Southern Oregon Climate Action Now

SOCAN

Confronting Climate Change

# Climate Change in the Oregon 1st Senate District

**August 2019**

## 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!

**Compiled by Emily Patrick & Alan Journet (patricke@sou.edu, 541-880-6563) (alanjournet@gmail.com, 541-301-4107**

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

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**August, 2019**

## *Global and Regional Temperature:*

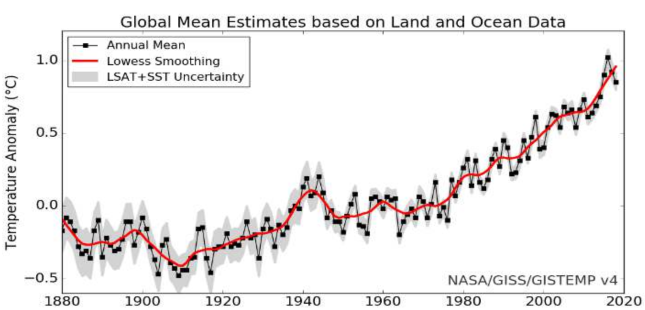



**Figure 1.** Historic global mean temperature 1880 - 2018 based on land and ocean data. (NASA-GISS 2019).

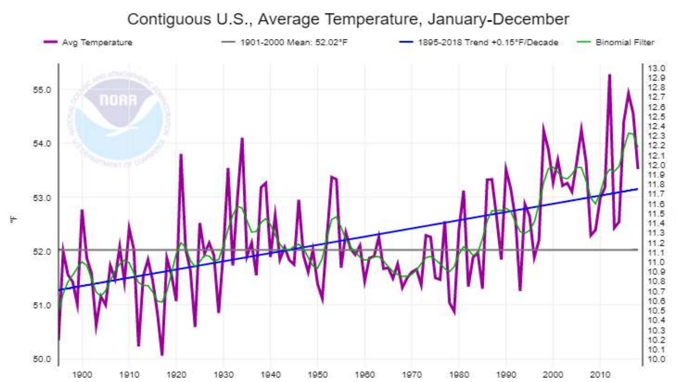



**Figure 2.** Contiguous U.S. Average Annual Temperature 1895 - 2018. (NOAA 2019).

Data from NASA reveal that the Global and U.S. atmospheric temperatures have increased substantially since 1880 (Figures 1 and 2).

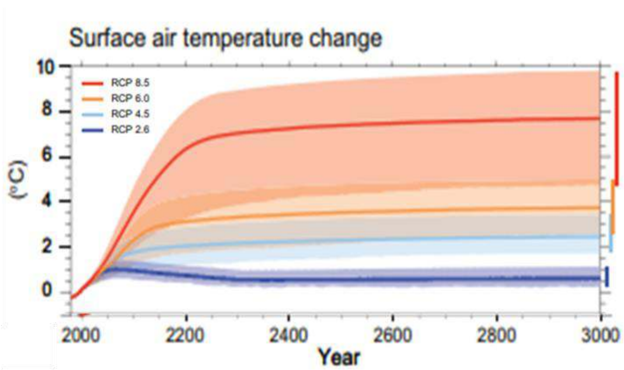



**Figure 3.** Long term global temperature trends according to RCP values. (IPCC 2013).

Meanwhile, global temperature projections are presented (Figure 3) in terms of RCP scenarios, where RCP refers to Representative Concentration Pathway meaning the concentration of greenhouse gases in the atmosphere and the warming impact (radiative forcing) they induce. The RCP 2.6 scenario assumes we rapidly eliminate emissions, whereas RCP 8.5, sometimes also identified as the Business as Usual (BAU) scenario, 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. It is noteworthy that actual temperature trends we have experienced follow the RCP 8.5 scenario which is exactly why it is identified as the Business as Usual (BAU) scenario. Regrettably, we have yet to undertake sufficient action to slow this trend.

Depending on the RCP we follow globally (Figure. 3), this century may result in from a $1^0$C (1.8$^0$F) increase, assuming immediate action, to a high of over a $4^0$C (> $7^0$F) increase. The trajectory beyond the century offers an even more challenging high extreme with an annual extreme approaching $10^0$C ($18^0$F) warmer. Meanwhile, temperature projections for this century in Oregon (Figure 4) suggest a similar range of temperature increases, reaching – as a possible average – over a $13^0$F increase by the end of the century under the BAU scenario (RCP 8.5) in which we continue the current trajectory of accelerating emissions.

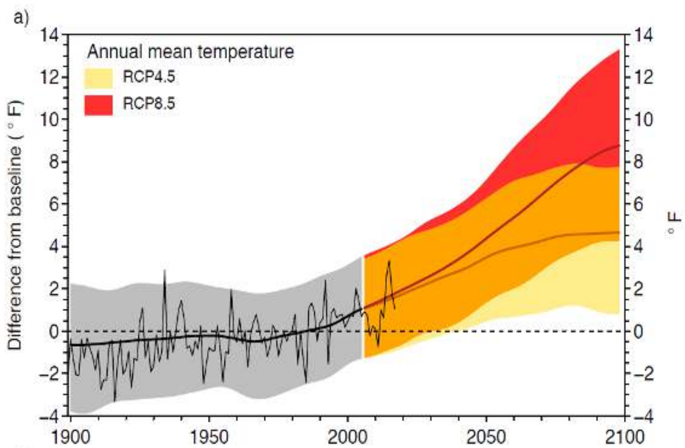



**Figure 4.** Oregon temperature history and projections through the century; baseline: 1970 - 1999 (Mote *et al.* 2019).

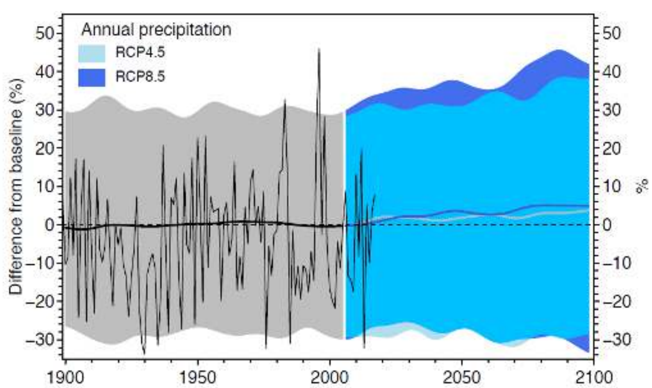



**Figure 5.** Oregon precipitation history and projections through the century; baseline: 1970 - 1999 (Mote *et al.* 2019).

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 and natural and agricultural systems would likely increase because warmer temperatures enhance insect growth and development rates and enable greater overwintering populations. Similarly, invasion of forest, natural, and agricultural systems by drought tolerant invasive species and pests will likely be enhanced.

The lower range for continued temperature increase resulting from the greenhouse gases ***already released*** is inevitable; for this we will simply have to prepare and adapt.

## *Regional Precipitation:*

Much of Oregon (especially between the coast and the Cascades) experiences a Mediterranean climate where winters are cool and wet while summers are warm and dry (Dalton *et al*. 2013).

Fire is a dominant factor determining the plant species composition and diversification in these climates (Rundel *et al.* 2018).

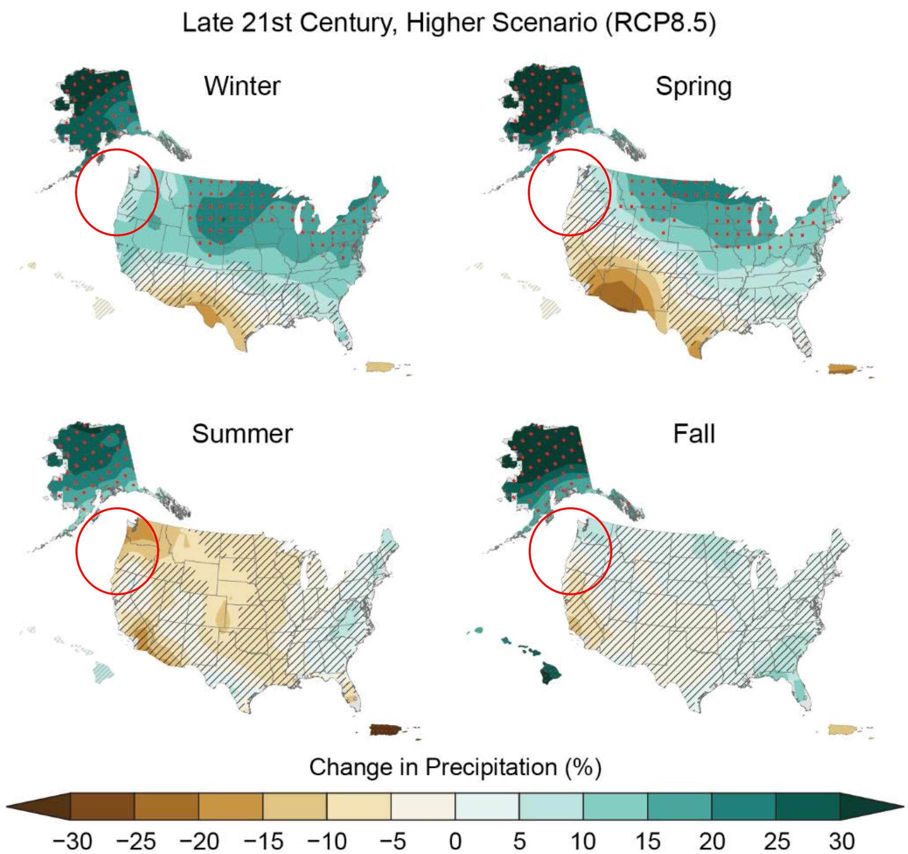



**Figure 6.** Projected late century seasonal precipitation patterns in the U.S. compared to the 1900 – 1960 average (USGCRP 2018).

Annual precipitation is expected to increase very slightly in Oregon through the balance of this century (Figure 5). However, the 2018 US Climate Change Assessment Report (USGCRP 2018) provides projections for seasonal late century precipitation patterns (Figure 6) according to the 'business as usual' 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, in our current western U.S. Mediterranean 'winter wet - summer dry' climate, summers will likely be considerably drier.

Increasing temperature combined with the trend towards drier summers (Figure 6) will likely counter any increase in precipitation. Thus, drought conditions will likely increase. 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 rejuvenates soil moisture continues. This will likely enhance floods, soil erosion and potentially landslides.

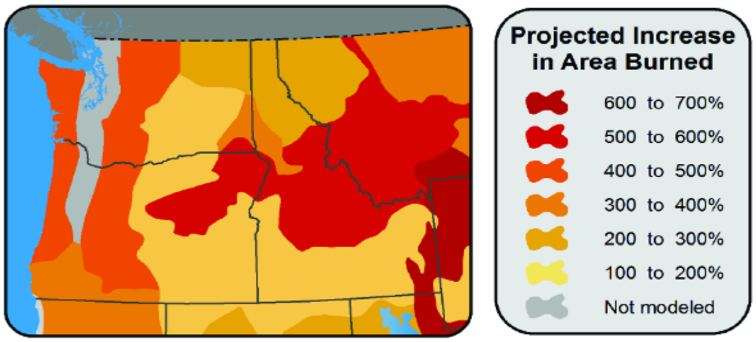



**Figure 7.** Anticipated wildfire consequences of a 2.2$^{0}$F warming in area burned (Melillo *et al.* 2014).

Stream and river flow occurring during summer/fall will decline and become warmer compromising many iconic Pacific Northwest cold-water and migratory aquatic species. Meanwhile, peak river flow will continue to advance further potentially compromising migratory fish species.

Over a decade ago, Westerling *et al.* (2006) reported that growing season temperature and date of spring snowmelt served as major predictor of fire season severity. Our future climate will exacerbate this problem

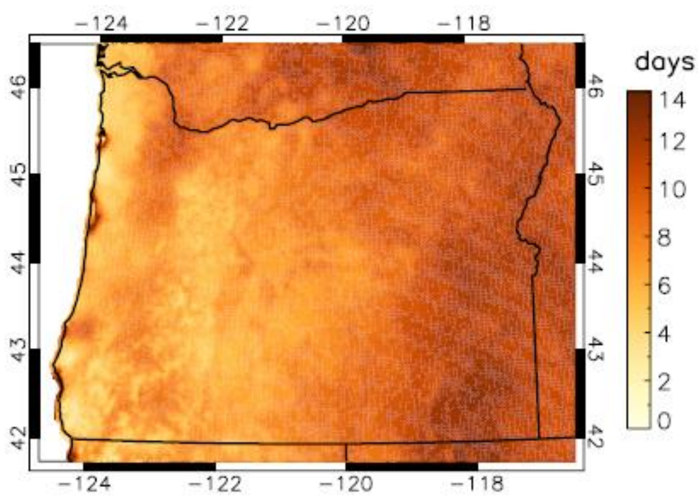



**Figure 8.** Increase in number of days experiencing high fire risk by mid- century (2040 - 2069) compared to the end of the last century (1971-2000). (Mote *et al.* 2019).

Melillo *et al.* (2014) offered wildfire projections for area burned consequent upon just a 2.2$^{0}$F warming (Figure 7), a condition potentially evident within a couple of decades (Figure 4). Meanwhile, 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 evident (Figure 8).

The fire season, already extended by 105 days since 1970s (Kenward *et al.* 2016), will likely become longer and more severe in Oregon. Both human safety and human health will likely be threatened.

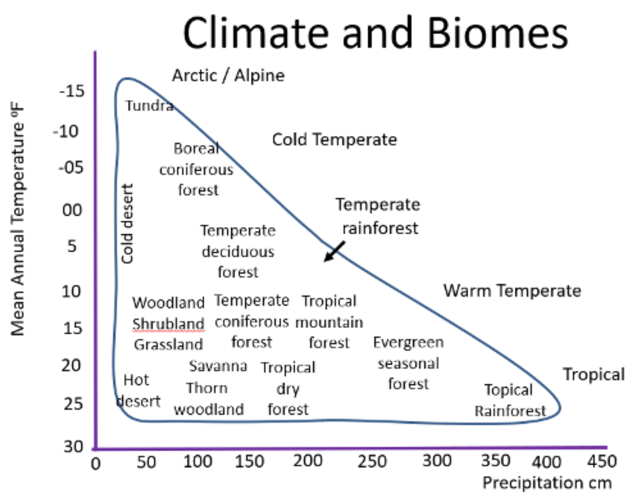



**Figure 9**. Global distribution of natural ecological systems in relation to mean annual temperature and precipitation patterns. (Modified from Whittaker 1975).

## *Natural System Consequences*

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 9). 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 composed. This will be especially true for biomes currently existing at the edge of their climatic range. It is especially worth comparing these temperature ranges to the potential shifts in Oregon's temperature through the century (Figure 4). From this, it is evident that between many and most of our state's precious natural systems will be threatened if not eliminated under future conditions. It is worth remembering 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, will likely compromise agriculture and forestry in the state. Indeed, Dalton *et al.* (2017) indicate not only that "suitable climates for many important tree species and vegetation types may change considerably by the end of the 21$^{st}$ century…" but also that: "different trees have varying degrees of sensitivity to climate change and adaptive capacity." This issue will be explored in the local district discussion below.

## *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 sea surface temperature, warming of oceans is already documented with further increases at the rate of 0.05°C to 0.5°C per decade expected (Alexander *et al.* 2018). Besides influencing species directly, temperature changes impact such factors and events as dissolved oxygen concentration, 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). As the ocean warms, it inevitably expands and sea level 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 a subsiding coastal plate 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 sea level rise along the coast. In Oregon, the impact of the oceanic Juan de Fuca plate sliding under the continental North American plate is a rising continental plate (Lieberman 2012) countering the 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, indicated that by century's end, the actual sea level rise off the coast of Oregon could plausibly reach 8 feet. 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 is 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 consequence 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 carbon-based shells since either, they are unable to form shells in acid conditions, or they lose shells already established. Oysters suffering directly, and salmon indirectly, have been noted as particularly threatened by acidification. 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**

Although climate change has a far greater direct effect on rural communities than urban areas, it must be remembered that urban areas rely on healthy rural regions for their water supply and their agricultural, and forestry products. 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 as reduced snowpack diminishes skiing, reduced river flow potentially diminishes fishing and water recreation, rising seas compromise our coastal communities, and increasing wildfire risk compromises our forests and air quality. 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 impose a greater burden on our natural resources and dwindling water supplies.

## *The 1st Oregon Senate District Climate History and Projections:*

Although climate change is a complex issue, current models indicate several important trends in weather and climate that Oregon's 1st senate district is likely to experience if greenhouse gas emissions continue to increase. These trends include an increase in mean annual temperature and a decrease in overall precipitation (including both rain and snowfall).

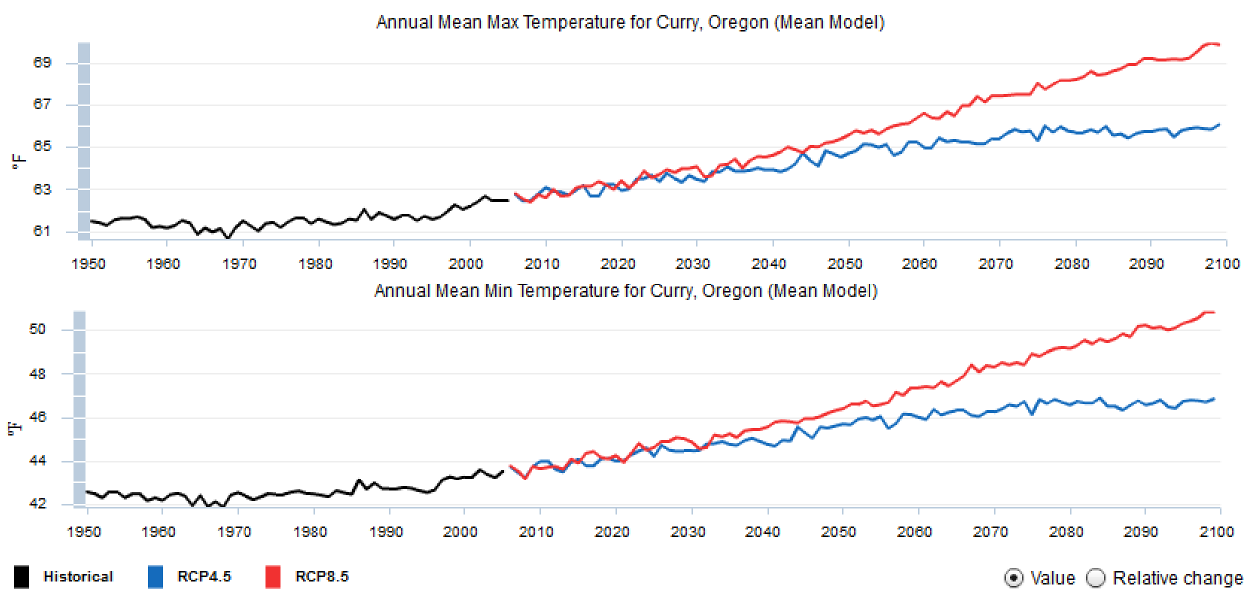



**Figure 10.** Recent historic temperature trend and projections for Curry County, Oregon (USGS 2019).

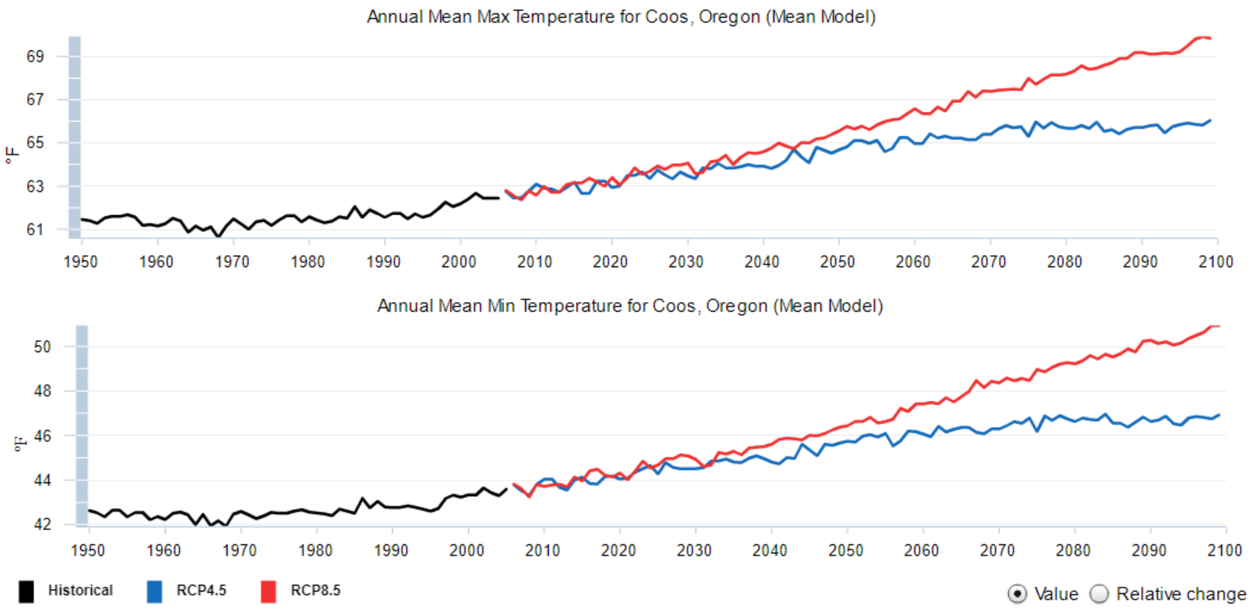



**Figure 11.** Recent historic temperature trend and projections for Coos County, Oregon (USGS 2019).

Climate trends (black line) and projections are provided by the United States Geological Survey (USGS 2019). The red line represents the Business As usual (BAU) projected scenario of accelerating fossil fuel use and greenhouse gas emissions while the blue line assumes some reduction in that trajectory.

Temperature trends and projections for Curry and Coos Counties are presented in Figure 10 and 11 while Josephine and Douglas Counties are presented in Figures 12 and 13.

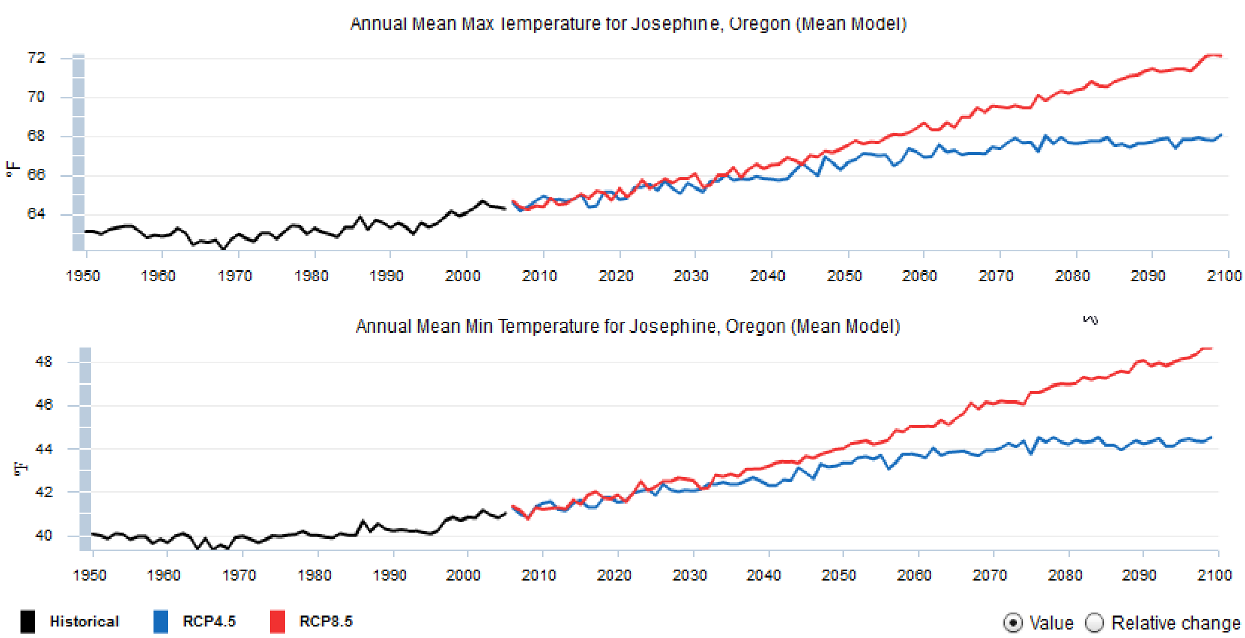



**Figure 12.** Recent historic temperature trend and projections for Josephine County, Oregon (USGS 2019).

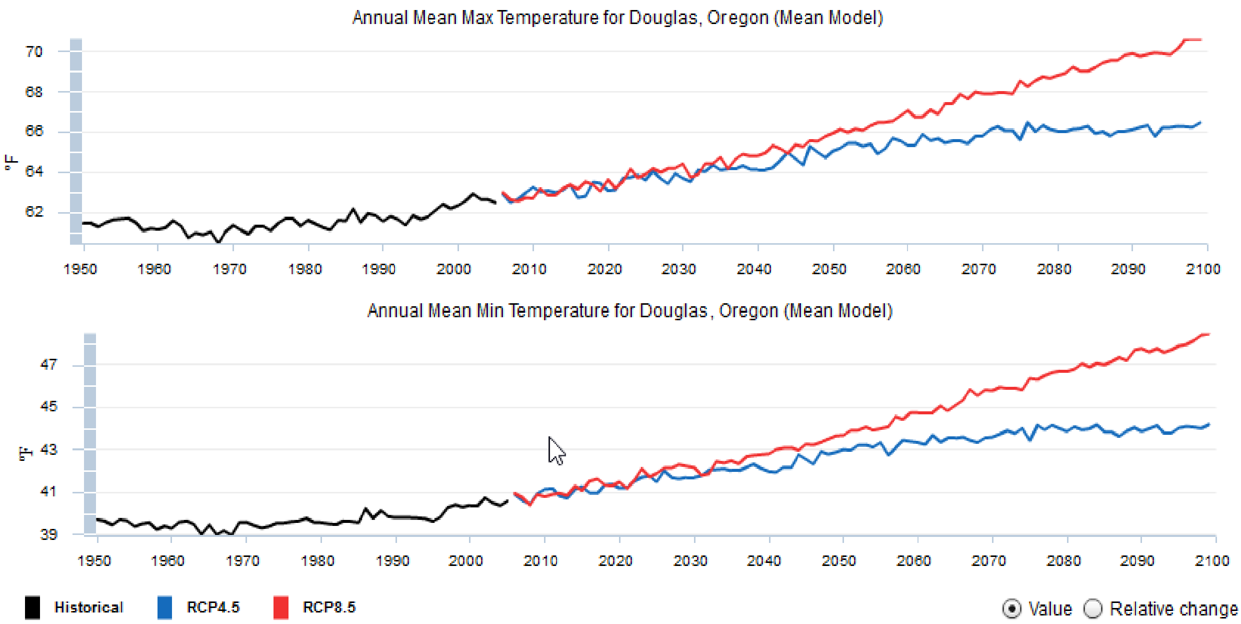



**Figure 13.** Recent historic temperature trend and projections for Douglas County, Oregon USGS 2019.

For Curry County, the increase to 2005 compared to the 1950 – 2005 average was 1°F while by 2100 warming is expected to be about 8.3°F above that late 20th Century average according to the BAU scenario. For Coos County, these values are 1°F and 8.4°F respectively, For Josephine County the values are 1.1°F and 8.8°F respectively and for Douglas Co they are 1°F and 8.85°F respectively. The pattern of greater warming inland than at the coast extends across the state.

The historic and projected precipitation pattern for Curry County is presented in Figure 14 with an average precipitation of 116 -118 inches. Both historical trend and projections suggest little or no change annually while the future variability increases with more pronounced wet and dry years according to both scenarios.

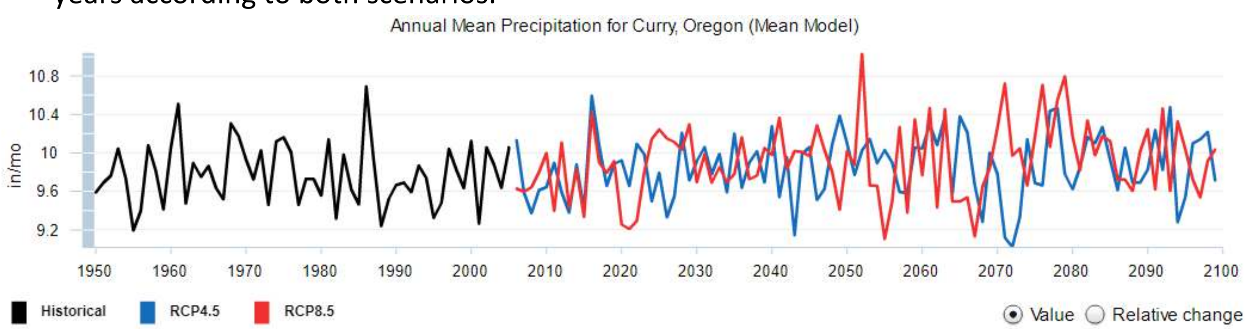



**Figure 14**. Historic trend and projections for precipitation in Coos County, Oregon (USGS 2019)

Coos, Josephine, and Douglas Counties exhibit similar patterns though the annual average is about 73-74 inches for Coos, 62 inches for Josephine and 55 inches for Douglas County.

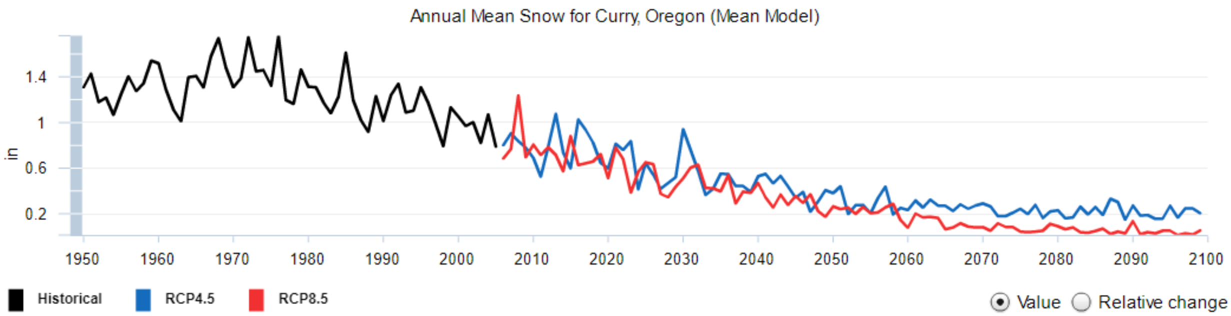



Figure 15. Snowfall history and projections for Curry County (USGS 2019).

The snowfall trend and projection (measured as Snow Water Equivalent) for Curry County is indicated in Figure 15. The trend and projections are typical of surrounding counties though Coos County has much lower values, Josephine County is about the same and Douglas County slightly higher. The trend of reducing winter snow water equivalent accumulation has many adverse impacts on the coastal valleys such as reduced summer water for natural communities, crop irrigation, and human consumption. The lack of high elevation snowpack (these patterns are evident also in Jackson and Klamath Counties) also suggests a more severe wildfire season. The projected trend in snowpack is for a continued decline, possible to only 10% or less of historical levels by late century. The trend towards precipitation falling in heavy downpours rather than light rain has occurred historically and will continue.  This trend, combined with decreased stream flow, resulting from declining high elevation snowfall poses a serious threat to those agricultural activities dependent on late summer and early fall snowmelt as a water source for irrigation. Migratory fish species will also be negatively affected.

According to National Park data, the trend in the declining mid-elevation snowfall at Crater Lake has been occurring since the 1930's. This trend is repeated in the mid elevation northern Siskiyou's which lost 13% snowpack in the second half of the last century (Howat and Tulascyk 2005).

The current trend towards precipitation falling in more frequent heavy thunderstorms as opposed to the light rainfall that rejuvenate soil moisture is also expected to continue (Karl *et al.* 2009; USGCRP 2017). This means an increased risk of floods, soil erosion and landslides.

## *Federal Congressional District 4*

Oregon State Senate District 4 falls entirely within Federal Congressional District 4.  The historic temperature trend for this Congressional District (Figure 16) shows an increase of app 2.2°F during the last century, with a warming trend since 1960 of 3.7°F per century.  These values are comparable with this State Senate District and the state as a whole although exhibiting the slightly slower trend typical of coastal regions.

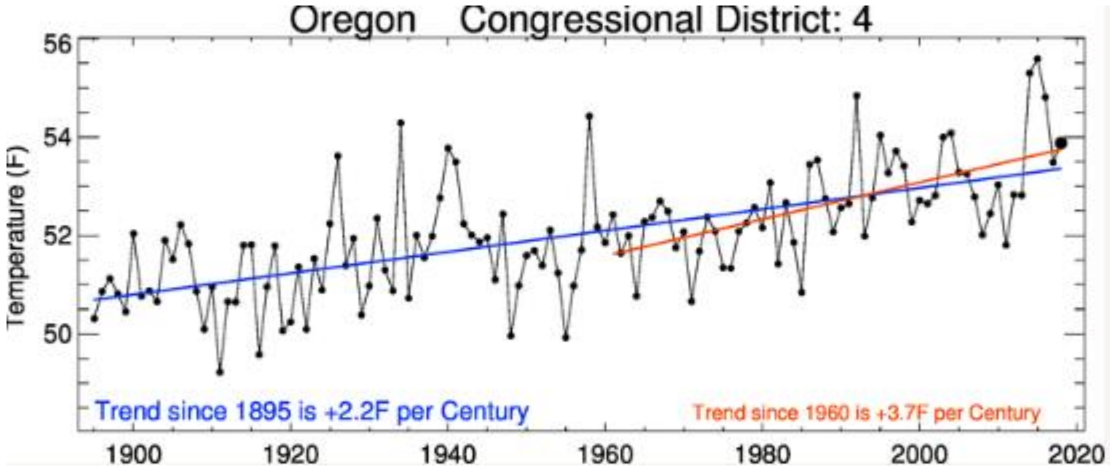


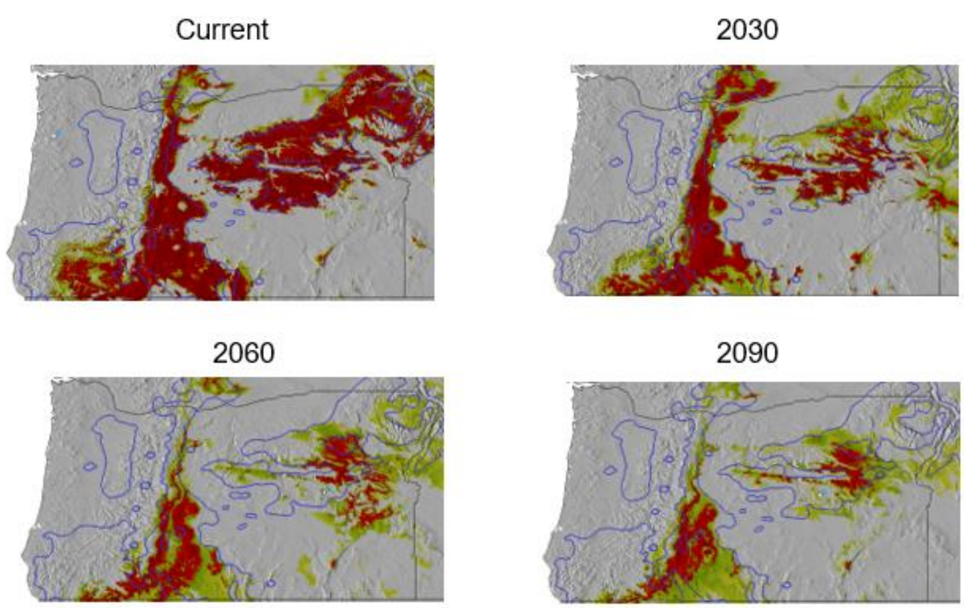

**Figure 16.** Temperature trend for Federal Congressional District 4 (CTT 2018).

## *Oregon 1st Senate District Economy:*

Oregon's 1st senate district boasts a diverse economy, made up in part by tourism, agriculture, and forestry. All sectors will undoubtedly feel the effects of climate change as it progresses.

The region takes pride in being a major timber producer with Ponderosa pine, Douglas fir, Incense cedar, Sugar pine, White fir, Western hemlock, and Lodgepole pine continuing to support the regional economy. If levels of carbon dioxide in our atmosphere continue to

**Figure 17** Ponderosa pine (*Pinus ponderosa*) Current and Projected Distribution through the 21st Century (Crookston 2019).



increase stimulating climate change as expected, the viability and range of these species will also likely be affected. Current projections for the range and distribution of these species (Figures 17 – 24) through the 21st Century as climate change progresses indicate

**Figure 18** Douglas fir (*Psuedotsuga menzeisii*) current and projected distribution through the 21st Century (Crookston 2019).

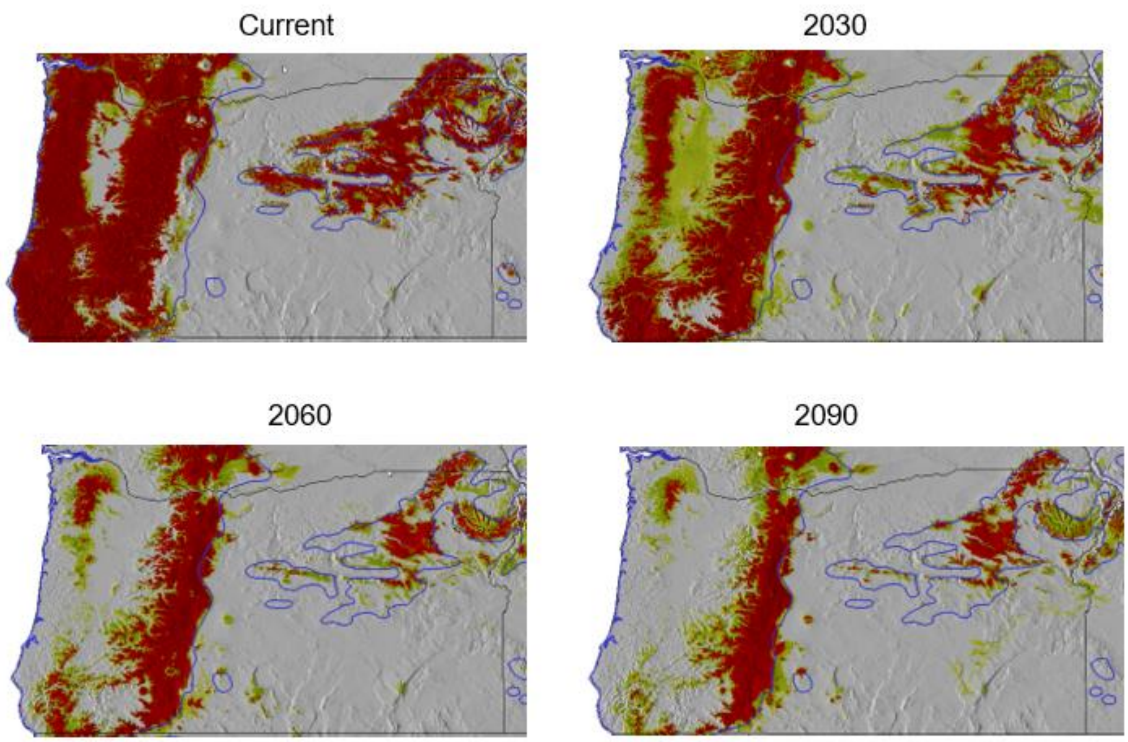
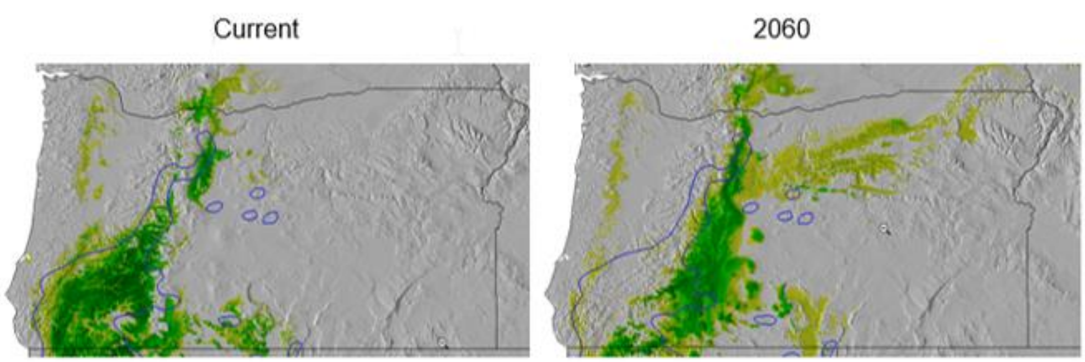



**Figure 19.** Incense cedar (*Calocedrus decurrens*) Current and Projected distribution (Crookston 2019).




2030 and 2090 not available

**Figure 20.** Sugar pine (*Pinus lamertiana*) Current and Projected distribution (Crookston 2019).

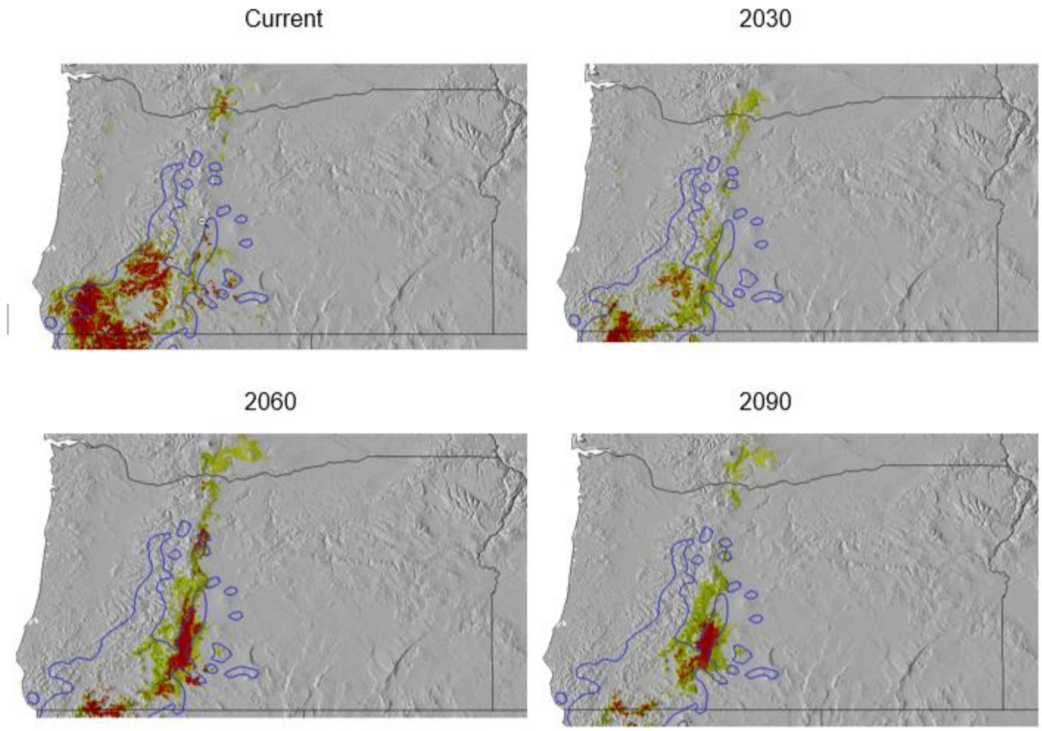
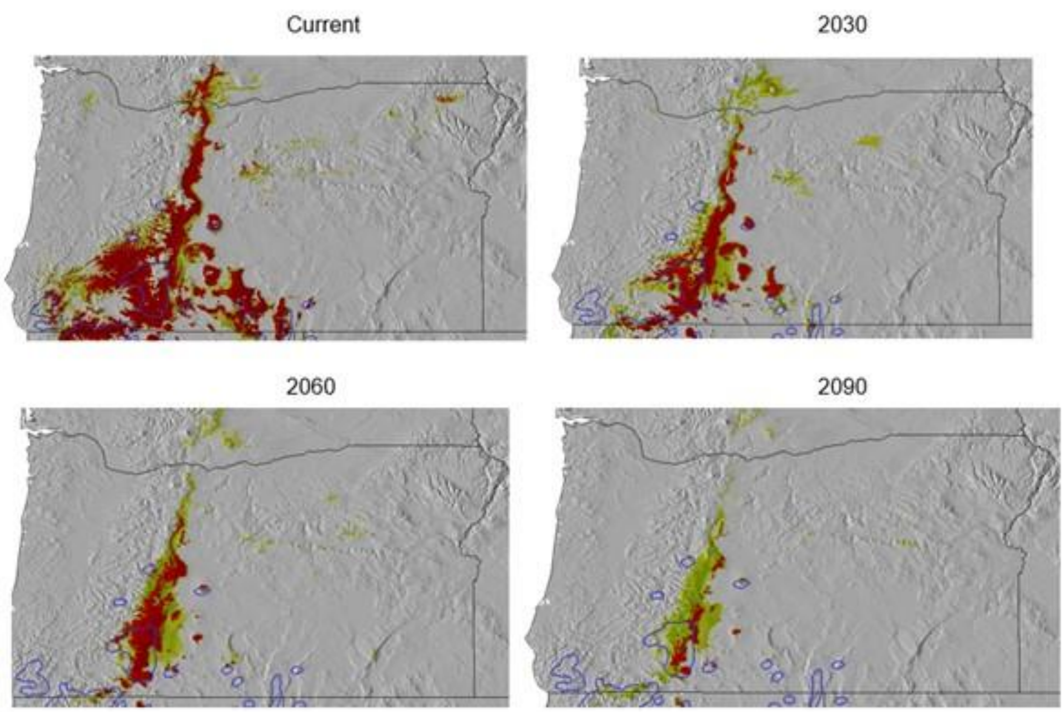


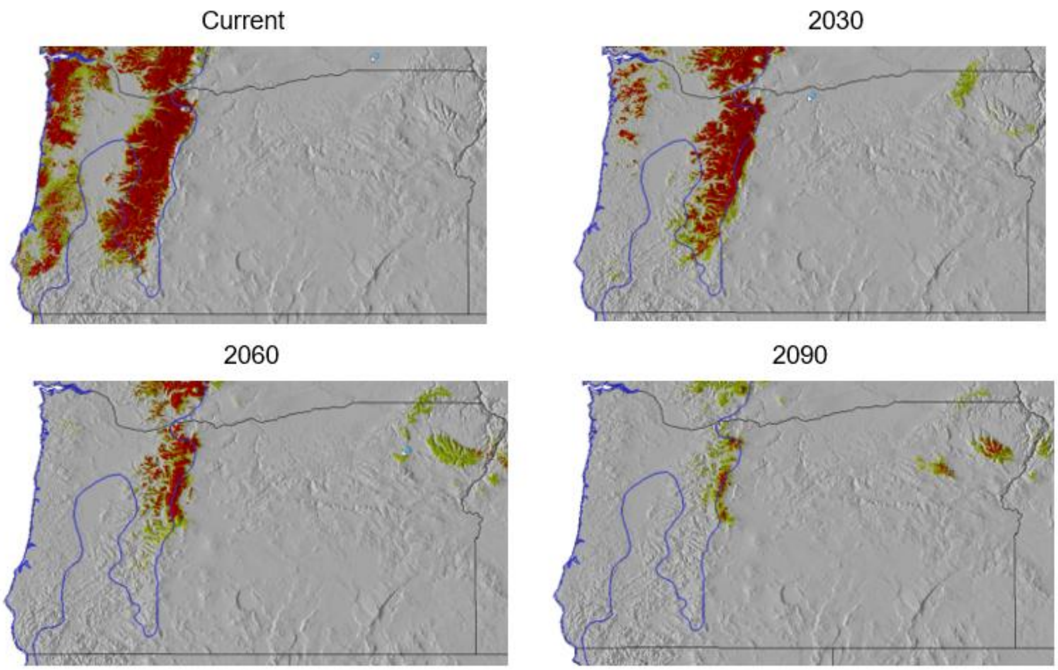

**Figure 21.** White fir (*Abies concolor*) Current and Projected distribution (Crookston 2019).




remarkable reductions in the range of appropriate growing conditions for most species.

High tree viability is indicated in red, low viability in green and absence in areas without

**Figure 22** Western hemlock (*Tsuga heterophylla*) current and projected distribution through the 21st Century (Crookston 2019).




color.

**Figure 23.** Lodgepole pine (*Pinus contorta*) current and projected distribution (Crookston 2019).

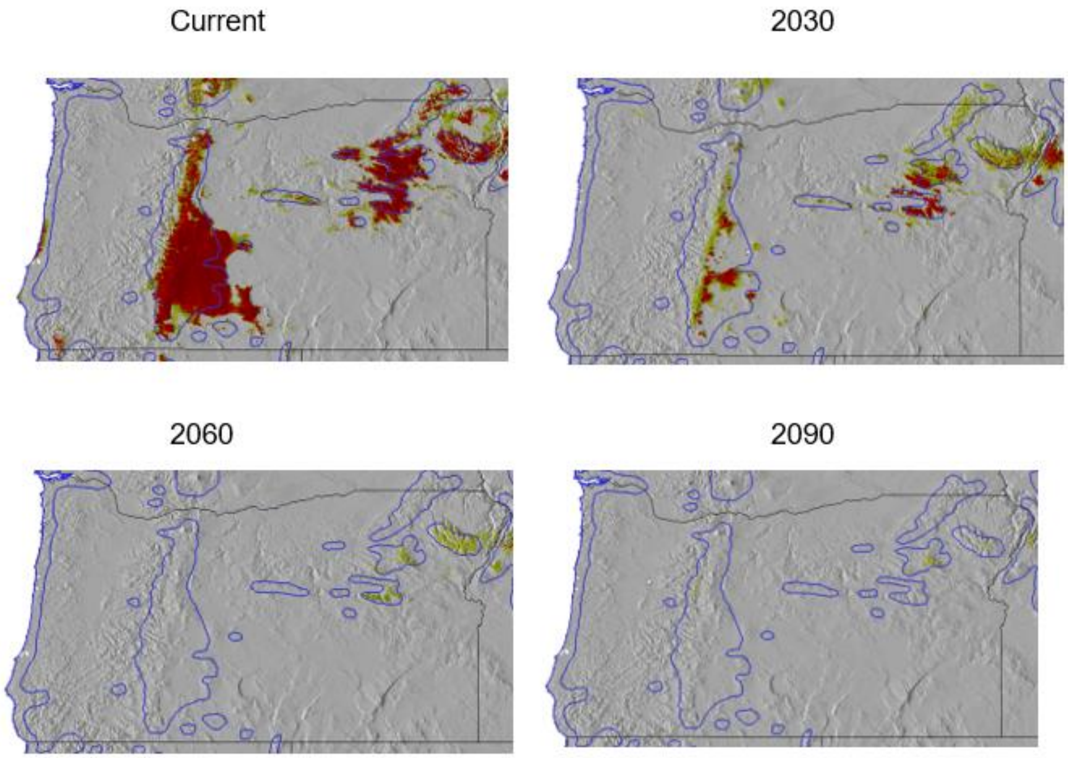
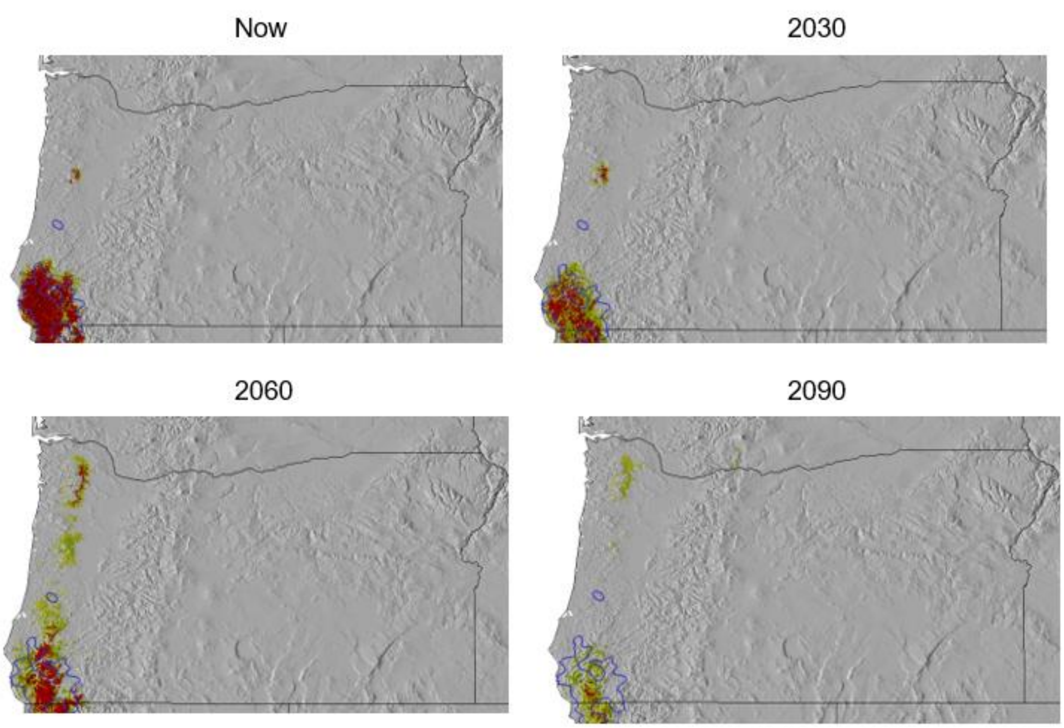



**Figure 24.** Tanoak (*Lithicarpus densiflorus)* Current and Future Distribution (Crookston 2019).



What these projections suggest is that Oregon's 1st Senate district will become a less favorable place for these species as the climate changes. If we do nothing to mitigate climate change, the forestry industry in Oregon's 1st Senate district will face continuing challenges as the viability of these species drop and they become less abundant.

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. Halafsky *et al.* (2016) discuss the potential and disturbing impacts of climate change on 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 2014) posing a great risk of extended drought. Farmers and home gardeners in Oregon should be concerned about a compromised future.

The region is justifiably proud of its quality wine production and anticipates expanding gthis crop. Thus, the Umpqua Community College recently established a wine program. The predominant wine varietals in this area are Pinot Gris, Syrah, Merlot, Cabernet Sauvignon, Pinot Noir, and Chardonnay. Figure 25 depicts the growing season optimal temperatures for varietals grown in the region including the impact climate change will likely have on wine growing. While many of the grape varietals grown in this area seem reasonably well-adapted to mid-century growing season temperatures, even some of the warm climate varietals could be compromised by late century. However, of particular note are the cooler growing season varietals of the region (especially Illinois Valley wines) such as Pinot gris, and Gewürtstraminer, which could be severely compromised even by mid-century. soil moisture posing a great risk of extended drought. Farmers and home gardeners in Senate District 1 should be concerned about a compromised future. Future climate patterns as projected would negatively impact the economy through a reduction in crop yields since increasing temperature consistently reduces crop productivity, and a potential for lost tourism due to wildfire.

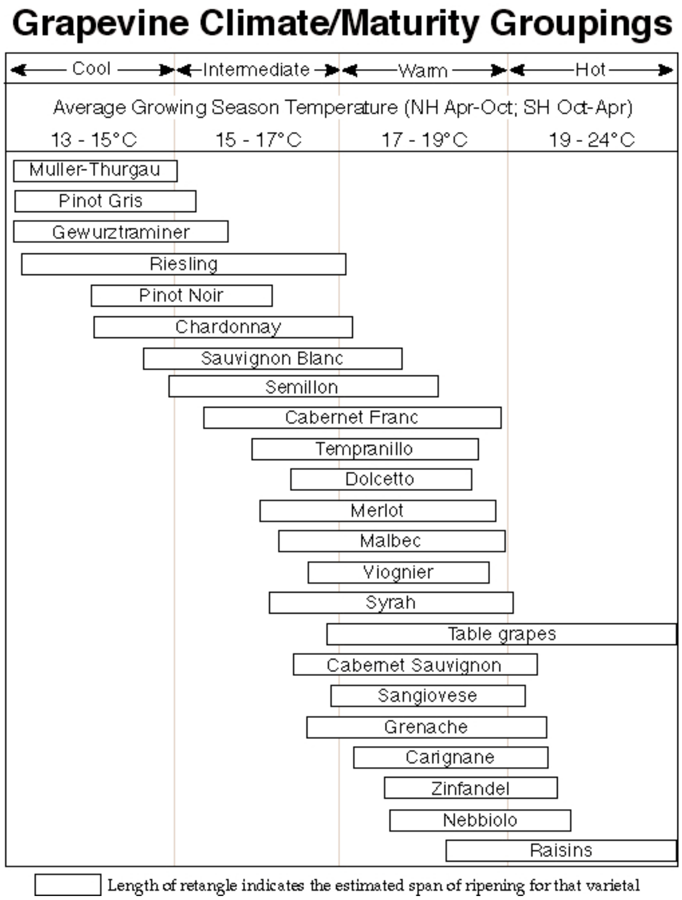



**Figure 25.** Grape varietal optimum growing season temperature (Jones 2015).

If elected leaders at all levels of government do not act and climate change continues as projected, Oregon's 1st Senate District will face a barrage of negative consequences. Not only will the natural order of this beautiful district be disrupted, these phenomena will have economic impacts as well. Acting now could mitigate some of the threatening consequences of climate change.

## *Southern Oregon Coastal Concerns*

Mote *at al.* (2019) report that coastal Oregon can expect more severe winter storms, increased ocean temperature is likely to produce harmful algal blooms affecting commercial, recreational, and tribal fisheries. Meanwhile, ocean acidification will compromise fisheries, especially shellfish, and sea level rise, plausibly reaching over 8 feet by 2100, will increase the risk of flooding, coastal erosion and threaten estuaries and coastal marshes.

Because much of Oregon's 1st senate district lies along the state's famed coastline, this district has special concerns to address as climate change progresses. One result of climate change is a rise in sea level. If sea levels continue to rise throughout this and the next century, then Oregon's 1st senate district could face development and infrastructure problems in its coastal cities. The 1st Senate District's economy relies heavily on tourism generated by these popular vacation spots near the coast, and much of this revenue could be lost if nothing is done to buffer coastal cities from the negative impacts of climate change. Predictions for coastal

Oregon range from 6 inches over the next century to a sea level rise of 5 feet. Even a sea level rise of 6 inches could be devastating to coastal Oregon's infrastructure, economic development, and the booming tourism industry.

## *Potential Health Risk:*

According to the Oregon Health Authority (2014), the main climate impacts to health are likely to be: storms, floods, and sea level rise. The main health concerns resulting from these are: disruption in core services, injuries, displacement, landslides, income loss, economic instability, and mental health impacts. Communities that are especially vulnerable will be: low-income households, older adults, people living on steep slopes, farmers of fish and shellfish, first responders, and children and pregnant women. The increased smoke and particulate matter produced by wildfire are also becoming a serious health concern throughout the District.

## *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$^{o}$C (preferably 1.5$^{o}$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$^{o}$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$^{o}$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$^{o}$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$^{o}$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 $24^{th}$ 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 capture and sequestration, 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 based on the assumption 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.

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