Coos Bay Climate Hazards Adaptation Plan






Photos courtesy of SSNERR

September 2022 | Final Report

Prepared for:

Coos County and the cities of Coos Bay and North Bend
under direction from the Partnership for Coastal Watersheds

Prepared by:

UNIVERSITY OF OREGON
Institute for Policy Research and Engagement

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FEMA

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Other Districts, Agencies, and Organizations

Charleston Marine Life Center
Coos Art Museum
Coos History Museum
Coos Watershed Association
Crag Law Center
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Institute of Applied Ecology
International Port of Coos Bay
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North Bend Library
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About the Institute for Policy Research and Engagement

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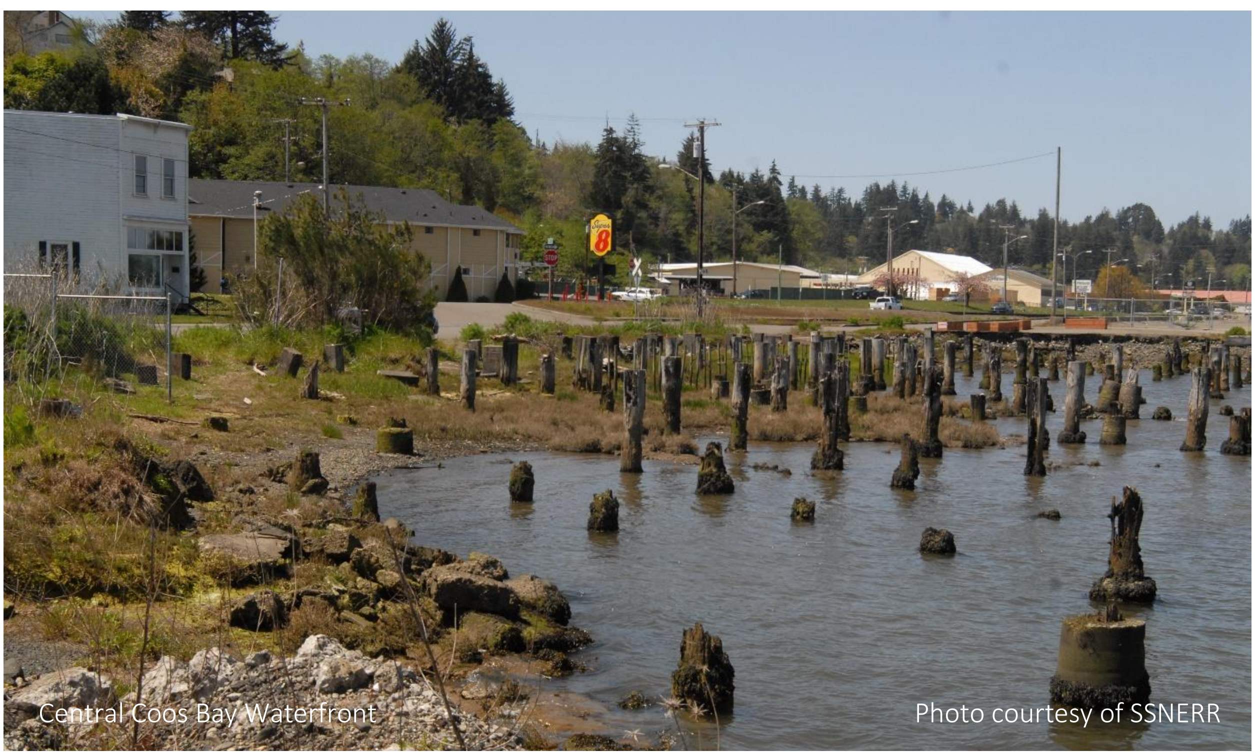
The Institute for Policy Research & Engagement (IPRE) is a research center affiliated with the School of Planning, Public Policy, and Management at the University of Oregon. It is an interdisciplinary organization that assists Oregon communities by providing planning and technical assistance to help solve local issues and improve the quality of life for Oregon residents. The role of IPRE is to link the skills, expertise, and innovation of higher education with the transportation, economic development, and environmental needs of communities and regions in the State of Oregon, thereby providing service to Oregon and learning opportunities to the students involved.



Central Coos Bay Waterfront

Photo courtesy of SSNERR

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Windthrow on Pack Trail Photo courtesy of SSNERR

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Introduction

The Partnership for Coastal Watersheds (PCW) was formed in 2009 to bring key community stakeholders together to address local economic, social, and environmental issues through informed collaboration. In 2016, the PCW initiated and guided a long overdue revision of the Coos Bay Estuary Management Plan (CBEMP). Phase 1 of the CBEMP revision presented a unique opportunity to connect coastal hazard risk reduction goals with the CBEMP policy framework which guides, "waterfront development, tidal wetland restoration and mitigation actions… and zone amendments" (SSNERR/UO-IPRE, Coos Estuary Land Use Analysis, 2019). At the conclusion of the Phase 1 CBEMP revision process, the group identified coastal hazards-related challenges, including climate-related hazards (e.g., sea level rise) as critical gaps in the planning process. Specifically, PCW identified additional mapping, assessment, and planning tasks.

In Phase 1 of the CBEMP revision, the local community made clear the limitations of a revised CBEMP that does not include planning for climate-related changes as part of its coastal hazards planning. Before the community could complete the CBEMP revision they determined it would be beneficial to consider how climate change vulnerability and associated resiliency and mitigation concepts (adaptation planning) could be addressed especially during the critical zoning review phase of the plan revision.

Locally, some municipal and private organizations are already taking steps to reduce their exposure to climate-related hazards, but nothing is being coordinated at the community or watershed scale. Incorporating climate change/coastal hazards vulnerability and adaptation planning into county and city planning efforts will help ensure their approach to protecting the community, and the local economy and environment from climate-related threats is both comprehensive and coordinated.

Local organizations are seeking to understand their vulnerabilities to a range of coastal hazards (e.g., sea level rise, ocean acidification, coastal erosion, fire, etc.) and consider adaptation strategies that coordinate local responses to those threats. To this end Coos Bay's Partnership for Coastal Watersheds, a local community coalition that includes representatives of key organizations in the area (e.g., Coos County, Cities of Coos Bay and North Bend, Coquille Indian Tribe, Confederated Tribes of the Coos, Lower Umpqua and Siuslaw Indians, Port of Coos Bay, South Coast Development Council, Oregon Department of Fish and Wildlife, Coos Watershed Association, South Slough Reserve, Southwestern Community College) contracted with the Institute for Policy Research and Engagement (IPRE) to develop this coastal hazards vulnerability assessment for the Coos Bay area.

Introduction

The Coos estuary is the largest estuary fully within Oregon and the sixth largest on the US West Coast. It is rich in natural resources and has abundant economic opportunities as one of the only estuaries in Oregon that allows deep-draft development. It supports two cities and multiple unincorporated communities. Because of its coastal setting, the natural and cultural resources and dependent industries of the Coos estuary are vulnerable to both episodic and chronic climate- related natural hazards.

These types of episodic hazards have been well-studied and some statewide and local planning has occurred around them (e.g., seismic design and construction requirements; OCD 2012). The impacts to the Coos estuary, and other Oregon estuaries, from many hazards related to climate change are also well studied. These include sea level rise (SLR) (Sweet et al 2017), ocean acidification (Gruber et al 2012), changes to weather patterns (OCCRI 2019); and more frequent and intense marine heat waves (Frölicher 2018), among others. Systems that are vulnerable to these climate-related hazards are numerous yet have been assessed to a much lesser degree. Those studied include tidal wetlands loss due to SLR (Brophy and Ewald 2017), Dungeness crab population impact from ocean acidification (Bednaršek 2020), increased mortality of commercial oysters from marine heat waves (Green et al. 2019) and impacts to statewide transit systems from SLR on Oregon's north coast (ODOT 2012). However, many vulnerable systems have not been assessed collectively and not at a local scale.

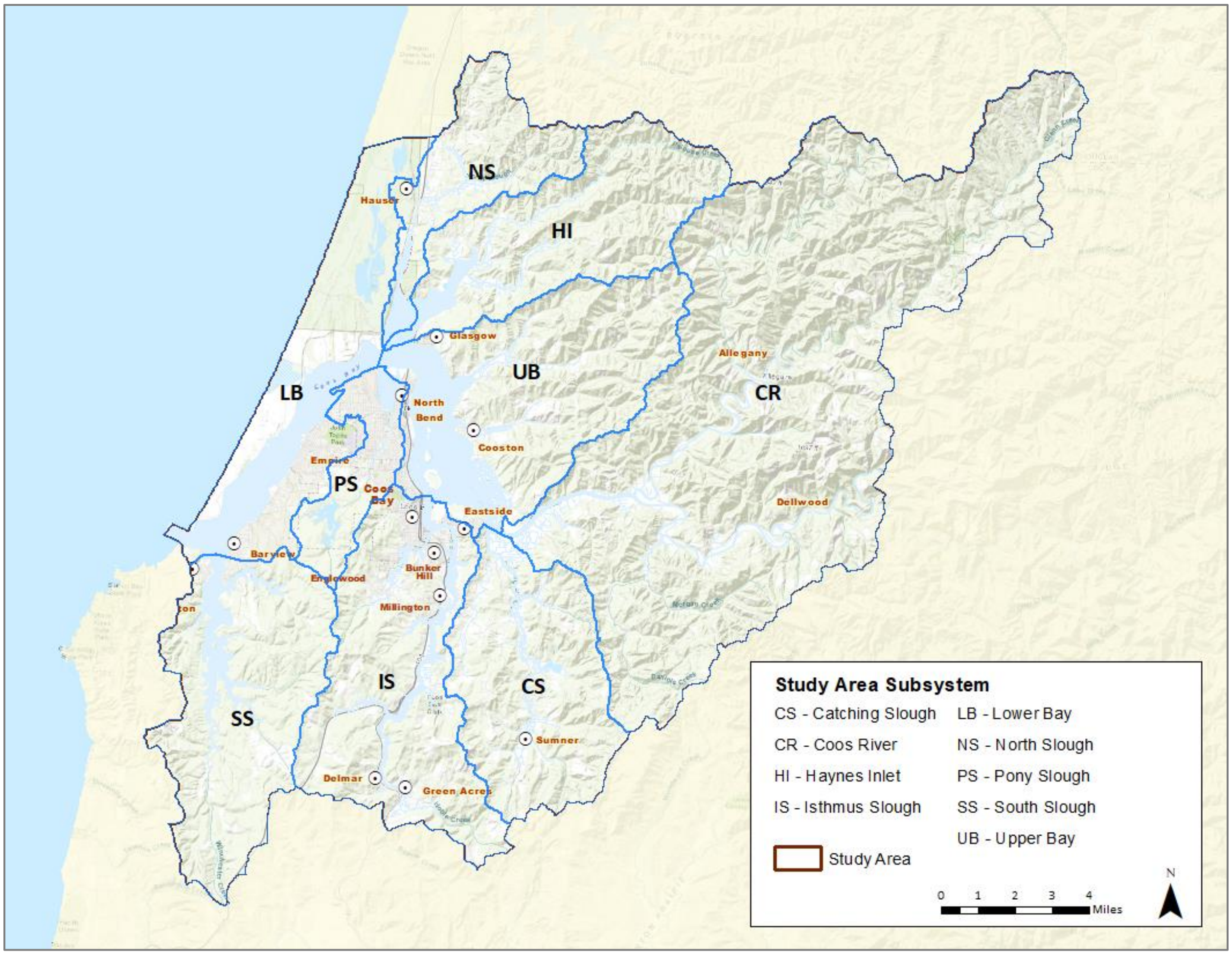
Thus, the need has been identified to compile a comprehensive vulnerability assessment for the Coos estuary and surrounding communities to better understand adaptation strategies the community can take in response to both chronic and episodic hazards. Current and existing planning efforts have occurred largely as independent efforts, concentrated primarily on episodic hazards, or focused on only one part of the community. For example, a climate change vulnerability assessment of the neighboring Coquille estuary focused solely on the environment (key habitats and species) but did not include social (people) or economic (profit) assets (Mielbrecht et al. 2014). While these are valuable assessments, a more holistic approach is needed for the Coos area to develop adaptation planning strategies.

In addition, known localized efforts, including the examples provided above, are not focused on the Coos estuary and surrounding communities but rather other coastal communities in Oregon. This project focuses on the vulnerability of five key sectors of the Coos Bay community: Natural World, Built Environment, Economy, Public Health and Social Systems, and Cultural Heritage to a suite of principal climate stressors that are anticipated to affect them along with the compounding effects of climate change and non-climate variables.

Study Area

The Study Area encompasses about 315 square miles and is composed of nine subsystems: Lower Bay, South Slough, Pony Slough, Isthmus Slough, Catching Slough, Coos River, Upper Bay (including Kentuck Slough, Willanch Slough and Echo Creek), Haynes Inlet and North Slough. The estuary has the geomorphology of a drowned river mouth and is considered a major deep draft development estuary under the Oregon Estuary Classification system. During the winter months the Coos estuary is fed with sediments from the South Fork Coos and Millicoma rivers and numerous smaller creeks. Along their journeys, the rivers flow through dense forests, then quietly meander by green pastures and small towns before entering Coos Bay. The area supports a population of about 43,000 (approximately 2,100 are exposed to sea level rise and flooding) within the cities of Coos Bay, North Bend and surrounding communities including Barview, Bunker Hill, Charleston, Libby, Isthmus Heights, Millington, and Sumner.

Figure 1 Study Area and Subsystems



Source: IPRE

For more information on the Study Area visit the Partnership for Coastal Watersheds Lands and Waterways Data Source: [https://partnershipforcoastalwatersheds.org/physical-description-chapter-summary/.](https://partnershipforcoastalwatersheds.org/physical-description-chapter-summary/)

Methods

The PCW and IPRE initiated the vulnerability assessment and adaptation plan during the summer of 2020.

Data and Document Collection, Research, and Review

The IPRE team collected available data related to specific climate models, emissions scenarios, down-scaled data, and projections for the region that describe the range of possible climate related impacts the region may experience. Collected data ensured that projections of future climate change to be used in Coos County are consistent with projections used be neighboring regions. This information was used to better understand appropriate ranges or extent of potential vulnerabilities while preparing the vulnerability assessment.

Establishing the Local Context

A series of collaborative listening sessions were held to establish the local context for coastal hazards vulnerability assessments and adaptation planning. Each listening session had a unique team of local and regional experts assessing the sectors vulnerability. Due to the COVID pandemic the listening sessions were held remotely and were limited to the natural world, built infrastructure, and social sectors. Additional follow-up meetings were held with regional stakeholders to fill in gaps left following the listening sessions. Follow-up conversations were conducted to better understand current conditions and vulnerability to cultural heritage, economy, and the natural world. The listening sessions helped the IPRE team better gauge awareness of coastal hazards vulnerabilities, understand priority coastal hazard concerns, and determine what plans are being developed or actions being taken to address those concerns. The SSNERR led a series of three focal habitat meetings covering tidal fresh wetlands, native oysters, tide flats, and upland forests to add to the assessment of the natural world. Each unit had a unique team of local and regional experts assessing that habitat.

Hazards Vulnerability Assessment

The IPRE team generated a broad list of climate change risks and stressors that arose from the listening sessions and data research. This information was utilized to develop future risk scenarios for the five sectors profiled in this plan. The sum of this data was utilized to make determinations of the consequences, likelihood, spatial extent, and the time horizon of the identified climate risks that was then evaluated by stakeholders.

Climate Change Adaptation Strategy

The IPRE team conducted a series of workshops in late Spring 2022 to filter the set of risks and to decide where to focus community resources. Six remote workshops were held for each of the five sectors identified in this plan. An additional cultural heritage workshop was held for members of Tribal nations in the Study Area which included content relevant to each of the five identified sectors.

Pasture on Filled Wetland Photos courtesy of SSNERR

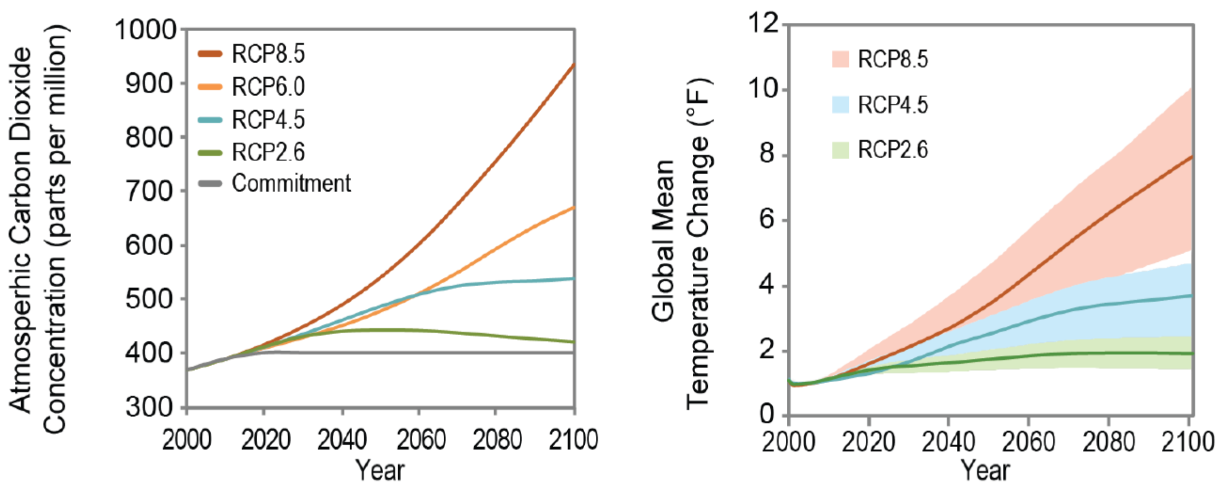
Chapter 2: Climate Trends

Climate projections indicate an increase in the occurrence of many climate related natural hazards. The IPRE team utilized the following assumptions and of the key climate stressors that influence natural hazards in the Coos Bay area.

Climate models

Figure 2 shows the Representative Concentration Pathways (RCP) that show various greenhouse gas concentration trajectories. Since the precise amount of greenhouse gas concentration is not known RCPs are used to describe different trajectories. In general, the higher the volume of atmospheric carbon dioxide concentration the greater the global mean temperature change. The projections in this report are based primarily upon a report by the Oregon Climate Change Research Institute (OCCRI) that presents climate projections for Coos County. The report provides climate projections for a lower emissions scenario (RCP 4.5) and a higher emissions scenario (RCP 8.5).

Figure 2 Representative Concentration Pathways, Atmospheric CO2 Concentration and GMT Change



Source: OCCRI. Future Climate Projections Coos County, Oregon. May 2022.

In addition to warming the ambient air and water temperatures, climate change is likely to intensify the extreme weather patterns, like wildfires, droughts, and king tides, that are already underway. Table 1, created by The Oregon Climate Change Research Institute (OCCRI), summarizes some of the future climate projections for Coos County that are described further in the sections that follow (OCCRI 2022).

Table 1 Confidence in hazard risk changing over time

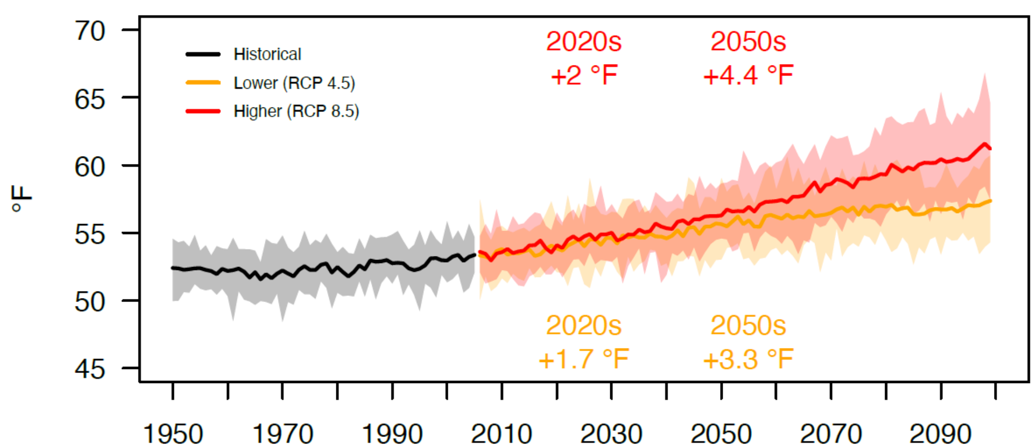
	Low Confidence	Medium Confidence	High Confidence	Very High Confidence
Risk Increasing ↑	Reduced Air Quality Loss of Wetlands	Drought Expansion of Pests, Pathogens, and Non-native Invasive Species	Heavy Rains Flooding Wildfire Changes in Ocean Temperature and Chemistry Coastal Hazards	Heat Waves
Risk Unchanging =	Windstorms			
Risk Decreasing ↓				Cold Waves

Source: OCCRI. Future Climate Projections Coos County, Oregon. May 2022.

Extreme Weather/Drought

Coos County is expected to warm at a rate like Oregon as a whole. Figure 3 shows that by the 2050s average annual temperatures will increase by about 3.3 degrees Fahrenheit (° F) under the low emissions scenario (RCP4.5) and 4.4 ° F under the high emissions scenario (RCP 8.5).

Figure 3 Average Annual Temperature Projections, Coos County



Source: OCCRI. Future Climate Projections Coos County, Oregon. May 2022.

Hot summer days (temperatures 90 ° F) are expected to increase from an average historical baseline of less than 1 to about 3 under the lower emissions scenario and 5 under the higher emissions scenario.

Overnight lows will continue to be warmer. Additionally, the frequency, intensity, and duration of extreme heat events is also expected to increase. It is expected that higher air temperatures will results in increases to estuarine water temperatures. Higher air temperatures will also decrease the number of days per year on which the maxim temperature is 32° F or lower.

The area's seasonal precipitation pattern is projected to intensify as summer rainfall decreases and winter precipitation increases due to winter storms. Climate models project warmer, drier summers for the state, including its coastal areas, leading to lower summer soil moisture (more likely than not, >50%) and runoff (likely, >66%), and warmer winters that facilitate greater cold-season growth (DLCD 2020). Secondary impacts of this precipitation shift include increased drought frequency (represented by low summer soil moisture, low summer runoff, and low summer precipitation) and wildfire risk.

Increased winter precipitation and decreased summer precipitation could affect the estuary by increasing inflow from coastal rivers and creeks in winter and early spring and reducing flow in summer. However, tide-dominated estuaries such as Coos Bay would experience less impact than river-dominated estuaries.

Sea Level Rise/Flooding

According to the local NOAA tide station in Charleston, the long-term (1970-2020) sea-level trend in the Coos estuary is increasing at 1.04 mm/yr. Rates are expected to accelerate over time. Sea level rise (SLR) projections from the National Research Council (NRC) in 2012 estimated a 0.75', 1.6' and 4.7' rise in sea levels by 2030, 2050, and 2100 respectively, when taking a low risk tolerance approach (i.e., upper end of the estimated range for greenhouse gas emissions). Sweet and colleagues (2017) estimate 0.79', 2.07' and 7.81' rise in sea level during those same years. Sea level rise will exacerbate coastal flooding caused by precipitation-driven flood events (e.g., 2-year or 100-year events), storm surges and high tides.

Riverine flooding usually occurs from November through February when storms moving inland off the Pacific Ocean cause heavy rainfall (FEMA 2018). It is expected that riverine flooding will increase in the coastal rain dominated watersheds as winter temperatures increase. According to OCCRI, the number of days with at least 0.75 inches of precipitation is not expected to change substantially by the 2050s, however, the amount of precipitation on the wettest day, and wettest five days, is ex expected to increase by 12% and 9% respectively.

Sea level rise combines with river and tidal flooding (including king tides) through storm surges and more intense winter precipitation to increase the frequency and severity of flooding. On the Oregon coast, sea level rise projections vary, mostly due to variation in vertical land motion. While the central coast will experience the most sea level rise, the southern coast, including the Coos Bay region, will experience sea level rise that surpasses the current rate of upward land movement (DLCD 2020). Sea level has risen about 1 inch since 1978 (measured at the NOAA water level station at Charleston) and is expected to rise 4.7 feet by 2100.

Incremental increases in sea level rise produce exponential increases in coastal flood frequency since the starting point (water level) for waves, storm surges, and high tides (King tides) is higher. Often, only a few inches separate what would be called a once-in-a-century flood from what would be called a once-in-a-decade flood. Rising seas are thus experienced through ever-more-frequent floods — long before anyone notices the average change (Climate Central n.d.). According to OCCRI, the multiple-year likelihood of a flood reaching four feet above mean high tide is 25-100% by the 2050s and 100% by 2100.

These flood risk projections also do not incorporate changes to wave dynamics or storm surges expected to accelerate flood levels. Projections also assume existing levees and flood control structures are properly maintained to remain high and strong enough for flood protection. Most levees across Oregon, however, are in unacceptable or unknown condition, according to the U.S. Army Corps of Engineers. Conservative planning strategies would account for these factors.

Waves/storms

Waves, especially large ones from storm events, can increase coastal erosion and flooding (Ruggiero 2013). Modeling suggests sea level rise can be magnified by a factor of five, on average, by storm surges. Wave heights overall and extreme wave events in the Pacific Northwest have increased in the past few decades (Reeder et al. 2013; Bromirski et al. 2013). Predictions on future trends in wave heights is unclear due to complexities with natural variability, ENSO and PDO cycles.

On the U.S. west coast, 2.1 inches of sea level rise doubles the odds of exceeding the current 50-year flood (that which has a 2% chance of occurring each year) (OCCRI 2021). King tides occur each winter lunar orbit when the sun, moon, and earth are in direct alignment (OCMP n.d.). As sea level rise increases tide levels, these events provide insight to the degree in which flooding can affect the region, especially when heavy storm runoff occurs in conjunction.

Precipitation

Oregon coastal climate is indicative of its status as temperate rainforest with wet winters and dry summers and moderate temperature shifts between seasons. Precipitation models suggest that PNW summers in the future will become drier and other seasons will become wetter (OCCRI 2020). However, natural high year-to-year variability in overall precipitation is expected to continue (OCCRI 2020). Frequency and intensity of extreme precipitation events are expected to increase (Dalton et al. 2017). Heavier rain events are likely to cause increased risk from landslides.

Saltwater Intrusion and Inundation

Rising sea levels change the historic salinity of natural water features, like estuaries, rivers, and aquafers. This impacts the species living in these environments as they become more saline, driving further ecological changes. Sea water inundation occurs throughout the Study Area. Waterways commonly inundated include the Coquille River, Willicoma River, Ten Mile Creek, Palouse Creek, Larson Creek, Pony Creek, Millicoma Marsh, Kentuck Slough, Coalbank Slough, and the Willanch Slough (Coos County 2016).

As much as 70-95% of the historic extent of the Coos estuary's tidally influenced wetlands have been converted to terrestrial-based land uses, and many of these converted low-lying lands are at greater flood risk. Within the larger estuary, more than 17,300 acres are protected by levees and tide gates (Stillman 2019), and the flood protection of these lands will be determined by the continued effectiveness of these flood control structures. Stream flows are also projected to increase in the winter by about 18% (Burke et al 2017).

Tidal Wetland Landward Migration Zones (LMZs)

Tidal wetlands are expected to migrate landward as sea levels rise. As sea levels rise tidal wetlands will be forced inland. It is expected the wetland area will decrease continuously with increases in sea level rise, with a sharper decrease with a 4.7-foot (or more) sea level rise (Brophy et al 2017). The 4.7-foot scenario is the upper end of the projected SLR for the year 2100. This amount of SLR could occur earlier or later than that date. The 4.7-foot SLR scenario was chosen for two reasons (1) it is the earliest scenario that shows distinct change in distribution of tidal wetlands and (2) it represents a long-range planning horizon that allows coastal planning groups to consider a range of options to conserve and restore tidal wetland resources (Brophy et al. 2017). For more information see:
http://www.midcoastwatersheds.org/landward-migration-zones/

Ocean Acidity (pH), Water Temperature, and Hypoxia

Globally, over the last 150 years, surface ocean waters absorbed large amounts of anthropogenic carbon dioxide from the atmosphere and became 30% more acidic than the ocean pre-Industrial Revolution. During this time, ocean temperatures have also been rising. While both increased ocean temperature and acidity could affect species in the Coos estuary and the overall ecosystem, local stakeholders identified ocean temperature as the larger concern. Warming is also the most direct and well-documented effect of climate change on oceans.

Increasing atmospheric CO2 concentration will continue to change the chemistry of ocean waters, making them more acidic. Oregon's coastal waters are expected to drop from pH of 8.1 to 7.8 over the next 100 years (Jewett and Romanou 2017). With increased acidification (lower pH), shell-building organisms may have difficulty building or maintaining their hard body parts. Plankton along with shellfish (e.g., clams and oysters) are among some of the most vulnerable organisms.

Water temperatures in the estuary are influenced by both marine and freshwater temperatures. Coastal waters off the Pacific Northwest have increased 1.2^{o}F between 1900 and 2012 and are expected to increase another 5.0 ^{o}F by 2080 (Dalton and Fleishman 2021). As temperatures rise, dissolved oxygen will decrease, and harmful algal blooms are expected to increase in frequency and toxicity.

Open-ocean, surface waters in the eastern North Pacific, offshore of the Pacific Northwest, warmed at a rate of 1.15 ± 0.54°F (0.64 ± 0.30°C) per century from 1900 through 2016, and are projected to warm by 5.0 ± 1.1°F (2.8 ± 0.6°C) by 2080 relative to the period 1976–2005. In addition to gradual ocean warming due to climate change, severe episodic events, known as marine heat waves, are now being documented (Dalton et al 2021).

Climate change may increase water temperatures in the brackish region of the estuary due to increases in water temperature of freshwater inputs, reductions in freshwater inflow in summer, and increases in air temperature. However, sea level rise could increase intrusion of cool ocean water into the estuary. Water temperatures in the upriver portions of Oregon's estuaries already frequently exceed temperature criterion for salmon and trout protection, so warmer temperatures caused by climate change could affect the distribution and survival of cold-water species. Increased mean annual water temperature correlate with lower dissolved oxygen in estuaries. More research is needed to determine to what extent climate change may influence estuarine water temperatures (Dalton et al 2021).

Impacts of Ocean Acidity and Hypoxia

At current levels, negative impacts are already evident across marine organisms, including toxicity of harmful algal blooms, olfactory senses in fish, and shell formation in shellfish. Over the next 100 years, surface ocean waters are projected to acidify by 100–150% (assuming RCP 8.5), resulting in a decline of open ocean pH from 8.1 (current average) to as low as 7.8 (Dalton et al 2021). Research suggests that ocean acidification causes a wide range of deleterious physiological responses in marine fishes. Elevated levels of carbon dioxide in the water may induce a condition in fish known as "hypercapnia," which can limit the function of the respiratory, circulatory, and nervous systems. The long-term effects of hypercapnia may inhibit important life functions by reducing growth, reproduction, and calcification. The effects are greatest in fish eggs, larvae, and juveniles -- this implies that salmon in their early life cycles are more at risk from the effects of ocean acidification.

Increased ocean acidity has unknown effects on estuaries and could pose a major environmental problem because of implications for marine species. For example, oyster reproduction could be negatively impacted as lower pH means less carbonate, an essential element for crustaceans to build their shells (NOAA n.d.). By 2100, ocean water could be nearly 150% more acidic, resulting in ocean acidity not experienced on earth in 20 million years (PCW n.d.). The relationship between ocean acidification and pH values in the Coos estuary, and riverine system, is not straightforward based on data gathered from the South Slough.

Air temperature

Average annual temperatures for Oregon are expected to warm 3.6^{o}F by the 2050's in low emission scenarios, and by 5^{o}F under higher emissions scenarios with summers warmer than other seasons (Dalton et al. 2017). Extreme air temperatures are expected to increase in frequency, duration, and intensity along the Oregon coast due to warming air temperatures (OCCRI 2020). The number of days ≥ 90^{o}F is expected to increase, as is the temperature of the hottest day each year (OCCRI 2020). Some research suggests that within 10 miles of the ocean stronger NW winds might largely ameliorate warming due to strong ocean upwelling and cool air movement inland.

Drought

In Oregon's coastal climate, drought is represented by infrequent summer precipitation and low soil moisture, and high evaporation (OCCRI 2020). Ground moisture is driven by precipitation (rather than snowpack) from wet winters. Projections in the OCCRI 2020 report warn of declining summer soil moisture and precipitation and increasing summer evaporation with more frequent 1-in-5 year drought events. Warming air temperatures and more frequent drought are expected to make forests more stressed and susceptible to insects and diseases including Swiss needle cast (Littell et al., 2013; Halofsky and Peterson, 2016; Vose et al., 2016). Combined with lower summer soil moisture, wildfire risk is expected to increase, even in relatively wetter areas of western Oregon (OCCRI 2020).

Invasive species, Pests, Pathogens

Generally, prevalence of invasive species and pests is expected to increase with the increase in temperate (air and water) and increased duration, frequency, and intensity of droughts.

Wildfire and Air Quality (Smoke)

Wildfires and smoke typically occur during late summer when vegetation is dry. As air temperature increases and snowpack decreases, the fire season will become longer. In Coos County, the frequency of very high fire danger days per year is projected to increase by 11 days by the year 2050 (DLCD 2020, Dalton et al 2022). Drought and heat waves are related climatic stressors that can increase the probability of wildfires. The propensity of landslides and erosion is increased as wildfires continue to become more common, affecting air quality as well.

Wildfire smoke can have significant detrimental effects to air quality, raising particulate levels 20 times higher than average in some areas (Hirschlag 2020). OCCRI anticipates a decrease in the number of "smoke wave" days, number of days wildfires lead to poor air quality, however, the concentration (intensity) of poor air quality is expected to increase by 69% by the 2050s under a medium emissions scenario.

Coos Bay's marine climate receives on average 65 inches of rain per year. Accordingly, the Oregon State Natural Hazard Mitigation Plan (DLCD 2021) finds the Coos Bay region has a low risk of wildfire. Wildfire danger also be conveyed through the increases in vegetation dryness, caused mostly by high air temperature, and vapor pressure deficit (VPD). Vegetation dryness may promote pest outbreaks that cause widespread mortality that can increase wildfire risk while high VPD reduces moisture in live vegetation and is strongly associated with wildfire acres burned. Wildfires are also associated with extreme weather including aridity, high winds, and high temperatures. OCCRI uses the number of days with extreme values of 100-hour fuel moisture (FM100) and VPD as indicators of wildfire risk. It is expected that fuel moisture will decline by the 2050s under the higher emissions scenario (RCP 8.5). It is expected that the number of days that fire danger is very high will increase by 11, and the number of days that VPD is extreme will increase by 30, under the higher emissions scenario (RCP 8.5) by the 2050s.

Although residential areas in Coos Bay are under a low threat of burning, wilderness areas east and south in the Coquille National Forest and Coos County Forest have a much higher likelihood of wildfires with higher densities of coniferous evergreens. Wildfires along the western coast range of the Coos and Coquille Rivers would likely require evacuations of the region.

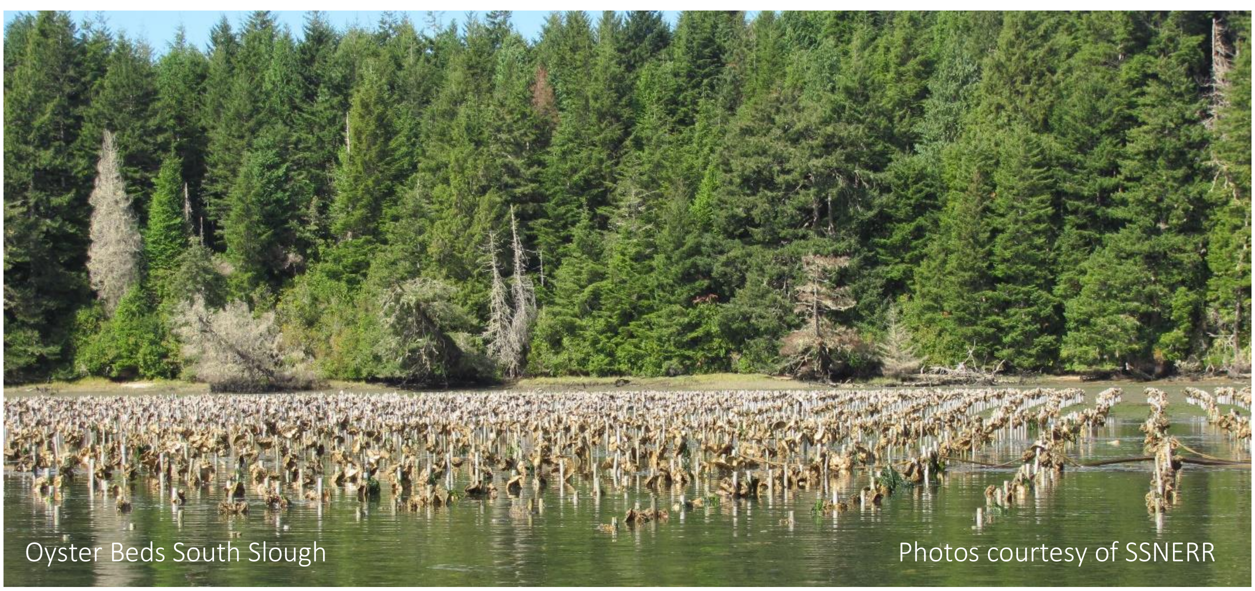
Wildfires and smoke typically occur during late summer when vegetation is dry. As air temperature increases and Cascadia snowpack decreases, the fire season will become longer. In Coos County, the frequency of very high fire danger days per year is projected to increase by 11 days by the year 2050 (DLCD 2020, Dalton et al 2022). Drought and heat waves are related climatic stressors that can increase the probability of wildfires. The propensity of landslides and erosion is increased as wildfires continue to become more common, affecting air quality as well.

Smoke from wildfires affects the region's population. Wildfire smoke can have significant detrimental effects to air quality, raising particulate levels 20 times higher than average in some areas (Hirschlag 2020). Vulnerable populations include people with respiratory diseases, cardiovascular disease, children under 18, pregnant women, older adults, people of low socio-economic status, and outdoor workers (EPA 2019). OCCRI anticipates a decrease in the number of "smoke wave" days, number of days that wildfires lead to poor air quality, however, the concentration (intensity) of poor air quality is expected to increase by 69% by the 2050s under a medium emissions scenario. Wildlife will likely be impacted to some degree, impacts to forests and pastures may not be notable, and aquatic species may not be impacted.


Millicoma Marsh at High Tide


Juvenile Dungeness Crab in Eelgrass


Coos Bay Waterfront Gulls in Storm


Oyster Beds South Slough

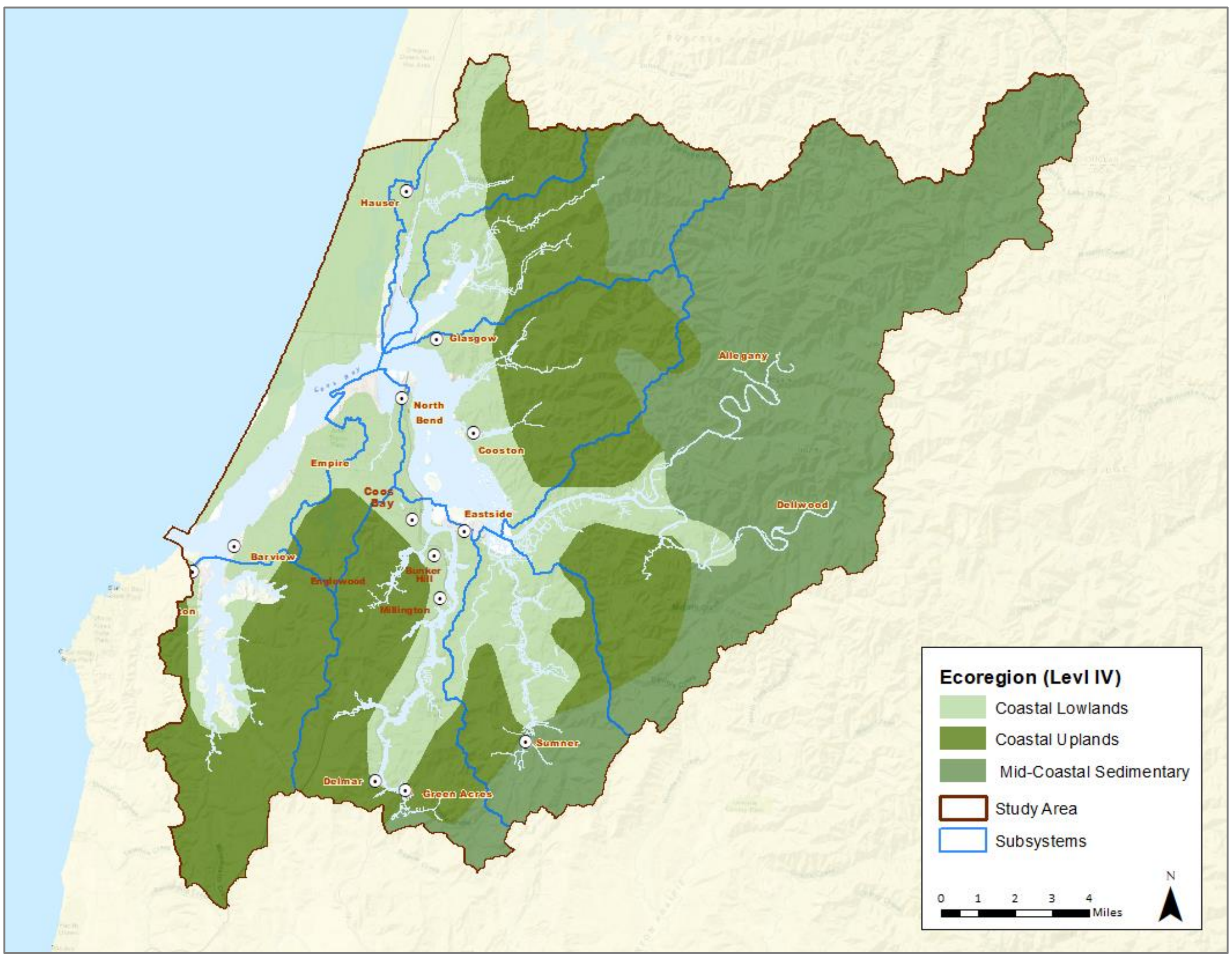
Photos courtesy of SSNERR

Chapter 3: Natural World

This section describes the sensitivity and adaptive capacity of the natural environment of the project Study Area. The IPRE team and SSNERR evaluated six focal areas including “salt marshes”, “tidal fresh wetlands”, “native oysters, shellfish, and tidal flats”, “eelgrass”, “salmonids”, and “upland forests”.

Figure 4 shows the distribution of non-estuarine habitat (ecoregions) with the Study Area. The Study Area is within the Coast Range ecoregion (Level III), specifically the Level IV ecoregions Coastal Lowlands, Coastal Uplands, and Mid-Coastal Sedimentary.

Figure 4 Study Ecoregions (Level IV) and Subsystems



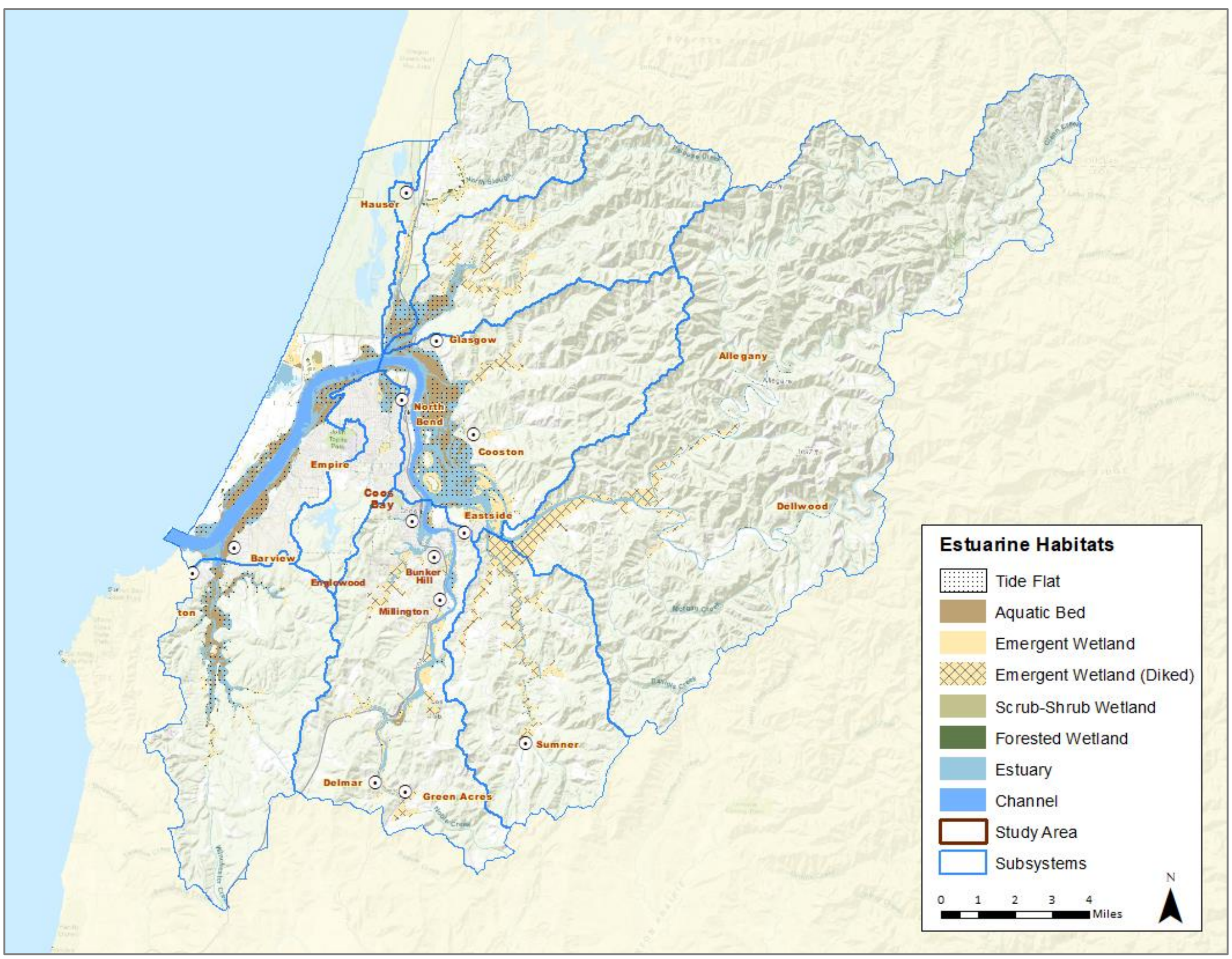
Source: IPRE

Coastal Lowland and Estuarine Habitats

The Coastal lowland ecoregion is defined by the Environmental Protection Agency as features that are 400’ above sea level to the shoreline. Included in this ecoregion are estuaries, flood plains, wet forests, beaches, dunes, spits, and low terraces. Coastal lowlands cover 76.6 square miles (8%) of the Study Area generally at elevations below 400 feet (the estuary encompasses an additional 25.8 square miles). The landscape is characterized by low gradient, meandering, creeks, and rivers along with beaches, dunes (stabilized by shore pine and invasive beachgrass), estuaries and coastal wetlands, wet forests (Sitka spruce, cedar, hemlock,), and marine terraces. The coast lowlands include agricultural land (pasture), some logging, and much of the area’s residential, recreational, commercial/industrial, and port development.

The Coos Bay Study Area is characterized by the Coos estuary habitats including aquatic beds, tidal flats, salt marshes, and tidal fresh wetlands (Figure 5). Estuaries provide a unique plant and animal ecosystem of brackish water and serve as filter and buffer zones of pollutants and runoff.

Figure 5 Estuarine Habitats



Source: IPRE

While constantly adapting to an array of non-climate and environmental changes, estuaries are also affected by climate change hazards such as ocean temperature increase, sea level rise, ocean acidification, and erosion, which can cause reduced habitat health.

Estuaries house more than 75% of all fish and shellfish harvested in the U.S. (NOAA n.d.). Development and industry have changed the ecosystem significantly in the last century. It is home to a major shipping port vital to the region's economy, and the commercial channel is routinely dredged for deep draft development purposes. The estuary supports economically and recreationally important species such as oysters, salmon, clams, and Dungeness crabs. The habitat also supports native eelgrass, phytoplankton, and algae flora rarely found on other parts of the coast (Rumrill n.d.). Figure 5 shows the distribution of estuarine habitats including aquatic beds (1437 hectares), tide flats (2124 hectares), emergent wetlands (2612 hectares), scrub-shrub wetlands (158 hectares), and forested wetlands (89 hectares). In Oregon, 80% of estuarine wetlands have been lost to diking (58%) or conversion to another vegetative class (22%) from 1870 to 1970 – the Coos Bay estuary has lost 66% of emergent "tidal marsh" wetlands, 98% of scrub-shrub wetlands, and 96% of forest wetlands, making it among the most impacted estuaries in Oregon (Brophy 2019).

Sensitivity and Adaptive Capacity of Coastland Lowlands and Estuaries

The overall sensitivity of the Coastal Lowlands and estuaries is connected to the health of the focal habitats (i.e., estuaries, salt marshes, tide flats, and tidal fresh wetlands) and key species (i.e., eelgrass and native oysters). Native eelgrass provides a unique habitat ecosystem in Coos Bay and its deterioration will have effects throughout the estuarine system. Most, if not all, eelgrass beds and wetlands will be affected by sea-level rise and increasing ocean temperature in the next decade.

The stakeholders stated that their management goals include adaptive restoration. However, resources for restoration are limited. Stakeholders also suggested that tribal relations may be key for funding access and ecosystem knowledge.

By 2100, sea level rise is likely to increase future flooding events beyond what Coos Bay experiences during annual high tides or king tides (8.69 feet above mean lower low water (MLLW) observed February 9th, 2020) (NOAA 2021). The upslope extent of tidal wetlands is commonly defined as the elevation of the highest tides of the year (Brophy et al 2019). Given this definition, the extent and distribution of saltwater, intertidal, and freshwater marshes are anticipated to be reshaped as more frequent flooding changes tidal influences, salinity levels, sedimentation, and water depth. Saltwater marshes may lose their tidal regime, converting to mudflats as waters become too deep and wave energy too powerful. Barriers to migration, including both dikes and natural topographic relief, will impose limited adaptability to ecosystems such as tidal marshes, forested swamps, and scrub-shrub wetlands. Freshwater marshes may see stressors to their habitat due to increases in salinity and ocean temperatures. Therefore, the Coos Bay wetland systems are very sensitive to coastal hazards.

Two of the six focal habitats identified in this report were assessed using climate variables: flooding/sea level rise; increased ocean temperature; drought; saltwater intrusion & inundation; ocean acidification and non-climate stressors: sedimentation and coastal development & erosion. The other four focal habitats were assessed using a pilot vulnerability tool developed be the National Estuarine Research Reserve System (NERRS). The climate variables assessed using the NERRS tool included: carbon dioxide, temperature, precipitation, sea level rise, and extreme climate events. The NERRS tool also included non-climate stressors including invasive species, nutrients, sedimentation, erosion, and contamination.

The adaptive capacity (i.e., the potential, capability, or ability of a system to adjust to climate change) of each focal habitat was also assessed. The assessment included intrinsic responses (e.g., ecological, physiological, and behavioral responses) but also external factors (natural and anthropogenic) that will influence the ability of a habitat to adjust to climate change. The following elements of adaptive capacity were considered for each habitat: current condition; degree of fragmentation of habitat, barriers to migration (natural or anthropogenic); diversity of functional groups; rate of recovery/regeneration following disturbance, management actions, and institutional/human response.

Collaboratives, including the PCW, working to adapt to climate change are key to driving adaptation measures. Ecologically speaking, without intervention, many species and habitats are not expected to be resilient in the face of changing conditions and ecosystems.

Salt Marshes Vulnerability Assessment

Salt marshes are characterized by emergent, rooted herbaceous or woody halophytes along low wave-energy, intertidal areas of estuaries and rivers that grow between about mid tide level and upland habitat. Tidal saltmarsh is often classified as high or low saltmarsh based on how frequently it is tidally inundated. Different species have different thresholds- for example, pickleweed (*Sarcocornia perennis*), a common low marsh plant, is adapted to withstand more frequent and longer tidal flooding than Pacific silverweed (*Potentilla anserina*), a high marsh plant. Salinity varies greatly depending on location (from 0.5-30), with more salt tolerant plants able to colonize marsh flats closer to the ocean, while less salt tolerant species colonize marshes in the upper portions of the estuary where salinities are more influenced by river inputs (Cornu et al 2015).

Direct Climate Effects

Tidal wetlands have historically been considered impediments to productive land use, and have commonly been altered to accommodate uses that are traditionally viewed as high-value alternatives (e.g., agriculture, urban development, etc.) (Giannico and Souder 2004). The Coos estuary has already lost much of its historic tidal marshes as those lands were converted to other uses. The Coos estuary historically had an estimated 1,790 ha of emergent tidal marsh, nearly triple the extent of any other estuary on the Oregon coast (not including the Columbia estuary; Brophy 2019). Now, nearly half of that habitat is lost behind dikes while another 16% has been converted to a different vegetation class (Brophy 2019).

In recent decades, as the ecological importance and economic value of wetlands has become increasingly recognized, public policies have been put in place to protect these resources. Now tidal wetlands are recognized as providing many important “ecosystem services,” including processing and cycling of sediments and nutrients, improving water quality, buffering human communities from floods and destructive waves, providing critical rearing habitat for juvenile fish and crabs, and facilitating recreational activities like hunting, fishing, and wildlife watching (Cornu 2005; Gedan et al. 2009; Portnoy and Giblin 1997).

Current Condition

Although climate change has yet to significantly alter marsh and wetland ecosystems, stakeholders noted that wetland habitat is severely impacted by human influences. These include effects from historical impacts such as levee building and draining of wetlands, and more contemporary effects from dredging, oyster aquaculture, sediment runoffs, and waste dumping.

Restoration efforts have helped to mitigate some salt marsh loss, with approximately 268 acres of tidal wetlands restored between 2003 and 2015. Marsh restoration efforts include removing levees, filling ditches and pools, regrading floodplains, and replacing invasive plant species with native species.

CO2

Some research suggests that more CO_2 may correspond to greater plant growth in emergent wetland systems, especially in seedlings (Rozema et al. 1990, 1991; Farnsworth et al. 1996; Ball et al. 1997; Scavia et al. 2002). However, it's important to note that these benefits may be offset by other climate-related changes that would limit plant production (e.g., changes in precipitation, nutrient delivery) (Scavia et al. 2002).

Temperature

Similar to CO_2 effects, increased soil and water temperature may enhance plant growth and increase the extent of salt marsh habitats (Scavia et al. 2002). Temperature limitations in wetland plants are more frequently related to low temperatures, thus warmer overall temperatures may favor exotic or invasive species (Malcolm and Markham 1997).

Climate projections indicate a warmer ocean surface temperature and an increase in ocean acidity (Brophy et al. 2021). These changes will have harmful effects on species that depend on salt and freshwater marshlands, such as salmon, shellfish, eelgrass populations, and forested upland and plant communities, creating changes in dominant and competitive interaction among species. Low shallow lagoons may also be created, increasing the risk of disease and harmful algae blooms.

Precipitation

Changes to timing and volume of freshwater delivery will affect composition of salt marsh plants. Changes in precipitation will also affect sediment supply, which allows marshes to accrete soils and maintain marsh elevation in a healthy, functioning wetland.

Sea level rise

Sea level rise is likely to affect surface elevations of marsh, tidal ranges, and sediment accretion. Sea level scenarios project about 1.4-meter (4.7-feet) increase by 2100 (Dalton et al. 2021), resulting in inundation for marshlands in Haynes Inlet, Millacoma River, Kentuck Slough, Coalbank Slough, Willanch Creek, and Coos River. Much of the Coos Estuary will be threatened by future flooding events under this scenario. Analysis by Karen Thorne at the U.S. Geological Survey suggests 60% of middle marsh habitat and 95% of high marsh habitat will be lost under conservative 2100 scenarios (Askew 2018). Increased flood hazards from these rises will exacerbate issues of erosion and sedimentation.

Gradual changes to salinity as sea levels increase will change community composition of salt marshes, with fresh and brackish marshes likely to convert to salt marsh.

Even small persistent increases in sea level will likely affect the distribution of species with narrow habitat requirements, particularly important for rare or endangered species, such as salt marsh bird's beak (*Chloropyron maritimum* ssp.*palustre*).

Marsh communities are also expected to shift habitat types. For example, Bull Island, the largest marsh in the Coos estuary, could convert entirely to low marsh under moderate sea level rise scenarios, or convert entirely to unvegetated mudflat under extreme sea level rise scenarios (Cornu et al. 2015).

Marshes are more vulnerable to sea level rise when more of their vegetation is low in the tidal frame and when they are composed of highly erodible soils. For example, several marsh sites monitored as part of the National Estuarine Research Reserve Sentinel Site program have shown eroded marsh edges (SSNERR, unpublished data). Tidal marshes in the Coos estuary are especially vulnerable to sea level rise when compared to other west coast estuaries due to the estuary's relatively small tidal range and relatively high amount of marsh below mean tide level (NERRS-NOAA 2021).

Extreme climate events

The frequency of peak events will likely result in 1% annual chance (100-year) events occurring at shorter intervals. Future 100-year flood scenarios are expected to impact the Willicoma River, Ten Mile Creek, Palouse Creek, Larson Creek, Pony Creek, Kentuck Slough, Coalbank Slough, and the Willanch Slough (Coos County 2016). Marshes in these locations may receive 3-6 feet of flooding, creating the potential for significant erosion and turbidity events. However, impacts from short-term flooding events tend to be short-lived as water recedes with the tidal flow.

River flooding has the potential to be more common in the winter and spring months during king tide events, creating fewer tidal flows and resulting in long-term damages in erosion and changes in saline levels, especially in high marsh areas and freshwater marsh zones.

Droughts are expected to become more frequent in Coos County by the 2050s (Dalton et al. 2022). North Bend's annual precipitation has decreased over 15% in the last 30 years (Mielbrecht et al. 2014). With expected drier summers and windier winter storms, precipitation changes might not only induce drought but also cause erosion and saltwater intrusion that impacts coastal marshes. Given that the Coos Bay area has mostly rain-dominated ecosystems, water scarcity and quality are likely to be affected by drought in the summer months.

Sensitivity/Exposure to Non-climate stressors**:**

Non-climate stressors include: dikes and tide gates (conversion of tidal wetlands to other land uses), eutrophication, dredging (changes to inundation regimes), habitat loss (development), and erosion (bank slumping). There are 76 miles of intact functioning levees, 17 miles of breached levees, and 138 tide gates in the project area, restricting normal tidal action to marshes (Cornu et al 2015). The structural integrity and function of tide gates, levees, and other waterway structures will be impacted by sea level rise, potentially increasing tidal hydrology to wetlands behind those structures.

Coastal erosion will be a greater hazard as seas continue to rise and wave energy increases with tidal influences. Long-term (late 1800s–2002) and short-term rates (1967–2002) of erosion in Coos Bay have been higher than the state coastal average, having lost on average 1.3 feet per year to accretion since the late 1800s (Dalton et al. 2021). Some areas highlighted as being affected by coastal erosion in the Coos County Natural Hazard Mitigation Plan are the Pony Slough and along East Bay Road.

Salt Marshes: Adaptive Capacity

The adaptive capacity of coastal marshes in the Coos Bay estuary is tied to sediment accumulation rates, frequency of erosion, presence of hardened and artificial structures, and space available for marshes to migrate. Marshes with more space and fewer barriers to migration have a greater capacity to survive sea level rise. Artificially armored shorelines reduce the ability for marshes to expand their distribution range. Space available for marshes to migrate up estuary could help offset losses from sea level rise. Marshes are continually flooded, forming decades of marine and terrestrial sediment layers, which allows them to maintain their surface elevation through vertical accretion. For some salt marshes, the rate of that accretion will allow them to keep pace with sea level rise and remain largely unaffected, while those that cannot accrete sediments fast enough will change dramatically.

Degree of Fragmentation:

More marsh edges allow for increased exposure to erosion. Coos estuary salt marshes are characterized by a poor marsh core to edge ratio, high amounts of unvegetated marsh edges, and generally high amounts of surrounding hardened shoreline (NERRS-NOAA 2021).

Barriers to Migration:

Marshes located at higher elevations within potential growth ranges have a higher capacity to adapt to sea level rise (Colombano et al 2021). Sea level rise will escalate flooding events, increasing water depth in numerous marshland locations. Steep upland topography (forested and non-forested) acts as a firm barrier to migration, decreasing available tidal wetland resources for aquatic life that depend on these environments. Sea level rise will gradually convert areas of non-tidal floodplains to tidal wetland, decreasing overall acreage availability for freshwater marshes as well as salt marshes as they move into narrower valleys. Many of these locations have also been developed into farmland or dwellings, road networks, or otherwise influenced by human activity.

Diversity of Functional Groups:

The following indicators are used locally for measuring biodiversity: total number of species, species distribution, composite index of richness and evenness, and effective number of species (PCW n.d.). Habitats can be identified by salinity, with the difference of riverine/freshwater/brackish (0-18 ppt salinity), polyhaline/intertidal (18-30 salinity), and marine/saltwater (>33 salinity) being represented (PCW n.d.). Among the intertidal wetlands, 25-30 emergent vascular plants is considered healthy, with a high abundance of a few marked species (pickleweed, fleshy jaumea, salt grass, tufted hairgrass, arrowgrass, creeping bentgrass, and Lyngby's sedge).

Other factors that involve a range of diversity in saltwater marshes include tidal inundation periods, salinity regime, and surface elevation. As sea level rise increases and inundation periods become more common, the current brackish environments will be threatened by increased water depth, reducing light penetration for the array of vegetation. While brackish environments can migrate upslope, salinity regimes will limit freshwater vegetation. Protection of these diverse environments must be established against sea level rise to maintain rich biodiversity.

Since saltwater marshes, intertidal marshes, and freshwater marshes all coexist within the estuary, the diversity of marshlands promotes cohabitation of a multitude of species. It is difficult to project how changing atmospheric conditions will alter or fragment these ecosystems; however as more brackish environments travel upslope to narrower and higher gradients, freshwater and forested habitats have the potential to be heavily impacted and reduced. This change will alter vegetation and juvenile anadromous fish zones, reducing overall habitat. Heavy flood inundations will overwhelm marshes, turning them into larger pools unable to recede with the tide.

Recovery and Regeneration Following Disturbance:

Filling and draining alterations of tidal, forested swamps, and shrub scrub wetlands throughout the estuary have greatly reduced the quantity and function of these ecosystems. As these converted agriculture lands are abandoned due to poor drainage, they become opportunities for re-establishing tidal flood regimes to a wetland.

Restoration takes years to complete, as an area must experience tidal inundation for years before solid sedimentation can occur and thus healthy vegetation. While human-developed wetland systems take years to produce as much as the biodiversity that naturally developed wetlands maintain, the Oregon Watershed Restoration Inventory and SSNERR have recorded 348 acres of restoration since 1996. These management efforts have seen incremental increases of plant stability and diversity (PCW n.d.). Without these restoration efforts, natural recovery remains low due to barriers previously described.

Impacts of Non-Climate Stressors:

Coastal wetlands are a natural carbon sequester, storing up to 700 billion tons of carbon globally (WDOE 2021). Coastal development and activities such as dredging and dumping upend decades worth of compacted sedimentation, releasing nitrogen and phosphorus. This process upsets carbon storage via soil trapping and sediment buildup. . Most roads and highways have been built along estuarine and lowland rivers. Overall, most of the marsh loss acreage can be attributed to dikes, levees, and the transition to farmland. Many of these alterations would take dedicated funding and restoration efforts to return to their original state.

Tidal Fresh Wetlands Vulnerability Assessment

Tidal freshwater wetlands include both tidal freshwater scrub/shrub and forested tidal swamps with salinities under 0.5. These habitats are generally above the saltwater influence and are distinguished by high water tables for all or most of the year. Historically these were the most extensive habitat types in Oregon estuaries but they have been the most impacted by human activities (e.g., ditching, draining, tide gates, levees, deforesting, conversion to agriculture). While restoration efforts (primarily in the form of dike breaching) have occurred in recent years, impacts such as subsidence, soil compaction and ditching have limited function at many sites. In addition, forested tidal wetlands by their nature have naturally slow recovery times following disturbances.

Historically tidal forested swamps made up 28% of vegetated tidal wetlands in the Coos estuary (Brophy 2019). Now, forested swamps such as Sitka spruce tidal swamps are one of the rarest wetland types in the region. In the Coos, much of this habitat is lost to either diking or conversion to another vegetation type and now covers only 4.8% of the estuarine tidal area (Brophy 2019).

In general, Oregon's tidal freshwater marshes and forested swamps are expected to convert to brackish marshes due to seawater intrusions as sea levels rise (Glick et al. 2007, Scavia et al. 2002, Brophy 2019). The ability of these wetlands to migrate further inland will be crucial for maintaining this habitat.

Direct Climate Effects

Current Condition

Tidal fresh habitats are already being directly impacted by climate changes. Impacts include greater frequency and duration of inundation (from the combined effects of watershed hydrologic changes, storm surges, and sea level rise (SLR)), changes in temperature, and salinity (from SLR and increased storm surge). There is some evidence of increased windthrow (i.e., tree mortality from blowdown) of forested wetlands with higher winds. However, tidal fresh forest systems are already fundamentally altered and function reduced in many areas due to deforestation of forested wetlands, diking and channelization, making it difficult to parse out climate change impacts. For example, water temperatures are likely warmer than before trees and their shade were removed from forested tidal wetlands.

CO2

Tidal fresh wetlands are likely to directly benefit from an increase in CO2, at least in the short-term (Wang 2021). Increases in CO2 may increase plant productivity, which could lead to increased C-sequestration and increased accretion rates, helping tidal fresh wetlands keep pace with SLR (Lu et al 2019, Langely et al 2009). However, nutrient levels, inundation, and temperature will also play a role in determining overall productivity (Lu et al 2019). If nutrients are limited or inundation too high, growth could be limited.

Temperature

Increases in temperature likely have both negative and positive effects on this habitat. Heightened air and water temperature can increase the competitive advantage of some plant species and reduce it for others, resulting in plant community shifts over time. Temperature increase could extend the growing season for tidal fresh plant thereby increasing annual growth rates. Productivity rates would then increase, which would lead to higher biomass production and potentially increased elevation, which could partially offset SLR impacts. Temperature could also increase decomposition rates, which could have beneficial effects (e.g., more particulate organic matter for food webs) and detrimental effects (e.g., more CO2 outputs) (Kirwan et al 2014).

Higher water temperatures are not beneficial for the organisms utilizing this habitat (e.g., juvenile salmonids). Tidal freshwater wetlands are likely more impacted by increasing air and water temperatures than brackish and saline tidal wetlands because they are usually situated farther inland where the influence of ocean (e.g., cooler ocean water, fog) have less of an impact. Altered wetlands (e.g., impounded) will be particularly at risk for high temperature effects.

Duration of elevated air temperatures are also important to consider, where chronic small gradual changes are more likely to have a positive biomass effect. Episodic events such as heat waves may have more of a detrimental effect.

Precipitation

Changes in the amount, frequency, and timing of precipitation events will affect tidal fresh wetlands. In the Pacific Northwest this habitat is vulnerable to both increases and decreases in coastal precipitation. Greater precipitation could lead to prolonged inundation and potential episodic disturbance due to flooding and debris flows. Less precipitation in turn could lead to greater salinity intrusion due to horizontal shifts in the tidal freshwater-tidal brackish boundary. Wetlands behind dikes and tide gates currently receive minimal tidal influence and will likely be more impacted by precipitation shifts. Likewise, portions of the habitat on the fringes (e.g., upland edge) will likely be heavily impacted. For example, Sitka spruce trees growing in freshwater may not be able to tolerate higher salinities expected with salinity intrusion.

Sea level rise

With SLR, tidal fresh wetlands will migrate upriver valleys due to changes to the salinity regime. These valleys narrow substantially upstream, which will result in an overall decrease in tidal fresh wetland extent. Salinity intrusion will likely most detrimentally affect forested tidal wetlands as they are not able to rapidly adapt to changing environmental conditions (as compared to emergent marsh). Infrastructure, water management and development will impede migration ability of some wetlands. Those tidal fresh habitats in locations that prevent the habitats to migrate upslope as sea levels rise will transition to intertidal brackish and salt marsh habitat and perhaps eventually, to unvegetated mudflat habitat. However, local rates of sedimentation and vertical accretion may help tidal fresh wetlands keep pace with SLR or at least greatly slow the pace of habitat transition.

Extreme climate events

Tidal fresh wetlands are vulnerable to extreme climate events, including extreme flooding, terrestrial heat waves, and high windthrow events (for forested wetlands). Additions of sediments from increased surface runoff, erosion, and debris flows could potentially help tidal wetland keep pace with SLR. Extreme heat events like the PNW's 2021 heat dome will likely affect intertidal invertebrate prey resources that fish populations rely on when using tidal fresh marsh channels as rearing habitat and may even directly affect fish and other animals using upper estuary channels.

Sensitivity/Exposure to Invasive Species

Current Condition

Tidal fresh wetlands are exceptionally susceptible to non-native species invasions even before climate-related changes are considered. Invasive species are already common and sometimes dominant in this habitat locally, with reed canary grass (*Phalaris arundinacea*) being a large nuisance species. Those tidal freshwater marshes with livestock grazing are usually dominated by reed canary and exotic species of bent grass (e.g., *Agrostis stolonifera*). Nutria (*Myocastor coypus*) are an exotic animal that has become well established in local tidal freshwater wetlands. The current overall effects to local freshwater plant communities are not well understood but considered negative as they have been locally documented as a strong force consuming native plants such as wild rice (*Zizania palustris*), Wapato (*Sagittaria latifolia*), and small-fruited bullrush (*Scirpus microcarpus*). These grazing pressures can push dominance of wetland plant communities toward invasives such as reed canary grass. Other non-native plants frequently found in this habitat include trefoil (*Lotus* spp), velvet grass (*Holcus lanatus*), and tall fescue (*Schedonorus arundinaceus*).

CO2

It is likely that increases in CO2 will benefit reed canary grass, increasing its vigor and making it more dominant within wetlands. However, some native plants may uptake CO2 at increased rates (i.e., C3 plants) and boost their productivity, which may provide a competitive edge over non-native grasses (Mishra et al. 2019).

Temperature¬

Temperature changes could result in plant species range shifts that begin to favor the establishment and competitive advantage of invasive plant species. Increased temperature will result in drying of freshwater tidal marshes along the fringe and could benefit species such as reed canary grass and Scotch broom (*Cytisus scoparius*). Nutria will likely benefit by increased temperatures especially in the winter as their underfur is not as thick and insulative as beaver and winter stress is a documented factor that can reduce nutria reproductive success and survival (Norris 1967). In forested tidal swamps, temperature-induced drought stress may limit tree growth (Barber et al. 2000).

Precipitation

Dryer summers will likely provide an advantage to some non-native species such as reed canary grass, which can tolerate a wide range in environmental conditions. However, non-native plant species in tidal wetlands generally tend to be upland species and may be less competitive than native wetland species under conditions of increasing inundation caused by wetter winter months. Reduced precipitation overall would result in greater salinity intrusion of the lower reaches of tidal freshwater marsh, which could benefit some native plants.

Sea level rise

In general, increased flooding from sea level increases will negatively impacts some invasives and favor others. Disturbance events could increase in frequency with SLR (e.g., large wood moved by very high tides), leaving openings in native plant communities where invasive species could become established. However, slight increases in salinity with SLR could result in within-marsh species and plant community shifts, potentially forcing out some of the less salt tolerant invasive species such as reed canary grass.

Extreme climate events

Research on extreme climate events in tidal fresh wetlands is very limited. Large sediment deposition events and openings from windthrow of forested swamps, increasingly facilitated by extreme events, could provide openings for invasive species to colonize.

Sensitivity/Exposure to Nutrients

Current Condition

Nitrogen inputs can be high in tidal fresh wetlands and can occur naturally (e.g., nitrogen fixing species such as alder) or be human derived (e.g., livestock grazing). High nutrient inputs (both nitrogen and phosphorous) from pasture grazing on diked and tide gated tidal wetlands is common in the Coos River basin and has resulted in reduced stream water quality. Nutrient inputs from active agricultural fertilization is not common or frequent in the Coos basin.

CO2

Abundant nutrients coupled with increases in CO2 could provide a productive advantage to both invasive and native species.

Temperature

Abundant nutrients coupled with increases in temperature could provide a great advantage of invasive species over native species. In addition, the interactive effects of high nutrients and high temperatures would adversely affect channel habitat, which is used by juvenile fish and other important native fauna.

Precipitation

Nutrient-loaded streams could be exacerbated by diminished summer precipitation and later timing of fall freshet events. Increased winter precipitation events could result in more frequent floodplain overflow, mobilizing livestock nutrients into channel habitats.

Sea level rise

SLR will have little impact on nutrient loading of these habitats as most nutrients in the Coos system are derived from upland sources (e.g., livestock grazing).

Sensitivity/Exposure to Sedimentation

Current Condition

High sediment inputs into tidal fresh wetlands already occurs to varying degrees in the Coos system, depending on location. Upland forest timber management occurs in locally short rotations (~30 yrs) using clearcut harvest methods, resulting in erosion, debris torrents and landslides input of sediment into coastal streams. Sediments from upstream are commonly deposited into the tidal fresh zone.

Temperature

Though less likely in relatively wet coastal forests, there may be a link between increasing air temperatures and sedimentation via possible increased prevalence of wildfires. Increased wildfire could lead to greater erosion in coastal valleys and thus greater sediment supply to tidal freshwater wetlands.

Precipitation

More intense winter storms will lead the movement of more sediments in the system from upstream sources. In addition, less frequent summer precipitation could stress forested upland plants, destabilizing ground cover and resulting in more upstream erosion events.

Sea level rise

Sea level rise is not expected to exacerbate sedimentation in this habitat. The only expected change will be location of the zone where sediment drop-out and deposition occurs, as the tidal frame moves upstream from its current location.

Extreme climate events

Sediment inputs into this habitat could increase during stronger and more frequent storm events, due to bank destabilization and uprooting of upslope trees. Extreme wind events will lead to higher windthrow events, which uproot trees and expose sediment. Higher risk of landslide from intense winter storms will also increase sediment input into tidal fresh systems. Extreme heat waves could lead to wildfires, again exposing and destabilizing upslope sediments.

Sensitivity/Exposure to Erosion

Current Condition

Tidal fresh wetlands are relatively low energy habitats, so erosion is not typically a major feature of these wetlands. Erosion impacts have been focused on diked and tide gated pastures where channelization and livestock impacts interact to exacerbate erosion. Channel banks in pasture-converted tidal fresh wetlands often lack riparian plant communities, and bank destabilization is common.

Precipitation

Predicted increases and concentration of seasonal precipitation will likely exacerbate erosion in tidal fresh wetland habitats, particularly human-modified habitats. Increased peak flows and associated water velocities may result in some erosion adjacent to stream channels.

Extreme climate events

Extreme wind events often result in windthrow, which will uproot trees in forested swamps and cause localized erosion. Extreme precipitation events will likely exacerbate erosion of stream banks.

Sensitivity/Exposure to Contamination

Overall, there is very limited contamination concerns with freshwater tidal wetlands in the Coos Estuary. The various climate stressors are unlikely to exacerbate this.

Tidal Fresh Wetlands Adaptive Capacity

Degree of Fragmentation

Much of the area's tidal freshwater wetlands are fragmented due to conversation to agriculture or development. Channelization, diking and tide gating of the tidal zone including the road network has fragmented much if not most of this habitat.

Barriers to Migration

Elevation barriers to aquatic connectivity are ubiquitous in the assessment area and include dikes, roads, tide gates, and failed culverts. These barriers restrict water flow and movement of nektonic species. These same barriers will limit the ability of tidal wetlands to migrate with sea level rise. In addition, the naturally steep topography and constricting, narrowing valleys of the Coos watershed will limit upslope migration

Recovery and Regeneration Following Disturbance

Many wetland plants are typically resilient to pulse disturbances, however many invaders have a higher capacity to establish in the face of disturbance (e.g., Himalayan blackberry - *Rubus armeniacus*). In addition, long-term, chronic disturbances may change the ecosystem structure of tidal freshwater wetlands. For example, trees and shrubs of forested wetlands are less likely to recover quickly and may instead convert to emergent marsh. Many tidal fresh wetlands are impacted already (e.g., pasture wetlands) that additional disturbance will further reduce their productive capacity and impact fauna, such as salmon, that are reliant on the habitat.

Diversity of Functional Groups

As compared to salt marsh systems, tidal freshwater wetlands have high vegetative species diversity and a high degree of functional group diversity including trees, shrubs, and a variety of emergent grasses, sedges, rushes and forbs. There is also high structural diversity due to presence of nurse logs, trees and shrubs. However, due to long-term perturbations to this habitat, much of that complexity and species diversity has been reduced in many areas (e.g., few old growth tidal spruce remain; historically abundant wood ducks are now rare; reduced numbers of salmon, mink, otter, and beaver).

Potential for Management Actions

There are several existing management actions that would increase resilience of tidal fresh wetlands by converting lands back to a more natural state, or by conserving intact wetlands. Mostly centered around restoration actions, measures include:

- Hydrologic restoration – removal or upgrades to tide gates, levee setbacks or breaches, culvert upgrades
- Habitat complexity restoration – large wood placement, native species plantings, non-native species control

Improvements to grazing management so it is more wetland-compatible would assist with recovery of tidal freshwater wetland behind tide gates and within grazed zones.

Removal of barriers to landward migration will continue to be important as sea levels rise. Management actions associated with this concept include conservation easements, land trades, levee removals, and acquisition, all of which will allow marshes to migrate naturally.

It is unknown however, if these actions can be implemented on a scale necessary to reverse declines in iconic species (such as salmonids) and improve estuarine resilience to maintain ecosystem function and climate change resilience.

Likelihood of Institutional or Human Response

There is widespread acceptance, funding, and implementation of estuarine wetland restoration along the Pacific Northwest coast, particularly as it relates to salmon recovery. Local regional and statewide initiatives are maturing and growing in effectiveness and impact. Currently however, the social value of natural tidal freshwater wetlands is viewed as very low. Demographic and economic changes may support an increased appreciation for the value of natural lands and their associated ecosystem services in the future.

Native Oyster, other Shellfish, and Tidal Flats Vulnerability Assessment

The Olympia oyster (*Ostrea lurida*) is the only native oyster to the US West Coast. It is a bivalve mollusk that filter feeds (providing ecosystem service by removing excess nutrients from water). Larvae tend to settle near other oysters, forming three-dimensional aggregations or beds, often bordered by mudflats. Beds help stabilize sediment, provide habitat for other estuarine animals to hide, feed, settle or lay eggs, and may improve eelgrass habitat conditions.

Along the west coast, native oyster populations declined pre- and post-European settlement, the latter largely due to overexploitation and commercial removal, which in turn degraded habitat through lack of replenishment of suitable shell substrate (White et al. 2009). Olympia oyster populations were extirpated from the Coos estuary pre-European settlement (likely due to sediment burial from a tsunami) and were accidentally reintroduced in the 1980's (Groth and Rumrill 2009). Populations are now mainly present in the upper portion of Coos Bay with dense patches along the waterfronts of Coos Bay, North Bend, and Eastside.

Settlement of Olympia larvae are non-selective on oyster shell species. Thus, there is potentially a recruitment sink, with larvae settling on commercial Pacific oysters effectively becoming bycatch upon harvest (Sawyer 2011).

Clams are recreationally fished in Coos Bay. Many of the recreationally important clams are concentrated in the lower bay, notably on Clam Island, Pigeon Point, and near the mouth of the South Slough.

There are around thirty crab species found throughout the bay area, but research is mainly focused on the Dungeness crab *(Cancer magister)* and the red rock crab (*Cancer productus*), with the remaining crabs lumped together, including yellow (H*emigrapsus oregonensi*s), purple (*Hemigrapsus nudus)*, and green (*Pachygrapsus Crassipe*s) shore crabs. Dungeness crab populations are stable, and their commercial fishing is currently sustainable. They live throughout the bay and are crabbed mostly in the lower bay. Red rock crab populations also appear to be stable, but there is little research on them. Most information gathered on red rock crabs in the Coos Bay area come from stations in the South Slough. All the other crab populations are not monitored but play a significant role in the ecology of the bay (PCW n.d.).

Estuarine shellfish species are very resilient to changes in ecosystem. However, all species have their thresholds of which they can withstand. The following are factors that directly affect the survivability of shellfish species in Coos Bay.

Direct Climate Effects

Current Condition

There is a gap in research to understand the effects of climate change on tide flat benthic communities and shellfish such as Olympia oysters. For example, Olympia oyster larval abundance, dispersal and recruitment patterns are not well understood. Anecdotal evidence suggests that there have been die-offs of shellfish in recent years related to marine heat waves. Within Oregon estuaries, current direct climate impacts to Olympia oysters are likely small relative to past overharvesting and sedimentation issues related to anthropogenic stressors.

CO2

Tide flat bivalve communities and native oysters are likely to be impacted by ocean acidification as lowered pH levels causes juvenile bivalves to have trouble forming and maintaining their shells (Barton et al 2012). Without these shells, clam and oyster larvae can't form feeding and swimming appendages. Butter clams (*Saxidomus gigantea*) and cockles (*Clinocardium nuttallii*), both recreationally and commercially important, are likely more susceptible to ocean acidification effects due to their pelagic larval life cycles (D'Andrea pers. comm). Species that brood their larvae (such as Olympia oysters) are likely more tolerant of acidified seawater than those with pelagic larvae (e.g., the non-native Pacific oyster, Crassostrea gigas). However, shell size of larval and juvenile Olympia oysters has been shown to be reduced when directly exposed to acidified water (Forsch 2010). In addition, acidification may impact crabs, clams and oysters indirectly by limiting food availability (calcified plankton species) (Orr et al 2005; Fabry et al 2008). Additionally, larvae of many species (shellfish, crabs, etc.) may originate their lives outside the Coos estuary and have gone through sensitive windows at a great distance which may impact their survivability due to changes in acidity.

Ocean acidification is expected to cause a multitude of effects on crabs including low molt success rate and decreased larval survival. Lower pH makes it harder to molt, increasing the energy crabs' put into molting. Acidification, like ocean warming and sea level rise, is likely to stress crab populations and shift their range, distribution, and habitat usage.

Temperature

Temperature is a key element of phenology, so changes to water temperature are likely to affect life stage development of benthic communities, but effects are likely to vary by species. For example, reproductive cycles for some species may shift to earlier development and spawning with warmer water temperatures. If this occurs, it is unknown whether shifts in cycles will align with blooms of nutritious algal foods. For Olympia oysters in particular, reproductive success occurs in water temperatures between 15-19ºC (59-66ºF) with a positive relationship between food availability and reproductive output (Oates 2013; Santos et al. 1993). Warmer winter water temperatures could potentially benefit Olympia oysters allowing them to develop larger larvae (Spencer et al. 2021). Detrimental effects of warm air temperatures for adults will affect intertidal portions of the habitat more than subtidal populations.

Precipitation

Patterns of precipitation and water delivery are predicted to change resulting in more flooding and increased sediment delivery to the estuary. These events may affect oyster beds and tidal flats, but in different ways. Increased sedimentation will likely bury and smother oyster beds, especially restored or newly established beds. As sediment covers these beds, it will also reduce hard substrates that are necessary for successful larval settlement. Increases in freshet events can lead to mortality of estuarine bivalves that live close to the surface of mudflats. These mortality events have been observed among cockle populations in Coos Bay and Yaquina Bay in recent years. Oates 2013 found that low salinity regimes appeared to repress reproductive success; however more study was needed to understand the complexities of the estuarine salinity regime on oysters. Cheng and colleagues in 2016 found a growing concern for prevalence of extreme precipitation events causing salinities to decrease enough to cause mass mortality events of native oysters.

Sea level rise

Sea level rise is likely to have little overall impact on Olympia oyster populations. Location shifts may occur as salinity regimes shift, as there is evidence that Olympia oysters are most viable in polyhaline regions of the Coos estuary (Pritchard et al., 2016). Tidal flats may benefit from sea level rise as more tidal marsh areas become subtidal and convert to tide flat. The percentage of tidal flats that are intertidal (vs subtidal) will likely decrease however, diminishing feeding and breeding habitat for shorebirds and altering food webs (Galbraith et al. 2015). For example, intertidal macroalgae and eelgrass could decline, limiting foraging habitat for juvenile Dungeness crab. Similarly, as salt marsh habitats diminish with sea level rise, habitat for numerous crab species will also decline. Overall, sea level rise is likely to make estuarine intertidal areas less diverse and productive through declines in abundance and diversity or intertidal organisms like clams, oysters, and crabs (Yamanaka et al 2013).

Extreme climate events

Marine heat waves and dry air conditions (especially during summer daytime low tides) have already diminished vegetated tidal flat communities (e.g., eelgrass). Intense winter storm events and heavy precipitation events are likely to negatively affect Olympia oysters due to sedimentation, as hard substrates are required for oyster survival. Heavy precipitation events may also cause freshets that lead to mass mortality of some shellfish species.

Sensitivity/Exposure to Invasive Species

Current Condition

Invasive species, such as Atlantic and Japanese oyster drills, are already affecting Olympia oysters and other bivalves (Buhle and Ruesink 2009). European green crabs, whose populations are increasing in the Coos estuary, are known predators of juvenile oysters (Yamada and Kosro 2010; Snyder 2004).

Temperature

Increasing water temperatures could allow new invasive species to colonize the estuary (e.g., range expansion). It may also allow invasive green crabs to thrive and expand their numbers within the Coos estuary.

Precipitation

Many invasive species have a higher range of tolerances than native species. Depending on salinity tolerances, predicted changes to precipitation may favor invasive species over native oysters and bivalves. Heavy winter precipitation may be more negatively impactful on native oysters and shallow burrowing bivalves than on invasive species.

Sea level rise

As different portions of the estuary are inundated for longer periods of time by sea water, there is a potential for expansion of green crabs further into the estuary. There are also potential shifts in native species distributions as the balance between intertidal and subtidal habitats change.

Extreme climate events

Extreme temperature events (e.g., marine heatwaves) may lead to mortality of native species, allowing invasive species to increase. Warmer winters could enhance invasive species recruitment events, and reproductive and larval development and timing, changing the balance of native to invasive species.

Sensitivity/Exposure to Nutrients

Tidal flats and native oyster beds are not currently impacted by eutrophication. Nutrient concentrations are generally low in the Coos estuary, with its large tidal exchange and flushing rate (O'Higgins and Rumrill 2007). Expected climatic changes to CO2, temperature, precipitation, sea level, and extreme events are unlikely to change nutrient effects on these habitats. In fact, any increase in macroalgae such as Ulva sp. (which can increase with heightened nutrient loads) will increase nutritious food source for filter-feeding shellfish as the algae breaks down.

Sensitivity/Exposure to Sedimentation

Current Condition

Sedimentation is the greatest threat to native oyster beds. Like most Oregon estuaries, the Coos is largely soft bottomed. Reduction and extirpation of native oysters in Oregon estuaries led to a decline in additions of shell substrate to oyster beds, causing many to be buried over time. Native oysters are unable to survive periods of burial. Unconsolidated tidal flats, in contrast, can survive sedimentation to some extent as most species within are ambulatory. Sediment dynamics is complicated in estuarine environments and effects are likely to be localized and dependent on anthropogenic tidal restriction (e.g., levees, tide gates) and other modifications (e.g., channel dredging).

Precipitation

Changes to precipitation regimes are likely to lead to more delivery of sediments into the estuary from upland sources.

Sea level rise

Sea level rise may lead to increased sedimentation at certain tide cycles as waters are slowed and more sediments drop out of the water.

Extreme climate events

Oregon coastal streams are inherently flashy and more intense rain events may increase this affect, bringing more sediment into the estuary. Sedimentation from these events will bury native oyster beds, and lead to reduction of diversity and abundance of benthic invertebrates in tidal flats. For example, sediment deposition on tide flats can be up to 12cm thick, causing mortality events or altering tide flat ecology (Peterson 1985; Williams et al. 2001).

Sensitivity/Exposure to Erosion

Erosion is not a major factor affecting these habitats, although increased storm intensity and frequency of storm events may lead to some erosion of tidal flats. Sea level rise and increased storm events, however, may erode tidal marshes and convert them to tide flats.

Sensitivity/Exposure to Contamination

Current Condition

Contaminants to the estuarine system are introduced from wastewater, forestry practices, urban run-off etc. Build-up of chemicals such as now-banned polychlorinated biphenyls (PCBs) have been found to be seven times the concentration in Olympia oyster tissues in the Coos estuary than is normal (Granek et al. 2016). While the effects of this on the health of benthic invertebrates is largely unknown, buildup of chemicals such as polycyclic aromatic hydrocarbons (PAH's) may cause greater stress on them making them more susceptible to diseases and climate stressors.

Precipitation and extreme climate events

As heavy precipitation events increase, more chemicals from land sources will enter the estuary.

Native Oyster, other Shellfish, and Tidal Flats Adaptive Capacity

Degree of Fragmentation

Regional overharvest of the Olympic oyster by European settlers occurred in Oregon estuaries in the late 1800's, leading to widespread collapse (Groth and Rumrill 2009). However, the Coos estuary population is thought to have already been naturally extirpated by that time likely due to burial by a Cascadia event (Baker et al., 2000). Ephemeral populations of native oysters are known to currently exist in three estuaries in Oregon, including more substantial populations in the upper Coos estuary (Groth and Rumrill 2009).

Barriers to Migration

Connectivity between estuaries for many tidal flat benthic organisms and native oysters (via planktonic larval stages) is extremely limited as many estuarine species are not adapted to survive the ocean environment during transport between estuaries (Pritchard et al 2015). Therefore, these species are limited to the estuary in which they reside with the ocean as a barrier to migrating between estuaries.

Recovery and Regeneration Following Disturbance

Native oysters are not resilient to any disturbance that reduces the hard substrate required for oyster settlement. Movement within the estuary is often limited by tidal currents, as larvae are not strong enough to swim against a current. Therefore, source populations following a disturbance event need to be relatively close by (Pritchard et al 2015).

Diversity of Functional Groups

There is limited functional diversity in native oyster beds. However, there is functional diversity present in tide flat benthic invertebrate communities and estuarine crabs.

Potential for Management Actions

For Olympia oysters, there are many different restoration efforts and initiatives to create suitable hard substrate to support native oyster recovery in Oregon, often consisting of artificially spreading oyster shell to create an artificial bed and inoculating with hatchery-reared larval oysters (Pritchard et al 2015).

Contaminant introduction into the estuary could be reduced by better sewage treatment filtration systems and filtering road runoff before it enters the bay.

There are regulatory protections in place to protect both native oyster and tidal flat habitats. Oregon Department of State Lands oversees removal/fill permits to mitigate for any deleterious effects on submerged aquatic lands, including tide flats. There are also regulatory protections of native oyster and benthic bivalves by Oregon Department of Fish and Wildlife, which regulates commercial and recreational shellfishing. For example, it is illegal for recreational shellfishers to harvest native oysters.

Likelihood of Institutional or Human Response

Restoration of native oyster populations was identified as a priority by the Oregon Shellfish Taskforce commissioned by the Oregon legislature (link to pdf here). And there are already efforts in the Coos and other Oregon estuaries to restore native oyster populations.

Eelgrass Vulnerability Assessment

Eelgrass is an aquatic flowering plant that inhabits brackish, soft-sediment tidelands and shallow waters. The Coos estuary has two eelgrass species: native eelgrass (*Zostera marina*) and nonnative Japanese eelgrass (*Zostera japonica*).[1] Eelgrass can inhabit subtidal and intertidal zones and serve many important ecological functions such as sediment stabilization, nutrient processing, trapping of detritus, and provision of important habitat for many species of estuarine animals (especially for juvenile finfish and shellfish) that are commercially, recreationally and ecologically valuable (Cornu et al. 2012, Phillips 1984, Rumrill 2006). Eelgrass acts a sediment regulator by stabilizing shorelines through its root system and decreasing the size of sediment particles into a more stabilized and nutrient-rich sea floor. Plants also absorb nutrients from the sediment that stimulate leaf growth and further stabilize bottom materials through leaf formation and leaf litter.

The reduction or elimination of such a resource would have trophic effects to the natural resources of the region. Species such as oysters, crustaceans, marine mammals, and birds all depend on the vitality of this resource. Eelgrass also supports carbon sequestration, aquaculture, and water quality.

Eelgrass vitality was identified by community stakeholders as the Study Area's most important natural asset, as both a species and foundational habitat for invertebrates and anadromous fish. In initial survey responses, eelgrass was mentioned twice as a critical resource for Dungeness crab and Olympic oysters. Eelgrass beds require a specific set of ecological conditions for success. They are areas of high environmental quality, and the health of these communities is widely considered to be indicative the overall health of an estuary (Bricker et al. 1999, Cornu et al. 2012, Dennison et al. 1993). Eelgrass distribution is linked to many physical factors such as currents, tides, salinity, temperature, depth, and wave energy (Thom et al. 2003).

Direct Climate Effects

Current Condition

Globally, seagrasses (which include eelgrass) have declined markedly since 1990 and are considered among the most threatened habitats (Waycott et al. 2009). Eelgrass has declined in multiple estuaries in the Pacific Northwest in recent years (Magel et al, 2022). The South Slough Reserve continuously monitors current water temperatures, salinity, pH, dissolved oxygen and turbidity as well as conducts regular eelgrass monitoring. Data collected from Charleston Bridge water quality station, near the bay entrance, show healthy water quality levels for eelgrass vegetative growth.While it is inherently difficult to quantitatively measure changes to eelgrass habitat, in the past few decades, up to 11% of the Coos estuarine area has been covered by aquatic vegetation (based on CMECS 2018). Drastic declines have been seen in portions of the estuary in recent years where focused monitoring occurs, in particular in the South Slough arm of the estuary, with evidence supporting aquatic thermal stress as a primary root cause (Marin Jarrin et al. 2022). In the Coos estuary, greatest eelgrass densities have been found at sites closest to the ocean, which are characterized by smaller seasonal temperature ranges, higher salinity, and lower turbidity (Thom et al. 2003).

Historically, successful meadow growth of both native and non-native eelgrass is found in shallow, intertidal brackish areas of the Coos estuary, particularly within the open tide flats at Barview Wayside, Brown's Cove, and on the south side of Younker Point (Rumrill n.d.). The upper regions of the Coos estuary, such as around Valino Island in South Slough, see less consistent growth, typically in 1-3 square meter patches (PCW n.d.). Although data to track eelgrass distribution in the Coos Estuary is incomplete, research shows that the density of eelgrass is affected by regular dredging of the channel.

Eelgrass habitat is threatened by a multitude of stressors, climate related and otherwise. The leading threats to Oregon eelgrass beds in the face of climate change are increased sedimentation, sea level rise, and changes to sea temperature (Sherman and DeBruyckere 2018; Shaughnessy et al., 2012). Increased storms waves and hotter summer days have been identified as additional climatic factors threatening these populations. As the environment continues to change due to increasing water and air temperature and sea level rise, upslope migration to currently unvegetated mudflats will be a key factor to eelgrass adaptability. The Oregon Department of Fish and Wildlife states that existing mitigation plans do not do enough to protect eelgrass from adverse impacts.

Eelgrass is affected by numerous climate related factors and human activities. It is difficult to isolate one factor from another to study how each sensitivity specifically effects the spatial extent and distribution of eelgrass in a particular region or subsystem, and therefore difficult to predict how and where distribution and density might occur. The main drivers of biomass are upwelling, ocean current strength, water temperature, and freshwater flow (Magel 2020). Due to how sensitive eelgrass is to these drivers that are currently affecting Coos Bay, the abundance of eelgrass is likely to decline.

CO2

Increases in atmospheric CO_2 may lead to increased eelgrass flowering and vegetative shoot production, which in turn may help this species adapt to light limitations, such as from increased depths caused by sea level rise (Palacios and Zimmerman 2007). Additionally, enhanced survival and growth from increased CO_2 levels help eelgrass counter stress from warm water temperatures (Zimmerman et al. 2017).

Eelgrass acts as a climate change mitigator through its natural carbon sequestration. One acre of eelgrass can sequester up to 740 pounds of carbon (Smithsonian n.d.), simultaneously moderating the causes of ocean acidification. Current monitoring data from SSNERR show locations within the South Slough at healthy pH ranges. Given eelgrass's ability to mitigate this hazard in concert with current pH levels, the species possesses low sensitivity to ocean acidification.

Temperature

Increased water temperatures have been linked to declines in the Coos estuary (see Current Condition above, and Extreme Climate Events below) as well as elsewhere in the Pacific Northwest, with high degrees of regional variability (Thom et al. 2003). The Coos estuary water temperatures are especially influenced by conditions of the nearshore Pacific Ocean, especially close to the mouth (Marin Jarrin et al. 2022). Shallower areas of the estuary also store and retain heat longer, which can contribute to temperature stress on eelgrass beds. In general, eelgrass exhibits more stress in warmer waters and can die off if their temperature stress threshold (>18°C or 64°F for Coos Bay) is exceeded (Marin Jarrin et al. 2022, Thom et al. 2003). Eelgrass leaf growth increases linearly between ocean temperatures of 40-77°F. Above this threshold, however, eelgrass experiences significant strain, with die-off occurring consistently at temperatures above 86°F (Kaldy 2014).

Temperature stress and poor tidal flushing can also make eelgrass more susceptible to wasting disease (Kaldy 2014). Eelgrass wasting disease is caused by a pathogen and is often associate with rapid population die-offs of eelgrass. Recent data has shown that increased water temperatures increase virulence of the pathogen (Eisenlord et al., 2017, Graham et al 2021).

Though eelgrass can slowly migrate between subtidal and intertidal areas, it remains extremely sensitive to rising temperatures as an immediate threat to its ecosystem. Stakeholders expressed an extreme urgency to mitigate changes produced by rising ocean temperatures, especially as the effect changing ocean temperatures will have on the eelgrass population will have trophic effects on species reliant on this habitat (e.g., Dungeness crab).

Precipitation

The Coos estuary is characterized by a summer dry season (May-October) and a rainy winter season (November-April). During winter storms, river discharge events lower the salinity and temperature while increasing the turbidity in the estuary. Temperature, salinity and turbidity (i.e., effects to light levels) are environmental parameters that can cause stress to eelgrass when thresholds are exceeded.

For example, in the Coos estuary, summer salinities between 25 and 32 appear to be optimal for healthy eelgrass, but elsewhere eelgrass has shown resiliency beyond these thresholds, surviving in both freshwater and salinities as high as 93 (Thom et al. 2003, Philips 1984). However, seed germination, shoot density, and elongation are all heavily reduced beyond the salinity range for optimal growth. Although eelgrass can tolerate periodic immersion in freshwater (salinity <5), it cannot persist in these environments for long periods of time before mortality occurs (Nejrup and Pedersen 2008). Seed germination occurs most frequently in brackish conditions (i.e., 5-10) (Phillips 1972, Phillips et al. 1983; Nejrup and Pedersen 2008; Rumrill 2006).

Depth distribution of eelgrass becomes more restricted as turbidity (increased suspended sediment) levels increase in a system (Borde et al. 2003).

Sea level rise

Like all tidal wetlands, eelgrass beds exist in a dynamic equilibrium between sediment accretion, surface elevation, and sea level. Light availability is the most important factor for eelgrass growth, survival and reproduction (Dennison 1987). Changes to depth from sea level rise will decrease light penetration, affecting eelgrass distribution and survival (Borde et al. 2003). As eelgrass beds decline in cover and density, effects from sea level rise are exacerbated as sediments are no longer trapped as efficiently, accretion rates decline and erosion rates increase (Kairis and Rybczyk 2010). Greater wave energy in deeper waters will further weaker root systems. Changes will likely be incremental and may vary across the estuary.

Eelgrass can adapt to a wide range of saltwater environments, but it grows successfully only in intertidal areas (see salinity discussion under Precipitation above). In Coos Bay, freshwater habitats may become more brackish environments as saltwater intrusion increases from sea level rise, leading to potential alternative habitat distribution.

Extreme climate events

Marine heat waves may be one of the biggest threats to eelgrass beds. The "Blob", an anomalously warm ocean during 2014-2016 has been linked to severe eelgrass loss in the Coos estuary (Marin Jarrin et al, 2022). The persistence of native eelgrass beds that are relatively exposed may be jeopardized with more frequent and intense storm events, particularly in the lower Coos estuary where large storm-generated waves may be propagated (Cornu et al. 2012).

Severe droughts, as was seen in 2013-2014 where only 50-71% of average river discharge was seen in the Coos, is directly linked to higher-than-average salinity in the estuary and retention of warm water (Marin Jarrin et al. 2022). Up estuary, shallow locations retain warmer water for longer periods as compared to deep channels and areas closer to the mouth (Marin Jarrin et al 2022).

One of the leading factors of the "Blob" and the 2013-14 drought years was a perfect combination of North Pacific Oscillation and El Nino events, both of which are expected to occur more frequently in the future (Wang et al. 2014).

Sensitivity/Exposure to non-climatic factors:

All the participants in the natural resource stakeholder listening session agreed that dredging and other non-climatic stressors that alter sediment dynamics, nutrient and turbidity levels severely impact eelgrass habitat. Both stakeholder and research sources discuss how human activities have historically had the largest impacts on eelgrass health and density. Pollution runoff (including herbicides), eutrophication, dredging, invasive species (e.g., European green crab, non-native eelgrass), sedimentation and erosion, and turbidity were identified as important non-climatic factors during community listening sessions. In the Coos estuary, fisheries, aquaculture, recreational clamming, and shoreline development routinely disrupt habitats through physical disturbance, sedimentation, and nutrient and chemical runoff. For example, propellor scour commonly cuts or uproots eelgrass and disturbs bed sediment stability while recreational clammers frequently digging for clams inside eelgrass beds can cause diminished biomass and cover months after disturbance (Boese 2002). While eelgrass is resilient to many of these impacts, to an extent, coastal developments will continue to homogenize estuarine ecosystems and have trophic effects on fish, shellfish, and invertebrates.

The U.S Army Corps of Engineers North Bend routinely dredges the channel floor and provides sea floor navigation aids for larger commercial vessels. For over four decades, data has shown that dredging poses the greatest threat to eelgrass habitat (Phillips 1984). Dredging reverses the normal oxidation potential of the sediments of an eelgrass system, reversing the nutrient-flow mechanics of the ecosystem. The entire physical structure of the ecosystem changes from the process, effectively ending viability for eelgrass growth in dredged areas.

Runoff and erosion from coastal development impact nutrients and turbidity and cause increases to chemical runoff, while overwater structures (e.g., bridges) reduce light availability. Coastal development can cause trophic effects to eelgrass environments, altering water quality, salinity levels, and increasing water temperature.

Timber harvest practices, including herbicide and fertilizer applications, may have deleterious effects on eelgrass beds. Current forest practices can also lead to increased stream temperatures as riparian cover is diminished, and increased turbidity levels through erosion. If non-climate stressors continue to induce turbidity without proper regulation and planning intervention, eelgrass populations will likely decline.

Climate change may provide an advantage to nonnative Japanese eelgrass (*Z. japonica*). For example, disturbance events have been shown to enhance Japanese eelgrass productivity and fitness (Bando 2006). Currently in the Coos estuary, native eelgrass grows lower in the tidal frame than nonnative eelgrass and distribution has limited overlap. However, in other estuaries, such as Willapa Bay, WA, Japanese eelgrass has been shown to outcompete native eelgrass in transition zones where the two species overlap (Fisher et al. 2011).

Eelgrass: Adaptive Capacity

The ability of eelgrass to adapt to changing conditions is based on these five factors: 1) current condition (i.e., density and percent cover of eelgrass beds; percentage of reproductive shoots); 2) fragmentation of ecosystem; 3) barriers to migration; 4) continued impacts of non-climate stressors; and 5) rate of recovery. How eelgrass can adapt underscores the potential to reduce impact of sensitivity to the region's hazards.

Due to poor current conditions, loss of suitable habitat, limited ability to migrate, and high impact of non-climate stressors, the capacity for eelgrass to adapt to anticipated changes in the Study Area is low.

Degree of Fragmentation:

Changes to sediment dynamics can occur from climate and non-climate stressors, including increasing wave energy, flooding events, shoreline development, dredging, and coastal erosion and landslides. Most of these events will overwhelm eelgrass's regulatory effects by reducing overall water quality, which induces greater fragmentation of its ecosystem.

The ability for eelgrass to thrive in suitable habitats in the Coos estuary is marginalized by the commercial use of the bay. Eelgrass possesses high capacity to adapt to changing conditions, yet viable habitats are routinely disrupted by dredging, propellor scour, aquaculture (e.g., commercial oyster harvest practices), and recreational shellfish harvest.

Growth rates and shoot density fluctuate throughout the year, with warmer seasons producing denser meadows in the Coos estuary. The greatest potential for density may have historically been within the Coos channel, which has a strong intertidal influence and steady physical conditions (e.g., water temperature and salinity). Yet, this figure highlights dredging maintenance and use of the shipping channel as an area of habitat loss. Other factors that affect eelgrass distribution are water clarity, substrate availability, wave action, and desiccation stress from direct sunlight during low tides.

Barriers to Migration:

As sea levels change, eelgrass will be forced to migrate both upriver and up the tidal frame onto currently unvegetated tide flats. These regions of the watershed tend to have less light penetration, less salinity, a smaller tidal range, and more competition from freshwater species. Areas in the Upper Bay, North Slough, and Haynes Inlet are examples of regions that may have fewer human impacts yet are further from the estuary mouth and therefore less stable in terms of temperature and salinity regulation. Narrow upstream river channels will provide less space and increase shade stress (which reduces leaf lengths, carbohydrate reserves, and shoot density) (Cimon et al. 2021).

Human developed barriers include transportation infrastructure, levees, and dredged channels. For example, the diking of tidal wetlands and creation of the Marshfield Channel decreased depths and velocity of tidal transport (Eidam et al. 2020).

The combination of coastal development and limited landward migration zones present strong limiting factors for eelgrass dispersal throughout the Study Area. An extinction assessment on all eelgrass species conducted in 2011 showed that 33% of worldwide species were in decline where data were available (Short et al. 2011). While eelgrass can relocate where there is suitable habitat, the Coos Bay landscape is far too unique to predict successful migration with certainty. The unique barriers in the Coos estuary have the potential to create drastic deleterious effects if coastal development continues (Sherman et al 2018).

Another factor that could limit migration of *Z. marina* is its non-native counterpart, *Z. japonica. Z. japonica* is less affected by tidal and freshwater regimes (PCW n.d.) and adapts well to higher elevation mudflat habitats (Sherman et al 2018). Several Pacific Northwest estuaries have shown evidence of nonnative Japanese eelgrass outcompeting native eelgrass in zones where they overlap (Fisher et al. 2011).

Recovery and Regeneration Following Disturbance

Limited current data on the rate of recovery of eelgrass exists for the Coos estuary. Stakeholders expressed that recovery of eelgrass beds were linked to fragmentation of the ecosystem and that the spatial extent throughout the entire estuary had not been assessed since 2016. Observations recorded in listening sessions reported significant changes in eelgrass migration in the upper Coos Bay, as well as complete die-off in some areas (e.g., South Slough arm). SSNERR data collection showed that eelgrass density has declined in the South Slough and to a lesser extent Barview, Strawberry Island, and the airport flat.

Following the 2016- die-off of eelgrass in the South Slough arm of the estuary, there have been moderate increases in eelgrass density and cover at some sites with sites closest to the mouth beginning to recover the quickest. Yet six years later, no site has recovered to pre-2016 average conditions and some sites still have no eelgrass (Marin Jarrin et al 2022).

With a higher resiliency towards changing conditions from sea level rise and short-term ocean acidification events, nonnative *Z. japonica* may provide “reserve sites” for native *Z. marina* as the species migrates upslope more successfully (Sherman et al 2018). Japanese eelgrass is found in higher intertidal zones where it has greater growth success than native eelgrass, can tolerate higher water temperatures, and is able to tolerate a greater salinity range. While competition with Japanese eelgrass for migrating areas could become a mitigating factor for native *Z. marina*, more research could be conducted between the relationship of *Z. japonica* and *Z. marina* in identifying migrating patterns between species.

Diversity of Functional Groups

As compared to other wetland systems, eelgrass beds have very low vegetative species diversity with one native (and one nonnative) species present in the estuary. There is limited structural diversity, especially during low tides when intertidal eelgrass leaves lay prone.

Salmonids Vulnerability Assessment

The Coos Bay watershed is home to four species of salmonids: Coho salmon, fall Chinook salmon, Winter steelhead trout, and coastal cutthroat trout. A fifth species, Chum salmon, is effectively extinct (except for a relict population in Marlow Creek) in the Coos basin. The salmonid populations are well-monitored due to their economic and cultural value for the Coos Bay region. Salmon are considered keystone species due to their ecological significance in marine, estuarine and terrestrial systems.

Salmonid species have extraordinarily complex life cycles and thus can be affected by different environmental changes depending on life stage.

Direct Climate Effects

Current Condition

Overall, the salmonid population is considered stable and has a low extinction possibility, yet multiple species are listed as threatened. Fall Chinook and cutthroat trout both have relatively strong populations in the Coos basin (Cornu et al. 2015). The status of Coho and steelhead are of concern, with highly variable ocean returns across years and depending on stream system (Cornu et al 2015). In the ocean, climatic oscillations are likely to have direct and important effects on salmon populations in both the ocean and the local river systems. Tidal conditions like the Pacific Decadal Oscillation (PDO) and the El Niño Southern Oscillation (ENSO) first affect species lower in the food chain, and in turn affect the higher levels of the chain like salmon. As such, ocean current events are likely to affect salmon abundance through marine survival rates due to increased stratification in the California Current and poor foraging conditions (Hare et al 1999).

CO2

Research suggests that ocean acidification causes a wide range of deleterious physiological responses in marine fishes. Elevated levels of carbon dioxide in the water may induce a condition in fish known as “hypercapnia,” which can limit the function of the respiratory, circulatory, and nervous systems. The long-term effects of hypercapnia may inhibit important life functions by reducing growth, reproduction, and calcification. The effects are greatest in fish eggs, larvae, and juveniles -- this implies that salmon in their early life cycles are more at risk from the effects of ocean acidification (PCW n.d.).

Ocean acidification will additionally affect marine food webs as the growth, metabolic activity, and quality of primary producers (phytoplankton) is diminished, affecting growth and survival of higher trophic level organisms such as salmon (Jin et al, 2020).

Temperature

Increasing ocean temperatures may affect the distribution of salmonid species, with warmer temperatures creating more favorable habitats away from Coos Bay and closer to the poles and deeper in the ocean. Salmonids have slow development rates and very complex life histories and are less capable of adjusting to mass migration to the poles (Perry et al 2005). Therefore, Salmonids are more affected by rising ocean temperatures due to their inability to rapidly respond to unfavorable habitat changes.

Rising ocean temperatures also effect salmon by encumbering basic life functions and altering marine food webs. The amount of energy the fish spend toward growth and reproduction declines as ocean and stream temperatures approach the extreme ends of species-specific tolerance ranges. Increased ocean temperatures may reduce marine survival rates and accelerate the loss of areas that provide cool water refuge and resting habitats for salmon.

Predicted decreases to summer precipitation will compound estuarine temperature as stream temperatures increase from low stream flow and elevated air temperatures. Hypoxia (low dissolved oxygen levels) is linked to temperature and similarly expected to become more common with expected warmer and dryer summers (OCCRI 2010). An increase in estuarine temperature could also lead to increased occurrence of harmful algae blooms (HABs), which can increase hypoxic conditions. Both high temperature and low dissolved oxygen affect juvenile and returning adult salmon. For example, weight loss, diminished growth rates, disease, displacement or predation by nonnative fish, and mortality can all occur when stream and estuarine temperature and oxygen levels exceed salmonid tolerances (Richter and Kolmes 2005; ODFW n.d.).

Precipitation

Stream flows are expected to decrease in spring (5-10% less) and summer (15-20%) for Coos streams that support Coho salmon (ODFW n.d.). Reduced summer stream flows can limit suitable salmon rearing habitat by loss of peripheral streams, low water levels, and heightened water temperature (ODFW 2014). As sufficient stream habitat is diminished, loss of thermal refugia will more frequently expose salmonids to stressful or lethal temperatures (Richter and Kolmes 2005).

Winter stream flows are expected to increase up to 5% in the Coos basin (ODFW n.d.). This can lead to increased redd (nest where eggs are deposited) scour and egg mortality. Destabilization of stream banks will increase fine sediment inputs into streams, which can limit suitable spawning substrate, and reduce riparian shading (ODFW 2014).

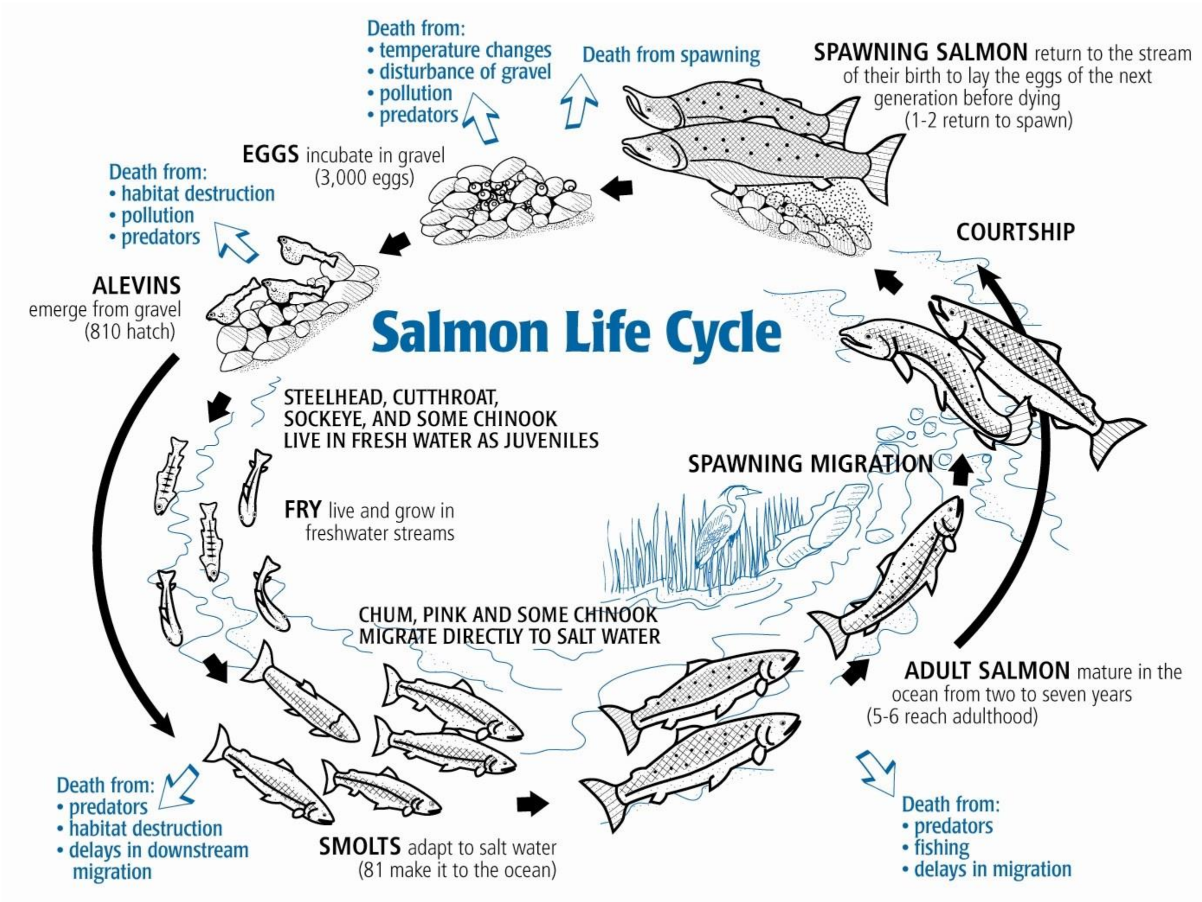
Sea level rise

Sea level rise threatens estuaries, which are vital for salmonid life cycles. Sea level rise is expected to reduce tidal marsh habitat and alter estuarine food webs. Changes to availability and quality of estuarine habitats will affect salmon survival (Miller and Simenstad 1997). Sea level rise-related salinity changes will likely shift or reduce estuarine rearing habitat.

Extreme climate events

Extreme flood and drought events will both affect salmonid habitat, as describe in "Temperature" and "Precipitation" above.

Figure 6 Salmon Life Cycle



Source: Skagit Fisheries Enhancement Group

Sensitivity/Exposure to non-climatic factors:

Many non-climatic factors influence salmonid abundance and distribution including commercial and recreational fish harvests, availability of spawning and rearing habitat, effects of hatchery fish on wild populations, and diminished water quality (e.g., high stream temperatures).

Increased sedimentation can smother salmon eggs upriver. In saltwater, it is likely that increased sedimentation will have little direct effect on salmonid species. It can, however, affect salmonids' food source.

Local salmonid populations are often preyed upon by sharks, orcas, pinnipeds (seals and sea lions), lamprey, and by sea birds (e.g., common murres) (PCW n.d.). Pacific harbor seal (*Phoca vitulina richardsi*) populations have grown since the Marine Mammal Protection Act of 1972 and are nearing capacity in the area. Salmonids make up anywhere from 1-30% of the seals' diet (Orr et al. 2004). Young salmon are preyed upon by sea birds, particularly the double-crested cormorant and common murres. Studies found that salmon make up about ten percent of their diet (Adkins et al 2010). In both cases, an increase in predator species leads to a decrease in returning salmon.

Oregon Department of Fish and Wildlife have many fish hatchery and rearing programs that affect salmonid populations in the Coos Bay Area. There is widespread support for hatchery production and the Coos hatchery efforts are highly effective at increasing fish available for recreational harvest. Research suggests that declines in wild populations, coupled with increases in hatchery production, may accelerate genetic changes in salmon. These changes may alter the long-term fitness of the fish by reducing genetic adaption that exist locally to help native salmon reach their spawning sites. In addition, hatchery and wild fish interbreeding may have a cumulative, negative influence on the reproductive fitness of wild stocks. As such, it can take many years for wild stocks to recover after hatchery practices are terminated. There may also be competition for food and habitat between wild and raised salmon in the bay. Studies show that raised salmon grow larger and quicker than native salmon but are more at risk of being preyed upon. Overall, the effects of rearing hatched fish in the area are not fully understood.

Salmonids: Adaptive Capacity

According to Partnership for Coastal Watersheds, many environmental and human-related factors influence migration timing and the location/abundance of salmonid species in the Coos Bay Are. Factors include: 1) the condition and availability of spawning habitat, 2) the condition and availability of rearing habitat, 3) the connectivity between the ocean and headwater habitats, 4) commercial and recreational fish harvests, and 5) the effect of hatchery fish in wild fish populations.

Degree of Fragmentation

Availability of spawning habitat (streams) and rearing habitat (streams and wetlands) is already diminished in the Coos estuary due to anthropogenic modification. Salmon habitat is highly fragmentated due to roads, diking of wetlands and conversion to other land use types, reduction in spawning habitat and other anthropogenic activities such as logging, mining, dam construction and water diversion (McClure et al 2008).

Barriers to Migration

Reduced habitat connectivity due to anthropogenic barriers remains a top concern for salmon. Tide gates and inadequately sized culverts block access between waterbodies, which collectively add up to large areas of reduced habitat availability (Waples et al. 2009).

Thermal migration barriers occur when water temperatures exceed thresholds for salmon success and survival, restricting their ability to use those waters.

Recovery and Regeneration Following Disturbance

Pacific salmon have evolved in dynamic habitats that are both physically and climatically dynamic (Waples et al. 2009). For example, they are adapted to seasonal changes (e.g., stream flows), annual shifts to habitat structure (e.g., stream pool formation), and decadal scale ocean dynamics (e.g., El Niño Southern Oscillation) (Waples et al. 2009).

Diversity of Functional Groups

Life history diversity (e.g., migration timing), genetic diversity, ecological diversity and geographic range all differ across salmon species (Waples et al 2005). Intra- and interspecific diversity in salmonids leads to differences in spawning timing and location and duration spent in the variety of habitats that different life stages require (Service et al, 2019).

Potential for Management Actions

Adaptation actions through habitat restoration have been a focus of state and conservation efforts in recent years. Preserving existing intact habitats while continuing to restore former wetlands lands back to a more natural state through floodplain connectivity, converting incised stream ditches back to more complex stream morphologies, and enhancing riparian vegetation, will continue to benefit salmon populations (Beechi et al, 2012). Improving fish access between stream and estuarine systems by reducing barriers (e.g., tide gates) will benefit salmon by restoring natural tidal flows. Reduction in urban runoff directly entering the bay will help maintain healthy water quality. Changes to Oregon forest practices (e.g., increasing buffers from streams that are no-cut) could further protect stream and estuarine habitat by protecting spawning substrate, reduce evapotranspiration loss, and improve water quality for juvenile rearing salmon.

Sensitivity and Adaptive Capacity of Coastal Uplands Ecoregion

The Oregon Coast Range juts up against regions of the Coos Bay estuary and wetlands, creating diverse dunal and swamp forests of evergreen and deciduous trees (PCW n.d.). The deciduous red alder is common along streams and riparian habitats. A wide array of conifer trees is found in the Coos coast range including Port Orford cedar, Sitka spruce, Douglas fir, western redcedar, and western hemlock (OFRI n.d.). Decades of logging in the region have altered the diversity of treescape, with native trees like Sitka spruce being replanted with Douglas-fir. Approximately 88% of the Coos watershed is managed for the commercial production of timber (Rumrill n.d.).

The EPA defines the coastal uplands ecoregion as the hills and valleys that border the coastal lowlands. Coastal uplands vary from 400’ to 2,500’ above sea level and receive high levels of moisture (mist or rainfall) due to its marine climate. Coastal upland forests are homes to many species trees and grasslands are common between groves. The Elliot State Forest is the most notable coastal upland natural asset in the Study Area. The Coastal Uplands ecoregion (Figure 4) covers 99.3 square miles (32%) of the Study Area generally at elevations between 400 and 1,200 feet. The landscape is characterized by headlands and low mountains surroundings the Coastal Lowlands with medium to high gradient creeks and rivers. Forests in this ecoregion consist of spruce, cedar, hemlock, Douglas-fir canopy which has replaced much of the Sitka spruce which dominated before logging. The coastal uplands support some pastureland and logging and has some recreation, rural residential, and commercial development. The Mid-Coastal Sedimentary ecoregion (Figure 4) covers 113.2 square miles (36%) of the eastern part of the Study Area including a large portion of the Coos River subsystem generally at elevations between 500 and 1,200 feet (but the ecoregion does extend to lower elevations near creeks and rivers). The landscape is characterized by moderately slopping mountains with medium to high gradient creeks and rivers. The forest canopy is dominated by Douglas-fir and western hemlock. The ecoregion has some pastureland with some rural residential development in valleys but is mostly forest that supports recreation and logging.

Upland Forest Vulnerability Assessment

Upland forests in the Coos watershed are typically closed canopy temperate coniferous forests that are second or third growth and dominated by Douglas fir. Upland forests are important habitat for birds, mammals, reptiles, and amphibians including the iconic endangered species Marbled Murrelets and Northern Spotted Owls. Forest canopies shed rain, collect fog, shade streams, and roots hold steep slopes in place. Forestry is a primary industry in the project area. Upland forests also provide space for recreational activities (e.g., mushroom gathering, hunting).

While coastal forests are adapted to warm dry summers, a strong maritime effect adds moisture and reduces temperatures. Wildfires are relatively uncommon in these coastal forests, yet high severity fires have occurred historically, facilitated by extremely dry springs and summers along with high winds (Spies et al. 2018).

Direct Climate Effects

Current Condition

Increased tree mortality from droughts, insects and diseases is already occurring and the expectation of warmer, drier summers will only exacerbate this. Swiss needle cast (*Nothophaeocryptopus gaeumannii*) for example is a native fungal disease that historically was considered innocuous but has intensified in recent years likely due to short-term climate changes (Mildrexler et al., 2019).

Interactions among climate variables are likely to play a complicated and sometimes unclear role in trajectories of upland forests. For instance, increased summer temperature stress is compounded by decreased summer precipitation and even higher prevalence of drought conditions.

CO_2

The general pattern that emerges from CO_2 research in moist forests suggests that elevated CO_2 reduces stress in forest species when it is experiencing moisture stress (i.e., dry conditions) and enhances net annual productivity (McMurtie et al. 2008; Hudiburg 2012). Seasonal variations in atmospheric CO_2 concentrations can substantially and positively affect photosynthesis by increasing water use efficiency (Jiang et al. 2019; Keenan et al 2013). This CO_2 "fertilization effect" works only if other resources (i.e., nutrients, water) are available. When something else limits growth, such as nitrogen, the fertilizer effect will taper off and there will no longer be a net increase in productivity. What is unknown is whether the CO_2 fertilization effect will outpace drought stress brought on by warming temperatures and decreased summer precipitation (Sperry et al. 2019, Dusenge et al 2018). Some evidence suggests any benefits of CO_2 fertilization will be outweighed in the future as the climate warms and water becomes more limiting (Gedalof and Berg 2010, Restaino et al. 2016).

Temperature

Changes in temperature may have diverse effects across coastal forests and will vary by distance from ocean as well as changes to frequency and duration of El Niño events. Increased temperature could initially extend growing seasons and increase productivity for energy-limited forests closer to the coast. However, this increase in productivity will eventually be offset by decreased moisture availability, especially if there is continued loss of summer fog (Dye et al., 2020). Expected warmer, drier summers will increase moisture stress and decrease productivity with forests experiencing higher temperatures the further they are from the ocean. Additionally, consistently warmer summer temperatures will lead to increased risk of large and severe fires (Halofsky et al 2020). For instance, Davis et al (2017) projected slight increases in probability for large wildfires (>200 ha) during the 21st century (under RCP 4.5 and 8.5, respectively) for the Coast Range.

Phenology shifts related to climate change will also affect coastal forests. Differing sensitivities to climate cues may result in species composition shifts over time. For example, hazelnut, salal, and Oregon grape are all expected to experience earlier flowering and ripening of fruits under RCP 8.5 (Prevéy et al. 2020). A major concern in the assessment area associated with warmer winters and earlier springs is the requirement for many species (e.g., Douglas-fir, western hemlock, pine and fir species) to experience chilling in order for new leaves or buds to emerge (Harrington and Gould 2015). Douglas-fir may experience earlier budburst in some portions of its range due to warming in early spring, but reduced chilling may cause later budburst in the southern portion of its range (Harrington and Gould 2015) and lead to delayed initiation of growth (Ford et al. 2016). Some tree species ranges will likely shift northward to survive and reproduce (Monleon and Lintz 2015).

Precipitation

The interaction between changes in temperature and precipitation are a major factor in forest health. For example, even small increases in air temperature can increase vapor pressure deficit, which results in increased rates of water loss from soils, leading to greater transpiration rates, and quicker mortality events (Will et al. 2013). Similar to effects from increased summer temperature, a decrease in precipitation, especially in the spring and early summer, will result in moisture stress and decrease woody plant productivity. This effect will likely be amplified by decreased summer fog, which plays an essential role in mitigating summer drought and has been decreasing over the last several decades (Dye et al. 2020). Some species are better adapted to moisture stress than others, so decreased summer moisture will likely result in species composition shifts over time, especially at drier, inland sites. Severe drought events can cause stem loss, decreased canopy biomass, and even tree mortality (Choat et al. 2018, Saiki et al 2017). As with higher temperatures, decreased humidity and precipitation will increase frequency of fire weather (Jain et al., 2022).

Conversely, predicted increases in the number and intensity of winter rainfall events will facilitate more frequent mass land movements (OCCRI 2020). These catastrophic events will accelerate erosion and impact forest road and trail structures (e.g., culverts) (NRC 2008).

Sea level rise

Direct impacts from sea level rise on forest systems are likely to be minimal and focused at the forest/tidal wetland transition zone (Smith and Kirwan 2021). Forested swamps are a critical habitat, which are threatened as they convert to saltwater marshes as sea-levels rise and saltwater intrudes. In these zones, upland forests will convert to tidal marsh communities. Adjacent steep terrain and human infrastructure limit these forests' ability to migrate. In addition, sea level rise will increase salinity in coastal aquifers (Werner and Simmons 2009), which many forest tree species utilize.

Extreme climate events

Extreme climatic events will inevitably occur, including extreme winter precipitation, high wind events, and extreme summer drought (Mass et al. 2022). Higher intensity winter storms, which bring heavy precipitation and wind, will result in increased windthrow (i.e., tree mortality from blowdown) disturbance and landslides. Riparian area composition along debris flow tracts could lead to increasing amounts of hardwoods in the future (OCCRI 2020). The increased precipitation will have other localized impacts such as head wall retaining system failures along forest roads.

High wind events may increase windthrow, especially in areas where trees are unprotected (e.g. adjacent to clear-cuts or burn areas) and/or weakened by overcrowding causing trees to be less "wind firm". Extent of windthrow will vary by topography (Harcombe et al 2004).

Extreme drought combined with high air temperatures, such as occurred during the “heat dome” of 2021, will lead to increased defoliation and leaf scorch in Oregon’s coastal forests, with Western hemlock (Tsuga heterophylla) and Western red cedar (Thuja plicata) being most impacted (OSU 2021). Severity of the 2021 heat dome was related to exposure, with south facing slopes most heavily impacted (OSU 2021).

Mass et al. (2022) project that the frequency of dry, east wind events that drive the largest, most severe fires in this region will decrease modestly. However, even as frequency decreases, more ignitions and more intense fire are likely to occur concurrently with east wind events when they do happen. An increase in extreme drought/high temperature events especially when coupled with east wind events will increase the likelihood of high-intensity stand-replacing fires.

Sensitivity/Exposure to Non-Climatic factors

Forests and wildlife are threatened by wildfire, drought, invasive species, and pathogens (e.g., Swiss needle cast and Port-Orford-cedar root rot). Extensive clearcutting and replanting primarily with Douglas fir has reduced the spatial complexity of coastal forests, allowing forests to dry quicker, fires to spread horizontally and vertically with relative ease, and risk of fire intensity to become greater (OCCRI 2020). Complex interactions from other stressors such as insects and pathogens, also anticipated to increase with changing climate conditions, could potentially exasperate effects of drought and wildfire occurrence.

Sensitivity/Exposure to Invasive Species

Current Condition

Nonnative and invasive plants gain a toehold when there are areas of disturbance, including those created by forestry management practices (e.g., clearcuts, thinning, roads). Common species already threatening upland forests include gorse (Ulex europaeus), Scotch broom (Cytisus scoparius), thistles (Cirsium spp), St. John’s-wort (Hypericum perforatum), non-native species of blackberry (e.g., Rubus armeniacus), old-man's beard (Clematis vitalba), butterfly bush, jubata grass (Cortaderia jubata), knotweeds (Polygonum spp), purple loosestrife (Lythrum salicaria), foxglove (Digitalis purpurea), and policeman's helmet (Impatiens glandulifera) (Gray 2005, Schmitt et al, 2015). These plants compete with native shrubs and young trees for light and nutrients. Many of these species, once established, develop abundant seed banks in the soil, allowing them to quickly respond to future disturbances (Gray 2005). Unlike many other invasive plants, English holly (Ilex aquifolium) and English ivy (Hedera helix) are two species that thrive even in highly shaded conditions (Gray 2005). Invasive pathogens also threaten forest health, including sudden oak death (Phytophthora ramorum) and Port Orford cedar root disease (Phytophthora lateralis), both of which damage coastal trees. Exotic insects such as spruce aphids and gypsy moths also damage forest ecosystems (Williams 2020).

CO2

Invasive species have an edge over native species in that they have escaped the pressures of natural predators. These species tend to be good resource scavengers in general and will increase productivity as CO2 levels increase. While invasive and native plants all increase productivity in response to elevated levels of CO2, invasive species also possess traits that allow them to invade native ecosystems, giving them an extra advantage (Weltzin et al 2003).

Temperature

As temperature increases, relative humidity declines, and water evaporates more quickly, leading to drought conditions (Udall and Overpeck 2017). Effects on how native vs invasive plants will respond to this is uncertain as both include species that are more drought tolerant than others (USDA 2017). Non-native species with a higher ecological competence to warmer and drier conditions in summer and wetter conditions in winter will likely spread more quickly and across a larger range.

Climate change may favor some invasive species that were held at bay by cold temperatures, allowing their ranges to expand northward (Weltzin et al 2003). This may be especially true for invasive insects and pathogens expanding into coastal forests. Stressed native trees will likely have difficulty defending against both new and existing outbreaks (e.g., bark beetles; Phytophthora spp).

Precipitation

Some invasives can change fire regimes by providing more fuel and some, such as gorse, are highly flammable. Increased moisture stress will slow early growth of native tree species and make it harder for regenerating trees in disturbed sites to outcompete ruderal invasive species. Without management, the result will be persistent communities of invasives that are low in species and structural complexity. Moisture stress will generally make tree species more susceptible to pathogens, yet pathogens themselves may be sensitive to changes to precipitation regimes (Finch et al., 2021)

Extreme climate events

Invasive species are more likely to pioneer newly exposed habitats (debris flow tracts, blowdown patches, floodplains) resulting from severe climate events and taking away valuable nutrients from native vegetation. High severity fires, intense rain events, and increased incidence of windthrow will all create disturbance that will facilitate the spread of invasive species into newly disturbed areas.

Sensitivity/Exposure to Nutrients

Current condition

Historically and to a lesser extent currently, anadromous fish (e.g., salmon, lamprey) provided an extensive amount of marine derived nutrients to forests, which contribute to the growth of forest vegetation by providing phosphorous, which is generally limited in coastal forests (Gende et al 2002).

CO2

As CO2 levels rise, carbon becomes less limiting than nutrients for growth. Elevated nutrients and elevated CO2 in the system could mean rapid growth. Reduced nutrients and elevated CO2 would benefit the growth of species which don't rely on high nutrient levels over those that do, resulting in species shifts.

Precipitation

Alders are trees that fix nitrogen, supplying important nutrients to forest soils. Red alders (Alnus rubra) are fire resistant due to scarcity of flammable debris, and propensity to grow in moister sites (Harrington 2006). They are pioneer species and establish quickly into areas of high light and exposed mineral soil (e.g., following disturbance events, such as wildfires). However, alders may not be as drought tolerant as conifers and exposure to drought can cause alder top dieback and mortality (Harrington 2006). The future of red alders in a hotter dryer climate is uncertain.

Timber industries often fertilize planted forests with nitrogen. Heavy rain events may wash some nutrients down the watershed and into streams, although likely not in high concentrations (Fox et al 2007). Forest buffers along streams can help alleviate input of nutrients into the system (Fox et al 2007).

Extreme climate events

Increased likelihood of wildfires due to severe drought will affect nutrient availability in the system. Following fires, total nutrient capital might decrease due to volatilization, yet some will be broken down into different forms, depending on fire severity (Fisher and Binkley 2000). For example, moderate intensity fires will convert organic nitrogen in soils to forms of inorganic nitrogen, which is more easily taken up by plants (Certini 2005). Shifts in nutrient availability will also cause changes to microbial functions, which are crucial to nutrient cycling (Knelman et al., 2015).

Gorse (Ulex europaeus) and Scotch broom (Cytisus scoparius) are two invasive species that fix nitrogen and colonize quickly following disturbance events, such as wildfires.

Sensitivity/Exposure to Sedimentation/Erosion

Current Condition

Exposure of mineral soils through ground disturbance from logging and road building can increase sediment delivery to streams. High winds and periods of heavy rainfall can elevate sediment transport rates into stream – depending on amount, location and type of sediment this can be positive or negative to stream health. Large quantities of sediment over a short time can be delivered to streams when forestry activities take place on steep slopes prone to landslides.

Precipitation

Expectations for heavier winter rain events will lead to higher levels of sediment delivery into streams from all sources, including landslides (Mauger et al., 2015).

Extreme climate events

High intensity winter storms will deliver more sediment to streams including through more frequent mass-movement and windthrow events (Puntenney-Desmond et al., 2020).

Hotter, drier summers will increase the probability of wildfires, which produce burn scars that are more prone to mass-movement events, as well as expose mineral soils that can be transported into aquatic systems.

Sensitivity/Exposure to Contamination

Current Condition

Current contaminants on upland forest lands include chemicals from illegal grow operations, illegal dumping (e.g., paints, batteries), legacy mining sites (which can leak tailings), herbicides used in forestry practices, and chemicals used in fire suppression to fight wildfires. All of these contaminants can impair stream water quality.

Precipitation

Chemicals could mobilize into streams after heavy rain events. Timing of spraying and rain events are interrelated

Extreme climate events

Wildfires in proximity to developed areas will introduce many toxins from burned structures into the environment and water systems. Wildfire retardants (often used most heavily in the urban/forest interphase) use ammonium phosphate, which is detrimental to aquatic life and can also lead to harmful algal blooms.

Upland Forest Adaptive Capacity

Degree of Fragmentation

Coastal forests are highly fragmented due to combined pressures from forest management practices and development (e.g., roads and other impervious surfaces; agriculture; urban growth). Forest fragmentation from forest practices such as clearcutting affects the amount and spatial arrangement of large trees and large dead wood, soil conditions, and microclimates on forest landscapes, which all affect the quality of this habitat (McComb et al. 1993). Fragmentation is especially high on privately owned forest lands (Spies et al. 1994). Forest fragmentation creates more forest edges, which can lead to higher rates of windthrow and be more vulnerable to climate conditions (e.g., edges are hotter and drier and more exposed to wind) (Haila 1999, Matlack and Litvaitis 1999). Fragmented forests are also more susceptible to pathogens and insects (Spies and Franklin 1996).

Barriers to Migration

Tide gates and dams both restrict fish movement to and from upland streams. Roads and other impervious surfaces impede movement of wildlife using upland forests. For example, habitat connectivity is crucial for viability of amphibian populations (Cushman 2006). In respect to vegetation migration with climate change, trees (conifers in particular) will migrate very slowly, if at all (Zhu et al 2012; Liang et al 2018). Shore pines (Pinus contorta) for example, are one of many conifers already lagging behind their optimum range based on climate (Bisbing 2021).

Recovery and Regeneration Following Disturbance

Coastal upland forests are well adapted to disturbance and can generally regenerate quickly following disturbance events. However, stand development is a slow process and developing quality old-growth habitat after disturbances will take decades to centuries, depending on the nature of the disturbance. The ability of an upland forest to develop in a timely manner following disturbance is greatly affected by the influences of weather (e.g., normal vs drought years) and competing vegetation (e.g., invasive species). Some coastal species are better adapted for change and respond more quickly than others (e.g., red alder). Unfortunately, some of these species that respond most quickly are often invasive (e.g., Scotch broom, gorse). Early seral species can quickly reestablish on disturbed site (e.g., red alder), while shade-tolerant species (e.g., western hemlock, western red cedar) are slower to reestablish.

The intensity, duration, and frequency of disturbance events will also affect recovery. For example, some seed banks will likely remain following minor to moderate forest fires. There is evidence that dominant tree species (e.g., Douglas-fir) regenerate relatively rapidly following historical fires. However, short interval reburns (e.g., Tillamook Fires) cause much slower recovery times. Duration and intensity of drought or high heat events will affect severity of damage and mortality to forest trees, as was seen in the 2021 heat dome (OSU 2021).

Finally, the habitat quality and structure prior to disturbance is important for recovery. For example, old growth trees may still mature cones even if the tree itself died from high intensity fires. Seedlings are very vulnerable to drought as witnessed during the 2021 heat dome event, while older trees are more resilient (OSU 2021).

Diversity of Functional Groups

Due to industrial forest management practices, coastal Oregon forests are generally relatively homogeneous Douglas fir plantations composed of younger trees as compared to pre-settlement conditions. Very little naturally regenerating forests, including structurally diverse early-seral, late seral and old growth forest remain (Swanson et al 2014). Naturally occurring forests are more diverse in plant form (e.g., bryophytes, grasses, shrubs, hardwoods, conifers) and structural complexity (e.g., standing and downed dead wood) (Swanson et al 2014). For example, only 6% of forested land in the lower Coos watershed contains late successional old-growth forests (Cornu and Souder 2015). High structural complexity supports rich biodiversity in upland forest habitats. For instance, larger diameter snags are more likely to support bird nesting, important since nearly 40% of bird species in North America are cavity nesters (Cornu and Souder 2015). Insect species richness and density have been shown to increase with forest age and complexity (Brokaw and Lent 1999).

Potential for Management Actions

Forest management can improve forest health and resilience, mitigate risk from forest fires, and promote carbon sequestration. Management actions to promote diversified tree species, reduce stand densities, increase spatial heterogeneity, and retain key legacy features would enhance resilience of upland forests. Forest stand dynamics are well understood and there are multiple tools to move beyond the agricultural production model and instead manipulate forests to improve habitat quality including thinning, prescribed burning, mixed-species management, managing for multi-aged stands, and conserving older forests (ODF 2021; Puettmann 2021). Initiatives already exist to promote more climate-friendly forests, including “climate-smart forestry incentives” on private forestlands, maintaining slash piles post-harvest instead of burning to maintain carbon stocks, and deferring harvest to maintain carbon storage (ODF 2021). Similarly, resources for land managers including publications, Oregon Extension Programs and national efforts (e.g., Adaptive Silviculture for Climate Change) are already beginning to bridge science and practice.

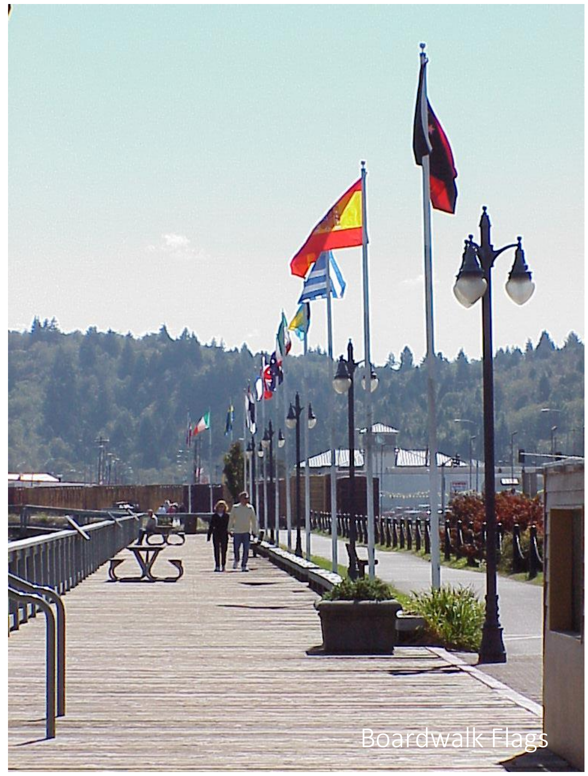
The change in climate is expected to outpace the natural ability of trees to shift their ranges and new research is looking at the success of facilitating more rapid adaptation to climate change through managed relocation or assisted gene flow (Young et al., 2020; Aitken and Bemmels 2016; Williams and Dumroese 2013).

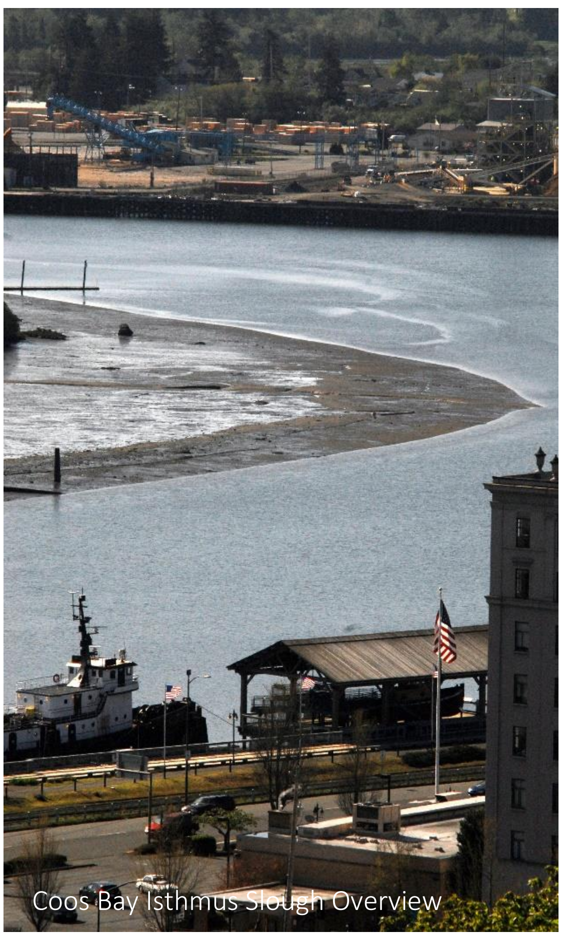
Use of best management practices can mitigate some effects of climate change. For example, following best management practices for road and trail construction to limit fine sediment disposition into streams or maintaining broad riparian buffers are potential actions to conserve watershed health (Keith Mills 1997).

Likelihood of Institutional or Human Response

As scientists and land managers learn more about forest ecosystems and expected vulnerabilities to climate change, forest managers have already begun to adopt strategies that protect existing quality habitat and increase the quality of habitat within heavily managed stands. Continued research, outreach, education, and political support are all important to continue moving initiatives forward. Management strategies will need to be modified according to ongoing research, understanding and priorities moving forward.


Charleston Public Boat Launch


Boardwalk Flags


Coos Bay Isthmus Slough Overview

Charleston from Cape Arago Highway Bridge


McCullough Bridge

Photos courtesy of SSNERR

Chapter 4
Built Environment

This section describes the sensitivity and adaptive capacity of the built environment for the project Study Area. Built environment includes buildings, transportation network, and utility systems. The built environment is key to adaptation to climate change and these buildings and infrastructure have many vulnerabilities that need to be addressed.

Sea levels may rise by 4.7 feet on the Oregon coast in the next 80 years (OCMP 2017). Added to this are the risks of tidal flooding, which can be amplified by heavy rainfall and riverine flooding. The Coos Bay Area has significant low-lying and shorefront areas along the estuary, coast, and rivers, which contain railroads, highways, bridges, utilities, and other infrastructure. Coos Bay, of all of Oregon's estuaries, has the most infrastructure at risk of flooding.

Building Exposure

The planning sector listening session focused on buildings and critical facilities. Planning-sector stakeholders indicated that funding, zoning, and permitting were the greatest limiting factors in mitigating hazards in Coos Bay. Third-party partnerships (DLCD, DOGAMI) for grant research and funding are necessary for adaptive hazard planning.

The IPRE team analyzed the buildings in the Study Area that fall within the DLCD sea level rise scenarios. The two scenarios that the team used are the 2050 sea level rise (SLR) + 1% chance flood scenario and the 2100 sea level rise + 1% chance flood scenario. Table 2shows the total number of buildings in the Study Area and breaks the Study Area down into Coos Bay, North Bend, and the remainder of the county within the Study Area. The table shows how many buildings in each area will be affected by these flooding scenarios. Overall, 5% of the 24,000 buildings in the Study Area are projected to be inundated by the 2050 scenario, and 8% in the 2100 scenario. Coos Bay has the highest percentage affected in both scenarios with 7% of buildings in the 2050 scenario and 9% of buildings in the 2100 scenario. It should also be noted that most of the impact to Coos Bay, and portions of the county in the Study Area, are projected to be impacted by SLR by 2050, while North Bend is not expected to experience as much SLR impact until the 2100 scenario.

Table 2 Buildings Exposed to Sea Level Rise + 1% Chance Flood (2050, 2100) – Study Area

Community	Total Buildings	SLR 2050 + 1% Chance Flood		SLR 2100 + 1% Chance Flood	
		# Buildings	% Buildings	# Buildings	% Buildings
Study Area	24,073	1,264	5%	1,826	8%
Coos County (in Study Area)	11,021	585	5%	864	8%
Coos Bay	8,672	607	7%	757	9%
North Bend	4,380	72	2%	205	5%

Source: Analysis by IPRE

Table 3 gives more detail of the types of buildings in Coos County (excluding Coos Bay and North Bend) that will be affected by 2100 SLR + 1% chance flood scenario. It breaks the county down by community and gives the total percent of buildings exposed and the number of buildings that are residential, employment, resource based, or exempt (e.g., government buildings, churches). Within the Coos County Study Area, residential buildings are affected the most, followed by employment and resource buildings. The community of Charleston has by far the highest proportion of buildings affected at 31%. Bunker Hill-Bay Park and Libby are also areas of concern with 12% and 10% affected respectively.

Table 3 Buildings Exposed to 2100 SLR + 1% Chance Flood by property class – Coos County

	Buildings		Number of Buildings Exposed by Property Class			
Community	Total	Percent Exposed	Residential	Employment	Resource	Exempt
Coos County (Study Area)	864	8%	384	212	209	59
Allegany	0	0%	0	0	0	0
Barview	95	5%	62	26	1	6
Bunker Hill-Bay Park	91	12%	28	58	0	5
Charleston	157	31%	38	75	5	39
Cooston	22	5%	9	0	13	0
Dellwood	0	0%	0	0	0	0
Glasgow	34	5%	22	6	6	0
Green Acres	58	8%	40	2	16	0
Hauser	10	2%	2	7	1	0
Libby	46	10%	45	0	1	0
Millington	43	6%	12	22	7	2
Sumner	66	9%	30	1	34	1
Willanch	5	2%	3	0	2	0
Rural	237	9%	93	15	123	6

Source: Analysis by IPRE

Table 4 and Table 5 provide similar information for the cities of North Bend, Coos Bay, and their neighborhoods. In both cities, residential buildings are affected the most followed by employment buildings. Overall North Bend is less vulnerable to sea level rise key neighborhoods of concern in North Bend are Airport Heights and Simpson Heights with nine percent and seven percent of buildings affected respectively.

Table 4 Buildings Exposed to 2100 SLR + 1% Chance Flood by property class – North Bend

	Buildings		Number of Buildings Exposed by Property Class			
Community	Total	Percent Exposed	Residential	Employment	Resource	Exempt
North Bend	205	5%	104	65	0	36
Airport Heights	68	9%	47	11	0	10
Sherman Heights-Pony Creek	90	5%	30	38	0	22
Simpson Heights	38	7%	21	15	0	2
West North Bend	9	1%	6	1	0	2

Source: Analysis by IPRE

Key neighborhoods of concern in Coos Bay are Central Coos Bay, Englewood, and Telegraph Hill-Mingus Park with 33%, 24%, and 11% of buildings affected respectively.

Table 5 Buildings Exposed to 2100 SLR + 1% Chance Flood by property class – Coos Bay

Community	Buildings		Number of Buildings Exposed by Property Class			
	Total	Percent Exposed	Residential	Employment	Resource	Exempt
Coos Bay	757	9%	331	325	30	71
Central Coos Bay	310	33%	148	138	0	24
Eastside	45	6%	25	20	0	0
Empire	32	2%	13	10	0	9
Empire Lakes	0	0%	0	0	0	0
Englewood	180	24%	107	53	4	16
Isthmus Heights	53	7%	6	36	0	11
Hospital Park-Milner Crest	51	4%	22	3	26	0
Radar Hill-Ocean Blvd	0	0%	0	0	0	0
Telegraph Hill-Mingus Park	86	11%	10	65	0	11

Source: Analysis by IPRE

Significant commercial and residential development is at risk of SLR flooding and should be mitigated to avoid significant damage. The interdependency of land use and transportation networks has major implications for adapting to future sea level rise and flooding. Incremental relocation of commercial or residential areas that will be impacted by 2100 should consider the necessary changes to bridges, roads, and railroads needed for access. These assets are likely integral to the function of community services and should be prioritized for adaptation.

Tsunami Hazard

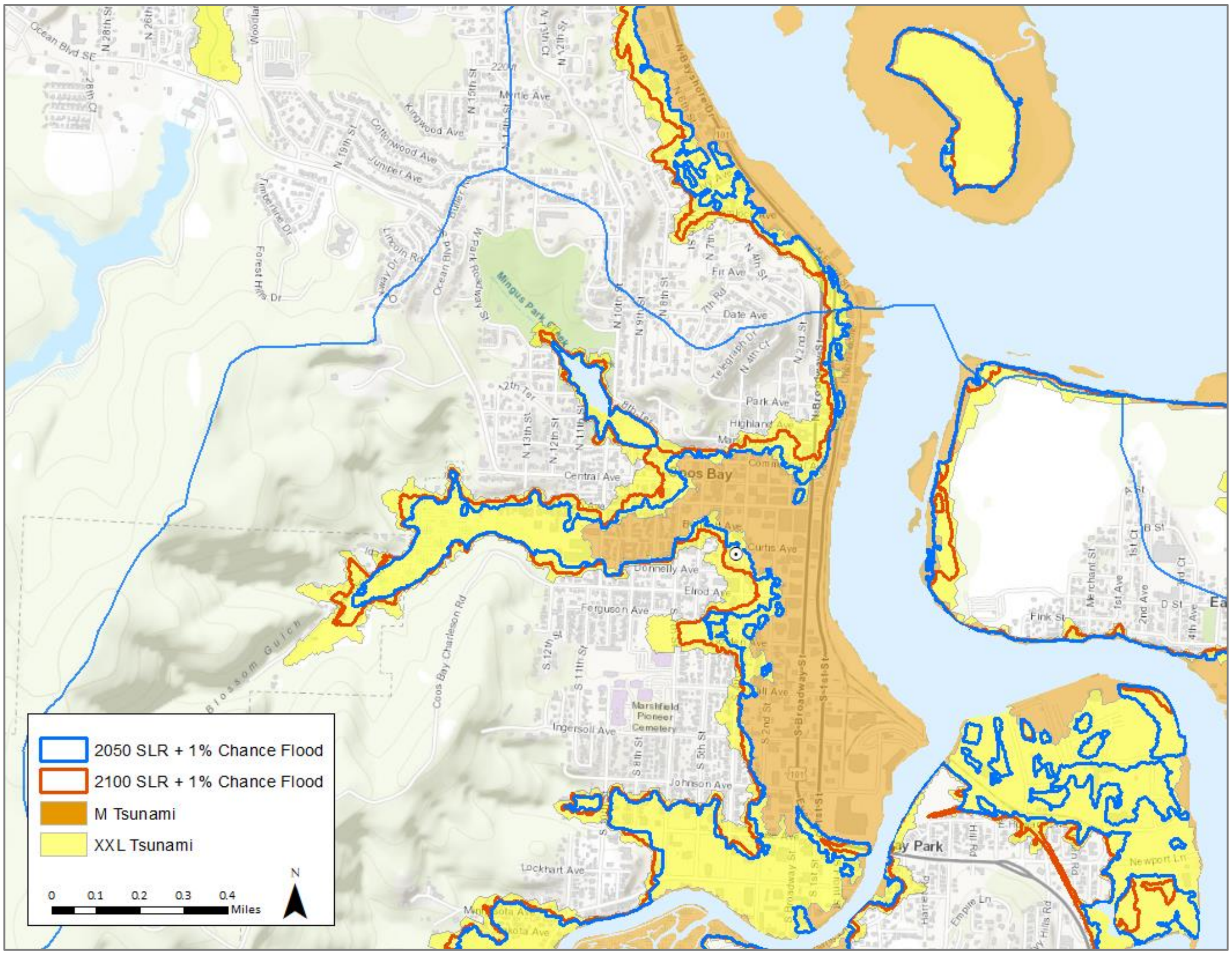
Although not a climate related hazard the Coos Bay area is vulnerable to the Cascadia Subduction Zone earthquake and resultant tsunami. Subduction zones like the Cascadia Subduction Zone have produced earthquakes with magnitudes of 8 or larger. Significant areas of the Study Area may be impacted if an earthquake and tsunami occur.

Tsunami destruction can come from both the tsunami wave and from the rapid retreat of the water from the coastline. Tsunami waves tend to be fast moving rising surges of water. As a tsunami wave enters coastal bays and rivers, it may move as a high velocity current or a breaking wave that travels up an estuary as a bore (wall of turbulent water like the waves at the coast after they break). This inland surge of water can often cause most or all the damage from a distant tsunami. In addition, storm waves ride on top of the tsunami waves and may cause even more destruction.

Tsunami inundation maps were created by the Department of Geology and Mineral Industries (DOGAMI) to be used for emergency response planning for coastal communities. The local source tsunami inundation maps display the output of computer modeling showing five tsunami event scenarios shown as “T-shirt” sizes S, M, L, XL, and XXL. The IPRE team compared the locations of buildings to the geographic extent of the local source tsunami inundation zones to assess the exposure for the areas of Coos County, Coos Bay, and North Bend within the Study Area. The exposure results are shown for each of the five "T-shirt" sizes. We chose the M tsunami scenario to show the level of risk to Study Area communities because it is the most likely to occur from a CSZ event (Priest et al 2013).

Figure 7 compares the M (orange polygon) and L (yellow polygon) tsunami inundation scenarios to the 2050 (blue line) and 2100 (red line) SLR + 1% chance flood scenarios. The figure shows that both of the SLR + 1% chance flood scenarios extend beyond the M tsunami inundation scenario and come close to the extent of the XXL tsunami inundation scenario in Central Coos Bay.

Figure 7 Comparison of M & XXL Tsunami Scenarios to 2050 & 2100 SLR + 1% Chance Flood Scenarios – Central Coos Bay



Source: Analysis by IPRE

Table 6 shows that exposure from the M to L tsunami scenario is roughly equivalent to exposure to the projected SLR + 1% chance flood scenarios (Table 2).

Table 6 Buildings Exposed to Cascadia Subduction Zone Tsunami – Study Area

Community	Total Buildings	Small		Medium		Large		X-Large		XX-Large	
		#	%	#	%	#	%	#	%	#	%
Study Area	24,073	588	2%	1,070	4%	2,255	9%	4,600	19%	5,272	22%
Coos County (in Study Area)	12,381	440	4%	582	5%	1,219	10%	2,803	23%	3,154	25%
Coos Bay	7,347	118	2%	391	5%	723	10%	1,188	16%	1,444	20%
North Bend	4,345	30	1%	97	2%	313	7%	609	14%	674	16%

Source: Analysis by IPRE

Community Lifelines

This exposure inventory provides data using FEMA's community lifelines. FEMA developed the community lifelines construct to assist in identifying the most critical capabilities and services to residents whether provided by the public, private, or non-profit sectors. Each of the seven lifelines is composed of multiple components and subcomponents. Each building identified in this inventory is assigned one (or more) of the seven community lifelines. *NOTE: community lifeline data was not reviewed for communications infrastructure. Transportation lifelines are reported in the transportation section of this chapter.*

Safety and Security. This lifeline covers community safety and the continuity of government. Also included are services that provide mental and emotional comfort to a community (e.g., churches). Subcomponents include: law enforcement/safety, fire service, search and rescue, government services, community safety, etc.

Food, Water, and Shelter. This lifeline includes traditional housing, food (grocers, agricultural, farmers markets, food pantries, etc.), and water services. There are four subcomponents: food, water, shelter, and agriculture.

Health and Medical. This lifeline includes medical services required during a natural hazard event including survivor care, fatality management, public health, and medical supply chain. This lifeline also includes services for pets and farm animals. Subcomponents include: medical care, patient movement, fatality management, public health, medical supply chain, and veterinarian services.

Energy. This lifeline includes electricity and fuel including retail and commercial electricity and fuel (gasoline, diesel, etc.) operations.

Communications. This lifeline includes communications that are necessary to respond to a hazard event and includes operation of electronic payment and banking needs. Subcomponents include communications infrastructure (energy substations, power lines, etc.), alerts, warnings, and messages, 911 and dispatch, responder communications, and finance (ATMs, banking). *Except for electric substations communications lifelines were outside the scope of this assessment.*

Transportation. This lifeline includes all types of transportation for people and resources. Subcomponents include highways and roads, mass transit, railway, aviation, and maritime**.** *Included in transportation section later in this chapter.*

Hazardous Materials. This lifeline includes materials that are considered hazardous and could lead to contamination through air, water, or other means during an event. Subcomponents include facilities that store or generate hazardous materials and any other known pollutants or contaminants.

Within the Study Area there are four main hazardous materials sites. Environmental Cleanup Sites, Hazardous Substance Facilities, Hazardous Waste Generators, and Underground Storage Tanks. Table 7 shows that about half of all hazardous material sites exposed to the 2100 SLR + 1% chance flood are located within Coos Bay.

Table 7 Hazardous Materials Exposed to Sea Level Rise + 1% Chance Flood (2100)

	ECSI	HSIS	HazWaste	UST	Total
Study Area	33	77	29	33	172
Coos County (in Study Area)	13	21	9	2	45
Coos Bay	12	40	15	21	88
North Bend	8	16	5	10	39

Note: ECSI = Environmental Cleanup Site, HSIS = Hazardous Substance Facility,
HazWaste = Hazardous Waste Generator, UST = Underground Storage Tank

Table 8 shows the community lifelines that are exposed to the 2050 and 2100 SLR + 1% chance flood scenarios for the Study Area communities.

Table 8 Community Lifelines potentially exposed to 2050 and/or 2100 SLR + 1% chance flood scenarios

	Safety and Security		Food, Water, Shelter		Health & Medical		Energy	
Community	SLR 2050	SLR 2100	SLR 2050	SLR 2100	SLR 2050	SLR 2100	SLR 2050	SLR 2100
Study Area	43	52	46	59	5	6	13	18
Coos County (in Study Area)	11	14	7	12	0	0	2	3
Coos Bay	25	29	36	42	4	5	9	10
North Bend	7	9	3	5	1	1	2	5

Source: Analysis by IPRE

Table 9 shows the community lifelines within the City of Coos Bay that are potentially exposed to the 2050 and 2100 SLR + 1% chance flood scenarios. Note: the exposure assessment does not account for current mitigation to reduce the impact of flood (including first floor height). Further analysis is needed to determine the actual extent of exposure to sea level rise flooding.

Table 9 Coos Bay Community Lifelines Potentially Exposed 2050 and/or 2100 SLR + 1% chance flood scenarios

Facility Name	SLR 2050 + 1% Chance Flood	SLR 2100 + 1% Chance Flood	Historic Site	Subtype
Safety and Security				
Coos Bay Four Square Church		Yes	Yes	Church
South Coast Gospel Mission		Yes		Church
St. Monica Catholic Church		Yes		Church

Facility Name	SLR 2050 + 1% Chance Flood	SLR 2100 + 1% Chance Flood	Historic Site	Subtype
The Hollering Place		Yes	Yes	Cultural Site
Coos Bay Farmer's Market	Yes	Yes		Food
Englewood Market	Yes	Yes		Food
Coos Bay Public Library	Yes	Yes	Yes	Library
Coos Art Museum	Yes	Yes	Yes	Museum
Coos Historical and Maritime Museum	Yes	Yes		Museum
Marshfield Sun Printing Museum	Yes	Yes	Yes	Museum
OR Coast Historical Railway	Yes	Yes	Yes	Museum
Coos Bay City Shop	Yes	Yes		Office
Coos Bay City Shop	Yes	Yes		Office
Coos Bay DMV	Yes	Yes		Office
Port Office	Yes	Yes	Yes	Office
Yes0th Street 'Pirate' Park	Yes	Yes		Park
Boardwalk Park (City Dock)	Yes	Yes	Yes	Park
Firemen's Memorial	Yes	Yes		Park
Millicoma Marsh	Yes	Yes		Park
Mingus Park	Yes	Yes		Park
Preway	Yes	Yes		Park
Coos Bay City Hall/Police Dept	Yes	Yes	Yes	Police
Coos Bay USPS	Yes	Yes		Post Office
Blossom Gulch Elementary School	Yes	Yes	Yes	School
Coos Bay City Shop	Yes	Yes		Shop
Coos Bay City Shop	Yes	Yes		Shop
U.S. Coast Guard Station - Cutter Orcas	Yes	Yes		Terminal/Dock
Food, Water, and Shelter				
Bi-Mart	Yes	Yes		Food
Coos Head Food Co-Op	Yes	Yes		Food
Fred Meyer	Yes	Yes		Food
Ladybug Landing Community Garden	Yes	Yes		Food
Lighthouse Grocey & Deli		Yes		Food
McKay's Market #Yes		Yes		Food
Natural Grocers		Yes		Food
Safeway	Yes	Yes		Food
Smith's Bayway Market	Yes	Yes	Yes	Food
Lucky Loggers RV Park	Yes	Yes		RV Park
Saints Trailer Park	Yes	Yes		RV Park

Facility Name	SLR 2050 + 1% Chance Flood	SLR 2100 + 1% Chance Flood	Historic Site	Subtype
unnamed Yes	Yes	Yes		RV Park
unnamed 2	Yes	Yes		RV Park
unnamed 24	Yes	Yes		RV Park
unnamed 25	Yes	Yes		RV Park
unnamed 27	Yes	Yes		RV Park
unnamed 29	Yes	Yes		RV Park
unnamed 30	Yes	Yes		RV Park
unnamed 3Yes	Yes	Yes		RV Park
unnamed 32	Yes	Yes		RV Park
unnamed 33	Yes	Yes		RV Park
unnamed 34	Yes	Yes		RV Park
unnamed 35	Yes	Yes		RV Park
unnamed 36	Yes	Yes		RV Park
unnamed 37	Yes	Yes		RV Park
unnamed 38	Yes	Yes		RV Park
unnamed 39	Yes	Yes		RV Park
unnamed 40	Yes	Yes		RV Park
unnamed 4Yes	Yes	Yes		RV Park
Bay Area Senior Center	Yes	Yes		Shelter
Best Western Holiday		Yes		Shelter
Edgewater Inn Coos Bay	Yes	Yes		Shelter
Motel 6 Motel	Yes	Yes		Shelter
Motel 6 Motel	Yes	Yes		Shelter
Red Lion Inn	Yes	Yes		Shelter
SouthSider Hotel	Yes	Yes		Shelter
Super 8 Motel		Yes		Shelter
Terrace Motel	Yes	Yes		Shelter
THE House/ Bay Area First Step		Yes		Shelter
Coos Bay Wastewater Department	Yes	Yes		Wastewater
Coos Bay Wastewater Treatment	Yes	Yes		Wastewater
VendWest	Yes	Yes		Water
Health and Medical				
All Saint's Columbarium	Yes	Yes	Yes	Mortuary
Coos Bay Chapel	Yes	Yes	Yes	Mortuary
Hanson Animal Hospital	Yes	Yes		Veterinarian
Harmony Homecare, Inc	Yes	Yes	Yes	Home Care

Facility Name	SLR 2050 + 1% Chance Flood	SLR 2100 + 1% Chance Flood	Historic Site	Subtype
Morgan Veterinary Clinic		Yes	Yes	Veterinarian
Energy				
Electric Substation	Yes	Yes		Electric
Basset-Hyland Fuel Center	Yes	Yes		Gas/Diesel
Bassett-Hyland Energy Co.	Yes	Yes		Gas/Diesel
Bayshore Chevron	Yes	Yes		Gas/Diesel
Chevron Gas Station		Yes		Gas/Diesel
Fred Meyer Gas Station	Yes	Yes		Gas/Diesel
Mobil Gas Station	Yes	Yes		Gas/Diesel
Shell Gas Station	Yes	Yes		Gas/Diesel
U-Haul	Yes	Yes		Gas/Diesel
Pacific Power	Yes	Yes		Office
Communications				
None identified				
Transportation				
Airport Runway	Yes	Yes		Airport
Eastside Boat Ramp	Yes	Yes		Boat Ramp
Empire Boat Launch	Yes	Yes		Boat Ramp
Bayshore Dock/Saus Bros	Yes	Yes		Terminal/Dock
Citrus Dock - Port of Coos Bay	Yes	Yes		Terminal/Dock
Dolphin Terminal - Port of Coos Bay Utility/ Work Dock	Yes	Yes		Terminal/Dock
Sause Bros. Ocean Towing Co., Inc.		Yes		Terminal/Dock
USACE Port of Coos Bay Moorage	Yes	Yes		Terminal/Dock

Source: Analysis by IPRE

Table 10 shows the community lifelines within the City of North Bend that are potentially exposed to the 2050 and 2100 SLR + 1% chance flood scenarios. Note: the exposure assessment does not account for current mitigation to reduce the impact of flood (including first floor height). Further analysis is needed to determine the actual extent of exposure to sea level rise flooding.

Table 10 North Bend Community Lifelines Potentially Exposed 2050 and/or 2100 SLR + 1% chance flood scenarios

Facility Name	SLR 2050 + 1% Chance Flood	SLR 2100 + 1% Chance Flood	Historic Site	Subtype
Safety and Security				
Jehovah's Witnesses	Yes	Yes		Church
First Baptist Church of North Bend		Yes		Church

Facility Name	SLR 2050 + 1% Chance Flood	SLR 2100 + 1% Chance Flood	Historic Site	Subtype
U.S. Coast Guard Sector North Bend		Yes		Coast Guard
Pony Village Mall/Daycare Facility	Yes	Yes		Daycare
Ferry Road Park	Yes	Yes		Park
North Bend Boardwalk	Yes	Yes		Park
Simpson Park	Yes	Yes		Park
North Bend Senior High School	Yes	Yes	Yes	School
Oregon Virtual Academy	Yes	Yes		School
Food, Water, and Shelter				
Safeway	Yes	Yes		Food
North Bend Presbyterian Food Cupboard		Yes		Food
Mill Casino and Hotel	Yes	Yes		Shelter
Quality Inn and Suites at Coos Bay	Yes	Yes		Shelter
Airport Water Treatment Facility		Yes		Water Treatment
Health and Medical				
VA Clinic	Yes	Yes		Hospital/Clinic
Energy				
Tyree Oil	Yes	Yes		Gas/Diesel
Tyree Oil	Yes	Yes		Gas/Diesel
Chevron North Bend		Yes		Gas/Diesel
Ferrel Gas		Yes		Gas/Diesel
Safeway Fuel Station		Yes		Gas/Diesel
Communications				
None identified				
Transportation				
Southwest Oregon Regional Airport		Yes		Airport
California Street Boat Ramp	Yes	Yes		Boat Ramp
Commercial Boat Launch	Yes	Yes		Boat Ramp
unimproved boat launch (small craft, paddle)	Yes	Yes		Boat Ramp
K2 Terminal	Yes	Yes		Terminal/ Dock
Ocean Terminals Dock	Yes	Yes		Terminal/ Dock
Oregon Chip Terminal	Yes	Yes		Terminal/ Dock
Tyree Oil Inc	Yes	Yes		Terminal/ Dock

Source: Analysis by IPRE

Table 11 shows the community lifelines within the unincorporated portions of Coos County that are within the Study Area that are potentially exposed to the 2050 and 2100 SLR + 1% chance flood scenarios.

Note: the exposure assessment does not account for current mitigation to reduce the impact of flood (including first floor height). Further analysis is needed to determine the actual extent of exposure to sea level rise flooding.

Table 11 Coos County Community Lifelines Potentially Exposed 2050 and/or 2100 SLR + 1% chance flood scenarios

Facility Name	SLR 2050 + 1% Chance Flood	SLR 2100 + 1% Chance Flood	Historic Site	Subtype
Safety and Security				
Box Car Hill Campground		Yes		Campground
Horsfall Beach Camping	Yes	Yes		Campground
Charleston Community Baptist Church	Yes	Yes		Church
Coos Bay Coast Guard Station	Yes	Yes		Coast Guard
Charleston RFPD - 3	Yes	Yes		Fire Agency
Millington RFPD	Yes	Yes		Fire Agency
Charleston Marine Life Center	Yes	Yes		Museum
Haynes Inlet	Yes	Yes		Natural Area
Barview State Wayside (historical)	Yes	Yes		Park
Conde B McCullough State Wayside	Yes	Yes		Park
Jordan Cove	Yes	Yes		Park
North Beach	Yes	Yes		Park
USPS Charleston		Yes		Post Office
OIMB		Yes		School
Food, Water, and Shelter				
Bay Point Landing	Yes	Yes		Campground
Chuck's Seafood		Yes		Food
Clausen Oysters	Yes	Yes		Food
General Store		Yes		Food
Qualman Oyster Farm	Yes	Yes		Food
Davey Jones Locker Grocery	Yes	Yes		Food/Fuel
Charleston Marina RV Park		Yes		RV Park
Coal Bank Ln Mobile Home Park	Yes	Yes		RV Park
Seaport RV Park	Yes	Yes		RV Park
Captain John's Motel		Yes		Shelter
Charleston Harbor Inn		Yes		Shelter
OIMB Housing	Yes	Yes		Shelter
Health and Medical				
None identified				

Facility Name	SLR 2050 + 1% Chance Flood	SLR 2100 + 1% Chance Flood	Historic Site	Subtype
Energy				
Electric Substation - North Spit		Yes		Electric
Russell's Marine Fuel and Supply	Yes	Yes		Fuel
Pacific Pride	Yes	Yes		Gas Station
Communications				
None identified				
Transportation				
Catching Slough Boat Ramp (unimproved)	Yes	Yes		Boat Ramp
Conde B. McCullough (boat/paddle)	Yes	Yes		Boat Ramp
Doris Place County Park (boat/paddle)	Yes	Yes		Boat Ramp
Green Acres (boat/paddle)	Yes	Yes		Boat Ramp
Myrtle Tree (boat/paddle)	Yes	Yes		Boat Ramp
North Spit - BLM Boat Launch	Yes	Yes		Boat Ramp
Rooke-Higgins (boat/paddle)	Yes	Yes		Boat Ramp
Charleston Marina Complex	Yes	Yes	Yes	Marine
Distant Water Fleet Facility	Yes	Yes		Marine
Englund Marine		Yes		Marine
Port of Coos Bay Yes	Yes	Yes		Marine
Coastal Fibre Barge Moorage	Yes	Yes		Terminal/Dock
Coos Bay Docks	Yes	Yes		Terminal/Dock
DB Western Inc	Yes	Yes		Terminal/Dock
Georgia-Pacific (not in use)	Yes	Yes		Terminal/Dock
GMA Garnet (Pierce Terminal)	Yes	Yes		Terminal/Dock
Knutson Log Yard Moorage	Yes	Yes		Terminal/Dock
Oregon International Port of Coos Bay	Yes	Yes		Terminal/Dock
Roseburg Forest Products	Yes	Yes		Terminal/Dock
Southport Lumber Company / Southport Forest Products	Yes	Yes		Terminal/Dock

Source: Analysis by IPRE

Sensitivity

Flood Zone Extents

If sea levels, storm surges, and other floods exceed the height of flood protection measures (levees, dikes, etc.) significant areas of Charleston, Bunker Hill-Bay Park, Libby, Central Coos Bay, Englewood, and Telegraph Hill-Mingus Park will be impacted. Areas of North Bend are also vulnerable, but to a lesser degree, including areas around the Airport and Pony Slough. Residential structures are most exposed; however, significant impact is expected to commercial and industrial areas.

Interdependencies

The Coos County built environment relies on the ability to access a functioning transportation network. The road system is integral to many other services in the Coos estuary. Area residents, hospitals/health, economy, tourism, recreation, and food systems all rely on functioning roads and developed areas outside of flood impacts.

Economic Sensitivity

Because many of the economic centers of the Coos Bay Area are in low-lying areas, many of the area's businesses are vulnerable to climate impacts. It is important to consider the benefits of mitigating the risk of flooding with the costs that could be incurred.

Adaptive Capacity

Current Condition

Much of Coos Bay's commercial and industrial development and historic structures are located within the downtown area that may be impacted by future sea level rise and flooding. Recent studies indicate that there is available residential land to accommodate projected residential growth. Several critical facilities are located within the 2050 and 2100 SLR + 1% flood zone.

Redundancies

The commercial areas of Coos Bay and North Bend are essential to the economic wellbeing of the area. There is land outside of the potential flood areas, however, the extent of flood inundation in these areas would make relocation difficult. Residential land is more available, however, much of the historic and less expensive housing stock (e.g., manufactured housing, etc.) is in areas that may be impacted by flooding. Relocating residential development may impact vulnerable populations disproportionally.

Management Actions

Area communities maintain comprehensive plans that describe natural hazards that impact the Coos Bay area. However, there is not a comprehensive study of land use and impacts of sea level rise to vacant commercial, industrial, and residential land.

Transportation Infrastructure

Coos Bay's transportation infrastructure consists of its road system, network of bridges, and the Southwest Oregon Regional Airport. The transportation network in the Study Area is both highly vulnerable and key to the adaptation strategy of the Coos Bay Study Area. Many roads and bridges in the Study Area are old and in need of repair or replacement and these problems will be exacerbated by climate change. The network of roads and bridges is key for people of the county to move away from potential natural hazards associated with climate change and it will be key to protect and update these assets.

Survey and Listening Session Results

The natural resources group discussed concern for physical infrastructure affecting the natural environment. These stakeholders listed the road network, levees, and dikes as potential causes of eelgrass habitat fragmentation. Listening session participants stressed the importance of maintaining the arterial roads and Highways 101 and 540 that connect the regions communities to each other and the rest of the state. However, participants felt that repairs or upgrades to built infrastructure would be difficult due to the financial and labor resources required.

Roads

The Coos Bay area is built around Highway 101 (US 101). This interstate bisects downtown Coos Bay and connects the community to the north and south. The Coos River Highway (OR 241) connects to the east. The Cape Arago Highway (OR 541) connects Coos Bay and North Bend to Charleston. Oregon state routes are maintained by ODOT. Coos County maintains an additional 188 miles of gravel roads and 341 miles of paved roads in the area.

Some roads may become unusable due to flooding increased by sea level rise. Currently, flooding cuts off some roads periodically. Specifically, the Coos Sumner Lane dike regularly experiences flooding that cuts off rural communities from the cities. This will become exacerbated with sea level rise and increased winter precipitation. Flooding can cause both temporary disruption of service along roads a well as more permanent damage to the roads themselves.

Table 12 summarizes the impact to roads and railroads in the Study Area by the 2050 SLR + 1% chance flood and the 2100 SLR + 1% chance flood scenarios. Railroads are most heavily impacted by the near-term sea level rise and flooding scenario and will require adaptive measure by 2050. Roads, on the other hand, have a nearly equal amount of miles in each impact zone, meaning that adaptive measure will need to address short-term and long-term impacts. Climate change is expected to cause buckling of roads due to increased temperature and increased washouts of roads from more intense precipitation (EPA 2015). Washouts and problems with the structural integrity of roads could also increase with increased flooding.

Table 12 Transportation Facilities miles affected by sea level rise scenarios

	Impacted Miles of Road	
Facility	**2050 SLR + 1% Flood**	**2100 SLR + 1% Flood**
All Roads	56.5	93.6
Cape Arago Hwy (OR-540)	0.2	0.5
Coos Bay-Roseburg Hwy (OR-42)	0.8	2.8
Coos Bay-Roseburg Hwy Conn	0.1	0.2
Coos River Hwy (OR-241)	1.2	3.8
Millington Frontage Rd. Hwy	0.5	0.6
Oregon Coast Highway	4.1	10.3
Railways	11.6	18.3

Source: OCMP Sea Level Rise Exposure Inventory for Oregon’s Estuaries

The Oregon Coast Highway (Hwy 101) has a very large portion that will be affected by sea level rise (OCMP 2017). This is problematic because it is a key artery through the Coos Bay region and it will be important to study whether portions of the road can be moved to higher ground or if alternate routes can be established.

Sensitivity

Flood Zone Extents

If floods exceed the height of roads, the roads will become temporarily to permanently unusable. Different flood scenarios have different implications on the Coos Bay road system as shown in Table 12.

Currently, flooding cuts off some roads periodically. Stakeholders from the schools and community centers listening session identified the Coos Sumner Lane dike as a road that regularly experiences flooding. Flooding along rural roads, such as Coos Sumner Lane, can cut off rural communities from cities and the services they provide.

Interdependencies

The Coos County transportation system depends on maintenance from local, regional, state, and federal governments. The road system is integral to many other services in the Coos estuary. Waste management, emergency management, hospitals/health, economy, tourism, recreation, and food systems all rely on functioning roads. It is also key for moving people in and out of, and throughout, the Study Area.

Economic Sensitivity

Stakeholders from the infrastructure interviews suggested that flooding will not cause significant damage to the road infrastructure. However, there are costs associated with debris removal and drainage ditch repair. Debris removal costs depend on the spatial extent and severity of the flood. Drainage ditches require constant maintenance and repair. This will only worsen as flood events become more frequent and severe.

ODOT's model shows that there are not likely to be long-term economic impacts to the region in the case of a major failure along Highway 101. However, there will be long-term effects on the local area where the road failure occurs, with as much as a 20% reduction in employment in that area.

Adaptive Capacity

Current Condition

The Coos County Transportation Plan (2020) describes their roads as being in good condition. The pedestrian and bicycle infrastructure are less comprehensive but in fair condition. City of Coos Bay Transportation Plan has citywide plans for pavement maintenance and plans for capital improvements for pedestrian and bicycle projects.

Stakeholders from Coos Bay Public Works suggest that roads in the Study Area are within their design capacity. Drainage systems are at capacity for current conditions. There are significant flooding events that overflow drainage systems each year. Refer to the section of this chapter on stormwater for more information on the stormwater system.

Redundancies

US 101 is essential in connecting Coos Bay and North Bend to the rest of Oregon. Some areas in Coos County may be completely inaccessible by road if US 101 is impassable. In cases when US 101 is closed, Coos residents may need to take major detours as such it will be important to identify alternate routes for Coos Bay residents.

Management Actions

Stakeholders from Coos Bay Public Works emphasized the need for proactive efforts to prevent drainage ditches from failing. However, there is not a plan in place to accomplish this. Listening session participants stressed the importance of maintaining the arterial Highways 101 (Oregon Coast Highway), 241, and 540 (Cape Arago Highway) that connect the communities to each other and the rest of the state. However, participants felt that repairs or upgrades to built infrastructure would be difficult due to the financial and labor resources required.

Coos County has a tsunami evacuation plan in place. The plan does not address concerns of flooding and sea level rise.

Bridges

Due to Coos Bays geography and numerous waterways, the Study Area contains many bridges that allow for transportation throughout the region. Coos County's bridges are integral in moving people and goods throughout the area. The McCullough Bridge and Isthmus Slough Bridge are key for connecting Coos Bay to the rest of Oregon. The bridge is integral to Oregon Highway 101, which connects the coastal communities in southwest Oregon to coastal communities further north, as well as the rest of the state.

Coos County contains approximately 120 total bridges. Approximately 80 of these bridges fall within the Study Area, and 44 fall within the 2100 + 1% chance flood SLR scenario. Table 13 includes all bridges in the Study Area that fall within the 2100 + 1% chance flood SLR scenario and describes the level of inundation shown in the 2100 sea level rise scenarios on a scale from 0-3. It is important to note that this analysis did not consider bridge elevation and only the inundation of the roads approaching these bridges.

Table 13 also includes bridge condition and scour vulnerability. These are two key factors in the stability and structural integrity of a bridge. Condition is a rating of the combination of the deck, superstructure, and substructure of the bridge. Scour vulnerability is a rating of the soil surrounding the foundation and the integrity of the foundation. The combination of condition, scour vulnerability, and inundation risk should be considered in the prioritization of bridges to be upgraded.

Table 13 Inventory of bridges in the Study Area that fall within the 2100 SLR + 1% chance flood Area and their level of projected inundation

Bridge ID	Bridge Name	Detour Length (mi)	Year Built	Condition	Scour Vulnerability	2100 Inundation Risk
006T1	Pony Slough, Broadway St	1	1962	Fair	U	3
006T2	Pony Slough, Vermont Ave	2	1965	Poor	3	2
01132F	Isthmus Slough, Hwy 241 (Eastside)	9	1931	Fair	4	3
016682	Catching Slough, County Rd 23 (Lone Tree)	2	1986	Fair	4	3
01823	Coos Bay, Hwy 9 (McCullough Main Spans)	16	1936	Fair	5	2
01823A	Coos Bay, Hwy 9 (McCullough N Approaches)	16	1936	Fair	5	2
01823B	Coos Bay, Hwy 9 (McCullough S Approaches)	16	1936	Fair	5	2
01940G	South Slough, Hwy 240	6	1991	Fair	4	2
02278E	Catching Slough, Hwy 241	17	1995	Good	8	2
02390	Hwy 241 over CBRL	9	1939	Fair	N	1
02478C	Coalbank Slough, Hwy 9	7	1987	Fair	4	1
02513A	Coos River, County Rd 26 (Anson Roger)	7	1975	Fair	3	2
03166B	Shinglehouse Slough, Hwy 9 SB	25	1989	Fair	4	2
03168A	Davis Slough, Hwy 35 EB	23	1962	Fair	4	2
03170	Pogue Gulch Slough, Hwy 35	0	1949	Fair	6	2
03225A	Pony Creek, Hwy 240	2	1983	Good	5	3
06514A	Shinglehouse Slough, Hwy 9 NB	25	1990	Fair	4	2
06516A	Davis Slough, Hwy 35 WB	23	1987	Fair	4	2
07176	Coos River, Hwy 241 (Chandler)	19	1952	Fair	4	2
08281	Hwy 35 over Hwy 9 NB	25	1959	Fair	N	1
11C112	Haynes Slough, County Rd 7A	3	1971	Fair	U	3
11C35B	Russell/Willanch Creek, County Rd 202G	124	1980	Fair	U	3
11C49E	Noble Creek, County Rd 118G	124	1970	Poor	U	3
11C59D	North Slough, County Rd 15	124	1977	Poor	6	2
11C75E	South Slough, County Rd 68	124	1977	Poor	U	3
16514A	North Slough, Menasha Rd #218	124	1992	Good	8	2
16724	Joe Ney Slough, County Rd 43	9	1989	Fair	3	1
16767	Daniel Creek, Stein Smith Rd #145	124	1987	Fair	5	3
16869	South Slough, Pedestrian Br	124	1955	Fair	6	3
17931	Manning Gulch Slough, Hwy 35	23	1997	Fair	5	3
18029	Ross Slough, County Rd 205	124	1997	Good	8	3
18030	Larson Creek, County Rd 17	2	1997	Fair	8	3
18544	Haynes Inlet Slough, Hwy 9	2	2001	Fair	4	1
18628	Davis Slough, Hwy 9 at MP 244.82	25	2001	Fair	8	2
18821	Larson Slough, County Rd 7A	3	2001	Good	8	2

Bridge ID	Bridge Name	Detour Length (mi)	Year Built	Condition	Scour Vulnerability	2100 Inundation Risk
19663	Coos City/Isthmus Slough, FAS A-396	3	2006	Fair	8	2
20356	Kentuck Slough, County Rd 45	22	2007	Good	8	3
20719	Culvert HWY 009 AT MP 245.27	0	2007	Fair	U	3
21007	Matson Creek, Catching Slough Rd.	0	2008	Good	5	3
22491	Southport Slough, Hwy 9 NB, MP 244.04	0	2018	Good	5	1
22492	Southport Slough, Hwy 9 SB, MP 244.04	0	2018	Good	5	1
6C117	Sumner-Catching Slough, County Rd 59	1	1974	Fair	U	3
C1109	Lillian Creek, County Rd 6	124	1977	Fair	U	3
C1110	Willanch Slough, County Rd 45	17	1978	Fair	U	2

Source: Bridge Section ODOT, Oregon Explorer Bridges 2020
Condition: The deck, superstructure, and substructure on a bridge are periodically rated on a 0-9 scale. A bridge is considered good condition if all are rated at least 7 on 0-9 scale, fair if an element is rated 5 or 6, and poor if any element is rated 4 or less .
Scour Vulnerability: N=Not over water, U=Unknown scour, 8=Bridge foundations determined to be stable for the assessed or calculated scour condition, 6=Scour calculation not made, 5=stable for scour condition, scour within the limits of footing or piles, 4=stable, needs action to protect exposed foundation, 3=bridge is scour critical/unstable
2100 Inundation Risk: 0 = no inundation, 1 = minor inundation, small portion covered, 2 = moderate inundation, 1 approach flooded, 3 = severe inundation, both approaches flooded

The 2050 sea level rise + 1% chance flood will affect a total of 34 bridges in the Study Area. The 2100 sea level rise + 1% chance flood will affect 44 bridges.

Table 14 shows the number of bridges of each condition that are affected by the 2100 + 1% chance flood scenario. The bridges in poor condition are structurally deficient and need to be repaired and refurbished as soon as possible. Priority for these upgrades should be given to bridges with the highest risk of inundation from sea level rise. Retrofitting of these bridges should be aimed at mitigating sea level rise and flooding impacts in addition to normal upgrades and should be undertaken as soon as possible.

Table 14 State of bridges in Different Impact Zones

Bridge Condition	2050 SLR + 1% Flood	2100 SLR + 1% Flood
Good	7	9
Fair	24	31
Poor	3	3
Total	**34**	**44**

Source: Bridge Section ODOT, Oregon Explorer Bridges 2020

Sensitivity

Flood Zone Extents

The 2050 sea level rise + 1% chance flood will affect a total of 34 bridges in the Study Area. The 2100 sea level rise + 1% chance flood will affect 44 bridges. Affected bridges are defined as those that fall within the DLCD defined sea level rise layer in ArcGIS. The IPRE team did further analysis on these bridges to identify the level of flood. Table 13 identifies these inundation levels for the 2100 flood scenarios. Further analysis will be needed to understand if these bridges are expected to fail during flood events or if they are capable of quick recovery.

In addition to flooding, scour also causes bridges to fail. This is the wearing away of soil at the foundations of bridges over time. With changes to water flow under these bridges due to climate change, there is an increased risk of bridges failing if they are not reinforced to increase their structural stability (EPA 2015).

Interdependencies

The bridges and roadways of Coos Bay are heavily interconnected. The bridges may cause bottlenecks if the traffic isn't adequately distributed across this road system. In a natural hazard scenario this could cause problems with evacuation. Proper maintenance of both roads and bridges is important for traffic circulation to be as efficient as possible.

Different bridges are maintained by different levels of government depending on which entity owns and maintains the road that it carries. ODOT manages and maintains state-owned bridges, while county owned bridges are maintained by Coos County. There are also a small number of city and parks owned and maintained bridges. Coordination between these entities will be important to improve adaptive capacity.

Economic sensitivity

Bridges are more economically sensitive than roads because they are inherently more expensive to build and maintain. The major bridges of the Study Area are well maintained and not expected to fail. However, several bridges in the region are in poor condition and the vast majority are in fair condition which will require updates and upgrades as infrastructure continues to age.

Adaptive Capacity

Current Condition

ODOT classified the conditions of the bridges within the Study Area as "Good", "Fair", and "Poor". Table 13 shows the bridges of each condition that fall within each sea level rise scenario. Most of these bridges are in fair condition. Some are considered good condition, and some are described as being in poor condition. Bridges in poor condition are structurally deficient.

Redundancies

Table 13 includes the detour length that would be needed if a bridge is closed. Detour lengths vary greatly, but certain bridges have detour lengths as high as 124 miles which could be extremely problematic in the cases of bridges being temporarily or permanently closed.

McCullough Bridge connects the coastal communities of North Bend, Coos Bay, and Charleston to the rest of Oregon. The Chandler Bridge and the bridge that crosses Catching Slough on Coos River Road may serve as a back-up to travel to the north and west. However, both bridges lie within the 2050 sea level rise + 1% chance flood zone.

Brainard Creek Bridge (also known as the Shinglehouse Slough Bridge) and South Slough Bridge provide for travel to the south of the North Bend/Coos Bay/Charleston area. They both lie within the 2050 sea level rise + 1% chance flood zone. There is redundancy for traveling to the south as there are rural county roads that can be used.

According to members of the planning listening group, inundation of the bridge above Pony Creek on Virginia Ave. would split the town in two, limiting access and resources for most of the population. This poses threats to the community as most emergency personnel are located on the east side of the bridge while the fire station is located on the west side of the bridge. This bridge also falls within the 2050 SLR + 1% chance flood zone.

Management Actions

There are no existing management activities to prepare bridges for sea level rise flooding. ODOT performs routine bridge inspections and prioritizes bridges for refurbishment/reconstruction based on the status of the bridge, but prioritization does not currently include susceptibility to climate change.

Southwest Oregon Regional Airport

The Southwest Oregon Regional Airport is in North Bend at 17 feet above sea level. The airport served 13,000 passengers in 2019 (USDOT 2019). It is owned and operated by the Coos County Airport District. The property is approximately 619 acres and is accessed by Highway 101. It has facilities for commercial, general aviation, cargo, and military air traffic with three intersecting runways (CCAD 2013). Due to its low elevation, stakeholders expressed concern that the airport will be deeply affected by increasing sea levels and flooding. There is also a 30,000-gallon fuel tank on the airport property that was identified as vulnerable to flooding and sea level rise in interviews with the infrastructure industry.

Sensitivity

Flood Zone Extents

Portions of the land surrounding the airport already fall into the 100-year flood plain. A large amount of the area around the runways is projected to flood in the 2050 SLR + 1% chance flood scenario, and the entire runway area is projected to flood in the 2100 SLR + 1% chance flood scenario. Figure 8 shows the flooded airport area for the two sea level rise scenarios.

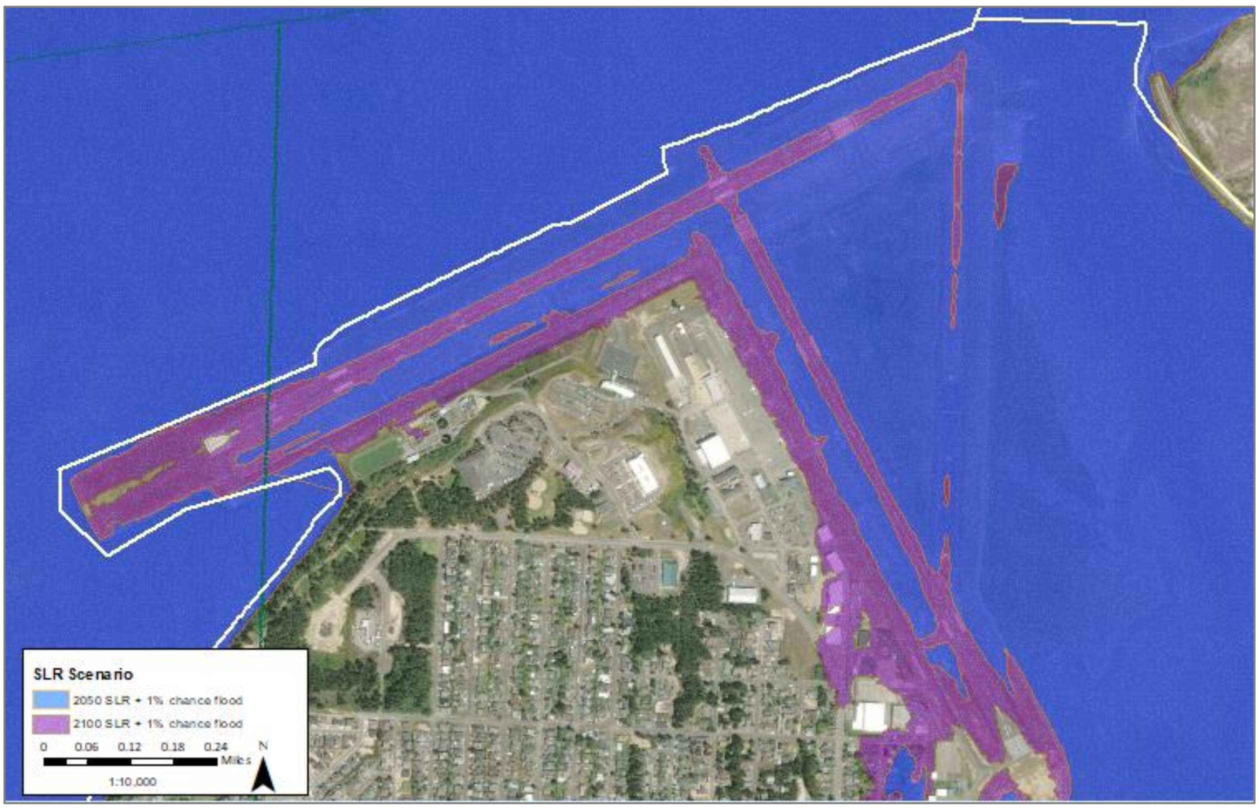
Interdependencies

The Southwest Oregon Regional Airport depends on the existing road network to connect airline passengers and goods to be dispersed throughout the area. Its stormwater system is partially connected to the Coos Bay stormwater system and it relies on the surrounding cities for some if its utility infrastructure. The airport also depends on governmental regulations.

Economic Sensitivity

According to the Oregon Department of Aviation, the Southwest Oregon Regional Airport contributes approximately $266.3 million for local business sales and $313.2 million for state business sales.

Figure 8 Southwest Oregon Regional Airport Projected SLR + 1% chance flood (2050, 2100)



Source: IPRE

Adaptive Capacity

Current Condition

The Southwest Oregon Regional Airport is in good condition. A representative of the airport stated in an interview that many facilities at the airport are currently operating over capacity. The airport has a master plan that was written in 2013 that identifies updates needed at the airport. It essentially functions as a capital improvements plan, identifying and prioritizing needs for keeping the airport operational. This plan does not reference updates needed for climate change and accommodations for sea level rise.

Redundancies

The alternative to using the Southwest Oregon Regional Airport is for passengers to travel by car and freight to travel by truck, ship, or railroad. In the case of inundation, the nearest airport is Bandon State Airport. Bandon State Airport is 30 miles from Southwest Oregon Regional Airport. It does not offer commercial flights and the next closest commercial airports are Medford Airport (170 miles away) and the Eugene Airport (100 miles away).

The Bay Area Hospital heliport can serve as a back-up in case of an emergency. The heliport is located less than a mile away from the airport.

Management Actions

The IPRE team identified no known efforts to plan for SLR flooding of the Southwest Oregon Regional Airport. However, the Southwest Oregon Regional Airport Master Plan does acknowledge that the airport lies within the 100-year floodplain.

Utility Infrastructure

Survey and Listening Session Results

The planning sector listening session focused buildings and critical facilities. They also talked about land use. These stakeholders asserted that critical infrastructure, such as the airport, bridges, and the wastewater treatment plant are most vulnerable to flooding. They described the resiliency of this infrastructure as poor.

Management Goals

The City of Coos Bay has both a stormwater and wastewater master plan for updates to these systems. North Bend is currently in the process of creating their own stormwater master plan. The only countywide plan that includes utility infrastructure is the county comprehensive plan.

Stormwater

Coos County receives approximately 65 inches of rain per year. Changes in climate are expected to lead to more rainfall in the winter and less rainfall in the summer. Additionally, many areas of Coos Bay are at or below the higher high tide level. The drainage system in Coos Bay already faces issues with flooding and backflow at high tide and as sea level rises these problems will be exacerbated. Much of the downtown Coos Bay area is protected by levees that keep sea water from flooding the area.

Coos County does not have a countywide drainage system. It appears that most of the rural drainage is handled privately or by ODOT. The cities of North Bend and Coos Bay, however, have relatively robust public stormwater systems.

Coos Bay has approximately 48 miles of gravity stormwater piping, three pump stations, and many outfalls that discharge to the bay or other ditches and creeks that feed into the bay. Many of the outfalls to the bay penetrate the levees that protect the city and are protected from backflow from by tide gates.

However, a large amount of these outfalls are missing tide gates. The city has National Pollutant Discharge Elimination System (NPDES) permits for all these outfalls. They completed stormwater master plans for the downtown area in 2004 (Kerbo et al 2004) and the remainder of the city in 2006 (Nicholson 2006).

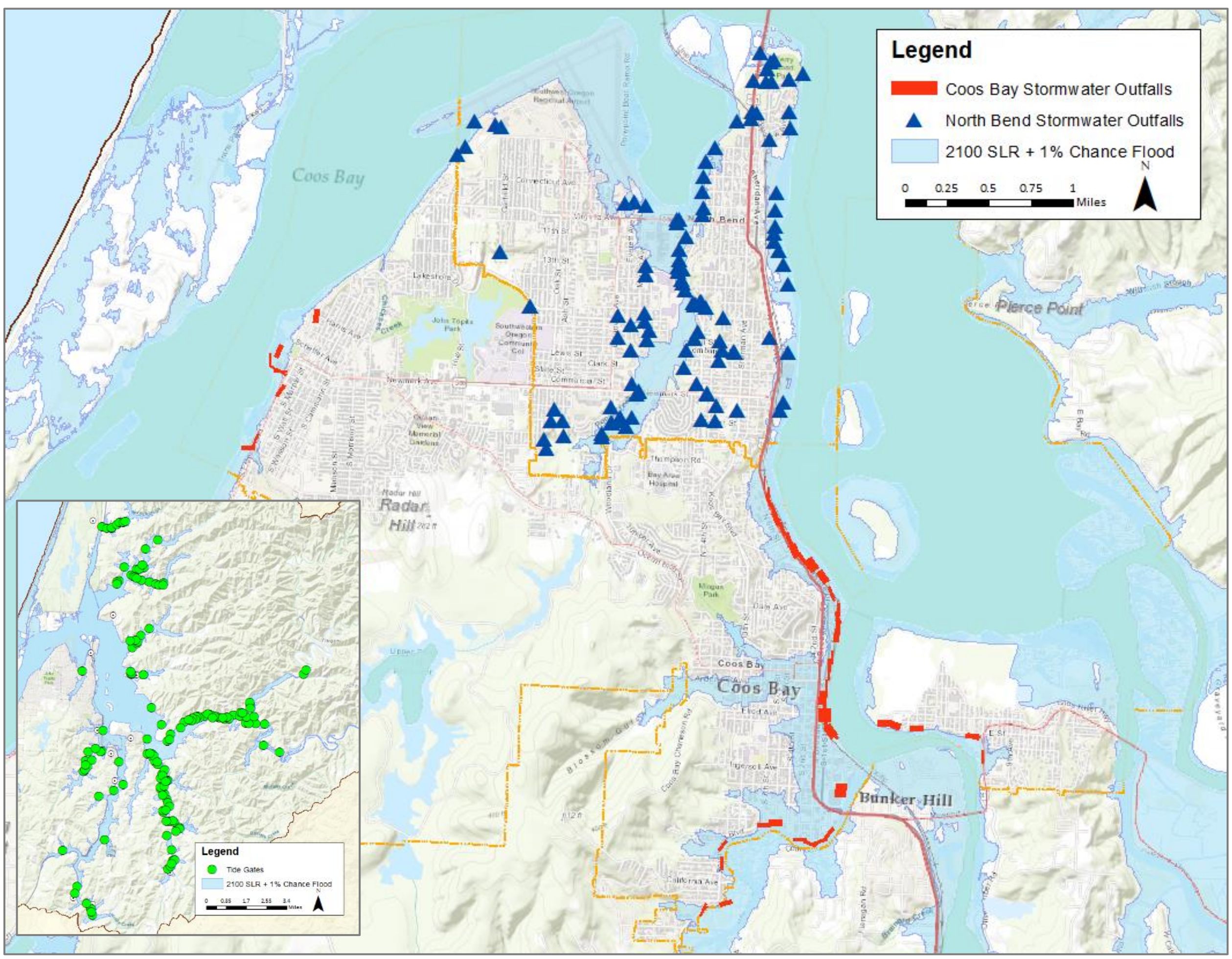
North Bend has approximately 37 miles of stormwater piping, 6 miles of which are maintained by ODOT, the airport, and other small private entities. Most of the city drains to Pony Creek or the estuary. As of 2022, they are in the early stages of developing a stormwater master plan.

Sensitivity

Flood Zone Extents

Coos Bay's stormwater infrastructure's sensitivities come from multiple directions. Both from rainfall and the bay itself. It faces the most flooding in the winter when high tide levels tend to be higher and rainfall increases. With climate change, both factors will intensify (Kerbo et al. 2004). Figure 9 shows the location of stormwater outfalls and tide gates for the Study Area.

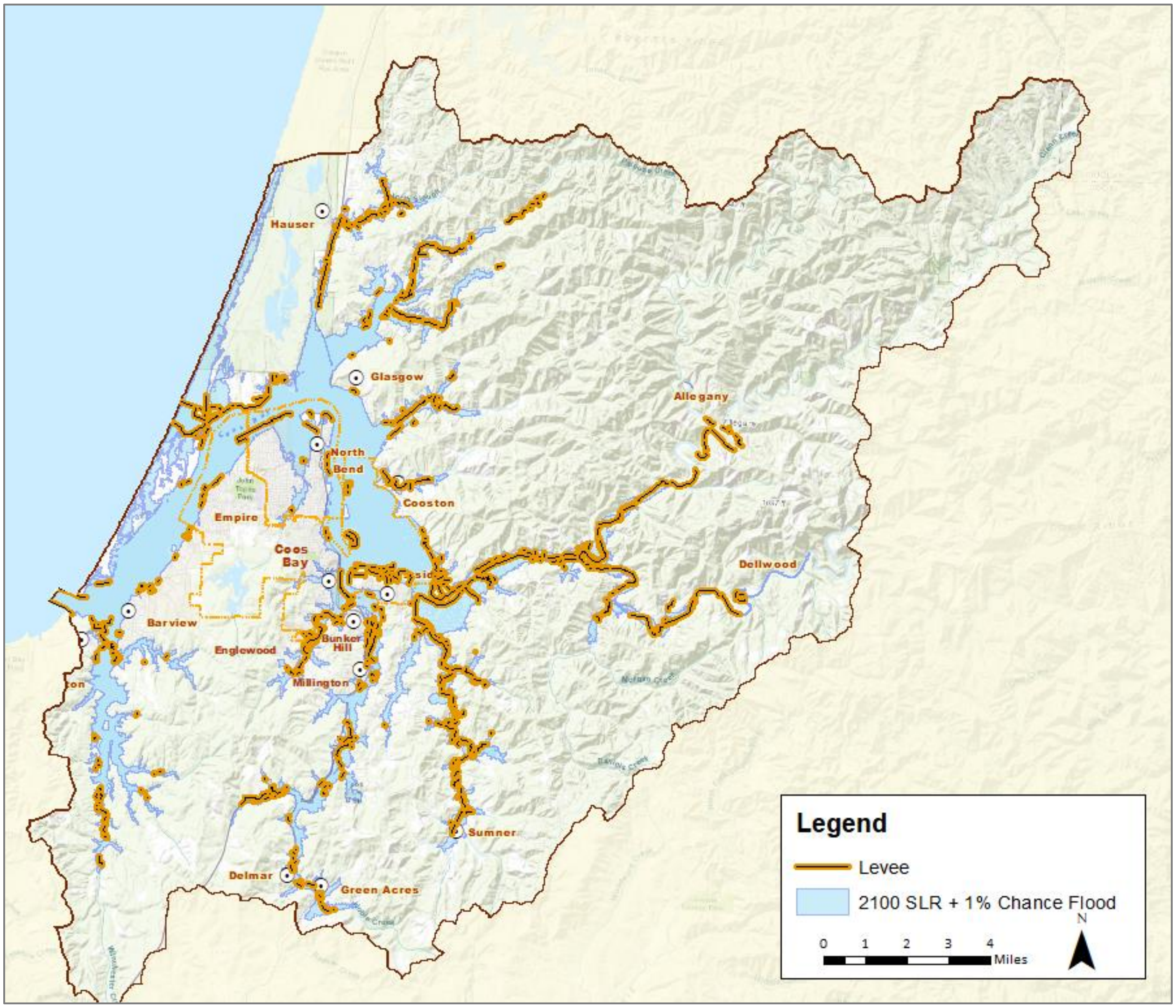
Figure 9 Stormwater Outfalls (and Tide Gate -inset) for Coos Bay and North Bend



Source: IPRE

Portions of Coos Bay were built on fill in what was originally tidal marshes. As a result, it is prone to flooding, and much is below the higher high tide level. There are levees protecting much of this area from tidal inundation. See Figure 10 Levees Map for map of levees. However, some of these levees in the Englewood area are not built high enough to hold back the higher tides that Coos Bay has already been experiencing (Kerbo et al. 2004).

Figure 10 Levees Map



Source: IPRE

Many outfalls from the Coos Bay stormwater system run through these levees and discharge to the bay. During higher tides, the bay rises above the outfalls and tide gates are used to keep seawater from backing up into the stormwater system. However, according to the 2004 plan about 20 of these outfalls do not have tide gates. Additionally, many of the tide gates that are in place are old and need to be replaced to be functional. When the tide gates are closed, the drainage system is unable to discharge to the bay. During rain events this means that the pipes can surcharge and cause flooding upstream in areas including Downton Coos Bay, Blossom Gulch, and Englewood (Kerbo et al. 2004).

Interdependencies

During flooding and storm events and potential flooding events, it is key to have a well-functioning stormwater system that quickly and effectively removes stormwater as quickly as possible. Roads rely on stormwater systems to keep water off the roads and keep them open to traffic. Homes, businesses, and public facilities rely on stormwater systems to keep water out of buildings and key facilities.

Economic Sensitivity

The cities of Coos Bay and North Bend allocate budget to their stormwater system each year and make updates in order of priority. However, with climate change these updates may need to happen more quickly which will increase cost.

Adaptive Capacity

Current Condition

The stormwater systems in Coos Bay and North Bend already face issues when it comes to elevation, especially in the downtown Coos Bay area. At high tide, tide gates on the outfalls need to be closed to stop ocean water from backflowing into the pipes. When those tide gates are closed, if there is a storm event, it causes those pipes to flood upstream. Because of the limiting factor of elevation, the physical adaptive capacity of the system is limited. The outfalls that do not have tide gates can have tide gates added, and green infrastructure and detention/retention basins can be strategically placed in flood prone areas. The levees in areas around downtown Coos Bay can also be made taller. However, after an undetermined amount of sea level rise, there is a limit to the adaptive capacity.

Redundancies

In general, piped stormwater systems to not have redundancies in place because they are gravity systems. Coos Bay has started to implement more green infrastructure best management practices which can be a first line of defense against stormwater and have overflows into the piped system. There is the possibility to install more stormwater detention and green infrastructure for infiltration that could act as redundancies to the piped system.

Management Actions

The stormwater master plans do not include references to climate change, however due to the nature of Coos Bay's stormwater system being heavily affected by tides, there are some efforts to improve outfalls with new tide gates. Coos Bay also informally encourages the use of green infrastructure in landscape design.

Wastewater

Wastewater in Coos County is divided into rural wastewater management and municipal wastewater management. Most wastewater outside the urban growth boundaries is handled by individual septic systems. In Oregon, the DEQ requires that septic system owners file permits for their systems (starting in 1972). Septic systems require regular maintenance and pumping of solids to remain functional (DEQ

2022). Some property owners may have illegally installed systems that were either built before 1972 or installed without obtaining a permit. Septic systems are very sensitive to the high groundwater of Coos County

Coos County allows public municipal sewer systems to extend to areas outside the urban growth boundaries for some cases. These include industrial sites, recreational PUDs, places with documented health hazards that could be improved by a public system, and publicly owned parks (Coos County 1985).

Coos Bay and North Bend both have wastewater collection and treatment systems. North Bend has about 75 miles of sewer pipe, 10 lift stations, and one wastewater treatment plant with a peak capacity of 10 million gallons per day. Their effluent is discharged into Coos Bay. The collection system is over 50 years old, and the treatment plant is 30 years old. The city maintains the collection system through regular cleaning and replacement of small portions of the system every year (North Bend 2022).

Coos Bay has about 90 miles of sewer piping, 26 pump stations, and two wastewater treatment plants. WWTP #1 is in downtown Coos Bay and has a peak capacity of 15 million gallons per day. WWTP #2 is in the Empire area and has a peak capacity of 8 million gallons per day. The city recently finished construction on a new WWTP #2 to replace the old one that was originally built in 1964 (Coos Bay 2021). Coos Bay treats wastewater from within the city limits as well as the Charleston Sanitary District and the Bunker Hill Sanitary District (Pallo 2006).

There are some interconnections between systems where North Bend and Coos Bay border one another. This means that some residents of North Bend are connected to the Coos Bay system and some residents of Coos Bay are connected to the North Bend system. These connections have been in place for several years and both cities are able to operate them cooperatively (Pallo 2006).

Sensitivity

The Coos Bay area, much like many coastal communities, has relatively high groundwater. This can pose problems for septic systems and can lead to failure if groundwater is too high. Wastewater can leach into groundwater if not properly constructed. Sea level rise and aging septic systems increase the risk of these systems failing. Some septic systems that were built prior to DEQ requiring permits may be at a higher risk for failure (Coos County 1985).

Both the North Bend and Coos Bay systems experience a large amount of inflow and infiltration due to a combination of factors including high groundwater and the age of the systems. This means that non-wastewater is entering the system and being treated at the wastewater treatment plant, greatly increasing the flows that are treated during winter months and storm events. Inflow is water that enters the system above ground such as through roof drains being connected to wastewater systems or stormwater entering the system through leaks in manhole lids. Infiltration is water that enters the system below ground, such as through cracks in pipes and high groundwater.

Flood Zone Extents

Both wastewater treatment plants in Coos Bay are at least partially in the 2050 sea level rise + 1% chance flood zone. The North Bend wastewater treatment plant is not within the 2050 sea level rise + 1% chance flood zone but is partially within the 2100 sea level rise + 1% chance flood zone.

Interdependencies

Residential homes and businesses all heavily rely on the wastewater system for removal of sanitary sewage.

Economic Sensitivity

Inflow and infiltration can lead to flows almost doubling in the treatment plants in the winter months. Because the large-scale overhaul of the wastewater treatment systems would be cost prohibitive, the authors of the Coos Bay Wastewater master plan suggested that inspection, repairs, and rehabilitation of portions of the system should be performed every year (Pallo 2006).

Adaptive Capacity

Current Condition

Inflow and infiltration are an issue caused by an aging wastewater system. This is slowly being addressed through pipe upgrades every year, but Coos Bay and North Bend have limited money and capacity to expedite that process. In interviews with representatives of the infrastructure industry, they made it clear that the wastewater treatment systems are often over capacity.

The two Coos Bay wastewater treatment plants fall within the sea level rise scenarios. Additional study will be needed if this would require a new wastewater plant at higher ground or if upgrades can be made to flood proof the plants. A new wastewater plant will require much more investment and lead to many technical challenges.

Redundancies

Both Coos Bay wastewater treatment plants fall within the boundaries of the 2050 SLR + 1% chance flood scenario. The North Bend wastewater treatment plant falls within the 2100 SLR + 1% chance flood scenario. In wet weather, the plants are already operating at capacity. There are no redundancies in place if these plants were to flood or become incapacitated.

Septic systems also do not have redundancies in place. Without regular maintenance they are prone to fail. Increases in groundwater and flooding could also cause an increase in septic system failures.

Management Actions

Coos County, Coos Bay and North Bend do not appear to consider climate change in their wastewater master planning.

Drinking Water

Drinking water in Coos County is divided into rural water and municipal drinking water systems. Rural properties outside the urban growth boundaries are mainly serviced by private wells. Coos County allows public municipal water systems to extend to areas outside the urban growth boundaries in some areas.

These include industrial sites, recreational PUDs, places with documented health hazards that could be improved by a public system, and publicly owned parks (Coos County 1985).

The Coos Bay and North Bend Water Board provide water for approximately 10,000 customers inside the cities of Coos Bay and North Bend and 3,000 customers outside the city limits. Their largest source is Pony Creek but they also use Merritt Lake, Joe Ney Slough Reservoir and wells in the Dunes Aquifer. The water board operates the Pony Creek Filtration plant and there are approximately 250 miles of water pipe in the system (Water Board 2020).

Sensitivity

Coos County tends to have shortages of available water during the summer months because its watershed is mostly fed by rain and it has a lack of snow pack and natural reservoirs. Climate change is expected to increase water shortages as rainfall decreases in the summer and temperatures rise leading to even less snowfall. This will lead to a decrease in stream flow in the Coos county area and a decrease availability of drinking water for the Coos County population (Dalton et al 2022).

Flood Zone Extents

The Pony Creek treatment plant does not fall within either the 2050 or 2100 sea level rise scenarios. Merritt Lake also does not fall within these scenarios. The Joe Ney Slough falls within both sea level rise scenarios.

Interdependencies

Residential homes and businesses all heavily rely on the wastewater system for access to water.

Economic Sensitivity

The cities of Coos Bay and North Bend allocate budget to their drinking water system each year and make updates in order of priority. However, with climate change these updates may need to happen more quickly which will increase cost. Water availability may also become a concern if summertime scarcity occurs due to lack of natural storage and built storage in reservoirs.

Adaptive Capacity

Current Condition

The limiting factor of Coos County's adaptive capacity for water is water availability. On the Oregon Coast, the watersheds are mainly fed by rainwater because there is not a large amount of snowpack in the coast range. Therefore, Coos County relies on water from stream and rivers, which decreases in the summer months, and groundwater.

Due to climate change, summers are expected to be even drier and water availability will decrease. Drawdown of the aquifer will need to be monitored and water in the rivers will decrease. The adaptive capacity for water in the region is low and alternative methods may need to be explored for supplying water to the region.

Redundancies

The Coos Bay and North Bend Water Board draw water from several sources including Pony Creek, Merritt Lake, The Joe Ney Slough Reservoir, and the Dunes Aquifer. If one of these sources is temporarily unavailable, they may be able to use the others short term to provide water but due to the scarcity of water in the summer and water rights, it is not a long-term solution.

Management Actions

Residents are regularly encouraged during the summer to conserve water but a larger long term solution is needed.

Electrical

The Study Area is served partially by Coos -Curry Electric Cooperative, partially by Pacific Power, and partially by Central Lincoln PUD. Coos-Curry Electric Cooperative and Central Lincoln PUD both receive their power from the Bonneville Power Administration, approximately 85% of that power is hydroelectric, with 10% nuclear and 5% other forms of power (CCEC 2019). In general, Pacific Power's "basic fuel mix" in 2021 was 47% coal, 18% natural gas, 15% wind, 6% hydro, and 14% other (Pacific Power 2021).

Sensitivity

Flood Zone Extents

There are two electrical substations in the Study Area that fall within the 2100 SLR + 1% chance flood. One is located on Jordan Point and one on W Lockhart Ave between Broadway and Second Street in Coos Bay.

Interdependencies

Electrical power is a key component to keeping systems running that are used every day. Homes and businesses rely heavily on the electric grid.

Economic Sensitivity

With increasing temperatures due to climate change, there will be an increase in electrical demand throughout the summer months. Although Coos Bay and the Oregon Coast are generally cooler than the rest of the state, it is still likely that more occurrences of hot weather will occur. Wildfire smoke will also lead to an increase in electrical demand for air purifiers.

Adaptive Capacity

Current Condition

All but two substations in the Study Area fall outside the 2050 and 2100 sea level rise scenarios. The remainder of the electrical infrastructure is relatively resilient to flooding.

Redundancies

Individual locations may have electrical generators to supplement the electricity in the event of an outage, but it is not a long-term solution and not all buildings have access to generators.

Management Actions

There are no known electrical management actions in place to address climate change.

Log Ship in Coos Bay

Photos courtesy of SSNERR

Chapter 5
Economy

This section describes the sensitivity and adaptive capacity of the Coos Bay Area economy. While much of the economy is grounded in the built environment (retail shops, offices, warehouses, manufacturing, and industrial areas), this section focuses mainly on the human component of the economy. Refer to the Built Environment section for more information about physical assets.

Coos Bay is the largest deep-water port between San Francisco and Seattle and therefore an important economic center on the Oregon Coast. Although historically Coos County's post-white settlement economy was based on natural resources, employment in industries directly related to natural resources has since declined. In 2021, only 3.5% of Coos County's private, non-government employment was in agriculture, forestry, fishing, or hunting. Although employment is low in these industries, however, the county's economy remains grounded in natural resources. Despite low employment in fishing, agriculture, and logging and wood product manufacturing, these industries still produce significant output and remain culturally important in the community. Additionally, tourism is an increasingly important economic driver, and visitors are drawn to the area by its stunning natural beauty.

The future of the Coos Bay Area's economy depends on working to strengthen its resilience. As the environment that underpins the economy changes, the industry and jobs that rely on natural resources must remain flexible, adaptable, and good stewards of the land and water.

Stakeholder Survey and Listening Session Results

There are several key takeaways relating to the economy from the stakeholder survey and listening sessions. The first is that the businesses and structures along the Coos Bay waterfront and coastal rivers are the most vulnerable to sea level rise and flooding. This includes downtown Coos Bay and the airport.

Stakeholders also raised the concern that a large portion of their economy is tied to tourism. If a large natural disaster were to occur in the area, it would take a long time for the local economy to recover. Another large portion of the economy is tied to fisheries and fishing. Changes to the climate and changes in tidal levels could lead to large scale negative effects on these fisheries which could in turn negatively affect the economy.

Finally, stakeholders pointed out that most commercial centers are along the bay and/or near rivers, creeks, and sloughs and in the projected floodplain (as well as vulnerable to sea level rise). Businesses could be subject to major disruption of day-to-day functions in flood events.

In terms of future efforts to support economic needs of the region, it is important to highlight two key projects that impact ports. Since the Port of Coos Bay is an important driver of economic activity in the region, the implications of these projects should be monitored:

- **Ports Needs Assessment** – Business Oregon is supporting an assessment of ports' most pressing needs throughout the state. This needs assessment will highlight areas where ports need support and may help clarify the vulnerabilities and needs of the Port of Coos Bay.
- The Department of Land Conservation and Development (DLCD) is working with ports to identify key project opportunities. This work can both pull from and complement the work of this vulnerability assessment. In general, the Port of Coos Bay will be an important partner in economic adaptation strategies, so the results of these projects should be considered and leveraged as the region moves forward with adaptation strategies.

Sensitivity

There are two main economic conditions to consider when evaluating sensitivity due to climate change: the inputs into economic activity and the location of economic activity.

Economic Inputs: Reliance on Natural Resources and the Environment

Many of Coos County's highest employment sectors are either directly or indirectly tied to the environment. In some cases, this is because jobs are based around inputs or a product coming directly from the land or sea (agriculture, timber, and fishing). In other cases, this is because jobs are related to tourism, which in turn depends heavily on that area's natural beauty and outdoor recreation opportunities.

Natural resource sectors depend on the health of the land and water. While only 3.5% of Coos County's employment is in agriculture, forestry, fishing, or hunting, the outputs from these sectors are significant exports to the rest of the state and beyond. As climate impacts harm and shift fisheries and agricultural and forestry products, these sectors will experience disruptions. A "business as usual" scenario will no longer be possible and firms will either have to adapt or close.

High employment sectors are low wage and related to tourism. Two of the non-government sectors with the highest employment in Coos County – retail and leisure & hospitality – are closely related to the tourism economy. Collectively, these sectors account for 25% of the county's total employment (Table 15). There are two particularly concerning attributes of these sectors: they are at least somewhat dependent on a presence of visitors to the area, and they are comparatively low-wage.

Although retail and leisure & hospitality are not completely dependent on tourism (there will always be a local need for these services), they are significantly boosted by visitors to the area. If climate impacts – whether from sea-level rise, wildfire and smoke disruption, or increased severity of weather events – make the area less desirable and less accessible to visitors, these two sectors will suffer. Leisure and hospitality already vary seasonally, and if volatility in visitation increases, these jobs will become increasingly less stable.

These sectors are also low-wage. On average, retail jobs pay only 75% of the overall average wage in the county. Leisure and hospitality work is even lower wage: only 59% of the county average. This places residents employed in these sectors in a vulnerable position. Because their incomes are low, they have a smaller financial cushion to rely on in the event of economic disruption. If jobs are cut due to a decline in tourism, this quarter of the county's workforce would find themselves in a precarious position.

Table 15 Employment and Wages for Key Sectors

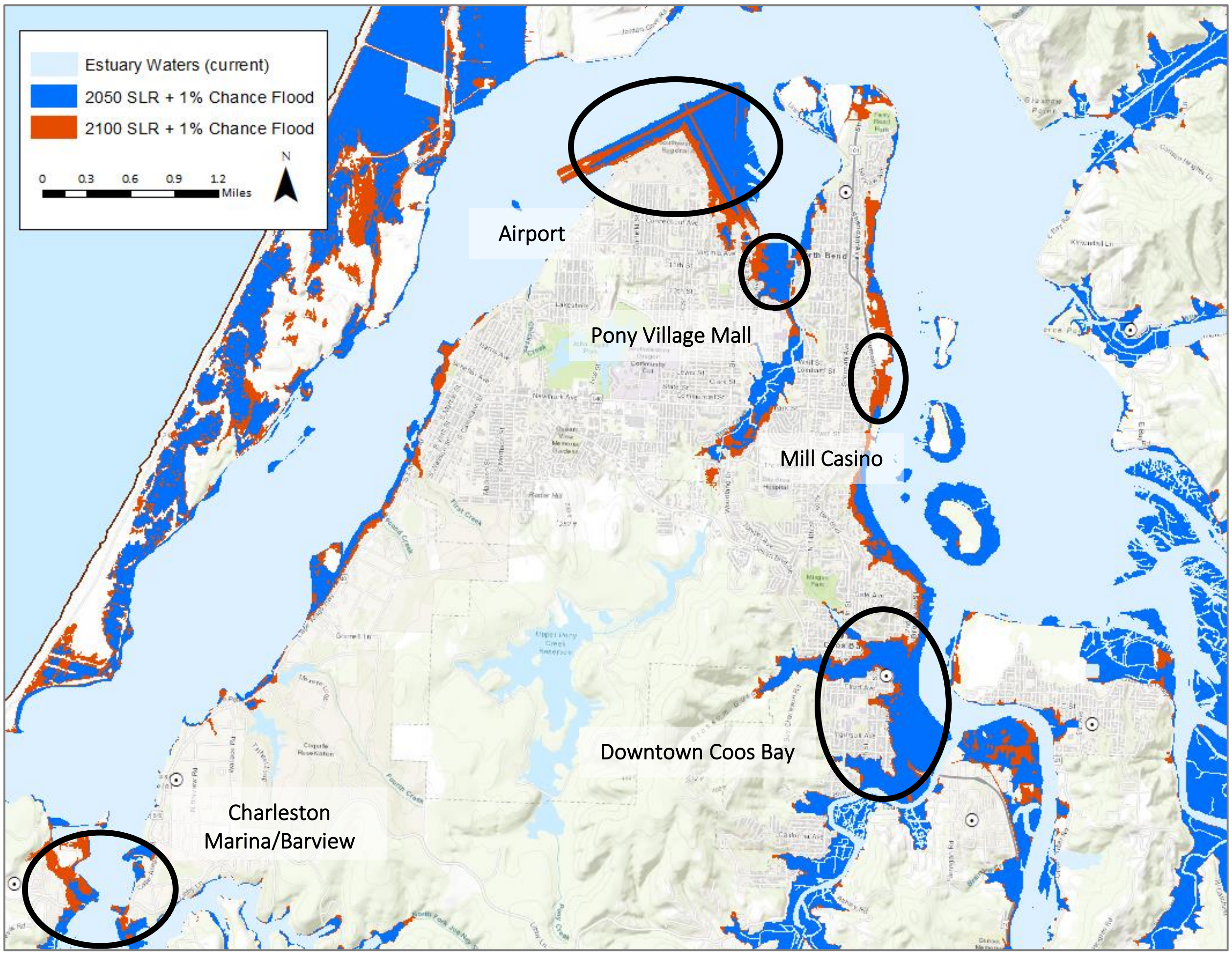
Industry	Ownership	Total Units	Total Employment	Annual Average Wage	Percent of All Employment	Wage as percent of County Average Wage
Total all ownerships	**All**	**2,103**	**22,536**	**$45,884**	**100%**	**100%**
Total private coverage	**Private**	**1,966**	**17,345**	**$41,579**	**77%**	**91%**
Education and health services	Private	424	3,265	$42,785	14%	93%
Retail trade (44-45)	Private	236	3,003	$34,294	13%	75%
Leisure and hospitality	Private	198	2,666	$27,039	12%	59%
Professional and business services	Private	237	2,348	$38,205	10%	83%
Agriculture, forestry, fishing and hunting	Private	102	789	$53,662	3.50%	117%
Crop production	*Private*	*11*	*38*	*$32,766*	*0.20%*	*71%*
Animal production and aquaculture	*Private*	*12*	*125*	*$35,990*	*0.60%*	*78%*
Forestry and logging	*Private*	*48*	*432*	*$59,526*	*1.90%*	*130%*
Fishing, hunting and trapping	*Private*	*15*	*42*	*$76,085*	*0.20%*	*166%*
Support activities for agriculture and forestry	*Private*	*16*	*152*	*$50,557*	*0.70%*	*110%*
Total all government	**All Govt.**	**138**	**5,190**	**$60,279**	**23%**	**131%**
Total federal government	Federal Govt.	25	310	$72,369	1%	158%
Total state government	State Govt.	24	457	$67,183	2%	146%
Total local government	Local Govt.	89	4,424	$58,705	20%	128%
Tribal government	Local Govt.	15	683	$51,851	3%	113%

Source: Oregon Employment Department. “Employment and Wages by Industry (QCEW).” Annual 2021 Data. Accessed 9/7/22.

Location: Physical Business Infrastructure in Vulnerable Areas

Because many of the economic centers of the Coos Bay Area are in low-lying areas, many of the area's businesses are vulnerable to climate impacts. Development patterns and the land use show that the percentage of jobs in areas predicted to experience flooding and sea level rise are higher than the percentage of permanent residents. Job concentration within inundation areas presents additional disaster recovery challenges, as places of employment will likely be extensively damaged or destroyed by flooding. Figure 11 presents the 2050 and 2100 sea level rise + 1% chance flood scenarios and key commercial, employment, and production areas that may be impacted in these scenarios.

Figure 11 Key Commercial, Employment, and Production areas & SLR Scenarios (2050 & 2100)



Source: IPRE

Based on these predictions of inundation, five areas of concern stand out:

- Airport – The Southwest Oregon Regional Airport is in the 2100 SLR + 1% chance flood zone. As a transportation hub for the region, impacts to the airport would not only disrupt the airport's employees, but also the movement of goods and people through the Coos Bay Area.

- **Pony Village Mall** – This large shopping center is in a low-lying area that will be among the first affected by flooding and sea level rise because of its terrain and location. Losing access to the retail and grocery resources in this area would cause issues for residents and visitors alike.
- **Mill Casino** – The Coquille Indian Tribe's Mill Casino Hotel & RV Park is along the bay and in the 2050 and 2100 SLR + 1% chance flood zones between Coos Bay and North Bend. The Mill Casino alone employs about 500 people in full-time, part-time, and on-call positions filling shifts 24/7 (Mill Casino n.d.). If these structures were affected, the entire operation would experience major disruption.
- **Downtown Coos Bay** – Much of Coos Bay's downtown is in the 2050 and 2100 SLR + 1% chance flood zones. The retail businesses, offices, and lodging concentrated here would suffer damage, disrupting daily operations and threatening long term stability.
- **Charleston Marina/Barview -** The Charleston Marina is the location of one the largest commercial fishing fleets in Oregon. The area is also the location of the Oregon Institute of Marine Biology (University of Oregon), offices and labs for the South Slough National Estuarine Research Reserve, Oregon Department of Fish and Wildfire, US Coast Guard, Charleston Rural Fire Protection District, Charleston Marine Life Center, and many other industrial and commercial enterprises. The Charleston Shipyard, off Troller Road in Barview, provides repair and fabrication services for the fishing and recreational boating fleets. This area is protected by existing levees; however, widespread inundation may occur under the 2100 SLR + 1% chance flood scenario that would disrupt daily operations and threaten long term stability.

Adaptive Capacity

Some characteristics of the Coos Bay Area's economy are less resilient and some more resilient. Low economic diversity and the characteristics of many jobs indicate that the overall economy has some concerning vulnerabilities. Other characteristics like the proximity of workers to jobs and the area's natural assets can become the foundation of a more resilient future.

Less Resilient Characteristics

Low economic diversity. The Oregon Employment Department produces an indicator called the Hachman Index to measure economic diversity (Tauer 2022). Using indicators such as gross domestic product (GDP) and employment, the index measures the mix of industries present in a particular region relative to a (well-diversified) reference region. Coos County's Hachman score is 0.24 (on a scale from 0 to 1 where 0 is low diversity and 1 is high diversity). The county is ranked 27th in terms of economic diversity out of Oregon's 36 counties, indicating that the county's economy is among the least diverse in the state. The county's position has fallen over time as well: in 1999, Coos County was 23rd out of 36 counties with a score of 0.38.

Economic diversity is an important component of overall economic resilience. Diversity spreads risk, thereby lessening the impact of one sector's decline on the overall economy. It is therefore troubling that the trend in Coos County in the past two decades has been towards concentration of activity in fewer economic sectors, especially when these sectors are reliant on natural resources that are quite likely to experience climate change related disruption.

Financial insecurity of residents. Several factors related to employment and income indicate that many residents of Coos County are in vulnerable financial positions:

- **Low Wages** – As previously noted (**Table 15**), all four of the highest employment non-government sectors in Coos County pay below the average wage in the county overall. Two of these sectors (retail trade and leisure & hospitality) pay significantly less than the county's average wage. This means that over a quarter of the workforce is working low-wage jobs.
- **Poverty** – Almost one-fifth (16%) of the population in Coos County had incomes below the poverty line according to 2020 estimates (ACS 2020). This is a higher percentage of residents than in the state overall, where only 13% of the population had incomes below the poverty line.
- **Unemployment** – In 2021, Coos County had an unemployment rate of 6.3% compared to the state's rate of 5.2% (OED 2021). In the past two decades, Coos County has consistently had a higher unemployment rate than the state overall.

People who are in a weaker financial position have less ability to withstand or quickly bounce back from either human-caused or natural disruptions. As the likelihood of climate change related disruptions increases, so too will the vulnerability of financially insecure residents. In the increasingly likely event of major disruptions, these residents will need to rely more heavily on social services, and many may struggle to fully recover from financial blows.

Slow recovery in the government sector. Just about one quarter of jobs in Coos County are in the public sector (**Table 15**), particularly at the local level. While these jobs have significantly higher wages than the county average, they are also impacted by the peaks and particularly the valleys of the economic cycle. While government jobs cuts due to economic downturn are usually less immediate than cuts in the private sector, they are also slower to recover (Rosewicz et al 2021). If economic volatility increases due to local climate change impacts, the Coos Bay Area's government jobs may suffer, making it more difficult to provide public services during a time when they may be most needed.

More Resilient Characteristics

Living and working patterns. Over two-thirds of workers employed in the Coos Bay Metropolitan Statistical Area also live in the area (US Census 2019). This is a good sign for two reasons. First, the businesses in the area are likely to capture more local economic activity that might otherwise be lost if residents primarily commuted (and therefore spent money) elsewhere for work. Second, if a major disaster or disruption were to strike, many residents would likely still be able to work because of their proximity to their place of work. This local access is critical to economic recovery post-disaster.

Natural assets. Despite the vulnerabilities associated with having a natural resource-based economy, these same resources also suggest opportunities. As green and "blue" (World Bank Group 2017) technologies develop, the opportunities for growth increase in industries related to sustainable natural resource use and management. The Coos Bay Area has the chance to invest in green and blue economic growth that brings many interrelated benefits: more sustainable interactions with the environment, economic diversification, and job growth in promising new industries.

Chapter 6:
Public Health and Social Systems

A community's social vulnerability is defined by many factors that increase and decrease their ability to anticipate, survive, and recover from natural hazards and disasters (Flanagan et al 2018). These factors include socioeconomic status, transportation access, cultural resources, community centers, social services, and economic conditions. In the U.S., people experiencing poverty are more vulnerable at all stages of a catastrophic event, as are people of color, non-native English speakers, children, elderly, and people with disabilities (Flanagan et al 2018). Socially vulnerable communities experience higher rates of mortality, morbidity, and property destruction and are less likely to fully recover from a disaster.

Social resilience can be planned for by identifying and prioritizing risk reduction for more vulnerable populations and the facilities and resources they rely on.

Vulnerable Populations Sensitivity and Adaptive Capacity

The 2020 Oregon Natural Hazards Mitigation Plan deems Coos County the most socially vulnerable of Oregon's coastal counties due to higher rates of residents with disabilities, residents who lack access to a vehicle, and unemployment (DLCD 2020). Many people experience multiple vulnerability factors. For example, almost half of residents 65 and older have a disability (DLCD 2020).

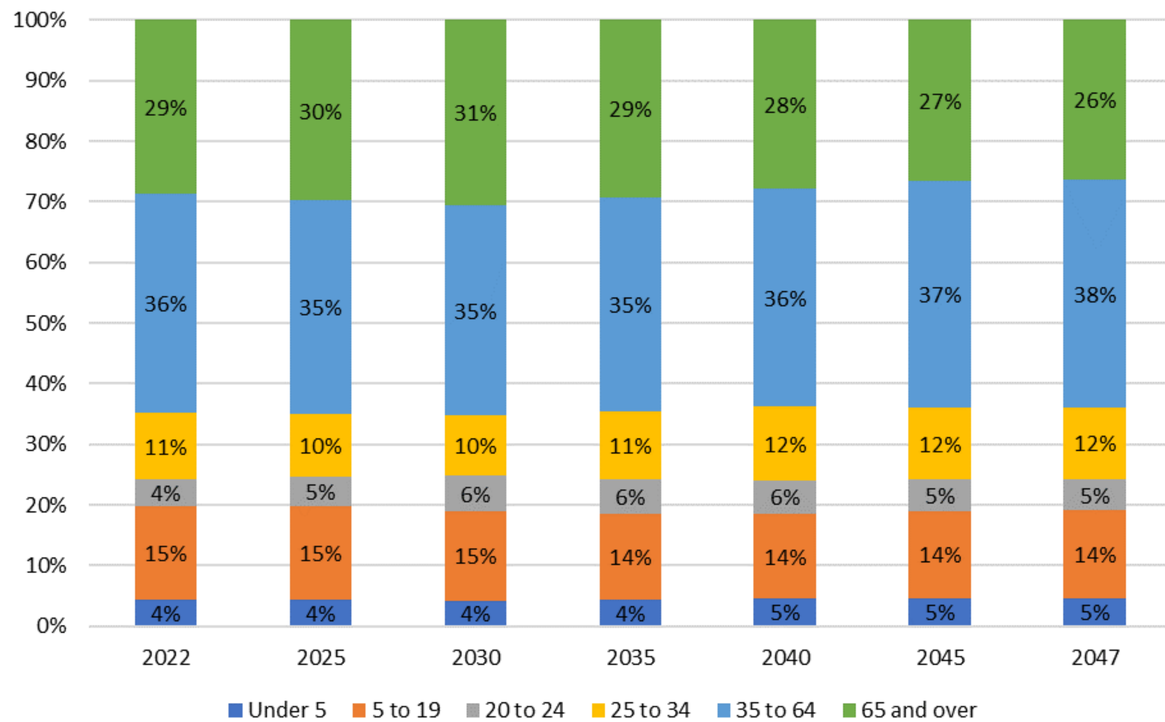
Some demographic characteristics can't be changed (e.g., age, gender, race, pre-existing health conditions) and thus are critical to consider and accommodate in planning. Other characteristics (e.g., income, wealth, employment, literacy, housing, insurance status, social isolation) can and should be improved to strengthen community resilience (NAACP 2015). The following sections describe these vulnerable groups in more detail.

Elderly residents: Approximately 26% of Coos County's 2020 population is over 65 years old, significantly higher than the 2020 state (17.6%) proportion (ACS 2020). This subpopulation is expected to grow to 32% by 2030 and then stabilize at about 30% (PCW n.d., Chen 2022). Elderly residents compose a slightly higher proportion of the population in North Bend (23.5%) than in Coos Bay (22.4%).

According to the State of Oregon's official population forecast the Coos County population (65,215) is expected to remain relatively stable between 2025 (65,296) and 2047 (65,317) (Chen 2022). Approximately 1/3 of the population of Coos County is 65 and older is projected to increase until about 2030 and then decrease to about 1/4 the population (decrease by about 1,500 persons) by 2047 (Figure 12). During that same period age cohorts from 20 to 64 are projected to increase by about 2,000 persons while the population from 5 to 19 is expected to decrease by about 600. Trends for the Study Area are expected to follow those of the County. The Study Area includes about 2/3 of the population of the County (ACS 2020). Coos Bay is the largest City (about 16,000), followed by North Bend (about 10,400), the remainder of the population lives in unincorporated communities including Allegany, Barview, Bunker Hill-Bay Park, Charleston, Cooston, Dellwood, Glasgow, Green Acres, Hauser, Isthmus Heights, Libby, Millngton, Sumner, and Willanch.

Older adults are more susceptible to air pollution, including ground level ozone, particulate matter/smoke, and dust (Balbus et al. 2009, Bell et al. 2014). Age is also the key risk factor related to illness or death from extreme heat. Since elderly individuals are also more likely to have pre-existing medical conditions, it is important to take action to reduce their risks. The Study Area has seven assisted living facilities and retirement communities, with three assisted living facilities in Empire, two retirement communities in West North Bend, one assisted living facility in Barview, and one assisted living facility in Central Coos Bay.

Figure 12 Population Forecasts by Age Cohort (2022-2047)



Source: Portland State University, Population Research Center, "Population Forecasts", 2022

Residents with disabilities: Roughly one in four Coos County residents has a disability which is a higher proportion than the state average (23.5% report living with at least one disability) (ACS 2020). The rate of disability is higher in Coos Bay (23.5%) than North Bend (17.2%).

Low-income residents: The Study Area's education levels, median household income, and wages are below state averages. The median household income for Coos County was roughly $49,500 in 2020, compared to $65,700 for the State (ACS 2020). About 35% of Coos County households earn less than $35,000 a year, and the county's poverty rate has remained at roughly 16 percent for over a decade, with a quarter of children living in poverty (ACS 2020). About 35% of all Coos County households were cost-burdened (paying more than 30% of their income on housing) in 2020 (about 31% of owners and 42% of renters are cost burdened) (ACS 2020). In general, households with lower incomes are more cost burdened. Coastal communities including Coos County were hit particularly hard by the financial crisis that began in 2007, and the community has been impacted by the economic effects of the COVID-19 pandemic.

Low-income households and individual residents often have little or no savings and other assets to withstand economic setbacks. When a disaster interrupts work, the ability to provide housing, food, and other necessities becomes more difficult. This is especially true if public transportation, food assistance, housing, and other low-income assistance programs are impacted.

Residents living in poor quality and/or in group housing: Much of the housing around Coos Bay, particularly single- and multi-family homes, has minimal to fair construction functionality (PCW n.d.). The county's housing has a higher portion of mobile home units (16 percent) compared to the state (PCW n.d.). As of 2020, the area had 36 manufactured/RV parks, with the majority in the Barview (10) and Radar Hill-Ocean Boulevard (9) neighborhoods. More than 10 percent of the housing in the neighborhoods of Barview, Bunker Hill-Bay Park, Charleston, and Libby is manufactured homes. Manufactured housing is more likely to be damaged by coastal hazards, and residents are less likely to be able to repair and return to their housing without support. Manufactured housing (RV Parks included) that are exposed to the 2100 Sea Level Rise + 1% chance flood scenario include: Charleston Marina RV Park, Coal Bank Lane Mobile Home Park, Kelly's RV Park, Lucky Loggers RV Park, Midway RV Park, Mystic Woods Mobile & RV Park, Plainview Motel and RV Park, Saints Trailer Park, and Seaport RV Park.

Other housing factors to consider in planning include supportive group housing and unhoused community members. Englewood and Libby each have one adult foster home, according to April 2021 research. Coos County's homelessness rate is relatively high, according to Oregon Housing and Community Services, with more than 500 people experiencing homelessness in an average year between 2015-2019. Unhoused people are disproportionately susceptible to illness and mortality from climate change. Following floods, these communities are the most likely to experience death, disease, post-traumatic stress disorder, and anxiety (Snyder et al 2004).

Almost half of all Coos County homes were built before 1970, when floodplain management laws began to be implemented (ACS 2020). Neighborhoods that experience issues with flooding currently include Englewood and Millington. There are a total of four government subsidized apartment buildings and this housing type is home to more vulnerable populations.

A 2020 analysis of housing needs and supply within the city limits of Coos Bay concluded that the city has enough buildable capacity and residential land use opportunity within existing zoning to accommodate the number of projected housing units needed over the next 20 years (LCOG 2020). However, the research team noted that questions remain about current and future housing affordability for lower- and middle-income residents, especially since the developer of a 400-unit manufactured home project has changed plans and the units may no longer be affordable at those income levels.

Residents Living in manufactured/mobile homes: Much of the area's housing, particularly single- and multi-family homes, has minimal to fair construction functionality, according to the Communities, Lands & Waterways Data Source produced by the Partnership for Coastal Watersheds (PCW n.d.). The county's housing also has a higher portion of manufactured home units (15.5%) compared to the state (7.6%) (ACS 2020). Neighborhoods with the most manufactured/RV parks are Barview, Radar Hill-Ocean Boulevard, and Charleston, as shown in Table 16 Bunker Hill-Bay Park, Eastside, Empire, Empire Lakes, Englewood, Libby, and Sherman Heights also have manufactured/RV parks (see the section above for RV Parks exposed to sea level rise).

Table 16 shows the number of multi-unit housing facilities in the Study Area neighborhoods. Multi-unit housing facilities may be home to more vulnerable populations. For example, assisted living facilities and retirement communities house elderly people and people with disabilities, the manufactured/RV park category may indicate areas with poor quality housing construction, and manufactured/RV parks and larger apartment buildings may house lower-income residents.

Table 16 Housing with Five or More Units by Neighborhood in Coos Bay Study Area

	Coos Bay								North Bend				County				
Housing Type	**Central Coos Bay**	**Eastside**	**Empire**	**Empire Lakes**	**Englewood**	**Hospital Park - Milner Crest**	**Radar Hill - Ocean Blvd.**	**Telegraph Hill - Mingus Park**	**Airport Heights**	**Sherman Heights-Pony Creek**	**Simpson Heights**	**West North Bend**	**Barview**	**Bunker Hill - Bay Park**	**Charleston**	**Libby**	**Total by Housing Type**
Multi-family w/ Gov't Subsidy	1			1								1			1		4
Commercial (>4 units)	26	3	14	2	7	3	9	11	3	17	5	6		3	1		110
Assisted Living Facility	1		3										1				5
Retirement Community												2					2
Manufactured/RV Park		2	3	1	1		9			1			10	3	5	1	36
Apartment Other										1							1
Apartment 5-9 Units							1										1
Apartment 10-19 Units							3										3
Apartment 20-49 Units	1						1										2
Apartment 50-99 Units			1				1				1						3
Apartment 100+ Units													1				1
Total by Neighborhood	29	5	21	4	8	3	24	11	3	19	6	9	12	6	7	1	168

Source: Partnership for Coastal Watersheds "Communities, Lands & Waterways Data Source. Chapter 4: Community Demographics: Population and Housing," using 2016 data from the Coos County Assessor's Office.

Residents lacking transportation access: Of the county's occupied housing units, 8% lack access to a vehicle (ACS 2020). Coos County Area Transit provides limited public transportation services on weekdays within traditional businesses hours.

Indigenous, Hispanic, and Non-Native English-Speaking Residents: Native American residents (American Indian alone or in combination with other races) and Hispanic or Latino residents (of any race) comprised 2.0% and 6.7% percent respectively of the Coos County population in 2020 (ACS 2020). Indigenous, Hispanic, non-white, and non-native English-speaking residents experience higher poverty rates in the Study Area. These residents may experience a lack of access to culturally appropriate services, social support, and representation among decision-makers as well as communication barriers.

Members of the Confederated Tribes of Coos, Lower Umpqua, and Siuslaw Indians (CTCLUSI) and the Coquille Indian Tribe live and work in the Study Area. Kyle Powys Whyte, among others, notes that "Indigenous peoples face climate risks largely because of how colonialism, in conjunction with capitalist economics, shapes the geographic spaces they live in and their socioeconomic conditions. … [S]ettler colonial laws, policies and programs are 'both' a significant factor in opening up Indigenous territories for carbon-intensive economic activities and … a significant factor in why Indigenous peoples face heightened climate risks" (White 2016).

The Hispanic portion of the population has increased slightly (by about 1%) since 2010 while the non-Hispanic white portion has decreased (by about 2%). Native American people are most dominant in eight

Census blocks, including the Kilkich development on the Coquille Tribal Lands in the Barview neighborhood (PCW n.d.).

Stakeholder Survey and Listening Session Results

Local stakeholders expressed concern in the survey and listening sessions about groups that are more vulnerable to flooding, severe storms, wildfire, and other hazards. Stakeholders and existing management plans focused on people who are older, low income, have disabilities, and lack access to transportation. School and community center representatives also named their staff, students, and visitors as community assets that would be impacted by hazards.

Existing Management Plans and Goals

The research team was not able to find local or regional management goals or planning specific to local vulnerable populations.

To assess the vulnerability of these populations within the Study Area, the team analyzed their sensitivity, adaptive capacity, and hazard exposure and then combined qualitative scores for these three factors to create an overall vulnerability score.

Sensitivity

To understand differences in hazard sensitivity among subpopulations, we used census tract-level results from the most recent Centers for Disease Control and Prevention (CDC) Social Vulnerability Index.

According to the CDC index,[1] social vulnerability in the Study Area is high relative to state averages. The most vulnerable census tracts include the neighborhoods of Empire, Empire Lakes, and Radar Hill-Ocean Boulevard as well as land belonging to the Coquille Indian Tribe. The second most vulnerable tracts include Bunker Hill-Bay Park, Central Coos Bay, Englewood-Libby, Hospital Park-Milner Crest, Millington, and Telegraph Hill-Mingus Park.

The CDC index also indicates geographies with higher social vulnerability in four categories: socioeconomic status, household composition/disability, race/ethnicity/language, and housing type/transportation. The neighborhoods with the highest social vulnerability scores in each of the four categories relative to the rest of the Study Area are shown in Table 17.

[1] The 2018 CDC Social Vulnerability Index combines percentile rankings of U.S. Census Bureau American Community Survey (ACS) 2014-2018 variables for the state at the census tract level. Tracts are scored using a combination of 15 factors across four themes: Socioeconomic status (poverty, unemployed, per capita income, no high school diploma), household composition/disability (aged 65 and over, aged 17 and younger, single-parent household, aged 5 and over with a disability), race/ethnicity/language (minority, English language ability) and housing type/transportation (multi-unit, mobile homes, crowding, no vehicle, group quarters).

Table 17 Neighborhoods with the Highest Social Vulnerability in Four Sensitivity Categories

Neighborhood	Highest SVI Themes	
Airport Heights	Household Composition/Disability	
Barview	Socioeconomic Status	
Bunker Hill-Bay Bark	Household Composition/Disability; Housing type/transportation access	
Charleston-Cape Arago	Socioeconomic Status	
Central Coos Bay	Household Composition/Disability; Housing type/transportation access	
Empire	Socioeconomic Status; Household Composition/Disability; Housing type/transportation access	
Empire Lakes	Socioeconomic Status; Household Composition/Disability; Race/ethnicity/language	
Englewood-Libby	Household Composition/Disability; Housing type/transportation access	
Hospital Park-Milner Crest	Household Composition/Disability; Housing type/transportation access	
Millington	Household Composition/Disability; Housing type/transportation access	
Radar Hill-Ocean Boulevard	Socioeconomic Status; Household Composition/Disability; Housing type/transportation access	
Sherman Heights-Pony Creek	Household Composition/Disability; Race/ethnicity/language	
Simpson Heights	Household Composition/Disability	
Telegraph Hill-Mingus Park	Household Composition/Disability; Housing type/transportation access	
West North Bend	Household Composition/Disability	
Key:		
Socioeconomic Status		Lowest per capita income and/or the highest portion of residents living below the federal poverty level, who are unemployed, and/or did not finish high school
Household Composition/Disability		Highest portion of residents 65 or older, 17 or younger, 5 and older with a disability, and/or living in a single-parent household
Race/ethnicity/language		Highest portion of residents that are people of color, Hispanic, and/or speak English less than well
Housing type/transportation access		Highest portion of residents lacking access to a vehicle and/or living in housing categorized as multi-unit, mobile homes, crowded, and/or group quarters

Source: Table created by IPRE using CDC Social Vulnerability Index (2018)

Five notable social vulnerability factors are more prevalent among residents in the Study Area:

- Low-income
- Older residents
- Living with a disability
- Tribal/Indigenous peoples
- Living in manufactured/mobile homes

Social vulnerability as measured by the CDC's index has generally increased or remained high across the Study Area, especially in the more populous areas, since the first iteration of the index was released in 2000.

Adaptive Capacity

We evaluated the adaptive capacity of vulnerable populations, or their ability to recover from the impacts of climate-related natural hazards, by analyzing level of awareness, projected population changes, and the presence of social services and social cohesion.

Level of Awareness

To reduce the area's social vulnerability by increasing adaptive capacity, decision-makers must be aware of where the community's most vulnerable populations are and factors that increase their vulnerability. Then decision-makers must make and implement plans to reduce risk factors, focus resources, and provide support.

It's important to note that impacted groups and communities should be not only aware of natural hazard plans and available resources but also involved in the planning process. Emergency response agencies can plan more effective and equitable responses if their planning process includes collaboration with people who speak multiple languages; live in isolated locations; are marginalized based on their race, ethnicity, gender, or sexual identities; have low incomes, chronic illnesses or impairments, or a disability; and/or are over age 65. Local officials should recognize the knowledge, skills, and relationships within neighborhoods and remember that people who appear vulnerable may also have vital knowledge and skills that serve the broader community.

We evaluated this level of awareness by analyzing three of the most locally relevant hazard reports — the Natural Hazards Risk Report for Coos County (2021), the Tsunami Evacuation Analysis of Communities Surrounding the Coos Bay Estuary (2019), and the Fifth Oregon Climate Assessment (2021).

Specifically, the Natural Hazards Risk Report for Coos County mentions populations only in reference to more vulnerable buildings rather than demographic factors (Williams et al 2021); the Tsunami Evacuation Analysis of Communities Surrounding the Coos Bay Estuary mentions some vulnerable demographics (elderly, disabled, Spanish-speaking) but does not mention plans for them (Gabel et al. 2019); and the Fifth Oregon Climate Assessment mentions vulnerable demographics and references plans to address them but is focused statewide rather than locally (Dalton et al 2021).

The Coquille Indian Tribe — through its Emergency Preparedness and Disaster Mitigation Committee, Housing Authority, Health Center and Elders Program, and Community Center (a designated tsunami evacuation site) — has worked to identify natural hazard strategies, including developing plans, identifying escape routes, and mapping vulnerable populations (CIT 2010). The Tribe has also focused on understanding climate change impacts, engaging its community in climate change discussion, and strengthening collaboration and partnerships with non-tribal organizations in the region.

Population and Forecasted Change

It's important to note that these factors would not by themselves lower the adaptive capacity of vulnerable populations unless the area's social services and hazard planning do not provide adequate resources specific to these populations and the area's social cohesion is lacking.

Social Services and Social Cohesion

Reducing isolation, poverty, stress, and poor physical and mental health on an ongoing basis can reduce losses from any climate change hazard. This requires strong social and economic services and infrastructure within a community.

Traditional social service models don't address the unique barriers that the most vulnerable populations face, such as social isolation, dependence on public transit, limited English proficiency, reliance on medical equipment, and insecure housing. Many cities and counties have not had the resources to invest in the workforce and services that support these populations and build resilient communities. As a result, the communities hit hardest by climate change have the least capacity to respond (Lou 2020).

According to a 2016 report, Oregon's public health system is not currently equipped to handle the complex and emerging environmental risks that climate change will exacerbate (Berk 2016), with only one of the state's 33 local public health authorities reporting that it has full ability to identify and prevent environmental health hazards.

Social cohesion refers to the ongoing process of developing well-being, sense of belonging, and voluntary social participation among community members and creating communities that promote and incorporate a multiplicity of values and cultures and grant equal rights and opportunities. Social cohesion enables collective problem-solving and support and happens at the community level when individuals have opportunities to interact and develop strong relationships within and across the social, cultural, economic, spiritual, and political institutions that bond them together (Lou 2020).

Some social cohesion elements that decision-makers could measure are the number, and per capita participation rates if applicable, of:

- Arts and cultural organizations
- Nonprofits
- Faith-based organizations
- Locally owned businesses

There is limited information on the Study Area's social services and the level of social cohesion, and the research team recommends local decision-makers look further into this analysis.

Hazard Exposure

We evaluated the risk level of the two most concerning climate-related hazards that affect more vulnerable populations: sea level rise and flooding (combined hazard) and wildfire.

Flooding

To evaluate risk exposure to the combined hazard of flooding and sea level rise, we assessed the projected spatial extent of the 2050 and 2100 SLR + 1% chance flood. Note that the exposure maps assume that existing levees, dikes, tide gates, and other flood-reducing infrastructure will not continue to function as intended.

Based on the spatial extent of these projections, the following neighborhoods may be exposed to increased flood risk **by 2050 or earlier**:

- **High flood exposure:** Central Coos Bay, Green Acres, Hauser, and Sumner
- **Medium flood exposure:** Bunker Hill-Bay Park, Charleston-Cape Arago, Empire, Englewood-Libby, Millington, Sherman Heights-Pony Creek, and Telegraph Hill-Mingus Park

Risk level increases for those neighborhoods and grows to include more neighborhoods by the end of the century. The following neighborhoods would face flooding exposure **by 2100 or earlier**:

- **High flood exposure:** Bunker Hill-Bay Park, Central Coos Bay, Charleston-Cape Arago, Englewood-Libby, Green Acres, Hauser, Millington, Sherman Heights-Pony Creek, and Sumner
- **Medium flood exposure:** Airport Heights, Empire, Hospital Park-Milner Crest, Simpson Heights, Telegraph Hill-Mingus Park, and West North Bend

The hazard exposure of vulnerable populations to sea level rise and flooding is increased due to this hazard's high probability, significant spatial extent, and longer-duration impacts.

Wildfire

To evaluate hazard exposure to wildfire, we assessed the burn probability of land in the Study Area and its spatial extent. The highest burn probability for populated areas or their immediate surroundings was low (less than or equal to a 1-in-10,000 chance) and affected the following more rural areas within the wildland-urban interface:

- Green Acres
- Sumner

Although most communities in the Study Area are unlikely to burn due to a wildfire, forest lands and rural areas to the north and east of these communities have a moderate chance (1-in-1,000 to 1-in-5,000) of burning. Any nearby wildfires would produce harmful smoke that disproportionately affects the health of more vulnerable populations.

Resident groups to plan for include those who are: 65 and older; 5 and younger; living with disabilities and chronic health conditions; low-income; unhoused; living in poor quality housing; marginalized by race, ethnicity, or other identity or status.

The hazard exposure of vulnerable populations to wildfire is impacted by its low probability, limited spatial extent, and shorter-duration impacts.

Coos History Museum at High Tide Photo courtesy of Oregon King Tides Project

Coos History Museum at King Tide Photo courtesy of Oregon King Tides Project

Chapter 7: Cultural Heritage

Heritage resources are central to community identity and often provide significant economic benefits. Coos County includes a diverse array of heritage resources including historic houses, buildings, downtown districts, artifacts, museum collections, historic cemeteries, sacred places, and records.

Like all aspects of human society, heritage resources are not immune to risk from natural and human-caused disasters. For example, forecasts suggest that climate change will increase the frequency and severity of natural hazards which will increase the vulnerability of heritage resources and of the organizations that steward them (Murthy 2013). Moreover, unexpected events that result from the natural decay of buildings, lack of building renovation, and human-caused incidents such as theft or vandalism also contribute to the vulnerability of heritage resources.

Collective heritage is part of what binds communities together. Heritage contributes to a community's overall sense of cultural identity. Heritage resources can inspire and strengthen social bonds within communities, through the places that are cared for, events that celebrate the past, and the interactions that community members experience in the practice of preservation. Heritage resources can also make crucial contributions to local economies. The promotion of heritage sites as tourist destinations can have significant impacts not only to the organizations that steward heritage resources, but to local businesses, hotels, and other associated services. The prioritization of heritage resources within disaster and emergency planning has significant implications both culturally and economically.

Few examples of collaborations across disaster planning and cultural and historic preservation planning exist. The lack of connection is evident within the statewide Natural Hazards Mitigation Plan (NHMP) and Historic Preservation Plan (HPP). The Oregon HPP makes mention of emergency and disaster planning within its policies, initiatives, and plan objectives. That said, Oregon's NHMP did not include any preservation representatives on the planning team or describe heritage resources as part of the statewide mitigation strategy (Appler et al 2016). The limited cross-referencing and collaboration between plans and planning processes highlights opportunities to leverage shared goals between the two planning documents and the groups involved in developing and implementing those plans.

Mitigation and adaptation strategies for heritage resources focus on prevention and reduction of the causes, impacts, and consequences of unexpected events. These strategies may include:

- **Education and outreach activities** that increase community investment and organization capacity to preserve heritage resources.
- Changes to **policies and procedures** that increase internal communication and risk management practices.
- Projects that **improve the physical buildings and locations** where heritage resources are housed.

- **Increase capacity for asset management** through securing resources for preservation activities, such as trainings or funding, and diversifying the volunteer base.

Heritage Resources Sensitivity and Adaptive Capacity

Historic and cultural resources such as historic structures and landmarks can help to define a community and may also be sources for tourism revenue. Protecting these resources from the impact of disasters is important because they have an important role in defining and supporting the community. According to the National Register Bulletin, "a contributing resource is a building, site, structure, or object adds to the historic associations, historic architectural qualities, or archeological values for which a property is significant because it was present during the period of significance, related to the documented significance of the property, and possesses historical integrity or is capable of yielding important information about the period; or it independently meets the National Register criteria" (NRB n.d.). If a structure does not meet these criteria, it is non-contributing.

Table 18 identifies the number of eligible/significant (ES), eligible/contributing (EC) historical sites, and non-eligible historic sites in the Study Area. The table also shows how many ES and EC sites are listed on the National Register and are located and in incorporated cities, and how many contributing and non-contributing resources are located at ES and EC sites. Overall, there are a total of 320 nationally registered historic places in the Study Area. One site is within the unincorporated area of the County (Hauser), 172 in Coos Bay, and 144 in North Bend. Sixty percent of the sites in Coos Bay and 34% of the site in North Bend are considered ES or EC.

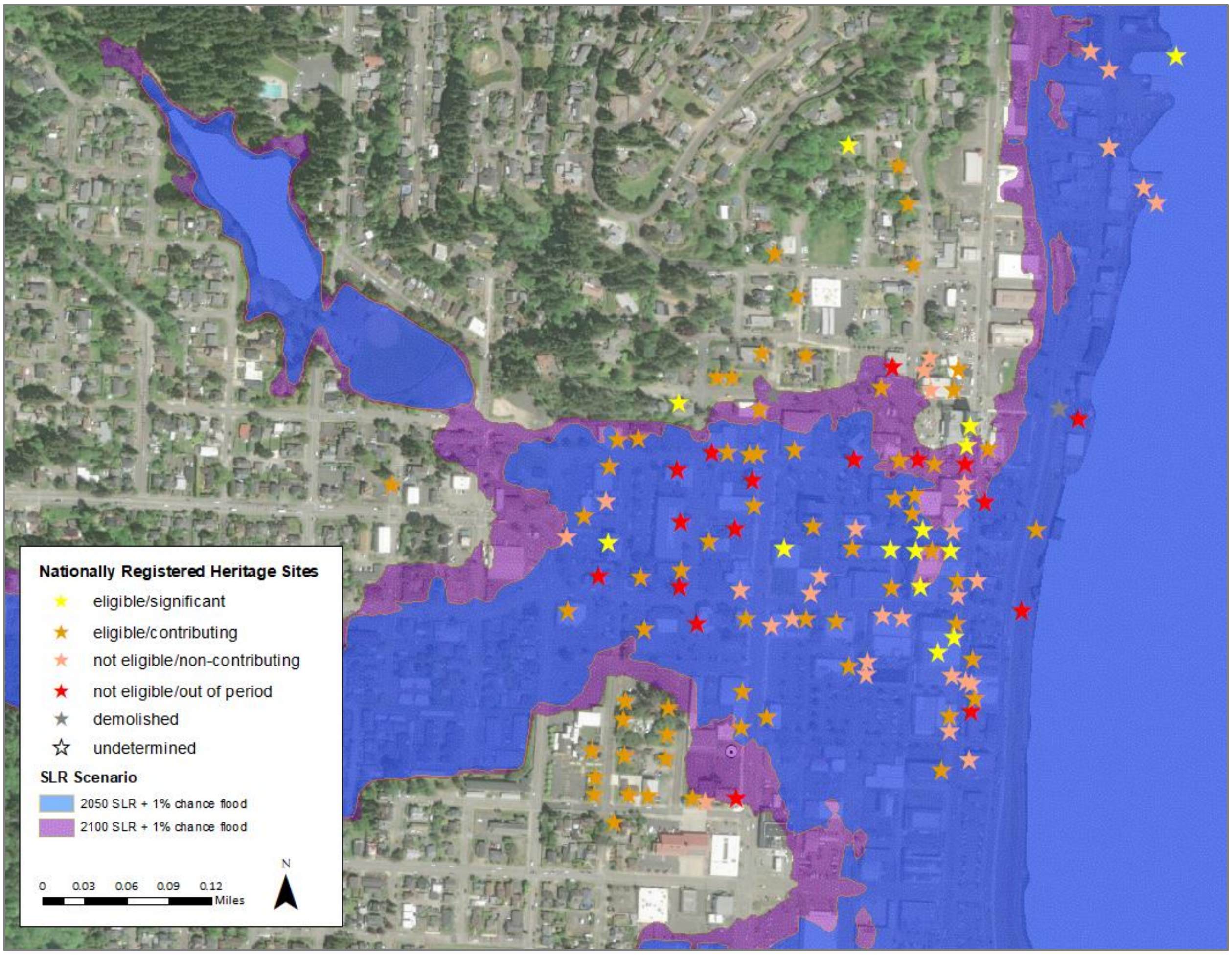
Table 18 Nationally Registered Heritage Sites

Eligible Sites	Total Sites	County		Coos Bay		North Bend	
Eligible Significant	39	0	0%	28	16%	11	8%
Eligible Contributing	114	1	100%	75	44%	38	26%
Not Eligible / Not Contributing	128	0	0%	46	27%	82	57%
Not Eligible / Out of Period	27	0	0%	17	10%	10	7%
Undetermined	7	0	0%	4	2%	3	2%
demolished	5	0	0%	2	1%	3	2%
Total	**320**	**1**	**< 1%**	**172**	**54%**	**144**	**45%**

Source: Oregon Historic Site Database

Of the nationally registered sites in Coos Bay (excluding those that are demolished) 88 are exposed to the 2050 SLR + 1% chance flood scenario and an additional 20 (total of 108) are exposed to the 2100 SLR + 1% chance flood scenario. Figure 13 shows that many of the nationally heritage sites exposed to sea level rise and the 1% chance flood are located within Downtown Coos Bay.

Figure 13 Nationally Registered Heritage Sites and SLR Exposure - Coos Bay Downtown



Source: Map developed by IPRE, data provided by Oregon Historic Site Database

Table 19 Coos Bay Nationally Registered Heritage Sites exposed to Sea Level Rise and 1% Chance Flood

Eligible Sites	Coos Bay		SLR 2050 + 1%		SLR 2100 + 1%	
Eligible Significant	28	16%	11	39%	14	50%
Eligible Contributing	75	44%	35	47%	45	60%
Not Eligible / Not Contributing	46	27%	29	63%	32	70%
Not Eligible / Out of Period	17	10%	13	76%	17	100%
Undetermined	4	2%	0	0%	0	0%
Total*	170	100%	88	52%	108	64%

Source: Oregon Historic Site Database

Of the nationally registered sites in North Bend two are exposed to the 2050 SLR + 1% chance flood scenario and an additional two (total of four) are exposed to the 2100 SLR + 1% chance flood scenario. The two sites identified as ES in North Bend are the McCullough Bridge and the Railroad Bridge (the impact of sea level rise has not been determined for these two bridges).

Table 20 Coos Bay Nationally Registered Heritage Sites exposed to Sea Level Rise and 1% Chance Flood

Eligible Sites	North Bend		SLR 2050 + 1%		SLR 2100 + 1%	
Eligible Significant	11	8%	2	18%	2	18%
Eligible Contributing	38	26%	0	0%	0	0%
Not Eligible / Not Contributing	82	57%	0	0%	2	2%
Not Eligible / Out of Period	10	7%	0	0%	0	0%
Undetermined	3	2%	0	0%	0	0%
Total	144	100%	2	1%	4	3%

Source: Oregon Historic Site Database

Existing Management Plans and Goals

The Oregon Statewide Land Use Planning goals include Goal 5: Natural Resources, Scenic and Historic Areas, and Open Spaces. This goal requires local governments to create inventories of these resources. Coos Bay's Goal 5 Inventory is included in the Coos Bay Estuary Management Plan. However, stakeholder, especially representatives of the tribal nations, expressed in the adaptation workshops that Coos Bay's Goal 5 Inventory is outdated and needs to be updated to protect cultural resources.

Sensitivity

The research team has identified many cultural and historic assets that fall within risk areas in Coos Bay. These assets were identified both through the National Register of Historic Sites and through conversations with local stakeholders. Table 21 shows additional detail for named assets from the National Register of Historic Sites that are exposed to the 2050 and 2100 sea level rise + 1% chance flood scenarios.

Cultural assets that are located along the waterfront are extremely sensitive to flooding and sea level rise, and those that are further away are less susceptible, but in the longer term many of those will also flood. There is a large amount of variability in how vulnerable different cultural assets within the community are to flooding. Stakeholders said that some could potentially function at normal levels in the short term during a flood scenario. However, facilities would quickly become unstable without power and water. However, in the long term, flooding would cause expensive damage to buildings, loss of irreplaceable artifacts, reduced research, and reduced public education.

There are other sites within the Study Area that are not nationally registered that are also significant. Additional significant sites include: the North Bend Airport, all schools in the Study Area, Charleston Marina, the Coos History Museum, Coos Art Museum, Coos Bay and North Bend Boardwalks, Coos Bay City Hall/Police Department, Coos Bay Library, North Bend Library, North Bend City Hall/Policy Department, the Printing Museum, and tribal nations heritage sites.

Table 21 Cultural and Historical Assets Inventory

Resource ID	Property Name	City	SLR 2050 + 1% Chance Flood	SLR 2100 + 1% Chance Flood
665729	Art Connection	Coos Bay	Yes	Yes
34475	Camp Castaway Landmark	Coos Bay	Yes	Yes
34440	Chandler Hotel & Annex	Coos Bay	Yes	Yes
665748	City Subs	Coos Bay	Yes	Yes
34441	Coke, J S, Building	Coos Bay	Yes	Yes
665694	Coos Bay Boardwalk	Coos Bay	Yes	Yes
34466	Coos Bay Bridge	North Bend	Yes	Yes
665728	Coos Bay City Hall	Coos Bay	Yes	Yes
649953	Coos Bay Iron Works	Coos Bay	Yes	Yes
34443	Coos Bay National Bank Building	Coos Bay	Yes	Yes
665711	Coos Bay Public Library	Coos Bay	Yes	Yes
654270	Coos Bay Railroad Swing-Span Bridg	North Bend	Yes	Yes
665705	Coos Bay Visitor Center	Coos Bay	Yes	Yes
665709	Dairy Queen	Coos Bay	Yes	Yes
34555	Egyptian Theatre	Coos Bay	Yes	Yes
665749	Firefighters Memorial	Coos Bay	Yes	Yes
665744	First American Title	Coos Bay	Yes	Yes
665739	Hall Building	Coos Bay	Yes	Yes
34530	Horsfall, Dr William, House	Coos Bay	Yes	Yes
34448	Hub Department Store Building	Coos Bay	Yes	Yes
665703	IOOF Building	Coos Bay	Yes	Yes
649951	Junk Storage Building	Coos Bay	Yes	Yes
665696	Koos #2	Coos Bay	Yes	Yes
34449	Koski Building	Coos Bay		Yes
665726	Law Offices	Coos Bay		Yes
649943	Logger Supplies Warehouse	Coos Bay		Yes
34450	Marshfield City Hall	Coos Bay	Yes	Yes
34468	Marshfield Elks Temple	Coos Bay		Yes
34452	Marshfield Sun Printing Plant	Coos Bay	Yes	Yes
657303	Marshfield's South Fifth Street Histo	Coos Bay		Yes
665742	Masonic Temple	Coos Bay		Yes
34469	Myrtle Arms Apartment Building	Coos Bay	Yes	Yes
665731	NW Mutual Financial Network	Coos Bay	Yes	Yes
665725	Oregon Coast Dermatology	Coos Bay		Yes
34479	Overland Landmark	Coos Bay	Yes	Yes
665674	Palace Building	Coos Bay	Yes	Yes
665724	South Coast Printing	Coos Bay	Yes	Yes
34499	Southern Oregon Company Sawmill	Coos Bay		Yes
665741	The World	Coos Bay	Yes	Yes
651914	US Post Office	Coos Bay	Yes	Yes
665706	Wells Fargo Bank	Coos Bay		Yes

Source: Table developed by IPRE, data provided by Oregon Historic Site Database

Tribal Nations Cultural Resources

Tribal nation heritage sites include key buildings and archaeological sites that should be considered when reviewing development permits. Additional sites of importance include shell middens, traditional foods, and plants (including tulle, sedge, camas), village sites, cemeteries, gathering and ceremonial sites.

Adaptive Capacity

This section focuses on the adaptive capacity of heritage sites to the impacts from sea level rise and flooding. It is limited to the immovable and tangible heritage sites, such as historical buildings and monuments.

Current Condition

A large portion of the nationally registered heritage sites located in Coos Bay are vulnerable to sea level rise and flooding. Other cultural resources, not documented on the national register, are also vulnerable. It is important that the governments within the Study Area update their Goal 5 inventory in order to preserve and protect heritage sites from development and climate change hazards.

Redundancies

Heritage resources typically lack redundancies. The values of tangible heritage sites are embedded in their physical structure and cannot be substituted. As such, when a heritage site is lost so is the connection. However, there is value in the expanding the heritage paradigm from a preservation perspective to one that also embraces the

Management Actions

There are no heritage resources management actions in place to address climate change.

The limited tools and models for heritage resource disaster resilience planning creates hurdles for energizing collaborative efforts between natural hazard mitigation planning and heritage preservation. Limited awareness about the vulnerability of heritage resources to natural and human-caused hazards, insufficient funding, and the limited capacity of local heritage organizations to address hazards can present additional obstacles.

A Disaster Resilience Plan for Heritage Resources (DRHR) is one method that could enhance the Coos Bay community's ability to protect sites vulnerable to climate hazards. The overarching goal of a DRHR is to increase community level knowledge and provide a framework for decision-making about heritage resources in the case of a disaster. For more information on resources that are available visit: https://www.oregon.gov/oprd/OH/Pages/DisasterPrep.aspx.

Chapter 8:
Adaptation Strategies & Actions

This chapter focuses on adaptation strategies that the Coos Bay community can take to reduce vulnerabilities to people, places, infrastructure, buildings, and the natural world. Climate adaptation is the process of preparing for a changing climate and adjusting for the negative and positive consequences of that change. Appropriate adaptation strategies are those that anticipate future conditions and offer solutions to mitigate, transfer, avoid, or accept that risks the future conditions entail. There are typically four strategies to address risks:

- **Mitigate**: taking action to reduce the likelihood of exposure to risk.
- **Transfer**: identifying another group to accept or take action to reduce the risk (e.g., purchasing floodplain insurance to protect against foreseeable losses).
- **Accept**: taking no action and accepting the climate impacts that occur.
- **Avoid:** removing the cause of the risk (e.g., not developing in a flood plain).

In general, the strategies developed in this plan seek to mitigate risk by taking action to lower the consequence of the climate stressors impacting a system. Other actions seek to avoid the risk altogether. There are some risks that cannot be avoided or mitigated that the community will accept and monitor, reassessing options in the future.

Those who participated in the adaptation planning process developed ten main strategies and 61 specific actions as shown in Table 23.

Prioritization

Action prioritization was determined through analysis of stakeholder conversations during adaptation strategy workshops in June 2022. High priority strategies/actions are those that will garner the most attention and resources in the immediate term following the completion of the adaptation plan. Although the prioritization provides a guide for implementation, the Coos Bay community has the option to implement any of the action items at any time. This option to consider all action items for implementation allows the Coos Bay community to consider new strategies as new opportunities arise, such as capitalizing on funding sources that could pertain to an action item that is not currently listed as the highest priority.

Action prioritization also considered ease, impact, and cost in the determination of priority.

Ease

- Low = Difficult to accomplish with existing resources/capabilities
- Medium = Moderately easy to accomplish with existing resources/capabilities
- High = Relatively easy to accomplish with existing resources/capabilities

Impact

- Low = will have little impact on decreasing vulnerability/increasing resilience
- Medium = will have moderate impact on decreasing vulnerability/increasing resilience
- High = will have large impact on decreasing vulnerability/increasing resilience

Cost

- Low = $100K or less
- Medium= $100k to $1 million
- High=$1 million or more

Based on these three factors, we then assigned each action a priority:

Priority

- Low = generally ease (lower), impact (lower), cost is a factor
- Medium = generally ease (low, medium), impact (low, medium), cost is a factor
- High = generally ease (high, medium), impact (high, medium), cost is a factor

Actions

Action items are organized by one of ten main strategies and each action item includes a brief description intended to provide direction for future activity. Actions are fact-based and tied directly to issues or needs identified throughout the vulnerability assessment. Each action has an associated lead and partners. This helps to identify who should oversee moving an action forward and who might be available to provide support. Each action additional includes a designation of whether it incorporates a "Nature Based Solution." Together, these details are designed to help the region move forward with adaptation measures.

Lead(s)

The lead agencies or departments are the entities with the responsibility to address the identified action, organize resources, find appropriate funding, and oversee implementation, monitoring, and evaluation.

Partners

The partner entities listed in the action item are potential partners recommended by the stakeholders through the planning process but not necessarily contacted during the development of the plan. The coordinating entity should contact the identified partner entities to see if they are capable of and interested in participation. This initial contact is also to gain a commitment of time and/or resources toward completion of the action item.

Nature Based Solutions

Nature-based solutions are sustainable planning, design, environmental management, and engineering practices that weave natural features or processes into the built environment to promote adaptation and resilience. The IPRE team evaluated each action item to determine if it had the potential for a nature-based solution. Actions that have a nature-based solution identified will be evaluated at time of implementation for readiness and fit for such a solution. See section below for implementation of nature-based solutions.

Implementation and Maintenance

Moving the Coos Bay community towards climate hazard adaptation will require leadership, structure, and community support. While the County and cities of Coos Bay and North Bend, as well as the Partnership for Coastal Watersheds (PCW) can take the lead on many actions, particularly those involving policy, funding allocation, and public infrastructure development, many other groups and individuals will have to step up to help with privately driven improvements and marketing/outreach. It will be critical to provide a clear path for community members and local and regional organizations to support the adaptation actions. One method to achieve community involvement is to include them in a subgroup to implement actions in the plan.

The PCW convenes monthly and can evaluate and recommend adaptation actions for upcoming funding opportunities (see Appendix A for some potential funding options). Local governments, the PCW, and other partners should also engage additional stakeholders and other relevant organizations and agencies to implement the identified action items. Although, some organizations have been identified as partners in the action items, they should not be considered the only organizations that should be involved.

The local governments currently address statewide planning goals and legislative requirements through their comprehensive land use plans, capital improvement plans, mandated standards and building codes. To the extent possible, they may incorporate the recommended actions into existing programs and procedures. The county and cities also maintain a FEMA compliant Natural Hazards Mitigation Plan. To the text possible they may incorporate actions from this plan into their mitigation strategy identified in their NHMP.

Maintenance is a critical component of the plan. Proper maintenance of the plan ensures that it will maximize the community's efforts to reduce the risks posed by climate hazards. Local governments, the PCW, and other stakeholders should regularly review adaptation actions to determine funding suitability and incorporate new risk data to identify issues that may not have been identified during the plan creation.

Coordination

The success of this plan is tied to the commitment for coordination. Coos County and the cities of Coos Bay and North Bend are the main implementers and maintainers of this plan. Coordination should occur throughout the implementation and maintenance of this plan with the Confederated Tribes of the Coos, Lower Umpqua, and Siuslaw Indians and the Coquille Indian Tribe. Additionally Federal, State agencies, special districts, non-governmental organizations, and residents should be actively involved in the maintenance and implementation of the plan. The list of actions provided in Table 23 includes lead and partners organizations. The leads and partners should be considered an initial list and should be evaluated and updated regularly.

Integration into Natural Hazards Mitigation Plan and Other Plans

The Coos County Natural Hazards Mitigation Plan (NHMP) includes a range of action items that, when implemented, will reduce loss from hazard events in the Study Area. Many of the recommendations contained in this Climate Hazards Adaptation Plan are consistent with the goals and objectives of the NHMP. Where possible, the NHMP steering committees for the County and Cities of Coos Bay and North Bend should implement the recommended actions contained in the NHMP through existing plans and policies. Action 2.01 specifically references the need to integrate, monitor, and implement applicable actions from this Climate Hazards Adaptation Plan into the Coos County Multi-Jurisdictional Natural Hazards Mitigation Plan (NHMP) and Community Wildfire Protection Plan (CWPP). Including actions in the NHMP and CWPP allows the projects identified to be eligible for FEMA hazard mitigation assistance (NHMP) and the Community Wildfire Defense Grant (CWPP) to reduce disaster losses.

Examples of actions identified in this Climate Hazards Adaptation Plan that the NHMP steering committees may want to integrate into the NHMP include:

Audit and upgrade existing infrastructure
1.01, 1.02, 1.03, 1.04, 1.05, 1.06, 1.07, 1.08, 1.10, 1.11, 1.12, 1.13

Audit and update zoning and comprehensive planning
2.02, 2.03, 2.04, 2.05, 2.07

Floodplain management
4.01, 4.02

Implement green infrastructure
5.01

Restoration
6.01, 6.02, 6.04, 6.06, 6.07, 6.08

Cultural and historical resources inventory
8.04

Economic development
9.01, 9.03

Education
10.03, 10.08, 10.09

Additionally, plans and policies already in existence often have support from residents, businesses, and policy makers. Many land-use, comprehensive and strategic plans get updated regularly and can adapt easily to changing conditions and needs. Implementing the action items contained in this Climate Hazards Adaptation Plan through such plans and policies increases their likelihood of being supported and implemented.

Nature-Based Solutions Implementation

Out of the 61 adaptation actions developed through this process, 15 were identified for potential nature-based solutions alternatives (Table 22). Nature-based solutions include adaptation actions which mimic or enhance natural processes to improve resilience and typically rely on natural ("green") infrastructure components (e.g., reconnected floodplain, native vegetation, set-back levees, etc.), but may also include hard ("gray") infrastructure components such as culverts and tide gates. Nature-based solutions can be effective, low-cost options that provide long-term benefits to human and natural communities.

As a first step towards implementation, the nature-based adaptation actions identified in this process will be further developed as part of the Coos County Estuarine Resilience Action Planning process by the Oregon Coastal Management Program. Participants in the adaptation action planning workshop were presented a brief primer on green infrastructure and asked to identify additional candidate sites, ideas, and projects for further project planning and development. The first set of candidate sites, ideas, and projects, developed through use of a Google Jamboard during the adaptation workshops, is summarized in Table 22.

Table 22 Coos County Estuarine Resilience Action Planning Candidate Projects

Nature-Based Solution	Site(s)	Partner Organizations	Status
Salmon population and habitat restoration		CIT	Planned project
Wasson Creek watershed restoration	Wasson Creek watershed	SNERR	Planned project
Acquisition of two parcels for restoration	Winchester Creek uplands	SNERR	Planned project
Native plant rain garden, bioswales, at SNERR education center	SNERR	SNERR, CWA	Planned project
Develop restoration opportunity/inventory layer		CWA, IAE	Planned project
Refinement of CMECS habitat classification biotic layer for the Coos estuary		CWA, IAE	Planned project
Enhancement of Olympia oysters and oyster habitat along vulnerable estuarine shorelines	Coos Bay estuary	ODFW	Planned project
Conservation, protection, and enhancement of native eelgrass at strategic sites throughout the estuary	Coos Bay estuary	SSNERR, Padilla Bay NERR, OSU	Planned project
Development of a dynamic revetment approach to dissipate wind fetch waves at particularly vulnerable locations along the shore	Coos Bay estuary	PoCB	Project idea
Spawning gravel enhancement on Winchester creek (Coho/lamprey), on Coos County forest lands (heavy sediment loads main issue)	Winchester Creek		Project idea
Marbled murrelet habitat restoration	Coastal forest lands	SNERR	Project idea
Prescribed and cultural burns to manage targeted habitats and fuels; use as training opportunities		SNERR	Project idea
East branch of Echo Creek restoration project	Echo Creek	North Bend	Project idea
Wildfire recovery and resiliency hubs legislation in upcoming OR session that could create resources for Coos County		Coos County	Project idea
Set aside $$ to buy out flood prone areas and turn into green spaces/parks. Allow to flood naturally but use for recreation in non-flood times.		Coos County	Project idea

Source: IPRE and OCMP

Sumner Lane at High Tide Photo courtesy of Oregon King Tides Project

Sumner Lane at King Tide Photo courtesy of Oregon King Tides Project

Table 23 Adaptation Actions

Action #	Action Description	Lead	Partners	Nature Based Solution? (Y)	Ease (L, M, H)	Impact (L, M, H)	Cost ($, $$, $$$)	Priority (L, M, H)
1	**Audit and upgrade existing infrastructure**							
1.01	Conduct a study of the existing stormwater system, including pipes, outfalls, and inlets, to better understand how sea level rise will affect the stormwater system and, if applicable, which mitigation strategies would be best (e.g., backflow prevention, pumping, or large-scale changes, maintenance, and sediment removal, etc.). Consult with the tribes about appropriate locations (or locations to avoid) and to avoid disturbance of sensitive cultural resources.	City and County Public Works	Contractor civil engineer, CIT, CTCLUSI, CTSI		medium	high	$$	high
1.02	Relocate Ivy Street wastewater treatment (in Coos Bay) out of the flood area. Consult with the tribes about appropriate locations (or locations to avoid) and to avoid disturbance of sensitive cultural resources.	City and County Public Works	Contractor civil engineer, CIT, CTCLUSI, CTSI		low	medium	$$$	medium
1.03	Upgrade outdated or failing wastewater infrastructure and perform routine maintenance. Consult with the tribes about appropriate locations (or locations to avoid) and to avoid disturbance of sensitive cultural resources.	City and County Public Works	Contractor civil engineer, CIT, CTCLUSI, CTSI		medium	high	$$$	high
1.04	Connect homes and businesses to the municipal or community wastewater systems where possible.	City and County Public Works	Contractor civil engineer		medium	medium	$$	medium
1.05	Provide education, incentives, and/or funding for households to upgrade their septic systems.	City and County Public Works	OR DEQ, CIT, CTCLUSI, CTSI		high	medium	$$	high
1.06	Conduct a study of existing roads, bridges, and culverts in the region to determine which are most vulnerable to sea level rise flooding. The most vulnerable and most heavily used facilities should be prioritized for upgrades. Consult with the tribes about appropriate locations (or locations to avoid) and to avoid disturbance of sensitive cultural resources.	City and County Public Works	ODOT, CIT, CTCLUSI, CTSI		medium	high	$$	high
1.07	Update capital improvement plans to include considerations for sea level rise. Prioritize areas projected to be within the sea level rise areas for capital improvements such as sewer line replacements.	City and County Public Works	CIT, CTCLUSI, CTSI	Y - rezoning vulnerable areas	medium	medium	$	high
1.08	Create a clear strategy for capital improvements that combines short- and long-term actions for each jurisdiction aimed at reducing climate related impacts to infrastructure. Coordinate with ODOT to determine impacts and connections with their facilities.	City and County Public Works	CIT, CTCLUSI, CTSI	Y - strategy can include variety of green infrastructure options	high	medium	$	high
1.09	Confirm local transportation agencies and design contractors are following AASHTO "Applying Climate Change Information to Hydrologic and Hydraulic Design of Transportation Infrastructure" into transportation design.	City and County Public Works	ODOT, CIT, CTCLUSI, CTSI	Y - identifying opportunities for green infrastructure actions	low	medium	$	medium
1.10	Perform a benefit-cost analysis of protecting vs. moving facilities and infrastructure (community lifelines) from areas vulnerable to sea level rise flooding. Consult with the tribes about appropriate locations (or locations to avoid) and to avoid disturbance of sensitive cultural resources. Utilize the DLCD Sea Level Rise Planning Guide for Coastal Oregon as a resource to assist with the cost-benefit analysis as applicable.	City and County Public Works	City and County Planning, cost estimator, CIT, CTCLUSI, CTSI, DLCD, FEMA		medium	high	$$	high

Action #	Action Description	Lead	Partners	Nature Based Solution? (Y)	Ease (L, M, H)	Impact (L, M, H)	Cost ($, $$, $$$)	Priority (L, M, H)
1.11	Relocate critical facilities and infrastructure (community lifelines), that meet a cost-effective benefit-cost analysis, out of areas vulnerable to sea level rise flooding (e.g., Coos Bay Public Works shops). Consult with the tribes about appropriate locations (or locations to avoid) and to avoid disturbance of sensitive cultural resources.	City and County Public Works	CIT, CTCLUSI, CTSI, city planning commissions		low	high	$$$	high
1.12	Incentivize retrofits of buildings (public and private) in areas vulnerable to flooding (dry and wet flood-proofing).	City and County Public Works	CIT, CTCLUSI, CTSI		medium	high	$$	high
1.13	Assess areas with high potential for nature-based actions such as bioswales, raingardens, culvert daylighting, and tree planting that buffer stormwater.	City and County Public Works	OR DEQ, CIT, CTCLUSI, CTSI		low	high	$	high
2	**Audit and update zoning and comprehensive planning**							
2.01	Integrate, monitor, and implement applicable actions from this Climate Hazards Adaptation Plan into the Coos County Multi-Jurisdictional Natural Hazards Mitigation Plan (NHMP) and Community Wildfire Protection Plan (CWPP). Including actions in the NHMP and CWPP allows the projects identified to be eligible for FEMA hazard mitigation assistance (NHMP) and the Community Wildfire Defense Grant (CWPP) to reduce disaster losses.	Coos County NHMP Steering Committee	City NHMP Steering Committee		low	high	$	high
2.02	Audit the zoning code to ensure it is not encouraging maladaptive development in areas that will flood. Identify potential impacts on physically and demographically vulnerable populations and eliminate barriers so that some populations do not disproportionately bear the brunt of climate change impacts.	City and County Planning	PCW members and others, CIT, CTCLUSI, CTSI	Y - rezoning vulnerable areas	medium	medium	$$	high
2.03	Add requirements to development standards to minimize impervious areas and minimize stormwater runoff on project sites through green infrastructure and infiltration	City and County Planning	PCW members and others, CIT, CTCLUSI, CTSI	Y - green spaces, permeable pavements, bioswales, et al.	high	medium	$	high
2.04	Add requirements to encourage higher density development in less vulnerable areas. Consult with the tribes about appropriate locations (or locations to avoid) and to avoid disturbance of sensitive cultural resources.	City and County Planning	PCW members and others, CIT, CTCLUSI, CTSI		medium	medium	$$	medium
2.05	Create a sea level rise/flooding overlay in the zoning code with specific requirements for how to develop in that area. Consult with the tribes about appropriate locations (or locations to avoid) and to avoid disturbance of sensitive cultural resources.	City and County Planning	PCW members and others, CIT, CTCLUSI, CTSI	Y - encourage/incentivize incorporation of green infrastructure options	medium	medium	$$	high
2.06	Create a position specifically for an adaptation specialist/grant/hazard coordinator at each of the cities and county to upkeep the plan and push implementation forward.	County, City of Coos Bay, City of North Bend	PCW members and others, CIT, CTCLUSI, CTSI		medium	high	$$	high
2.07	Utilize the "Sea Level Rise Planning Guide for Coastal Oregon" as a guide to develop model code to help planning departments implement land use changes to reduce impact from climate change, particularly sea level rise.	DLCD	City and County Planning, CIT, CTCLUSI, CTSI	Y - encourage/incentivize incorporation of green infrastructure options	medium	high	$	high

Action #	Action Description	Lead	Partners	Nature Based Solution? (Y)	Ease (L, M, H)	Impact (L, M, H)	Cost ($, $$, $$$)	Priority (L, M, H)
3	**Public Private Partnerships**							
3.01	Create community benefits agreements with project developers to include conservation and restoration and social/community benefits.	City and County Planning	CIT, CTCLUSI, CTSI, Rogue Climate	Y - conservation & restoration of natural areas	medium	medium	$	medium
4	**Floodplain Management**							
4.01	Create incentives or requirements for building outside the floodplain or with a certain amount of freeboard (e.g., development north of the bay, parking lots by the creek, etc.)	City and County Planning	CIT, CTCLUSI, CTSI		medium	high	$$	high
4.02	Develop an open space acquisition, reuse, and preservation plan that target hazard areas. Consult with the tribes about appropriate locations (or locations to avoid) and to avoid disturbance of sensitive cultural resources.	City and County Planning and Parks & Recreation	local land trusts, CIT, CTCLUSI, CTSI, ODFW	Y - eg acquisitions for restoration of tidal floodplain	low	high	$$$	medium
5	**Implement green infrastructure**							
5.01	Incentivize or require use of green stormwater best management practices in stormwater design.	City and County Public Works Department	Coos County, Coos Bay, North Bend, CIT, CTCLUSI, CTSI	Y - green infrastructure for better stormwater management	medium	high	$	high
5.02	Collaborate with tribal nations on planning for green infrastructure and co-management of the ecosystem to understand how it can align with cultural stewardship of the estuary. Work with CIT, CTCLUSI, and CTSI to identify candidate sites or priority areas for protection.	City and County Parks & Recreation	CIT, CTCLUSI, CTSI, DLCD	Y - green infrastructure options for estuarine resilience	high	medium	$	medium
6	**Restoration**							
6.01	Identify sites where wetland restoration work can be done to reduce flooding. Prioritize focus on historic estuarine floodplain. Consult with the tribes about appropriate locations (or locations to avoid) and to avoid disturbance of sensitive cultural resources.	City and County Planning	watershed organizations, conservation organizations, CIT, CTCLUSI, CTSI, SWCDs, ODFW	Y - acquisitions and restoration of tidal floodplain	medium	high	$$$	high
6.02	Require more trees to be preserved and planted in landscape design to reduce runoff and provide shade.	City and County Planning	watershed organizations, conservation organizations, CIT, CTCLUSI, CTSI, SWCDs, ODFW, DEQ	Y - restoration work, improve natural function	medium	low	$$	low
6.03	Create a stricter process for habitat and wetland mitigation activities and require closer monitoring and evaluation.	City and County Planning, DSL	watershed organizations, conservation organizations, CIT, CTCLUSI, CTSI, ODFW, DEQ		medium	high	$$	high

Action #	Action Description	Lead	Partners	Nature Based Solution? (Y)	Ease (L, M, H)	Impact (L, M, H)	Cost ($, $$, $$$)	Priority (L, M, H)
6.04	Establish a strategy in which landward migration zones can be protected to allow tidal wetlands to move in response to future sea level rise. Management actions associated with this concept include conservation easements, land trades, levee removals, and acquisition, all of which will allow marshes to migrate naturally.	Conservation organizations	ODFW, BLM, CoosWA, USGS, USFWS, CIT, CTCLUSI, CTSI, SSNERR, DEQ, planning departments DSL, DLCD	Y - acquisitions, restoration, reconnecting historic floodplains, et al	low	high	$$	medium
6.05	Develop a statewide strategy to include Sea level rise in mitigation planning/activities.	DSL, DLCD	ODFW, DEQ, Rogue Climate		medium	high	$	medium
6.06	Restore wetland hydrology through removal or upgrades to tide gates, levee setbacks, and culverts.	Conservation organizations	ODFW, BLM, CoosWA, USGS, USFWS, CIT, CTCLUSI, CTSI, SSNERR, DEQ, planning departments DSL, DLCD		low	high	$$$	high
6.07	Work with landowners of "working wetlands" to increase riparian and natural wetland buffers.	Conservation organizations	ODFW, BLM, CoosWA, USFWS, CIT, CTCLUSI, CTSI, SSNERR, NRCS		high	high	$	high
6.08	Restore habitat complexity through large wood placement, native species plantings, non-native species control, and other methods.	Conservation organizations	ODFW, BLM, CoosWA, USFWS, CIT, CTCLUSI, CTSI, SSNERR, NRCS		medium	high	$-$$	high
7	**Natural Resource Management**							
7.01	Develop coordinated ecosystem-based management framework to protect eelgrass that goes beyond existing state and federal wetland protections.	Conservation organizations	BLM, USFWS, CIT, CTCLUSI, CTSI, SSNERR, DSL, ODFW, Rogue Climate	Y - prioritize habitat restoration	medium	medium	$$	medium
7.02	Collaborate with local scientists on long term monitoring of the status and conditions of coastal natural resources.	Conservation organizations	BLM, USFWS, CIT, CTCLUSI, CTSI, SSNERR, ODFW		medium	low	$$	medium
7.03	Collaborate with local scientists on studies of how invasive species affect estuarine health (i.e., green crabs).	Conservation organizations	BLM, USFWS, CIT, CTCLUSI, CTSI, SSNERR, ODFW		medium	low	$	low
7.04	Identify older intact forests for preservation.	Conservation organizations	ODFW, OSU		low	medium	$$-$$$	medium
7.05	Improve forest habitat quality and mitigate wildfires through thinning, prescribed burning, mixed species management, managing for mixed aged stands, and conserving older forests.	Conservation organizations	ODFW		medium	high	$$	medium
7.06	Promote existing climate-smart forestry incentives on public and private forest lands including maintaining slash piles post-harvest to maintain carbon stocks, and deferring harvest to maintain carbon storage.	Conservation organizations, ODA, Ranchers	ODF, ODFW		high	medium	$	high
7.07	Make improvements to grazing management so it is more wetland compatible to assist with recovery of tidal freshwater wetland behind tide gates and within grazed zones.	Conservation organizations, ODA, Ranchers	ODFW, BLM, CoosWA, USFWS, CIT, CTCLUSI, CTSI, SSNERR, NRCS		high	medium	$	high

Action #	Action Description	Lead	Partners	Nature Based Solution? (Y)	Ease (L, M, H)	Impact (L, M, H)	Cost ($, $$, $$$)	Priority (L, M, H)
8	**Cultural and Historical Resources and Inventory**							
8.01	Work with CIT, CTCLUSI, CTSI, State Historic Preservation Office (SHPO), and DLCD to update Goal 5 Inventory per OAR 660-015, OAR 660-016, OAR 660-023, and OAR 660-031. Update the inventory at least every 5 years, or as needed to add newly identified resources.	Coos County, Coos Bay, North Bend	CIT, CTCLUSI, CTSI, SHPO, DLCD		low	high	$	high
8.02	Improve the method for Tribal nations to review and monitor projects/permits to best protect cultural resources while maintaining tribal nations' confidentiality.	City and County Planning	CIT, CTCLUSI, CTSI, SHPO, DLCD, Rogue Climate		medium	high	$	high
8.03	Include information on tribal nations and importance of cultural resources in the story map text. Coordinate with the tribes and utilize the Tribal History/Shared History curriculum.	PCW	County, Cities, CTCLUSI, CIT, CTSI, UO-IPRE, Rogue Climate		high	medium	$	medium
8.04	Develop a Disaster Resilience Plan for Heritage Resources (DRHR) to protect sites vulnerable to climate hazards. The overarching goal of a DRHR is to increase community level knowledge and provide a framework for decision-making about heritage resources in the case of a disaster.	Coos County, Coos Bay, North Bend	Museums and cultural organizations, CTCLUSI, CIT, CTSI, UO		high	medium	$	high
9	**Economic Development**							
9.01	Coordinate with the chamber of commerce and small business groups to provide trainings to local businesses about sea level rise and concrete actions they can take to protect their businesses.	Coos County, Coos Bay, North Bend	Chamber of commerce, CIT, CTCLUSI, CTSI, SSNERR, DLCD, Rogue Climate		high	medium	$	high
9.02	Offer support, training, and resources to encourage and help businesses develop Continuity of Operations plans that will help them through a major natural or human-caused disruption.	CCD Business Development	Southwestern CC SBDC, Main Street programs/ downtown associations/ Chambers of commerce, South Coast Development Council, Inc., Rogue Climate		medium	medium	$$	medium
9.03	Develop, grow, and maintain a fund to support businesses in the event of a major natural or human-caused disruption.	CCD Business Development	City and County Economic Development, Southwestern CC, Business Oregon, Rogue Climate, Port		low	medium	$$$	low
9.04	Support home-grown businesses that contribute to the green and blue economy.	South Coast Development Council, Inc.	CCD Business Development, Southwestern CC SBDC, Main Street programs/ downtown associations/ Chambers of commerce, Rogue Climate, Port		medium	medium	$	medium
9.05	Support the transition from natural resource extraction-based jobs to jobs based in renewal resources and sustainable practices.	CCD Business Development	South Coast Development Council, Inc., Rogue Climate		medium	high	$$	high
9.06	Develop a tourism resilience strategy that capitalizes on the region's natural assets, expands visitation in the off-seasons, and redirects visitors towards education about and conscientious use of fragile natural resources.	Oregon Coast Visitors Association	Chambers of commerce and Destination Marketing Organizations, Travel Oregon, Rogue Climate		medium	low	$	low

Action #	Action Description	Lead	Partners	Nature Based Solution? (Y)	Ease (L, M, H)	Impact (L, M, H)	Cost ($, $$, $$$)	Priority (L, M, H)
10	**Education**							
10.01	Partner with community college to create courses relating to climate change adaptation or certificate program in related industries.	Coos County, Coos Bay, North Bend	Community College, CIT, CTCLUSI, CTSI, Rogue Climate		high	medium	$$	low
10.02	Utilize social media at a local government level to educate the community about climate change impacts upon the people, place, and economy.	Coos County, Coos Bay, North Bend	CIT, CTCLUSI, CTSI, Rogue Climate		high	low	$	medium
10.03	Make coastal hazard (climate and other natural hazards) risk assessment maps available to the public to better understand how climate change will affect their community (e.g., include in a story map or web viewer).	Coos County, Coos Bay, North Bend	CIT, CTCLUSI, CTSI, DLCD, DOGAMI, Rogue Climate		high	medium	$	high
10.04	Identify non-profits and other organizations with climate change education programs and explore options for funding for them to expand their reach or programming.	Coos County, Coos Bay, North Bend	local non-profits, CIT, CTCLUSI, CTSI, OSU, Rogue Climate		high	medium	$	medium
10.05	Maintain a story map with up-to-date information and make it accessible to the public.	Coos County, Coos Bay, North Bend	PCW members and others, CIT, CTCLUSI, CTSI, Rogue Climate		high	medium	$	medium
10.06	Design trainings for local governments to understand cultural resources and tribal nation sovereignty.	Coos County, Coos Bay, North Bend	CIT, CTCLUSI, CTSI, Rogue Climate		high	medium	$	medium
10.07	Incorporate natural resource issues into K-12 curricula and emphasize hands on field trips and volunteer activities. Coordinate with the tribes and utilize the Tribal History/Shared History curriculum.	OSU, SSNERR, schools	CIT, CTCLUSI, CTSI, Rogue Climate		high	medium	$	high
10.08	Hold listening sessions and focus groups with members of the community with a focus on those that are most vulnerable. Use multiple languages and formats to for accessibility.	Coos County, Coos Bay, North Bend	PCW members and others, CIT, CTCLUSI, CTSI, Rogue Climate		medium	high	$	high
10.09	Promote the benefits of natural lands, including tidal and freshwater wetlands, and the ecosystem services that they provide.	OSU, SSNERR, schools	PCW members and others, CIT, CTCLUSI, CTSI, Rogue Climate		high	medium	$	high
10.10	Promote resources for land managers including publication, Oregon State Extension programs, and national efforts (e.g., Adaptive Silviculture for Climate Change) to bridge science and practice.	OSU, SSNERR	ODF, Rogue Climate		high	medium	$	medium
10.11	Promote “citizen science” to engage community and increase data collection and knowledge of species, habitats, and hazard events through applications such as inaturalist, ebird, King Tides Project, etc.	OSU, SSNERR	PCW members and others, CIT, CTCLUSI, CTSI, Rogue Climate		high	medium	$	medium

Appendix A:
Grant Programs and Resources

There are numerous local, state, and federal funding sources available to support climate change adaptation projects and planning. The following section includes an abbreviated list of the most common funding sources utilized by local jurisdictions in Oregon. Because grant programs often change, it is important to periodically review available funding sources for current guidelines and program descriptions.

Additional funding opportunities are maintained by the University of Oregon's Pacific Northwest Tribal Climate Change Project: https://tribalclimateguide.uoregon.edu/

Post-Disaster Federal Programs

Hazard Mitigation Grant Program

The Hazard Mitigation Grant Program (HMGP) provides grants to states and local governments to implement long-term hazard mitigation measures after a major disaster declaration. The purpose of the HMGP is to reduce the loss of life and property due to natural disasters and to enable mitigation measures to be implemented during the immediate recovery from a disaster. The HMGP is authorized under Section 404 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act. The HMGP involves a paper application which is first offered to the counties with declared disasters within the past year, then becomes available statewide if funding is still available.

http://www.fema.gov/hazard-mitigation-grant-program

Physical Disaster Loan Program

When physical disaster loans are made to homeowners and businesses following disaster declarations by the U.S. Small Business Administration (SBA), up to 20% of the loan amount can go towards specific measures taken to protect against recurring damage in similar future disasters.
http://www.sba.gov/category/navigation-structure/loans-grants/small-business-loans/disaster-loans

Non-Disaster Federal Programs

Building Resilient Infrastructure and Communities Grant Program

The Building Resilient Infrastructure and Communities (BRIC) program provides funds to states, territories, Indian tribal governments, communities, and universities for hazard mitigation planning and the implementation of mitigation projects prior to a disaster event. Funding these plans and projects reduces overall risks to the population and structures, while also reducing reliance on funding from actual disaster declarations. BRIC grants are to be awarded on a competitive basis and without reference to state allocations, quotas, or other formula-based allocation of funds. The BRIC grant program is offered

annually; applications are submitted online. Applicants need a user profile approved by the State Hazard Mitigation Officer, which should be garnered well before the application period opens.
https://www.fema.gov/grants/mitigation/building-resilient-infrastructure-communities

Flood Mitigation Assistance Program

The overall goal of the Flood Mitigation Assistance (FMA) Program is to fund cost-effective measures that reduce or eliminate the long-term risk of flood damage to buildings, manufactured homes, and other National Flood Insurance Program (NFIP) insurable structures. This specifically includes:

- Reducing the number of repetitively or substantially damaged structures and the associated flood insurance claims;
- Encouraging long-term, comprehensive hazard mitigation planning;
- Responding to the needs of communities participating in the NFIP to expand their mitigation activities beyond floodplain development activities; and
- Complementing other federal and state mitigation programs with similar, long-term mitigation goals.

http://www.fema.gov/flood-mitigation-assistance-program

Eligibility for FEMA Hazard Mitigation Assistance

Currently Coos County and the cities of Coos Bay and North Bend are eligible to apply for FEMA Hazard Mitigation Assistance grant programs. Detailed program and application information for federal post-disaster and non-disaster programs can be found in the Hazard Mitigation Assistance Unified Guidance, available at: https://www.fema.gov/media-library/assets/documents/103279. Note that guidance regularly changes. Verify that you have the most recent edition. Flood mitigation assistance is usually offered annually; applications are submitted online. Applicants need a user profile approved by the State Hazard Mitigation Officer, which should be garnered well before the application period opens.

For Oregon Department of Emergency Management (OEM) grant guidance on Federal Hazard Mitigation Assistance, visit: https://www.oregon.gov/OEM/emresources/Grants/Pages/HMA.aspx

Contact: shmo@mil.state.or.us

Economic Development Administration (American Rescue Plan)

On March 11, 2021, President Joseph R. Biden signed the American Rescue Plan into law. This historic legislation was designed to enable all Americans to respond to and recover from the impacts of COVID-19. Under the American Rescue Plan, EDA was allocated $3 billion in supplemental funding to assist communities nationwide in their efforts to build back better by accelerating the economic recovery from the coronavirus pandemic and building local economies that will be resilient to future economic shocks. American Rescue Plan funding enables EDA to provide larger, more transformational investments across the nation while utilizing its greatest strengths, including flexible funding to support community-led economic development.

With an emphasis on equity, EDA investments made under the American Rescue Plan will directly benefit previously underserved communities impacted by COVID-19. EDA is making this funding available through a series of six innovative challenges: Building Back Better Regional Challenge, Good Jobs Challenge, Economic Adjustment Assistance, Indigenous Communities, Travel, Tourism, and Outdoor Recreation, and Statewide Planning, Research and Networks. For more information visit: https://eda.gov/arpa/

US Department of Housing and Urban Development: Community Compass Technical Assistance and Capacity Building Program

Community Compass helps HUD's customers navigate complex housing and community development challenges by equipping them with the knowledge, skills, tools, capacity, and systems to implement HUD programs and policies successfully. The goal of Community Compass is to empower communities so that successful program implementation is sustained over the long term.
https://www.hud.gov/program_offices/comm_planning/cpdta

National Science Foundation: Environmental Sustainability

Supports engineering research that balances ecological protection and stable economic conditions through five general research areas: industrial ecology, green engineering, ecological engineering, Earth systems engineering, and circular bioeconomy engineering.
https://beta.nsf.gov/funding/opportunities/environmental-sustainability-1

US Department of Agriculture: Rural Decentralized Water Systems Grant

This program helps qualified nonprofits and tribes create a revolving loan fund to increase access to clean, reliable water and septic systems for households in eligible rural areas.
https://www.rd.usda.gov/programs-services/water-environmental-programs/rural-decentralized-water-systems-grant-program

NOAA: Coastal Zone Management (CZM) Habitat Protection and Restoration Infrastructure Investment and Jobs Act

Any coastal State or Territorial CZM Program that has been approved by NOAA pursuant to the Coastal Zone Management Act (16 U.S.C. § 1455) is eligible for habitat restoration and conservation funds. This grant is for coastal habitat restoration; coastal habitat restoration planning, engineering, and design; and land conservation projects that support the goals and intent of the Coastal Zone Management Act (CZMA), the Coastal and Estuarine Land Conservation Program (CELCP).
https://www.grants.gov/web/grants/view-opportunity.html?oppId=341538

NOAA Office of Coastal Management/USFW: National Coastal Resilience Fund

The National Coastal Resilience Fund restores, increases, and strengthens natural infrastructure to protect coastal communities while also enhancing habitats for fish and wildlife. Established in 2018, the National Coastal Resilience Fund invests in conservation projects that restore or expand natural features such as coastal marshes and wetlands, dune and beach systems, oyster and coral reefs, forests, coastal rivers and floodplains, and barrier islands that minimize the impacts of storms and other naturally occurring events on nearby communities. This approach is at the heart of this competitive grants program, a partnership between NOAA, the National Fish and Wildlife Foundation, and other governmental and private sector partners. Funded projects cover the spectrum of nature-based infrastructure efforts, and include project planning, design, and implementation. Background information about the program can be found on the National Fish and Wildlife Foundation's website: https://www.nfwf.org/programs/national-coastal-resilience-fund Other funding opportunities: https://coast.noaa.gov/funding/

State Programs

Infrastructure Finance Authority

The Infrastructure Finance Authority (IFA) provides funds for publicly owned facilities that support economic and community development in Oregon. Funds are available to public entities for: planning, designing, purchasing, improving, and constructing publicly owned facilities, replacing publicly owned essential community facilities, and emergency projects because of a disaster. Public agencies that are eligible to apply include: cities, counties, county service districts, (organized under ORS Chapter 451), tribal councils, ports, districts as defined in ORS 198.010, and airport districts (ORS 838). Facilities and infrastructure projects that are eligible for funding are: airport facilities, buildings and associated equipment, levee accreditation, certification, and repair, restoration of environmental conditions on publicly-owned industrial lands, port facilities, wharves, and docks, the purchase of land, rights of way and easements necessary for a public facility, telecommunications facilities, railroads, roadways and bridges, solid waste disposal sites, storm drainage systems, wastewater systems, and water systems. https://www.oregon.gov/biz/programs/homeareas/infrastructure/Pages/default.aspx

Community Development Block Grant Program

The Community Development Block Grant Program promotes viable communities by providing: 1) decent housing; 2) quality living environments; and 3) economic opportunities, especially for low- and moderate-income persons. Eligible activities most relevant to natural hazards mitigation include: acquisition of property for public purposes; construction/reconstruction of public infrastructure; community planning activities. Under special circumstances, CDBG funds also can be used to meet urgent community development needs arising in the last 18 months which pose immediate threats to health and welfare. http://portal.hud.gov/hudportal/HUD?src=/program_offices/comm_planning/communitydevelopment/programs

Business Oregon Regional Development: Sustainable Infrastructure Planning Project

Focus is on feasibility studies, asset management plans for water system Infrastructure need, seismic risk assessment, water system master plans for systems with less than 300 connections. Planning activities that promote sustainable water infrastructure may receive funding up to a maximum of $20,000 per project. Priority is given to systems that serve fewer than 300 service connections. https://www.oregon.gov/oha/PH/HEALTHYENVIRONMENTS/DRINKINGWATER/SRF/Pages/index.aspx

Oregon Watershed Enhancement Board

While OWEB’s primary responsibilities are implementing projects addressing coastal salmon restoration and improving water quality statewide, these projects can sometimes also benefit efforts to reduce flood and landslide hazards. In addition, OWEB conducts watershed workshops for landowners, watershed councils, educators, and others, and conducts a biennial conference highlighting watershed efforts statewide. Funding for OWEB programs comes from the general fund, state lottery, timber tax revenues, license plate revenues, angling license fees, and other sources. OWEB awards approximately $20 million in funding annually. More information at: https://www.oregon.gov/OWEB/grants/Pages/grant-programs.aspx

Department of Land Conservation and Development: Technical Assistance Grants

DLCD provides resources to help Oregon communities prepare and update local land use plans and implementing ordinances to respond to growth management and resource protection issues and changes in state agency programs and requirements. Technical Assistance grants are typically used to complete needed planning requirements that are not on periodic review work programs, or to satisfy local planning needs. Promote economic development, plan for resilience to natural hazards and climate change, provide infrastructure financing, and update comprehensive plans, and implementing codes to respond to changes in state law or advance regulatory streamlining.
https://www.oregon.gov/lcd/CPU/Pages/Community-Grants.aspx

Other Federal Mitigation Programs, Activities & Initiatives

Project Support

Coastal Zone Management Program, NOAA

Provides grants for planning and implementation of non-structural coastal flood and hurricane hazard mitigation projects and coastal wetlands restoration. http://coastalmanagement.noaa.gov /

Community Development Block Grant Entitlement Communities Program, US Department of Housing and Urban Development

Provides grants to entitled cities and urban counties to develop viable communities (e.g., decent housing, a suitable living environment, expanded economic opportunities), principally for low- and moderate-income persons.
http://portal.hud.gov/hudportal/HUD?src=/program_offices/comm_planning/communitydevelopment/programs/entitlement

Community Development Block Grant: Climate Resilience and Disaster Recovery

HUD seeks to improve long-term community resilience for disaster-stricken communities via itsCommunity Development Block Grants for Disaster Recovery (CDBG-DR). HUD's Consolidated Notice will require CDBG-DR grantees to incorporate disaster mitigation measures into all recovery activities involving construction. By incorporating resilience planning into recovery activities, CDBG-DR grantees can strengthen their community's resilience to future climate impacts. Resilience is defined for CDBG-DR grantees as a "community's ability to minimize damage and recover quickly from extreme events and changing conditions, including natural hazard risks." When implementing recovery efforts, CDBG-DR grantees are required to spend 70% of the funds on activities that benefit low- and moderate-income

persons.
https://www.hud.gov/sites/dfiles/CPD/documents/Climate_Resilience_Disaster_Recovery_at_HUD.pdf

National Fire Plan (DOI – USDA)

The NFP provides technical, financial, and resource guidance and support for wildland fire management across the United States. This plan addresses five key points: firefighting, rehabilitation, hazardous fuels reduction, community assistance, and accountability. http://www.forestsandrangelands.gov/

Community Wildfire Defense Grant

The Community Wildfire Defense Grants are intended to help at-risk local communities and Tribes plan and reduce the risk against wildfire. At-risk communities in an area identified as having high or very high wildfire hazard potential, are low-income, and/or have been impacted by a severe disaster are prioritized.

The Community Wildfire Defense Grant helps communities in the wildland urban interface (WUI) implement the three goals of the National Cohesive Wildland Fire Management Strategy (Cohesive Strategy):

- Restore and Maintain Landscapes: Landscapes across all jurisdictions are resilient to fire-related disturbances, in accordance with management objectives.
- Create Fire Adapted Communities: Human populations and infrastructure can better withstand a wildfire without loss of life and property.
- Improve Wildfire Response: All jurisdictions participate in making and implementing safe, effective, efficient risk-based wildfire management decisions.

To be eligible for project funds the applying community must have a Community Wildfire Protection Plan that is less than 10 years old that describes the project. More information: https://www.fs.usda.gov/managing-land/fire/grants

Emergency Watershed Protection Program, USDA-NRCS

Provides technical and financial assistance for relief from imminent hazards in small watersheds, and to reduce vulnerability of life and property in small watershed areas damaged by severe natural hazard events. http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/landscape/ewpp

Rural Development Assistance – Utilities, USDA

Direct and guaranteed rural economic loans and business enterprise grants to address utility issues and development needs. http://www.rurdev.usda.gov/Utilities_Programs_Grants.html

Rural Development Assistance – Housing, USDA

The RDA program provides grants, loans, and technical assistance in addressing rehabilitation, health, and safety needs in primarily low-income rural areas. Declaration of major disaster necessary. http://www.rurdev.usda.gov/HAD-HCFPGrants.html

Public Assistance Grant Program, FEMA

The objective of FEMA Public Assistance (PA) Grant Program is to aid State, Tribal and local governments, and certain types of Private Nonprofit organizations so that communities can quickly respond to and recover from major disasters or emergencies declared by the President. http://www.fema.gov/public-assistance-local-state-tribal-and-nonprofit

HOME Investments Partnerships Program, HUD

The HOME IPP provides grants to states, local government and consortia for permanent and transitional housing (including support for property acquisition and rehabilitation) for low-income persons. http://www.hud.gov/offices/cpd/affordablehousing/programs/home/

Disaster Recovery Initiative, HUD

The DRI provides grants to fund gaps in available recovery assistance after disasters (including mitigation). http://portal.hud.gov/hudportal/HUD?src=/program_offices/comm_planning/communitydevelopment/programs/dri

Partners for Fish and Wildlife, DOI – FWS

The PFW program provides financial and technical assistance to private landowners interested in pursuing restoration projects affecting wetlands and riparian habitats. http://www.fws.gov/partners/

North American Wetland Conservation Fund, DOI-FWS

NAWC fund provides cost-share grants to stimulate public/private partnerships for the protection, restoration, and management of wetland habitats. http://www.fws.gov/birdhabitat/Grants/index.shtm

Federal Land Transfer / Federal Land to Parks Program, DOI-NPS

Identifies, assesses, and transfers available federal real property for acquisition for State and local parks and recreation, such as open space. http://www.nps.gov/ncrc/programs/flp/index.htm

Wetlands Reserve program, USDA-NCRS

The WR program provides financial and technical assistance to protect and restore wetlands through easements and restoration agreements. http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/easements/wetlands

Secure Rural Schools and Community Self-Determination Act of 2000, US Forest Service

Originally enacted in 2000 to provide five years of transitional assistance to rural counties affected by the decline in revenue from timber harvests on federal lands. Funds have been used for improvements to public schools, roads, and stewardship projects. Money is also available for maintaining infrastructure, improving the health of watersheds and ecosystems, protecting communities, and strengthening local economies. http://www.fs.usda.gov/pts/

US Environmental Protection Agency: Technical Assistance Services for Communities (TASC) Program

TASC primarily assists communities by providing opportunities for environmental education and bringing diverse groups together to increase involvement. Under the TASC contract, a contractor provides scientists and engineers to provide technical assistance on a project-specific basis at no cost to the recipient community. TASC services provide information assistance, needs evaluation, and plan development to help community members collaborative participate in effective environmental decision-making. https://www.epa.gov/superfund/technical-assistance-services-communities-tasc-program#cost

Coos Bay Rail Line at High Tide   Photo courtesy of Oregon King Tides Project

Coos Bay Rail Line at King Tide   Photo courtesy of Oregon King Tides Project

Appendix B: References

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Port of Coos Bay Shoreline Access Point

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