3.4 Severe Weather (Extreme Heat, Winter Storm, Windstorm, Drought)

No hazard has increased more in visibility and concern since the 2017 version of this plan than climate-based weather events. Although many participating jurisdictions in the 2017 plan already had rated Severe Weather as of their highest risk, events over the last five years have increased the public perception of risk to extreme climate, and strategies to implement and communicate mitigation and preparation strategies have become more prevalent and visible.

Extreme heat and cold events were the two natural disasters (as defined in this plan) that caused the most loss of life in Multnomah County since the 2017 plan, and climate change projections are increasing concern that these events will become even more frequent and extreme. Weather events are also significant drivers of disparate disaster outcomes to local communities, with those unable to access cool or warm spaces most at risk due to lack of shelter, living in non-climate controlled spaces, or having to work outdoors. All of the jurisdictions and districts participating in this plan have been impacted by severe weather.

The 2017 NHMP collected a number of weather hazards into a single Severe Weather chapter as a loosely defined set of eight severe weather types, including heavy rain, hail, and lightning. For this update, the chapter has been more formally separated across four hazards, with each given consideration regarding their extent, probability and vulnerabilities created. The four hazards are **extreme heat**, **winter storm**, **windstorm** and **drought**. This approach better aligns Multnomah County's NHMP with the weather hazards defined in the 2020 Oregon State Hazard Mitigation Plan[60], leaving only Coastal Hazards as those defined in the Oregon NHMP and not part of this plan. Winter rain is no longer included here, as risk elements of that hazard have been described in the flood and landslide chapters.

Some jurisdictions or districts in this plan rated their risk of severe weather as a single combined hazard, while others have broken out one or more of the weather types separately, reflecting the differing ways different mitigation partners assess risk.

All of the participating jurisdictions/districts in this plan are vulnerable to severe weather impacts. Variations of vulnerability are most based on impacts to populations with existing health risks to climate effects and to underserved communities in the highest hazard living conditions. Some climate hazard impacts are magnified by effects of built environments and natural geography or topography.

Five-Year Report, 2017-2022

- *Events*

2021 Heat Dome

While hot summers were fairly commonplace over the last five years, the Heat Dome event of June 26-28, 2021 stands alone as a historic catastrophic disaster, killing 69 people in Multnomah County from direct heat illness. This is believed to be the single largest loss of life in

[60] The Oregon State Hazard Mitigation Plan is different in that it breaks these hazards into separate chapters.

a natural disaster (as defined in this plan) in Multnomah County in over 100 years. Across Oregon, at least 107 people died from direct heat-related causes.

For three consecutive days, recorded high temperatures in Portland broke the all-time record of 107 degrees Fahrenheit. On the hottest day, June 28th, the recorded high was 116 degrees, nine degrees hotter than had ever been recorded in Multnomah County. The unprecedented heat wave was particularly dangerous because it happened early in the summer before people's bodies had fully acclimated to hotter weather. Nights were also extremely warm. The 76-degree low temperature on June 28 was higher than the average high temperature for June in Portland. These warm nights prevented living spaces from gaining relief from any overnight cooling effects before temperatures spiked again during the day.

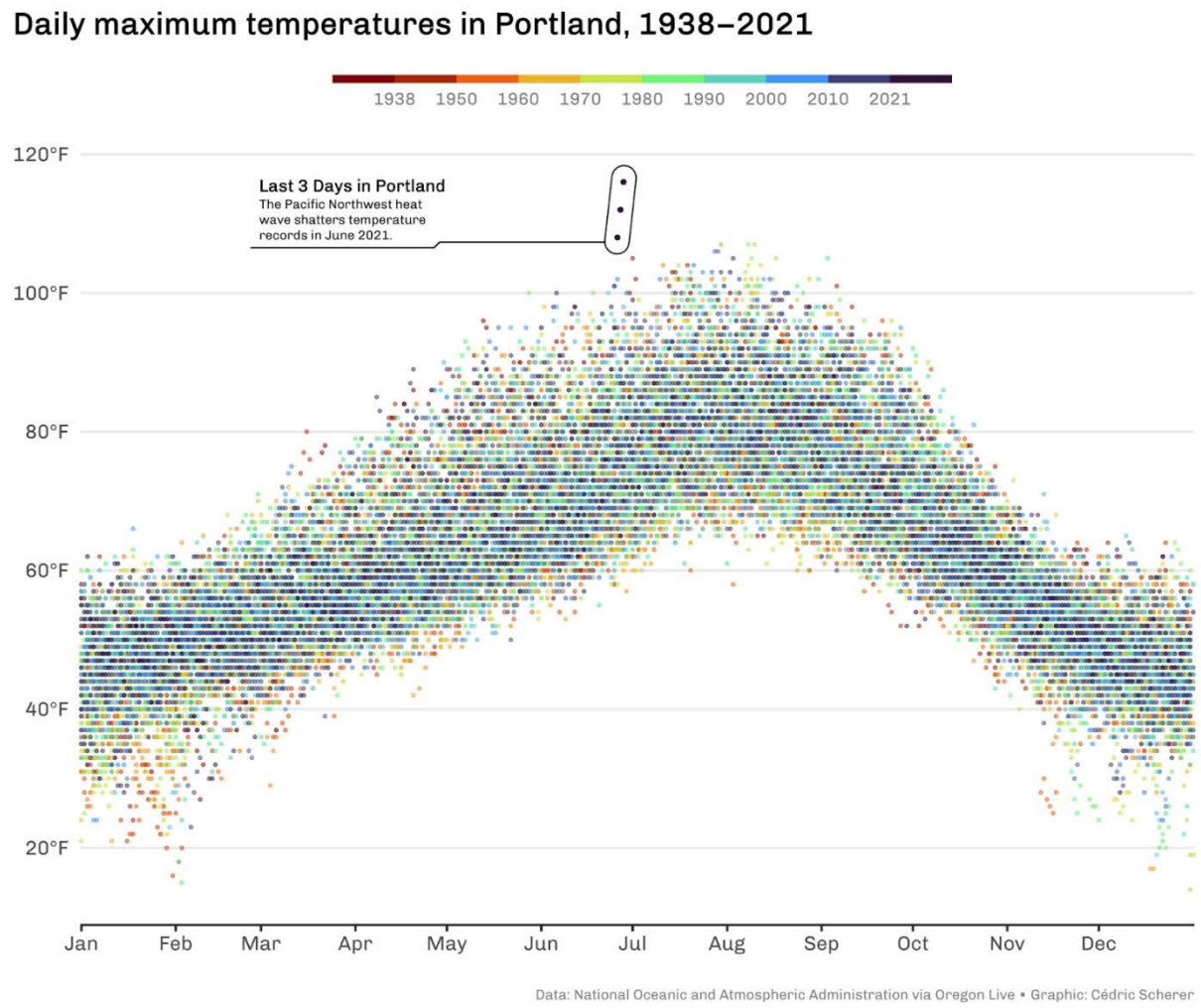

Figure 74 - Graph showing the extreme three-day event of June 2021 as compared to the previous 83 years of recorded temperature data in the City of Portland. Graphic by Cedric Scherer

The climate phenomenon that caused the Heat Dome is believed to have been an anticyclone[61], a system that rotates slowly around a center of high pressure. This process blocks other weather systems from pushing in and locks in heat by preventing it from escaping through the upper atmosphere.

This unusual event may have been made more likely because of climate-change driven weather effects. Although it has been preliminarily described as a 1,000-10,000 year event (0.1%-0.01% annual chance), it is theorized that similar events may become much more common if climate change scenarios continue on their current path[62].

Multnomah County published a Preliminary Review on Excessive Heat Deaths from the June event in July 2021 to recount the event and memorialize and tell the stories of those who died. Preliminary findings and action steps were published August 2021 and a final report of the summer of 2021 was published in June 2022.

Another heat spell in July 2022 set a new record for consecutive days over 95 degrees, and led to another five recorded hyperthermia deaths.

- *Notable Winter Storms*

Measurable snowfall occurred every year in Multnomah County between 2017 and 2022. Only the most notable events are listed here. Other hypothermia deaths occurred during this time period, but were outside of winter storms and occurred during more typical winter conditions. Impacts from the 2022-23 winter are not detailed, but included, in two separate events, the coldest low temperature since at least 2017, and the second largest calendar day snowfall in Portland's recorded history. Impacts from these events are still being gathered.

2017

The 2016-2017 winter season was the most deadly, with five deaths attributed to hypothermia during a long period of cold and snow. January 2017 was the coldest January in Portland in 32 years and the entire month averaged only 33.5 degrees. Eight to sixteen inches of snow fell in locations across Multnomah County over January 10-11[63], the local largest snowfall event in 20 years. Areas at higher elevations saw as much as two inches of snow per hour at the peak[64].

Multnomah County was hit by five separate winter storms over five weeks, from early December until mid-January and cold, wet conditions persisted into February. The long duration of the cold and wet weather was particularly harmful to those living without shelter. All five residents who died from hypothermia were unhoused.

[61] The 2021 Pacific Northwest Heat Wave and Associated Blocking: Meteorology and the Role of an Upstream Cyclone as a Diabatic Source of Wave Activity, Geophysical Research Letters (AGU), Emily Neal, Clare Huang, Noboru Nakamura, April 18, 2022

[62] Western North American extreme heat virtually impossible without human-caused climate change, World Weather Attribution, July 7, 2021

[63] National Weather Service, Portland 2017 Weather Recap

[64] KOIN 6, Portland snow storm one for the history books, January 11, 2017, Chelsea Wicks

Interstate 84 was closed multiple times between Troutdale and Hood River because of snow, ice and landslides and the Portland International Airport had a number of canceled flights in January.

2021

Freezing rain and snow fell on February 11-12, causing downed power lines and the closure of Interstate 84 between Troutdale and Hood River. This was the single largest power outage event in Oregon history, although effects in Multnomah County were not as severe as in neighboring areas. Clackamas County suffered much longer power outages and the death of four people from carbon monoxide poisoning while using heaters or cooking equipment inside recreational vehicles.

Another death in Multnomah County from hypothermia occurred during a cold, snowy snap in late December 2021. This death was of an older, housed adult.

- *High Winds and Tornadoes*

No extremely destructive windstorms occurred in this time period. However, unusually strong easterly winds fanned the explosion of wildfire on Labor Day 2020, leading to one of Oregon's worst ever fire seasons and catastrophic air quality in Multnomah County. Windstorm damage itself was limited to periodic minor events.

Tornadoes occurred in Multnomah County in 2018 and 2019 and additional tornadoes touched down in the Portland Metropolitan region outside of Multnomah County in 2020. These tornadoes were short-lived and never exceeded the level of F0, considered a 'weak' tornado with wind speeds less than 85 miles per hour. Nonetheless, these were notable events as tornadoes have been historically rare. The last tornado in Multnomah County had occurred in 2011 and the July 2019 tornado was the first July tornado in Oregon since 1937.

Increases in tornadoes may be related to climate change, and to improved weather radar, local weather reporting and modern documentation standards. Larger F3 tornadoes have happened in Oregon, including a fatal Portland-area tornado in 1972. Although tornadoes do not have a high level of local risk awareness, monitoring of scientific work should continue to refine understandings of their probability and risk.

- *Statewide Drought*

The effects of drought in Multnomah County were seen most in the creation of dangerous wildfire conditions, including the Eagle Creek Fire in 2017 and the 2020 statewide wildfire disaster which caused hazardous air quality in Multnomah County.

Statewide drought peaked in 2021, and Multnomah County was considered to have serious drought conditions. However, most of northwestern Oregon remained the only part of the state not under a Governor's disaster declaration. In the summer of 2021, the Columbia and Willamette Rivers reached their lowest levels in five years.

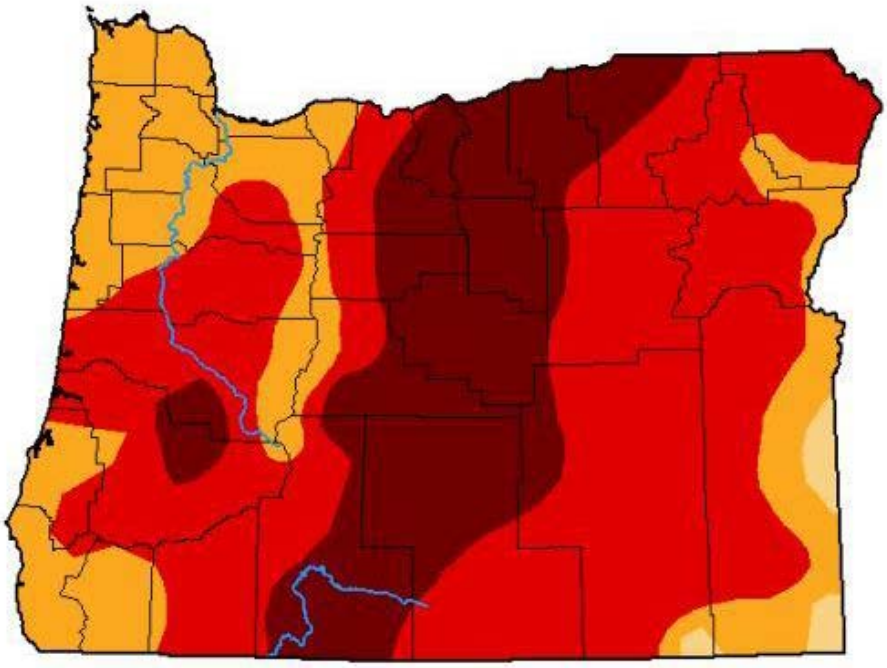

Figure 75 - Map showing drought conditions in Oregon on August 31, 2021. Colors in Western and Central Oregon range from severe to exceptional drought levels. Map from United States Drought Monitor

Because almost all water districts in Multnomah County receive their drinking water from groundwater instead of surface waters, impacts to water systems were limited. Other impacts have been to riverine ecosystems and recreational river uses.

- *Data and Risk Analysis*

The Regional Climate and Health Monitoring Report for the Tri-County Area (Multnomah, Clackamas, Washington) was released in 2019 and updated in Fall 2021. The report identifies climate and health indicators for a number of hazards, including extreme weather events, and provides strategies to address climate change impacts to public health.

A risk reduction report and workshop was jointly developed by the United States Environmental Protection Agency (EPA), Metro, and the Regional Disaster Preparedness Organization (RDPO) in April 2021. The report focused on extreme heat and wildfire smoke because of their effects on public health, inequitable impacts, and increased risk caused by climate change. The report outlined risk and vulnerability to heat, and provided a selection of potential mitigation strategies to reduce impacts from future events.

- *Climate Change Impact*

Extreme heat and drought are two of the natural hazards most likely to be worsened by climate change. Rising temperatures are the primary indicator of concern and more extreme and longer summer heat events and changing precipitation patterns are drivers of drought.

It is believed that 82% of increases in the frequency of hot summers from 2000 to 2010 can be attributed to climate change[65]. Each year in Oregon between 2000 and 2019, except 2011, was warmer than the average annual temperature between 1900 and 1999, and 2015 was the warmest year on record in Oregon between 1895 and 2019. Temperatures are projected to continue to increase in all seasons, but most of all in the summer, leading to increased frequency of dangerous heat events. Under accepted models where climate change continues without major policy intervention, Oregon is projected to have summers six degrees warmer on average by 2050 and ten degrees warmer on average by 2080.

The number of days above 90 degrees, when heat effects begin to become acute, has increased by 9 days since 1940. It is projected an additional 15 days per year will reach a heat index of 90 degrees by the middle of this century.

The atmospheric conditions related to increased heat may make the greatest increases more likely in Eastern Oregon than Western Oregon, but impacts in Northwestern Oregon will be intensified by the lower proportion of air conditioning and the effects of urban heat islands.

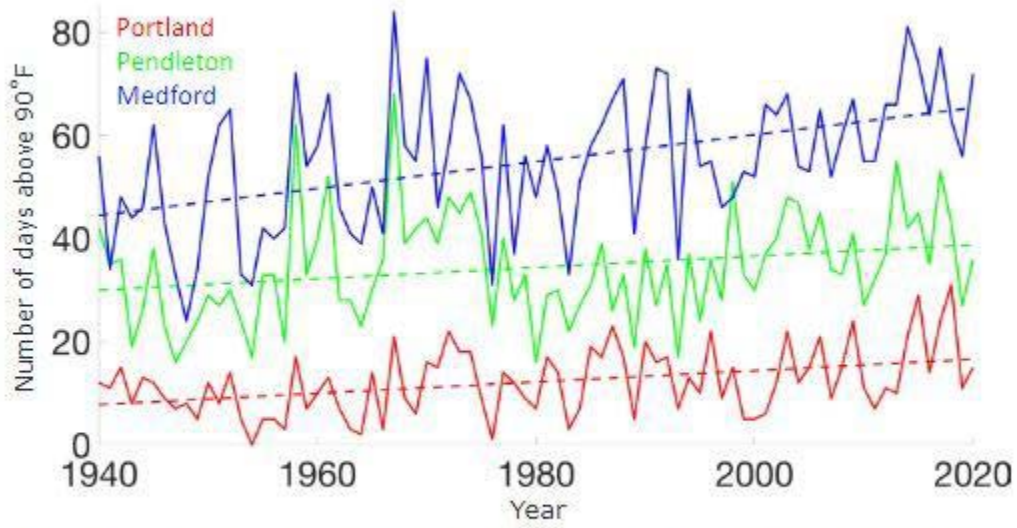

Figure 1. Number of days per year on which the daily high temperature exceeded 90°F at Medford, Pendleton, and Portland. Data source: NOAA National Centers for Environmental Information, www.ncdc.noaa.gov/ghcnd-data-access.

Figure 76 - Graph included in the Fifth Oregon Climate Assessment

Heat deaths across Oregon are projected to increase substantially, as much as 422% if current climate change trends continue. Mitigation efforts, such as increased access to cooling spaces and increasing tree canopies and pavement removal to reduce urban heat island effects, could lower this projection but excess deaths would still be expected.

Oregon has seen persistent, severe drought since 2000. Droughts in Oregon have been caused by a combination of different factors depending on the year: low snowpack, low summer and/or winter precipitation and high winter temperature.

[65] All data in this section from the Fifth Oregon Climate Assessment.

Warmer temperatures will continue to turn more winter snow into rain, and as more sunlight is absorbed by bare ground the effect becomes accelerated and further increases surface air temperatures. Multnomah County is less affected by local snow drought because of local groundwater sources and the huge drainage basins of the largest rivers. Increased risk of wildfire may be the most impactful short-term drought-related consequence for Multnomah County.

Potential impacts of climate change on winter storms are less understood, but there is the possibility that destabilization of weather patterns may maintain or even increase the probabilities of extreme cold, snow and ice events, even as winters on average become warmer and have less snow.

The effect of climate change on wind storms is similarly not well understood, but also may be impacted by increased atmospheric instability, warmer air and increases in wind shear—a phenomenon where wind speeds or wind directions are different within a small area and may contribute to storm activity. No long-term trends in the number of tornadoes have been observed in the United States, but there has been a change in where they are occurring, although there is not enough historical data yet to make conclusions whether this is a permanent effect. The recent small tornadoes that have occurred in Multnomah County do not provide enough data to understand if tornado risk has increased locally.

3.4.1 Severe Weather Impacts, Locations and Extents

Extreme Heat

Variations in high recorded air temperatures do not differ widely across Multnomah County. Temperatures at ground level, however, are highly affected by aspects of the built environment. These effects are most prevalent where there is a high proportion of impervious, reflective surfaces such as roads, roofs and parking lots that absorb and re-emit heat. This effect causes much higher temperatures at these locations and also increases the duration of heat as these surfaces continue to give off heat even as temperatures begin to drop in the evening. Shade from tree canopies lessens this effect, and vegetation absorbs heat instead of reflecting it back into the air[66].

The upward movement of re-emitted heat affects people living in the upper floors of multi-story residential buildings, where temperatures can be as much as 30 degrees hotter than on ground floors[67]. Air temperature differences have been recorded as much as 15 to 20 degrees from locations in Multnomah County with dense tree canopy compared to neighborhoods with large proportions of impervious surfaces and few trees[68].

Mapping that has been done to measure heat island effects is the best way to depict the extent of heat hazard to jurisdictions and districts, because it shows the different intensity the heat has on people in different locations across the county. These locations are often correlated with higher poverty rates, where historical neighborhood disinvestment in urban areas has resulted in fewer street trees and land-use patterns with larger roads and parking lots. Industrial

[66] About Urban Heat Islands, National Integrated Heat Health Information System
[67] Heat mapping Portland: Why do some areas get hotter than others, KGW, Megan Johnson, July 13, 2021
[68] Portland's hot spots: Urban heat islands pose threat to lower-income residents, *Street Roots*, Amanda Waldroupe, September 1, 2016

properties, and other outdoor workplaces such as parking lots, roads, bridges, runways, and roofs also have significant heat island effects.

An interactive version of this map can be found here

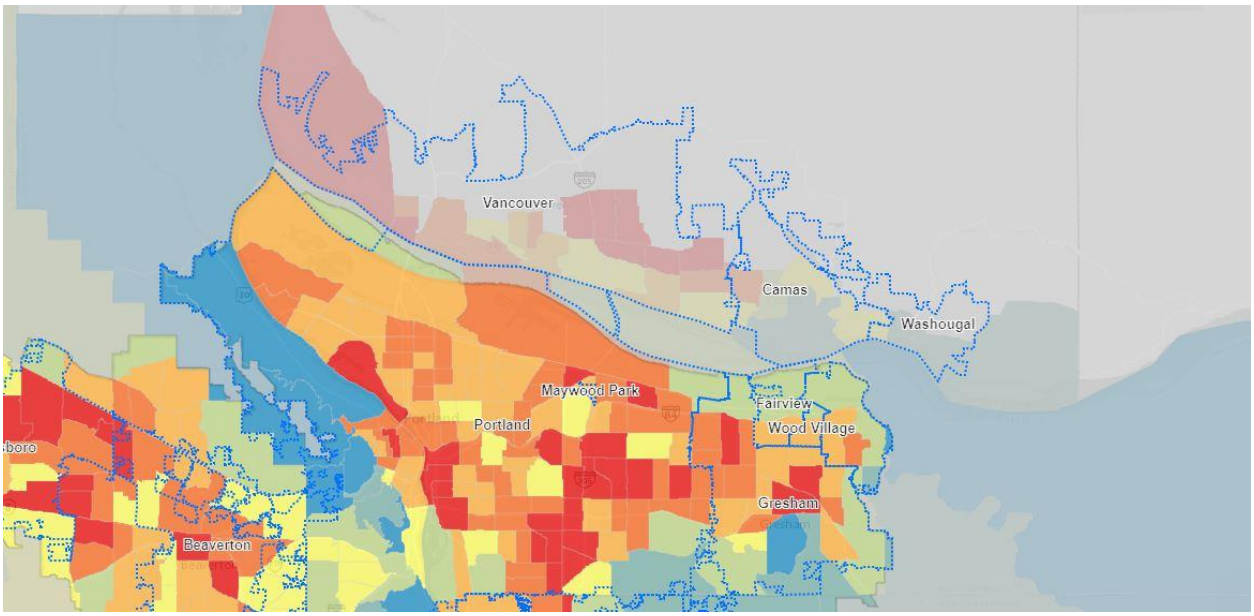

Figure 77 - Heat island effects by census tract. Tracts in red have the largest impact, generally clustered in downtown and east Portland, Gresham, and in industrial locations. More site specific heat island data can be found in jurisdictional chapters. Map - Metro

Winter Storm

Effects from winter storms are typically spread across the entire county when they occur, although higher elevations see much more snow and colder temperatures. Since most winter storm events occur when winds come into the county through the Columbia River Gorge, eastern portions of the county often experience the coldest temperatures. Snow, ice and poor visibility have frequently closed Interstate 84 between Troutdale and Hood River. Roads at higher elevations are also more prone to impact due to higher amounts of snow, or because grades make travel in winter conditions more difficult. The most serious health threats have been to unsheltered residents, wherever they are living.

Windstorm

The Columbia River Gorge is one of the windiest places in the Pacific Northwest, and sustained winds coming through the Gorge into Multnomah County cause wind damage and also strongly influence other climate hazards. The effects of gorge winds are most prominent between December and February. The elevated risks from repeated sustained winds in eastern Multnomah County are reflected in local building codes and resilient infrastructure strategies.

While the Columbia River Gorge provides the most consistent high winds, catastrophic wind events are not limited to this gorge flow. The two most damaging windstorms of the last 50 years in the region were from winds picking up speed as they moved south to north through the Willamette Valley.

Drought

Drought extents are assessed on a countywide or regional level when they occur. Impacts of drought are less based on geography and more on resilience of local water systems to low rain or snow years.

The largest river systems in Multnomah County have huge drainage basins which make them more resilient to regional drought, while other rivers and streams may rely on snow or glacial melt to maintain summer flows, and therefore may have more annual variation that will impact riverine ecosystems and recreational uses.

3.4.2 Severe Weather Probability and History

Table 37 – Severe Weather History of Multnomah County (Federally Declared Disasters Shaded)

Date	Location	Severe Weather Type	Description
Winter 1862, 1866, 1884, 1885, 1890, 1892, 1895	Portland area / Northern Willamette Valley	Snow	Severe winter conditions, especially in the Portland area. Record-breaking snowfalls (especially in 1892).
Mar. 1904	E. Portland	Tornado	"Cyclonic storm" damaged the Lewis and Clark Fairgrounds, several shacks and a large warehouse.
Dec. 1919	Portland area	Snow	Third heaviest snowfall on record. Columbia River froze, closing navigation.
Jan. 1921	Multnomah County	Ice storm	
Nov. 1921	Troutdale	Ice storm	Closed downtown Troutdale.
Winter 1927, 1936, 1937, 1943, 1949	Portland area, W. Oregon	Snow	Heavy snowfall.
Apr. 1931	W. Oregon	Winter storm	Unofficial wind speeds reported at 78 mph. Damaged fruit orchards and timber.
Jan. 1950	Statewide	Snow	Friday the 13th Storm. Heaviest snowfall since 1890. Freezing rain. Deep snow drifts closed all highways west of the Cascades and through the Columbia River Gorge. Roads and schools closed. Downed power lines. Severed communication. Hundreds of thousands of dollars in property damage.
Dec. 1951	W. Oregon	Winter storm	Statewide storm with wind speeds 60 mph in Willamette Valley. Widespread damage to transmission and utility lines. Damaged buildings.
Nov. 1958	Statewide	Winter storm	Every major highway blocked by fallen trees during windstorm. Gusts up to 71 mph.
Mar. 1960	Statewide	Snow	Snowfall amounts were 3-12 inches, depending on location.
Oct. 1962	W. Oregon	Winter storm	1962 Columbus Day Storm. Most severe windstorm for western Oregon due to sustained wind speeds and damage levels. Highest sustained winds, 88 mph, at Portland International Airport. Winds in the Willamette Valley up to 116 mph. Estimated damages $170 million. 84 homes destroyed, 5,000 severely damaged.
Jan. 1969	Statewide	Snow	Record-breaking snowfalls. $3 to $4 million in property damage.
Mar. 1971	W. Oregon	Winter storm	Great damage in the Willamette Valley; homes and power lines destroyed by falling trees.

Date	Location	Severe Weather Type	Description
Apr. 1972	Portland area	Tornado	F3 tornado, the most violent tornado in Oregon's recorded history. About $250,000 damages across the state. About $5 million damages, six deaths, 300 injuries in Vancouver, WA.
Aug. 1978	Near Gresham	Tornado	Small tornado touched ground briefly with some damage to buildings and crops.
Jan. 1980	Statewide	Winter storm	Series of storms bringing snow, ice, wind and freezing rain. Six fatalities.
Jan. 1990	Statewide	Winter storm	Heavy rain with winds greater than 75 mph; significant damage; one death.
Apr. 1991	Near Gresham	Tornado	Small weak tornado touched down. Slight damage.
Nov. 1991	Near Troutdale	Tornado	Small tornado damaged fencing, with minor damage to one building.
Jun. 1995	Gresham	Lightning	$115,000 in damages.
Dec. 1996	Statewide	Winter storm	DR-1160. Severe snow and ice. Up to four to five inches of ice in the Columbia River Gorge. Interstate 84 closed for four days. Hundreds of downed trees and power lines. Widespread power outages in the greater Portland area, including Multnomah County.
Feb. 2002	W. Oregon	Winter storm	DR-1405 Damages $6.14 million. Downed power lines and trees. Buildings damaged. Power outages caused some water supply problems.
Dec. 2003-Jan. 2004	Statewide	Snow and ice	DR-1510. Much of Portland area shut down. Twenty-six counties received assistance from the Federal Emergency Management Agency (FEMA).
Jun. 2005	Gresham	Lightning	$50,000 in damages.
Jan. 2006	Willamette Valley	Windstorm	DR-1632 Winds up to 58 mph caused total of $500,000 in damages over Clackamas, Columbia, Washington, Multnomah, Yamhill, Marion and Polk counties.
Feb. 2006	Multnomah, Clackamas, Washington, and Columbia Counties	Windstorm	Winds caused $167,000 in damages for Multnomah, Clackamas, Washington and Columbia counties; impacts also in Region 1 & 3 for a total of $575,000 in damages.
Jul. 2006	Statewide	Heatwave	Multiple days of temperatures over 100 degrees Fahrenheit.
Dec. 2007-Jan. 2008	W. Oregon	Winter storm	DR-1824. Severe winter storm, record and near-record snow, landslides and mudslides. Gresham received 26 inches of snow.
Jul. 2008	Fairview	Lightning	$2,000 in damages.
Dec. 2009	Statewide	Winter storm	Snow and freezing rain in Salem, and from Portland to Hood River. I-84 closed for 22 hours.
Nov. 2010	Statewide	Winter storm	Snow, freezing rain and ice from Portland to Hood River.
Jan. 2012	Multnomah County	Winter storm	Snow and ice east of Troutdale. I-84 closed for nine hours.
2015	Statewide	Drought	Record low snowpack across the Cascades. All of Oregon received a Federal drought declaration.
Dec 2016-Feb 2017	Statewide	Winter Storm	DR-4328 Seventh coldest January on record in Portland, coastal tornado causes damage in Manzanita, high levels of snow damage in Eastern Oregon, five hypothermia deaths in Multnomah County, major local road and school closures
Jul. 2018	Willamette Valley	Extreme Heat	July had 15 days over 90 degrees in Portland, setting a record.
Oct. 2018	Multnomah County	Tornado	Touched down in North Portland with a peak wind speed of 74 mph.

Date	Location	Severe Weather Type	Description
Jun. 2020	Near Gresham	Tornado	Damage caused in a two-mile swath in Damascus, just outside of Multnomah County
Sept. 2020	Statewide	Windstorm	45-55 mph winds from the east caused wildfire to explode and created catastrophic wildfire smoke covering Multnomah County
Feb. 2021	Statewide	Winter Storm	DR-4599 Freezing rain and snow, disaster declared in nine counties across Oregon. PGE reported 300,000 customers without power from ice damage and falling tree limbs. Interstate 84 closed.
June 2021	Statewide	Extreme Heat	Heat Dome event with Portland's all-time temperature record broken three consecutive days. Highest temperature reached 116 degrees. 69 people in Multnomah County died of hyperthermia, making it one of the worst natural disasters in Multnomah County's history. 107 deaths were reported across Oregon.
Summer 2021	Statewide	Drought	Multnomah County considered to be in severe drought. River levels on the Columbia and Willamette Rivers reached their lowest mark in five years. Fall colors of changing leaves arrived early.
April 2022	Multnomah County	Winter Storm	Two inches of snow fell on April 11-12 at PDX, the latest spring snow ever recorded.
July 2022	Multnomah County	Extreme Heat	Seven consecutive days above 95 degrees for the first time in Portland's recorded history. Five hyperthermia deaths were recorded in Multnomah County.
Dec.2022-Feb. 2023	Portland Metropolitan Area	Winter Storm	December 22 low temperatures were the lowest in five years and combined with gusting east winds to create single-digit wind chills. On February 22, Portland had 10.8 inches of snow, a calendar-day amount only exceeded by an event in 1943. The unexpected snow caused traffic gridlock across the region.

Extreme Heat

The 2021 Heat Dome event has been preliminarily described as a 1,000 year event (0.1 annual chance), but it is also theorized that the conditions that allowed this climate anomaly to form may be more likely as climate change increases ocean and air temperatures.

Weather hot enough to become dangerous is not unusual in Multnomah County, but has commonly been of short duration. Portland has historically averaged one day of 100-degree plus weather per year. 2021 had five total days over 100 degrees, tying 1941 and 1977 as the most on record. The number of days with high temperatures between 95 and 99 has increased significantly between 2010 and 2019 compared to any other decade in the last 80 years, so longer duration heat events are becoming more common and are expected to continue to increase[69]. This trend continued in July 2022, when Portland saw seven consecutive days with high temperatures above 95 degrees for the first time in recorded history. Five people in Multnomah County died from heat in that event, with similar demographic impacts as in the 2021 Heat Dome (older adults, primarily men, living in homes without air conditioning).

Winter Storm

[69] The Oregonian, Portland Temps, 1938-2023

Winter storms are a common occurrence in Multnomah County. Low elevations average about four inches of snow per season but do not have snow every year. Higher elevations get some snow annually. Predicting the frequency of extreme cold, snow or ice events is difficult, but it has been estimated that the northern Willamette Valley will experience some sort of extreme event about every four years, although these events are often short in duration. Cold-related deaths have maintained risk awareness, and emergency warming shelters have been used to respond to risks to those without access to warm spaces. Road maintenance preparation has also been expanded because of recent snowstorms.

The 2017 winter was extreme and caused loss of life, but more intense events have occurred in the last century. The largest amount of snow recorded in Portland in one day was 15.5 inches on January 21, 1943. One cold snap in 1950 recorded temperatures below zero in Portland, the only time that has occurred since records began in 1940[70]. The Columbia River froze solid for the last time in 1930[71] after high temperatures failed to break 32 degrees for 19 straight days.

Probabilities of extreme low temperatures and high snow and ice amounts may be increased by climate-change driven weather disruptions, although most models show that averages over time will result in warmer winters and less snow.

Winter storms are often linked with cold air blowing in from the Columbia River Gorge. One study has estimated that 70% of days with snowfall, 56% of total snowfall amounts, and 90% of days with freezing rain at the Portland Airport coincide with easterly Columbia River Gorge winds[72].

Windstorm

The 2020 State of Oregon Natural Hazards Mitigation Plan identifies the Northern Willamette region as having a 4% annual chance of seeing 65 mph winds (25-year event) and a 1% chance of 80 mph winds (100-year event). Wind speeds above 50-60 mph are considered to be damaging and will fell trees and power lines. Wind speeds up to 85 mph can damage shingles and siding, and wind speeds above 85 mph can knock over mobile homes and cause other building damage. There have been two events in Multnomah County in the last 60 years where wind speed has been estimated to have exceeded 100 mph.

Multnomah County can experience powerful straight-line winds or tornadoes as extreme events and also often has strong, sustained winds coming from the east through the Columbia River Gorge.

The most significant recorded windstorm in Multnomah County was a straight-line wind event—the Columbus Day storm in October, 1962, also known as the Big Blow. Winds in this event may have reached 116 mph, the equivalent of a major hurricane. Measurement equipment at the Portland Airport recorded sustained 90 mph winds before being damaged.

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[70] Joe Dorish Weather, Ten Coldest Weather Temperature Days Ever Recorded in Portland, Oregon, January 14, 2017.

[71] The building of upstream dams has also made freezing over of the Columbia River unlikely, by keeping flows high enough to prevent the river from slowing. In 1930, cars could drive across the frozen river.

[72] Columbia Gorge Gap Winds: Their Climatological Influence and Synoptic Evolution, *Weather and Forecasting*, Justin Sharp and Clifford Mass, December 1, 2004

Figure 78 - Wreckage at the Portland Airport after the 1962 Columbus Day windstorm

The Columbus Day storm was caused by the remnants of an extratropical typhoon reforming off the coast of California and maintaining its power as it traveled along the Pacific Coast. No other similar event has ever been recorded, and the large number of blown over trees that were 1,000 years or older gives an idea of just how infrequent an event this storm was[73]. However, it is also probable that warming oceans will increase the likelihood of offshore energy strengthening or revitalizing future typhoons.

Impacts from the storm reached from California to British Columbia, caused about $170 million in damages, and killed 50 people—primarily from flying debris and falling trees. At the time, it was considered to be the worst natural disaster to ever hit Oregon.

Figure 79 - A map showing the path of the 1962 Columbus Day windstorm and peak wind speeds across the Pacific Northwest. A peak gust of 116 miles per hour was recorded at the Morrison Bridge in Portland. Graphic from the Office of the Washington State Climatologist.

Tornadoes are rare in Multnomah County, but not unknown. While the most recent tornado events in 2018 and 2019 were at the lowest level of wind speed and of short duration, there have been two recorded instances of F3 (severely damaging) tornadoes in Multnomah County, in 1894 and 1972. Each of these events caused fatalities, although not necessarily in Multnomah County.

The April 5, 1972 event was the most deadly tornado in the United States that calendar year, killing six people in Clark County, Washington, and injuring 300. An elementary school was destroyed as well as businesses and homes—overall causing about $25 million in damage. The tornado touched down in Portland, at NE 33rd and Marine Drive along the Columbia River, damaging boats before it crossed the river into Washington and caused a wide swath of damage. Wind speeds were estimated to have peaked at 120 mph.

[73] The 1962 Columbus Day Storm, Office of the Washington State Climatologist, Wolf Read, Last Updated October 2015

Figure 80 - Damage in Vancouver, Washington caused by the 1972 tornado. Photo and oral recount provided by Clark History..

Overall, there have been five tornadoes in Multnomah County between 1904 and 2022, which suggests an approximate 5% annual chance, but that probability may be conservative because of climate change impacts or by more recent improvements in defining, recording and reporting of tornadoes. Similarly, an F3 tornado could be estimated to have a 1% annual chance, but the small number of events makes it an uncertain prediction. September and October have historically been the most active months for tornadoes in the Willamette Valley.

Drought

While climate change is making drought more extreme and more frequent, it is also part of a natural climatic cycle. Studies of tree rings in Central Oregon have shown that extreme drought periods occurred in the 1480s, 1630s, 1700s and 1930s[74]. The 1930s were recorded as the most sustained drought in the 545-years of available study information, and coincide with a period of extreme wildfire activity in Western Oregon.

It is extremely likely that the roughly 100-150 year historical recurrence of catastrophic drought has accelerated. The current 'mega-drought' that has been afflicting much of the entire Western United States since 2000 was considered in an article in the journal ***Nature*** to be the most wide-

[74] Physical Geography, A 545-Year Drought Reconstruction for Central Oregon, May 15, 2013, K. Pohl, K. Hadley, K. Arabas.

scale event in at least 1,200 years[75]. 42% of the drought condition has been attributed to climate change.

3.4.3 Severe Weather Vulnerability

Extreme Heat

Assessing the county's vulnerability to extreme heat requires identifying those who are most impacted because of social or environmental conditions. Consistent evidence has shown that the populations most at risk from extreme heat are:

- Older adults, especially those over age 65
- People without cooling systems in their home
- People experiencing homelessness
- People living within urban heat islands
- People with chronic medical conditions that affect the body's ability to cool itself, such as cardiovascular disease or poor blood circulation
- People with limited social connections and networks
- Children, whose vulnerability lies in their dependence on others to keep them safe
- People who are pregnant
- Outdoor workers, especially at worksites in urban heat islands
- People with mental, behavioral, or cognitive disabilities
- People who rely on medications that may decrease the body's ability to cool itself

Many of these risk factors were implicated in the 69 deaths that occurred in Multnomah County due to the 2021 Heat Dome event. None of those who died had access to central air conditioning, and very few had portable air conditioning units and most of those were not operational.

A majority of the deaths (55%) occurred in multi-family housing, and nearly half of those deaths occurred at the third floor higher in a building. Another 18% of the deaths occurred to people living in mobile homes, recreational vehicles, or automobiles. Four deaths were identified in subsidized affordable housing buildings, another four in housing for vulnerable people, and two in an independent senior living facility. Two people were identified as experiencing homelessness and were found in their vehicles. Two deaths in Oregon were to people working outdoors—one agricultural worker and one construction worker[76]. Neither death occurred in Multnomah County.

The youngest death in Multnomah County was a 48-year-old, but the average age of death was 70, including 10 people over the age of 80. 78% of deaths were people living alone. Men (64%) died at a higher rate than women, and people identified as white (92%) were overrepresented in deaths as a racial group.

Deaths occurred across the county, with the highest concentration in zip codes in downtown Portland and areas east of 42nd Avenue on the east side of the Willamette River.

[75] Associated Press, West megadrought worsens to driest in at least 1,200 years, February 14, 2022, Seth Borenstein

[76] The Oregonian, Oregon reports second workplace death from June heat wave, July 25, 2021, Jamie Goldberg

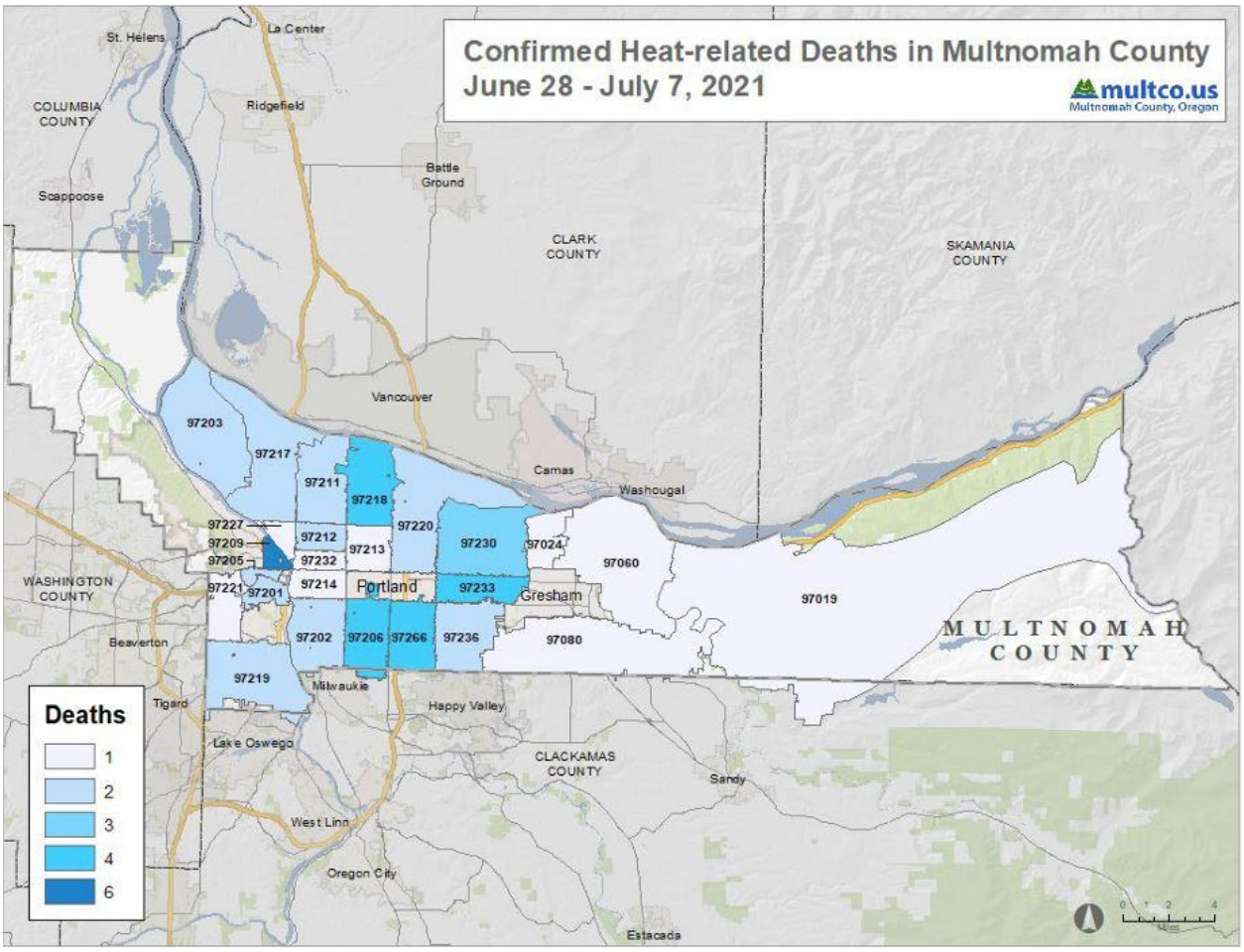

Figure 81 - Graphic of zip code locations of 2021 heat-related deaths. Map from Multnomah County.

High heat may also impact power infrastructure. Portland General Electric reported record demand for electricity during the Heat Dome—high usage combined with strain caused by high temperatures can threaten electrical equipment. Given the locations of those who died in the Heat Dome event, a widespread power loss causing a loss of home cooling would have put many more residents at risk.

When heat reaches 90 degrees, some light rail transit routes become delayed as trains reduce speed. At over 100 degrees, all lines become delayed. Some minor physical damage to road and rail infrastructure has occurred.

Winter Storm

The greatest vulnerability in recent cold events has been the risk of hypothermia to those living without shelter. Warming spaces and shelters have been used as an intervention to protect those who do not have access to safe locations. Injuries and deaths during winter storms are also caused by falling trees, downed power lines, treacherous walkways and car accidents.

Snow and ice may disrupt or damage infrastructure, including roads, sidewalks and power lines. Key transportation routes have been disrupted many times by snow or ice, which has limited the movement of emergency vehicles, prevented caregivers from reaching those in need, and

blocked important commercial transport routes. An ice storm in 2004 shut down major highways, public transportation and the Portland International Airport for three days[77].

Windstorm

Downed trees and power lines are a common risk from high wind events. Flying debris has also been a major cause of death in regional wind events, meaning that those unable to access safe spaces during extreme wind events may again be most at risk.

Structural damage can occur from falling trees and blown off shingles or siding. Mobile homes are particularly vulnerable to both straight-line winds and tornadoes, and may be pushed off foundations during extreme events. Because of the rarity of extreme wind events in this region, safe rooms purpose built for extreme winds are uncommon.

High winds often disrupt travel through the Columbia River Gorge because of blowing snow, limiting visibility or creating the risk of tall vehicles being blown over. Airport operations may also be disrupted by extreme wind events.

Power Loss

Long term loss of power is a threat from all severe weather types in this plan except for drought. Power loss may be most likely to occur during windstorm or winter storm because of damage to power lines. Winter storms may also see an increase in automobile collisions with power poles.

Long-term power loss is particularly dangerous to those who use powered medical devices or require refrigerated medicine. During heat or smoke events, power loss will prevent the use of air conditioning and air filtration equipment.

During extreme heat events, equipment may become overheated and power grids may become unstable because of excessive demand from widespread air conditioning use. Power loss was not an issue in the Heat Dome event, in part because the heat event did not impact the entire West Coast and create overwhelming regional demand. Because of the clear link between deaths in the event and a lack of access to air conditioning, a concurrent long-term power outage would have likely resulted in many more deaths and continues to loom as a risk factor in future extreme weather events.

Expanding the availability of backup power systems that can be accessed by those with urgent medical needs can limit risk during future outages. Outages during heat and smoke events will also impact those with existing health risk factors, expanding the need for backup power and accessible clean air or cooling spaces.

Drought

Multnomah County has particular resilience to drought compared to other locations in Oregon because most water users in the county get their water from the Bull Run Reservoir or from aquifer wells near the Columbia River. In both cases, these supplies are recharged by rains year-round and do not rely on melting snowpack to maintain surface water levels during the

[77] Notable Winter Storms in Oregon, *The Oregonian*, November 13, 2014, Lynne Palombo

summer. This resilience should also help manage effects from climate change, when more winter precipitation is expected to fall as rain instead of snow.

Low snowpack has particular impacts on the flow of the Sandy River, which is fed by snowmelt and glaciers on Mount Hood. During the historic low snowpack of 2015 where early spring snow levels were only 6% of normal, low flows impacted salmon recovery and recreational river use.

A more significant drought in Multnomah County could have impacts to the county's agriculture and forestry sectors. Water use restrictions have not been in place in recent years, but water conservation is regularly promoted