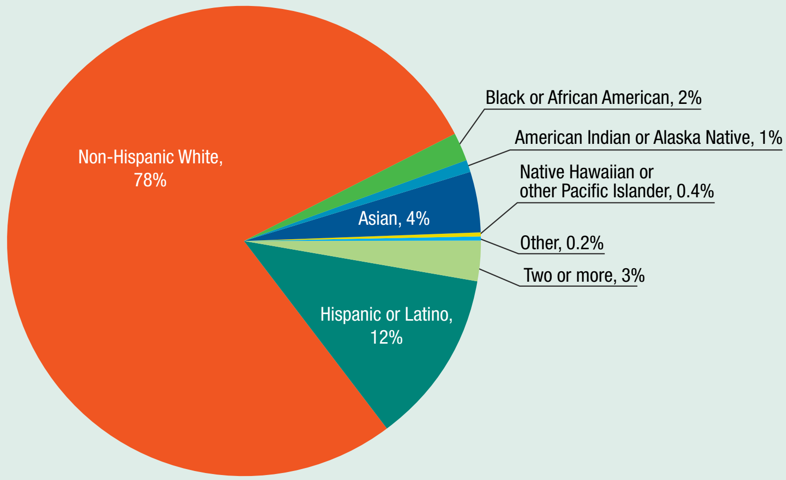
See also: American Indians in Oregon

Oregon's communities of color are already disproportionately burdened by illness and lack of access to health resources (34). Many of the social determinants of health benefit those in the racial, ethnic and cultural majority, yet create barriers to health and disproportionate rates of disease for Oregon's minority populations. The Oregon Health Authority Office of Equity and Inclusion has documented many of these disparities in the State of Equity Report. Data from the State of Equity Report demonstrate that African Americans and Native Americans are adversely affected by a disproportionate burden of disease across nearly every measure of health and well-being (34). Obesity rates are higher for Latinos (31%), American Indian/Alaska Natives (30%) and African Americans (29%) compared to non-Latino whites (24%). Such disparities could increase due to climate change through multiple causal pathways. Health inequities make it more difficult to cope with the health impacts of climate change and place some populations at a further disadvantage.

About 12% of Oregon's population is Hispanic or Latino (12). A larger percent of the population in Oregon is White (78%) than the nation as a whole (64%). A breakdown of race and ethnicity in Oregon is provided in Figure 5.1 (11).

The literature shows that communities of color are disproportionately impacted by climate change. Researchers have observed a greater sensitivity to increases in ambient ozone concentrations among African Americans, in part because of access to care and socioeconomic conditions (10,35). After Hurricane Katrina, African American survivors were more likely than White survivors to have hurricane-related health problems (36). Many communities of color have strong and varied social and cultural capital in the form of knowledge, skills, abilities and contacts, yet predominant systems frequently do not acknowledge these forms of capital (37). For example, there is evidence that existing warning systems are ill-suited to reach some ethnic minority groups (29). Research suggests that trusted resources, such as faith organizations or media controlled by racial/ethnic groups, are effective channels for some communities (38).

Figure 5.1 Race and ethnicity in Oregon 2008–2012



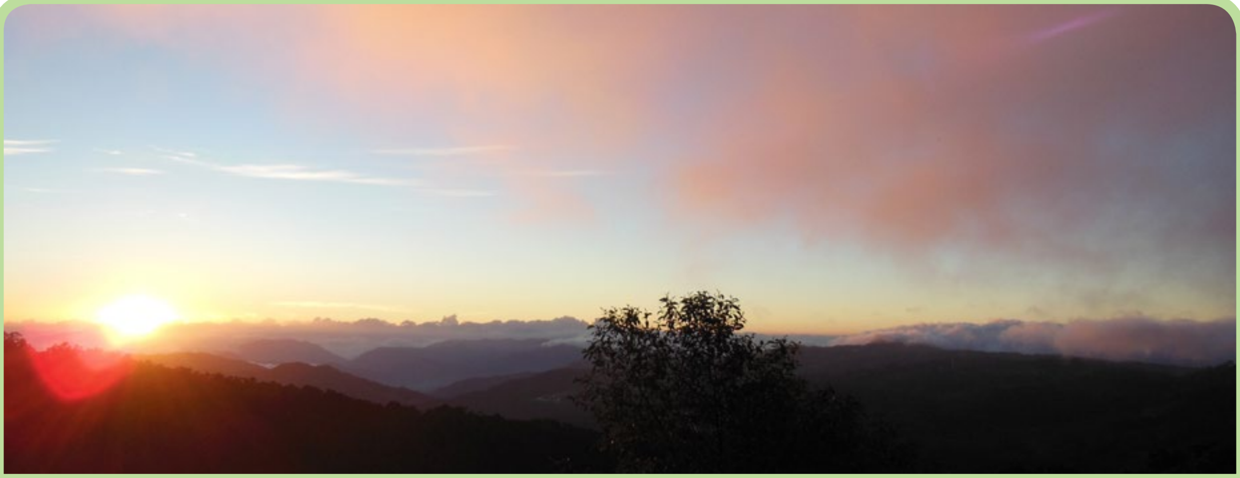
American Indians in Oregon

American Indians make up 1.8% of Oregon's population, and 1.2% of the total U.S. population. There are nine federally recognized tribes and numerous unrecognized tribes in Oregon.

Climate change threatens tribes' subsistence, ways of life, economic ventures, cultural survivability, rights, land ownership and access to resources (39). These risks are compounded by existing inequities in income and health, and by a history of exclusion from environmental planning and governance.

The impacts of climate change on tribes are complex and interrelated. One major concern among some Oregon tribes is food security and the impacts climate change will have on already disturbed patterns of First Foods harvesting. First foods are traditional and culturally important food sources, such as salmon or berries. Warming waters and shifting precipitation patterns are threatening salmon runs throughout the Northwest (40,41). Salmon and other First Foods are a vital source of nutritional, occupational and spiritual health among numerous tribes. Departure from traditional food systems affects food and economic security and is linked to an increase in diseases such as diabetes (42).

One measure of adaptive capacity is the ability to move one's physical location to less geographically-vulnerable areas, yet the rights of tribes are often tied to the fixed geographical boundaries of reservations or ceded lands. Relocation or displacement from tribal lands and reservations will impact tribal sovereignty and culturally significant resources (39). As climate change alters our environment through impacts like sea level rise and drought, it also disrupts localized ways of living that have been fine-tuned over thousands of years. One concern is the potential loss of tribes' traditional ecological knowledge and culture closely related to specific places and ways of living (43,44).



The loss of culture and connection to the land, in addition to the stress of food and economic insecurity can create mental and emotional distress. Tribes are at greater risk for mental illness, substance abuse and suicide in connection to climate change and its impacts. The rate of suicide among American Indian teens and adults is already the highest in the country. From 2005–2009, 17.48 per 100,000 American Indians and Alaskan Natives took their own lives, compared with 15.99 per 100,000 non-Hispanic Whites. (45).

Occupational vulnerability

Wildland firefighters

Wildfires can result in illness, injury and death among those fighting wildfires. From 2000 to 2012, there were over 200 fatalities among wildland firefighters in the Western U.S. (46). Equipment noise can impact hearing (47) and there are numerous injury risks in fighting wildfires (48). Wildland firefighters are at heightened risk of rhabdomyolysis, a condition resulting from the breakdown of muscle tissue after physical exertion (46). In reviewing studies of wildfire projections, Littell et al. (in Dalton et al. 2013) found that estimates ranged from <100% to >500% increases in median area burned, raising exposure risk for wildland firefighters.

Outdoor workers

Outdoor workers are more likely to be exposed to heat, vector-borne disease, air pollution and extreme weather events (49–51). Crop workers have a significantly higher heat-related death rate compared to all civilian workers (52). From 2003–2010 suicide among agricultural workers accounted for 2% of suicides among men and 1% among women (23).

Approximately 3.4% of the Oregon workforce is employed in outdoor industries such as agriculture, forestry and fishing (12).

Growers, ranchers and farmworkers

Growers, ranchers and farmworkers are especially vulnerable to the mental health impacts from environmental changes (51). Long term environmental changes can result in agricultural communities that are no longer economically viable, causing decline in the physical and social environments. Suicide rates are higher among this group during extended droughts (53,54). In Oregon, most rural counties have suicide rates similar to or higher than the state average.

"Migrant families have to acclimate to changing climates. **We commonly see kids suffer from bloody noses, fevers and dehydration.** We provide a packet for each of the growers to post in the migrant farmworker camps that includes tips for how to keep well-hydrated, especially during heat waves."

Migrant and seasonal farmworkers face additional stressors that make them vulnerable to impacts from climate change. As noted by Hansen and Donohoe (2003), “migrant and seasonal farmworkers suffer morbidity and mortality rates greater than the vast majority of the American population, due in large part to occupational hazards, poverty, substandard living conditions, migrancy, and language and cultural barriers.” One in four migrant farm workers experiences a mental health disorder such as stress, depression or anxiety (55). There is emerging evidence that Oregon migrant and seasonal farmworkers experience symptoms of heat-related illness and lack the knowledge or resources to take protective measures (56).

Responders and health care workers

During and after extreme events, emergency response and health care workers are often expected to work long hours in stressful or dangerous situations (51). Responders, including volunteers, face direct danger of injury and illness from extreme events such as storms, floods and landslides (57). There are nearly 100,000 health care workers in Oregon, about 5% of the labor force (58).

Geographic vulnerability

Urban and suburban

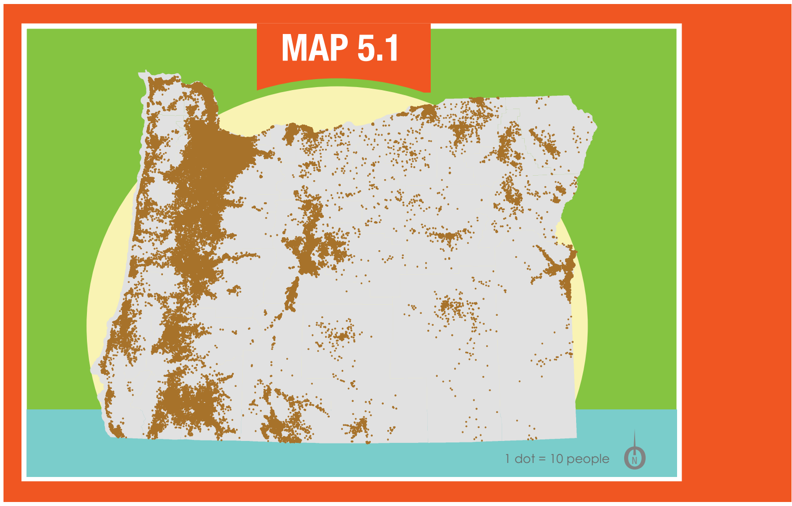
Extreme heat events, ozone pollution and wildfire have disproportionate impacts in urban and suburban areas. Urban areas are subject to the well-documented urban heat island effect, and there is some evidence that extreme heat events have increased faster in sprawling areas compared to more compact urban forms (59,60). This puts urban areas at greater risk of heat-related illness and heat-related death. Heat causes ground-level ozone formation that is most pronounced in urban areas, resulting in higher exposure to negative health effects (61).

Residents of wildland-urban interface, defined as places where structures or human improvement intermingles with vegetation (62) are at greater risk of wildfire and subsequent displacement (63,64). These areas are identified by Community Wildfire Protection Plans.

Most of Oregon’s population is found in the Willamette Valley, which includes the larger urbanized areas of Portland, Salem, Eugene and Corvallis. This distribution of population is reflected in Map 5.1. Approximately 81% of Oregon’s population lives in urban areas (65).

Rural

Oregon's rural communities are more dependent on agriculture, tourism, forestry and fisheries. These industries are highly dependent on natural resources and climate conditions, and are more at risk of disruption. Climate change impacts on these sectors have disproportionate impacts on rural communities.



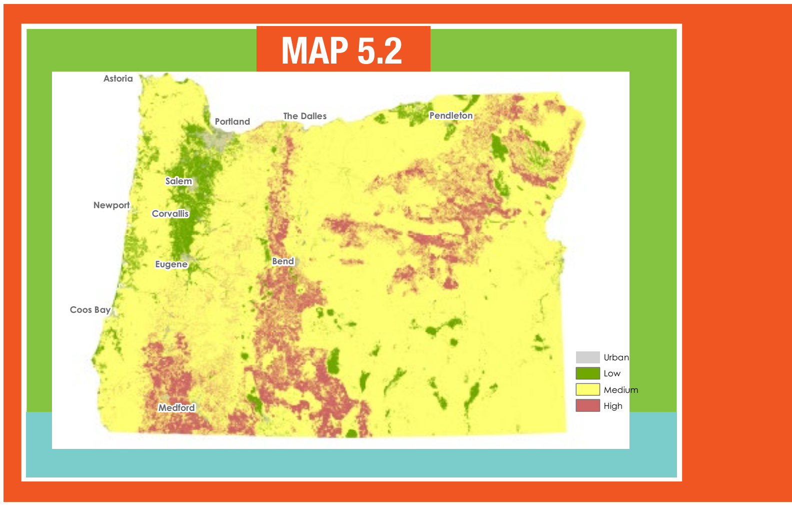
Map 5.1, Population distribution in Oregon

Community Wildfire Protection Plans indicate that most of Oregon's rural communities face risks from fire (62). The U.S. Census classifies nearly 99% of the land mass of Oregon as rural, but estimates that rural areas are home to just 19% of the state's population (65). In Map 5.2, urban areas are displayed in gray, with color-coded fire risk showing that many rural areas are at high risk for wildfires (66).

Coastal

Coastal communities are vulnerable to all of the impacts described in Section IV, including income loss, displacement, and mental and behavioral health impacts. Rising seas can inundate previously habitable areas, damaging infrastructure and causing displacement among coastal residents (67). Acidification and changing water temperatures can harm fisheries, causing economic distress or food insecurity for dependent populations (68).

About 40,000 Oregon residents are considered at risk from tsunamis, suggesting that thousands of residents could be affected by sea level rise (69). More extensive analysis of this vulnerability is warranted, given the complex interactions of coastal storms, sea-level rise, seismic activity and erosion. The OHA Climate and Health Program will work with other agencies to undertake detailed analysis in subsequent steps of BRACE.



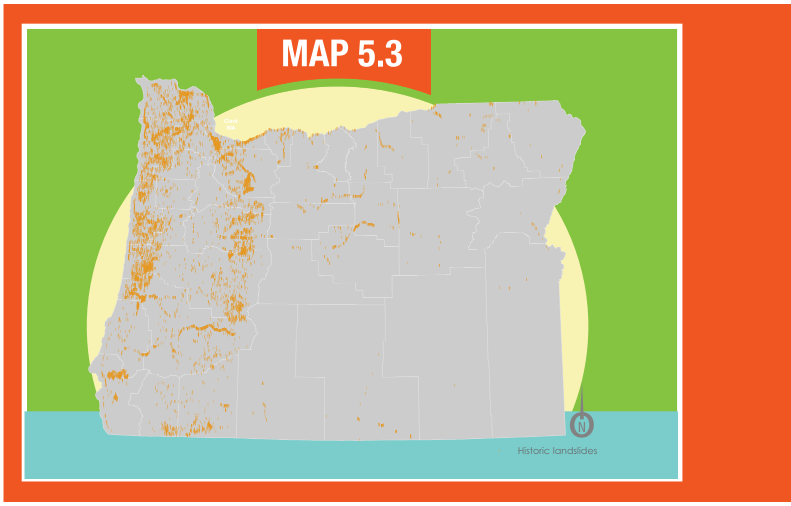
Map 5.2, Wildfire risk

Steep slopes

Steep slopes create a risk of landslides, which can result directly in injury or death. Landslides are common in Oregon and are overwhelmingly concentrated in the Cascades and Coast Range. Common landslide triggers include precipitation-related events such as intense rainfall or rapid snow melt, which could be influenced by climate change (70). Over 12,000 landslides have been documented in Oregon since the early 1930s. These are displayed in Map 5.3 (69).

Private water systems

Private water systems, such as domestic wells, are not required by any governing body to meet Safe Drinking Water Standards. All water quality testing and treatment is the responsibility of the system owner. Private water system users who do not test water quality and practice proper stewardship face a higher risk of water-borne disease or exposure to contaminants. During drought, declining water levels can concentrate contaminants in surface water and could expose new sources of groundwater contamination, such as arsenic. After wildfire, nutrient concentrations and sediment can lead to greater water treatment needs (71,72).



Map 5.3, Historic landslides

There are an estimated 350,000 active private wells in Oregon. When coupled with Oregon census estimates for household size, this suggests that approximately 23% of the state's population may be relying on private wells (73).

Conclusion

The extent that communities are vulnerable depends both on exposure to changes in climate and the ability to act and adapt. Because of Oregon's geography and climate, exposures will vary from place to place. Capacity to act and adapt also varies from community to community. Certain communities are at a disadvantage due to historical and systemic inequities that greatly influence existing access to opportunities and resources (34,39). The negative effects of climate change could create bigger gaps between those who are already vulnerable and those who enjoy relative advantages. (74).

Climate change not only creates new vulnerabilities, it also creates new opportunities. Market and political forces will likely drive the development of new technologies, new practices and even new industries as we adapt to changing climate conditions. The ways we develop and adapt could, in turn, influence vulnerability.

Identifying current vulnerabilities is an important step to building resilience. We can now work toward estimating the projected number of increased hospitalizations and protecting those most at risk. We also acknowledge that vulnerable communities are ready and willing to work toward protecting themselves. By engaging with vulnerable communities and supporting existing knowledge, assets and strengths we can help to build capacity and climate resilience from the ground up.

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Thomas Doherty, Psy.D. • Psychologist

"Climate change affects our relationships. For parents, this includes thoughts about how to best provide for our children. **There is a need to support people as they come to grips with increasing uncertainties.** There is a need to support those taking a lead and there is need to support those who are feeling alarm, alienation or despair."

6

Next steps

> "Like the patient recovering from a life threatening illness, we may find that our priorities have changed and that we're ready to make changes for a healthier planet."
>
> \- Pat O'Herron, General Surgeon, Salem Hospital

SECTION VI: NEXT STEPS

Climate change is increasing the risks to health and safety in Oregon. The resources needed to thrive, like clean air, water, and food are threatened by hotter, drier summers and warmer, wetter winters. While everyone will be affected by climate change, there are some groups that will be disproportionately burdened. Reducing risk will take collaboration among many partners, and everyone has a role to play.

Oregon Health Authority's Public Health Division (OHA) is working to prepare and protect our communities. With our partners, we're identifying Oregon's most vulnerable populations and partnering with them to develop strategies that build community resilience across the state. This section describes priority health risks and actions planned for the next two years.

Next steps for Oregon's Climate and Health Program

The BRACE Framework

OHA's Climate and Health Program is applying the BRACE (Building Resilience Against Climate Effects) framework to create a new statewide Climate and Health Adaptation Plan (see introduction). The following outlines our planned actions through 2016:

Step 1: Forecast climate impacts and assess vulnerabilities

This profile report fulfills the first step of the BRACE process. As part of the dissemination of this report, we will begin partnering with stakeholders and collecting input on solutions that address the risks outlined in this report.

Step 2: Project the burden of disease

After the release of this report, we will conduct more in-depth vulnerability assessments and begin to project the additional burden of disease resulting from climate change by mid-century. We will engage stakeholders in communities identified as most vulnerable. The Climate and Health Program will focus on heat, drought, and wildfire for further study in the near-term (for more information see Appendix A).

Lexie Zhang • OHSU

"I'm interested in understanding the links between climate change and food-borne illness in Oregon. **We need to equip our next generation with the kind of climate and health data that can save lives."**

Step 3: Assess interventions

A new advisory group will assist the program in compiling and assessing adaptation interventions. The climate and health program will apply principles of evidence-based public health practice to identify proven and promising strategies to reduce health risks. The planning process will include multiple opportunities for stakeholder input.

Step 4: Develop and implement a climate and health adaptation plan

The BRACE process will culminate in a Statewide Climate and Health Adaptation Plan. The plan will include a menu of recommended health-focused adaptation interventions based on the findings and input assembled in Steps 1–3.

Step 5: Evaluate impact

Oregon's Climate and Health Program has developed a program evaluation plan to assess progress toward reaching program goals. Stakeholders are invited to provide feedback on program activities and provide recommendations for program improvement. The Climate and Health Adaptation Plan will also include recommendations for monitoring and evaluating interventions during implementation.

Beyond BRACE

In addition to creating a Climate and Health Adaptation Plan, our program is working to build collaborations and communications that raise awareness of the connections between climate change and public health.

Local BRACE toolkit

Five local health jurisdictions (LHJs) in Oregon have already used the BRACE framework to develop adaptation plans at the local level. We continue to learn from our partners and are developing a toolkit to assist other LHJs to integrate climate change into local public health practice.

Long-term planning

OHA's Climate and Health Program developed an internal strategic plan. The plan focuses on building Oregon's collective capacity to adapt and thrive in a changing climate. It reaffirms our commitment to addressing climate change as a set of health equity issues. Program staff will continue to revisit these goals and build on the plan as we learn more.

Collaborations

Collaboration across communities and sectors increases Oregon's long-term capacity to prepare for climate change. Collaboration also encourages inclusion of different approaches and worldviews, potentially resulting in more simplified and unified strategies. In this way, collaboration is not only a way to advance climate strategies, but an adaptation strategy in itself. Through collaboration, we build the networks and capital necessary to increase resiliency.

Oregon's Climate and Health Program is participating in a number of related initiatives, with examples highlighted below. A full list of current partnerships can be found in Appendix B.

Regional and National Collaboration
Oregon's Climate and Health Program collaborates with other state health departments across the nation who are engaged in climate and health work. As part of a western state collaborative, we are developing a set of shared social vulnerability measures and identifying ways to align across state boundaries. We participate in the National Association of County and City Health Officials (NACCHO)'s Climate Change workgroup and currently receive technical assistance from the Georgetown Climate Center on climate and health adaptation planning

Global Warming Commission
The Global Warming Commission was created in 2007 to provide recommendations for reducing Oregon's greenhouse gas emissions and preparing our state for the effects of climate change. Public Health Division Director, Lillian Shirley, was appointed to the commission in early 2014 and will continue to work with leaders across the state to advance climate action in Oregon.

Healthy Climate Partnership
The Healthy Climate Partnership is facilitated by the Oregon Environmental Council and includes more than 100 public interest groups and businesses working on climate change across Oregon. OHA's Climate and Health Program has had the opportunity to present and receive feedback from this diverse coalition of experts and advocates.

Adaptation Framework Work Group
In 2010, the state of Oregon completed the Oregon Climate Change Adaptation Framework. The framework was developed by an inter-agency work group, including the Public Health Division. OHA continues to participate in the work group and align with other state initiatives.

Conclusion

Addressing the many impacts of climate change is one of our greatest global challenges. It cannot be solved by any one region, sector or discipline. In Oregon, cross-sector collaboration is essential to building resilience and the field of public health has an important role to play.

Primary prevention is widely recognized as the most cost-effective, long-term public health strategy for reducing injury, illness and death. In this case, prevention can be defined as taking action to mitigate climate change by reducing the amount of greenhouse gases emitted into the atmosphere. Many efforts to reduce greenhouse gas emissions have positive health impacts, such as increasing active transportation, improving the housing stock through energy efficiency upgrades and land use planning that reduces congestion and traffic pollution. There are ample opportunities for collaboration on these "co-benefit" strategies.

Within the field of public health, adapting to climate change means developing and implementing interventions that build our community's preparedness and resilience. Interventions could include making changes in our behaviors, practices, policies and systems so that we are better positioned to address the challenges and uncertainties that lie ahead. Successful climate adaptation will require coordinated efforts between federal, state and local agencies, and strong public-private partnerships. In many ways, the challenges we face with climate change are integral to the task of transforming our public health system. Addressing health disparities and prioritizing the needs of our most vulnerable communities will build Oregon's overall resilience to climate change.

Climate and health adaptation planning addresses the most fundamental determinants of our health — climate and environment. Our health and well-being are derived from a stable supply of healthy food, clean air and clean water. Climate change threatens to disrupt this stability. In the upstream model of health, our climate stands at the headwaters.

Appendix A

Near-term study priorities

Protecting Oregonians from the threats of climate change is a complex task. To focus our adaptation planning efforts, The OHA climate change work group considered health risks based on the following criteria:

- Current burden of disease
- Likelihood
- Severity
- Magnitude
- Frequency
- Impact on health disparities
- Economic impact
- Interest from other state and local agencies
- Cobenefits
- Contribution to the field of climate and health
- Existing adaptive capacity
- Value added from public health
- Potential for external inquiries requesting
- information on a specific impact

HEALTH RISKS CONSIDERED:

Wildfire
Drought
Heat
Storms and floods
Sea level rise
Allergens
Infectious diseases
Indirect impacts

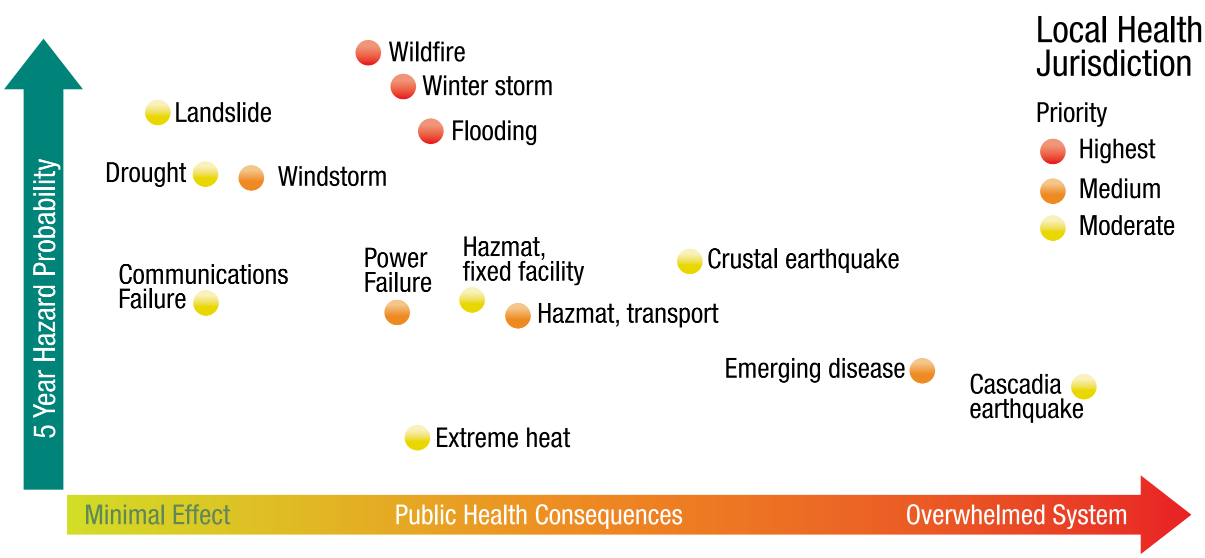
The work group included staff from the following programs: Climate and Health, Environmental Public Health Tracking, Health Impact Assessment, Healthy Workplaces, and Preparedness Surveillance and Epidemiology. This group reviewed information on eight causal pathways and qualitatively assessed each impact as part of an iterative assessment process.

Based on this review, OHA selected three climate impacts for more in-depth assessment: wildfire, drought and heat. We will continue to deepen expertise on other impacts and reexamine priorities as we learn more. The summary at the end of this section describes OHA's approach to learning more about these impacts and potential interventions to reduce risks.

Results from Oregon's Public Health Hazard and Vulnerability Assessment

The priorities identified in the process described above overlap with the existing OHA Public Health Hazard and Vulnerability Assessment (HVA), which considers a range of disasters. Emergency managers examine the probability of disasters over the next 5 years and ability of the public health system to respond and withstand them (Figure A.1). The current HVA identifies wildfire, winter storms and flooding a s leading concerns for emergency managers. The HVA will inform climate change adaptation plans and vice versa.

Figure A.1 Probability of disaster, Oregon: HVA 2013–2023



Appendix B

The following table lists collaborative partnerships between the climate and health program and various internal and external stakeholders. This list is included as an appendix to clarify and document the ways that the program interacts with other entities.

OREGON PUBLIC HEALTH DIVISION (PHD) PROGRAMS	
Partner	**Collaboration**
Oregon Health Promotion and Chronic Disease Prevention	Ongoing discussions related to cobenefit policie Climate team serves on planning committee for upcoming "Place Matters" conference
Oregon Environmental Public Health Tracking Program	Conducted heat-related morbidity study Partner in development of social vulnerability assessment Members participate in PHD's internal climate work group
Oregon Health Impact Assessment Program	Community Climate Choices HIA Members participate in PHD's internal climate work group
Oregon Health Security, Health Security, Preparedness, and Response Program	Hosted climate presentation to regional preparedness and healthcare liaisons Assists with outreach to vulnerable populations Ongoing conversations regarding resilience research and practice
Oregon Preparedness, Surveillance and Epidemiology Program	Co-leading the development of a new drought risk communication toolkit Assists climate team with syndromic surveillance, health data and risk communication Members participate in PHD's internal climate work group
Oregon Health Authority's Office of Equity and Inclusion	Provides guidance on integrating environmental justice and health equity in key messages and documents Assists with outreach to vulnerable populations
Oregon Healthy Waters Programs	Assists with new drought toolkit development
Oregon's Public Health Division Communications team and Publications team	Assists with communications strategies including the Climate and Community Health Story Project Assists with design and publication of program's communication materials and reports
Oregon Public Health Division's Office of Planning and Policy	Guidance on major publications and public forums

LOCAL JURISDICTIONS	
Partner	**Collaboration**
Conference of Local Health Officials, Healthy Communities Workgroup	Ongoing conversations about how to advance climate and health work at the local level
Multnomah County Health Department	Local partner in climate and health adaptation planning
Benton County Health Department	
Crook County Health Department	
North Central Public Health District	
Jackson County Health and Human Services	
National Association of County and City Health Officials	Partnership through climate work group

STATE AGENCIES AND COMMISSIONS	
Partner	**Collaboration**
Climate Adaptation Framework Work Group	Partnership between state agencies involved in climate adaptation work Sharing and aligning data and information
Dept. of Land Conservation and Development Depart. Of Geology and Mineral Industries	Ongoing conversations related to partnership opportunities, including application of forthcoming social vulnerability assessments
Oregon Global Warming Commission	Governor's commission addressing climate change Oregon Public Health Division's Director recently appointed to commission

NATIONAL AND REGIONAL PARTNERS	
Partner	**Collaboration**
CDC's Climate and Health Program	Funds the Oregon Climate and Health Program and provides guidance on program activities
California's Climate and Health Program Arizona's Climate and Health Program	Fellow CDC grantee and member of the West BRACE collaborative Sharing and aligning data and information
Additional CDC grantees	Including Wisconsin, Illinois, Maine, Vermont, Massachusetts, Rhode Island and New York Sharing and aligning data and information
Washington State's Climate and Health team	Advancing climate and health work separate from the CDC initiative Sharing and aligning data and information

NON-GOVERNMENTAL ORGANIZATIONS	
Partner	**Collaboration**
Oregon Environmental Council	Partnering with the Climate Protection initiative Planning climate and health outreach event with health care leaders
Healthy Climate Partnership	Connecting and aligning climate action across the state of Oregon
The Resource Innovation Group	Participating in new Transformational Resilience initiative, planning work group and training Jointly developed a resource guide for local health departments
Upstream Public Health	Codeveloped a Climate Change Policy HIA toolkit
PNW Tribal Climate Change Network	Ongoing discussions regarding partnership opportunities

UNIVERSITIES AND RESEARCH INSTITUTES	
Partner	**Collaboration**
Oregon Climate Change Research Institute	Ongoing discussions regarding climate science and data Presented at our Climate and Health brownbag
Oregon State College of Public Health	Ongoing discussions regarding partnership opportunities Health researcher, Dr. Jeff Bethel, presented at Climate and Health brownbag
Oregon Partnership for Disaster Resilience Portland State University's School of Community Health	Ongoing discussions regarding partnership opportunities

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