Southern Oregon Climate Action Now

SOCAN

Confronting Climate Change

Climate Change in the Oregon 12th Senate District

May 2023

History, Projections, and Consequences

1. The temperature has risen some 1°F during the last half of the 20th Century and may rise 8°F 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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Updated by Hogan Sherrow (hogan@you-evolving.com, 541-415-1013) February, 2023

Oregon Senate District 12 Climate Summary

For a more complete summary, including sources, from which these points are taken, visit: http://socan.eco/oregon-legislative-districts/

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Climate Change in the Oregon 12th Senate District

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July, 2017

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February, 2023

Global and Regional Temperature:

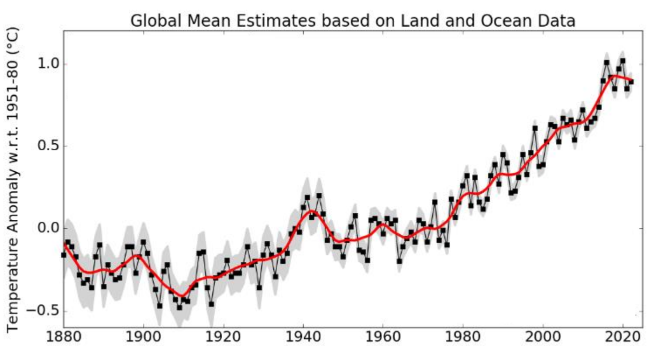

Figure 1. *Historic global temperature trend (NASA 2023).*

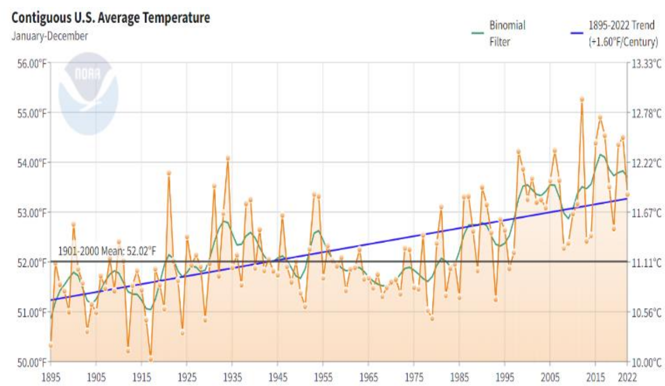

Figure 2. *Historic U.S temperature trend. (NOAA 2023).*

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.

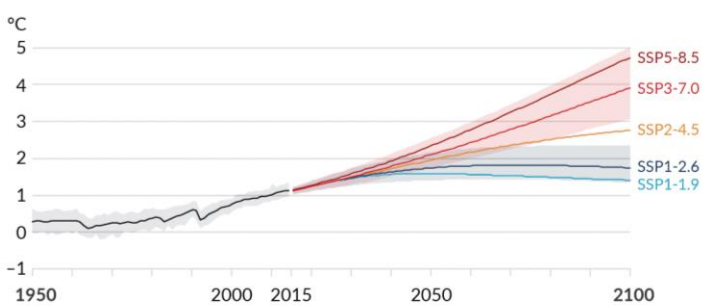

Figure 3. *Global temperature projections to 2100 relative to the 1850-1900 average. (IPCC 2021).*

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

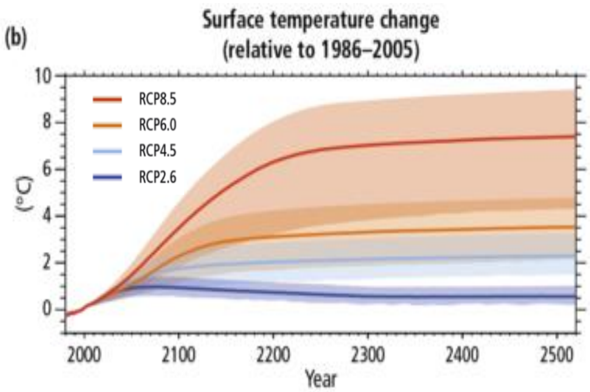

Figure 4. *Long term global temperature trends according to RCP values. (Jones 2017).*

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^{o}C (5.4 to 9.18^{o}F) above pre-industrial revolution temperatures by 2100 (Figure 3).

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.

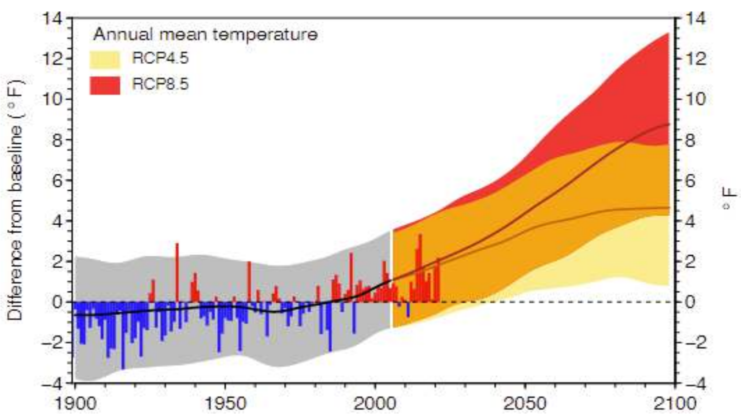

Figure 5. *Oregon temperature history and projections through the century; baseline: 1970 – 1999 (Fleishman 2023).*

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:

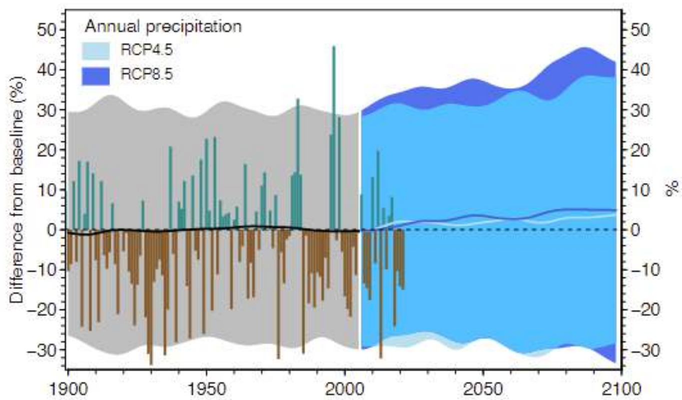

Figure 6. *History and projections for precipitation statewide. (Fleishman 2023).*

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.

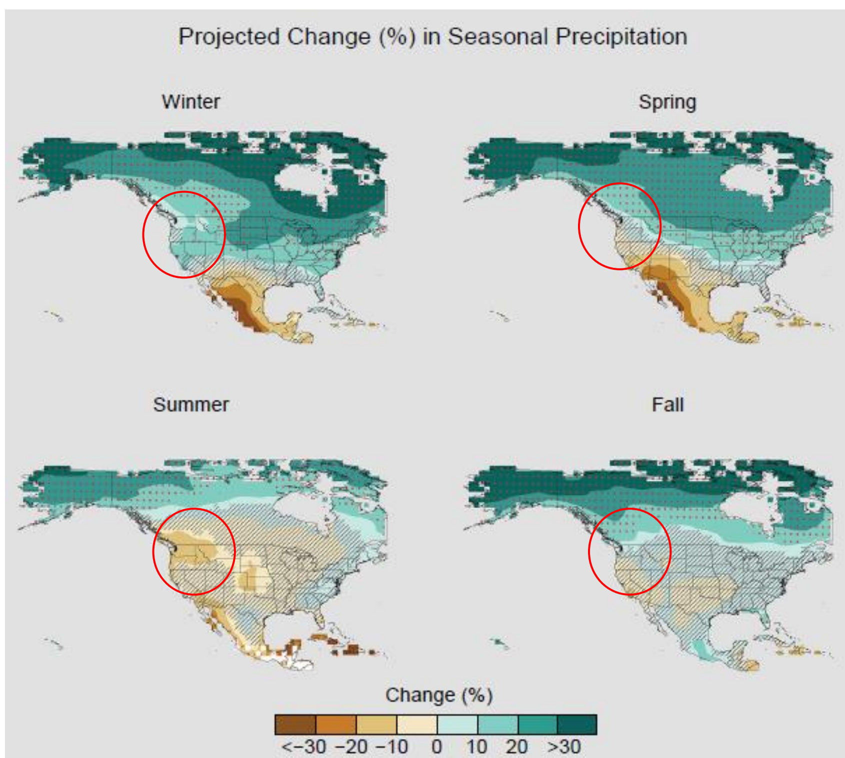

Figure 7. *Projected change in precipitation to 2077-2090 compared to 1960-2005 average; stippled areas indicate large change compared to natural variation; hatched areas small change. (Easterling et al. 2017).*

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.

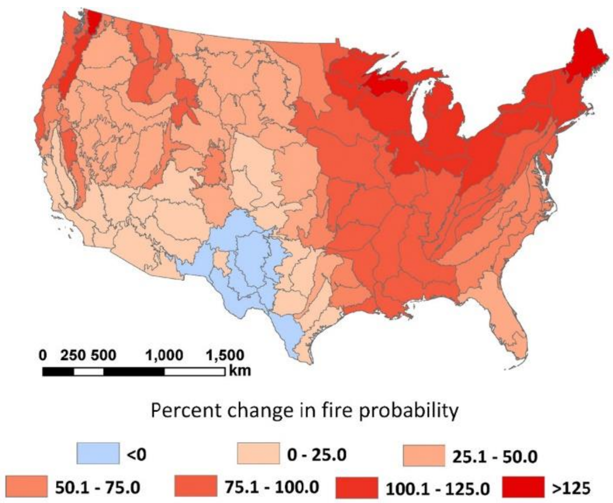

Figure 8. *Potential increase in fire risk from the 1971-2000 baseline across the U.S. assuming the RCP 8.5 scenario. (Gao et al. 2021).*

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.

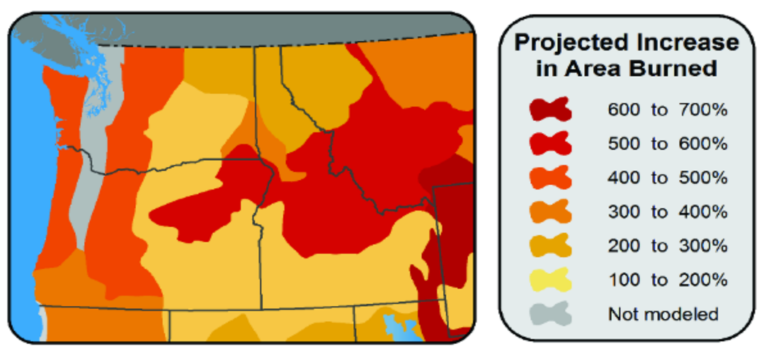

Figure 9. *Anticipated wildfire consequences of a 2.2^{o}F warming in area burned (Mellilo et al. 2014).*

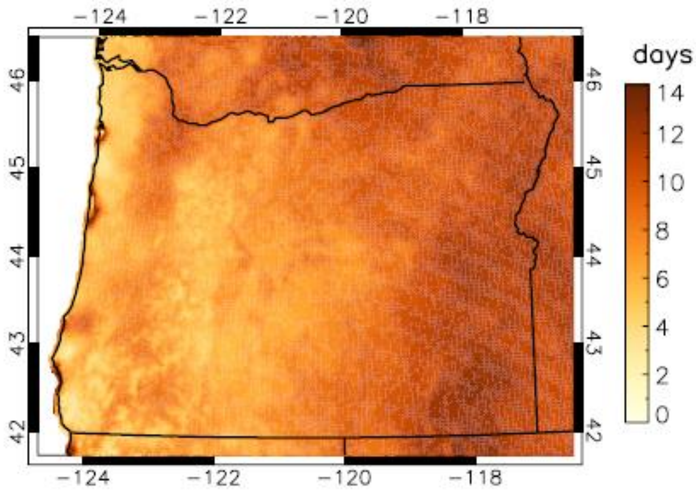

Figure 10. *Increase in number of days experiencing high fire risk by mid- century (2040 - 2069) compared to the end of the last century (1971-2000). (Mote et al. 2019).*

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

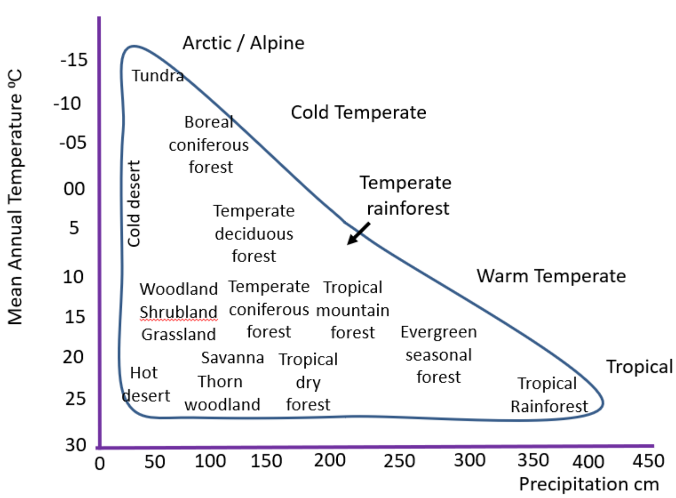

Figure 11. *Global distribution of natural ecological systems (biomes) in relation to mean annual temperature and precipitation patterns. (Modified from Whittaker 1975).*

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 4ºC (approximately 37ºF). 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 12th Oregon Senate District Climate History and Projections:

The historic and projected temperature trends (Figures 12 & 13) for the District, taken respectively from Benton County in the south and Yamhill County in the North indicate a historic rise of about a degree F during the second half of the 20th century but a projected rise through this century of over 8°F (red line) compared to the 1981-2010 average under the business-as-usual scenario of accelerating fossil fuel usage and emissions but also a rise of over 4°F (blue line) even if we reduce the rate of acceleration of that emissions trajectory substantially.

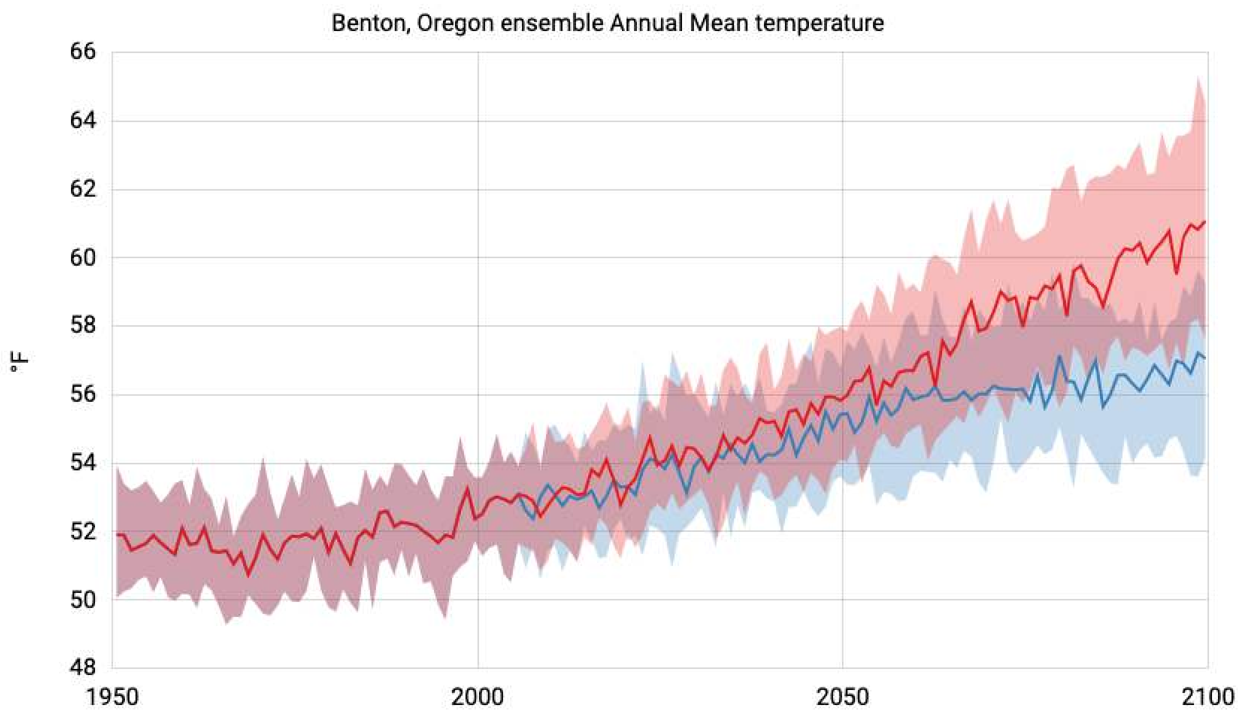

Figure 12. *Temperature history and projections for Benton County, Oregon (USGS 2021).*

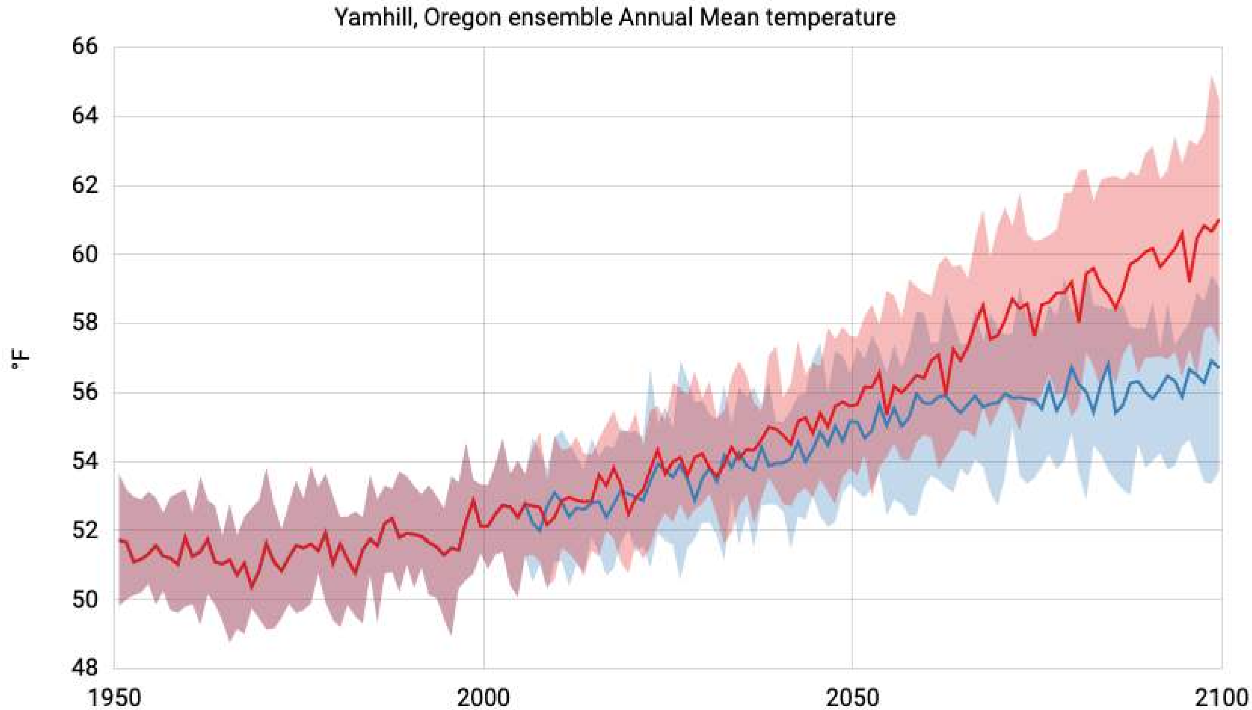

Figure 13. *Temperature history and projections for Yamhill County, Oregon (USGS 2021).*

Precipitation for Benton and Yamhill Counties (Figures 14 & 15) suggest a generally flat average trend though with greater variability through the balance of this century under both scenarios. This portends wetter wet and drier dry years will occur.

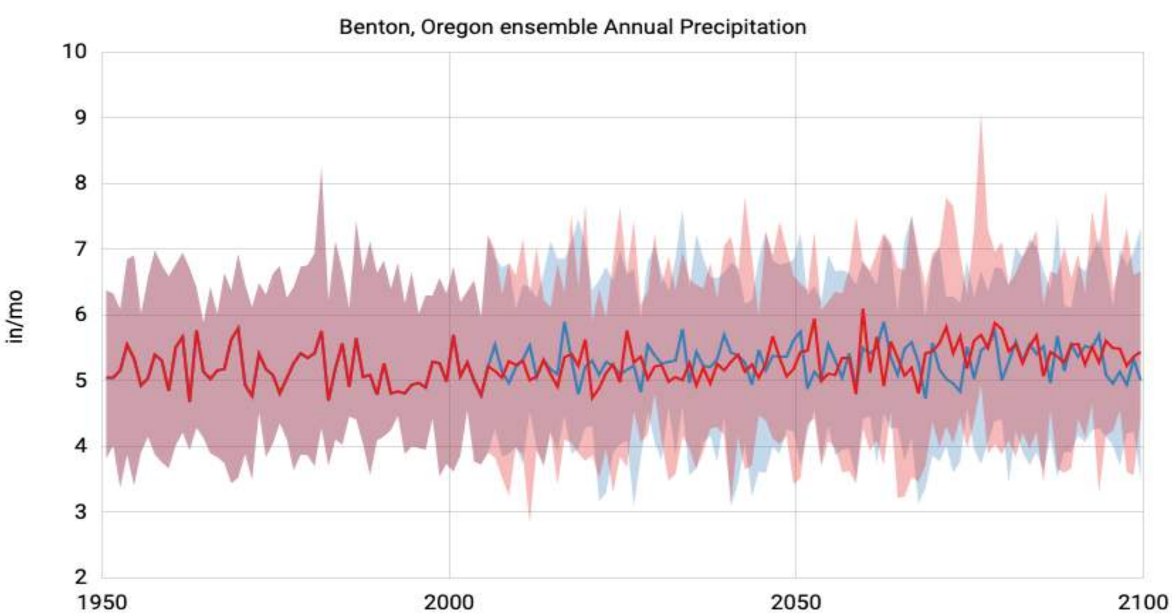

Figure 14. *Precipitation history and projections for Benton County, Oregon (USGS 2021).*

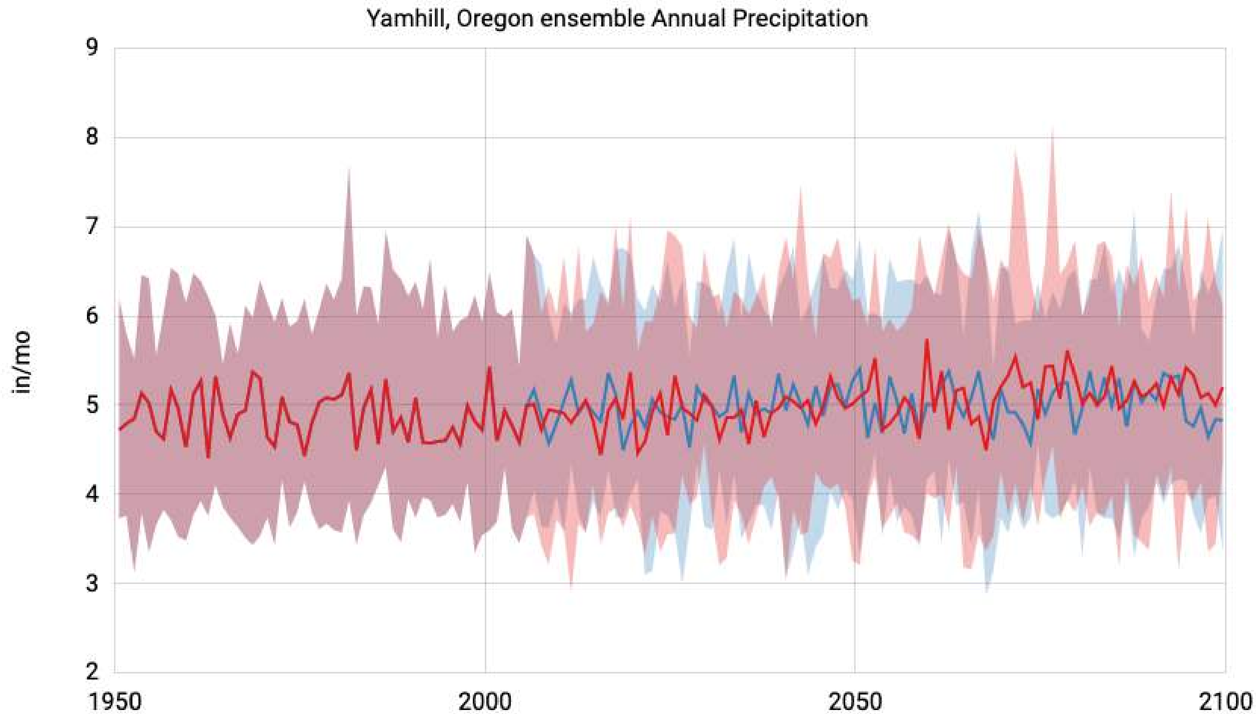

Figure 15. *Precipitation history and projections for Yamhill County, Oregon (USGS 2021).*

It is important to appreciate that the combination of comparable precipitation and higher temperatures will cause greater evaporation and thus extended droughts, particularly during the anticipated drier summer growing season. This will negatively affect both summer and winter recreational opportunities, and irrigation needs for agriculture.

Snowfall in the District for Benton and Yamhill Counties (Figures 16 and 17) decreased during the last century and is expected to drop further to minuscule amounts by late century if the Business-as-Usual scenario is followed through the century but only slightly more if we reduce emissions.

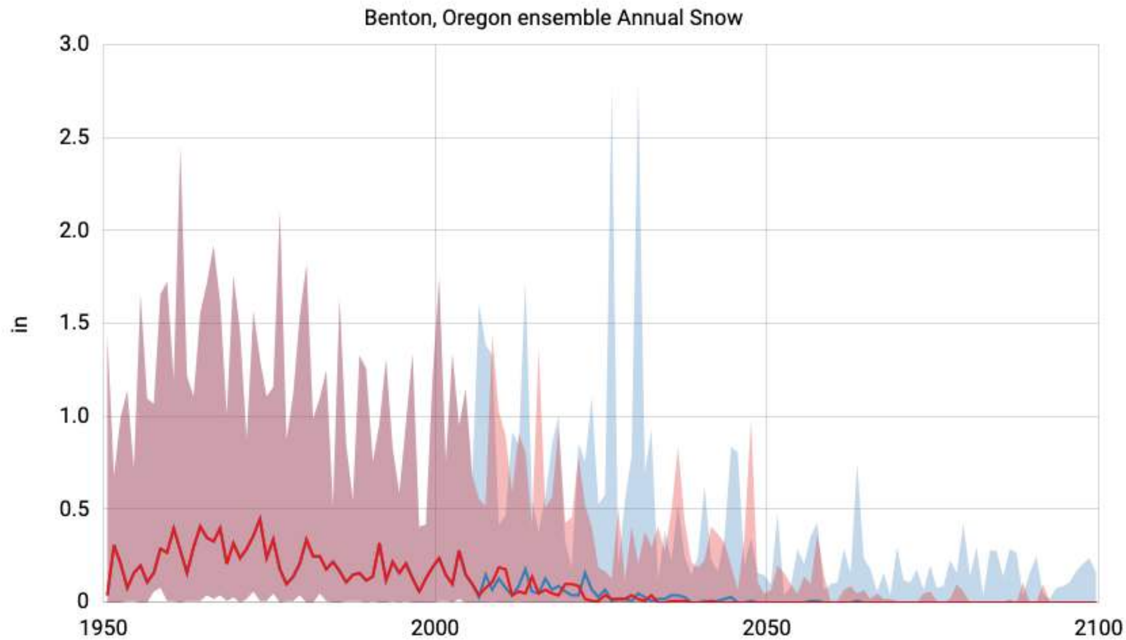

Figure 16. *Snowfall history and projections for Benton County, Oregon (USGS 2021).*

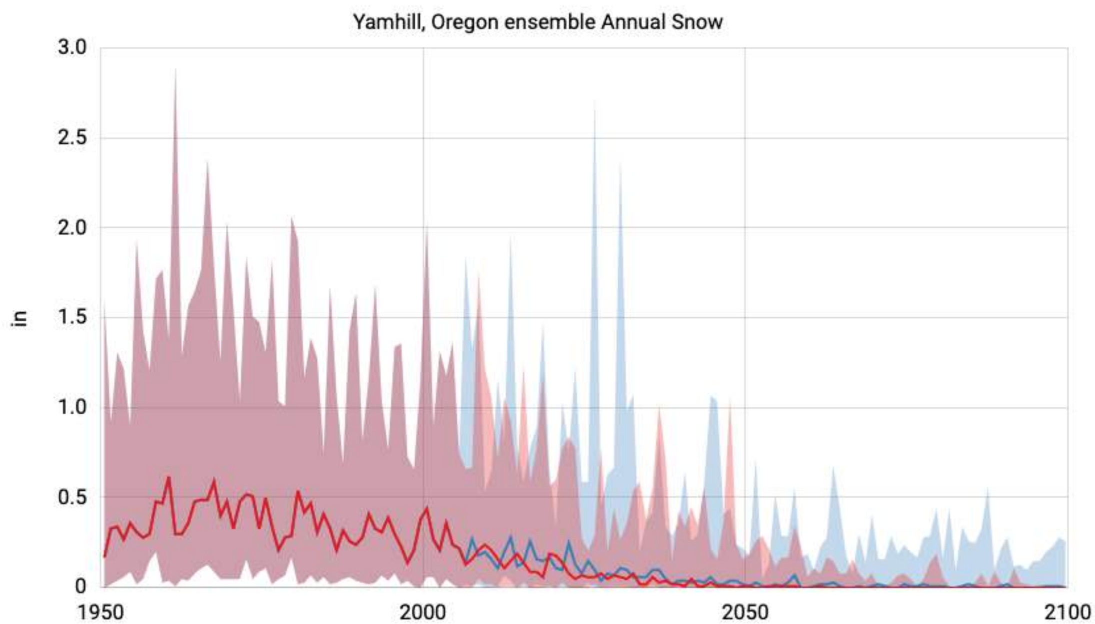

Figure 17. *Snowfall history and projections for Yamhill County, Oregon (USGS 2021).*

Federal 6th Congressional District Historic Temperature Trends

Oregon's 10th Senate District falls within Oregon's newest Congressional District, CD6. Figure 18 indicates that the 6th Congressional District has been warming at a rate of 3.3^{0}F per century since 1960. Clearly, this district is not immune from the consequences of climate change.

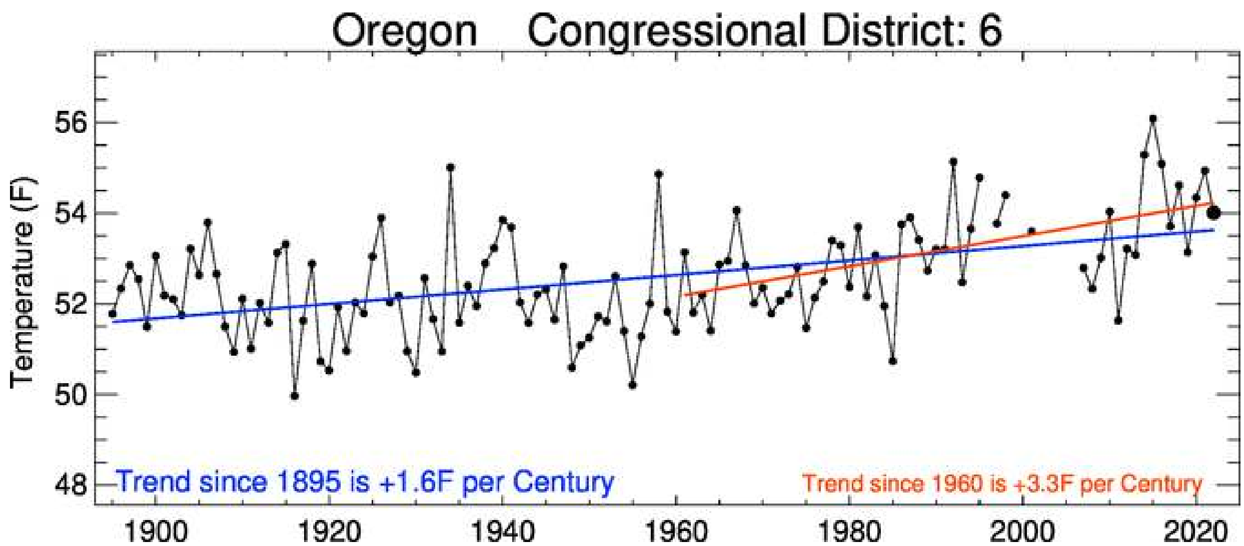

Figure 18. *Temperature trend for Federal Congressional District 6 (CCT 2021).*

Oregon 12th Senate District Economy

The economy of the 12th Senate district is rooted primarily in tourism, agriculture, and forestry, technology, and is the capital of Oregon's wine industry. The area is a world leader in production of seed crops, as well as Christmas trees, sheep, lumber, grass and legume seeds, and plywood. The ongoing health of our natural ecosystems is pertinent to retain the revenue stream provided by these activities. Much of the area in the district is forested; Benton County contains two National protected areas including the William L. Finley National Wildlife Refuge and portions of the Siuslaw National Forest, and Yamhill County contains the Tualatin River National Wildlife Refuge and portions of the Siuslaw National Forest.

The Siuslaw National Forest has two distinct vegetation zones: Sitka spruce and western hemlock. The Sitka spruce zone contains areas where the coast influence of mild temperatures, winds, and dense fog discourage other types of vegetation. Western hemlock grows well in shade beneath the dense Douglas-fir canopy. As Douglas fir matures, western hemlock takes over. Both zones contain freshwater, upland, offshore, and estuarine habitats that support a wide variety of vegetation, fish, and wildlife.

Future climate projections suggest that the 12th Senate District region may become less suitable for some of the critical forest species currently forming the basis of the logging industry, notably Douglas fir, Sitka Spruce, and Western hemlock (Figures 19 – 21). It would behoove those concerned about maintaining such activities in the district to address climate change to prevent these projections playing out to the detriment of our forests. 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.

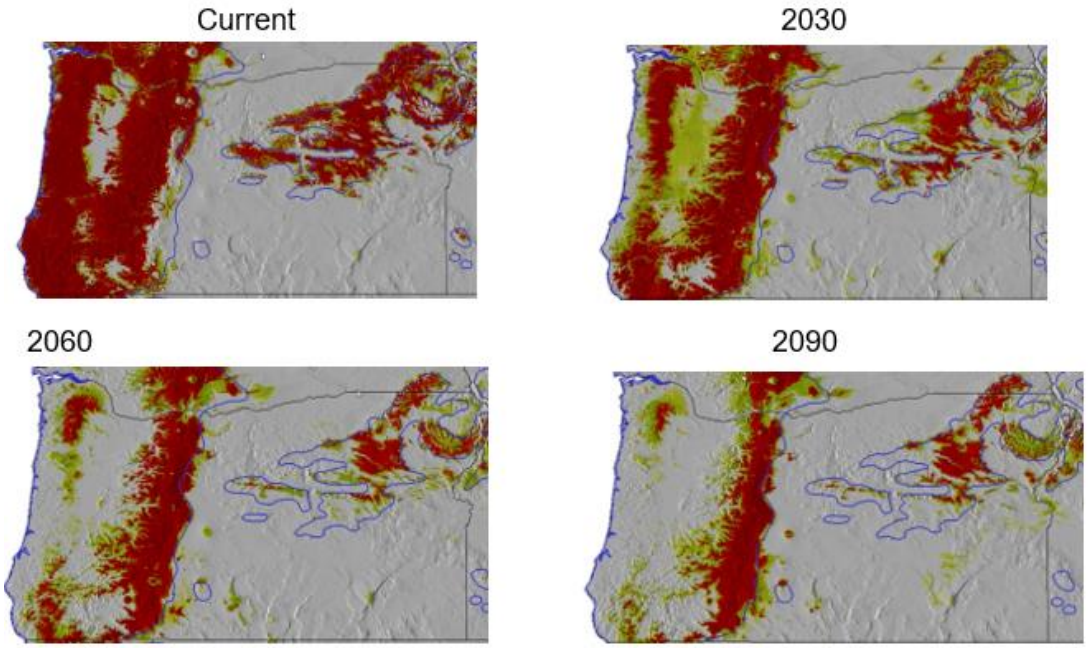

Figure 19. *Douglas fir, Psuedotsuga menzeisii) appropriate climate now and in the future (Crookston and Radtke 2023).*

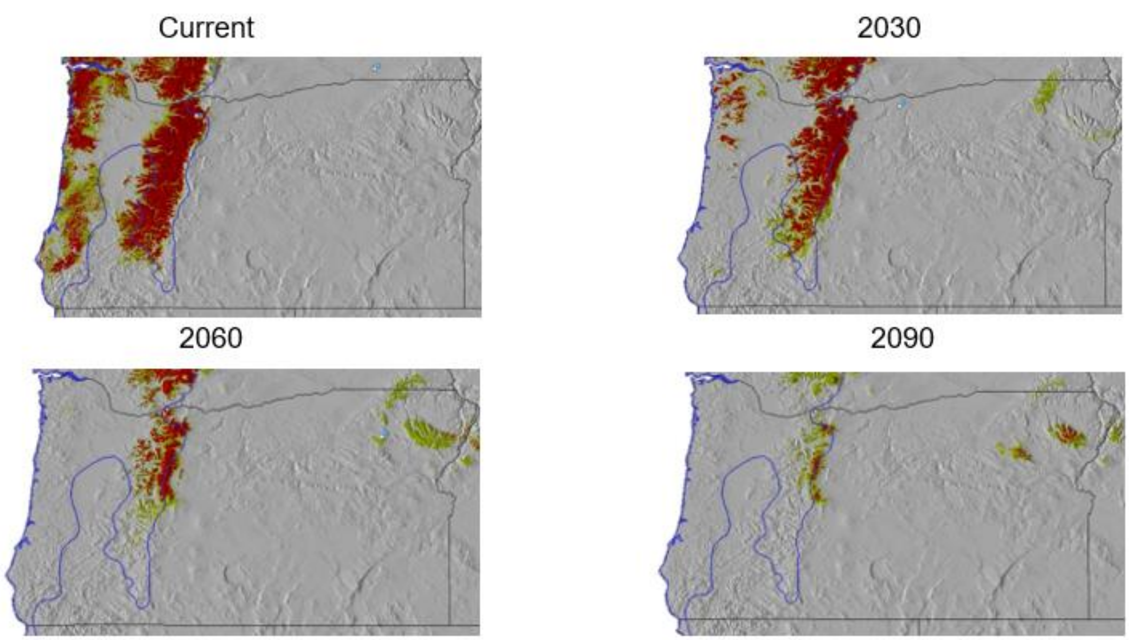

Figure 20. *Western hemlock (Tsuga heterophylla) appropriate climate now and in the future (Crookston and Radtke 2023).*

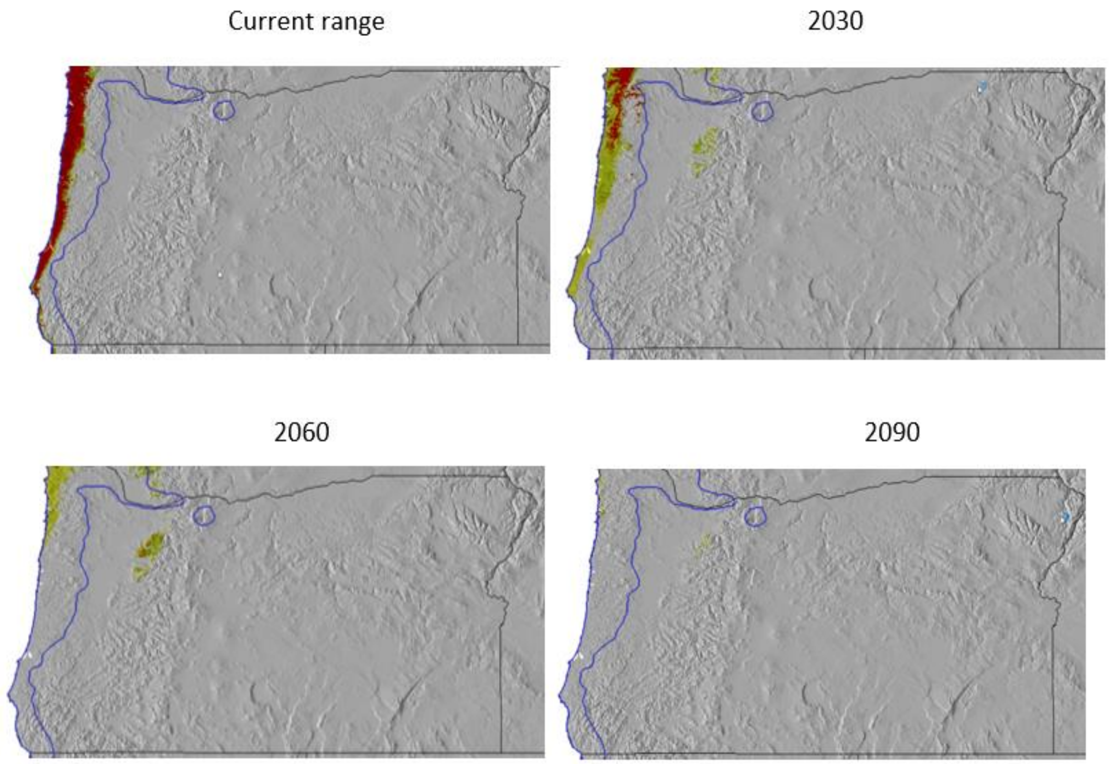

Figure 21. *Sitka spruce (Picea sitchensis) appropriate climate now and through the 21st Century (Crookston and Radtke 2023).*

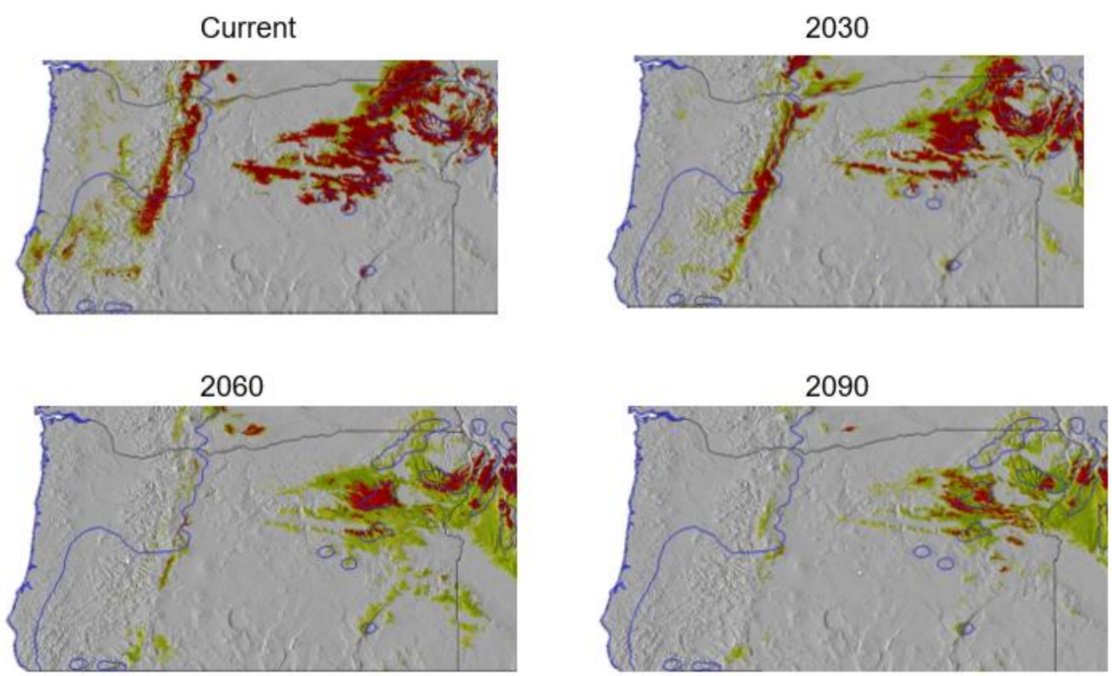

Figure 22. *Grand fir, Abies grandis appropriate climate now and in the future (Crookston and Radtke 2023).*

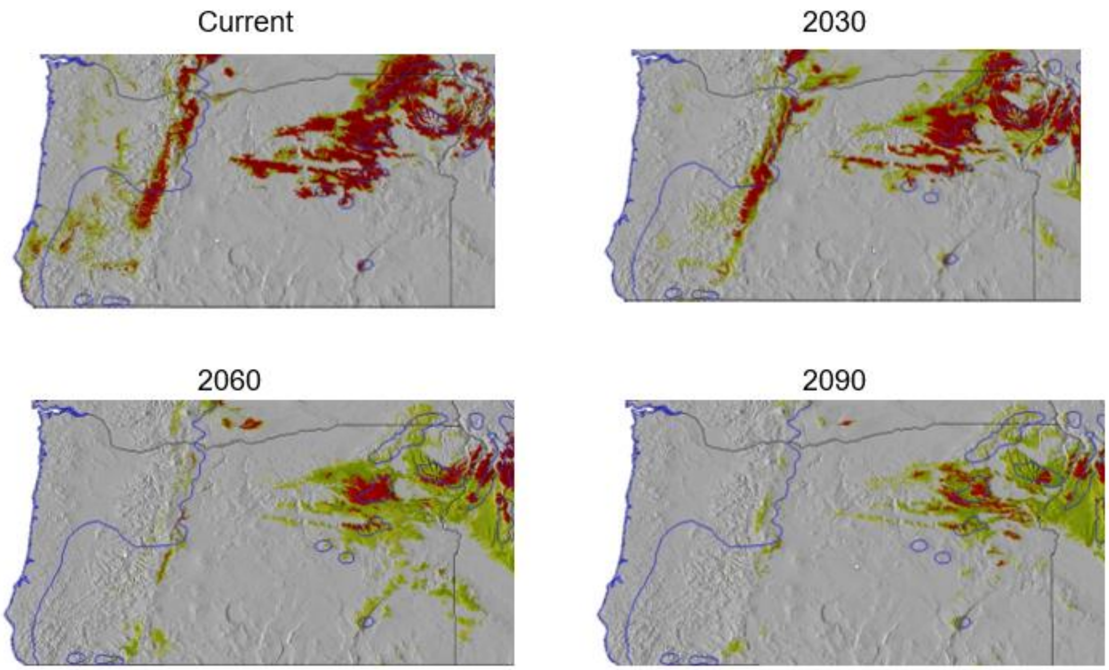

Figure 23. *Grand fir, Abies grandis appropriate climate now and in the future (Crookston and Radtke 2023).*

Potential Agricultural Impacts:

This region of Oregon contains a substantial portion of the state's swiftly growing wine industry. Decreased precipitation will affect groundwater recharge, which will, in turn affect the available water supply for growing grapes. Climate is a controlling factor in grape and wine production (Figure 24); changes can affect both the suitability of certain varietals to a region, and the quality and type of wine that can be produced. For high quality wines such as those produced in the 12th district, equilibrium between soil, varietal, and climate must be maintained. It is expected that increasing temperatures will lead to a northern shift of wine growing areas. Increased atmospheric concentrations of carbon dioxide (CO_2) and other greenhouse gases will also affect climatic conditions important for agriculture.

Since climatic factors are critical to the success of agriculture and forestry, it is anticipated that climate change could have profound effects for the economy throughout the region – not only because of the temperature impacts themselves (increasing temperature generally leads to reduced crop yield), but also because of the potential for much drier growing seasons with diminished water availability.

The continued economic success of the 12th District is substantially dependent on the maintenance of a favorable climate. Should the climate projections for the balance of this century play out; the 12th Senate District will be forced to undertake considerable adaptation to the developing conditions to sustain its economy.

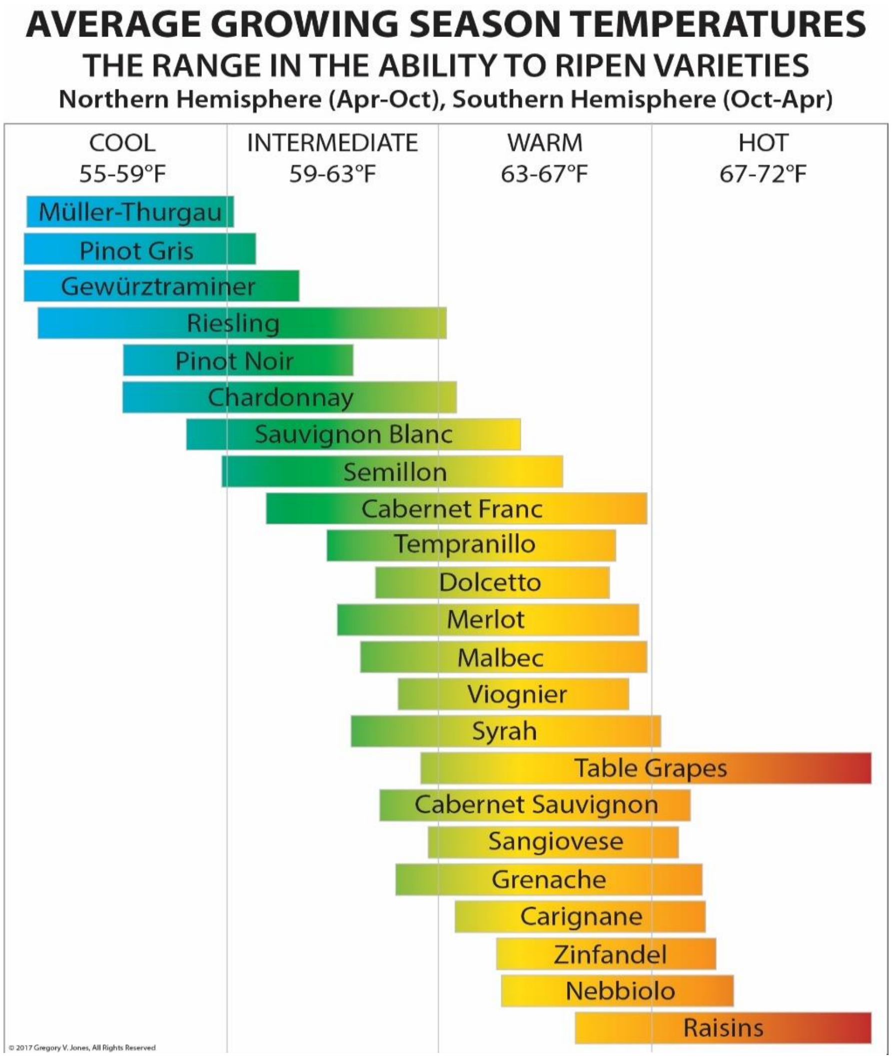

Figure 24. *Grape varietal optimum growing season temperature (Jones 2015).*

It would behoove governments and representatives throughout the district to be aware of the threat that climate change poses to the traditional economy of Western Oregon, to initiate steps to prepare for these changes, and promote efforts at all levels of government to minimize the threat that climate change poses by encouraging renewable energy and discouraging carbon emissions.

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 2014) posing a great risk of extended drought. Farmers and home gardeners in Oregon should be concerned about a compromised future.

Major crops within the region include nursery and greenhouse plants, grass seed, wine grapes, Christmas trees, poultry, dairy, vegetables, small fruits and berries, nuts, grains, and hops (Oregon Department of Fish and Wildlife, 2006). Future climate patterns as projected would significantly alter the growing seasons these crops and even certain viability of some crops within the region. This could negatively impact the economy through a reduction in crop yield 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 and was valued at more than $880 million (Dello and Mote 2010). Christmas tree farms constitute a significant commodity within the tree farm industry, being valued at more than $122 million. Many of the Christmas trees in the region are Grand or Douglas fir which will likely be compromised (see above). Additionally, common varieties such as Noble fir, Frasier fir, Scotch pine, and Nordmann fir could become less viable in the region or at least less able to grow in areas where they previously thrived. Many of the Christmas trees in the region are Douglas or Grand fir (Figures 19 and 23) which are likely to be compromised by our future climate. It is unclear whether the other species will be equally compromised. 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.

Climate change will affect each of these sectors differently. Orchard-based crops will mature more rapidly in higher temperatures affecting crop quality and affect 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 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 serious problem in the district.

Rising temperatures allow both insects and pathogens to develop more rapidly and expand their ranges to regions where they were once not found. Consequently, climate change is expected to enhance invasion risks from many crop diseases, pests, and weeds. In addition, warmer winter temperatures allow more insects to survive, 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 of codling moth populations under baseline conditions and four Global Climate Model (GCM) projections indicate 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).

Potential Health Risk:

According to the Oregon Health Authority (2014), the main climate impacts to health are likely to be: heat, allergens, 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, Native Americans, young children, and pregnant women.

A Timeline for Action:

Based on the projected consequences of the warming lobal climate, international agreements (e.g. UNFCCC 2015) some years ago established 2ºC (preferably 1.5ºC) 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 2ºC 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 1.5ºC 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 1.5ºC 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 2ºC. 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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