THURSTON COUNTY CLIMATE CHANGE VULNERABILITY ASSESSMENT

Technical Appendix to the Thurston County's Comprehensive Plan

November 2024

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II. INTRODUCTION

Thurston County is located in Western Washington at the south end of Puget Sound. With an area of 736 square miles, it is the 32nd largest of Washington's 39 counties. There are seven incorporated municipalities in the county, including the city of Olympia, which is the county seat and the Washington state capital (Figure II-1). The county also includes portions of the Confederated Tribes of the Chehalis Reservation and the Nisqually Indian Tribe Reservation.

Thurston County has a strong history of climate preparedness and investments, which includes its 2018 Climate Adaptation Plan and its 2020 Climate Mitigation Plan. This climate vulnerability assessment builds on these prior efforts, simultaneously expanding the scope of the prior vulnerability assessment, which was completed in 2016, and supporting compliance with new statewide regulations from House Bill (HB) 1181 that require local jurisdictions to integrate climate change into their comprehensive plan updates.

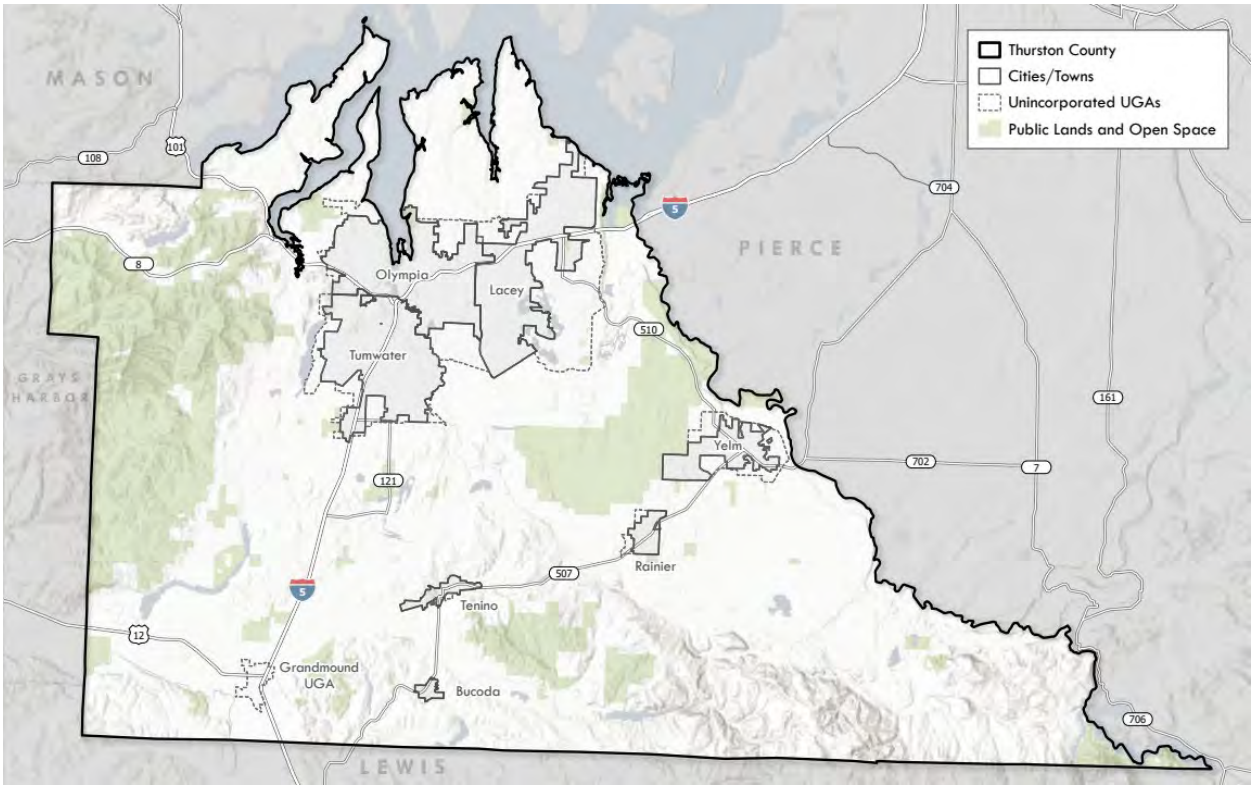


Figure II-1 Map of Thurston County

This vulnerability assessment will primarily inform the design and implementation of the county's Climate Element in its Comprehensive Plan. In addition to the Climate Element, this vulnerability assessment may inform other sections of the county's Comprehensive Plan. Table II-1 shows how each of these sections speak to core topics across the different elements of the Comprehensive Plan.

Table II-1. List of sectors in the climate vulnerability assessment and associated chapters in the county's Comprehensive Plan.

Sector	Topics Addressed	Relevant Chapters in Comprehensive Plan
Public Health	• Physical health • Mental and community health	• Health

Sector	Topics Addressed	Relevant Chapters in Comprehensive Plan
	• Medical care, emergency services, and community amenities	• Environment, Recreation, and Open Space • Capital Facilities
Ecosystems and Water Resources	• Critical areas • Surface water and groundwater • Water supply • Stormwater and wastewater • Shellfish habitats	• Environment, Recreation, and Open Space • Capital Facilities • Utilities • Natural Resource Lands
Infrastructure	• Energy systems • Transportation	• Capital Facilities • Utilities • Transportation • Appendix G, Capital Improvement Program
Community Design, Land Use, and Economic Development	• Building and zoning • Housing patterns and affordability • Commercial businesses	• Land Use • Housing
Natural Resource Lands and Rural Economy	• Agriculture • Fisheries • Forestry	• Natural Resource Lands

III. CLIMATE CHANGE TRENDS AND PROJECTIONS IN THURSTON COUNTY

A. CLIMATE CHANGE AND CLIMATE VARIABILITY

CLIMATE VARIABILITY

Climate in the Puget Sound region – including Thurston County – is influenced by natural variability, such as the El Niño and La Niña cycles as well as the Pacific Decadal Oscillation. These natural cycles can influence the county's climate from year to year. For example, Thurston County will experience warmer and drier winters during an El Niño year and will experience cooler and wetter winters during a La Niña year in addition to the long-term climate variability pattern of the Pacific Decadal Oscillation.

It is important to contextualize human-caused climate change within the broader context of natural variability. Weather patterns from year-to-year can be unpredictable and influenced by natural variability and human-caused climate change. Despite natural variability, there are still strong signals that the global and the region's climate is changing in a multitude of ways.

B. CLIMATE SCENARIOS AND MODELS

This climate vulnerability assessment uses several types of scenarios – specifically Representative Concentration Pathways (RCPs) and Shared Socioeconomic Pathways (SSPs). RCP scenarios show different greenhouse gas (GHG) concentration pathways while SSP scenarios show how GHG concentrations are affected by international climate policies. Both types of scenarios reflect a range of potential futures on land use, technological innovation, economic industries, energy sources, and human behaviors. These scenarios are used as part of global climate modeling efforts – such as CMIP5 and CMIP6[1] – which model past, current, and future projected impacts due to GHG emissions.

Currently, there is locally downscaled information for CMIP5 projections provided by the University of Washington Climate Impacts Group, allowing practitioners to understand potential futures in local climate. For some variables, there are downscaled CMIP6 projections. For this assessment, we will primarily use RCP4.5 and RCP8.5 scenarios.

C. CLIMATE TRENDS AND PROJECTIONS

TEMPERATURE

Thurston County's average annual temperature has warmed about 2.4°F between 1895 and 2024 (Figure) (NOAA National Centers for Environmental Information, 2024). While there is some year-to-year temperature variability, much of which is driven by natural climate variability cycles such

[1] CMIPs are an international collaboration among climate scientists to help understand historical, present, and future climate conditions. CMIPs support the validation and comparison of hundreds of climate models to ensure that climate scenarios are as accurate as possible in their future climate projections. CMIP generations are generally comparable, though have been refined with each iteration. These CMIPs are used as part of the Intergovernmental Panel on Climate Change (IPCC) and are used widely to understand future climate impacts.

as El Niño-Southern Oscillation (ENSO) and Pacific Decadal Oscillation (PDO), the county's warming trend is faster than the state's average of 2.0°F (Chang et al. 2023). Additionally, the maximum August temperature – an indication of potential summer heat stress – has increased from 74.9°F in 1895 to 81.8°F in 2023.

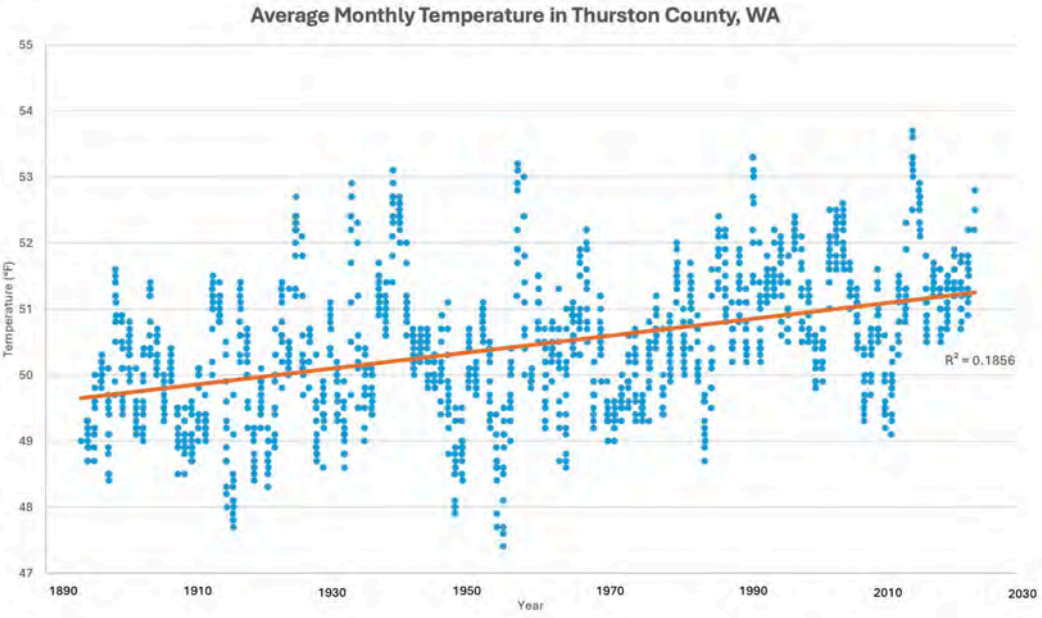


Figure III-1. The average monthly temperature between 1899-2024 in Thurston County, WA.

Data from NOAA's National Centers for Environmental Information. Accessed 10 June 2024. Graph created by Cascadia Consulting Group.

The county is expected to warm under all future climate scenarios. Relative to the 1952-2004 baseline, the county's average daily maximum temperature is expected to warm another 8.9°F under RCP8.5 and approximately 5.6°F under RCP4.5 by end of the century (Figure III-1; NEMAC). This warming is expected to be associated with more frequent and more intense heatwaves and extreme heat days (Chang et al. 2023).

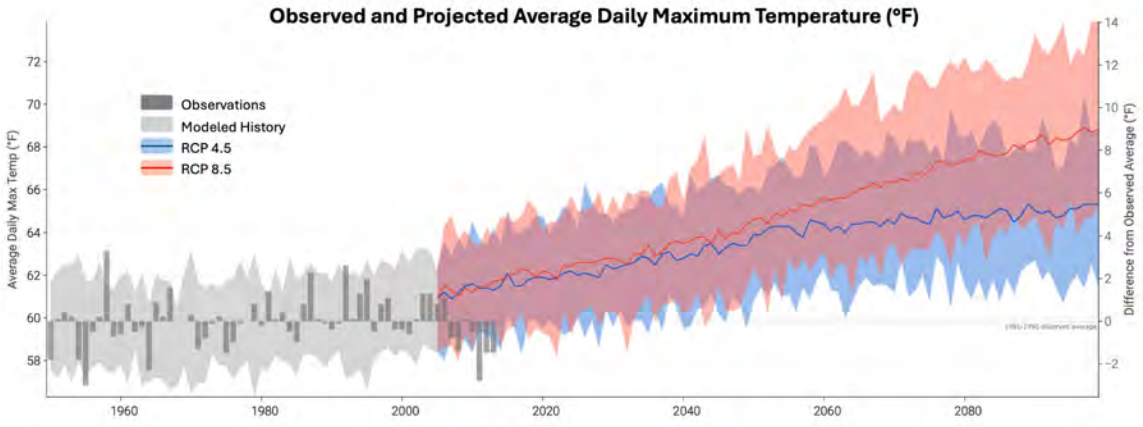


Figure III-1. Projected average daily maximum temperature (°F) under RCP4.5 and RCP8.5, relative to 1952-2004.

Data from the U.S. Climate Resilient Toolkit Climate Explorer, version 3.1. Accessed 10 June 2024. Climate projections and graphics were produced by the National Environmental Modeling and Analysis Center (NEMAC) at the University of North Carolina Asheville.

PRECIPITATION

Annual precipitation in Thurston County is highly variable from year to year. However, summer precipitation west of the Cascades is projected to decrease while fall and winter precipitation west of the Cascades is projected to increase under all emission scenarios by the 2080s, relative to 1950-1999 (Figure III-2; Mauger R. M., 2021). This change in precipitation – particularly decreases during summer months and the shift of snow-dominant basins to mixed or rain-dominant basins – is expected to contribute to regional drought conditions, which are expected to be more severe and prolonged in the future.

Additionally, extreme precipitation is expected to increase in intensity and frequency. Atmospheric rivers are long, narrow bands of water vapor in the atmosphere that can drive heavy rains to the Puget Sound region, especially during fall and winter months (Slinskey, Loikith, Waliser, Guan, & Martin, 2020). As the atmosphere warms, it can retain more water vapor like a sponge, and thus atmospheric river events are expected to become much more intense. By the end of the century, the magnitude of extreme precipitation events – or the intensity or the amount of rain associated with an event – in Thurston County is expected to increase by 31%, relative to 1980-2009 (Raymond & Rogers 2022).

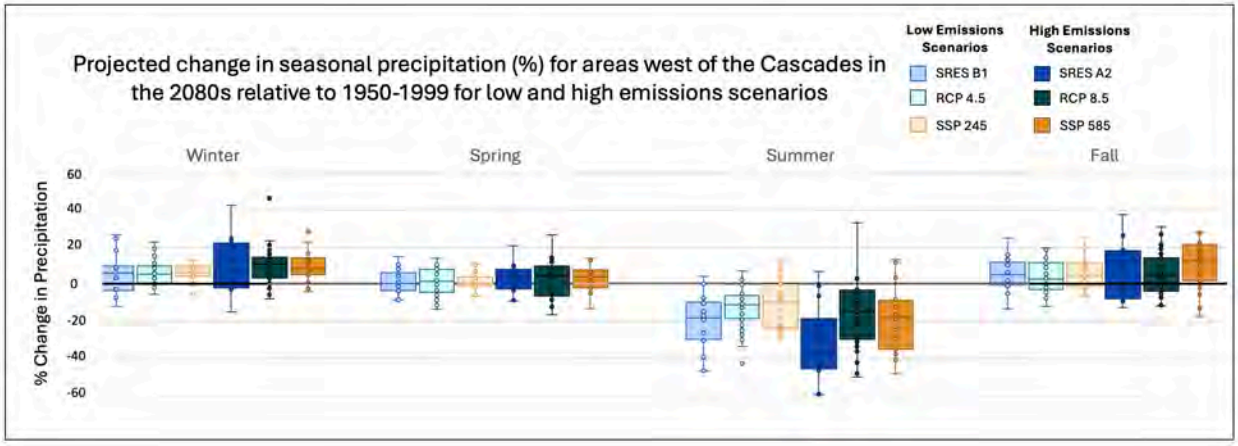


Figure III-2. Projected change in seasonal precipitation (%) for areas west of the Cascades in the 2080s, relative to 1950-1999 for low and high emissions scenarios.

Projections are shown for CMIP3, CMIP5, and CMIP6 models for winter (December-February), spring (March-May), summer (June-August), and fall (September-November) seasons. Individual climate model projections are shown using colored dots. Boxes show the average projected change – expressed as percent change – along the 10th, 25th, 75th, and 90th percentile values among all model projections. Data from the Pacific Northwest Climate Projection Tool (Rogers & Mauger 2021) and figure created by Cascadia Consulting Group.

STREAMFLOW

The changes to regional precipitation patterns will have an impact on streamflow timing and volume. In the Nisqually watershed, the only glacier-fed stream in the County, streamflow is expected to increase in winter months and decrease in summer and fall months. The expected average streamflow in winter months reflects the transition to more rain-dominant basins from mixed and snow-dominant basins across the Puget Sound region. Additionally, decreases in summer and fall streamflow reflect expected decreases in summer precipitation, affecting regional water supply and temperature along with salmon runs (Chang et al. 2023).

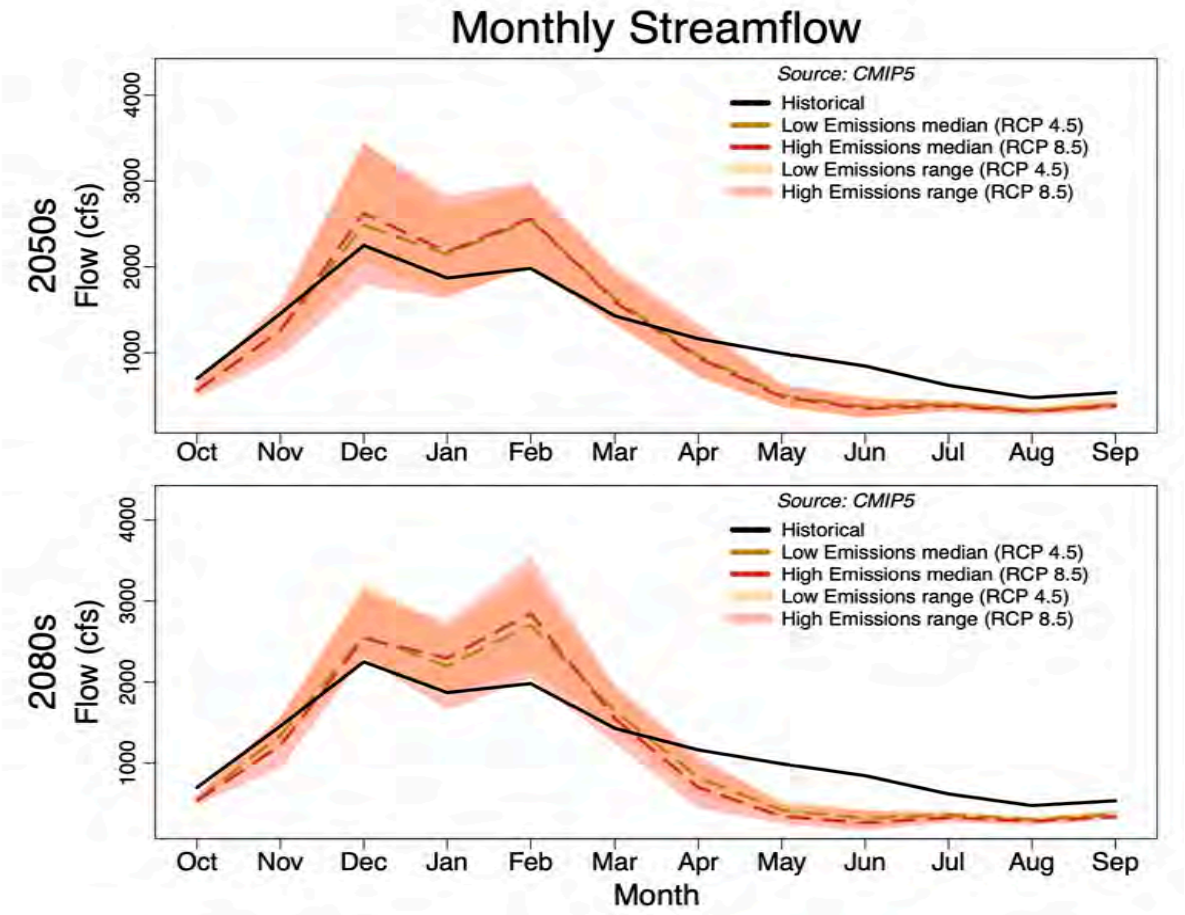


Figure III-3. Average monthly streamflow in the Nisqually watershed across water year for mid-century and end-of-century for CMIP5.

Figure from Mauger et al. 2015.

In addition to changes in monthly streamflow, peak flows and low flows are also expected to change. Peak flows – especially during winter months – are expected to intensify, which can amplify regional flooding risks. Additionally, low flows are expected to decrease, especially during summer and fall months. Low flows will have implications for regional water supply and available water for salmon migration and survival (Mauger et al. 2015).

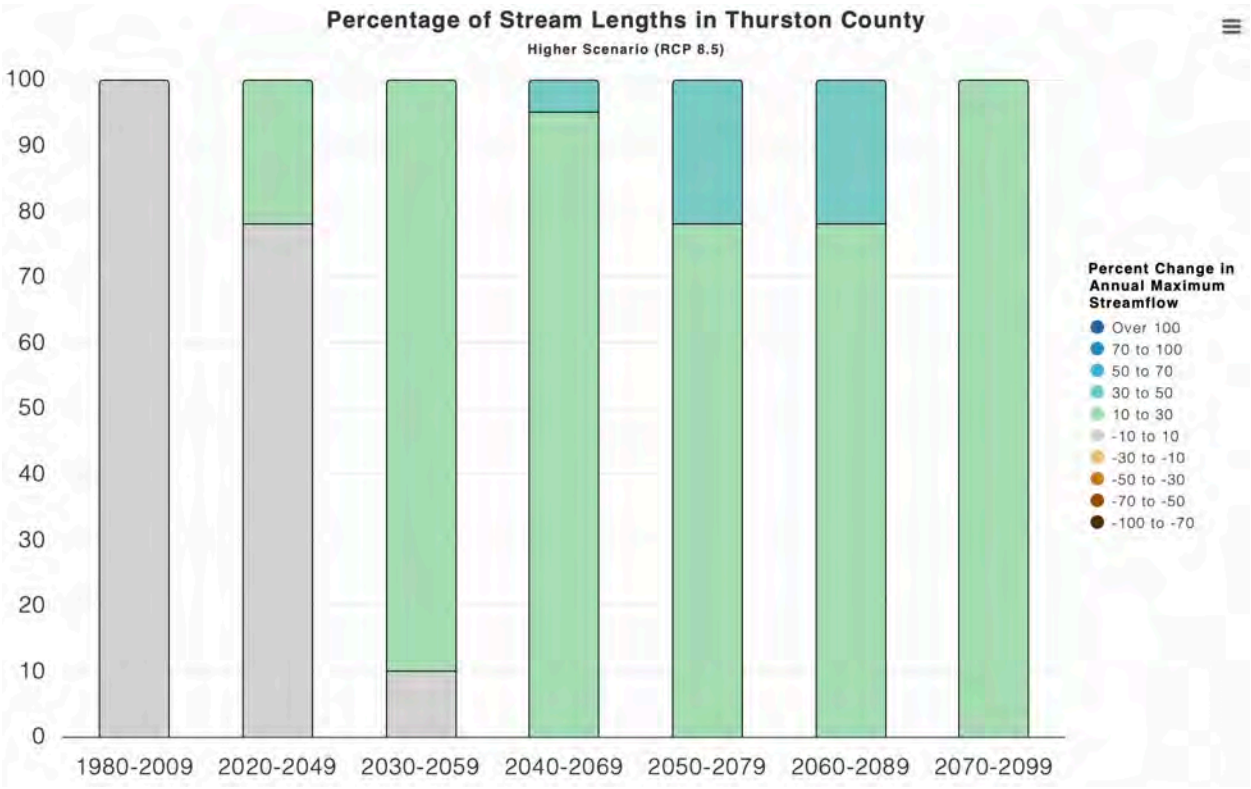


Figure III-4. Projected percent change in peak streamflow magnitude under RCP8.5.

SEA LEVELS

Sea levels in the Puget Sound region have already risen by 0.68 feet between 1899 to 2023 (Figure III-5; NOAA 2024). Sea levels are driven by multiple factors, including ice melt from glaciers and ice sheets, thermal expansion of water, and vertical land movement. In Washington State, vertical land movement has a particular effect on relative sea level rise (Newton, et al., 2021). Land in Thurston County is slightly subsiding, which can increase the risk of sea level rise affecting the county's coastal communities and infrastructure.

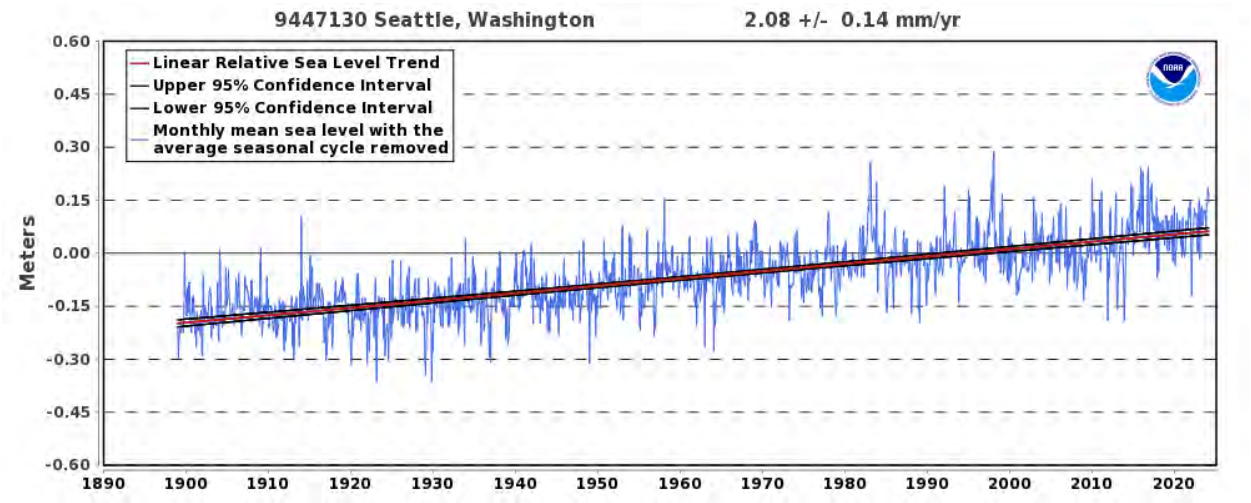


Figure III-5. Relative sea level trends at NOAA Tide Gauge 9447130 Seattle, WA, from 1899 to 2023.

Plots show monthly mean sea levels without the regular seasonal fluctuations from coastal ocean temperatures, salinity, wind, atmospheric pressure, and ocean currents. The relative sea level trend is also shown with its 95% confidence interval (NOAA Tides & Currents, 2024).

Sea levels are expected to continue to rise through the end of the century for Thurston County. Under RCP8.5, sea levels in Thurston County are expected to increase by 0.8 feet by 2050 and 2.2-2.3 feet by 2100 (Table III-1; Lavin, et al., 2019; Miller, et al., 2018).

Table III-1. Relative sea level rise projections, in feet, under RCP8.5 for Thurston County under a 99%, 50%, and 1% likelihood scenario.

	99% Likelihood	50% Likelihood	1% Likelihood
2050	0.1-0.3	0.8	1.4-1.6
2100	0.5-0.8	2.2-2.3	5.0-5.1
2150	0.9-1.4	3.7-3.9	10.2-10.4

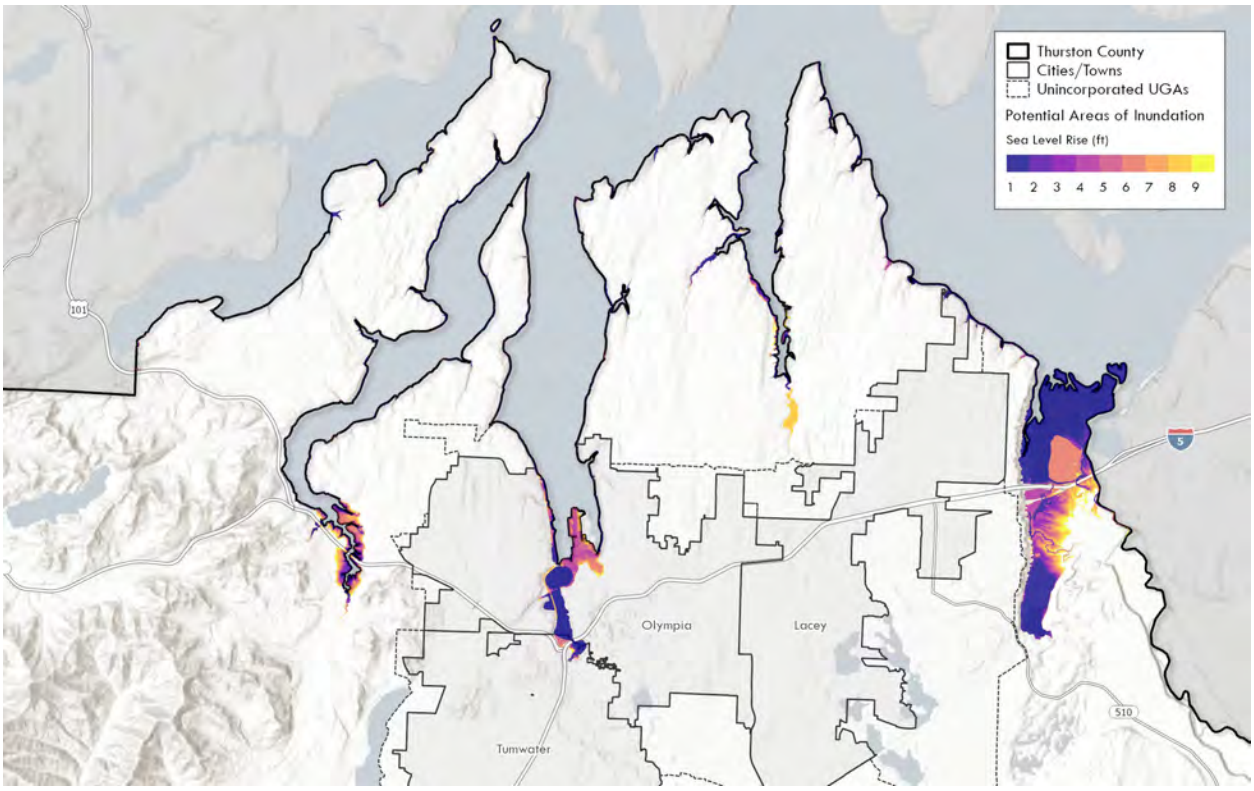


Figure III-6. Flooding risk in Thurston County for sea level rise exceedance thresholds.

WILDFIRE AND SMOKE

Fire has played an important ecological function in Thurston County, with the historical fire regime being frequent and mixed-severity fires that facilitated ecological function and tree diversity and growth (Spies, Stine, Gravenmier, Long, & Reily, 2018). Despite historical fire regimes, large and catastrophic wildfires in Thurston County have historically been very rare (Morgan, Bagley, McGill, & Raymond, 2018).

Climate change is expected to affect future wildfire risk across Thurston County. The annual burn probability in the Puget Sound lowlands is expected to increase from 0.009% to 0.052% under RCP8.5 by mid-century, which is a 478% increase in expected annual burn probability from the contemporary baseline (1992-2020) (Dye, et al., 2024). Additionally, the fire season is expected to be longer and have larger fires by mid-century (Figure III-7; Dye et al. 2024). While annual burn probability is relatively low compared to other parts of Washington, a large wildfire event could potentially be catastrophic considering this region does not experience them as frequently as eastern WA regions. Furthermore, wildfires across the Northwest have increased the number of smoke events for Thurston County, with these events becoming more frequent and prolonged (Chang et al. 2023).

The wildland-urban interface (WUI) includes developed areas that meet or intermingle with forests and vegetation areas. This type of land use pattern can exacerbate the impacts of wildfires—even small ones— for residents and structures. Approximately 34% of unincorporated Thurston County—or 18,500 structures—reside in the WUI, placing these structures and communities at increased risk of fires.

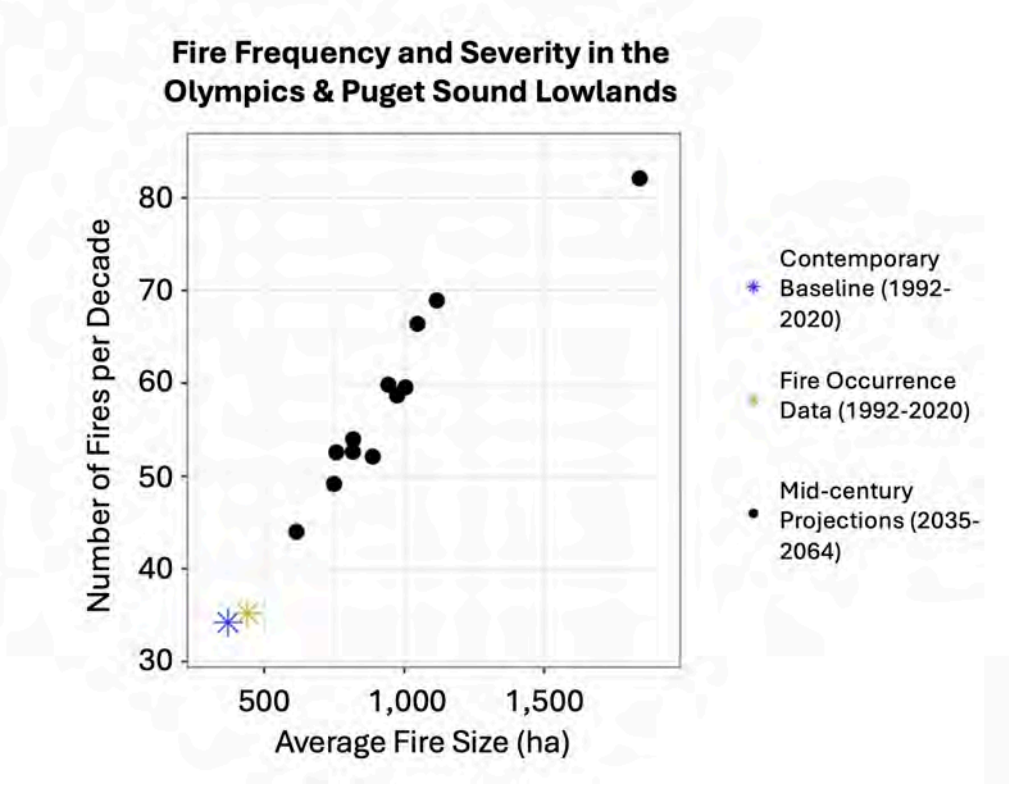


Figure III-7. Projected average fire size and number of fires per decade by mid-century (2035-2064) under RCP8.5.

Mode projections are based off of 12 global climate model simulations relative to contemporary baseline calibrated simulations (1992-2020) and the historical fire occurrence data (1992-2020). Figure adapted by Cascadia Consulting Group from Dye et al. 2024.

IV. CLIMATE VULNERABILITY ASSESSMENT RESULTS

D. INTRODUCTION

CLIMATE VULNERABILITY INDEX METHODOLOGY

The Thurston County Climate Vulnerability Index (CVI) was developed as part of the Thurston County Climate Vulnerability Assessment. The CVI includes 30+ indicators and combines them to form an index that supports a planning level view of climate vulnerability in Thurston County to help identify areas of the county that may be more or less vulnerable to the impacts of climate change. The indicators include metrics for climate stressors, demographics, community health, critical areas, and others relevant to the spatial variability of climate vulnerability.

An index is a calculation used to summarize multiple datasets into one measure, often utilized when datasets are not easily or directly comparable. The core function of an index is to normalize or standardize these dissimilar data across common geographic units and using a standardized range of values. In simpler terms, it allows for an 'apples-to-apples' comparison of dissimilar data. Every measure in the index is standardized, regardless of the type of measure, and rescaled so each indicator can be added together and each geographic area (e.g., census tract or block group-whichever geography is selected) is compared to other census geographies of the county. The Vulnerability Index (and its sub-indices) is meant to allow Thurston County to take a closer look at places that may be more or less vulnerable given planning level data.

Vulnerability to climate change is measured as a combination of three broad components:

- **Exposure** measures the frequency and magnitude of climate-related stresses.
- **Sensitivity** is the degree to which people or a system will be affected by a climate-related shock or stress.
- **Adaptive Capacity** is the ability of individuals, communities, institutions, or other systems to adapt to climate-related stresses or cope with the consequences of climate change.

Each of these components is measured through evaluation of relevant indicators. The indicators considered are based on scientific and professional literature regarding social vulnerability, health, environment, and climate change. For example, some areas are more vulnerable due to extreme heat, such as "heat islands" with more pavement and fewer trees, or areas with a higher concentration of older residents. Some areas are vulnerable to extreme precipitation such as floodplains and landslide hazard areas, along with populations that live alone or have less access to a vehicle. The index provides information useful for Thurston County to develop strategies to enhance the county's resilience over the medium and long term and include the strategies in plans, budgets, partnerships, and more.

For each component of climate vulnerability (exposure, sensitivity, and adaptive capacity), a sub-index is computed based on the associated indicators. The values for each indicator are first standardized using z-score normalization and then averaged by sub-category (as shown in Table IV-1). These sub-category scores are then averaged to create a sub-index score for each component. This two-step averaging process ensures that each sub-category contributes equally to the sub-index score, regardless of how many indicators it includes.

These three component scores are then averaged together to create the final CVI value. To visually present the CVI, final index values are classified based on quintile categorization, which distributes the values into five groups of an equal number of values based on the total range of scores. The final

group results in very low, low, moderate, high, and very high vulnerability classifications, emphasizing the relative nature of the calculation.

Table IV-1 shows the exposure, sensitivity, and adaptive capacity indicators selected for the index.

Interactive Tool

Link: Thurston County - Climate Vulnerability Indicators (arcgis.com)

- **Exposure Sub-index:** This sub-index contributes to the CVI and is comprised of equally weighted indicators for heat, flooding, and fire risk/air quality, considering local conditions. Regional climate exposures such as extreme precipitation could exacerbate the depth and extent of flooding. Extreme heat can exacerbate the health conditions of persons also exposed to air pollution, and extreme heat can be magnified by local environmental conditions (e.g., less trees, more pavement).
- **Sensitivity Sub-index:** Sensitivity is the component of the CVI addressing attributes inherent to the population or place that make them predisposed to increased impacts from climate exposure. The indicators for sensitivity are categorized into sub-categories of age, environment, and health conditions.
- **Adaptive Capacity Sub-index:** Adaptive capacity is the component of the CVI addressing attributes related to a population or environment's capacity to adapt to increased exposure to climate change. The indicators for adaptive capacity are categorized into sub-categories of socioeconomic, transportation, housing/built environment, employment, health, and environment.

These components—exposure, sensitivity, and adaptive capacity—taken together create the CVI. Subindex maps are presented and described below. Maps of each individual indicator are available at the tool (see link in the side bar).

Table IV-1. Thurston County Climate Vulnerability Index

Sub-Category		Indicator
EXPOSURE		
Extreme Heat	(+)	Change in Days with Maximum Humidex Above 90° F, RCP 8.5, 2040-2069 vs 1980-2009
	(+)	Land Surface Temperature – Urban Heat Islands
Extreme Precipitation, Flooding, and Sea Level Rise	(+)	100- and 500-yr Floodplains
	(+)	Extreme Precipitation - Percent Change in Magnitude of 2-year Storm, RCP 8.5, 2040-2069 vs 1980-2009
	(+)	Historically Flood-Prone Areas
	(+)	Sea Level Rise – ~5ft of inundation (2 ft of sea level rise plus 3.1 ft storm surge)
Fire Risk/ Smoke/ Air Quality	(+)	Wildfire Danger - Change in the number of days per year, relative to 1971 - 2000, with high fire potential based on dry fuels, fuel moisture below the 20th percentile.
	(+)	Wildland Urban Interface
	(+)	Ozone Concentration

Sub-Category		Indicator
	(+)	Air Quality (PM2.5)
SENSITIVITY		
Age	(+)	Under 5 years old
	(+)	Over 65 years old
Environment	(+)	Steep Slopes/Geologic Hazards
	(+)	Poor Stream/Waterbody Health – 303d list for bacteria, dissolved oxygen, and temperature
Health Conditions	(+)	Diabetes – crude rate in population >= age 18
	(+)	Asthma – crude rate in population >= age 18
	(+)	Respiratory Disease - COPD – crude rate in population >= age 18
	(+)	Coronary Heart Disease – crude rate in population >= age 18
	(+)	Poor Physical Health – crude rate in population >= age 18
	(+)	Poor Mental Health – crude rate in population >= age 18
ADAPTIVE CAPACITY		
Socioeconomic	(+)	People of Color
	(+)	Population Experiencing Poverty
	(+)	Low Educational Attainment – less than high school degree
	(+)	Linguistic Isolation – households with limited English speaking at home
	(+)	Living Alone – households comprised of householder living alone
	(+)	Housing Cost Burden – renter households spending >30% of income on housing
	(+)	Access to Vehicle – households without access to a vehicle
Population and Housing	(+)	Housing Condition – houses built before 1960
	(+)	Housing Cost Burden
	(+)	Population Density
Employment and Insurance	(+)	Unemployment
	(+)	Outdoor Professions – jobs likely to be performed outside (NAICS codes 11, 21, and 23)
	(+)	Adult Population Without Health Insurance
Environment/ Ecologic	(+)	Tree Canopy
	(-)	Impervious Surface Coverage
	(+)	Access to Parks/Open Space
Transportation	(+)	Access to Frequent Transit

NOTES: A (+) means that a higher indicator value contributes to a higher index value, while a (-) means that a higher indicator value contributes to a lower index value.
COPD = chronic obstructive pulmonary disease.
NAICS = North American Industry Classification System

Exposure Sub-Index

The Exposure Sub-Index captures risk associated with exposure to extreme heat, extreme precipitation and flooding, and wildfire, smoke, and poor air quality conditions. As shown in the map below, areas of high exposure are located primarily in the northern, more urbanized portion of Thurston County along the I-5 corridor. Areas of Moderate, High, and Very High exposure are also present in the southern county, particularly near Grand Mound and Tenino. The northwestern and southeastern portions of the county mostly contain lower exposure areas.

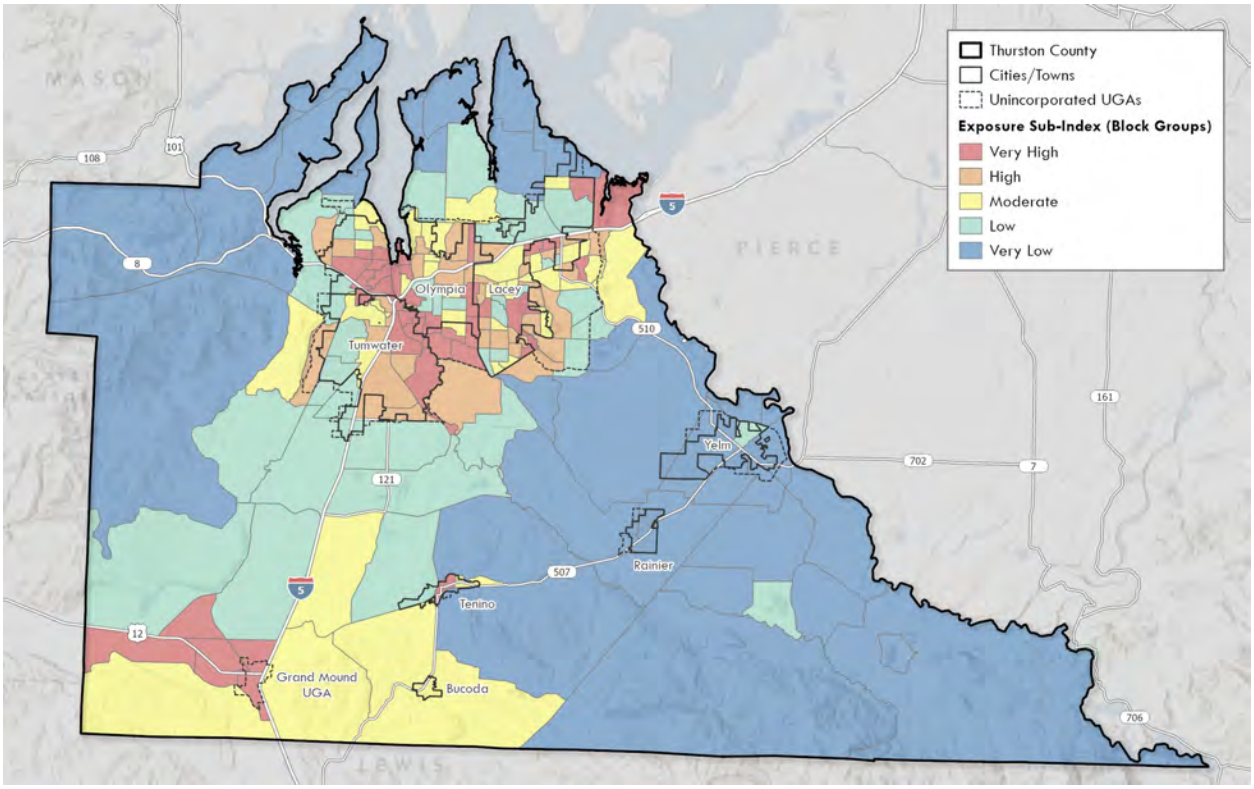


Figure IV-1. Exposure sub-index for Thurston County.

Sensitivity Sub-Index

The Sensitivity Sub-Index captures demographic, health-related, or environmental factors that make the population more or less sensitive to climate stressors. As shown in the map below, areas of high sensitivity are distributed across the county. The urbanized northern county includes a mix of high- and low-sensitivity areas, while the more rural southern portion of the county is generally rated as moderate to very high. The Nisqually subarea is also an area of very high sensitivity.

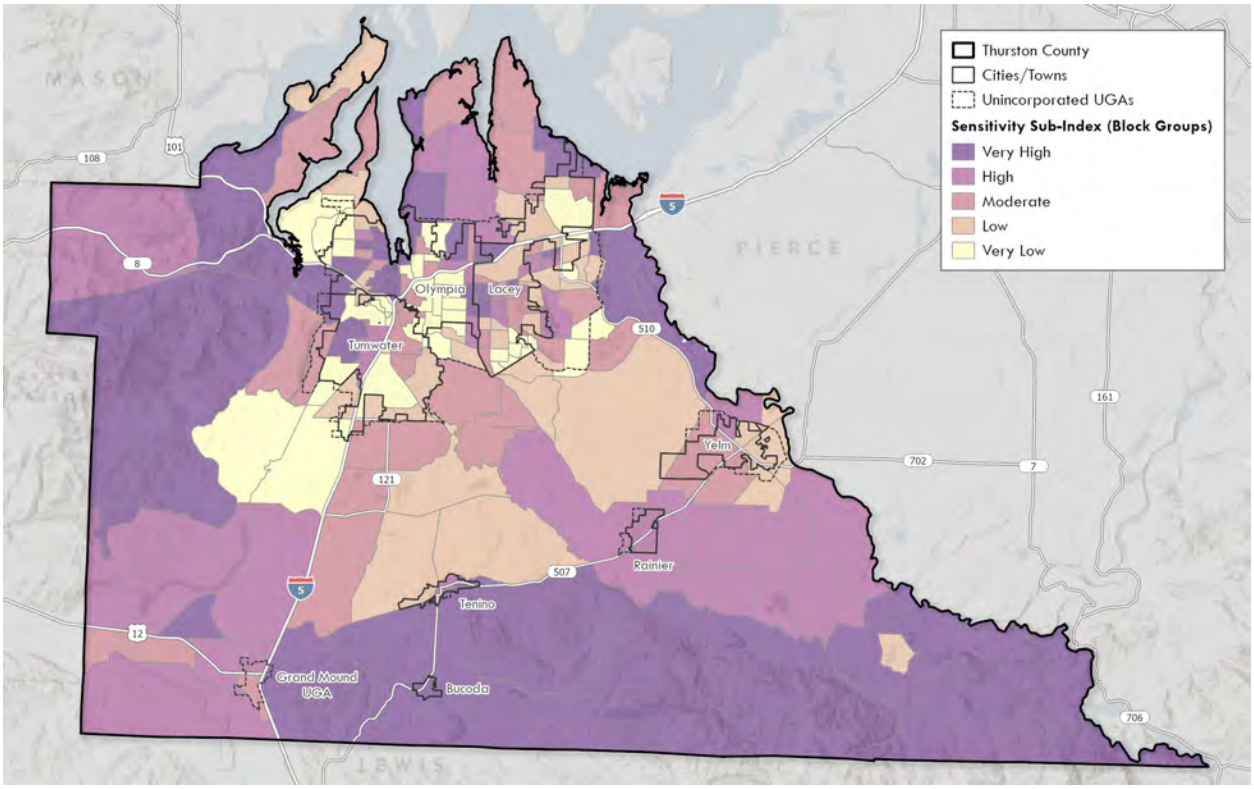


Figure IV-2. Sensitivity sub-index map for Thurston County.

Adaptive Capacity Sub-Index

The Adaptive Capacity Sub-Index reflects the ability of the local population to adapt to and cope with the effects of climate change. Areas of high adaptive capacity are mostly located in the northwestern and central portions of the county, though pockets of low and very low adaptive capacity are present in Olympia, Lacey, and the Nisqually reservation. The southern county generally possesses moderate to low adaptive capacity, particularly in Grand Mound, Bucoda, Tenino and Yelm.

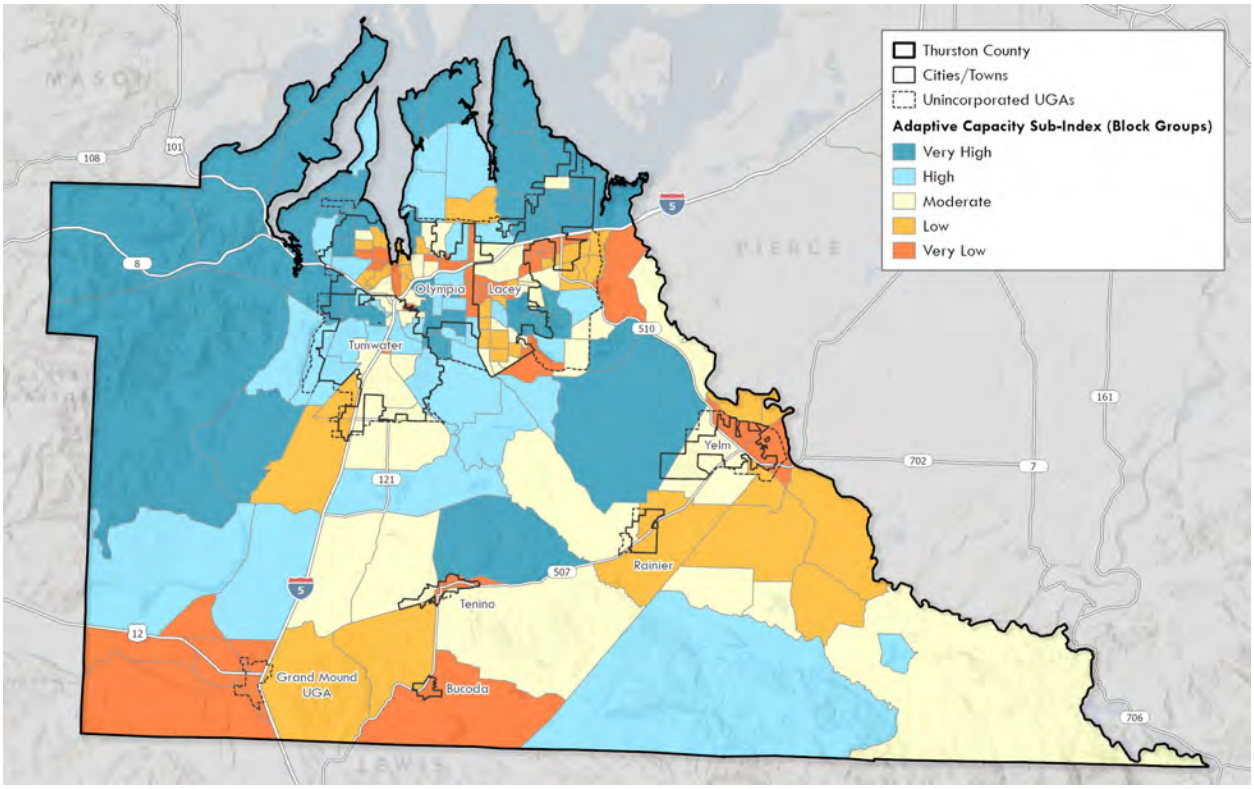


Figure IV-3. Adaptive capacity sub-index for Thurston County.

E. HUMAN WELLBEING AND PUBLIC SERVICES

As climate change continues to alter the frequency and intensity of extreme events and hazards, climate change will affect the health and wellbeing of communities across the county and stress the various public and social services that communities rely on. The burden of these impacts will be unevenly felt, with low-income communities, non-English speaking households, outdoor workers, rural and remote communities, older adults, and Tribal communities being more vulnerable to the public health impacts of climate change (Chang et al. 2023). Additionally, public services such as emergency response systems, and community spaces such as libraries, are both at risk from climate change yet can enable climate resiliency for the county.

This section focuses on different dimensions of human wellbeing and public services – specifically impacts and risks to public health, emergency management and social services, and community amenities.

PUBLIC HEALTH

Climate change can have profound and consequential effects on the health and wellbeing of people. The increased intensity and frequency of extreme events – such as heatwaves, large wildfires, extreme rainfall and flash flooding, and coastal flooding – can cause increased rates of injuries and deaths (Chang et al. 2023). Additionally, there is more evidence to establish the mental and psychological health impacts of these extreme events – causing increased rates of anxiety, post-traumatic stress disorder, and depression, among others (Hayden, et al., 2023).

Gradual changes such as warming temperatures and shifting precipitations can affect public health outcomes. For example, warmer temperatures are making allergy seasons longer and more intense (Anderegg, Abatzoglou, Anderegg, & Ziska, 2021) and increasing the rates of infectious diseases that the Northwest hasn't seen before (McVicar, Rivera, Reyes, & Gulia-Nuss, 2022). Climate change is also affecting the different types of amenities and services – such as parks and emergency response services – that allow people to be resilient to and recover from climate hazards and extreme events.

Physical Health

Climate change will affect physical health in multiple ways. The sections below document key climate vulnerabilities to physical health.

Extreme Heat

Heat is one of the deadliest climate hazards, killing more people than any other natural hazard (NOAA National Weather Service, 2023). As an example, the June 2021 heat dome event saw almost 1,500 deaths reported across the Pacific Northwest and at least six confirmed heat-related deaths during that period in Thurston County. The number of deaths and negative health outcomes are almost certainly an undercount of the true public health impacts, as these accounts may not account for indirect deaths (e.g., heatwave triggers a heart attack) and may undercount certain demographic groups (e.g., people who do not primarily speak English or people without insurance) (Casey, Parks, Bruckner, Gemmill, & Catalano, 2023).

Some groups will be more sensitive and likely to experience heat-related illnesses and mortality. For example, outdoor laborers and people who are experiencing homeless will be more exposed to extreme heat. Older adults, young children, people who are pregnant, people with chronic medical conditions such as cardiovascular disease or diabetes, low-income households, and people who live in older housing stock or don't have air conditioning are more sensitive to extreme heat (Chang, et al., 2023).

In Thurston County, heat islands are more prominent in more developed and urban areas such as Lacey, Grand Mound, and Yelm. Despite the heat island effect being more pronounced in these areas, sensitive populations span across the entire county. For example, south Thurston County has more outdoor workers around Yelm, Tenino, and Grand Mound and in the north in the Nisqually area and along marine shorelines, who are more exposed to the impacts of heat, and more people who experience poor physical health due to chronic medical conditions, who are more sensitive to the impacts of extreme heat (Figure IV-4Figure -7). Furthermore, in urban areas such as Tumwater and Lacey, there is a correlation between where communities of color reside and the heat island effect.

Warming temperatures are also associated with harmful algal blooms (HABs). HABs can increase toxins in the water or shellfish, which can cause skin irritation and illnesses such as paralytic shellfish poisoning.

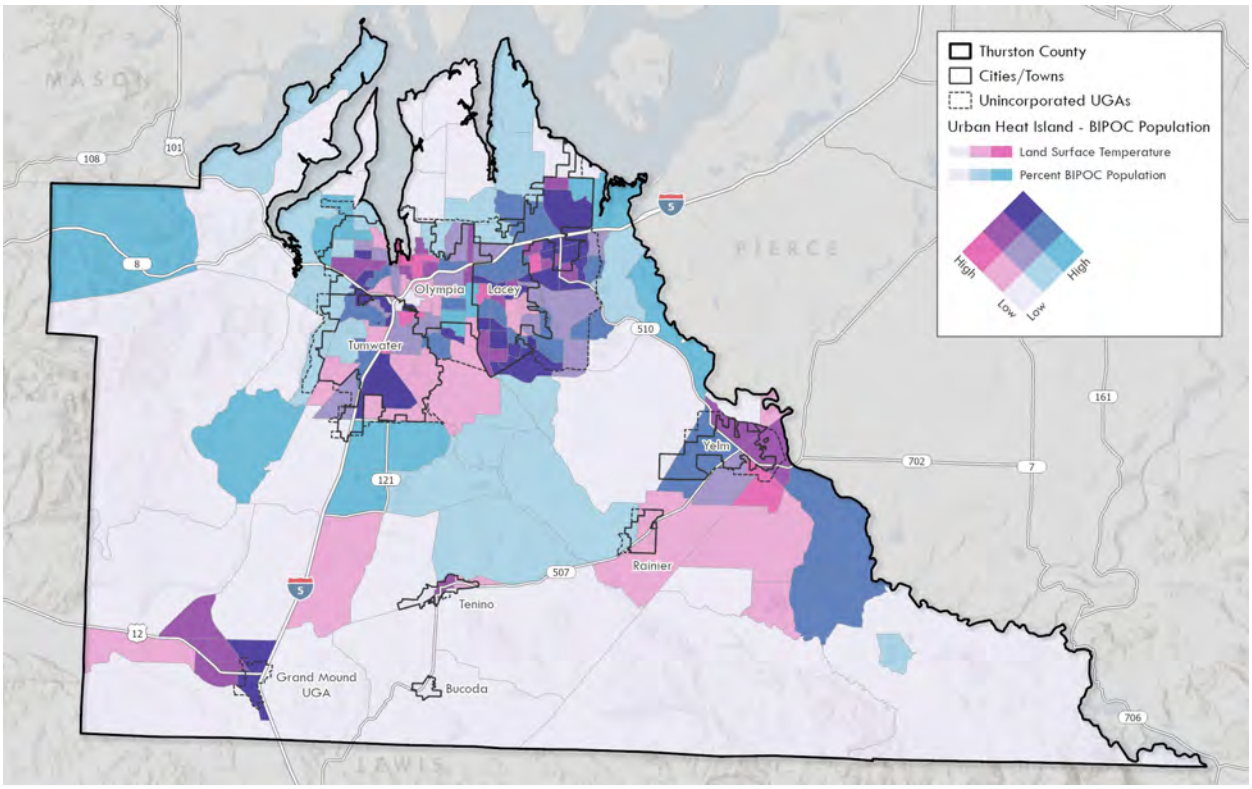


Figure IV-4. Bivariate map of heat island effect and BIPOC population.

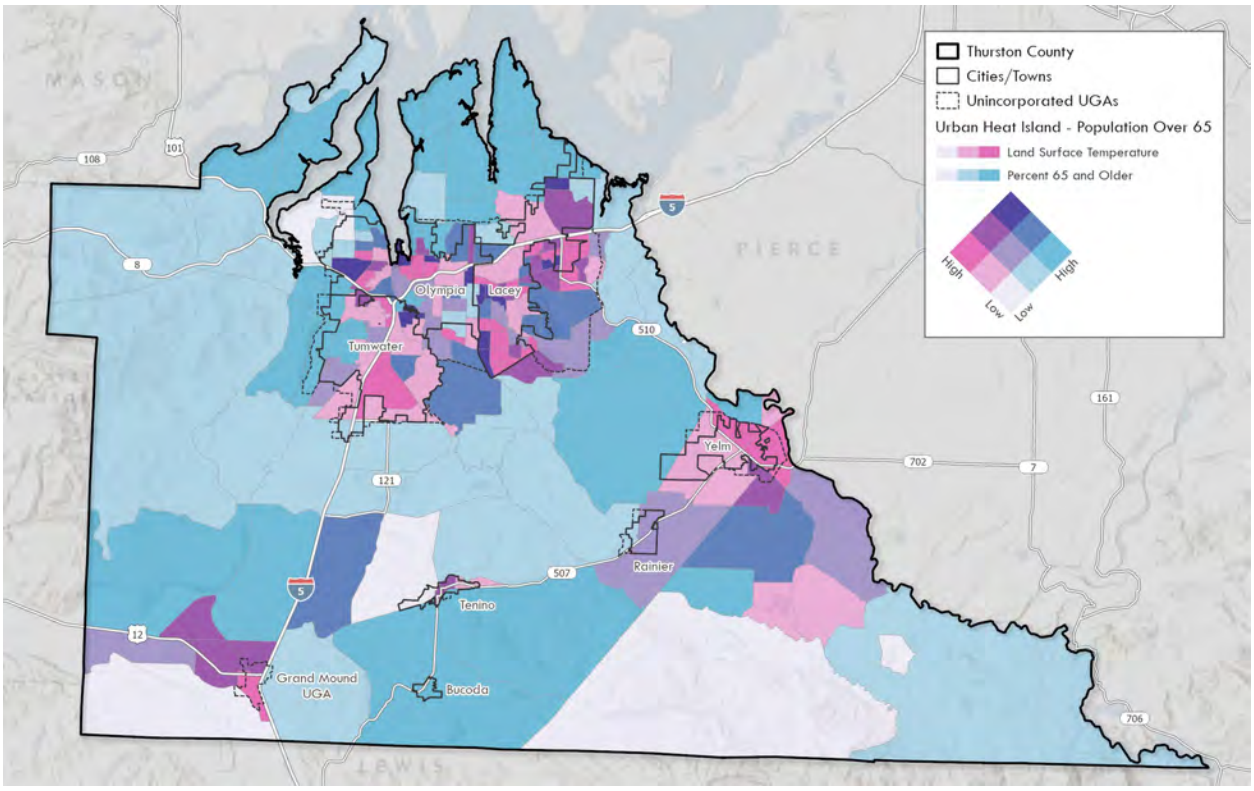


Figure IV-5. Bivariate map of heat island effect and older adults.

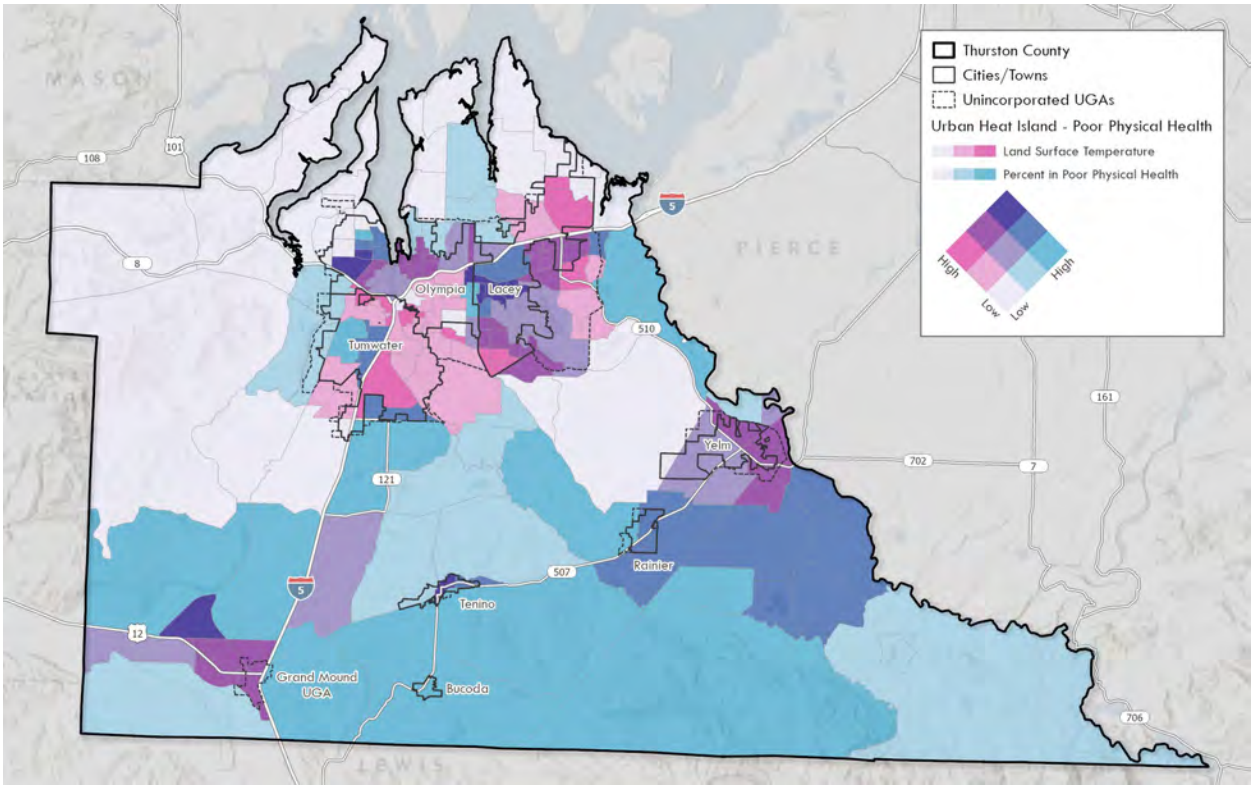


Figure IV-6. Bivariate map of heat island effect and people with poor physical health.

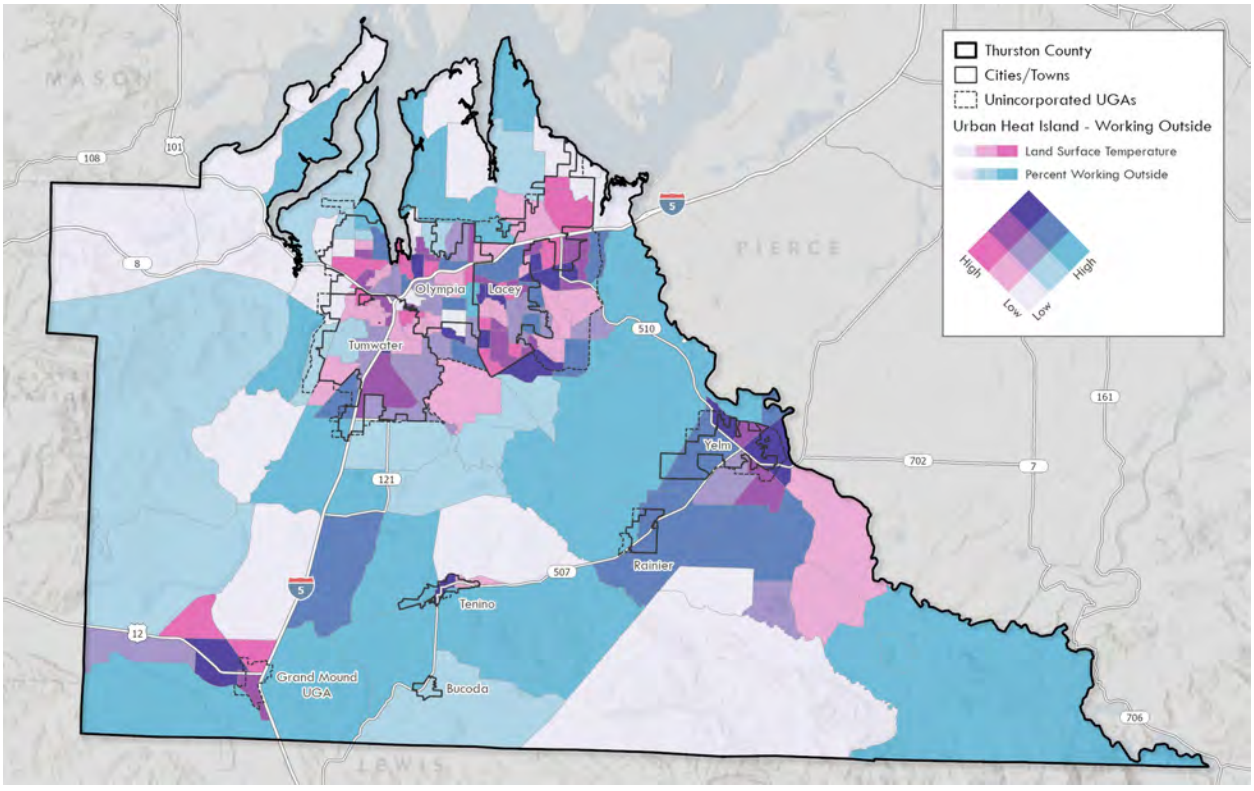


Figure IV-7. Bivariate map of heat island effect and people working outside.

Air Quality

Decreased air quality can be driven by a variety of factors, including warming temperatures, heatwaves, drought, and wildfire smoke events, affecting short-term and long-term air quality. Climate change can affect air quality and physical health impacts in a variety of ways – such as extended pollen seasons, acute extreme events such as wildfire smoke events, poorer air quality from drought conditions, or increased levels of ground-level ozone during heatwaves.

Pollen Seasons and Allergies

Pollen seasons in western Washington typically start in early March and persist through the spring and summer months and can trigger seasonal allergies for communities across the region (Figure IV-8). For example, in the Seattle area, pollen seasons are dominated by *Cupressaceae* (e.g., Douglas firs, cedar) and *Alnus* (e.g., alders) taxa (Lo, Bitz, Battisti, & Hess, 2019). Pollen seasons are expected to start earlier in the year – with the Puget Sound region expecting to see pollen seasons starting 20-30 days earlier – and are expected to extend to the late summer and fall months (Anderegg, Abatzoglou, Anderegg, & Ziska, 2021). Additionally, overlapping pollen seasons can make allergy impacts more intense.

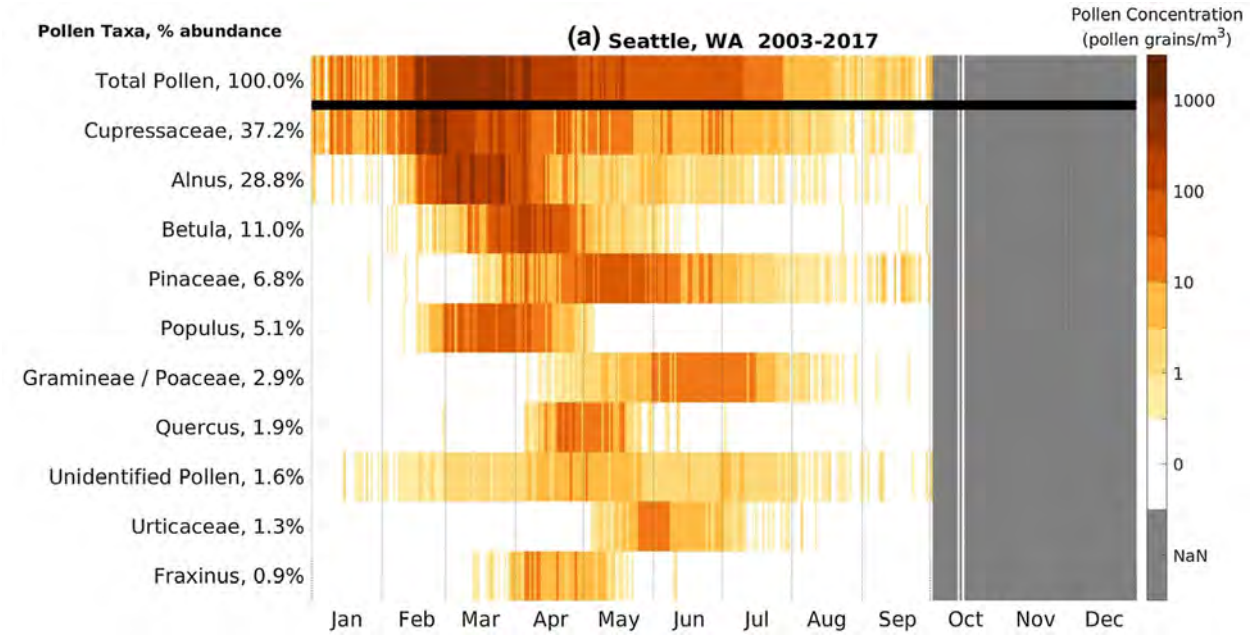


Figure IV-8. Pollen calendar for Seattle, WA.

Daily long-term mean of pollen concentration (pollen grains/m^3) by pollen taxa, 2003–2017. Missing data are shaded gray and denoted NaN in the color bar. Figure from Lo et al. 2019.

Drought

Droughts are periods of time when a region experiences below-normal precipitation and are responsible for the second-highest number of climate-related deaths across the U.S. (Hayden, et al., 2023). Drought conditions are associated with poorer air quality and decreased water quantity and quality, which can result in a variety of adverse health outcomes such as increased cardiovascular or pulmonary diseases (Stanke, Kerac, Prudhomme, Medlock, & Murray, 2013). In 2024, WA Department of Ecology declared a drought emergency for most of the State, including Thurston County, due to low winter snowpack (Department of Ecology State of Washington, 2024). Additionally, most of the State – including almost 60% of Thurston County, primarily concentrated in southwestern parts of the county – has experienced some level of long-term drought over the

past five years (a) (NIDIS, 2024). As droughts are expected to become more prolonged and severe, areas in the southeastern parts of the county are expected to have poorer air quality due to drought conditions (Figure IV-9b-d). People with chronic respiratory illnesses, such as COPD, or cardiovascular disease are more sensitive to the impacts of drought and decreased air quality. Areas in south Thurston County, which are projected to experience more ground level ozone, overlaps with areas experiencing long-term drought.

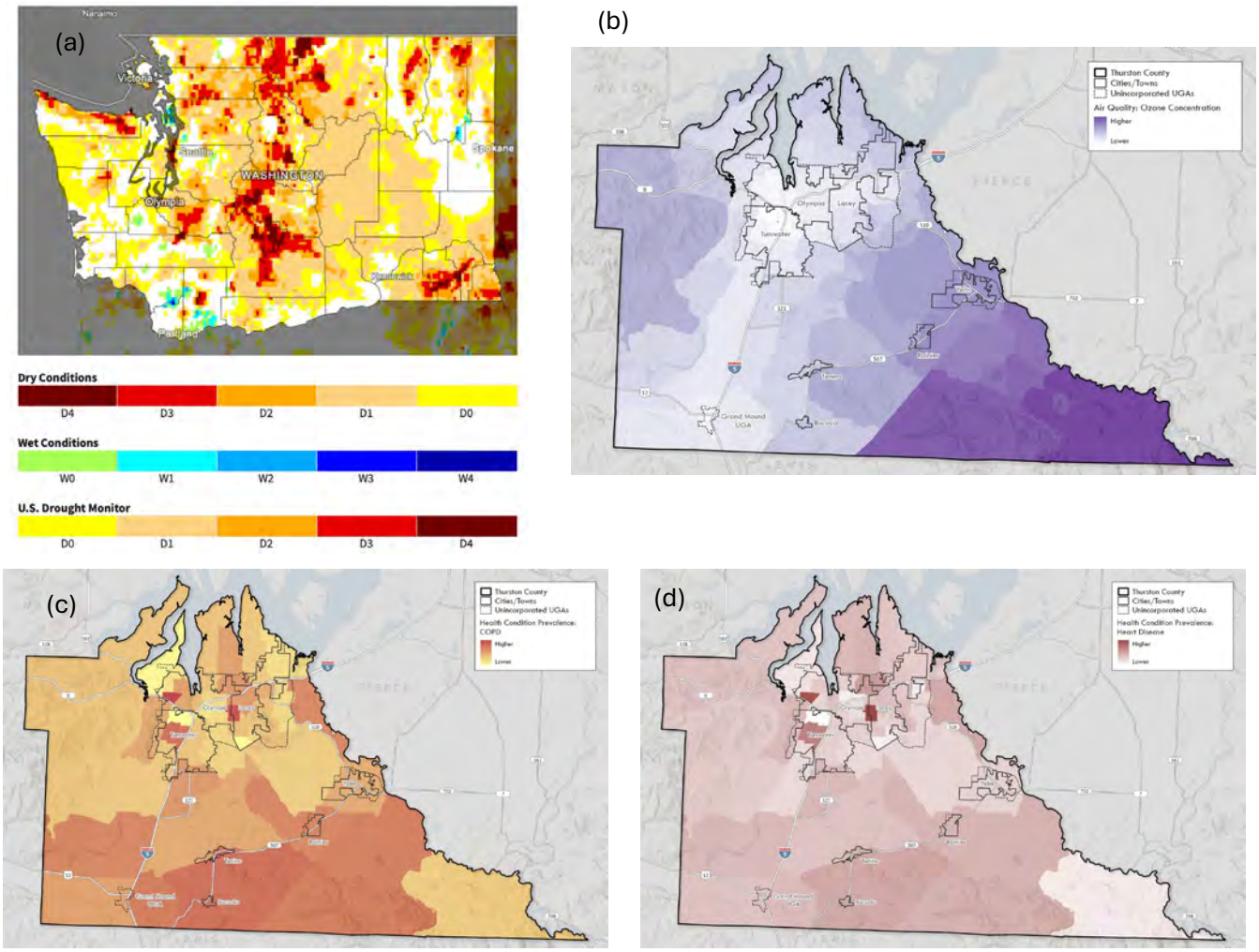


Figure IV-9. Drought Conditions in WA and Associate Impacts in Thurston County.

Figure illustrates the following: (a) drought categories associated with dry/wet conditions from National Integrated Drought Information System (NIDIS), accessed August 13, 2024; (b) ozone concentrations in Thurston County, which is associated with drought conditions; (c) rates of COPD across Thurston County, which makes an individual more sensitive to poorer air quality due to drought; (d) rates of heart disease across Thurston County, which makes an individual more sensitive to poorer air quality due to drought. Maps created by BERK Consulting.

Wildfire Smoke

Wildfire smoke events have already become an annual occurrence in western Washington, and wildfire smoke days are expected to increase as wildfire seasons continue to intensify (Chang, et al., 2023). People with asthma are expected to bear a disproportionate burden of smoke events, as Thurston County is expected to have an additional 40-60 excess asthma events per 10,000 people by 2050 (Figure IV-10) (Stowell, et al., 2021). There are higher rates of asthma in south Thurston County and in some urban areas, suggesting that these communities will be more sensitive to the impacts of more frequent and severe wildfire smoke events (Figure IV-11).

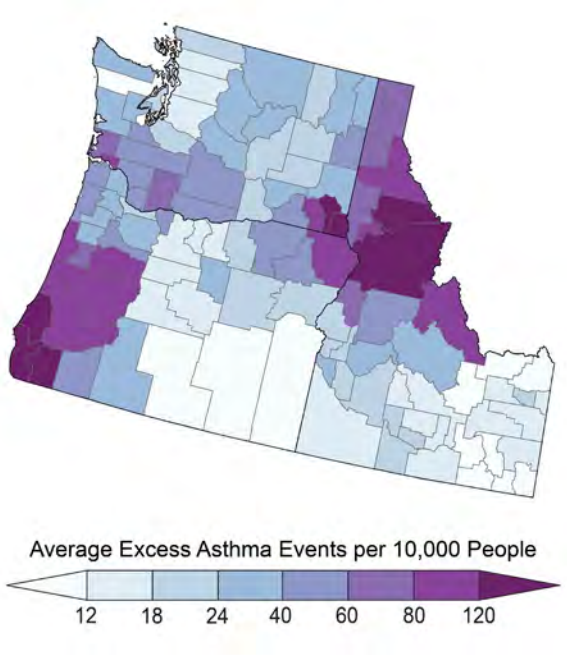


Figure IV-10. Projected Asthma Burden per Wildfire Season by 2050.

Excess asthma incidences related to wildfire smoke per 10,000 people per wildfire season by the 2050s under RCP 8.5. Figure from Chang et al. 2023, adapted from Stowell et al. 2022.

Additionally, residents who live in housing structures in poor condition – such as houses with old building envelopes – will be more susceptible to wildfire smoke impacts because housing structures will be less insulated and more permeable, allowing greater concentrations of ambient PM2.5 from smoke to infiltrate and reduce indoor air quality (Figure IV-11). People who live in trailer parks or people without shelter will also be more exposed to wildfire smoke events.

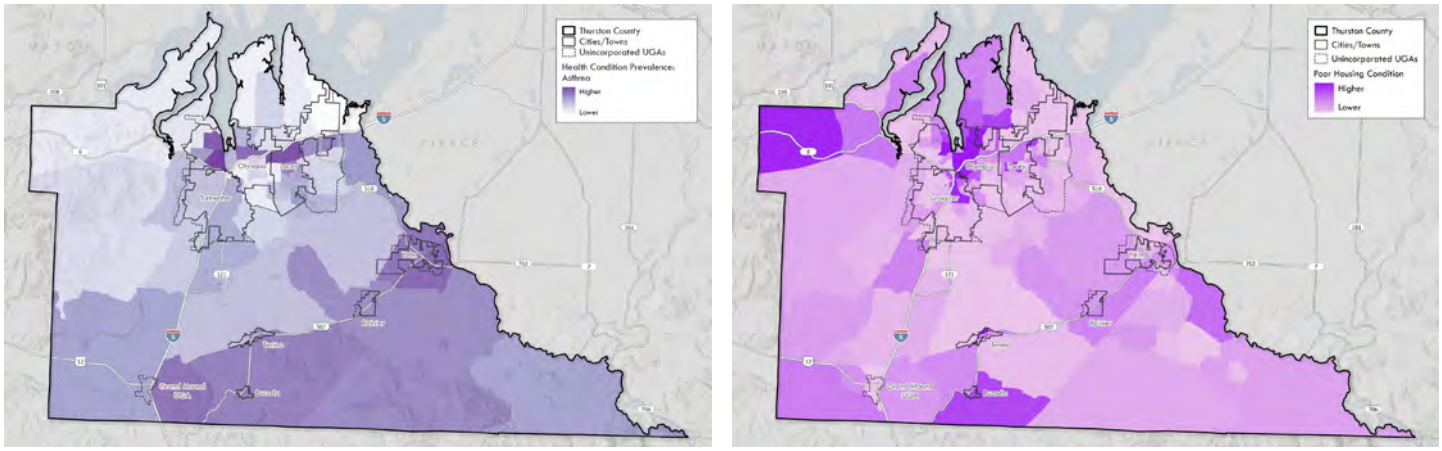


Figure IV-11. Asthma Prevalence and Housing Conditions can Increase Sensitivity to Wildfire Smoke Impacts.

Infectious Diseases

The distribution and prevalence of infectious diseases are expected to change in the Puget Sound area. For example, habitat suitability for some infectious disease vectors and hosts – such as ticks and mosquitos – are expected to expand northward, potentially increasing the prevalence of vector-borne diseases such as West Nile virus and Lyme disease (May, et al., 2018; McVicar, Rivera, Reyes, & Gulia-Nuss, 2022; USEPA, 2021).

The Puget Sound region may see some new types of infectious diseases. For example, Valley fever, a fungal disease endemic to the southwestern parts of the U.S. that can cause flu-like symptoms and can result in death in extreme cases, is expected to spread into the Pacific Northwest by end-of-century due to climate change (Gorris, Treseder, Zender, & Randerson, 2019). Valley fever is found in the soil, and can be transferred via soil disturbance, construction, or wind events; thus, outdoor laborers – particularly farmworkers and construction workers – are more susceptible to infection.

Infectious diseases endemic to the Puget Sound region are also expected to increase in incidence. For example, extreme precipitation and flooding can increase the risk of water-borne illnesses such as shigellosis and giardia, disproportionately affecting people without stable housing. Extreme heat events are also associated with outbreaks of salmonella and E. coli as well (May, et al., 2018).

Maternal Health

There is emerging evidence on maternal health impacts from climate change. For example, exposure to extreme heat and wildfire smoke is associated with lower birth weight, premature births, and miscarriages (APA, 2017; Clayton Whitmore-Williams, Manning, Krygsman, & Speiser, 2017; Pacheco, 2020).

Other Physical Health Vulnerabilities

In addition to the physical health impacts described above, there is evidence, both established and emerging, for many other types of negative impacts due to climate change. Different types of occupations may lead to different vulnerabilities to key hazards – for example outdoor workers will be more exposed to impacts of heat and smoke, whereas restaurant workers may be more sensitive to the impacts of heat and indoor air quality if their restaurant has limited ventilation capabilities. There is also emerging evidence of the long-term health implications from repeated exposure to events like wildfire smoke, which may increase the risk for health conditions such as certain types of cancers (Korsiak, et al., 2022).

Mental and Behavioral Health

There is an increasing amount of evidence that links adverse mental health outcomes with climate change (Thompson, Hornigold, Page, & Waite, 2018). Many extreme events – such as extreme heatwaves, wildfires, or flash flood events – have documented cases of post-traumatic stress and anxiety following the event (Cianconi, Betro, & Janiri, 2020; Jones, Ribbe, Cunningham, & Weddle, 2003). For example, there are documented increases in anxiety and stress in British Columbia and Oregon following the 2021 heat dome event in the Pacific Northwest (Bratu, et al., 2022; Washington County, Multnomah County, & Clackamas County, 2023). In extreme cases, some residents can lose their homes to extreme events or be forced to temporarily or permanently relocate, leading to stress, anxiety, and depression (Hayden, et al., 2023).

Additionally, chronic climate-related stresses may exacerbate existing mental health conditions. Chronic droughts associated with climate change may worsen food insecurity or disrupt agricultural livelihoods, increasing psychological distress and economic anxiety for some households (Vins et al. 2015). Many rural communities in south Thurston County already experience poorer mental health , and may be more susceptible to certain additional mental health challenges (Figure IV-12). Residents who use outdoor recreation to de-stress and relax may face additional mental health challenges if access is inhibited due to impacts such as heatwaves, flooding, and wildfire smoke (Chang, et al., 2023). Communities with strong ties to the land – such as Indigenous communities or multi-generational families – may face additional mental health impacts as landscapes and waterways continue to transform due to climate change.

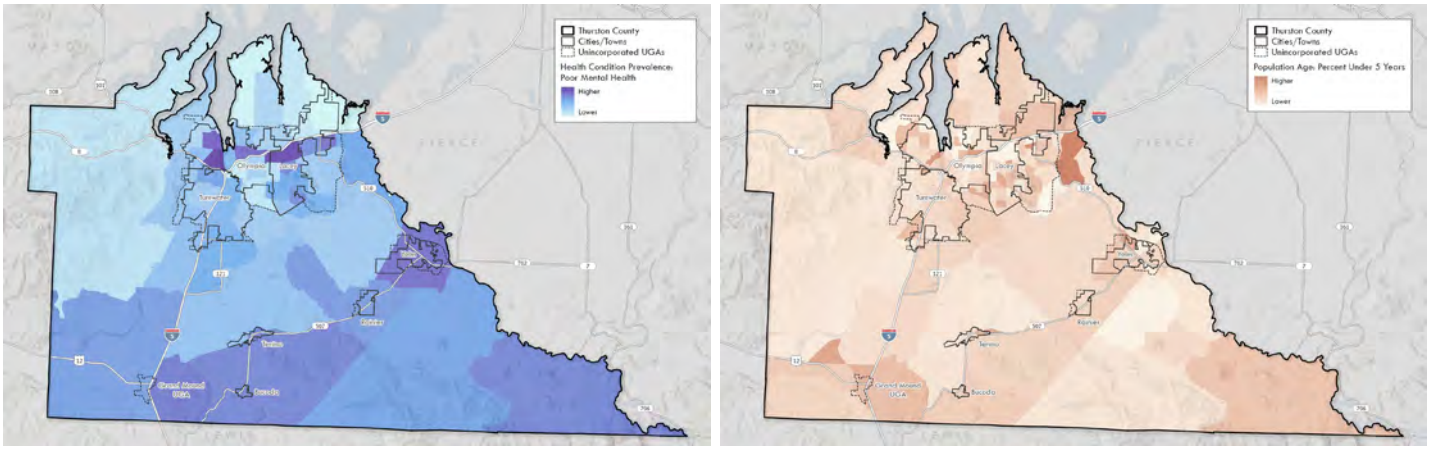


Figure IV-12. People with poor mental health and youth are more susceptible to harmful mental health impacts due to climate change.

Youth may also be more susceptible to mental health impacts from climate change. Climate change has been shown to affect the physiological, mental, and emotional development of children in multiple ways. For example, living through an extreme event can cause post-traumatic stress in children, which can compound and lead to other types of mental health conditions. Extreme heat can also inhibit cognitive development and learning capacity, affecting children who already have learning or development disabilities. Current generations of youths are being exposed to more news stories about climate change than other generations, increasing climate-related anxiety and despair (Clayton et al. 2017). Demographic data in 2022 estimate that there are almost 70,000 residents in Thurston County that are 19 years or younger – almost a quarter of the county's population (U.S. Census Bureau, Thurston County, Washington, 2024).

There is a rising amount of evidence that associates some climate impacts with various behavioral health challenges. For example, there is a rising amount of evidence that defines the associations between extreme heat and domestic violence, although there is uncertainty in the epidemiological drivers and causal pathways between these two events (Caridade, Vidal, & Dinis, 2021; Thompson, Hornigold, Page, & Waite, 2018). Furthermore, extreme heat is associated with increased incidences of suicide or self-harm (Burke, et al., 2018; Thompson, Hornigold, Page, & Waite, 2018), with Thurston County expecting an increase of 0.25-0.50 excess suicides per 100,000 people with each degree of warming (Belova, et al., 2022).

MEDICAL CARE, EMERGENCY SERVICES, AND COMMUNITY AMENITIES

Some public services and amenities—such as medical services and healthcare facilities, libraries, community centers, parks and open spaces—are at risk of being damaged, disrupted or destroyed

by climate change impacts. For example, flooding, landslides, or wildfires can cut off road access, which would particularly affect remote communities in south Thurston County or on Steamboat Peninsula that drive to purchase food, medical care, and to receive other social services.

These same services can also enable adaptation and resilience to climate hazards. For example, public spaces can build community resilience, as they can be cooling centers during heat waves; provide internet access, shelter, and a convening point during natural disasters; and strengthen social connections, which facilitate mutual aid networks.

This section discusses how climate change will affect medical care, emergency services, and other community amenities across Thurston County.

Critical Facilities

Critical facilities – such as hospitals, clinics, police and fire stations – are important assets to ensure quick responses and emergency services for communities across the county. They can play important roles during emergencies, such as providing medical care, coordinating resources, and supporting crisis response (Thurston County, 2017). These same facilities may also be affected by climate change, potentially inhibiting their services and operations. Figure IV-13 shows how various critical assets will be exposed to different climate impacts and hazards.

However, different hazards will affect facilities differently. For example, areas in Grand Mound will experience more extreme heat days relative to the rest of the county, potentially increasing the risk of energy disruptions through brownouts or energy shortfalls for emergency facilities in the area, affecting capacity to provide emergency services and medical care during heatwaves. Some critical facilities near the flood zone – such as areas along the Nisqually River or in low-lying areas of Tumwater and Olympia – may experience access challenges, as some routes may be partially or fully inundated during extreme precipitation events.

Critical facilities that are older will be more susceptible to the impacts of climate change. Building lifespans are typically 50-75 years, though can be extended with routine maintenance (Bathurst, 2023). Older buildings experience typical wear-and-tear that may make them more sensitive to damage during extreme events, such as extreme rain or flooding events. Older buildings are also typically less energy efficient, which may make them more susceptible to power shortages or outages during heatwaves. While critical assets are routinely assessed by the county's Office of the Assessor, some of these critical facilities are aging. For example, the fire station in Tenino was built in 1974 (Thurston County Assessor, n.d.) – or 50 years old – and thus may be more sensitive to some climate impacts.

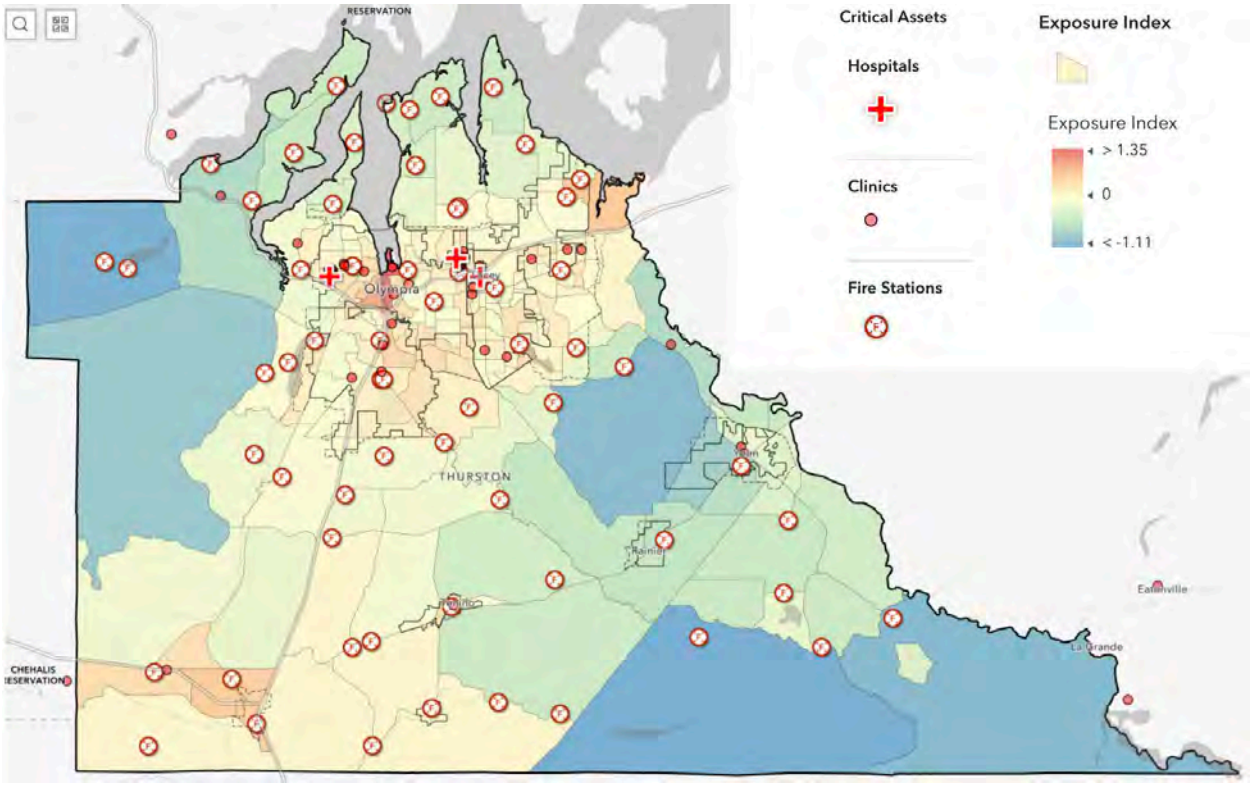


Figure IV-13. Critical assets across the county are exposed to a variety of climate impacts.

Social Services and Community Amenities

Social services and social safety nets – which include a range of public programs that cover a range of topics that support health and well-being such as food access, education, family care, and medical care – can enable resilience to climate change, especially for frontline communities such as remote households, low-income households, and communities of color (Marino, et al., 2023). Community amenities can enable positive health and wellbeing outcomes and strengthen resilience. For example, being close to parks and green spaces can enable positive mental, physical, and behavioral health outcomes in sensitive populations such as youth or socially-isolated individuals, potentially mediating other harmful health impacts of climate change (Hazlehurst, 2021; Pasanen, et al., 2023). Similarly, living closer to grocery stores can facilitate healthier diets.

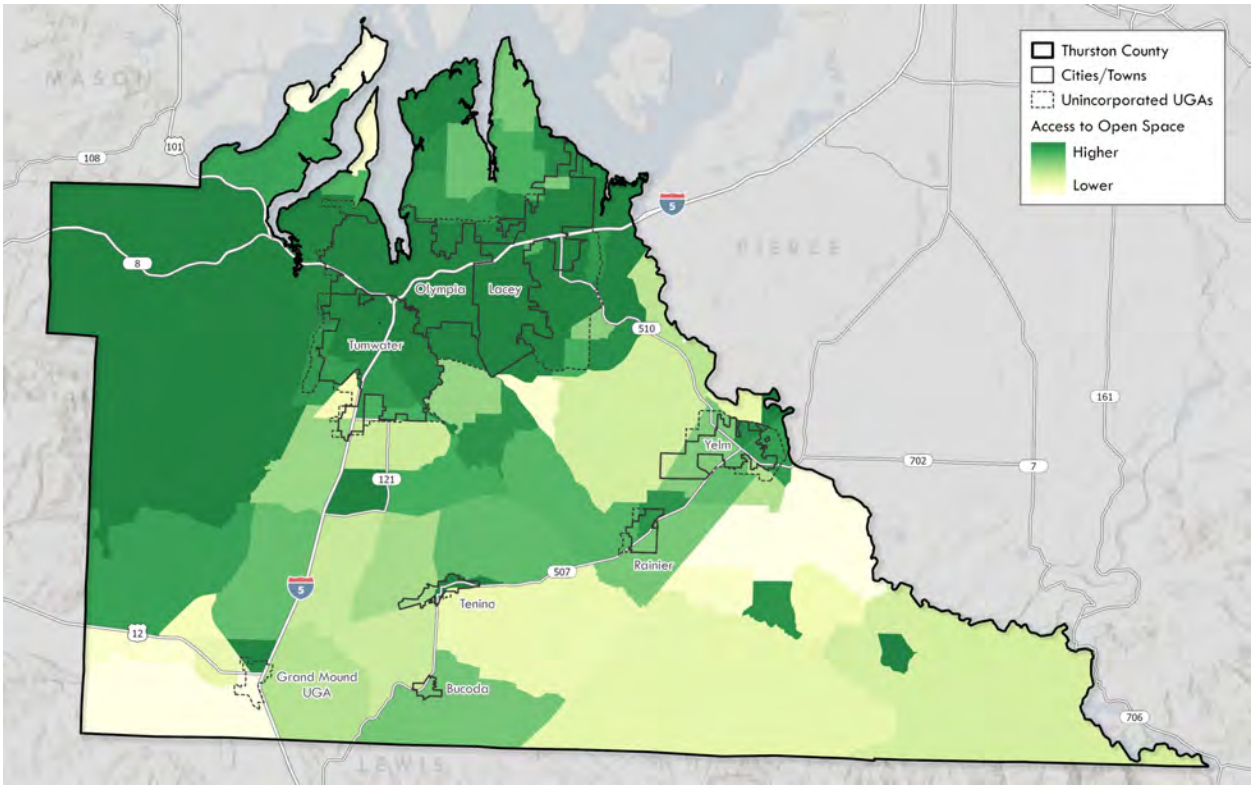


Figure IV-14. Proximity to open space is associated with positive mental health outcomes, making them less susceptible to mental health challenges due to climate change.

In some cases, these programs and services can be critical components of countywide responses to extreme events. For example, during the heatwave from July 5-9, 2024, where temperatures in Olympia exceeded 100°F (NOAA National Weather Service, 2022), the county repurposed six libraries and two senior centers to serve as daytime cooling centers to provide respite for community members (Thurston County Washington, 2024).

Health insurance can be an important indicator of sensitivity to health impacts from climate change. People living with chronic illnesses can be more sensitive to certain climate hazards, such as wildfire smoke or extreme heat events. Individuals with health insurance tend to have access to preventative care, which can reduce the risk of developing chronic illnesses. Additionally, health insurance coverage may make individuals more likely to call emergency services during extreme events. Approximately 4% of Thurston County residents do not have health insurance. However, insurance rates are not equally distributed across the county – with areas in south Thurston County having higher uninsurance rates, ranging from 8 to 12 percent. Additionally, residents in south Thurston County also rely on public health care options – such as Medicare and Medicaid – at relatively higher rates (U.S. Census Bureau, Selected Characteristics of Health Insurance Coverage in the United States, 2020).

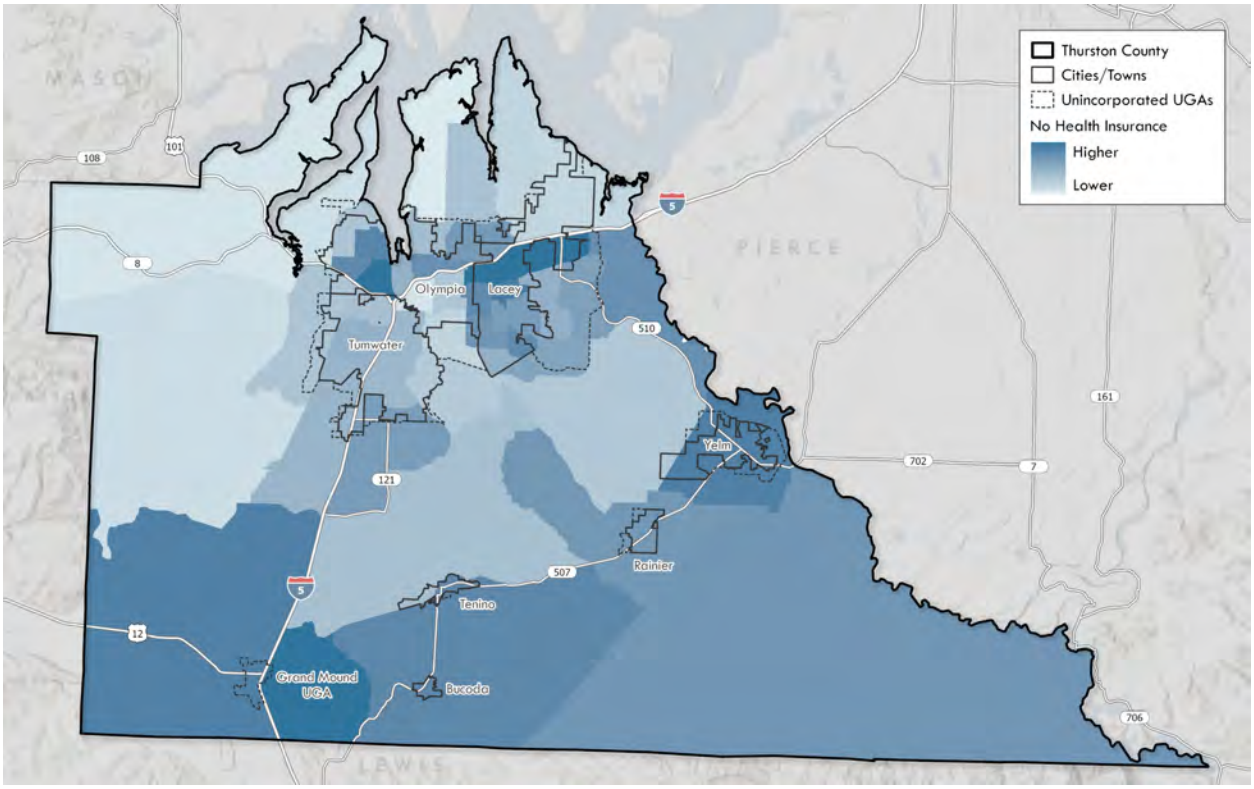


Figure IV-15. Lack of health insurance may make uninsured people more susceptible to health impacts due to climate change.

Evacuation Routes

Emergency and evacuation routes are critical during an extremely rare, but catastrophic, event. These can include climate-related hazards, such as wildfires and flash flooding, or non-climatic hazards such as earthquakes or tsunamis. As climate change contributes to more intense extreme events, more residents across Thurston County may become stranded and unable to access emergency services during and after an extreme event. Residents in remote areas, people without access to personal vehicles, and socially isolated individuals may be more susceptible to adverse health impacts. For example, climate change is affecting flood regimes – thus 100-year floods and 500-year floods are happening more frequently, potentially affecting the number of displaced individuals due to extreme flooding.

These flood events are expected to affect Thurston County residents. For instance, a less intense 50-year flood is expected to displace 143 residents in places such as Bucoda (Figure IV-16). Under a more intense flood event, such as a 500-year flood, over 400 residents across the county are expected to be displaced, potentially relying on evacuation protocols and emergency services.

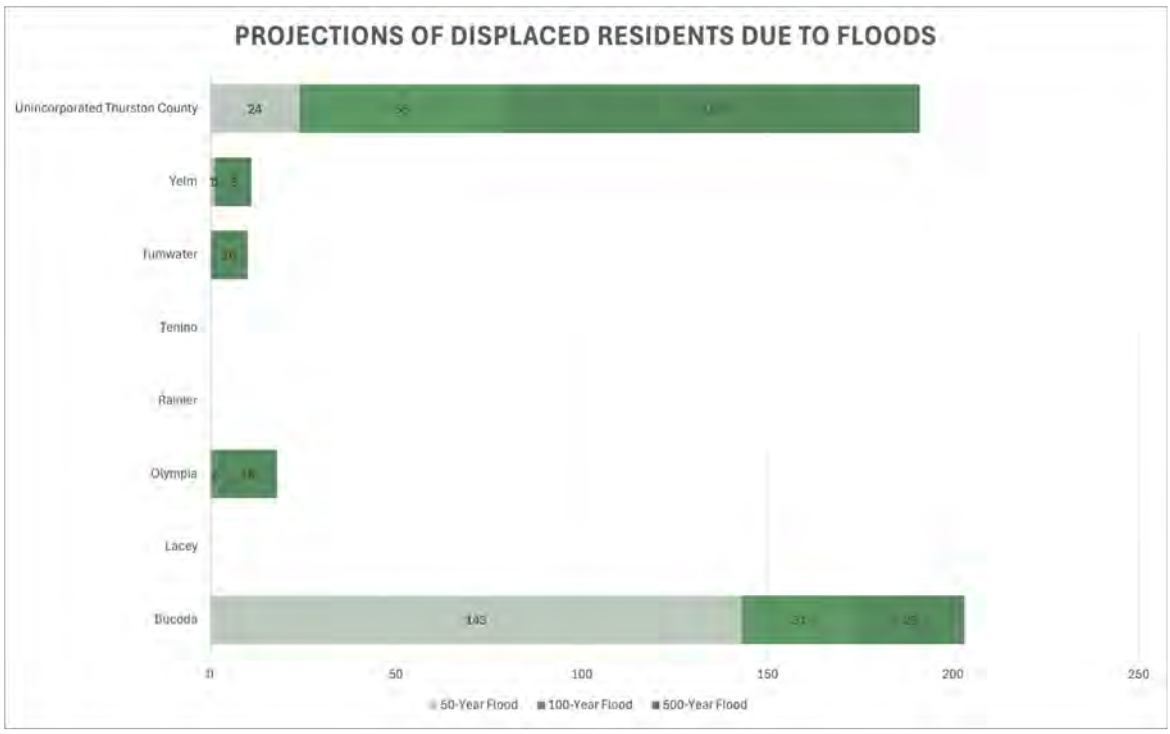


Figure IV-16. Projections of displaced residents due to flooding.

In Thurston County, there is a wide distribution of sensitive population groups. For example, there are households in urban and rural areas that do not have access to a vehicle, which can make it more difficult for households to evacuate and drive for food, medical services, or other supplies and services during an extreme event (Figure IV-17).

Many older adults that live alone may have less capacity to evacuate or respond during an extreme event due to challenges that range from limited mobility or limited understanding to accessing emergency communications across different technological platforms. Some remote communities – such as residents along Steamboat Peninsula – rely on a single road in and out, making them more susceptible to isolation if an extreme hazard damages or destroys transportation routes (Figure IV-18).

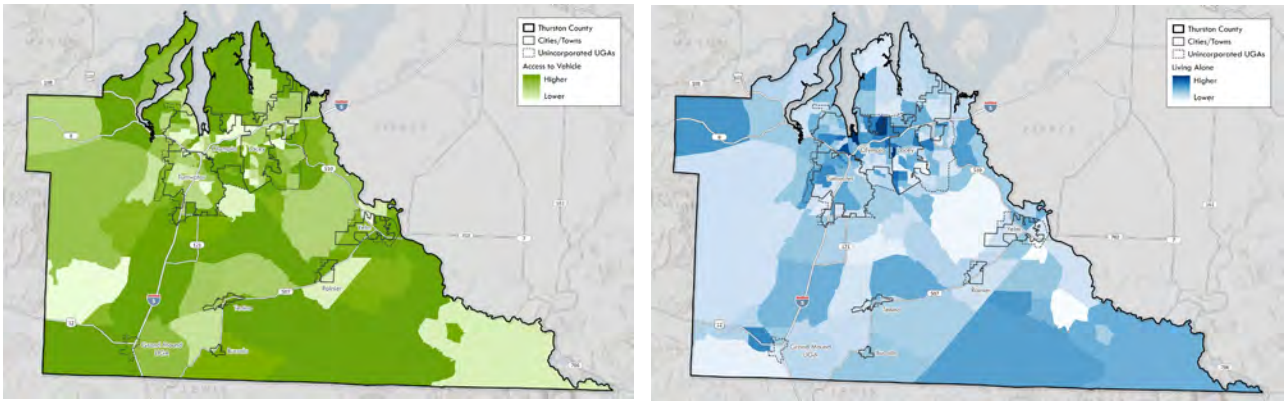


Figure IV-17. Living alone or not having a vehicle may make individuals more susceptible to health impacts from climate-related extreme events.

Figure IV-18. Steamboat Peninsula is a remote community with a single point of access, making them more susceptible to extreme events and flooding. Photo from Virgil Adams Real Estate.

F. ECOSYSTEMS & WATER RESOURCES

This section covers climate impacts on ecosystems, critical areas, water resources and infrastructure. As required by Washington State law[2], Thurston County recognizes[3] various categories of land, water, and hazard areas, protecting ecosystems and water resources that sustain human and non-human life. For example, marine vegetation such as eelgrass helps clean water, reduces the impact of waves on shorelines, sequesters carbon dioxide, and provides a nursery ground and refuge area for young salmon and other forage fish (Rubin, Hayes, & Grossman, 2018). The Nisqually Estuary, home of Thurston County's only significant eelgrass meadows, also provides critical habitats for birds migrating along the Pacific Flyway.

Climate change is expected to impact Thurston County's water resources and a wide range of ecosystems, including all critical areas.[4] High temperature records set in the Northwest from 2015 through 2021 were associated with many short-term or long-term ecological transformations, such as mortality or physiological damage to numerous native species of plants and animals, changes in

[2] RCW 36.70-Growth Management Act [GMA]

[3] All uses and activities on sites containing critical areas, associated buffers, or riparian/marine shoreline management zones are required to be located, designed and constructed to avoid or, where that is not possible, minimize all adverse impacts to those areas. The county does not authorize impacts to critical areas or buffers unless the applicant demonstrates an inability to avoid impacts and that there will be no net loss of critical area functions. Impacts to critical areas and associated buffers that cannot be avoided must be minimized by sensitive site design and appropriate precautions during the permitted activity.

[4] "Critical areas" means the following areas, as per RCW 36.70A: 1. Critical aquifer recharge areas; 2. Geologic hazard areas;3. Fish and wildlife habitat conservation areas;4. Flood and channel migration hazard areas; and 5.Wetlands. (Thurston County Code 24.03.010)

water availability, and wildfire dynamics (Chang et al., 2023). Shifts from snow and mixed-basins to rain-dominant basins will lead to higher streamflows in winter but lower flows in summer, reducing water availability for aquatic species and human use. More intense winter rainfall events will increase flood risks, particularly in low-lying areas, and increase stormwater runoff that can pollute and degrade water quality and damage habitat (Thurston Regional Planning Council, Vulnerability Assessment, 2016).

GEOLOGIC HAZARD AREAS

Thurston County regulates use and activities in three kinds of geologically hazardous areas: erosion hazards, landslide hazards including steep slopes (Figure IV-19), and marine bluff hazards (TCC 24.15.010 and 24.03). As an example, the Nisqually hillside overlay district, located on McAllister Bluff to the west of the Nisqually River, is characterized as a special landslide hazard area in Thurston County due to past unstable slope conditions.

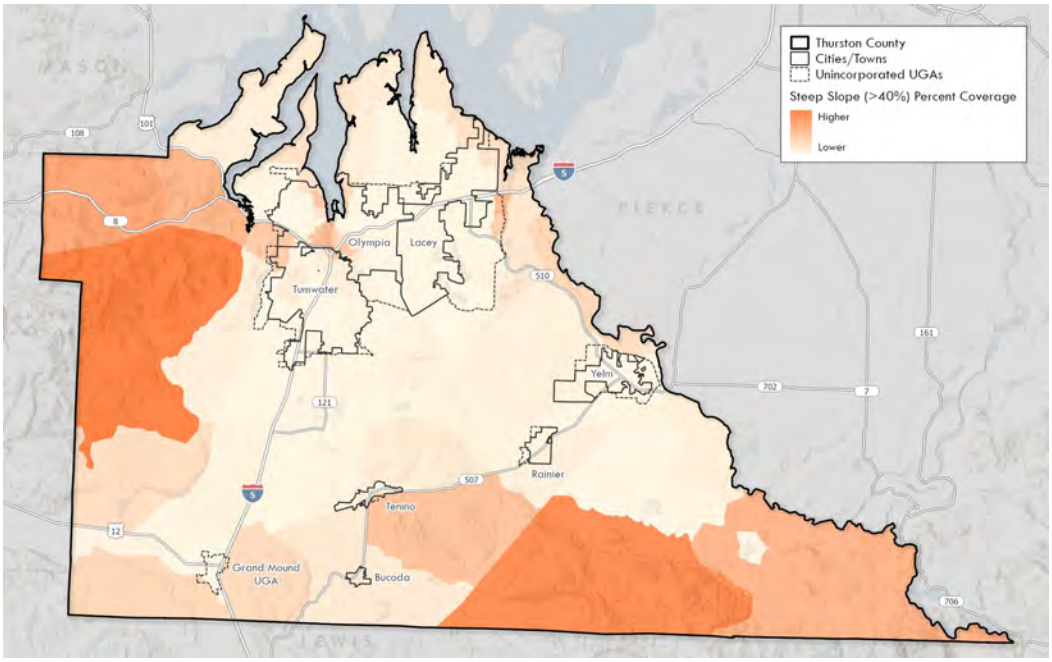


Figure IV-19. Steep slope areas in Thurston County.

In areas with steep slopes, heavy rainfall can trigger landslides and soil instability. This can not only cause property damage but also contribute to debris flows and blockages in rivers, exacerbating flooding downstream.

Additionally, wildfires can amplify landslide and mudslide risks. Wildfires can burn vegetation across a landscape, which can increase soil instability. There have been instances of heavy rainfall occurring after major wildfires, which can lead to major debris flows in the area (Chang, et al., 2023).

FISH AND WILDLIFE HABITAT CONSERVATION AREAS

Thurston County protects species that are federally-listed, state-listed, and/or are of local importance as well as their habitats. This includes riparian habitat areas (streams), marine riparian

habitat areas, ponds and lakes, wetlands, prairies, woodlands, forests, and shorelines due to their importance to fish and wildlife.

Endangered Species

Thurston County is home to several species listed as endangered or threatened under the federal Endangered Species Act (ESA) and/or by the Washington Fish and Wildlife Commission[5]. Listed fish species include:

- Bull Trout Dolly Varden (Threatened)
- Chinook Salmon (Threatened)
- Chum Salmon (Threatened)
- Coho Salmon (Threatened)
- Rainbow Trout/ Steelhead (Threatened)

The 2018 Thurston Climate Adaptation Plan which applied to the north and east part of the county (Kenney-Goldsborough, Deschutes, and Nisqually basins), noted several listed salmon species including Chinook and coho, spawn in streams and identified concerns about changes in streamflow and temperatures because of climate change (Thurston Regional Planning Council, 2018).

The primary basin in south Thurston County not included in the 2018 Climate Adaptation Plan is the Upper Chehalis Watershed, which is covered in the Chehalis Basin Strategy Aquatic Species Restoration Plan (2019). The Chehalis Watershed contains "Chinook, coho, and chum salmon, two species of anadromous trout - steelhead and coastal cutthroat trout, and many species of native fish, amphibians, freshwater mussels, birds, and semi-aquatic mammals (e.g. beaver)." The plan also notes the presence of critical habitat for bull trout, though little information is known about their presence and habitat use. Limiting factors in the watershed include water quantity, water quality, flooding, riparian conditions, fish passage, and sediment (Chehalis Basin Partnership, 2020).

Climate change trends are anticipated to include more frequent winter flooding, low-water and drought events, which will lead to higher water temperatures and loss of habitat. Between 2014 and 2019, low water levels affected the Chehalis River and junior water rights had water use curtailed in favor or senior water rights (Washington State Department of Ecology, n.d.). The Chehalis Basin Strategy involves an Aquatic Species Restoration Plan to "rebuild and protect a productive ecosystem that is able to bounce back in the face of climate change impacts" with about 80 projects in the basin between through 2022 including a number in Thurston County along the Black River, Skookumchuck River, and others (Washington State Department of Ecology, 2023).

The county's Habitat Conservation Plan (HCP)[6] which covers federal requirements as well as county requirements, addresses listed species and species under review associated with prairie habitats and wetlands. The Thurston County HCP covers the following species and subspecies:

- Mazama pocket gopher (threatened)
- Olympia pocket gopher (threatened)
- Tenino pocket gopher (threatened)

[5] Washington State has classified 36 species as endangered, four as threatened, and seven as sensitive, as of March 2024.

[6] The county's federal HCP permit jurisdiction covers all the unincorporated areas of Thurston County, which is generally rural areas, and the Urban Growth Areas of Olympia, Lacey & Tumwater which are under County permit jurisdiction. It does not include the cities of Lacey, Olympia or Tumwater, Tenino, Yelm or Bucoda.

- Yelm pocket gopher (threatened)
- Oregon spotted frog (threatened)
- Taylor's checkerspot butterfly (endangered)
- Oregon vesper sparrow (under review)

Some endangered species will be affected by climate change more than others. For example, Washington Department of Fish and Wildlife (WDFW) lists Taylor's checkerspot butterflies (TCB) as moderate-high in both sensitivity and exposure to climate change (Washington Department of Fish & Wildlife, 2024). Populations of TCB are variable, but they are sensitive to changes in increased temperature, increased frequency of extreme precipitation, and drought. Additionally, montane populations of TCB are affected by reduced snowpack and earlier snowmelt which creates highly exposed, novel conditions for overwintering larvae, increasing mortality and contributing to habitat degradation by hastening conifer encroachment in the butterfly's open, grassland habitat. Warmer temperatures influence butterfly behavior (e.g., mating, foraging, egg-laying time), adult life span, and larval development. Warming temperatures may also cause phenological mismatches between TCB and key plant species, causing low availability of nectar resources and pre-mature desiccation of larval forage, leading to reduced fitness or starvation of adults or larvae.

Coastal flooding driven by sea level rise, storm surges, and wave run-up can inundate or cause significant sediment alteration in low-lying coastal habitats of TCB, causing larval mortality and temporary or permanent habitat loss (Washington Department of Fish & Wildlife, n.d.). Extreme precipitation can wash away eggs and larvae and limit adult flight.

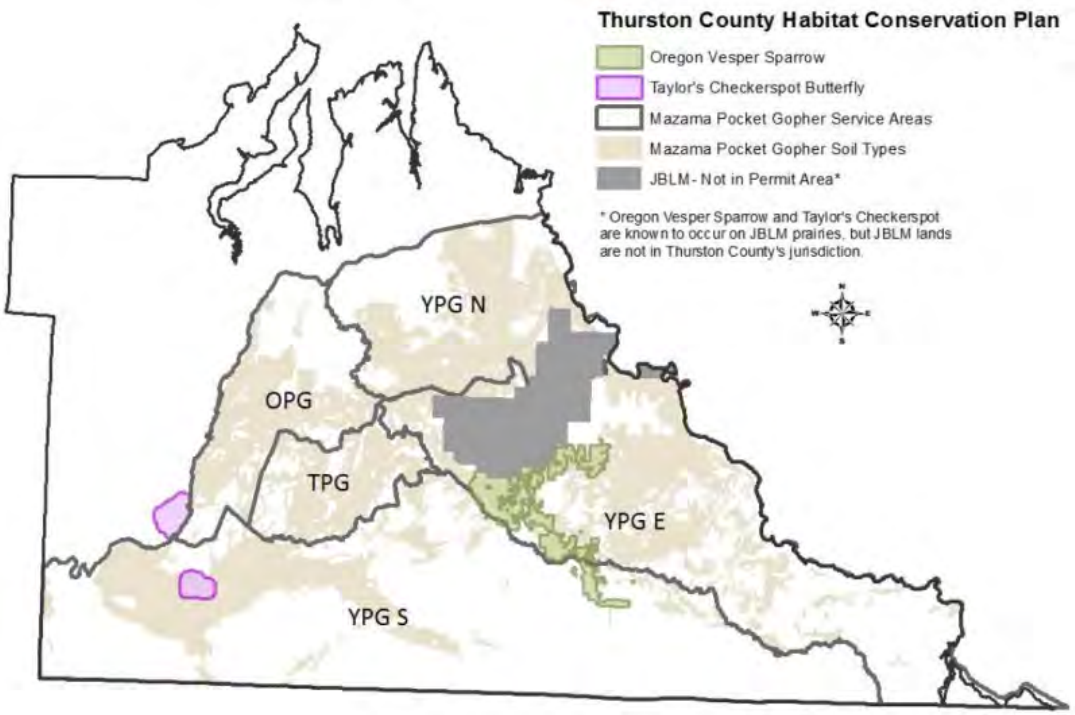


Figure IV-20. Habitat Conservation Plan, Upland Prairie Species Habitat in Thurston County. OPG, TPG, YPG N, YPG S, and YPG E sections represent service areas for the Olympia, Tenino, and Yelm pocket gopher subspecies (Yelm pocket gopher service areas are further broken down into north, south, and east service areas). Taylor's checkerspot and Oregon vesper sparrow habitat locations are based on WDFW Priority Habitats and Species locations and subject to change over time.

Prairies

Prairies, open native grasslands with little or no tree cover, are one of the rarest ecosystems in Washington. There are two prairie ecosystems in Western Washington: 1) dry, upland prairie, and 2) wet prairie. Upland prairies are more common and occur on deep, gravelly, well-drained glacial soils in bottomlands, along valley margins, and in lower foothills. Wet prairies occur on clay-rich soils that are saturated to the surface during the early part of the growing season which gradually dry out during the summer are usually found on glacial outwash soils in swales or low-gradient riparian areas. Prairies in Thurston County support a variety of plants and animals, including the Taylor's checkerspot and other imperiled butterflies, Mazama pocket gophers, Oregon vesper sparrow, the streaked horn lark, the mardon skipper, and the western pond turtle (Combs, Stinson, & Potter, 2023; Washington Department of Fish & Wildlife, n.d.; Washington Department of Fish & Wildlife, n.d.)

Prairies are typically fire-adapted ecosystems. Historically, Indigenous peoples used prescribed burns to prevent invading trees and shrubs, increase the growth of food plants such as camas, and improve habitat for game species. Prior to settlement by non-Indigenous people in Washington, prairie habitat covered an estimated 180,000 acres of Western Washington. In the ensuing years, large areas of prairie were converted to farmland and development. Only 3% of original prairies remain, and much of what is left is degraded.

Oak Forests

Oregon white oak (*Quercus garryana*) is Washington's only native oak, and their associated floras comprise distinct woodland and savanna ecosystems. The various plant communities and stand age mixtures within oak forests provide valuable habitat that contributes to wildlife diversity. At least 200 wildlife species use Oregon white oak for food, nesting, or shelter (Larsen and Morgen, 1998; Linders and Stinson, 2006). In conjunction with other forest types, oak woodlands provide a mix of feeding, resting, and breeding habitat for many wildlife species, including mammals, birds, reptiles, amphibians, various moths, butterflies, gall wasps, and spiders. Oak/conifer associations provide contiguous aerial pathways for animals such as the western gray squirrel, a state-listed threatened species, and they provide important roosting, nesting, and feeding habitat for the slender-billed white-breasted nuthatch, wild turkeys, and other birds and mammals. Dead oaks and dead portions of live oaks harbor insect populations and provide nesting cavities. As with prairies, Oregon white oak ecosystems are fire-adapted and were historically managed by indigenous peoples through prescribed burning: the acorns are an important food source, and the bark and other portions of the trees have medicinal and technological purposes.

The decline of Oregon white oak woodlands has been accelerated by human activities - primarily via oak removal. Conifer encroachment is a significant threat to remaining oaks, particularly on the west side of the Cascades, and is aggravated by urban development, fire suppression, timber conversion, and cattle grazing. Lack of fire management has resulted in dense oak woodlands with narrow, suppressed canopies as well as allowing conifer encroachment.

Shellfish Habitat

Shellfish makes up about a third of state inventoried agricultural acres, but some of the area with potential for production are not available due to point pollution (e.g., Budd Inlet, wastewater treatment plant outfall and marina/boating) or nonpoint pollution sources (e.g., Henderson Inlet, Nisqually vicinity) (Washington State Department of Health, 2024). Aquaculture sales in 2017 were $39.6 million and in 2022 were $35.1 million (USDA, 2023).

The warm, nutrient rich tidal flats of southern Puget Sound are a valuable shellfish growing area. The shellfish industry is at risk from multiple climate stressors, such as ocean warming, sea level rise, acidification, increased mobilization of pollutants in runoff, and heat stress in the tidal zone, and particularly during low tides as experienced in the 2021 Heat Dome that killed extremely large amounts of oysters, mussels, and clams. Pollution can exacerbate climate threats and make shellfish consumption dangerous (Mauger, et al., 2015; Thurston Regional Planning Council, 2018; USDA Northwest Climate Hub, n.d.). Extreme precipitation events could be a threat to shellfish, if large precipitation events cause pulses of freshwater from streams into marine waters lowering salinity levels (USDA Northwest Climate Hub, n.d.).

Figure IV-21. Shellfish areas in Thurston County

Source: (Washington State Department of Health, 2024)

Wetlands and Shorelines

Wetlands, including bogs, marshes, and swamps, act as natural sponges. They help prevent flooding and erosion by absorbing floodwater and sending it slowly to rivers, streams and aquifers. The plants and soil in wetlands also filter out sediment, excess nutrients, and pollutants from water. Wetlands provide a home for many species of native plants and wildlife. As with other natural floodplains, wetlands absorb and mitigate floodwaters, extreme precipitation can exceed their capacity. This can lead to more severe flooding in areas that were previously buffered by these natural systems (Mauger G. , 2019).

Sea level rise is projected to have significant impacts on beaches, marine bluffs, coastal wetlands, and shorelines, leading to erosion, habitat loss, and "coastal squeeze." [7] Marine bluffs along Puget Sound shorelines, particularly in areas like Boston Harbor and Burfoot Park, are at risk of accelerated erosion as rising sea levels increase wave action and destabilize these cliffs (see areas at high risk of inundation in Figure III 6. *Projected sea level rise).* Coastal wetlands, such as those in the Nisqually National Wildlife Refuge, face inundation, trapped between rising sea levels and human infrastructure with nowhere inland to migrate (Johannessen & MacLennan, 2007). This could result in the loss of critical near-shore habitats for species like salmon, forage fish, and migratory birds. Without space for natural habitat migration, species that cannot adapt quickly, such as certain amphibians and saltmarsh-dependent birds, may decline. The Nisqually River Delta and Mud Bay are particularly vulnerable, with low-lying areas that provide essential ecosystem services being threatened by both inundation and erosion, leading to long-term habitat degradation.

Biodiversity Corridors

The PHS program maps biodiversity areas and corridors that are important ecological connections between large contiguous blocks of wildlife habitat. Biodiversity corridors could support plant and animal movement in response to climate change (Azerrad, Michalak, & Johnson, 2023).

The multiagency "Washington Connected Landscapes Project: Cascades to Coast Analysis" (Washington Wildlife Habitat Connectivity Working Group, 2024) has identified important corridors for several mammal focal species including cougars, western gray squirrel, mountain beaver, pacific fisher, and American beaver. Some criteria to select focal species included climate sensitivity, and opportunity areas identified in this project can enhance or restore habitat connectivity. Areas identified in Thurston County include linkage zones across I-5 south of Olympia and across US 12 including in the south County. The Thurston County Comprehensive Plan includes an Open and Green Space Corridors map (Map E-4), that identifies areas where public lands, forests, parks, bases, and certain environmental areas exist in the County to create an informational visual of existing corridors as well as areas that are currently disconnected.

SURFACE WATER AND GROUNDWATER

Surface water and groundwater are critically important for ecosystems and residents in Thurston County. Groundwater recharge occurs when precipitation infiltrates the soil and replenishes aquifers. Virtually all drinking water in Thurston County comes from groundwater aquifers, underground layers of coarse cobbles and gravel that contain space where water collects. Aquifers not only supply the county's drinking water, but feed rivers, streams and wetlands.

Thurston County designates areas as "Critical Aquifer Recharge Areas" (CARAs) and/or "Wellhead Protection Areas" to protect drinking water supplies[8]. CARAs overlie significant groundwater

[7] Coastal squeeze is the process by which coastal habitats such as wetlands are trapped between rising sea levels and fixed human-made structures, such as seawalls, buildings, or roads. As sea levels rise, these habitats naturally migrate landward to maintain their ecological function. However, when human infrastructure blocks this inland migration, the habitat becomes "squeezed" and is gradually lost to erosion or inundation.

[8] As water seeps into aquifers, contaminants from aboveground activities can be carried with it. Toxic substances and fertilizers have already contaminated portions of Thurston County aquifers making the water in those areas no longer suitable for consumption. Typical pollutants include petroleum products from vehicles and other machinery, fertilizers, and inadequately treated animal and human waste, often from failing septic systems.

resources, including those used by public water wells and sole-source aquifers, can be influenced by geologic characteristics, soil, and depth. Thurston County classifies CARAs into three categories based on aquifer vulnerability, with Category I representing extremely vulnerable aquifers and Category III for moderately vulnerable aquifers.

Climate change in Thurston County will likely lead to more variable and extreme hydrological conditions (see trends in **Precipitation** [Section 2.3.2] and **Streamflow** [Section 2.3.3]). Due to these predicted changes, surface water systems will likely experience increased winter flooding and summer droughts, while groundwater systems may face declining water tables, reduced recharge, and contamination risks.

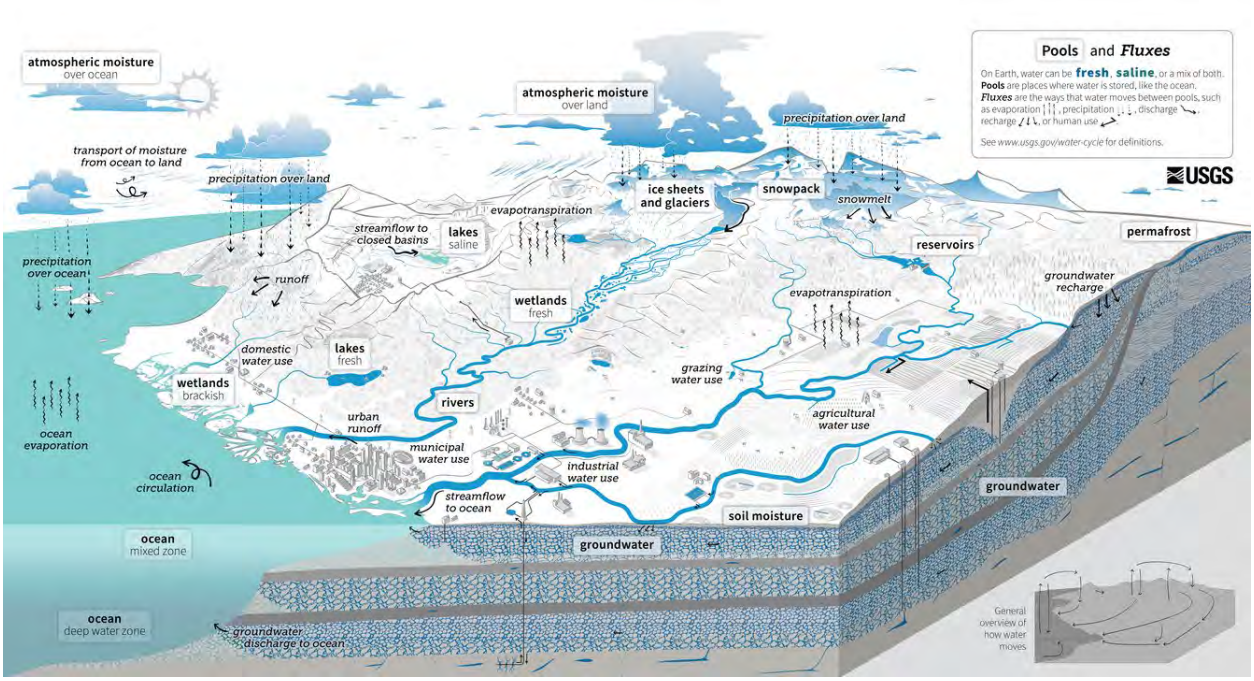


Figure IV-22. Conceptual model of the water cycle, showing interactions between landscape processes and groundwater recharge.

Source: USGS VizLab, in collaboration with the USGS Water Resources Mission Area Web Communications Branch, for the USGS Water Science School.

Though wetlands and smaller streams also play critical roles in the county's hydrology, the major surface water bodies in Thurston County include:

- **Puget Sound**: Coastal waters bordering the northern part of the county.
- **Deschutes River**: A primary river flowing through the county, draining into Capitol Lake and Puget Sound.
- **Nisqually River**: Forms part of the county's eastern boundary and flows into Puget Sound.
- **Capitol Lake**: A man-made lake near downtown Olympia.
- **Black Lake**: A large freshwater lake west of Olympia.
- **Munn Lake** and **Long Lake**: Smaller lakes used for recreation and habitat.

Thurston County has five Water Resource Inventory Areas (also called WRIAs, watersheds, or drainage basins), areas of land that drain to a common outlet: the Nisqually (WRIA 11), Deschutes (13), Kennedy-Goldsborough (14), Lower Chehalis (22), and Upper Chehalis (23) Watersheds.

As precipitation drains through these watersheds, some of it infiltrates into the ground and percolates through layers of soil and rock until it reaches an impermeable layer like clay or bedrock that prevents further downward movement. The water begins to accumulate in the spaces between rocks and sediment above this impermeable layer, forming a groundwater aquifer.

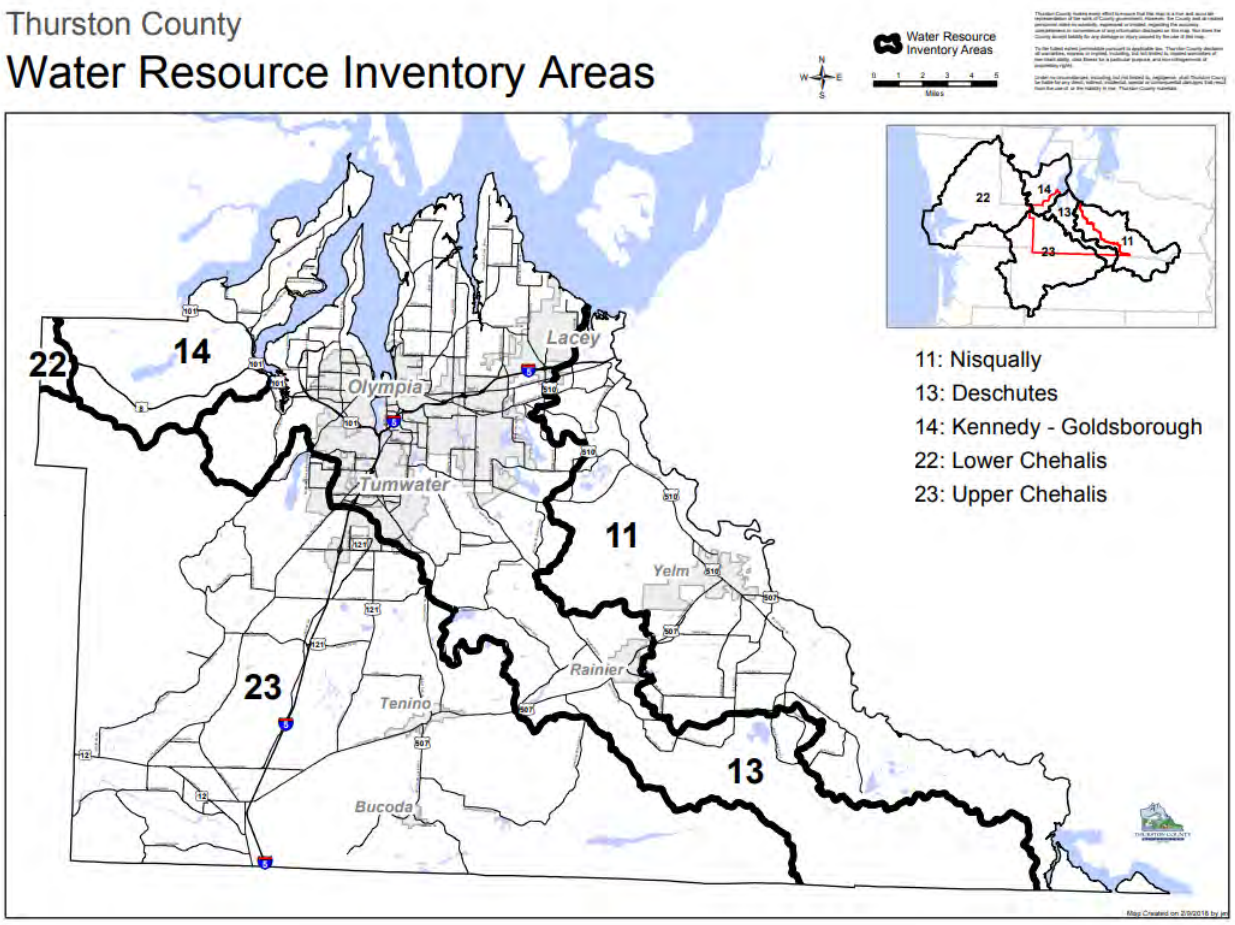


Figure IV-23. Water Resource Inventory Areas (WRIAs) in Thurston County.

Climate change can detrimentally impact freshwater quality and quantity in a number of ways. While extreme precipitation can lead to increased groundwater recharge in some areas, it can also increase flooding and erosion. Hence, the benefits for groundwater recharge depend on the ability of the groundwater system to absorb and store the excess water generated by extreme participation events.

More intense and frequent rain due to climate change will lead to higher streamflows and river stages. This will overwhelm riverbanks and floodplains, causing rivers to overflow and flood surrounding areas more often and more severely. Increased runoff from extreme precipitation also leads to greater soil erosion and sedimentation in rivers and streams. This can degrade water quality, harm aquatic habitats, and contribute to further flooding by reducing the capacity of river channels.

During periods of drought, the resulting declines in snowpack and rainfall reduces the water available to seep into the ground. This can result in lower groundwater levels over time. Prolonged drought can lower the water table, the depth at which groundwater is found. Simultaneously, during hot and dry periods, water demand typically increases for agricultural, residential, and recreational purposes. Reduced precipitation and higher demand can put additional stress on groundwater resources, potentially leading to overdraft. In some cases, excessive groundwater extraction during drought conditions can lead to subsidence, where the ground surface sinks due to the loss of support from underground water. While more common in certain geologies, subsidence is primarily a concern in areas with significant groundwater withdrawal.

Lower groundwater levels can also concentrate contaminants, leading to potential water quality issues. Additionally, reduced flow in aquifers can impact the natural filtration processes that help maintain water quality.

Groundwater contributes to water to streams and rivers through baseflow. When groundwater levels decline due to drought, streamflow in rivers and streams may decrease, which can affect ecosystems and water availability for various uses. Reduced stream and river flows can increase the concentration of pollutants in water and cause stagnation. Higher water temperatures in lakes, marine waters, and reservoirs lead to reduced oxygen levels. These levels can adversely affect fish and other aquatic life and water quality.

Runoff from drought-related wildfires can carry extra sediment, ash, charcoal, fire retardant chemicals, and woody debris to surface waters, killing fish and other aquatic life by decreasing oxygen levels in the water.

WATER SUPPLY

Watershed Planning

Though reductions in water use for industry, irrigation and aquaculture over the last decade have offset increased use of domestic and public water driven by population growth, Thurston County faces water scarcity due to both physical and legal constraints. All of Thurston County's watershed basins face significant restrictions on water withdrawals because streamflows in most major rivers and tributaries are currently sitting below the minimum instream water flows required by the Streamflow Restoration Act (RCW 90.94)[9]. As a result, some areas are considered "closed" to new rights for water withdrawals, or new rights may only be available for use in certain seasons.

Watershed plans under 90.94 examine water quantity, water quality, instream flow, and habitat conditions in the face of land use change and population growth. Climate change will also affect these conditions:

- **Nisqually Watershed (WRIA 11).** This approximately 761 square mile basin, the ancestral home of the Nisqually Indian Tribe, feeds the Nisqually River. The river originates from the Nisqually Glacier on the southern slope of Mt. Rainier: glacier melt, snow, and rainfall determine river flow, as well as the actions of dams located in its upper reaches. Although

[9] The state law, passed in 2018, clarifies how counties issue building permits for homes that use a permit-exempt well for a water source, directing local planning groups to develop watershed plans that offset impacts from new domestic permit-exempt wells and achieve a net ecological benefit within the watershed. The goal of the law is to "restore streamflows to levels necessary to support robust, healthy and sustainable salmon populations while providing water for homes in rural Washington".

river flow is generally lowest during late summer months (August to October), historically, summer flows remain relatively high due to snowpack and glacier melt. However, summer flows may be reduced in the future due to snowpack and glacier loss, further challenging attempts to maintain minimums. The Nisqually Watershed is projected to shift this century from a mixed rain-and-snow watershed (i.e., a watershed that receives 10-40 percent of its precipitation as snow) to a rain-dominant watershed (i.e., a watershed that gets less than 10 percent of its precipitation as snow). A 2023 National Park Service study estimates that Mount Rainier has lost more than half of its glacial ice mass in the last 125 years, and that the rate of loss is accelerating (Beason, Kenyon, Jost, & Walker, 2023). In WRIA 11, the movement of salt water into freshwater aquifers is a concern in coastal areas by Puget Sound. This is particularly a problem east of Johnson Point near the Nisqually River delta (Nisqually Watershed Planning Unit, 2019)

- **Deschutes Watershed (WRIA 13).** The 270 square mile Deschutes Watershed is almost entirely within Thurston County, and 26% of that area is within a city or designated urban growth area. Industry, agriculture (including salmon fisheries), commercial facilities, and municipalities compete for a limited water supply, causing a strain on water availability, especially when there are low seasonal flows in productive salmonid streams. The salmon fishery is utilized for commercial, sport, and subsistence harvest. This includes Tribes with usual and accustomed fishing areas that overlap with the watershed, such as the Squaxin Island Tribe. Due to lower stream flows and higher water demand, summer worst-case withdrawals are a significant portion of mean Deschutes streamflow (Department of Ecology, 2022, pp. 7-26). More severe and prolonged drought in the region due to climate change could further constrain an already limited water supply in WRIA 13 and impact salmon health.

- **Kennedy-Goldsborough Watershed (WRIA 14).** The 381 square mile Kennedy-Goldsborough Watershed is within Mason and Thurston counties. It includes an extensive network of independent streams that are issued from springs, wetlands, small lakes, and surface water drainages, but no major river system. Most of the portion of WRIA 14 that is in Thurston County is undeveloped land. Tribes with usual and accustomed fishing areas within WRIA 14 include the Skokomish and Squaxin Island Tribes. As with riparian areas in much of the Western U.S., WRIA 14 is projected to experience increasing stream temperatures, increased flooding, and declining summer minimum flows, impacting salmon health. The watershed plan estimates 760 acre-feet per year (AFY) of new consumptive water use in WRIA 14 between 2018 and 2038, putting even more strain on surface water availability (Department of Ecology, 2022).

- **Lower and Upper Chehalis Watershed (WRIA 22 and 23).** The Chehalis Basin is the largest river basin in western Washington, encompassing approximately 2,800 square miles, though Thurston County only covers 12% of that area. It is primarily forested but contains a variety of land uses. The watershed plan identifies an over-allocation of water rights and claims within the Chehalis Basin, particularly in the upper portion (WRIA 23), when describing why minimum instream flows are not always met. The region experiences mild winters with rare snow accumulation apart from the portion of the basin in the Olympic Mountains. The basin is characterized by wet winters and dry summers with river

discharge peaking between December and March (Chehalis Basin Partnership, 2020). Climate change-exacerbated flooding is a concern in several places across the Chehalis Basin due to increased instances of heavy rain events, often classified as Atmospheric River events (Mauger, Lee, Bandaragoda, Serra, & Won, 2016).

Drinking Water Systems

While rivers like the Nisqually and Deschutes and other surface water sources like lakes were historically used for drinking water by Indigenous peoples, groundwater aquifers have become the primary source of drinking water in the modern day.

North of Olympia, the county operates two water systems on either side of Budd Inlet: Boston Harbor and Tamoshan. Each water system has two wells, though only one is currently operational at Tamoshan, with plans for the other to be online soon. Both aquifers are well confined, but because the newest Tamoshan well is shallower, there is a potential path for saltwater intrusion between the well and Puget Sound which could be exacerbated by sea level rise.

Moving south, the largest water system the county operates is in Grand Mound. Grand Mound is a rapidly developing commercial and residential area with a different situation – not in proximity to Puget Sound, but concerns about drought and water shortages in addition to contamination are factors to consider. Contamination that happens up-valley from septic systems can travel quickly through the glacial gravel that makes up the valley.

For Thurston County, the impacts of drought and heat on drinking water systems will depend on local factors such as geology, extent of groundwater use, changes in demand during heatwaves, and existing water management practices. Water supply vulnerability will be lowest where hydrologic change is smallest (i.e., existing rain-dominant watersheds), where there are simple institutional arrangements, and where current water demand rarely exceeds supply.

Public Works reports that there have been no indications of groundwater overdraft in the county to date, but – as other counties in Eastern Washington have had wells reach critically low levels in the past – they will continue to monitor for overdraft indicators such as saltwater intrusion, land subsidence, groundwater depletion and/or chronic lowering of groundwater levels.

A combination of hazards including sea level rise, coastal flooding, and erosion will continue to push the contact between the freshwater aquifers and saline seawater farther inland. There is a risk of seawater intrusion into groundwater sources that result from the combined stressors of sea level rise and human uses which lower groundwater levels. WA DNR monitors multiple places for potential saltwater intrusion impacts (Gillum, 2019). If saltwater intrusion does occur, it may be necessary to bear the expense of treating poor-quality water for consumption or find alternative sources of freshwater.

According to the US Geological Survey (USGS), as they have become more severe, wildfires pose a substantial risk to water supplies because they can lead to severe flooding, erosion, and delivery of sediment, nutrients, and metals to rivers, lakes, and reservoirs (Water Resource Mission Area, 2023) (USEPA, 2024) (USEPA, 2019).

STORMWATER AND WASTEWATER

The Grand Mound sewer system serves an area that closely mirrors the service area of the Grand Mound drinking water system. This system is the largest in Thurston County. Wastewater collected

in the Grand Mound area undergoes treatment and is then discharged through an outfall pipe into the Chehalis River.

In the northern part of the County, the Boston Harbor collection area employs a unique wastewater management approach. Individual residences in this area utilize step/septic tanks to collect wastewater. The liquid portion is pumped from these tanks to a centralized treatment plant. This system was specifically designed to transition homes from individual septic tanks to a more unified wastewater treatment system. However, due to the area's topography, effluent must be pumped uphill to the treatment plant. After treatment, the outfall discharges into the middle of Budd Inlet.

On the Tamoshan side, a traditional sewer system is in place, with its outfall located closer to the beach. Additionally, the County operates the smaller Olympic View sewer system, which includes a community drain field to support septic tanks at individual residences.

Extreme precipitation events pose significant challenges to stormwater and wastewater systems across Thurston County. Intense, sustained rainfall can overwhelm these systems, particularly the two coastal wastewater systems managed by the County. During such events, stormwater may infiltrate aging infrastructure through poorly sealed sewer lines, manholes, and lidded tanks, leading to inflows that exceed the wastewater treatment facilities' capacity. When overwhelmed, these systems may discharge untreated wastewater into Puget Sound.

These untreated discharges, known as Combined Sewer Overflow (CSO) events, can introduce harmful bacteria into the environment, causing beach closures, harming aquatic ecosystems, and degrading water quality. Beyond ecological and public health impacts, these events also create financial and legal risks for Thurston County. Regulatory agencies such as the Environmental Protection Agency (EPA) or the Washington State Department of Ecology may impose fines ranging from thousands to millions of dollars, depending on the severity, frequency, and environmental impact of violations. The County also faces potential third-party lawsuits.

In addition to the risks posed to public wastewater systems, heavy rainfall events can lead to the failure of private septic systems. This failure can cause untreated waste to enter waterways or backflow into homes, exacerbating public health and environmental concerns.

Since January 2007, Thurston County has been operating under a Washington Department of Ecology-issued municipal stormwater permit governed by federal and state water pollution control laws. This permit requires the County to manage stormwater runoff from its municipal storm systems within the permit-regulated area[10]. When precipitation from rain and snow flows over impervious surfaces such as roads, roofs, and parking lots, it can collect oils, chemicals, debris, and other pollutants, which then wash into waterways. The stormwater permit mandates sizing stormwater management facilities based on historic precipitation data. However, as projected wet-season storms increase in intensity and duration due to climate change, designing infrastructure solely on historic patterns may result in more frequent instances of stormwater systems being overwhelmed.

Climate change, which is expected to increase the frequency and intensity of heavy rainfall events, will likely amplify these challenges. Rising sea levels may further complicate wastewater management in coastal areas by increasing groundwater levels, reducing system capacity, and heightening the risk of saltwater intrusion into wastewater infrastructure. Proactively addressing

[10] Thurston County's municipal stormwater permit covers unincorporated urban areas and urban growth areas (UGAs) associated with permitted cities (i.e., the Cities of Lacey, Olympia, Tumwater, and Yelm) falling under the jurisdictional control of the county.

these vulnerabilities will be critical for maintaining the functionality and resilience of Thurston County's stormwater and wastewater systems.

In 2018-2019, the City of Olympia, Port of Olympia, and LOTT (a regional wastewater utility serving portions of unincorporated Thurston County and the communities of Lacey, Olympia and Tumwater) developed a joint Sea Level Rise Response Plan to advance a coordinated strategy for protecting downtown Olympia, the Port peninsula, and the Budd Inlet Treatment Plant from the impacts of sea level rise. The plan notes that city staff track how, during high water events in Capitol Lake and Budd Inlet, flooding from these water bodies can enter City streets and catch basins connected to the combined storm/sewer system. This, in turn, can dramatically increase peak flows into LOTT's Budd Inlet Treatment Plant, and potentially could overwhelm the plant's hydraulic capacity.

Similarly, flooding in downtown Olympia can also occur when floodwater from Capitol Lake and/or Budd Inlet backflows into stormwater pipes and upwells in City streets through street drains. This happens when water levels in Capitol Lake or Budd Inlet exceed the elevation of the street drains. In some locations, floodwaters can then flow back into combined sewer catch basins that drain to the Budd Inlet Treatment Plant. City staff have been evaluating the impact of this dynamic and potential strategies for mitigating it.

Wastewater treatment plants are also vulnerable to extreme heat, primarily because of increased water demand and decreased operational capacity during extreme heat events. High temperatures degrade the plants' electrical infrastructure, decrease water quality of influent water, and change the rate of engineered biological processes, making treatment more difficult and costly. As heat waves are expected to become more frequent and intense, plant managers will need to monitor and adapt to these conditions.

In 2007, significant flooding in the Chehalis River broke off the Ground Mound system's outfall pipe located in the river. It was subsequently reconstructed, but Public Works notes that staff still view infrastructure in that area as vulnerable to damage during riverine floods/extreme rainfall events.

G. INFRASTRUCTURE

Energy and transportation infrastructure are vulnerable to climate impacts, including extreme heat, extreme precipitation, wildfire and wildfire smoke, and sea level rise. These climate impacts can damage roads, bridges, and pedestrian infrastructure, reduce carrying capacity of transmission lines, and change the productivity of hydropower energy production. This section focuses mainly on the physical impacts of climate change on energy and transportation infrastructure systems.

ENERGY SYSTEMS

Energy Generation

The productivity of hydropower dams in the Puget Sound region, including on the Nisqually River, is expected to be affected by projected changes in seasonal precipitation. Winter hydropower production is expected to increase, while summer hyperpower production is expected to decrease, given projected changes in rainfall and snowfall (Thurston Regional Planning Council, 2018; Chang, et al., 2023).The risks of reduced summer energy generation may be compounded by the expected increase in summer energy demand in response to extreme heat, which is expected to increase over 400% by end of the century under a high emissions scenario.

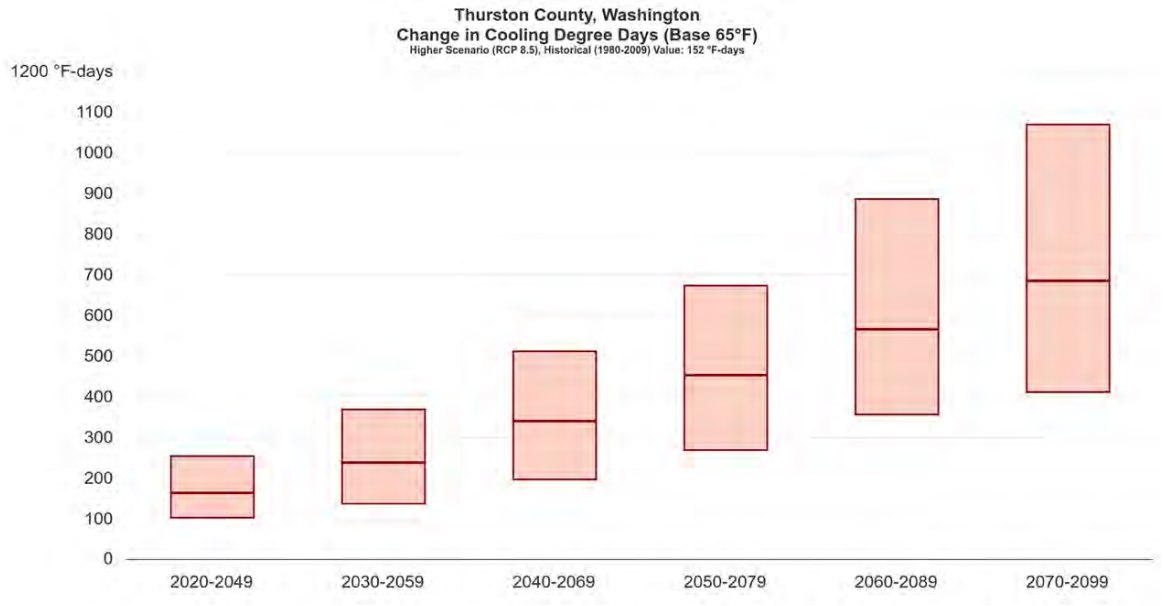


Figure IV-24. Change in Cooling Degree Days[11] Under RCP 8.5, Thurston County
Source: Raymond and Rogers, 2022.

Energy Transmission and Delivery

Transmission lines, power plants, and substations can be affected by extreme heat. Heat can cause transmission lines to sag and lose carrying capacity. Substations could also lose operating capacity because of extreme heat and can be overloaded and tripped as a result of increased demand. Extreme temperatures can also reduce the efficiency and output capacity of both natural gas-fired power plants and solar power plants. Rising air temperatures can impact chiller performance for dry cooled natural gas plants and combined cycle natural gas plants leading to capacity losses.

While energy generation and transmission may have reduced capacity, Thurston County has seen an increase in electricity consumption in the past few years (Thurston Regional Planning Council, 2023). Electricity demand in the summer is also high because of increased demand for cooling during extreme heat events, adding more stress to the power grid (Chang, et al., 2023)—a concern emphasized by Thurston County staff in interviews. This confluence of potential diminished capacity and high demand may pose challenges for meeting residents' needs and threatens grid reliability during extreme heat events.

[11] Cooling degree days is an indicator of energy demand for cooling, which can be useful on assessing energy impacts of warming trends. Cooling degree days are measured using degree days – or °F-days – and is calculated using the equation: Cooling degree days = Average daily temperature − 65°F. Thus, the equation for evaluating annual cooling degree days is: Annual cooling degree days = $\sum_{1}^{365} Avg\ daily\ temp_n - 65°F$, where n is the day of the calendar year. Therefore, the units for cooling degree days may be in the thousands.

Energy Assets

Energy infrastructure also be affected by extreme precipitation events, which may result in downed power lines or flooded energy assets. Substations are particularly sensitive to flooding because the submersion of electrical equipment can create electrocution hazards, threaten operations, or lead to emergency shutoffs. Although substations are designed to certain flooding standards, if those design criteria are exceeded by a flooding event, damage could be extensive.

Energy infrastructure in low-lying areas of Thurston County may be at risk from sea level rise. The performance of energy equipment may be compromised by sea level rise, which would result in costs for utilities and customers and may result in environmental pollution (Nazarnia, Sarmasti, Nazarnia, & Wills, 2020).

There are three energy community lifelines – or assets or services that are fundamental for societal function, according to FEMA – located in the 100-year special flood hazard area and four energy community lifelines located in the 500-year special flood hazard area (Thurston Regional Planning Council, 2023). As extreme precipitation events intensify, the risk of the energy community lifelines may be damaged by flooding, especially in areas where extreme precipitation intensity is expected to be higher such as the northwest area of the county by Capitol Forest and the southern area of the county by Bucoda and Grand Mound.

Power Outages

Thurston County's main energy provider, Puget Sound Energy (PSE), was unable to meet its energy demand in 2020 and expects a shortfall in future years as energy needs continue to increase (PSE, 2021). PSE has also implemented rolling blackouts in response to extreme heat (PSE, 2021).

Power outages—which may become more frequent due to a variety of climate impacts—can exacerbate social and health-related vulnerabilities, especially for those with electric medical devices or equipment.

Wildfires can pose a threat to energy assets in Thurston County, especially in areas with dense forest cover or wildland areas (Chang, et al., 2023). Wildfires can destroy wooden poles and damage smaller transmission lines, while heat, smoke, and particulate matter from wildfires can impact the transmission capacity of power lines; for example, soot accumulation on insulators can lead to leakage currents, and ionized air in smoke may cause arcing, resulting in power outages.

In addition to causing power outages, the impacts of wildfires described above can increase maintenance costs and reduce transmission efficiency. In other areas of the West Coast, electric utilities have increased customer rates to cover maintenance and improvement costs related to wildfires (The Public Advocates Office, 2024).

TRANSPORTATION

Transportation infrastructure and assets are vulnerable to climate change impacts, which increases the risk of disruptions in access and services for the region's communities and commercial activities. Transportation infrastructure in Thurston County includes roads and bridges, pedestrian and bike infrastructure, public transit, and port facilities. Thurston County provides two primary transit services: Intercity Transit and ruralTRANSIT. Some of the key roads in the county include Interstate 5 (I-5), U.S. Route 101 (US-101), State Route 510 (SR-510), State Route 507 (SR-507), and State Route 8 (SR-8).

Extreme heat can disrupt or damage rail systems and can result in expansions of catenary lines or rail buckling. Prolonged periods of extreme heat can cause asphalt to soften, leading to ruts and potholes as vehicles pass over and soften the road surface. This can affect road systems and bike and pedestrian paths. Metal components on bridges can expand significantly in high temperatures, potentially causing warping. Extreme heat can also cause bridge decks to crack which can compromise bridges' structural integrity and safety.

Thurston County has 205 vehicle bridges, 114 of which are owned and maintained by cities or the county. Two bridges—Capitol Boulevard over I-5 and the I-5 ramps over Eastside Avenue, both state-owned—are in poor condition, with the remaining bridges in good or fair condition (National Bridge Inventory (NBI), 2023). The 2023 Hazards Mitigation Plan for the Thurston Region states that there are 15 transportation community lifelines located in the 50-year special flood hazard area, 19 in the 100-year special flood hazard area, and 23 in the 500-year special flood hazard area (Thurston Regional Planning Council, 2023).

Heavy rainfall can lead to flooding of roads and pedestrian and bike paths, making them impassable and causing damage to road surfaces. Extreme precipitation and accumulation of water on roads and paths can also erode the edges and foundation of roads, leading to increased rates of corrosion or collapse. Wet surfaces can increase the risk of accidents and injuries while driving, walking, or biking. County staff noted that undersized culverts and conveyance systems seem especially vulnerable to the impacts of extreme precipitation, as rerouted water could result in road failures.

Bridges are particularly sensitive to extreme precipitation and flooding events because water can cause erosion damage to bridge approaches or where the roadway transitions from the bridge deck. Erosion from extreme precipitation and flash floods can damage the infrastructure of bridges and the ground supporting them. Bridges with support structures in rivers or streams may also face increased erosion because of increased velocity of water flow. Flooding events can also bring debris and wreckage, which can collect on bridge decks and cause damage. Older bridges will be more sensitive to the impacts of climate change and may experience accelerated corrosion rates.

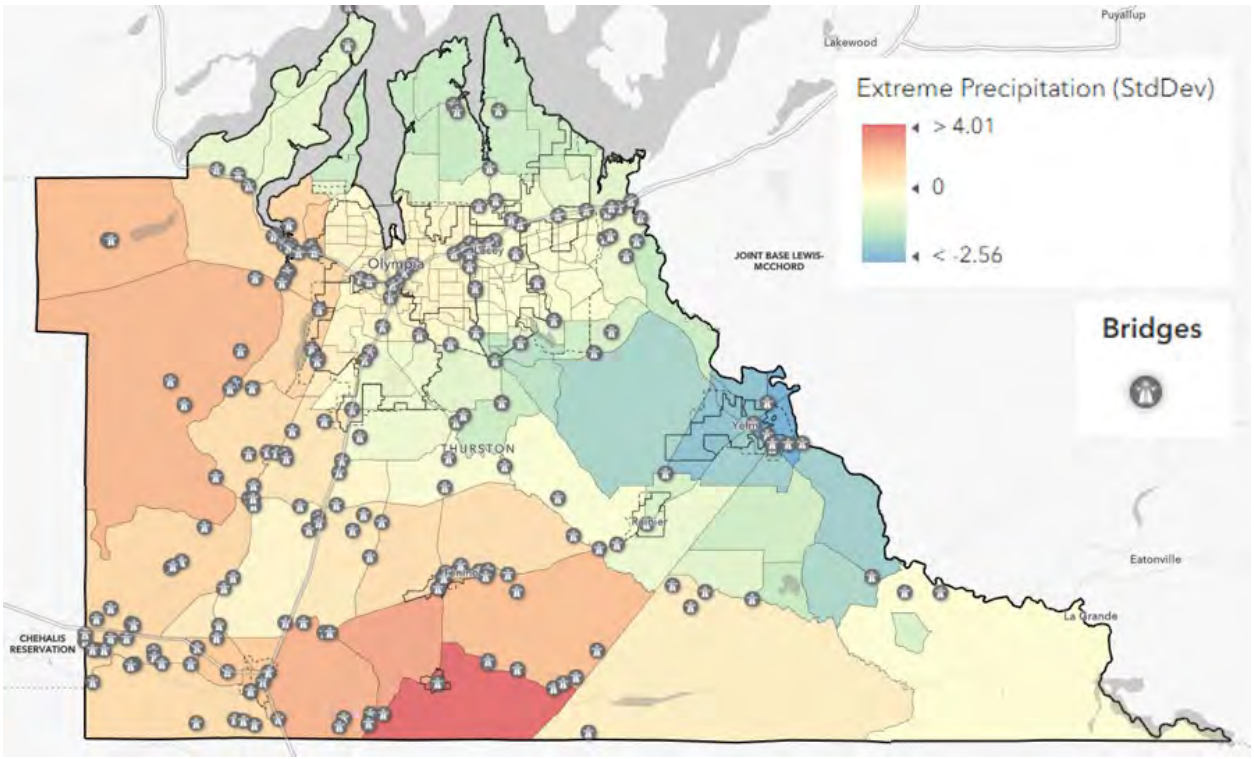


Figure IV-25. Bridges exposed to extreme precipitation in Thurston County.

The projected increase in extreme precipitation is highest in the northwest area of the county by Capitol Forest and the southern area of the county by Bucoda and Grand Mound (Figure). During interviews, Thurston County staff confirmed that Grand Mound has experienced road closures due to flooding and noted that the I-5 areas by the Nisqually and Chehalis Rivers experience high flood risk, which can severely impact people's ability to travel within and outside of the county. The county's Climate Adaptation Plan also notes sections of I-5 and US-101 as vulnerable infrastructure (Thurston Regional Planning Council, 2018).

Figure IV-26. Flooding near the Chehalis River in December 2007, overflowing into low-lying roads. Photo source: (Thurston Regional Planning Council, 2018).

Another impact of extreme precipitation is the increased risk of landslides. Thurston County staff emphasized the potentially harmful impacts of landslides on evacuation routes; the assets and infrastructure most vulnerable to landslides are located on or near steep slopes (Thurston Regional Planning Council, 2018). Roads, bridges, and active transportation infrastructure are vulnerable to sea level rise and associated coastal inundation. Roads, bike paths, and sidewalks in low-lying coastal areas may be regularly inundated due to rising sea levels, making them impassable and causing long-term damage. Bridges in coastal areas may be at risk of frequent inundation, which can compromise their structural integrity. Increased tidal action and storm surges can erode road and path surfaces and foundations, reducing their lifespan and safety, while saltwater can corrode or degrade materials used in roads, bridges, and other transportation infrastructure.

In Thurston County, low-lying sections of I-5 and US-101 may be especially vulnerable to sea level rise, recognizing that these roads are critical routes for commercial business, personal vehicles, and emergency personnel (Thurston Regional Planning Council, 2018). These areas may experience exacerbated risks with sea level rise, including I-5 by McAllister Creek, the Nisqually National Wildlife Refuge area, and the US-101 and Mud Bay area near Olympia (Thurston Regional Planning Council, 2018). Part of downtown Olympia is built atop fill and floods during high tides, which will likely be exacerbated by sea level rise, increasing the vulnerability of roads in the area (Thurston Regional Planning Council, 2018). Additionally, the Port of Olympia's Marine Terminal is located along the Puget Sound, serves as a valuable economic and commercial asset, and is at risk from future sea level rise (The Emergency Management Council of Thurston County, 2023).

Figure IV-27. Flooding in Olympia during a king tide on January 27, 2022. Photo credit: (City of Olympia, 2024).

H. COMMUNITY DESIGN, LAND USE & ECONOMIC DEVELOPMENT

Land use and zoning can enhance economic development opportunities and housing availability; however, land use and design when done without full consideration of climate impacts can exacerbate some types of climate-related risks. For example, suburban and rural development and urban sprawl can lead to more wildland-urban interface (WUI) – or areas where the built environment meets or intermingles with a wildland area. Climate change is also expected to affect county commercial zoning and economic development. Flooding, sea level rise, and wildfires could disrupt business operations and damage critical infrastructure. Climate change could also bring

economic opportunities addressing food systems, green technology, and other industries supporting economic resilience.

Residents in rural areas are dependent on cars for accessing goods and services in rural areas and towns in south Thurston County. Areas zoned for urban commercial business or industrial areas are typically in areas with higher impervious surface and less tree canopy, amplifying heat island effect. For example, commercial areas in Yelm experience some of the most pronounced heat island impacts in the county. Additionally, some county commercial areas are prone to sea level rise and coastal flooding (e.g., downtown Olympia), and business operations or assets can be disrupted or damaged as flooding events become more frequent and intense.

BUILDING & ZONING

Land Cover

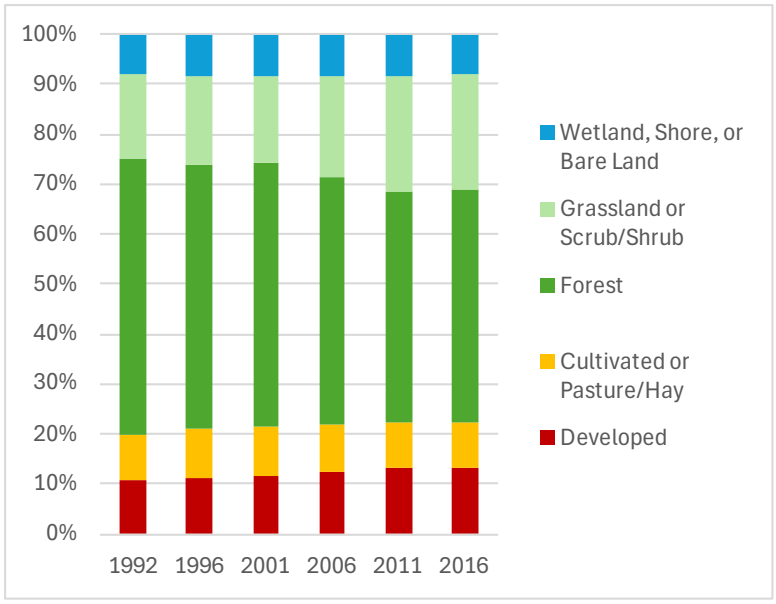
Thurston County primarily contains forestland, with lesser areas of development and cultivation. Since implementation of its Comprehensive Plan, the county has seen conversions and intensification of land even with the plan's intent to protect agricultural and forest lands of long-term significance and critical areas, while creating opportunities for housing and jobs.

Between 1992 and 2016, over 9,000 acres of land were converted to low, medium, or high-density developed land covers. Low density residential uses increasing in rural areas could place homes in greater proximity to the wildland urban interface. For example, a review of *development-related* tree canopy change from 2011 to 2017 showed over 75% of the tree canopy change was in rural residential areas even though the housing built represented less than 20% of housing constructed in the county. Residential uses predominantly occurred in cities and converted a smaller share of tree cover. (WDFW 2011-2017; BERK 2023)

Forests still cover over 40% of the county but declined by more than 41,000 acres between 1992 and 2016. Grassland and scrub/shrub increased by more than 28,000 acres. Depending on location of tree canopy cover loss, it could reduce shade in habitat areas and exacerbate effects of extreme heat or drought.

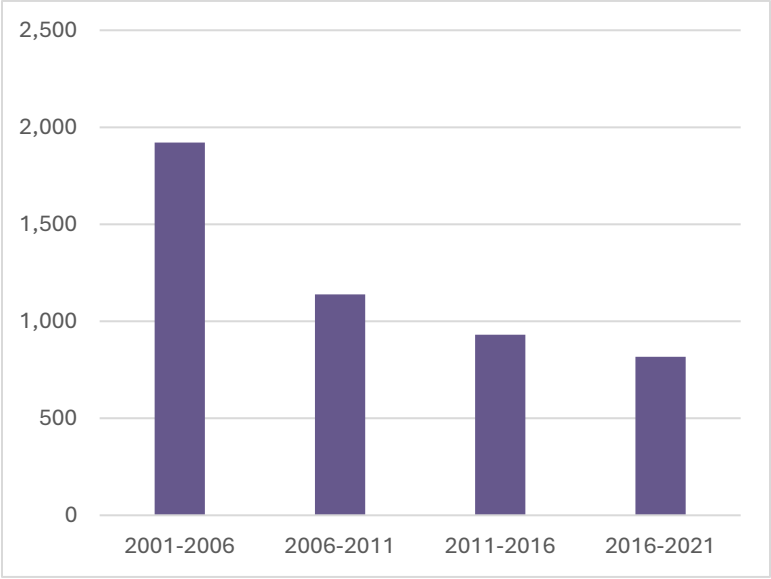
Land cover data for 2021 is not available. However, data related to impervious surfaces is available and shows increases in each 5-year period from 2001 to 2021, but the amount of the increases has moderated over time. Impervious areas can reduce infiltration and exacerbate flooding, and can absorb more solar radiation and increase local temperatures if not well vegetated.

Figure IV-28. Thurston County Land Cover 1990-2016



Source: TRPC 2024, BERK 2024

Figure IV-29. Thurston County Impervious Area Increase 2001-2021



Source: National Land Cover Database (2001-2021 Impervious Area Estimates); TRPC 2024; BERK 2024

Planned Growth

Thurston County works with other jurisdictions on a regional basis to GMA requirements. Through interjurisdictional planning the cities plan for their city limits and unincorporated urban growth areas (UGAs) assigned to them. While there are distributed roles in the interlocal planning agreements, ultimately Thurston County is responsible for allocating growth and approving changes to UGAs under GMA. Planned growth through 2045 includes:

- 88,707 new people, with at least 88% of the population in the cities and UGAs.

- 54,356 housing units countywide, with at least 86% of that growth in cities and UGAs.
- 67,000 jobs with most in cities and UGAs similar to housing units.

Thurston County plans for land use and zoning in unincorporated rural areas as well as the unincorporated Grand Mound UGA, which is its own economic center, and where the county provides water and sewer infrastructure and provides for transportation investments.

The county's growth share is under review in the Periodic Update and under the current plan Thurston County would take 14% of county housing unit growth in rural areas and Grand Mound. Under another alternative the county would have a lower share of 5% county growth in rural areas and Grand Mound based on a Sustainable Thurston regional growth strategy, and the difference in growth redirected to cities and UGAs.

The Sustainable Thurston plan showed that without focused growth and protection of natural resources and critical areas, the county would be between 2013 and 2035:

- Lose 32 percent of farmlands to urbanization
- Lose 10 percent of forest lands to urbanization
- Send 13 percent of growth into the rural areas, contributing to the loss of forests, farmlands, and prairies

The county may develop a growth scenario in between 5% and 14%. Considerations for any growth strategy include opportunities to transfer development from the Habitat Conservation Plan areas, cluster rural development, and availability of water and other infrastructure.

HOUSING PATTERNS AND AFFORDABILITY

Housing relates to climate change in at least two ways. First, the location, construction, and energy consumption of homes directly affect their contributions to greenhouse gas emissions and climate change. Second, where housing is located and how it is constructed offer residents varying degrees of exposure to (and protection from) climate-related risks and hazards. Housing and communities can be designed and built to be more resilient to natural disasters, which have become more frequent and severe because of these environmental shifts (U.S. Department of Housing and Urban Development, 2022).

Households across Thurston County are at risk of displacement due to social vulnerability, potential for demographic change, and appreciating or accelerating prices. As of 2020, there were about 34,485 cost-burdened households in Thurston County. These families and individuals have limited income remaining to cover other essentials like food, transportation, and health care. Many households experience housing insecurity and are at risk of losing their homes if housing costs continue to rise. This may exacerbate existing racial disparities in housing: BIPOC households have lower homeownership rates and are more likely to be cost-burdened compared to their white counterparts.

Climate change stressors that increase expenses have the potential to exacerbate the risk of displacement further. Costs associated with increased cooling demand during summer months, housing retrofits, such as those related to energy or air quality (weatherization, cooling), water and landscaping (drought), and insurance (increased flood hazards), as well as healthcare expenses for illnesses from extreme heat or smoke, may create additional strain on Thurston County residents, particularly those in older housing or facing housing cost burden.

Additionally, population migration patterns may be affected by climate change, and can exacerbate growth-related challenges in receiving areas, including issues of housing availability and affordability, and sending regions may face increased housing vacancies, leading to declining property values and neglected properties.

Challenges for the county include:

- Increased housing regulations applied to new development result in increased costs, though operationally, the dwellings would be more resilient to hazards and potentially less expensive to operate.
- Staff have structural challenges to pursue grant funding to address climate resilience implementation such as due to staff capacity.

Housing Affordability

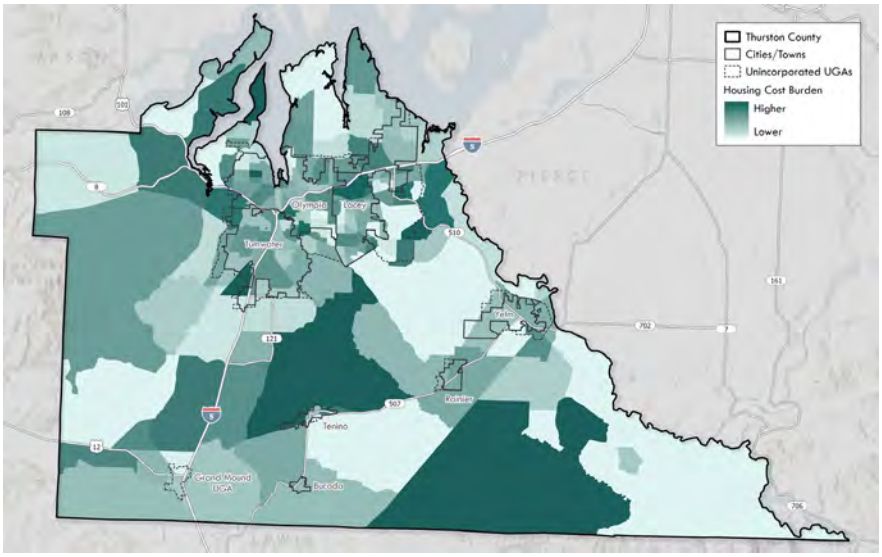
Housing and Energy Burden

Affordable-accessible housing refers to affordable homes situated in locations that provide easy access to essential services and activities, reducing transportation costs and helping to reduce household cost burdens (Litman, 2024). This section provides a brief overview of the state of housing production and affordability in Thurston County:

Housing production trends: Between 2013 and 2023, detached single family units represented the majority of permitted units in rural unincorporated Thurston County, followed by manufactured homes. In Grand Mound UGA, the housing types with the highest number of permits included both single-family and multifamily units, while in the cities and their respective UGAs, multifamily units were the predominant housing type among permitted units.

Approximately 39% of Person of Color households in Thurston County were either moderately or severely cost burdened in 2020, compared to only 29% of households that identify as white alone. Among Hispanic or Latino households, 40% are cost burdened. Typical rents have nearly doubled since 2015, dramatically reducing the supply of lower cost housing options. The typical home value continues to rise, making it difficult for a first-time homebuyer to purchase a home under $500,000.

Figure IV-30. Housing Cost Burden, Thurston County (2022)



Source: US Census Bureau, 2018-2022 American Community Survey 5-Year Estimates; BERK, 2024.

Anecdotal accounts from Thurston County staff interviews suggest that extreme heat may generate additional stress on the power grid, partially due to the lack of air conditioning systems in many buildings and homes. According to the 2016-2020 US HUD Comprehensive Housing Affordability Strategy (CHAS), more than a third of homes in Thurston County were rented, and nearly 48% of renter households were cost burdened. This means that these occupants may have less control over choosing appliances or making building improvements that could increase energy efficiency.

The cost of retrofitting heating and cooling systems would be costly and could particularly affect overburdened communities. Lower-income households may pay more for energy as a share of income compared to the county, and more so for those in homes built before 1960.

Table IV-2. Thurston County Low-Income Energy Affordability Data

	Energy Burden: All Housing Types and Ages	**Detached Homes before 1960**
All Incomes	2%	2%
0-30% Area Median Income	11%	14%
30-60% Area Median Income	4%	5%
60-80% Area Median Income	3%	3%

Source: U.S. Census ACS 2022 Public Use Microdata, US Energy LEAD Tool

As climate vulnerability represents the combination of exposure, inherent sensitivity of people or environments to a changing climate, and the community's capacity to cope with these impacts, several block groups in Thurston County may experience heightened vulnerability. For example, many block groups across the county show high or very high percentages of people under 5 years old or 65 years and older, alongside significant housing cost burden and heat exposure. This includes areas in Lacey, UGAs near northern cities, and parts of the Rochester subarea.

People Experiencing Homelessness

In 2023, around 12,500 individuals in Thurston County experienced homelessness or unstable housing conditions. Individuals experiencing homelessness represent one of the most vulnerable groups in developed regions, facing high rates of poorly controlled chronic diseases, smoking-related issues, respiratory conditions, and mental health disorders. These challenges heighten their susceptibility to health risks associated with climate change. As temperatures rise, this already at-risk population will be further impacted by extreme heat events. Moreover, if climate change leads to elevated levels of ground-level ozone, they may endure a substantial increase in disease burden, exacerbating their already precarious health situations (Ramin & Svoboda, 2009).

Mobile Homes

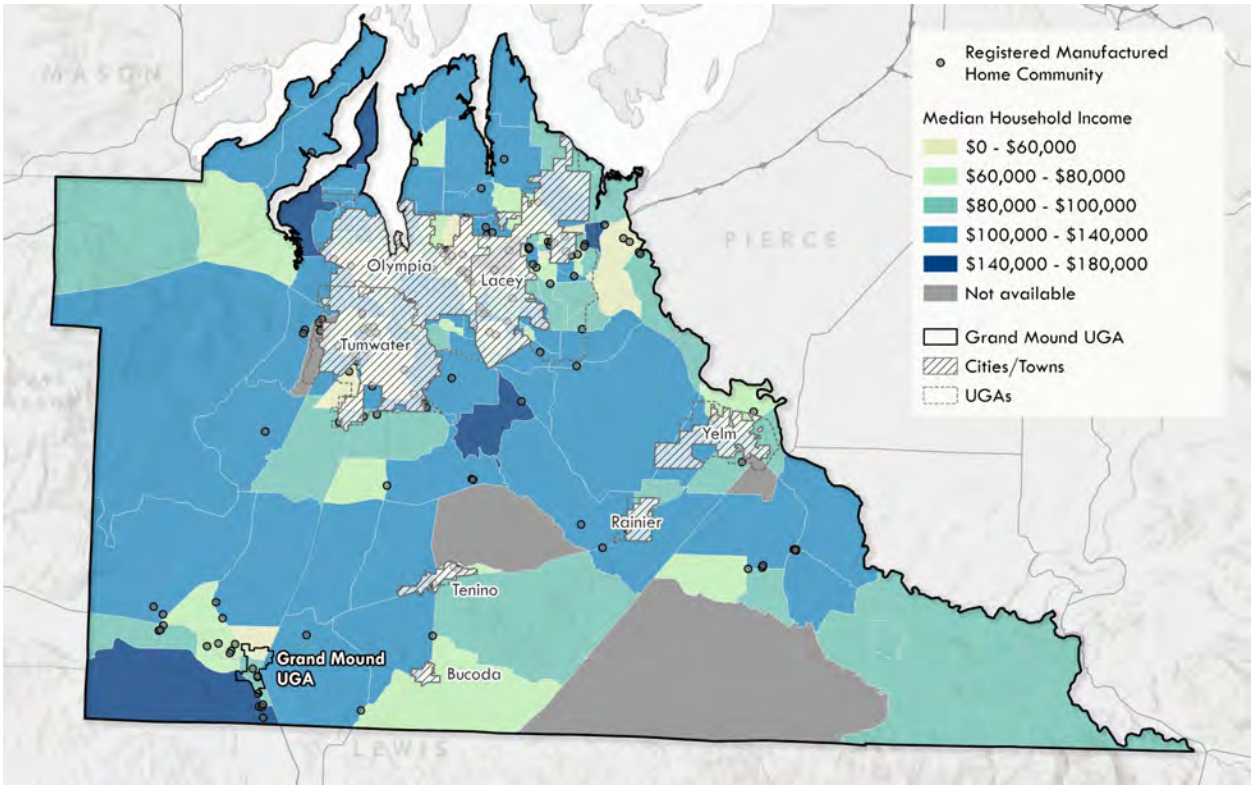
Mobile and manufactured homes are a common type of unsubsidized, affordable housing in Thurston County. Research has found that these structures are commonly located in floodplains (Baker, Hamshaw, & Hamshaw, 2014; Rumbach, Sullivan, & Makarewicz, 2020), an issue that can be exacerbated by climate change. In Washington, approximately 10% of census tracts show both high flood risk and high mobile home density (Headwaters Economics, 2022).

In several states, evictions from mobile home parks are common after floods and other disasters (Raymond, Green, & Kaminski, 2022). Mobile homes often cannot be moved due to the expense, failure to meet minimum codes for alternative locations, or structural integrity issues. In such cases,

the mobile home is sometimes abandoned, and owners simultaneously lose their homes and equity (Headwaters Economics, 2022; Rumbach, Sullivan, & Makarewicz, 2020).

All manufactured or mobile homes installed in Thurston County before June 1, 1983, are deemed to be out of conformance with National Flood Insurance Program (NFIP) requirements. Each person proposing to move a manufactured or mobile home, including a non-conforming manufactured or mobile home, to another location must first obtain a permit and be made to comply with all requirements of Chapter 14.44 of the Thurston County Code prior to their establishment or use on the new site.

Registered Manufactured Home Communities, Thurston County (2024)



Source: Thurston County, 2024; BERK, 2024.

Housing Patterns

Housing Stock

There are approximately 121,470 housing units across the county, with about 36,532 housing units in rural areas and the Grand Mound UGA, or about 28% of the 2023 housing stock. Most housing is in the rural area with almost 5,000 in the subareas of Green Cove in the north, Nisqually Subarea to the east, and Rochester Subarea to the southwest. Almost 500 housing units are in the Grand Mound UGA.

Table IV-3. Dwelling Units by Planning Area (2023)

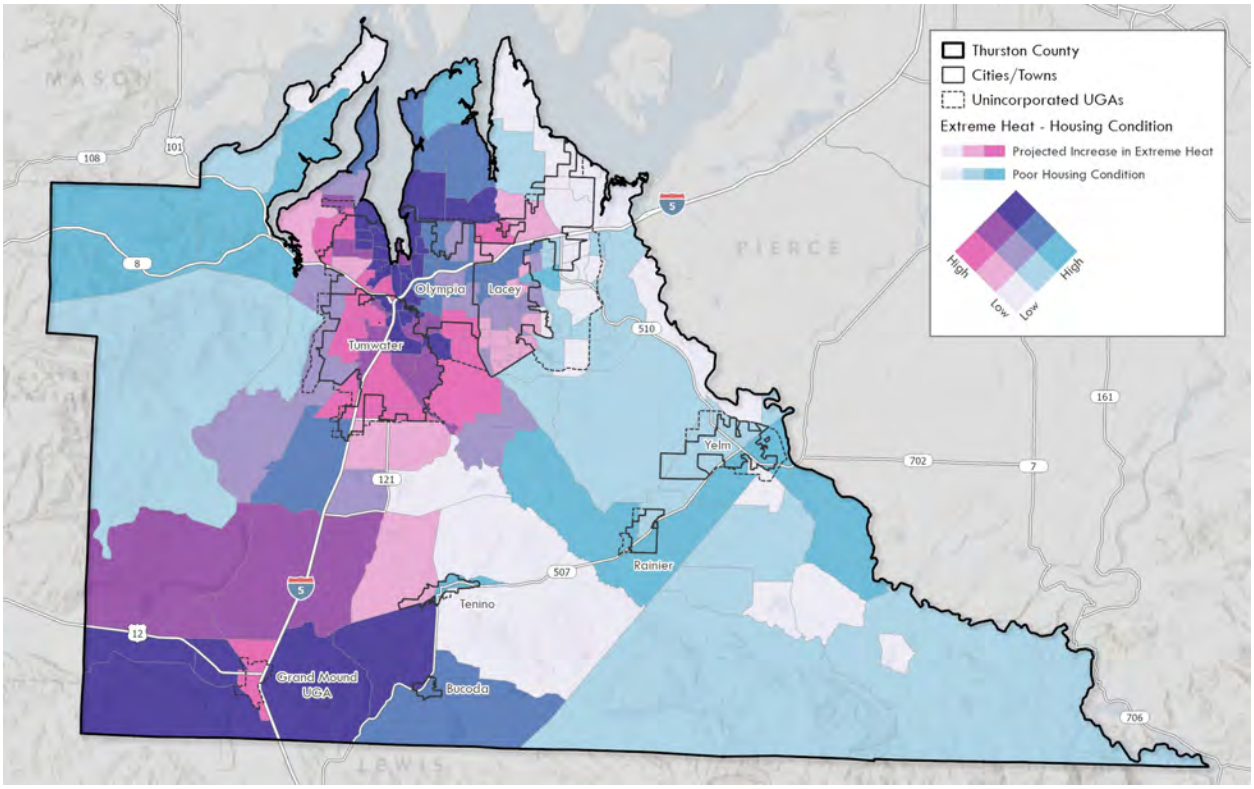
	City	City Associated UGA	Rural	Grand Mound UGA	Reservation	Countywide
Dwelling Units	71,300	22,348	36,058	474	295	121,470
Share	54.6%	17.1%	27.6%	0.4%	0.2%	100%

Source: TRPC, 2024

Households of different housing types face varying degrees of heat risk. Residents of subsidized (Gabbe & Pierce, Extreme Heat Vulnerability of Subsidized Housing Residents in California, 2020), older (White-Newsome, et al., 2012), manufactured (Pierce, Gabbe, & Rosser, 2022), or multifamily rental housing (Gabbe, Mallen, & Varni, 2022), for example, could be at higher risk during hot weather, as they may experience higher exposure to heat and indoor temperatures.

Housing stock built before 1960 typically lacks weatherization that supports energy efficiency, cooling, and air filtration, whereas newer buildings are subject to different energy and building codes that enable these assets to cope and withstand various climate impacts. Thus, residents in older houses are more susceptible to impacts such as power outages, extreme heat, or poor air quality. Most of the housing stock built before 1960 is in the urban areas of Olympia and Tumwater. However, the county has older housing stock in some rural areas along the Puget Sound, Highway 8, and rural areas east of Yelm and Bucoda (Figure IV-31).

Figure IV-31. Extreme Heat and Housing Condition (Built before 1960)



Source: UWCIG, 2022; Assessor, 2024

Along the Chehalis River and Nisqually Delta, the 100-year floodplain is particularly at risk with flooding. Currently in unincorporated Thurston County about 1.1% of over 53,000 structures are exposed to a 100-year flood, and about 2% are exposed to a 500-year flood (Thurston Regional Planning Council, 2024). Unincorporated lands in Thurston County are considered at medium risk for flood hazards in the Hazard Mitigation Plan. Changes or increases in the extent of floodplains due to more frequent or extreme flooding events could affect more residential or non-residential structures.

Downtown Olympia and the rural Nisqually Delta are at risk of up to 5 feet of sea level rise. The number of unincorporated residential structures at risk at as little as 6 inches of sea level rise is 134 residential structures and 19 commercial structures (Thurston Regional Planning Council, 2023).

Wildland-Urban Interface or Intermix

The location of housing beyond urban centers interacts with the impacts from climate change. The WUI is the area where structures and other human development meet or intermingle with undeveloped wildland or vegetative fuels. As wildfire risk increases in these transitional zones, they can inflict extensive damage on housing stock, isolate communities from vital services and amenities, and make timely evacuation more challenging.

About 34.3% of unincorporated Thurston County's population – over 18,500 structures, primarily residential – are at risk of wildfire in the wildland urban interface. And 56.9% of the rural population are exposed in the wildland urban intermix area.

Similar to the evaluation under Extreme Heat, older homes likely lack heating, ventilation and air conditioning (HVAC) that would help keep indoor air clean during smoke events. Thurston County and the Washington State Department of Health have identified techniques to keep indoor air as clean as possible by closing windows and doors, changing filters and settings on air conditioning or HVAC systems during smoke events.

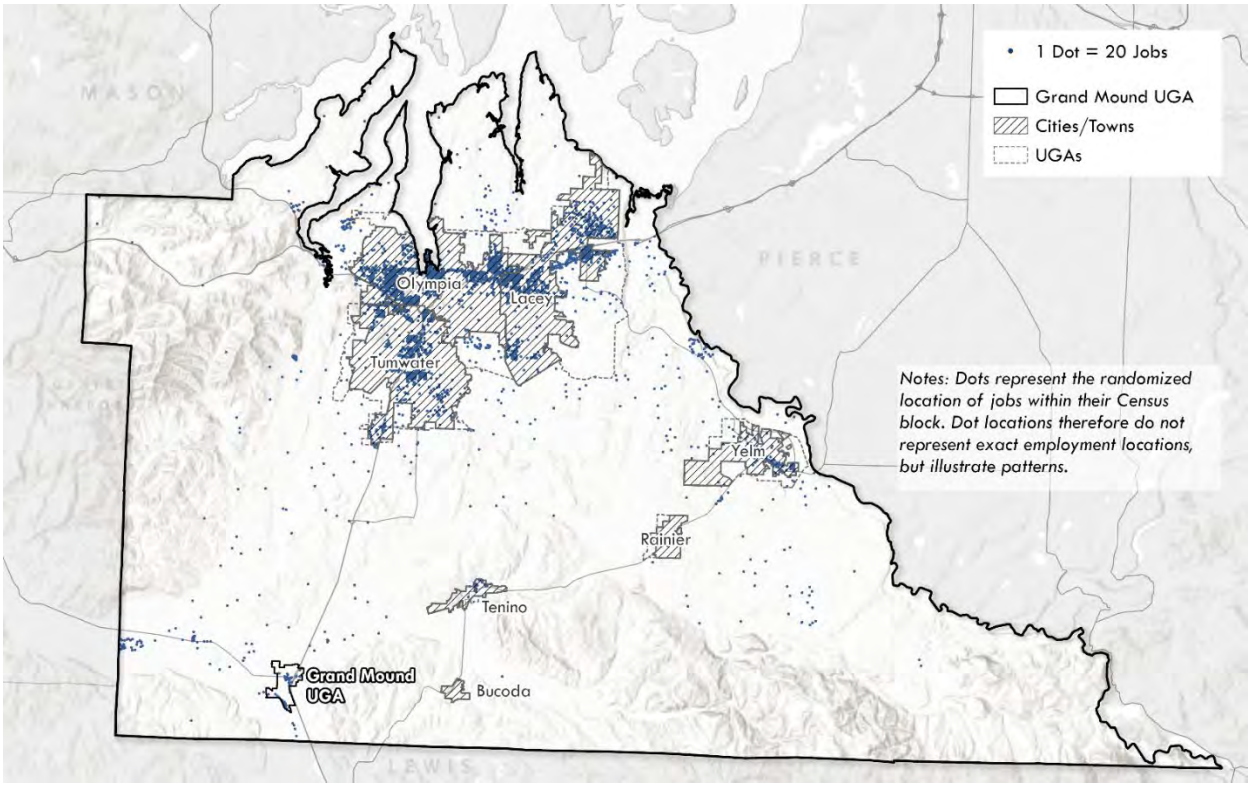
The quality of materials and the types of amenities used in housing design and construction can significantly impact exposure to risks like wildfire smoke. Homes equipped with HVAC systems and air filtration can enhance indoor air quality and lessen exposure to wildfire smoke. However, these measures may not be adequate to fully address the expected rise in wildfire smoke days and the associated increase in fine particulate matter and other pollutants.

BUSINESS AND INDUSTRIAL EMPLOYMENT

Employment and Commerce

In 2021, there were 119,477 people employed in Thurston County. Of these, 51.5% also lived in the county, while the remaining 48.5% lived outside the county. Figure shows the employment locations in Thurston County. In contrast, 46.4% of the Thurston County population worked outside of the county (U.S. Census Bureau, 2021). Pierce, Lewis, King, and Snohomish counties serve as employment hubs for Thurston County residents that work outside the county.

Figure IV-32. Employment location patterns across Thurston County (2021)



Source: U.S. Census Bureau, OnTheMap Application and LEHD Origin-Destination Employment Statistics (Beginning of Quarter Employment, 2nd Quarter of 2002-2021); BERK, 2024.

In 2022, the leading job sectors for the civilian employed population aged 16 and over included educational services, health care and social assistance; public administration; and retail trade (U.S. Census Bureau, 2022). Beyond state, local, federal, and tribal government, Thurston County has many private employers. Of the major employers listed below, the Lucky Eagle Casino & Hotel, the Nisqually Red Wind Casino, and the Great Wolf Lodge are located in the Grand Mound UGA and rural Thurston County. Reliance on commuting for jobs, and the ability of employers to adapt to climate change have implications for resilience described below.

Table IV-4. Major private employers in Thurston County, 2023.

Company	Employees
Providence Health & Services*	2,600
Albertsons/Safeway*	1,200
Walmart*	1,100
Lucky Eagle Casino	1,000
Nisqually Red Wind Casino	700
South Sound YMCA*	550
Continuum Global Solutions	500
Fred Meyer*	500

Company	Employees
Great Wolf Lodge	500
Northwest Cannabis Solutions	500

*Includes multiple locations in Thurston County

Source: (Thurston Regional Planning Council, 2024)

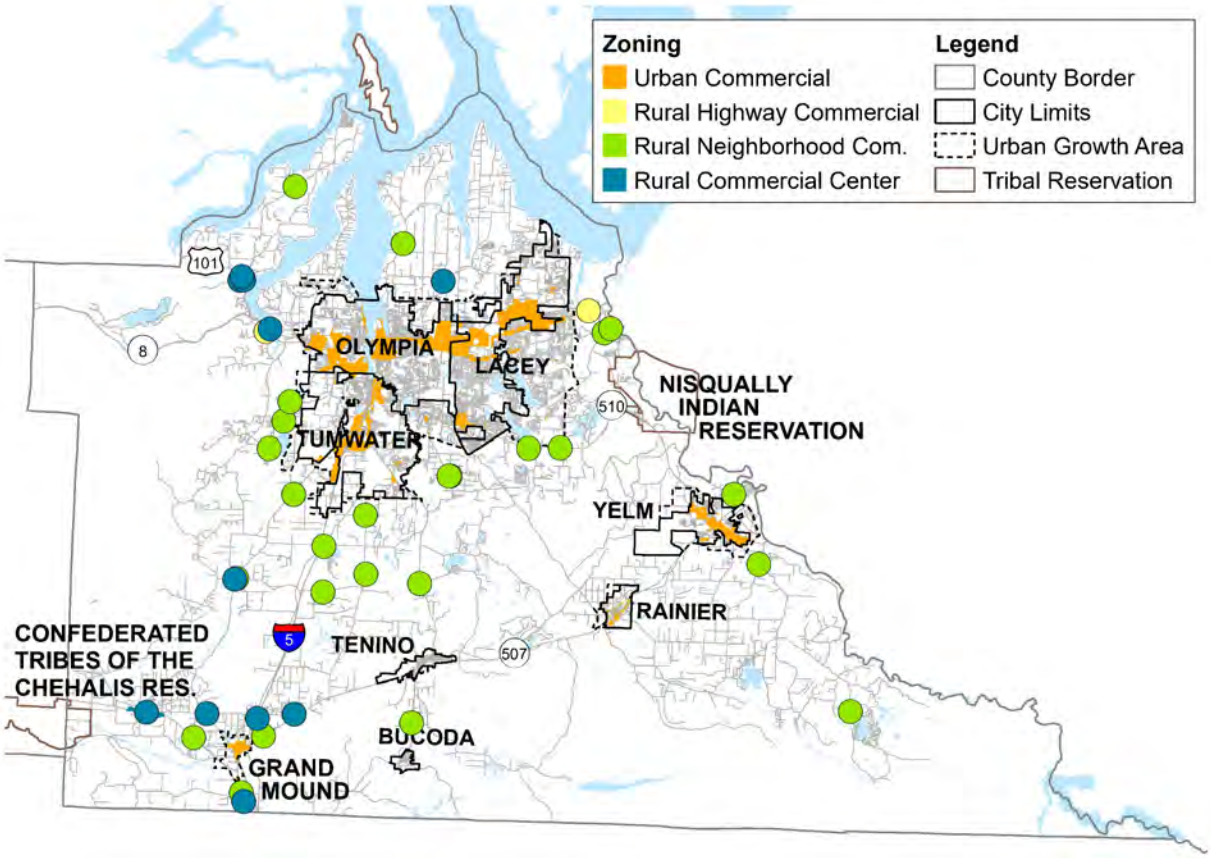
Climate change is expected to amplify the intensity and frequency of extreme events. These events can disrupt the supply chain and decrease the availability of inputs and exports, increasing costs and lowering productivity. Extreme heat will damage sensitive components, cause heat-related worker illness and injury, and decrease productivity. Some opportunities include localization of supply chains and new lower-carbon products and processes that tap new markets and lower costs (Economic Development Research Partners, 2022).

In 2017, the top job sectors in rural Thurston County, including the Chehalis and Nisqually Reservations, were agriculture, forestry, fishing, and mining, as well as professional services and construction. In Grand Mound UGA, the leading sectors were accommodation and food services, retail trade, and professional services (Thurston Regional Planning Council, 2019). Most of these sectors face specific vulnerabilities. Agriculture, forestry, and fishing are susceptible to crop damage, animal deaths (Washington State Department of Ecology, 2022), and infrastructure issues from major weather events, impacting crop production and increasing water demand and insurance costs. Mining and quarrying face risks from fires and floods that can raise operational costs. Construction is affected by wet conditions and weather-related incidents that can delay projects and affect work completion. Accommodation, food services, and retail trade may suffer from changing tourism patterns due to natural landscape degradation and increased temperatures, leading to fewer tourists, reduced revenues, and fewer outdoor activities (International Economic Development Council, 2022). In general, climate change could negatively impact productivity and business investment, as rising temperatures and heat waves could result in lower output per worker and a diminished drive for companies to expand (Congressional Research Service, 2022).

Rural Employment and Commercial Nodes

Rural commercial nodes serving rural residential areas are scattered on urban outskirts and along major roads. Residents in rural areas are more likely to travel a longer distance to a commercial area.

Figure IV-33. Commercial Zoning Nodes



Source: TRPC 2021

Table IV-5. Proximity to Commercial Centers

	Average Distance (Miles) to Commercial Area	Location of Nearest Commercial Center		
		Rural County	North County Urban Area	South County Urban Area
Urban Households	0.3	1%	92%	7%
Rural Households	1.4	76%	14%	11%

Source: TRPC 2021

There is an increased chance of extreme precipitation across the county with about 10% chance of increase along the northern coast, Nisqually Delta, and Yelm in the north and east and up to 18% in the southern and western part of the county by 2050 (Raymond C. M., 2022). In urban areas extreme rainfall could overwhelm stormwater management systems and in rural areas, heavy precipitation can damage crops and cause erosion.

Flooding impacts the community's economy through damage to businesses, utilities, and other infrastructure, and disruption to travel. According to the Thurston County Flood Hazard Mitigation

Plan (Thurston Regional Planning Council, 2017), nearly 265 businesses and 700 jobs were vulnerable to flooding from the 100-year floodplain in unincorporated Thurston County. This represented 2.4 percent of businesses and 2.9 percent of employees.

Businesses rely on infrastructure—energy, transportation, water, waste, and digital communications—for various functions, and failures can lead to significant economic losses and social disruptions. Heavier precipitation is expected to intensify flooding in low-lying areas and require higher capacity storm water drainage systems. Businesses are expected to have more disruptions to operations and damage to infrastructure (Raymond C. M., 2022).

The frequency of the Puget Sound region's heaviest 24-hour rain events (top 1 percent) is projected to increase — occurring about seven days a year by late century, compared to two days a year historically. The intensity of such events is projected to increase as well, making communities more vulnerable to downed trees and power poles, floods, landslides, and water-borne pollution (Thurston Regional Planning Council, 2018). The floods along the Chehalis River at the start of 2022, for example, led to the temporary closure of U.S. Interstate 5 and disruptions to other local highways (Washington State Department of Ecology, 2022). Flooding caused damage to crawl space HVAC systems, first floor structures and contents, and damaged or destroyed outbuildings and septic systems (Thurston Regional Planning Council, 2023). These events illustrate how changes in rainfall patterns and rising sea levels threaten existing infrastructure with flooding risks.

The Hazard Mitigation Plan shows 173 industrial structures in the wildland urban interface with 94 in unincorporated areas, and 32 structures in the wildland-urban intermix with 24 in unincorporated areas. Also 10 sites with hazardous materials and 44 transportation facilities are in the wildland urban interface and intermix areas (Thurston Regional Planning Council, 2023).

Moderate sea level rise will intensify coastal flooding during storms or extreme weather events, which can disrupt business operations and damage property. There are limited industrial structures in the 6-inch sea level rise inundation area, with three in Olympia. None were identified in unincorporated Thurston County. However, some natural resource industries such as aquaculture are located in sea level rise areas and could be affected even where structures are not located.

Employment Uses, Energy, and Commuting

Almost three quarters of industrial square footage was built prior to 2018, and with less stringent energy codes. Large warehouse and distribution centers total 88 percent of the building square footage built since 2018 (Maul Foster & Alongi, Inc., 2023). Industrial and commercial operations use almost half of the electric energy in the county and about a third of natural gas (Thurston Regional Planning Council, 2024).

Industrial growth potential has implications for building and site design and commute patterns. The future development of industrial land is primarily in incorporated areas and UGAs and less in unincorporated areas. However, Grand Mound is an important commercial and industrial employment center in South County.

Table IV-6. Grand Mound Share of Commercial and Industrial Square Feet (2017)

Use Type	Grand Mound UGA Square Feet	Share of South Urban	Share of County Total
Commercial	713,300	31.0%	2.7%
Industrial	153,800	35.0%	1.1%

Source: TRPC 2024

Other resource-based businesses involving aquaculture, agriculture, and forestry are located in resource lands and are addressed in Section I.

Wildfires pose multiple economic risks including lost timber value, home destruction and reduced property values, transportation disruptions, and increased carbon emissions. Climate change is expected to increase both the length of the fire season, and the frequency and area burned by wildfires in Washington. Infrastructure and people located in the WUI are at greatest risk. Lost hours worked, increased transportation disruptions, and mortality and morbidity should all be quantified as part of the economic costs associated with wildfires. Counties in western Washington generally have a much lower likelihood of climate and fuel conditions that can support wildfire in any given year. But the risk is expected to increase. (Climate Impacts Group, University of Washington with IMPACT Center at Washington State University, 2022)

Sea level rise will inundate and impact low lying roads and bridges causing damage to infrastructure. Transportation impacts are disruptive to a community's economy and overall quality of life. Delays will impact transportation across all sectors and trip purposes including personal travel, commutes to work and school, public transit, emergency services, and the movement of freight, goods, and services (Thurston Regional Planning Council, 2023).

I. NATURAL RESOURCE LANDS AND RURAL ECONOMY

Thurston County has a vibrant landscape of natural resource-dependent economies, from agriculture to shellfish to forestry.

AGRICULTURE

According to data collected for the Thurston County Voluntary Stewardship Program, land used for agricultural activities within the county is estimated at 64,000 acres in 2024.In Thurston County, much of the agricultural activities occur in rural areas. Just over 25% of the agricultural land, approximately 15,161 acres, is zoned Long-Term Agriculture or Nisqually Agriculture, lands of long-term commercial significance (Table IV-7).

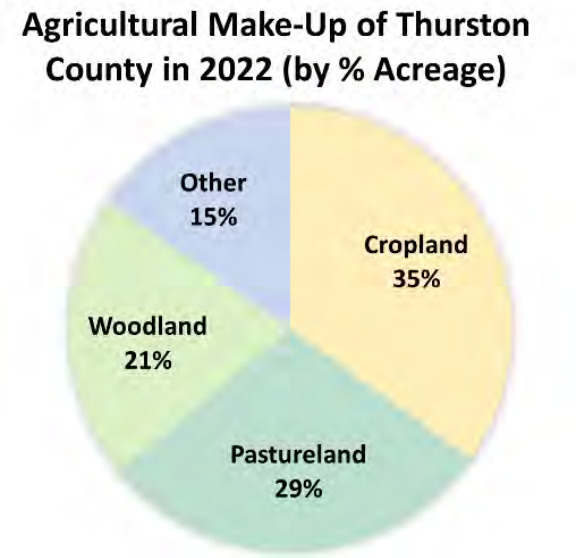
Table IV-7. Land use by zoning in Thurston County as of March 2024

Land Use Designation	Acreage
Nisqually Agriculture	938 acres
Long-Term Agriculture	14,223 acres

Source: Thurston County 2024.

The makeup of agriculture is cropland, pastureland, woodland, and other. See Figure IV-34.

Figure IV-34. Land use by zoning in Thurston County as of March 2024



Source: USDA Census of Agriculture, 2022; Thurston County 2024.

Property in agricultural activity (over 64,000 acres per VSP program) can intersect critical areas. Existing ongoing agriculture can voluntarily participate in the Thurston County Voluntary Stewardship Program (VSP). The County established a VSP work group made up of producers, environmental, and tribal participants who developed a work plan approved by the State Conservation Commission in 2017. The work plan contains measurable goals and benchmarks that are evaluated every 5 years. Goals and benchmarks are meant to address the protection and enhancement of critical areas while encouraging agricultural viability. With this work plan, and monitoring illustrating the goals and benchmarks are met in each watershed, County critical areas regulations developed under GMA would not apply. The intersect of agriculture with critical areas and high-resolution change detection (tree canopy, visible water, land cover) is shown in Table IV-8 below.

Table IV-8. Intersection of the Voluntary Stewardship Program (VSP) Agriculture and Critical Areas with High Resolution Change Detection (HRCD) Areas (2021)

Water Resource Inventory Area (WRIA)	WRIA #	Total Wetland Acres of Intersect	Total Wildlife Acres of Intersect	Total Geologic Hazards Acres of Intersect	Frequently Flooded Areas Acres of Intersect
Nisqually	11	1,566	803	2,627	803
Chehalis	22 / 23	2,780	2,260	1,844	2,260
Deschutes	13	999	511	755	511
Kennedy-Goldsborough	14	148	117	107	117
Total Acres		**5,493**	**3,691**	**5,333**	**3,691**

Note: High resolution change detection products include 1) tree canopy, 2) visible surface water, and 3) land cover.

Source: High Resolution Change Detection - Washington Department of Fish and Wildlife, and Thurston County, 2024.

The VSP Program addresses agricultural lands that intersect critical areas defined by GMA (WAC 365-190) and the County. The VSP program, while helpful in identifying conservation practices that protect critical areas, does not substitute for federally designated endangered species. Producers are also called to protect endangered species and habitats such as prairie and oak woodlands and species dependent on them per the Thurston County Habitat Conservation Plan (Thurston County, 2022). Producers are employing conservation grazing, water efficiency, and other conservation practices to address agricultural viability and ecosystem concerns.

Water conservation, water rights, and climate change effects on water infrastructure were issues noted by South Sound Agricultural Producers including Thurston and Lewis counties. (WSU Extension, 2016)

Crops

Thurston County producers reach county residents at farmers markets in Olympia, Tumwater, Lacey, Tenino and Yelm. Direct sales are made to schools and hospitals. (WSU Extension, 2024)

High value crop types in the county (Washignton State Department of Agriculture, 2024) include:

- Berries: Blueberries, strawberries, caneberries
- Vegetables: Market crops, pumpkins, corn, cabbage
- Commercial Tree Farms and Silviculture; Conifer Seeds

Natural resource-dependent industries will be impacted by climate change in a variety of ways. While warmer temperatures will extend growing seasons for some crops, climate change is expected to affect crop quality and quantity for most crops, affecting agricultural revenues for farmers and ranchers, and potentially hampering food systems. Drought could lead to soil erosion, and greater reliance on groundwater. In turn this could exacerbate saltwater intrusion in wells in coastal areas (Thurston Regional Planning Council, 2018).

Varietal crops such as fruits and vegetables may experience sunburns that affect produce quality and market revenues (Chang, et al., 2023; Thurston Regional Planning Council, 2018; Mauger, et al., 2015). Crop yields could be affected by extreme weather events. Associated pollinator loss could reduce yields of pollinator dependent fruits, vegetables, and nuts. Climate change impacts could also limit the availability of vitamin and mineral-rich foods important for healthy diets (Semba, Askari, Gibson, Bloem, & Kraemer, 2022)

Livestock

About 78% of the county's $190M in agricultural production was for livestock or poultry production (United States Department of Agriculture, 2022) . About 396 of the 1,108 farms have cattle and calves, primarily as beef cows. Other livestock (hogs/pigs, sheep, layers/broilers) are located on about 381 farms.

Warmer temperatures can reduce the nutritional quality of forage and pasture lands, which comprise of approximately one-third of agricultural lands in the county. Pasture and forage quality could in turn impact agricultural operation costs and livestock health. Additionally, cattle livestock typically experience heat stress when temperatures exceed 78°F, and more humid weather can exacerbate this (Kerr, 2015).

With beef cows being a primary livestock in the county, supporting infrastructure in the form of slaughter and meat processing has been a concern for the central and south Puget Sound. Providing shade and cooling options, including agroforestry practices, can also enable a more resilient livestock industry. Recommendations for Pierce and Thurston Counties include investing in fixed

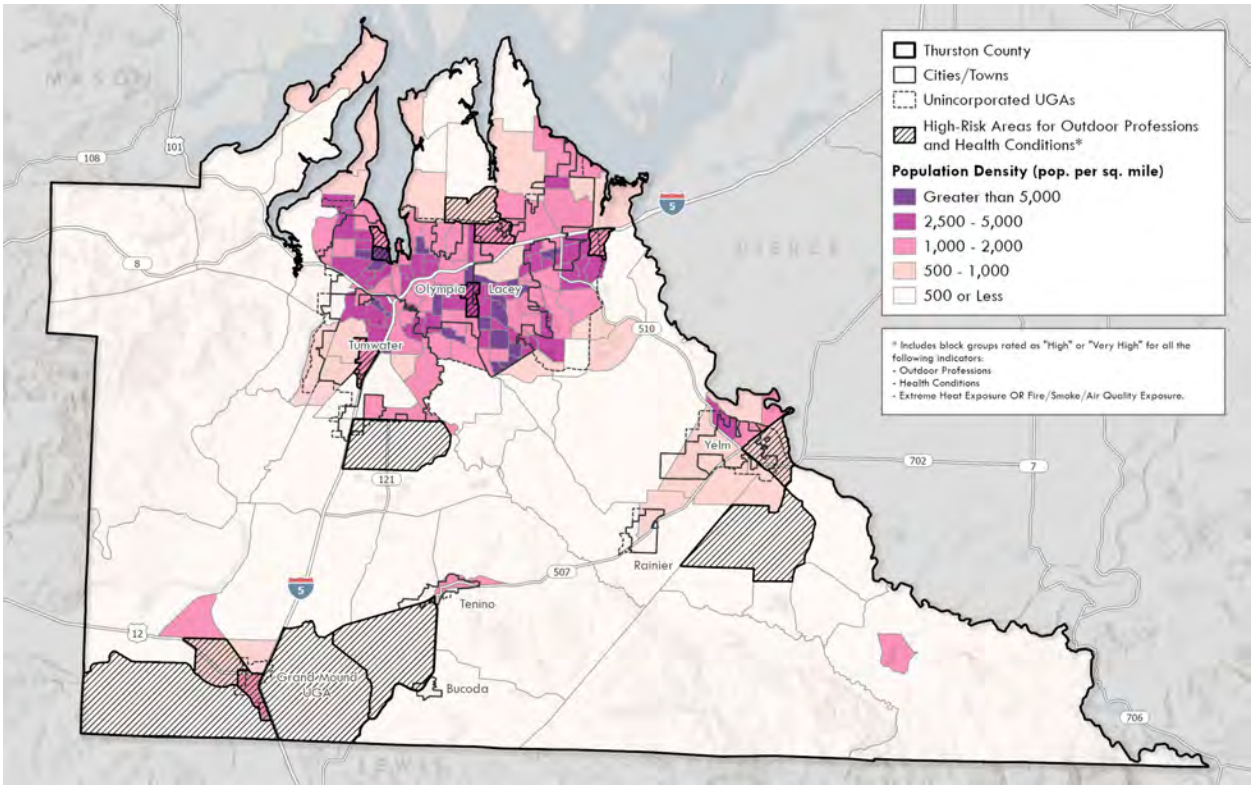
and mobile slaughter/processing facilities among other workforce, education, and funding activities (Maul Foster and Alongi, 2023).

Livestock would also be vulnerable to flooding and wildfire. Thurston County partnered with non-profits and others to promote emergency response plans for animals, barns, and agricultural facilities. State agencies provided funding for flood hazard reduction projects (Washington State Department of Ecology, 2022).

Farmworkers

Farm employment varied between 1,650 and 2,700 jobs between 2001 and 2022, most recently landing at 2,311 in 2022. Farm proprietors have been stable from 2021 to 2022 and stand at 1,143. Other outdoor professions include forestry at about 989 in 2022 and construction at 9,011 (Thurston Regional Planning Council, 2023). Outdoor workers are vulnerable to wildfire smoke and air pollution and to extreme heat. Unincorporated areas with outdoor workers and people with health risks are found in both northern and southern parts of the county. Census blocks that have a combination of High or Very High Outdoor Professions (natural resources, construction), Health Conditions, and exposure to Extreme Heat or Fire/Smoke/Air Quality are shown on Figure IV-35. A number of blocks are found in South County in the Grand Mound or Yelm Area with lower population densities consistent with rural and resource lands, as well as in the north part of the county where there is greater population density and construction-related jobs.

Figure IV-35. High-Risk Areas for Outdoor Professions



Sources: US Census, CDC Places, BERK 2024.

FISHERIES

Land based fish farms are found in Thurston County, including salmon and trout hatcheries. The upland fisheries are primarily operated by WDFW in Thurston County. Tribal fisheries are nearby at the Nisqually reservation east of the county boundary. These fisheries operations rely on clean water from shallow aquifers to raise fish, allowing for the consistent and sustained growth of the fish. There are also several natural populations of Chinook and Steelhead within Thurston County, including three federally threatened populations (Thurston County, 2020).

Table IV-9. Hatchery Facilities

Name	Address	Operator	Fish Type
Skookumchuck	Post Office Box 149 Tenino, WA 98589	WDFW	Steelhead, Coho
Tumwater Falls	114 Deschutes Way SW Tumwater, WA 98501	WDFW	Chinook
Nisqually Trout Farms, Inc.	5780 Martin Way E. , Lacey	Private	Trout, Carp
Clear Creek Hatchery	Reservation, East of County Boundary	Nisqually Indian Tribe	Salmon

Sources: (Nisqually Tribe; Nisqually Trout Farms; Wildlife; Washington Department of Fish & Wildlife, 2024; US Fish & Wildlife Service, 2023)

The frequency or magnitude of extreme precipitation events could damage fisheries infrastructure. In a 2021 WDFW climate change risk assessment, extreme precipitation and riverine flooding were identified as potential climate impacts for fisheries. For example, in 2006, record rainfall during an atmospheric river event caused an estimated one million dollars in damage to WDFW fish hatcheries and other facilities in 13 western Washington counties. Runoff debris clogged hatchery intake pipes, increased sediment loads clogged water filters, and flooded creeks transported downed logs which damaged dams and fish ladders. As watersheds become increasingly rain-dominant with warming, winter streamflow is projected to increase across Washington. This is likely to exacerbate the incidence of damage to agency lands and infrastructure during flood events.

The potential for drought, warming waters, decreasing water quality, and low stream flows could also affect fish mortality (USFWS, 2023). Warming waters could lead to increasing disease to fish hatchery stock. A state drought in 2015 and reduced snowpack caused more than 12 of 83 state fish hatcheries to experience high water temperatures or low water (Shirk, Morgan, Krosby, Raymond, & Mauger, 2021).

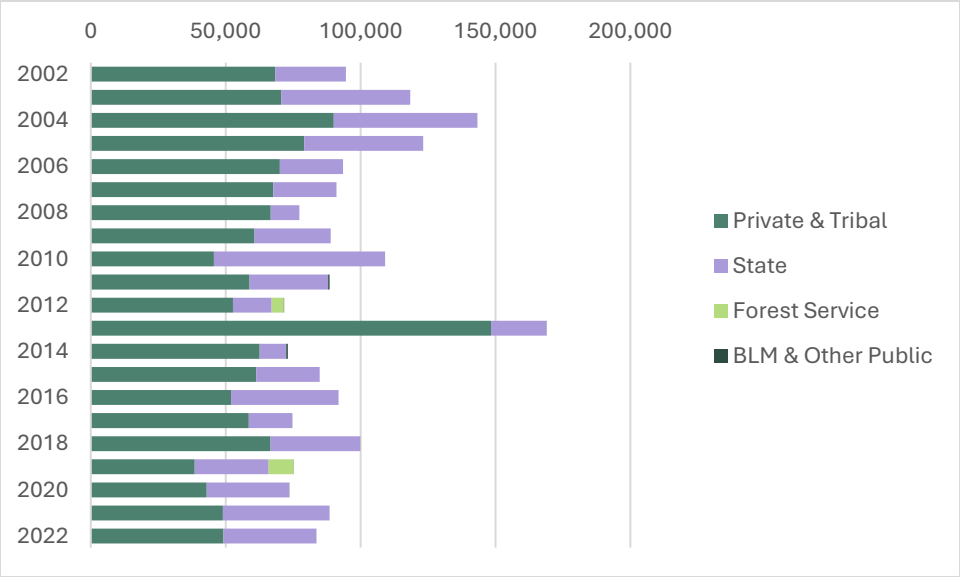
Where there is a potential of loss of sensitive species, there may be more of a need for captive breeding or rearing such as rearing salmon in state hatcheries (Shirk, Morgan, Krosby, Raymond, & Mauger, 2021).

FORESTRY

Forests cover over 40% of the county's area, but they have declined by more than 41,000 acres between 1992 and 2011; however, between 2011 and 2016, there was a small increase in forestland counter to previous losses (Thurston Regional Planning Council, 2024). Designated forest lands of long-term commercial significance make up about 31% of zoned land (see Table IV-7. Land use by zoning in Thurston County as of

Timber harvest has varied from around 70,000 to 168,962 thousand board feet, with a median of 88,939 between 2002 and 2022. The principal activity has been with private and tribal commercial forests (see Figure IV-36. Timber Harvest (thousand board feet) for Thurston County, Washington).

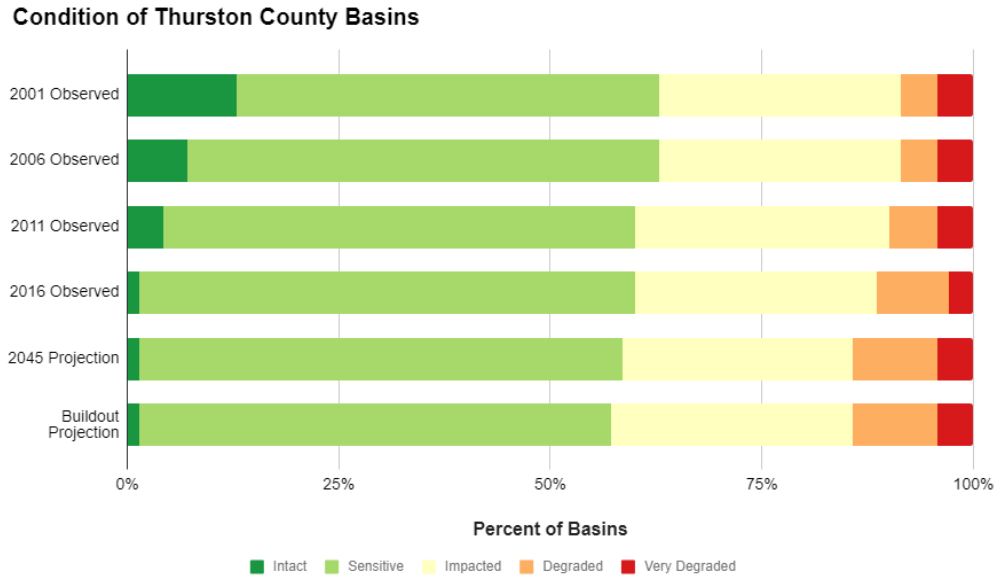
Figure IV-36. Timber Harvest (thousand board feet) for Thurston County, Washington



Sources: Washington State Department of Revenue, 2022; University of Montana, Forest Industry Research Program, 2024; BERK, 2024.

Based on a review of percent forest cover, riparian cover, and impervious surfaces, the number of intact basins has decreased, and the number of sensitive and degraded basins have increased in the same period. Greater degradation is projected by 2045 (see Figure IV-37. Thurston Basin Conditions - Forestland and Impervious area, Historic, Current, Projected).

Figure IV-37. Thurston Basin Conditions - Forestland and Impervious area, Historic, Current, Projected



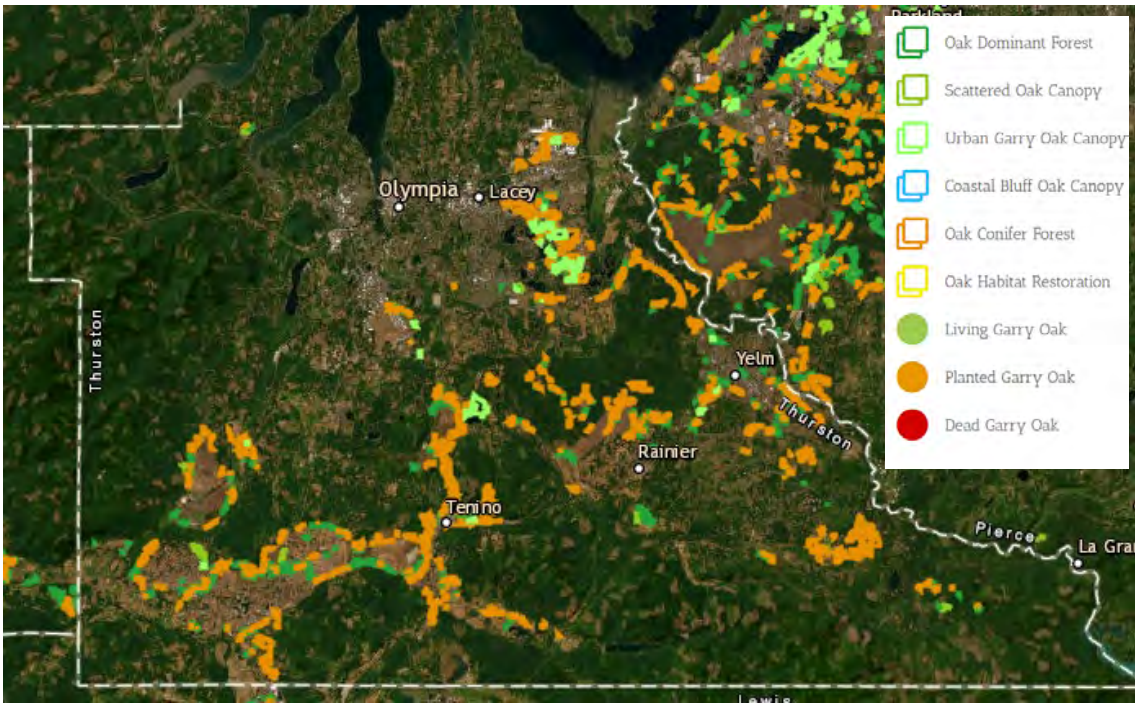
Source: Thurston Regional Planning Council (2021)

Forest growth could be hindered by summer moisture stress, wildfire, invasive species, and insects (Raymond, Morgan, Peterson, & Halofsky, 2022). Some notable findings of the Thurston Climate Adaptation Plan (2018) include:

- Hotter, drier summers will likely decrease the extent of suitable habitat for Douglas-fir trees, especially in South Puget Sound lowlands.
- Increased water stress associated with such hotter, drier summers may in turn lead to higher tree mortality (in forests and landscaped urban areas) and more intense fires.

Shifts in seasonal temperature and precipitation could alter the range of Oregon white oak (Garry oak), Douglas-fir and other species and lead to pest and disease outbreaks (Mauger, et al., 2015; Thurston Regional Planning Council, 2018). Oregon white oak are tolerant to disease, drought and periodic wildfire may facilitate sprouting of oak, but frequent fire could damage soil and allow for invasive species (Hudec, Halofsky, Peterson, & Ho, 2019).

Figure IV-38. Oregon White (Garry) Oaks in Thurston County



Source: Washington DNR, Garry Oak Society, 2024

V. CONSIDERATIONS FOR COMPREHENSIVE PLAN

The intent of this climate vulnerability assessment is to develop meaningful policies and strategies rooted in the scientific evidence base.

The following matrix details opportunities to leverage existing strategies or develop new strategies to adapt to climate change impacts related to the findings of this vulnerability assessment. The strategies are organized by Sector. Strategies are drawn from authors' recommendations based on scientific and professional literature, existing activities by County or State agencies that could be leveraged, the 2023 TRPC Hazard Mitigation Plan (Thurston Regional Planning Council , 2023), the December 2023 Commerce Climate Planning Guidance (Washington State Department of Commerce, 2023), particularly the Menu of Measures, and other sources. The relevant exposure is noted.

The strategies are also linked to the draft Climate Element resilience policies that are under development with the county's Comprehensive Update (as of November 18, 2024). The county's role in developing or implementing strategies is noted. The county is responsible for regulations or incentives in unincorporated areas, and in some locations is the primary provider of infrastructure or public services. In other respects, the county has a role that is countywide (e.g. public health, emergency management) but with cooperation with other agencies such as the cities or state. The county is often a partner agency contributing its expertise or resources (e.g. watershed plans).

Table V-1. Adaptive Capacity Strategies Matrix

Sector	Strategies/Ideas for Implementation	Exposure	Related Draft Climate Element Policy	County Role
Human Wellbeing and Public Services				
Physical Health: Air Quality	Potential New Strategies • Prioritize at-risk community members for actions that mitigate wildfire smoke, including providing personal protective equipment and filter fans or incentivizing infrastructure updates (e.g., HVAC updates and MERV 13 filters for air intake) for facilities that serve high-risk populations. (Menu of Measures) • Develop and implement notification alerts within the community to the reduce risk exposure to wildfire smoke and particulate matter. (Menu of Measures) • Develop and implement a wildfire smoke resilience strategy in partnership with local residents, emergency management officials, regional clean air agency officials, and other stakeholders. (Menu of Measures)	Wildfire, Extreme Heat (PM 2.5 and Ozone)	CL-5.A.2 Develop community-based resilience hubs, prioritizing access for at-risk populations, to support residents and coordinate the distribution of resources and services before, during, and after a hazard event. CL-5.B.1 Support enhanced data collection for climate hazard events to provide a fuller understanding of the community's hazard characteristics—including identifying demographic groups/community members most vulnerable to climate impacts such as extreme heat, flooding, and wildfire.	☐ Regulate/ Incentivize ☐ Manage infrastructure or public services ☒ Convene/ Coordinate ☒ Partner
Physical Health: Extreme Heat	Potential New Strategies Support the Hazard Mitigation Plan mitigation (CW-WH-2) to develop an Extreme Heat Incident Response and Illness Prevention Plan (Thurston Regional Planning Council , 2023).	Extreme Heat	See CL-5.A.2 and CL-5.B.1 above.	☐ Regulate/ Incentivize ☐ Manage infrastructure or public services ☒ Convene/ Coordinate

Sector	Strategies/Ideas for Implementation	Exposure	Related Draft Climate Element Policy	County Role
				☒ Partner
Physical Health: Extreme Heat	Potential New Strategies • Ensure that all community members have equitable access to green space within a half-mile in unincorporated UGAs and LAMIRDs. (Menu of Measures + county location priorities)	Extreme Heat	CL-7.A.4 Establish incentives and regulations to maintain open space buffers to increase resilience to climate impacts such as heat island effects, flooding, and wildfires.	☒ Regulate/ Incentivize ☒ Manage infrastructure or public services ☐ Convene/ Coordinate ☐ Partner
Infectious Diseases, Soil Borne	Potential New Strategies • For potential increases in soil-borne diseases, work in tandem with the Clean Air Agency and Conservation District to test soils and mitigate dust from soil and implement erosion control measures (Northern Arizona University Center for Health Equity Research, 2023).	Cross-cutting	None	☒ Regulate/ Incentivize ☐ Manage infrastructure or public services ☐ Convene/ Coordinate ☒ Partner
Diseases, Mental and Community Health	Potential New Strategies • Per the Fifth National Climate Assessment, "focusing on equity, proactively addressing mental health needs, and linking to community health resources such as community health workers and long-term support and services can create a climate-resilient health system" (Hayden, et al., 2023) . The county could support health care systems to facilitate vulnerability and resilience efforts, such as via the US Department of Health and Human Services' Sustainable and Climate Resilient Health Care Facilities Initiative.	Cross-cutting	GOAL 5: Protect community health and well-being from the impacts of climate-exacerbated hazards to promote environmentally just outcomes and ensure that the most vulnerable residents do not bear disproportionate health impacts.	☐ Regulate/ Incentivize ☐ Manage infrastructure or public services ☒ Convene/ Coordinate ☒ Partner
Ecosystems & Water Resources				
Geologic Hazards	Existing Strategies to Leverage • Upgrade undersized roadway culverts to allow fish passage and debris flow.	Flooding, Extreme Precipitation	CL-2.A.3 Relocate or retrofit low-lying roads, pedestrian and bicycle	☒ Regulate/ Incentivize

Sector	Strategies/Ideas for Implementation	Exposure	Related Draft Climate Element Policy	County Role
	Potential New Strategies • Evaluate the costs and benefits of raising road and bridge surface levels. • Implement and encourage measures to reduce sedimentation in streams resulting from wildfire damage and the associated impacts of landslides and flooding. (Menu of Measures)		trails, rail systems, and bridges vulnerable to coastal or inland flooding and repetitive flooding and/or landslides.	☒ Manage infrastructure or public services ☐ Convene/ Coordinate ☐ Partner
Fish and Wildlife Habitat Conservation Areas	Existing Strategies to Leverage • Implement actions identified in watershed, riparian ecosystem restoration, and salmon recovery plans to improve the climate resilience of streams and watersheds. (Menu of Measures); (Washington State Department of Ecology, 2023; Northwest Hydraulic Consultants Inc., 2020; Thurston Regional Planning Council, 2018). • Restore the structure and function of streams and floodplains to increase habitat climate resilience for cold-water fish (Menu of Measures); (Washington State Department of Ecology, 2023; Northwest Hydraulic Consultants Inc., 2020; Thurston Regional Planning Council, 2018). • Protect and restore wetlands and corridors between wetlands to provide biological and hydrological connectivity that fosters resilience to climate impacts. (Menu of Measures) • Increase aquatic habitat resilience to low summer flows by increasing water residence time, storing water on the landscape, conserving water, protecting groundwater, keeping waters cool, and protecting water quality. (Menu of Measures) • Promote wildlife habitat corridors to improve the resilience of habitat networks and help facilitate species range shifts and improve population demographics. Mitigate migration barriers in terrestrial habitats and streams (Shirk, Morgan,	Cross-cutting	CL-7.A.1Ensure no net loss of ecosystem composition, structure, and functions, especially in Priority Habitats and Critical Areas, such as prairie habitat, biodiversity corridors, habitat for anadromous fisheries, and others. When possible, striving for net ecological gains should be the standard to maintain ecological functions and resilient ecosystems.	☒ Regulate/ Incentivize ☒ Manage infrastructure or public services ☒ Convene/ Coordinate ☒ Partner

Sector	Strategies/Ideas for Implementation	Exposure	Related Draft Climate Element Policy	County Role
	Krosby, Raymond, & Mauger, 2021). Work with multiple agencies to implement recommendations stemming from the Washington Connected Landscapes Project (2024). Consider regulatory buffers, incentives, easements, and other measures to create corridors.			
Prairie and Related Endangered Species	Existing Strategies to Leverage • Per the HCP, there is little data on how climate changes might affect HCP Covered Species, but the HCP intends to adaptively respond to conditions such as altered hydrology and changes to fire frequency. Specific measures to consider climate change are required in the Site Management Plan for each Conservation Land engaged/enrolled in the Conservation Program of the HCP. Climate change is also included as an adaptive management trigger in HCP Chapter 6: Monitoring and Adaptive Management.	Cross-cutting	CL-7.A.1 Ensure no net loss of ecosystem composition, structure, and functions, especially in Priority Habitats and Critical Areas, such as prairie habitat, biodiversity corridors, habitat for anadromous fisheries, and others. When possible, striving for net ecological gains should be the standard to maintain ecological functions and resilient ecosystems. CL-7.A.6 Protect and restore natural ecosystems that sequester and store carbon, such as forests, wetlands, prairies, and estuaries.	☒ Regulate/ Incentivize ☐ Manage infrastructure or public services ☐ Convene/ Coordinate ☐ Partner
Oak Habitat	Potential New Strategies • Managed burning can help restore degraded oak habitat. Cut oaks only for stand enhancement. For	Wildfire, Drought	OBJECTIVE 7B: Create and support natural resource management	☒ Regulate/ Incentivize

Sector	Strategies/Ideas for Implementation	Exposure	Related Draft Climate Element Policy	County Role
	mixed oak/conifer stands allow selective cutting to reduce fragmentation, limit conifer encroachment, and benefit structural and vegetative species diversity within oak forests. Encroaching conifers within oak groves should be thinned, although conifers adjacent to these stands should be retained for wildlife.		plans that address existing stressors to forests and prairies, considering climate change impacts and integrating adaptive management principles.	☐ Manage infrastructure or public services ☐ Convene/ Coordinate ☐ Partner
Shellfish	Existing Strategies to Leverage • Enhanced marine vegetation (e.g., eelgrass) and reduced polluted runoff can help sustain local fisheries. Shellfish operations filter water and can allow more sunlight benefiting eelgrass. Kelp and eelgrass can decrease acidity and benefit shellfish (USDA Northwest Climate Hub, n.d.).	Ocean Acidification	CL-7.A.7 Identify, protect, and restore submerged aquatic vegetation (eelgrass, kelp, etc.) and ecosystems that provides aquatic habitat, "blue" carbon storage, or other ecosystem services.	☒ Regulate/ Incentivize ☐ Manage infrastructure or public services ☐ Convene/ Coordinate ☐ Partner
Water Resources: Surface and Groundwater	Existing Strategies to Leverage Deploy adaptive strategies to ensure the sustainability of both surface and groundwater resources. Water use limitations and water management rules for domestic-use wells already differ among different watershed areas but can be updated to better reflect changes in precipitation and streamflow. Identify and implement strategies to prepare for and mitigate the effects of saltwater intrusion into aquifers and drainage systems. (Menu of Measures) Potential New Strategies • Develop and implement a comprehensive drought resilience strategy that factors in projected climate impacts and sets action levels for different drought stages. (Menu of Measures)	Drought, Extreme Precipitation, Sea Level Rise (Saltwater Intrusion)	CL-4.A.6 Develop approaches to forecast surface and groundwater water quantities at the subwatershed and watershed scale.	☒ Regulate/ Incentivize ☒ Manage infrastructure or public services ☐ Convene/ Coordinate ☐ Partner

Sector	Strategies/Ideas for Implementation	Exposure	Related Draft Climate Element Policy	County Role
Water Resources: Stormwater	Existing Strategies to Leverage • Manage water resources sustainably in the face of climate change through smart irrigation, stormwater management, preventative maintenance, water conservation and wastewater reuse, plant selection, and landscape management. (Menu of Measures) • Develop and maintain a fund to build green infrastructure projects that help capture, filter, store, and reuse stormwater runoff. (Menu of Measures)	Drought, Extreme Precipitation, Sea Level Rise	CL-4.B.1 Encourage stormwater techniques, including infiltration where feasible, that enhance climate resilience for legacy development where stormwater facilities do not exist or are substandard. CL-4.B.2 Ensure that the county's codes support stormwater management plans, infrastructure designs, and operation and maintenance standards to account for projections in increased precipitation, storm intensities, duration, and stormwater runoff volumes as well as drought conditions. CL-4.B.3 Manage stormwater runoff through actions to protect, acquire, sustainably manage, or restore natural and modified ecosystems to help mitigate climate change-related impacts	☒ Regulate/ Incentivize ☒ Manage infrastructure or public services ☐ Convene/ Coordinate ☐ Partner

Sector	Strategies/Ideas for Implementation	Exposure	Related Draft Climate Element Policy	County Role
			on water quality, water supplies, and instream flows. CL-4.B.4 Developed water should be protected primarily as instream flow and be made available for other purposes based on prevailing annual conditions.	
Infrastructure				
Energy Systems	Potential New Strategies • Work with energy utilities to improve the safety and reliability of infrastructure vulnerable to climate change. (Menu of Measures) • Install distributed renewable energy generation and battery infrastructure at public facilities to store renewable electricity generated on site and provide emergency power that ensures continuity of operations. (Menu of Measures) • Require new subdivisions in unincorporated UGAs to bury electricity transmission lines and associated infrastructure to reduce damage from storms and wildfire ignition risks. (Menu of Measures) • Maximize renewable energy sources for the supply of electricity and heat to new and existing buildings. (Menu of Measures) • Develop local microgrid solar and battery storage facilities in low-impact sites. (Menu of Measures)	Extreme Heat, Wildfire	OBJECTIVE 1C: Reduce energy use and support decarbonization in new and existing residential, commercial, and government buildings. OBJECTIVE 1D: Increase the production of local renewable energy.	☒ Regulate/ Incentivize ☒ Manage infrastructure or public services ☐ Convene/ Coordinate ☐ Partner

Sector	Strategies/Ideas for Implementation	Exposure	Related Draft Climate Element Policy	County Role
Transport-ation	Potential New Strategies • Support the Hazard Mitigation Plan (CW-MH-4)) to develop a Regional Transportation Resiliency Plan: Identify and map "lifeline" transportation routes that are critical for regional mobility, public safety, and economic resiliency. A plan will guide long-term transportation infrastructure strengthening projects (Thurston Regional Planning Council , 2023). • Increase resilience to landslides by protecting roads and structures from higher landslide frequency, and reduce management activities that increase landslide potential (USDA Climate Hubs) • Incorporate hydrologic climate impacts into the design of water-crossing structures (i.e., climate-smart culverts and bridges) for fish passage and habitat quality. (Menu of Measures) • Reduce stormwater impacts from transportation and development through watershed planning, redevelopment and retrofit projects, and low-impact development. (Menu of Measures) Existing Strategies to Leverage • Design and site new and expanded roads and railroads to have the least possible adverse effect on the shoreline, account for sea-level rise projections, not result in a net loss of shoreline ecological functions, or adversely impact existing or planned water-oriented uses, public access, and habitat restoration and enhancement projects. (Menu of Measures) • Improve street connectivity and walkability, including sidewalks and street crossings, to serve as potential evacuation routes. (Menu of Measures)	Extreme Precipitation, Flooding, Sea Level Rise	CL-2.A.1 Continue to support the development of the Thurston Regional Planning Council Regional Transportation Plan, ensuring the integration of local climate impacts risk assessment into planning efforts. CL-2.A.2 Conduct audits of existing transportation systems to identify and address accessibility gaps among overburdened and vulnerable populations. CL-2.A.3 Relocate or retrofit low-lying roads, pedestrian and bicycle trails, rail systems, and bridges vulnerable to coastal or inland flooding and repetitive flooding and/or landslides.	☒ Regulate/ Incentivize ☒ Manage infrastructure or public services ☒ Convene/ Coordinate ☐ Partner

Sector	Strategies/Ideas for Implementation	Exposure	Related Draft Climate Element Policy	County Role
Community Design, Land Use & Economic Development				
Building & Zoning	Existing Strategies to Leverage • Consider a reduced growth share in rural areas that could reduce impacts to ecosystems and reduce exposure to climate hazards such as homes in the WUI or flood hazard areas. This could also focus more growth in UGAs like Grand Mound or small south county cities offering more services for rural residents.	WUI, Flood	CL-1.A.3 Support and maintain a stable urban growth area to reduce development pressure on rural and resource lands.	☒ Regulate/ Incentivize ☐ Manage infrastructure or public services ☐ Convene/ Coordinate ☐ Partner
Housing Patterns & Affordability	Existing Strategies to Leverage • Provide a greater quantity and variety of housing in urban hubs and along transit corridors, paired with anti-displacement policies to preserve affordability.	Cross-cutting	OBJECTIVE 2B: Prioritize development to increase housing diversity and supply in urban areas well served by public transportation and other services while increasing resilience to climate impacts.	☒ Regulate/ Incentivize ☐ Manage infrastructure or public services ☐ Convene/ Coordinate ☐ Partner
Housing Patterns & Affordability	Potential New Strategies • Enhance residential energy efficiency, e.g. energy audits at sale or substantial remodel, offering incentives for those who improve energy efficiency, and ensuring rental units meet specific energy efficiency standards. • Design buildings for passive survivability to ensure that they will stay at a safe temperature for occupants if the power goes out. (Menu of Measures) • Adopt fire-resilience standards for new and redeveloped sites in high-risk wildfire areas. (Menu of Measures)	Cross-cutting	CL-1.B.6 Prioritize increasing energy efficiency of existing buildings through adaptive reuse projects and weatherization. Focus on preserving and retrofitting buildings to be more energy efficient, emphasizing accessible and affordable weatherization of housing in overburdened communities, particularly those at higher densities,	☒ Regulate/ Incentivize ☐ Manage infrastructure or public services ☒ Convene/ Coordinate ☐ Partner

Sector	Strategies/Ideas for Implementation	Exposure	Related Draft Climate Element Policy	County Role
			to reduce emissions and increase resilience. CL-7.A.4 Establish incentives and regulations to maintain open space buffers to increase resilience to climate impacts such as heat island effects, flooding, and wildfires.	
Business & Industrial Employment	Existing Strategies to Leverage The Industrial Lands Study (Maul Foster & Alongi, Inc., 2023) identified the potential for more light and heavy industrial uses such as in Grand Mound. The new business centers are also opportunities for increasing green technology jobs and bolstering local food processing. • A local example includes a state-of-the-art hospitality event center and business resource, and innovation hub located within the City of Tenino on a 13-acre site (Thurston EDC Center for Business & Innovation, n.d.). • Thurston County is also considering options to add beef processing facilities in the county (Maul Foster and Alongi, 2023).	Cross-cutting	CL-9.A.4 Support expanded capacity for south Thurston County cities to develop a resilient local economy, such as expanding sustainability industries and supporting existing industries to cope with and be resilient to climate change. Ensure equitable protection and inclusion of these communities during the growth of green jobs and expansion of green industries (e.g., onsite solar and EV infrastructure installers), including through training and outreach programs, community engagement, and support	☒ Regulate/ Incentivize ☐ Manage infrastructure or public services ☐ Convene/ Coordinate ☒ Partner

Sector	Strategies/Ideas for Implementation	Exposure	Related Draft Climate Element Policy	County Role
			for small and local businesses.	
Business & Industrial Employment	Potential New Strategies The Industrial Lands Study (Maul Foster & Alongi, Inc., 2023) recommends the county consider the following: • Provide renewable fuel facilities at loading docks. This should be drafted broadly to include electric vehicles that are emerging, and hydrogen fueled trucks that will be prevalent as the technology matures. • Provide a substantial number of parking stalls (e.g., 20 percent) with alternative fuel sources for employees and visitor vehicles. • Require a substantial portion of onsite energy to be from renewable sources (e.g., 75 percent), and require that potential tenants provide the results of a renewable fuels audit prior to occupancy. • Encourage the use of building features that result in lower energy use such as rooftop skylights for natural light, the use of LEDs, and light-colored roofing material to reduce heat absorption. • Develop a policy to evaluate the equity impacts that proposed development may have on the surrounding community. • Require facility-specific waste-reduction measures.	Cross-cutting	OBJECTIVE 1C: Reduce energy use and support decarbonization in new and existing residential, commercial, and government buildings. OBJECTIVE 9B: Promote the growth of a circular economy by increasing demand for reused and recycled materials and decreasing demand for new raw materials with embodied carbon.	☒ Regulate/ Incentivize ☐ Manage infrastructure or public services ☐ Convene/ Coordinate ☐ Partner
Natural Resource Lands and Rural Economy				
Agriculture	Existing Strategies to Leverage Promote agricultural conservation practices that could also help resilience to climate change where they promote sustainable water use, healthy soil structure, and native plants where possible, while	Cross-cutting	CL-8.A.1 Provide climate education to agricultural producers and increase capacity for conservation technical assistance,	☒ Regulate/ Incentivize ☐ Manage infrastructure or public services ☐ Convene/ Coordinate

Sector	Strategies/Ideas for Implementation	Exposure	Related Draft Climate Element Policy	County Role
	allowing for the continuation of agricultural production. Farm conservation planning and voluntary stewardship program activities among others are ongoing activities. These programs could be modified to further promote practices that address the impacts of climate change, for example conservation grazing.		especially related to regenerative agricultural practices, climate-smart soil health or organic practices. CL-8.A.3 Promote environmentally sustainable water-storage and farming practices that help agricultural producers adapt to changing conditions and reduce production losses while balancing ecosystem needs.	☒ Partner
Agriculture	Existing Strategies to Leverage • Protect land for long-term agricultural use. The county is currently considering adding between 3,000 to 7,200 acres to the zoning that provides the most protection for agricultural activities and protects prime soils. • Support funding to protect agricultural land from conversion to other uses and assist farmers in transferring and accessing land. The county is promoting conservation easements and a transfer of development rights program. Further developing and implementing the programs are opportunities to support resilience and greenhouse gas emissions reductions.	Cross-cutting	See above and: CL-1.A.3 Support and maintain a stable urban growth area to reduce development pressure on rural and resource lands.	☒ Regulate/ Incentivize ☐ Manage infrastructure or public services ☐ Convene/ Coordinate ☒ Partner
Fisheries	Existing Strategies to Leverage • Tribal, state, and private fish hatcheries are investing in climate adaptation, and County incentives or shoreline/critical area regulations	Extreme Precipitation, Flooding, Drought	CL-1.A.5 Update and maintain a critical areas ordinance that	☒ Regulate/ Incentivize ☐ Manage infrastructure or public services

Sector	Strategies/Ideas for Implementation	Exposure	Related Draft Climate Element Policy	County Role
	could be designed to facilitate such actions. For example, the Clear Creek Hatchery desires to invest in water reuse infrastructure. Other hatcheries are elevating their facilities. (USFWS, 2023) • WDFW also anticipates changes to hatchery management plans and practices to consider climate impacts (e.g. water quality, low flow and fish survival) as well as to WDFW infrastructure to incorporate projected future streamflows and flood risk to reduce vulnerability to flooding and debris flows (Shirk, Morgan, Krosby, Raymond, & Mauger, 2021).		incorporates climate change considerations.	☐ Convene/ Coordinate ☐ Partner
Fisheries	Potential New Strategies • Thurston County allows fish hatcheries construction and maintenance in all shoreline environment designations in its recently amended SMP. (Thurston County Community Planning, 2023). The SMP standards could be amended to consider best practices in siting and design considering climate change trends and projections.	Extreme Precipitation, Flooding	CL-1.A.4 Identify and implement strategies to increase the resilience of the shoreline environment to sea-level rise and other climate hazards, while also protecting shoreline ecological functions, allowing and adjusting water-dependent uses, and providing public access consistent with what is required for shoreline protection.	☒ Regulate/ Incentivize ☐ Manage infrastructure or public services ☐ Convene/ Coordinate ☐ Partner
Forestry	Potential New Strategies • Forest managers, large and small, can act to increase forest health and resilience (Raymond, Morgan, Peterson, & Halofsky, 2022). For example, options could include: creating a forest stewardship plans; identifying current soils, tree	Wildfire, Drought	CL-10.B.3 Support local partners in climate-smart forest management and adopt a forest management plan to	☒ Regulate/ Incentivize ☐ Manage infrastructure or public services ☐ Convene/ Coordinate ☒ Partner

Sector	Strategies/Ideas for Implementation	Exposure	Related Draft Climate Element Policy	County Role
	species, invasives, and insects; and considering other tree species adapted for low soil moisture and shade.		improve tree and watershed health, prioritize carbon sequestration, and build climate resilience. Additionally, encourage participation in Washington's small forest landowner assistance cost-share and stewardship programs.	

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