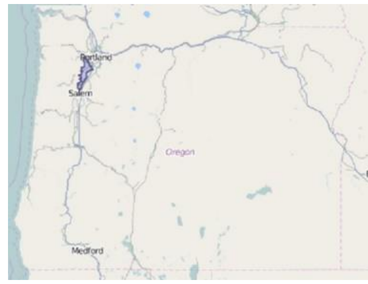
Climate Change in the Oregon 13th Senate District



May 2023

History, Projections, and Consequences

1. The temperature has risen some 1ºF during the last half of the 20th Century and may rise 8ºF by the end of the 21st Century.
2. While precipitation has been steady and is likely to remain so annually, wetter winters and drier summers.
3. The trend of declining snowfall will continue through the century, possible dropping to 10% of historic levels by 2100.
4. These precipitation projections, combined with the trend towards increasing heavy rainfall and reducing light rainfall will likely increase flooding and compromise irrigation availability in those months when it is most needed.
5. Several important forest species both commercially and in terms of forest composition will likely be compromised as climate change overtakes the District.
6. The western wildfire season is already 105 days longer than in the 1970s, while reduced snowpack, warmer summers and earlier snowmelt will increase wildfire risk, with 200 – 300% of the area burned by mid-century.
7. Agricultural activities such as wine growing that depend on temperature and water are likely to be threatened through the century.
8. As sea levels rise, increased urban storm damage and destruction will be probable in addition to the loss of beaches and coastal wetlands.
9. Those engaged in agriculture, forestry or fisheries will be most affected by the forthcoming climate trends, will need most to adapt, and probably should be most supportive of mitigation efforts
10. The main climate impacts to health are likely to be: storms, floods, and sea level rise. The main health concerns will be: disruption in core services, injuries, displacement, landslides, income loss, economic instability, and mental health impacts. Vulnerable communities will be: low-income households, older adults, people living on steep slopes, farmers of fish and shellfish, first responders, and children and pregnant women.
11. To achieve required emissions reduction goals, we need to reduce emissions 45% below 2010 levels by 2030; this requires immediate action!

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Southern Oregon Climate Action Now

SOCAN

Confronting Climate Change

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February, 2023

Global and Regional Temperature:

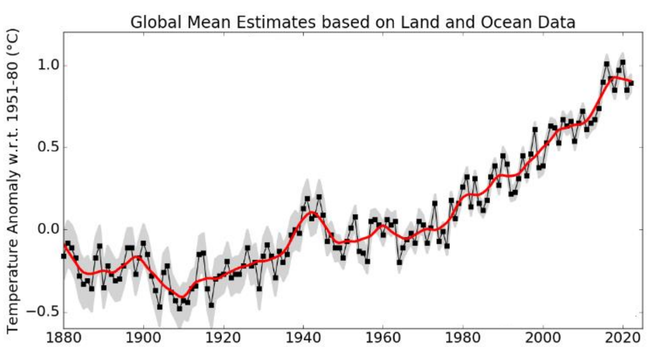

Figure 1. *Historic global temperature trend (NASA 2023).*

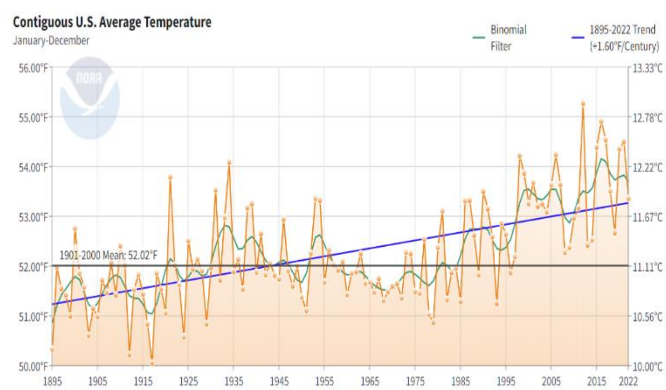

Figure 2. *Historic U.S temperature trend. (NOAA 2023).*

Data from NASA and NOAA reveal that the Global and U.S. atmospheric temperatures have increased substantially since 1880 (Figures 1 and 2) with the greatest effect occurring in the last five decades.

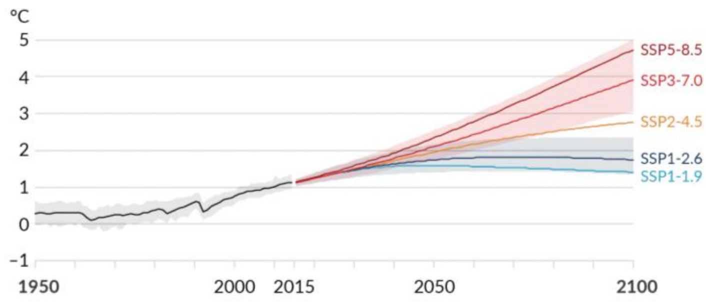

Figure 3. *Global temperature projections to 2100 relative to the 1850-1900 average. (IPCC 2021).*

Global temperature projections to 2100 provided by the Intergovernmental Panel on Climate Change (IPCC 2021) Assessment Report 6 (Figure 3) were based on Shared Socioeconomic Pathways (SSPs). Discussed by Hausfather (2018), these pathways represent an advance over the Representative Concentration Pathways (RCPs) previously employed by the IPCC in that they include characterization of the human behavior that leads to specific projected atmospheric greenhouse gas concentrations. The SSP5-8.5 pathway incorporates a: "push for economic and social development … coupled with the exploitation of abundant fossil fuel resources and the adoption of resource and energy intensive lifestyles around the world." Effectively this seems to echo the RCP8.5 projections employed in the previous IPCC report and is the trajectory we are currently following globally. This scenario would likely result in global temperatures in the range of 3 to 5.1°C (5.4 to 9.18°F) above pre-industrial revolution temperatures by 2100 (Figure 3).

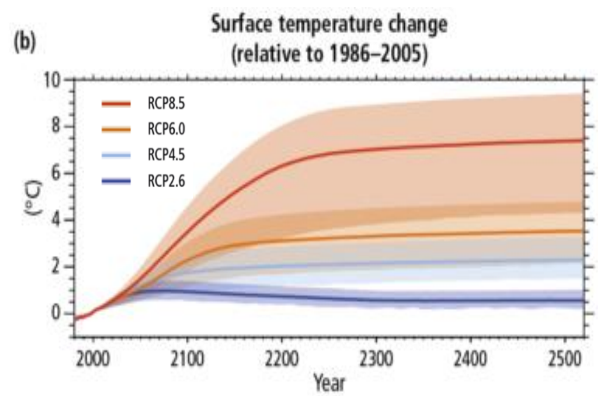

Figure 4. *Long term global temperature trends according to RCP values. (Jones 2017).*

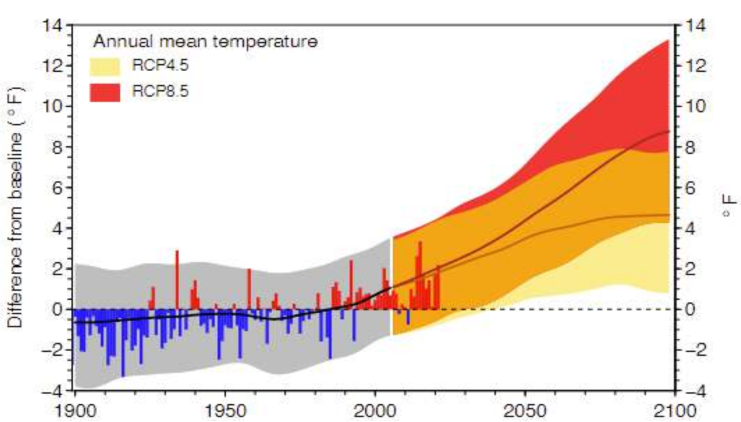

Figure 5. *Oregon temperature history and projections through the century; baseline: 1970 – 1999 (Fleishman 2023).*

Meanwhile, projections further into the future have been provided by the Intergovernmental Panel on Climate Change (IPCC) in terms of RCP scenarios (Figure 4) The RCP 2.6 scenario assumes we rapidly eliminate emissions, whereas RCP 8.5 assumes we follow the current trajectory of accelerating emissions. RCP 6.0 and 4.5 assume intermediate trajectories of emissions between the extremes. Note that only the RCP2.6 scenario results in a long-term global temperature increase below 2°C above pre-industrial conditions -

the upper target for the 2015 Paris Agreement. Because the actual temperature trajectory we have experienced follows the RCP 8.5 scenario this has been dubbed the Business-As-Usual (BAU) scenario; we have yet to undertake sufficient actions globally to slow this trend.

Meanwhile, temperature projections for this century in Oregon (Fleishman 2023, Figure 5) suggest a similar range of temperature increases possibly reaching over 13^{0}F above the 1970-1999 average by the end of the century under the BAU scenario (RCP 8.5).

Whether we consider the global or Oregon future, the higher range of temperature increase would be unmanageable. It would devastate natural systems (see below:) and simultaneously threaten our climate dependent agricultural, ranching, and forestry activities. Bark beetle and other pest destruction of forests would likely increase as warmer temperatures enhance insect growth and development rates and enable larger overwintering populations. Similarly, invasion of natural and agricultural systems by drought tolerant invasive species and pests will likely be enhanced.

Regional Precipitation:

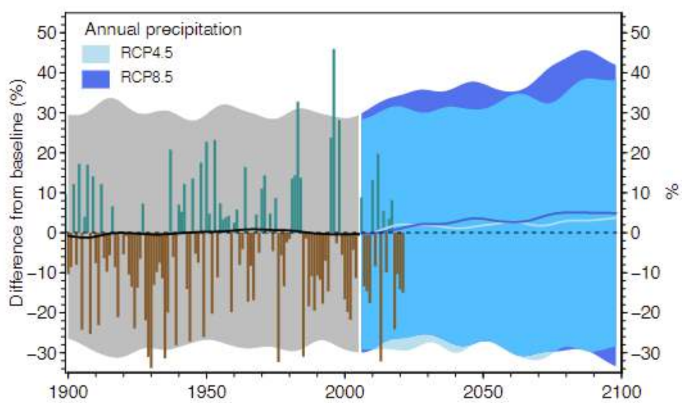

Figure 6. *History and projections for precipitation statewide. (Fleishman 2023).*

Annual precipitation is expected to increase very slightly (if at all) in Oregon through the balance of this century (Figure 6). However, the 2018 US Climate Change Assessment Report (Easterling *et al.* 2017) provides projections for seasonal late century precipitation patterns (Figure 7) according to the 'business as usual' RCP 8.5 scenario.

The region generally is expected to exhibit fall and spring seasons that are little different from historical patterns, with winters possibly a little wetter. Notably, however, accentuating the Mediterranean 'winter wet - summer dry' climate, winters will be wetter, and summers will likely be drier.

This Mediterranean climate exists in just 6 locations across the globe (IUCN undated) and leads to soils and vegetation drying out during summers such that vegetation tends to be fire prone, fire adapted and fire dependent (Safford *et al.* 2021).

Evaporation caused by increasing temperature will likely counter any increase in precipitation such that drought conditions continue. Water resources, already severely compromised in many locations, will become more threatened as snowpack continues to decline. Meanwhile, the current trend of precipitation occurring more frequently as severe storms rather than the light drizzle that replenishes soil moisture will continue. This will likely increase the risk of floods, soil erosion and landslides.

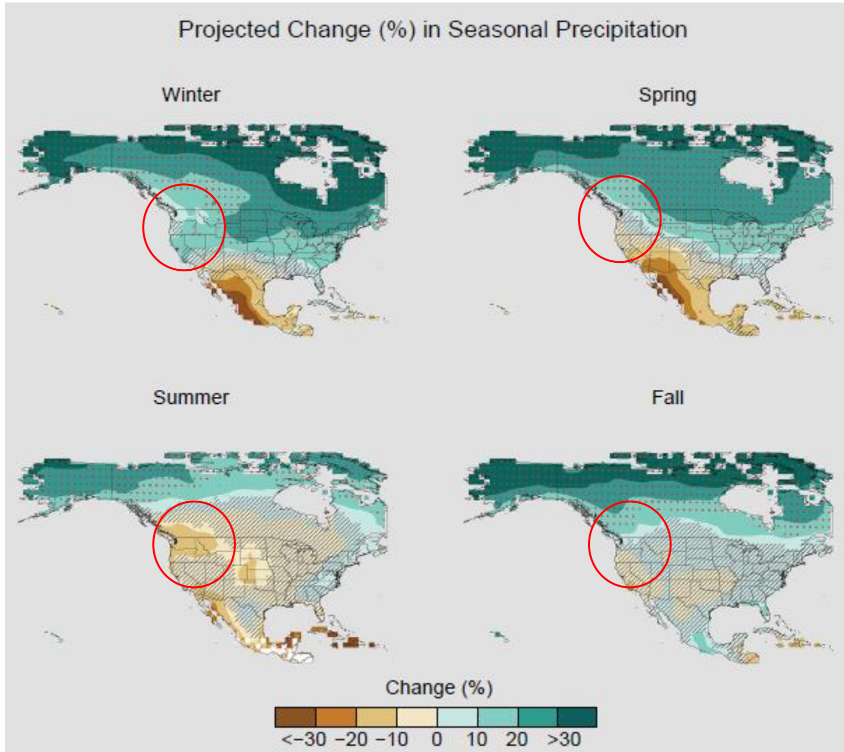

Figure 7. *Projected change in precipitation to 2077-2090 compared to 1960-2005 average; stippled areas indicate large change compared to natural variation; hatched areas small change. (Easterling et al. 2017).*

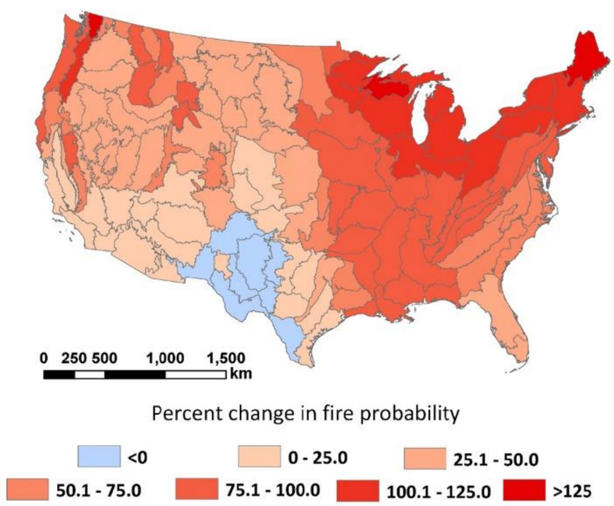

Figure 8. *Potential increase in fire risk from the 1971-2000 baseline across the U.S. assuming the RCP 8.5 scenario. (Gao et al. 2021).*

Stream and river flow occurring during summer/fall will decline and become warmer compromising many iconic Pacific Northwest cold-water aquatic species. Meanwhile, peak river flow will continue to advance earlier in the year, even reaching late fall of the previous year.

Gao *et al.* (2021) depicted the increasing risk of fire across the nation (Figure 8) under the RCP 8.5 scenario indicating that this would likely lead to increased fire probability throughout most of Oregon of at least 50%.

Several years ago, the national climate assessment, (Melillo *et al.* 2014) reported the impact of increasing temperature of just 2.2^{o}F on area burned from wildfire, a condition potentially arriving by mid-century (Figure 9). The range in increase is from 100% meaning a doubling of the area burned to 700% meaning 8-times the current area.

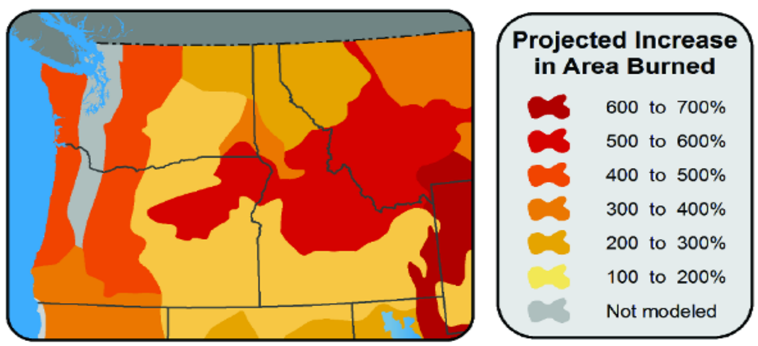

Figure 9. *Anticipated wildfire consequences of a 2.2^{o}F warming in area burned (Mellilo et al. 2014).*

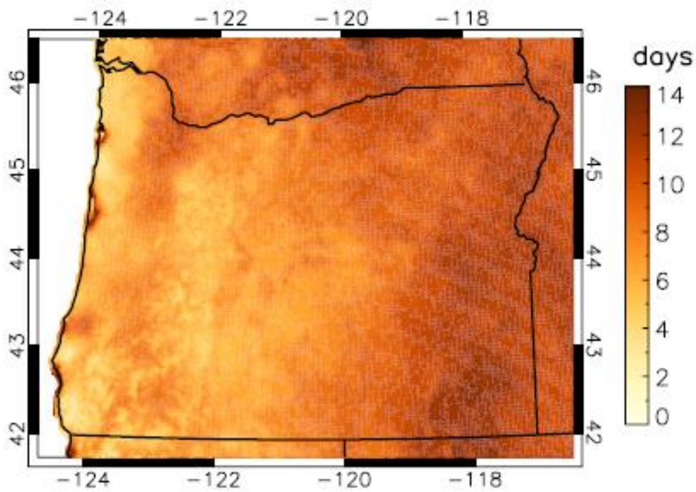

Figure 10. *Increase in number of days experiencing high fire risk by mid- century (2040 - 2069) compared to the end of the last century (1971-2000). (Mote et al. 2019).*

Mote *et al.* (2019) presented a summary of the potential increase in extreme fire risk days by mid-century (2040 - 2069) compared to historical conditions (1971 - 2000) where an increase of up to 14 days in the SE corner of the state is expected (Figure 10).

The fire season, already extended by 105 days since 1970s (Kenward *et al.* 2016), will likely become longer and more severe in Oregon. Even though our natural ecosystems have evolved with fire and are thus fire prone, fire adapted, and fire dependent, future trends may pose a serious threat to ecosystem ongoing health. In addition, of course, both human safety and human health will likely be threatened. It was recognized long ago (Westerling *et al.* 2006) that warming and early spring snowmelt correlate with increasing fire risk.

Natural System Consequences

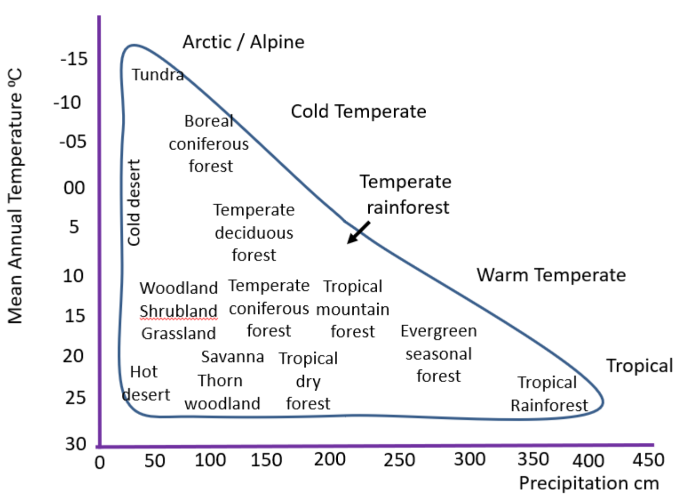

Figure 11. *Global distribution of natural ecological systems (biomes) in relation to mean annual temperature and precipitation patterns. (Modified from Whittaker 1975).*

That the geographic distribution of our natural ecological systems (biomes) is largely determined by the variables of temperature and precipitation (water availability) has been understood for decades. Community ecologist Robert Whittaker (1975) developed a classic chart indicating this relationship (modified in Figure 11). The chart depicts the climatic conditions that allow each of the designated biomes to exist. The critical message is that even a small shift in either of these variables from current conditions may threaten the viability of the biomes and the species of which they are comprised. This will be especially true for biomes currently existing at the edge of the climatic range that they require. It is especially worth comparing these temperature ranges to the potential shifts in Oregon's temperature through the century (Figure

5) from which it is evident that most of our state's precious natural systems will be threatened, and some (especially high-altitude cool climate systems) will likely be eliminated under future conditions. It is worth noting, also, that the same variables control our agricultural productivity, and clearly, our forest viability. Thus, climatic shifts of the dimensions anticipated, absent any adjustment in our collective behavior that thwarts that trajectory, will likely compromise agriculture and forestry throughout the state. Indeed, Dalton *et al.* (2017) indicate not only that "different trees have varying degrees of sensitivity to climate change and adaptive capacity." but also that "suitable climates for many important tree species and vegetation types may change considerably by the end of the 21st century…." Climate envelope projections (Rehfeldt and Crookston 2023), which assess the optimal conditions for tree species on the basis of their current and recent historic range and map these condition into the future, suggest that under the RCP 8.5 scenario, several species will likely suffer range reduction: Douglas fir, Western hemlock, Ponderosa pine, Grand fir, Western larch, Sugar pine, White fir, Pacific madrone, Western juniper, Western redcedar, Tanoak, and California laurel. Meanwhile, by the end of the century, the following species will likely find the Oregon climate completely outside their range (i.e., they will be extirpated from the state): Sitka spruce, Engelmann spruce, Lodgepole pine, Subalpine fir, and Jeffrey pine. Oregonians dependent on commercial timber harvest should be the first to demand climate action in the state.

Coastal Concerns:

Though much of Oregon is land-locked, and will suffer little directly because of ocean consequences, coastal regions and economies will have to contend with warming oceans, sea level rise, and increasing ocean acidification.

Warming Oceans. Although there is considerable seasonal fluctuation in ocean temperature, warming of oceans in the Northwest are already documented with a reported and anticipated increase at the rate of 0.35°C per decade (Alexander *et al.* 2018) off the coast of Oregon over the period 1976 - 2099. Besides influencing species directly, temperature changes impact such events as algal blooms and shellfish poisoning.

Sea Level Rise. Sea levels are rising and will continue to rise for two reasons: First, water expands as it warms from 4°C (approximately 37°F). Thus, as the ocean warms, it inevitably expands, and sea level inevitably rises. Second, as land borne ice enters the ocean, whether as water or ice, it increases the volume of the ocean. Both these phenomena have already caused sea level to rise and are expected to continue this impact. The impact is influenced by the pattern of land adjustment: if land is rising, the impact is reduced, whereas subsiding coastal land will exacerbate the impact. This complication is particularly relevant to the impact of the Cascadia Subduction Zone (CSZ) where a rising or falling land tectonic plate will influence apparent and locally detected sea level rise along the coast. The impact of the oceanic Juan de

Fuca plate sliding under the continental North American plate is a rising continental plate (Lieberman 2012) apparently confounding the ability of a land-based gauge to detect sea level rise. However, should the earthquake occur, there will likely result a drop in the land level of a meter (3 feet) or so. Mote *et al* (2019), however, indicate that by century's end, the actual sea level rise off the coast of Oregon could plausibly reach 8 feet, a value reiterated in Fleishman (2023). During storm surges, a higher sea level will generate conditions that promote far greater storm damage and flooding than would otherwise have been the case. The impact of Hurricane Sandy in 2012 was a perfect illustration of this problem. Not long ago, the suggestion that New York subways could be flooded by a coastal storm would not have been taken seriously – yet it happened! Results of ocean rise, such as increased erosion and compromised coastal habitat integrity for tidal flat, estuary, and marsh natural communities, could become serious.

Ocean Chemistry. Serious as direct climatic consequences are, they do not constitute the sum total of the impacts of our emitting carbon dioxide into the atmosphere.

Because carbon dioxide is absorbed by our oceans, and is transformed into carbonic acid, oceans are becoming more acidic. This is detrimental for marine organisms with carbonate-based shells since either they are unable to form shells in acidic conditions, or they lose shells already established. Bednarsek, *et al*. (2020) demonstrated that ocean acidification off the coast of Oregon is already having a negative effect on Dungeness crab (*Metacarcinus magister)* shell formation and durability. Dungeness crab is one of the most valuable species on the Oregon coast, and the further acidification of our coastal waters could be catastrophic for this population. The losses to the Northwest coast oyster industry, where larvae lose their capacity to form shells, is costing hundreds of thousands of dollars (Ben Achur 2022). Additionally, acidosis, a build-up of acidic conditions in the tissues, threatens many marine life forms.

In addition, warming oceans exhibit reduced oxygen levels, potentially critical for marine animals since, like terrestrial animals, they rely on oxygen for basic metabolic respiration.

These consequences of increasing atmospheric greenhouse gases (notably carbon dioxide) pose threats to marine life, and thus to our fisheries, coastal economies, recreation, and tourism.

Rural vs Urban Oregon:

Rural communities are typically characterized by local economies and livelihoods that are reliant on direct interactions with the environment through agriculture, timber, fishing or outdoor based tourism activities. Urban communities, by contrast are typically characterized by local economies and livelihoods that are reliant on activities that do not include direct interactions with the environment. The result is that climate change has a far greater direct effect on rural communities than urban areas, including the direct effects of reduced snowpack, decreased river levels, rising seas, altered growing seasons, extended drought, increasingly hot summers, and increased wildfire risk. The has led to the misconception that urban communities are not vulnerable to the impacts of climate change.

While rural communities are on the frontlines of the climate crisis and some of the most vulnerable communities across Oregon, urban areas are also vulnerable. The heat related deaths in the Portland-metro area in the summer of 2020 and the Labor Day fires later that year demonstrated that urban areas are under direct threat from the impacts of climate change. Beyond the direct impacts of climate change, urban areas rely on healthy rural regions for their water supply, their agricultural, and forestry products and recreational activities in wild and less developed areas. Indirect effects, therefore, can be substantial. Climatic events that compromise natural systems, and thus urban watersheds, and regional agriculture and forestry will also have a profound impact on life in the urban centers. This impact will not be limited to impacts on prices of food and wood products but will also compromise regional recreational opportunities. Additionally, because the Pacific Northwest is projected to suffer less than most of the country from the warming climate, the region will become the target for climate refugees from across the U.S. These migrants will increase our population and place a greater burden on our natural resources and dwindling water supplies.

The 13th Oregon Senate District Climate History and Projections:

Senate District 13 comprises Washington, Yamhill, Clackamas, and Marion counties. We use Marion County as the exemplar.

Temperature history and mean projections for Marion County are presented in Figure 12 where the red lines represent 'business as usual' scenario of increasing fossil fuel use and greenhouse gas emissions and blue assumes some reduction in emissions. During the latter half of the 20th Century the temperature rose about 1^{o}F. By the end of the century, temperatures could be up to 9^{o}F hotter than the 1981-2010 average.

The analysis for precipitation in Marion County (Figure 13), typical of the district, indicates a historical flat trend that is likely to continue regardless of scenario though with increased variability in extremes meaning wetter wet and dryer dry years. The current trend towards precipitation falling in more frequent downpours as opposed to the light rainfall that rejuvenate soil moisture is also expected to continue. This means that the rain that falls will more likely induce floods and soil erosion than replenish dry soils.

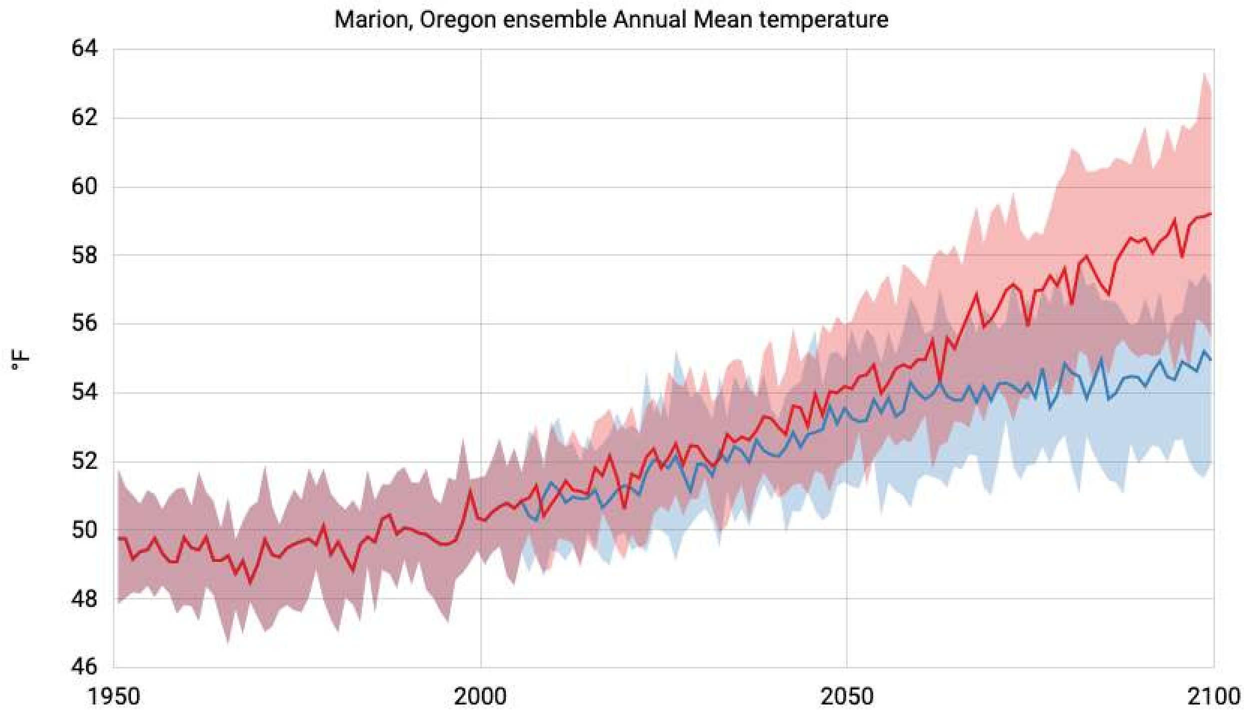

Figure 12. *Temperature trends for Marion County, Oregon (USGS 2021).*

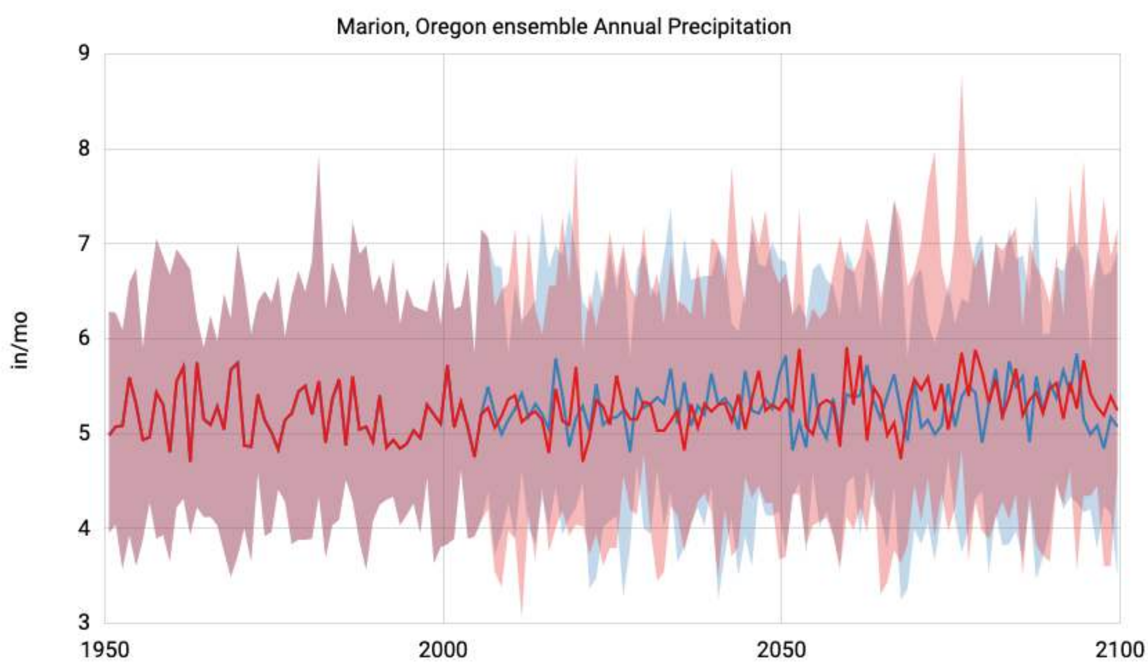

Figure 13. *Precipitation history and projections for Marion County, Oregon (USGS 2021).*

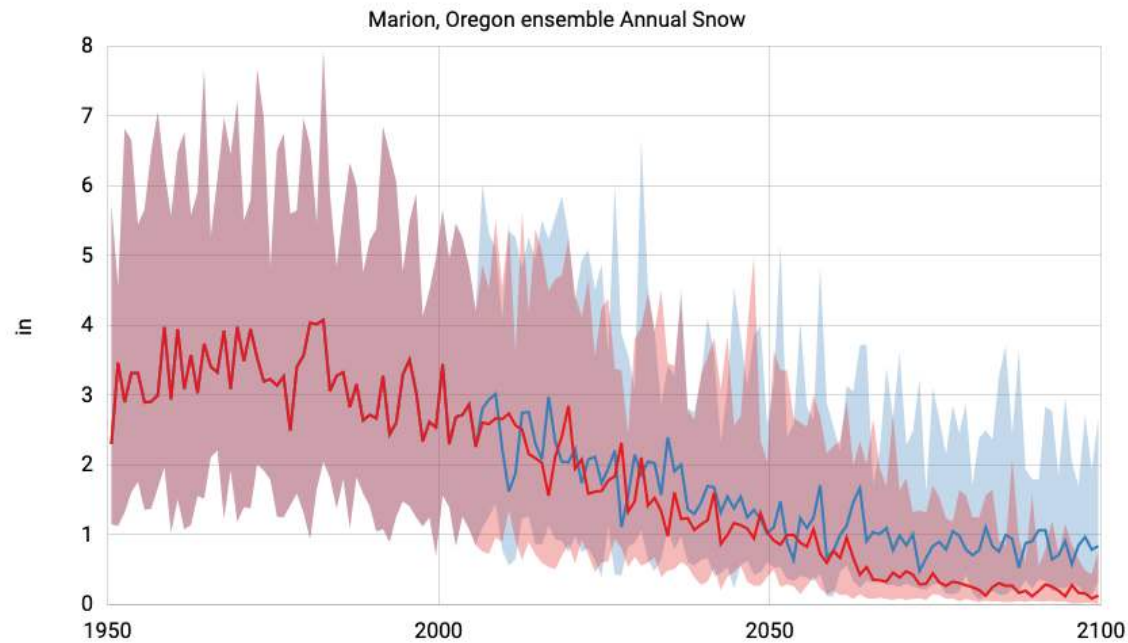

Figure 14. *Snowfall history and projections for Marion County (USGS 2021).*

Snowfall historic trends and projections are presented in Figure 14 showing a drop since the 1970s and further continued reduction whether the business as usual scenario (in red) or a less severe trajectory of increasing temperature emissions reductions (blue) is established.

Federal 5th Congressional District Historic Temperature Trends

Oregon Senate District 13 falls, primarily in the 6th Congressional District, with the northern part of the district lying in the 1st Congressional District. The data (Figures 15 & 16) indicate that the 6th Congressional District has been warming at a rate of 3.3^{0}F per century since 1960, while

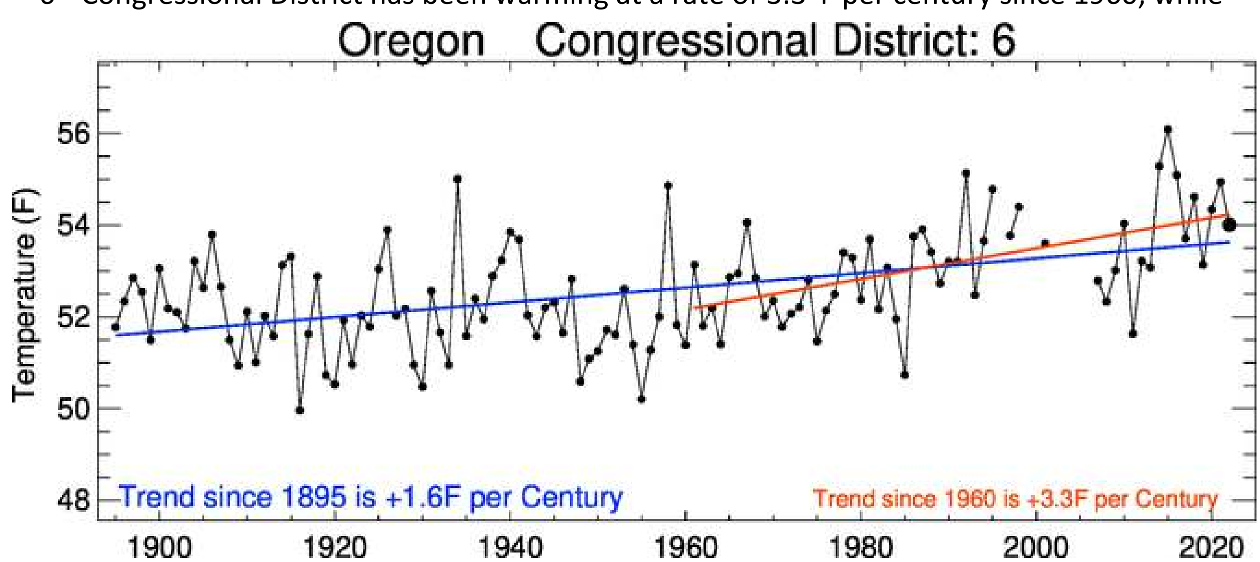

Figure 15. *Temperature trend for Federal Congressional District 6 (CCT 2021).*

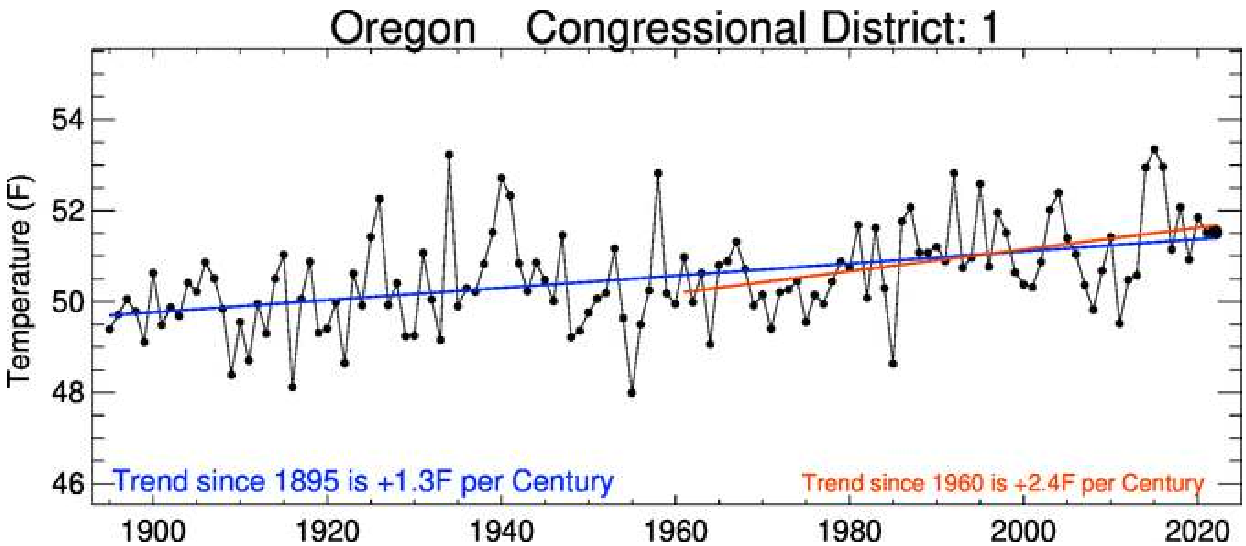

Figure 16. *Temperature trend for Federal Congressional District 1 (CCT 2021).*

Congressional District 1 is warming at a slower rate of 2.4^{0}F per century since 1960. The temperature rise is in CD1 is slower than CD6 because of its more northerly position and the relatively large amount of coastline within the district as compared to CD 6.

Oregon 13th Senate District Economy:

The largest industries in Oregon's Marion County are Health Care and Social Assistance, the Retail Trade and Manufacturing (Marion 2022). According to the USDA (undated) "The county is the largest agricultural producing county in the state of Oregon & producing over 254 varieties of crops Marion County is also the most diverse agricultural producing county in the United States." Additionally, "Federal and State forest covering approximately 35%." Meanwhile, Marion (undated) states: "Principal industries are Agriculture, Government, food processing, lumber, manufacturing, education, tourism."

Timber/lumber production is still a significant component of this district's economy. Marion (2016) identifies Douglas Fir, Western Hemlock, Western Red Cedar as the most ecologically appropriate conifers for the county The current and future appropriate climate distributions for Douglas fir, Western red cedar, Grand fir and Western hemlock are presented in Figures 17 – 20. High tree viability is indicated in red, low viability in green and absence in areas without color.

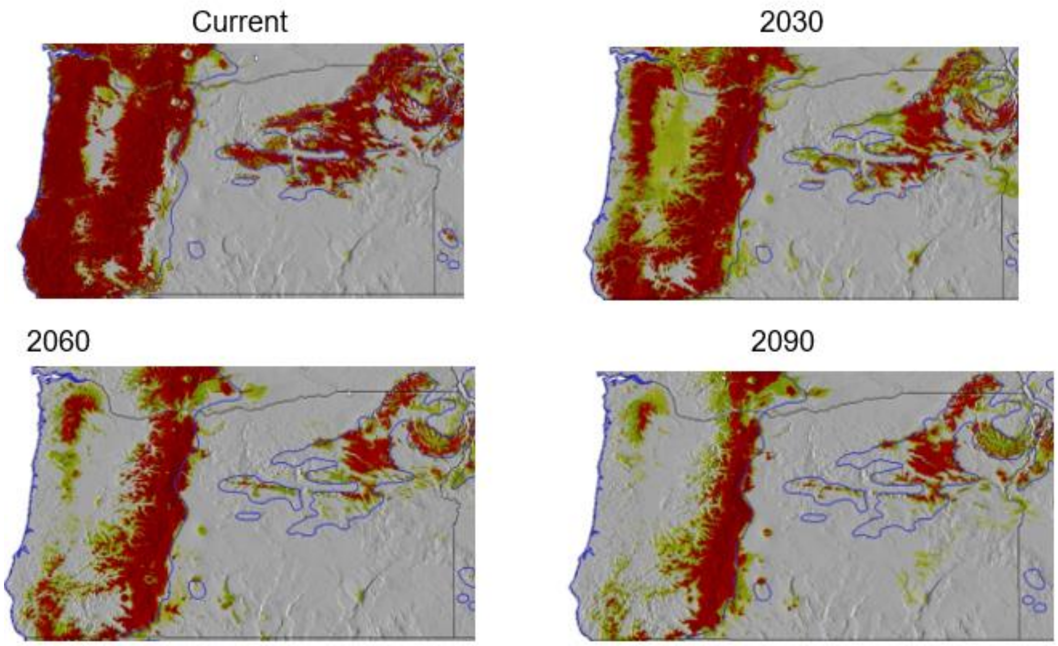

Figure 17. *Douglas fir, Psuedotsuga menzeisii) appropriate climate now and in the future (Crookston and Radtke 2023).*

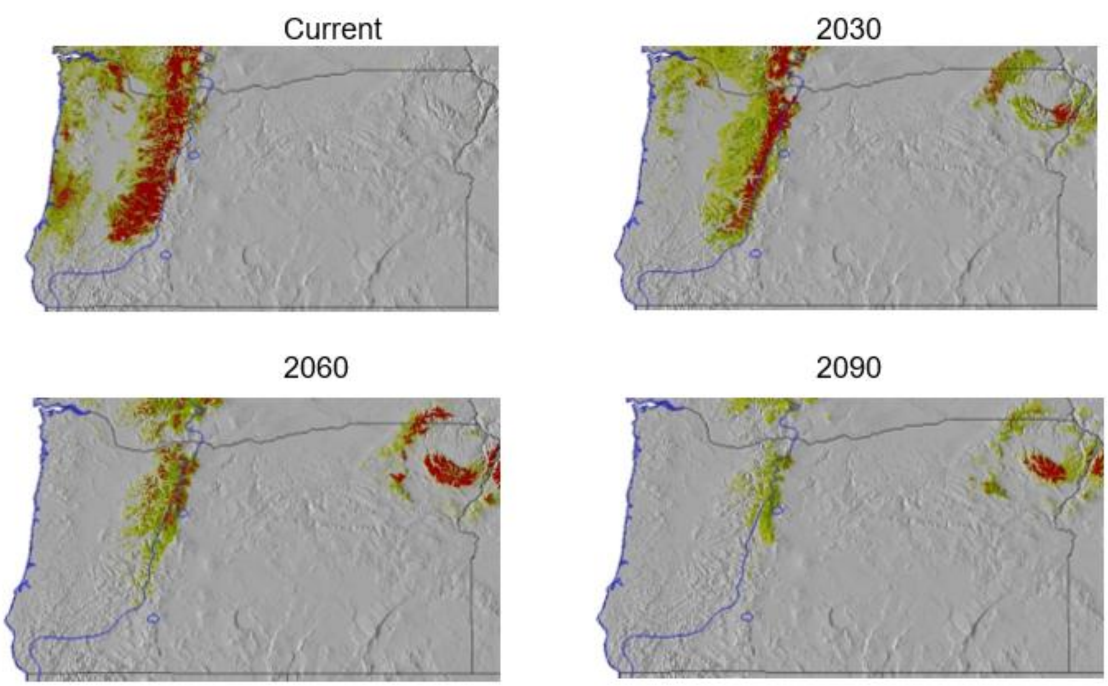

Figure 18. *Western redcedar (Thuja plicata) appropriate climate now and in the future (Crookston and Radtke 2023).*

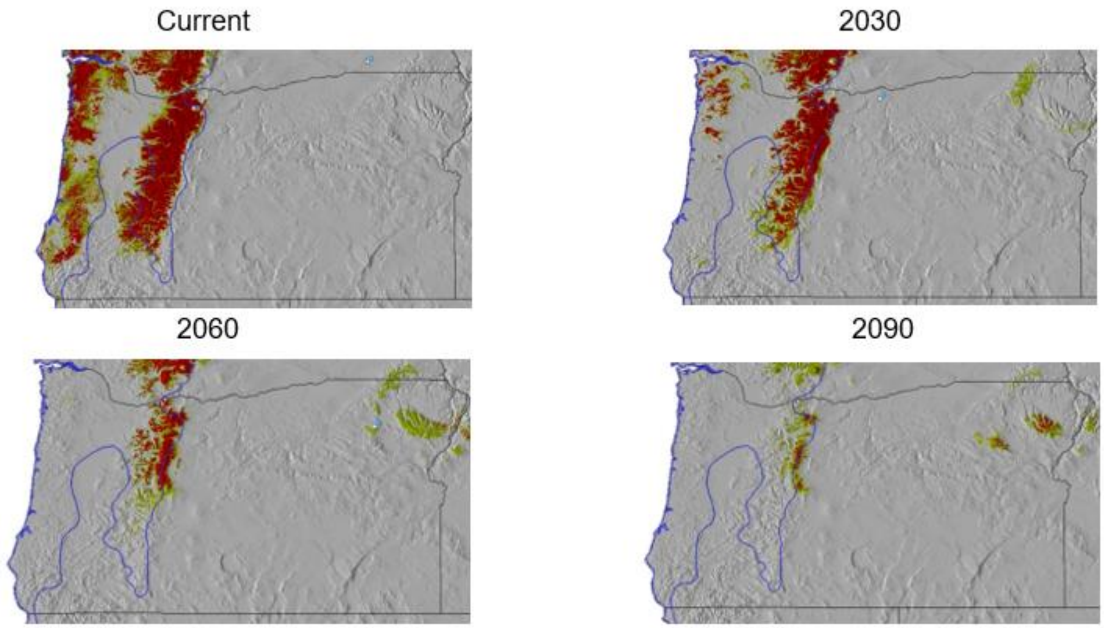

Figure 19. *Western hemlock (Tsuga heterophylla) appropriate climate now and in the future (Crookston and Radtke 2023).*

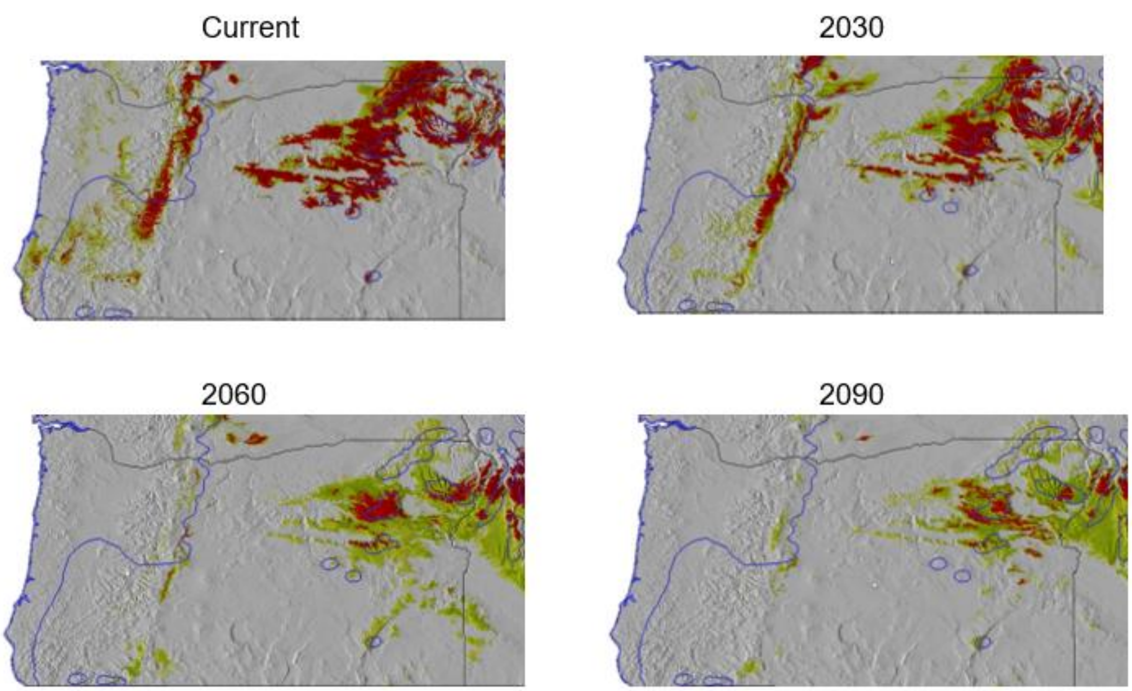

Figure 20. *Grand fir, Abies grandis appropriate climate now and in the future (Crookston and Radtke 2023).*

Consistent with these projections, several years ago, Ahrens and Stewart (2015) reported the occurrence of die back of Douglas fir, Grand fire, Noble fir and Western redcedar in the region.

These projections suggest conditions for these species may be considerably challenged as the century unfolds, especially if we do nothing to mitigate the climate trends already evident. Additionally, large fires could become more common in Western Oregon forests. Estimates increase in regional forest area burned range between 180% and 300% by the end of the century, depending on the climate scenario and estimation method examined (Dello and Mote 2010). Given the ability of many Oregon forests to store carbon (Hudiburg *et al.* 2009), it is critical that climatic conditions not diverge such that these important species are compromised. Furthermore, given the ability of many Oregon forests to store carbon (Hudiburg *et al.* 2009; Law *et al.* 2018), it is critical that climatic conditions not diverge such that these important species are compromised. Halofsky *et al.* (2016) discuss the potential and disturbing impacts of climate change of SW Oregon's forests.

Potential Agricultural Impacts:

Our field crops are planted in soil and climatic conditions to which they are well adapted. This means adjustments from current climate can be detrimental. The agricultural 'one degree problem' occurs because increasing temperature generally reduces crop yield, in fact for each degree C temperature rise crop yield drops some 5 - 10% (Brown 2006). Meanwhile, the 'business as usual' scenario of increasing greenhouse gas emissions suggests that throughout Oregon the temperature will likely increase 5 or more degrees C with decreasing soil moisture (USGS 2019) above 1981-2010 averages posing a great risk of extended drought. Farmers and home gardeners in Oregon should be concerned about a compromised climate future.

According to Willamette (2006): "The main crops grown are hops, prunes, alfalfa, flax, vetch and oats for hay, corn, blackberries, and apples." Future climate patterns as projected would significantly alter these crops' growing seasons and even compromise the viability of certain crops. This could negatively impact the economy through a reduction in crop yields since increasing temperature consistently reduces crop productivity.

As of 2008, greenhouses, nurseries, and tree farms made up nearly 20% of Oregon's total agricultural market valued at more than $880 million (Dello and Mote 2010). According to McCabe (2022) there are over 1000 holiday tree farms in Oregon, reportedly worth $107 million in 2020. Many of the Christmas trees in the region are Grand or Douglas fir, which were discussed above. Additionally, common varieties such as Noble fir, Frasier fir, Scotch pine, and Norddman could become less viable in the region or at least not be able to grow in areas where they previously thrived. Other crops such as field (27.42%), seed (11.11%), and fruit and nut crops (9.74%) make up nearly 50% of Oregon's agricultural commodity sector. Common crops within these sectors include grass seed ($510 million), wheat ($340 million), pears ($92 million), cherries ($56 million), hazelnuts ($52 million), corn ($52 million), and blueberries ($49 million). More locally, Marion County nursery crop sales reached sales of $134 million and nursery sales in Yamhill County were $82 million in 2011 (O'Connor, undated).

Climate change will affect each of these crops differently. Orchard-based crops will mature more rapidly in higher temperatures which will affect crop quality and timing to markets, potentially creating a conflict with historic market need. Further shifts to earlier and earlier harvests during warmer summers could both lower the quality of the fruit and shift the competitive environment in which Oregon producers must sell their crop. In addition, winter chilling requirements for orchard crops in Oregon appear to still be sufficient, unlike California. There, chilling hours during winter have declined by as much as 30% since 1950 in areas of the Central Valley to the point of not making some orchard crops viable. However, as climates continue to change, similar winter dormancy issues could mean trouble for Oregon's perennial crops (Dello and Mote 2010). Additionally, as snowpack decreases in the Cascades, availability of irrigation water could become more restricted as summer heat waves and droughts become more commonplace. The most consistent changes in global climate models show a regional warming and drying in the summer. The multi-model average decrease for summer precipitation is expected to be 14% by the 2080s. Over two decades ago, the EPA (2002) reported that as a result of water use "an estimated 130 kilometers [80 miles] of 2nd to 4th order streams go dry in a moderately dry summer. For a 1.8˚F rise in temperature, irrigation demands are projected to increase by 10% (Dello and Mote, 2010). Water availability is likely to become a substantial problem in the district.

Moreover, Climate change is expected to enhance invasion risk from many crop diseases, pests, and weeds. Rising temperatures allow both insects and pathogens to expand their ranges to regions where they were once not found. In addition, warmer winter temperatures allow more insects to survive over the winter, whereas colder winters once controlled their populations. Changes in climate have the potential to disrupt the natural enemies of some crop pests (beneficial insects), ultimately producing greater overall crop vulnerability. Warmer temperatures may also allow for additional generations of insect pests within a single growing season. Models codling moth populations under baseline conditions and four Global Climate Model (GCM) projections and finds earlier emergence of adults in spring coupled with warmer temperatures in summer would result in most apple-growing locations in Washington State experiencing a complete third generation hatch. These results suggest additional costs to apple growers from additional pheromone and sprays per season Dello and Mote 2010).

Much of the tourism in the district is driven by wineries. is connected to the North Willamette Valley's thriving wine industry. Allison (2022) identifies the top wines of the region as Pinot Noir, Pinot Gris, Pinot Blanc, Chardonnay Sauvignon Blanc, Riesling, Merlot, and Syrah. Statewide, the wine industry was the 11th largest agricultural sector, valued at more than $71 million in 2008 (Dello and Mote 2010). In Yamhill County, wine grape sales hit an all-time high of $30,160,000 in 2011 (O'Connor undated). Figure 20 indicates the preferred growing temperature ranges for each major grape varietal.

All these varietals will be affected by projected temperature changes, but over the course of this century, they are likely to remain viable. Of the varieties, Pinot Noir, due to its narrow range for optimum quality, is the most vulnerable. If there are further increases in temperature, vineyards will likely need move much of current acreage planted in the Willamette Valley outside of what is considered suitable for Pinot Noir. This would necessitate costly adaptation processes of replanting to different, warmer climate grape varieties, or moving to higher elevations or further north in latitude. Additional risks come from the marketing side, where changes in varieties or wine styles would require a substantial effort to inform consumers and maintain market viability (Dello and Mote 2010). Many vineyards in the area that contribute to our local economy will likely be directly affected.

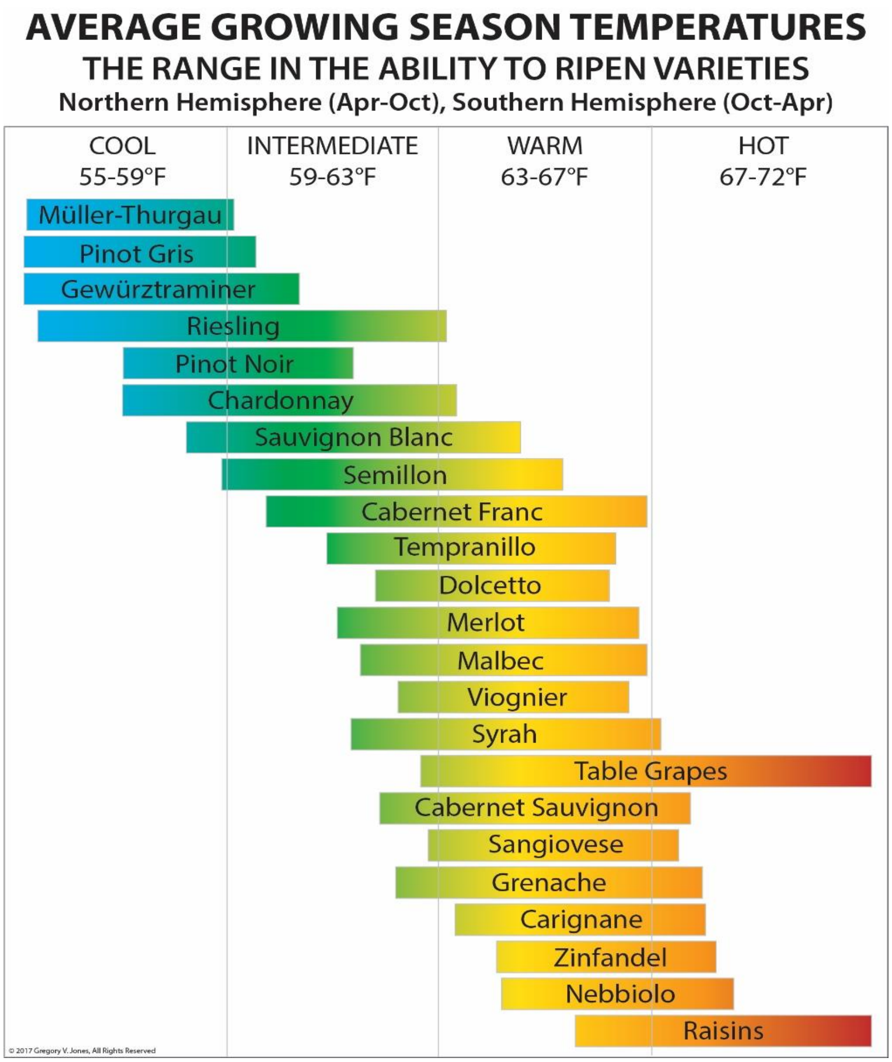

Figure 20. *Grape varietal optimum growing season temperature (Jones 2015).*

As with the agricultural sector, water may become a constraining factor for local residences, industry, and business. Many Oregonians depend on water pumped from the ground to provide much of their water supply. These below-ground aquifers are out of sight and may seem limitless, but in a number of areas within the Willamette Basin, aquifers are declining or becoming contaminated from salts, septic systems, and industrial pollution. (Sinclair, 2005) Many municipalities rely on rivers sourced from snowmelt which will become only more limited as snowpack decreases. As much of the region also sources its electrical power from hydroelectric sources, lower river flows could reduce reliability of power generation within the region (Oregon 2012) At the same time, efficiency and reliability of power transmission and delivery is likely to decline as power lines are stressed by higher ambient temperatures, increased risk from wildfires. As a result, more brownouts and blackouts are possible. Expansion of biomass-based energy production may also be limited due to loss of supply from forests and agriculture from increased wildfire (Dello and Mote 2010).

Potential Health Risks:

According to the Oregon Health Authority (2014), the main climate impacts to health are likely to be: heat, allergens, and storms and floods. The top health concerns will be: poor air quality, respiratory illness, heat-related illness, harmful algal blooms, recreational hazards, increased allergens, displacement, landslides, economic instability, and mental health impacts. Communities that will be especially vulnerable will be: low-income households and neighborhoods, communities of color, older adults, people living on steep slopes, people working in agriculture, first responders, and children and pregnant women.

Some seventy percent of Oregon's population lives within the Willamette valley (Haven 2022). Two decades ago, by 2050, the population was anticipated to be about 4 million (Sinclair 2005). As a result, any natural disaster in the Willamette Valley region will have a significant effect on Oregon's population and economy. The area is already at relatively high risk from floods, landslides, wildfires, and winter storms. It also faces moderate to high risk from earthquakes and volcanic activity. The extensive urban infrastructure in parts of the region means natural hazard events can lead to power outages, building collapse, dam failures and HAZMAT operations. (State of Oregon, 2012) Projected climate changes in precipitation rates and temperatures are likely to threaten the integrity of the built environment, including buildings, roads, highways and railroads, water and sewage systems, and energy facilities throughout Oregon (Dello and Mote 2010).

Climate change is likely to have an impact on public health issues in Oregon including the spread of communicable diseases as well as an increase in water-, food-, and air-borne infections. Predicted average increases in summer temperatures will make heat waves a greater likelihood, causing heat-related morbidity and mortality, especially among vulnerable populations, such as the elderly, low-income populations, pregnant women and those who work in outdoor occupations. Increasing temperatures in Oregon could raise the threat of vector-borne diseases and emerging infections. Respiratory insults, especially among persons with pre-existing lung health problems would be exacerbated by exposure to smoke from forest fires, as well as from the projected increases in air pollution levels in our region. Air pollution and increases in pollen counts (and a prolonged pollen producing season) may increase cases of allergies, asthma, and other respiratory conditions among susceptible populations (Dello and Mote 2010). Climate change and its consequences target the most vulnerable - such as the young and the old. The consequences depicted here could have a severe impact on the health of the elderly. Many of the health consequences involve respiratory problems for this vulnerable segment of the population. Not only will the projected climate change be negative for our economy, it will also change the lives of people in the 13th District.

If climate trends continue as projected, Oregon's 13th Senate District will experience considerable natural and economic disruption. In order to sustain a vibrant economy, the region will find it necessary to adapt. Avoiding the worst-case scenario depicted in these projections will require the concerted effort of elected leaders at all levels of government: regional, national, and international.

A Timeline for Action:

Based on the projected consequences of the warming lobal climate, international agreements (e.g., UNFCCC 2015) some years ago established 2°C (preferably 1.5°C) above pre-industrial conditions as the limit beyond which we should not allow the global temperature to climb. This limit was echoed by the World Bank (2014). Meanwhile, the Intergovernmental Panel on Climate Change (IPCC 2018a) indicated that the 2°C limit pushes us too close to many global tipping points beyond which recovery becomes a reducing possibility. Thus, they recommend that we absolutely should target 1.5°C if we wish a reasonable chance of retaining a livable planet. Unfortunately, underlining the urgency, emissions to date may have already committed us to the 1.5°C increase (Mauritsen and Pincus 2017).

Global greenhouse gas emissions during 2017 totaled 53.7 Gigatonnes (GT) of carbon dioxide equivalent (IPCC 2018b) which includes between 32.5 (IEA 2019) and 36.5 GT of carbon dioxide (WRI 2018). This implies that between 30% and 40% of the global warming emissions are due to gases other than carbon dioxide. The trends and consequences discussed here are based on readily available data. This underlines the urgency for immediate action across the globe to curtail greenhouse gas emissions if we wish to avoid an increase over 2°C. Considerable variability exists among estimates of the emissions budget remaining if we are to restrict warming to the 1.5°C increase targets (Levin 2018, Carbon Brief 2018). Indeed, the latter source identifies a large range in estimates for a 66% chance of keeping warming to below 1.5°C of between 28 GT and 779 GT. Meanwhile, the IPCC (2018a) indicated that the rate of carbon dioxide emissions alone is currently 42± 3 Gigatonnes annually suggesting that, for a 50% chance at a rise below 1.5°C, the remaining budget for emissions is 580 GT CO_2, while for a 66% chance, the remaining emissions budget is 420 GT CO_2. Considering the current accelerating rate of emissions, the IPCC (2018a) concluded that by 2030 we must impose a reduction in emissions of 45% below the 2010 level and by 2050 we must reach net zero emissions. Considering the increasing impact of greenhouse gases other than carbon dioxide, that seems both conservative and reasonable. Underlining the urgency and imperative of limiting warming to 1.5°C, long ago the World Bank (2014) acknowledged there is: "no certainty that adaptation to a 4^{o}C world is possible."

Representing the People at the 24th United Nations Framework Convention on Climate Change Conference of the Parties in Poland (COP24), British naturalist and broadcaster Sir David Attenborough argued that in climate change "we are facing a man-made disaster of global scale, our greatest threat in thousands of years…" and "If we don't take action, the collapse of our civilizations and the extinction of much of the natural world is on the horizon." (Domonoske 2018). The choice is ours!

From the trends and consequences discussed here, all based on readily available data, there should be little doubt that substantial urgency must be attached to addressing this issue.

Solutions:

In addition to individual action wherein we evaluate our actions and adjust our behavior to reduce activities that result in greenhouse gas emissions, or increase those that result in atmospheric greenhouse gas sequestration (capture and storage), we can promote local, state and federal actions that do the same on a larger scale. Local communities can develop Climate Action Plans that promote emissions reductions and capture/sequestration activities. Meanwhile, at the state and federal level, similar such programs can be instituted. The predominant proposals to achieve this involve either:

a) imposing a jurisdictional cap on emissions which declines over time to establish a trajectory of emissions reductions that meet long term reductions goals. This approach involves the issuance of allowances to emit that reduce over time. Allowances may be sold/auctioned, or allocated free, or involve some combination.
b) imposing a fee or tax on emissions that rises over time to achieve reductions that are consistent with a desired trajectory and long-term goals.

The cap approach is direct since it involves assessing emissions from target polluters and requiring that reductions occur while the tax/fee approach is indirect since it is assumed that a rising tax will result in reduced emissions.

Both approaches usually involve the generation of funds either via sold/auctioned allowance in the case of the cap, or a fee in the case of the tax/fee approach. The second question associated with either approach involves a decision as to what will be done with the funds raised. One approach is to return these to residents or taxpayers (the individuals who ultimately pay the cost of the pollution reduction); hence the concept of a Dividend. Alternatively, the funds raised can be used to offset allow reductions in other taxes, whether individual or corporate. Finally, these funds may be used for investments that (a) promote activities that themselves lead to reductions in atmospheric greenhouse gas concentrations, either by reducing emissions of promoting sequestration and/or (b) serve the goals of promoting environmental / social justice by assisting communities historically disadvantaged by pollution or likely to suffer disproportionately from the transition to a clean energy economy.

Since the state legislature has declined to implement a comprehensive policy, if Oregon is to contribute its share to addressing the climate crisis and wishes to appear credible when seeking action elsewhere, it will be necessary to take smaller targeted steps that reduce emissions in designated sectors or activities and/or promote the sequestration of carbon from our atmosphere in our natural and working lands.

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