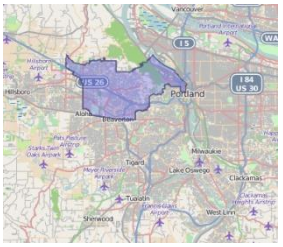
Southern Oregon Climate Action Now
SOCAN
Confronting Climate Change

Climate Change in Oregon's 17th Senate District

July 2017



History, Projections, and Consequences.

1. The last half of the 20th Century witnessed an annual temperature increase of about 1°F. Meanwhile, projections suggest a rise of some 7-9°F is possible by the end of the 21st Century, compared to the average for that period, with summers rising much more than winters.
2. Annual average precipitation is expected to remain steady, with winters expected to be a little wetter and summers drier, with more heavy downpours promoting floods and soil erosion.
3. Snowfall and snowpack accumulation, already dwindling, are projected to reduce to less than 15% of historic levels further threatening agriculture as snowmelt arrives earlier and summer and fall water availability declines.
4. Wildfires, already exhibiting a 2.5 month longer season than in the 1970s, are expected to become more serious, with some 200 to 300 percent greater area being consumed by mid-century.
5. Increased wildfires will likely pose a substantially greater problem not only for forests and tourism but also for human health.
6. Climatic shifts themselves will likely compromise the viability of important forest and timber species such as Douglas fir important in the district
7. With reduced snowpack and summer/fall stream flow, warmer water will likely compromise the ability of streams and rivers to support iconic freshwater species of the region. Additionally, changes in river flows could disrupt hydroelectric power generation.
8. Action is urgent because at the current accelerating emissions trajectory, we will exhaust our allowance in 17 years if we wish to maintain the global temperature increase below 2°C (3.6°F) as international agreements dictate.
9. Main health impacts 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. Vulnerable communities 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.

Compiled by Alan Journet (alanjournet@gmail.com, 541-301-4107) & Brianne Foster (fosterb2@sou.edu, 971-404-6181) April, 2015 April, 2015

For more information on these points, see the full summary at: http://socan.eco/oregon-legislative-districts/

This Page Intentionally Left Blank

Southern Oregon Climate Action Now

SOCAN

Confronting Climate Change

Climate Change in the Oregon 17th Senate District

Compiled by Alan Journet

(alanjournet@gmail.com, 541-301-4107)

July, 2017

Global and Regional Temperature:

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

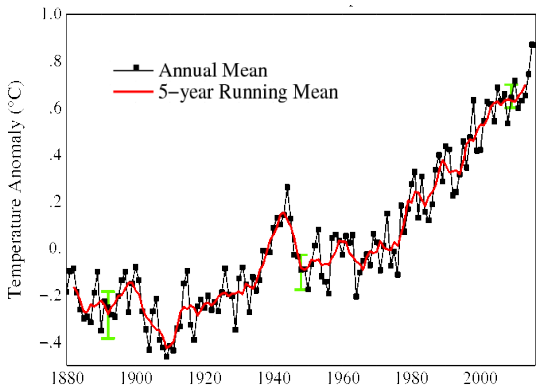


Figure 1. Historic global temperature trend NASA Goddard Institute for Space Studies 2017.

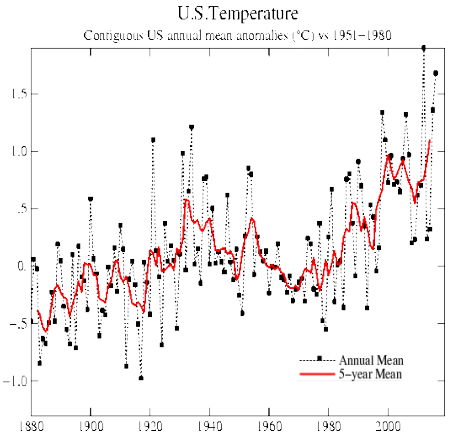


Figure 2. Historic U.S temperature trend. NASA Goddard Institute for Space Studies 2017.

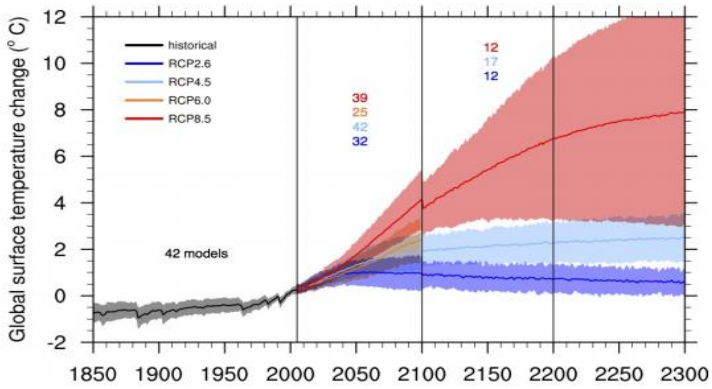


Figure 3. Intergovernmental Panel on Climate Change 2013 global projections. http://www.climatechange2013.org/images/uploads/WGIAR5_WGI-12Doc2b_FinalDraft_Chapter12.pdf

Depending on the RCP (Representative [Carbon] Concentration Pathway) we follow globally (Fig. 3), this century may result in from a 2^0F increase, assuming immediate action, to a high of over a 9^0F increase. The trajectory beyond the century offers an even more challenging high extreme with an extreme 20^0F hotter. Meanwhile, temperature projections for the Pacific Northwest (Figure 4) suggest a similar range of temperature increases are possible, reaching – as an average – nearly a 12^0F increase by the end of the century

under the Business as Usual scenario (RCP 8.5) in which we continue the current trajectory of accelerating emissions.

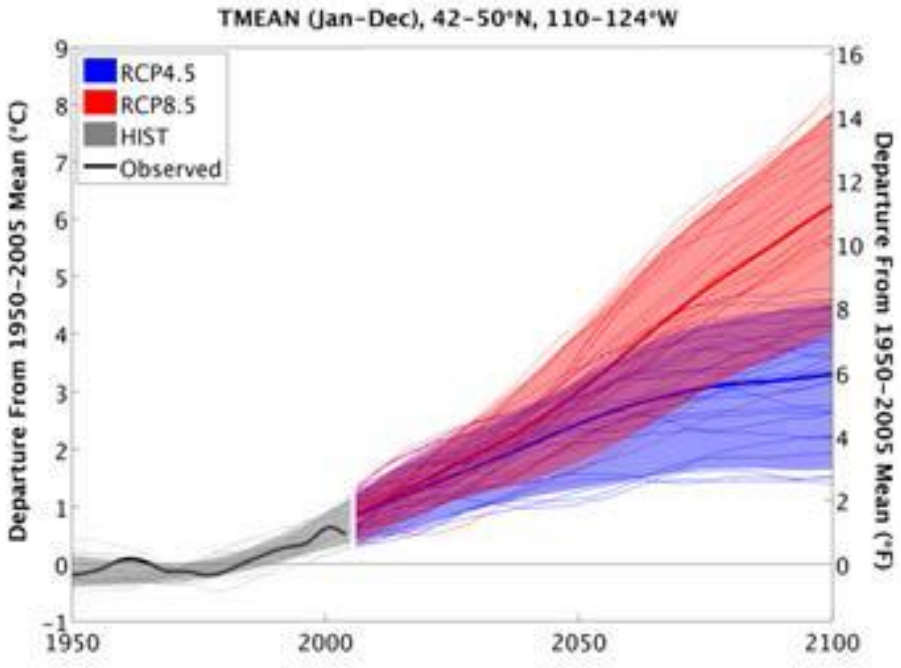


Figure 4. Oregon temperature history and projections through the century (Dalton *et al.* 2013).
http://library.state.or.us/repository/2010/201012011104133/summaries.pdf

The higher range of temperature increase would be unmanageable. It would devastate natural systems (forests, woodlands, shrub lands and the species they support) 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 greater overwintering populations. Similarly, invasion of 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:

The 2013 US Climate Change Assessment (Melillo *et al.* 2014) provides projections for future precipitation (Figure 5) 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, summers will likely be considerably drier.

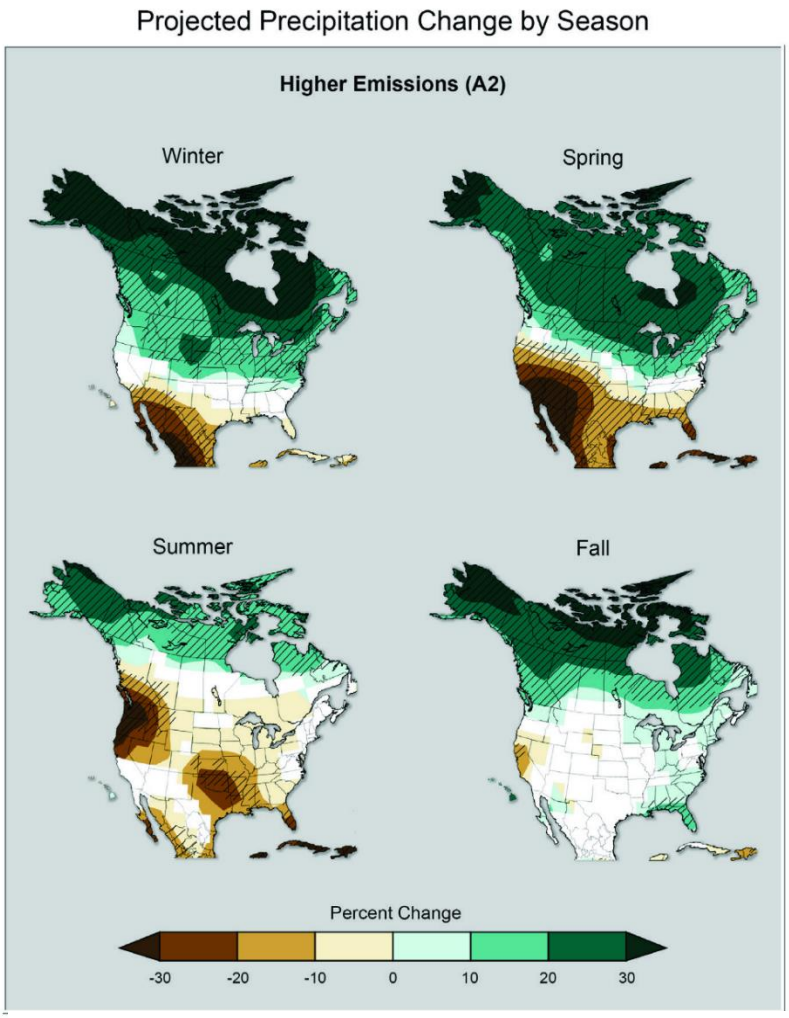


Figure 5. Projected precipitation patterns in the U.S. comparing 2071 – 2099 to the 1900 – 1960 average (Melillo *et al.* 2014). http://www.globalchange.gov/what-we-do/assessment

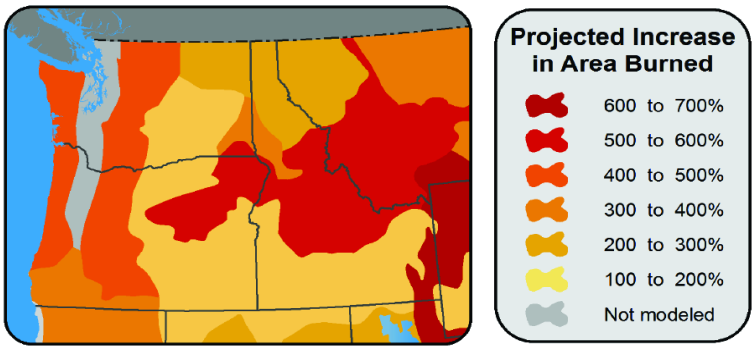


Figure 6. Anticipated wildfire consequences of a 2.2^{o}F warming in area burned (Melillo *et al.* 2014). http://www.globalchange.gov/what-we-do/assessment

Water resources, already severely compromised in many locations, will become more threatened as snowpack declines and precipitation occurs as severe storms rather than the typical light drizzle that rejuvenates soil moisture. This trend will likely enhance floods, soil erosion and potentially landslides.

The reduced stream and river flow occurring during summer/fall will be warmer compromising many iconic Pacific Northwest cold-water aquatic species.

Melillo *et al.* (2013) also offered wildfire projections accompanying just a 2.2^{0}F warming, a condition potentially evident by mid-century (Figure 6).

The fire season, already extended by 2.5 months since 1970 (Westerling *et al.* 2006), will likely become longer and more severe in Oregon, with two to six times as many acres burned. Both human safety and human health will likely be threatened.

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 between 1900 and this century are already documented with further increases to 2.0 ^{o}F by mid-century expected. 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^{o}C (approximately 37^{o}F). As the ocean warms, it 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. Projections for Newport suggest a potential century rise of between 6" and nearly five feet. Higher sea level poses a greater threat than merely its impact on tidal level. 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 have not received any serious consideration – 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 Acidification. Serious as 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, our oceans are becoming more acidic. This is detrimental for marine organisms with carbon-based shells since 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.

The 17th Oregon Senate District Climate History and Projections:

Historic trends and mean minimum and maximum projections temperature for Washington and Multnomah Counties (Figures 7 and 8) indicate warming since the 1970s and a future rise of a further 7- 9°F if the business as usual scenario is followed – but less if we reduce emissions.

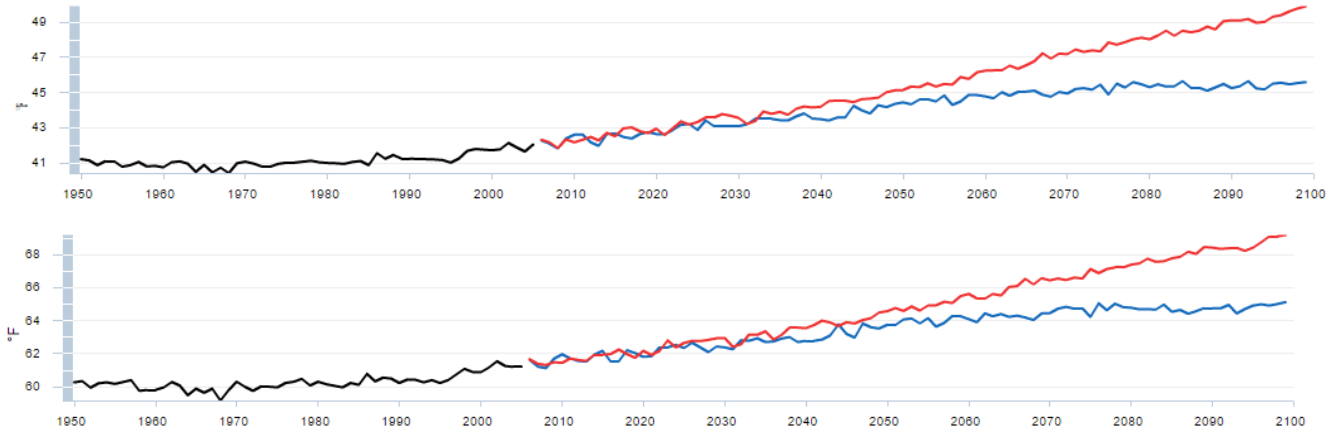


Figure 7. Historic and projected trends for mean minimum and maximum temperatures for Washington County, Oregon; upper is mean maximum, lower is mean minimum (USGS 2017).

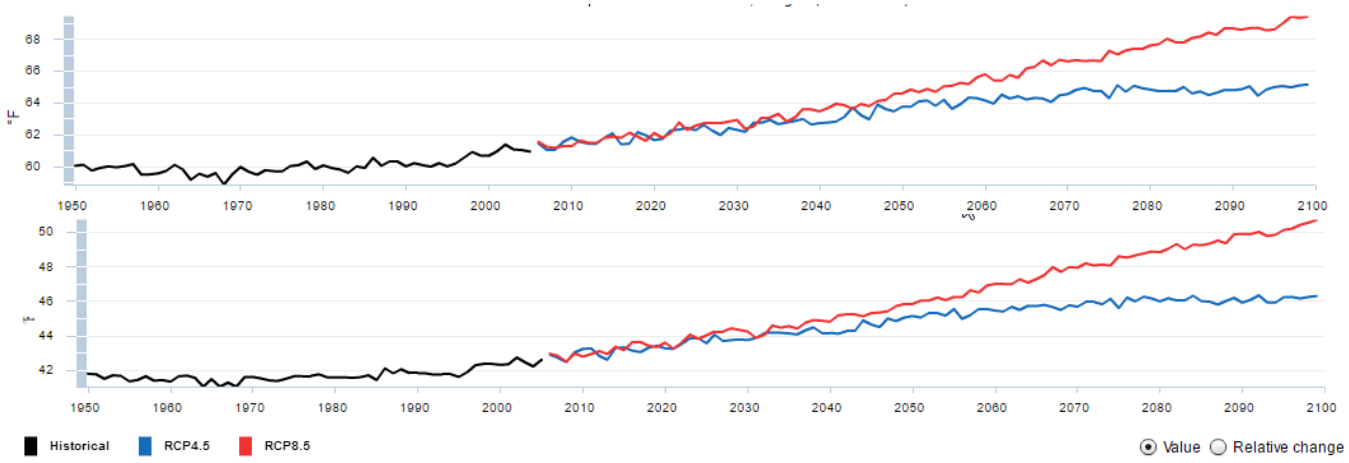


Figure 8. Historic and projected trends for mean minimum and maximum temperatures for Multnomah County, Oregon; upper is mean maximum, lower is mean minimum (USGS 2017).

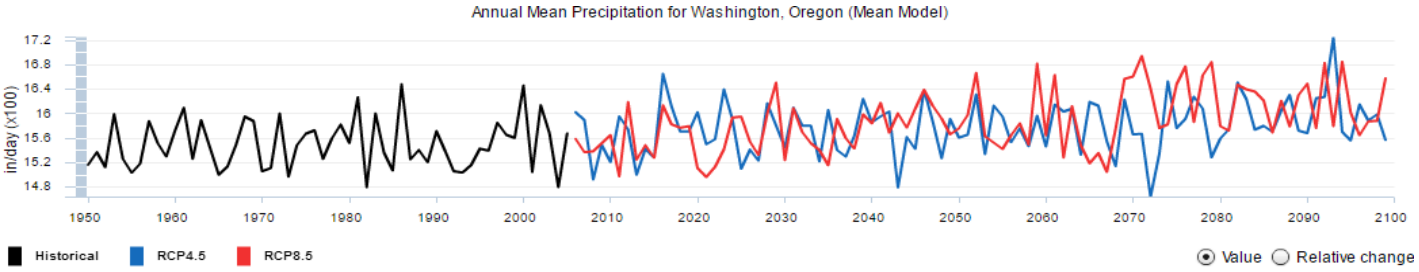


Figure 9. Historic and projected trend for precipitation in Washington County, Oregon (USGS 2017).

Precipitation history and trends for Washington County (Figure 9), indicate a historical trend of steady precipitation that is likely to continue. The current trend towards precipitation falling in more frequent downpours as opposed to the light rainfalls 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 (Vynne *et al.* 2011).

Meanwhile, the projected precipitation seasonal variation for the region (Figure 5) suggests a likelihood of increased summer droughts.

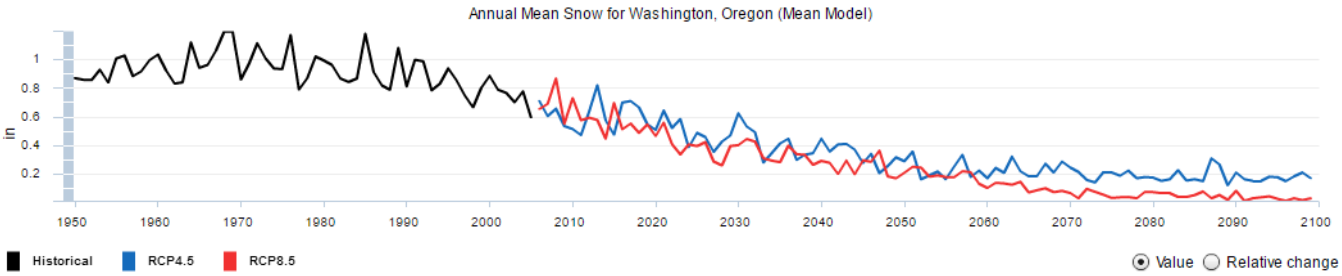


Figure 10. Snowfall history and projections for Washington County (USGA 2017).

The historic trend and projections for snowfall in Washington County (Figure 10)

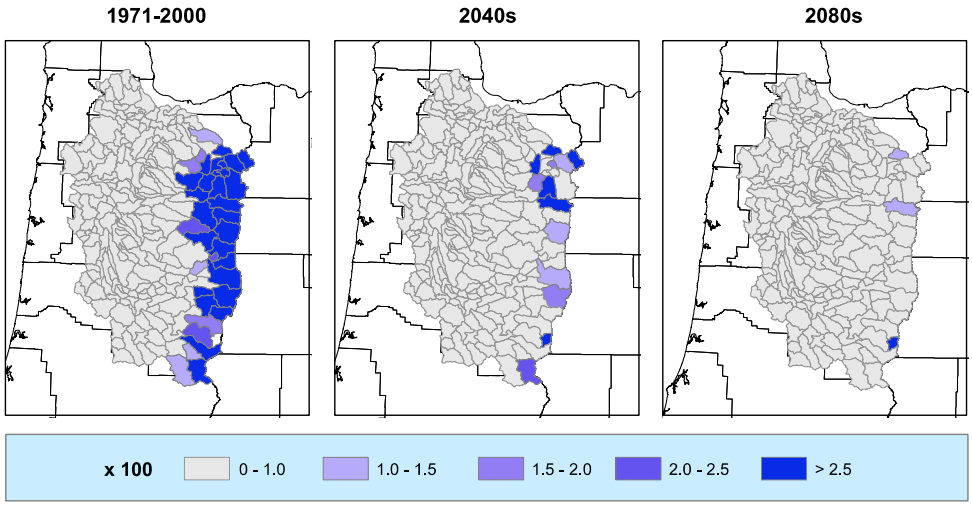


Figure 11. Projected Available Water Content in Snow as of April 1 through 2080 (Vynne *et al.* 2011).

indicate declining snowpack from the 1970s and into the future regardless of emissions scenario. During this century alone, snowfall in the region has dropped to less than 15% of historical records. This, combined with a consistent decrease of snow pack throughout the Cascade Mountains (Figure 11) have negative effects on the valley since the snowpack has been the historical reservoir for summer water supplies. Reduced snowpack, accompanied by earlier

snowmelt will likely increase the threat of spring floods followed by drought and wildfire in summer and fall (KTVZ News, 2012; Mote & Snover, 2014).

Federal 1st and 3rd Congressional District Historic Temperature Trends

Since the Oregon Senate 17th District falls in the 1st and 3rd Federal Congressional District, it is instructive to see how historic patterns have fared across those districts.

The data (Figure 12) indicates that the 1st Congressional District has been warming recently at a rate of 2.3^{0}F per century, while the District 3 value is 2.0^{0}F, both rates being slower than that of Oregon as a whole (2.4^{0}F per century) and the United States average rate of 4.3^{0}F for the century. Still, the average temperature is increasing and these districts are not immune to the consequences of climate change.

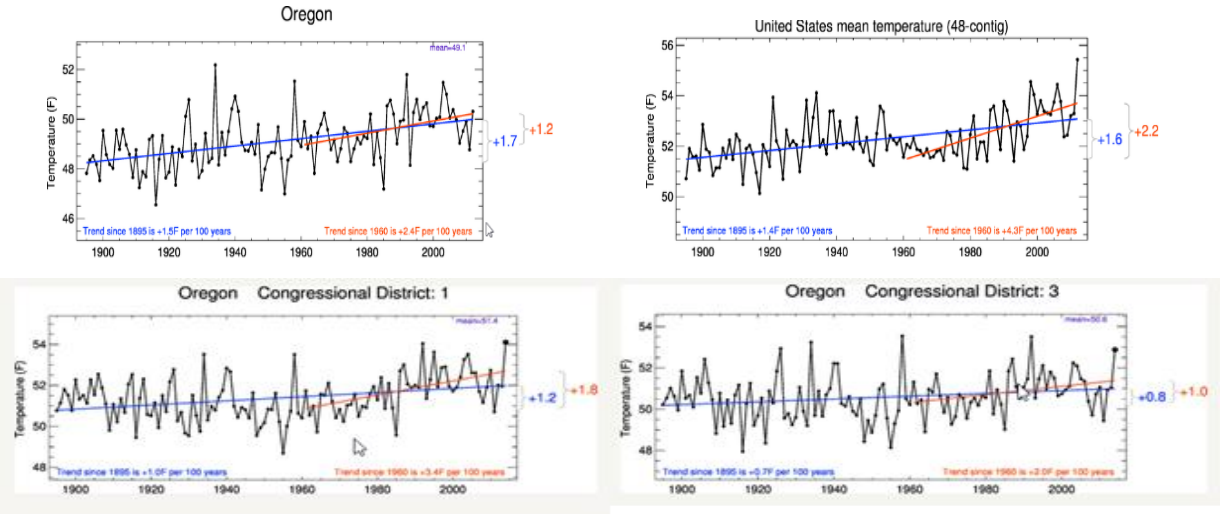


Figure 12. Temperature trends through the 1st and 3rd US Congressional Districts (Weaver *et al.* 2015).

Oregon 17th Senate District Economy:

The principal economic drivers of Multnomah County, the home of Portland, are manufacturing, transportation, trade, and tourism while the Washington County economy is driven by industries such as Nike and technology companies such as Intel plus agriculture, including wineries (Compiled from various sources). Although predominantly an urban area, agriculture, wineries, forest products, and tourism are relevant economic activities that are likely to feel the impact of a changing climate.

Among the tree species of most concern is Douglas fir projections for which are presented in Figures 13. These are based on models that assume a continuation of the current trend of increasing atmospheric carbon dioxide emissions with high tree viability indicated in red, low viability in green and absence in areas without color. These projections suggest

conditions for this species may be less favorable than currently - meaning timber activities in the district relying on the species could be severely 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 ranges 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.

The main impacts on agriculture will involve temperature change and water scarcity. While warmer weather and earlier spring seems positive, late summer and fall water shortages will likely pose severe problems. In addition, 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 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

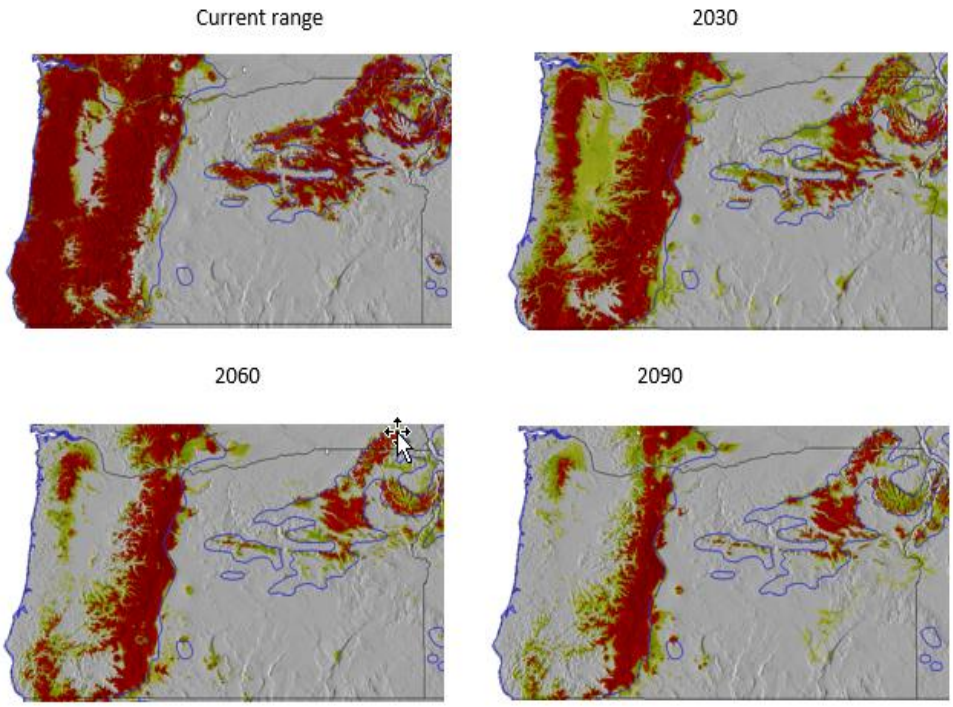


Figure 13. Douglas fir: Current and Projected Distribution through the 21st Century (Crookston, 2014).

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. Even in a normal water year, for example, some 60 miles of streams go dry in the Willamette Basin due to water withdrawals. (Environmental Protection Agency, 2000) For a 1.8˚F rise in temperature, irrigation demands are projected to increase by 10% (Dello and Mote 2010).

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 of codling moth populations, for example, under baseline conditions and four Global Climate Model (GCM) projections find earlier emergence of adults in spring. Coupled with warmer temperatures in summer this could result in most apple-growing locations 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 this tourism is connected to the North Willamette Valley's thriving wine industry, which is home to more than two-thirds of the state's vineyards (Morris, n.d.; Willamette Valley Wineries Association, 2014). State-wide, the wine industry was the 11th largest agricultural sector, valued at more than $71 million in 2008 (Dello and Mote 2010). The predominant wine varietals in the 15th district include Pinot Noir, Pinot Gris, Chardonnay, Riesling, and Cabernet Sauvignon (USDA National Agricultureal Statistics Service, 2011). Figure 16 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 niche 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 the local economy will likely be directly affected.

More than two-thirds of Oregon's population lives within the major urban centers that have developed in the Willamette valley with Washington county being the second most populous in the state. (Environmental Protection Agency, 2000) The population in the North Willamette Valley grew more than 14% between 2000 and 2010 and is projected to continue growing (State of Oregon, 2012). By 2050, an additional 1.5 million people are expected to live within the Willamette Valley, with more than 63% of them having migrated from outside of the state (Sinclair, 2005; Toulan School of Urban Studies and Planning, 2011). 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

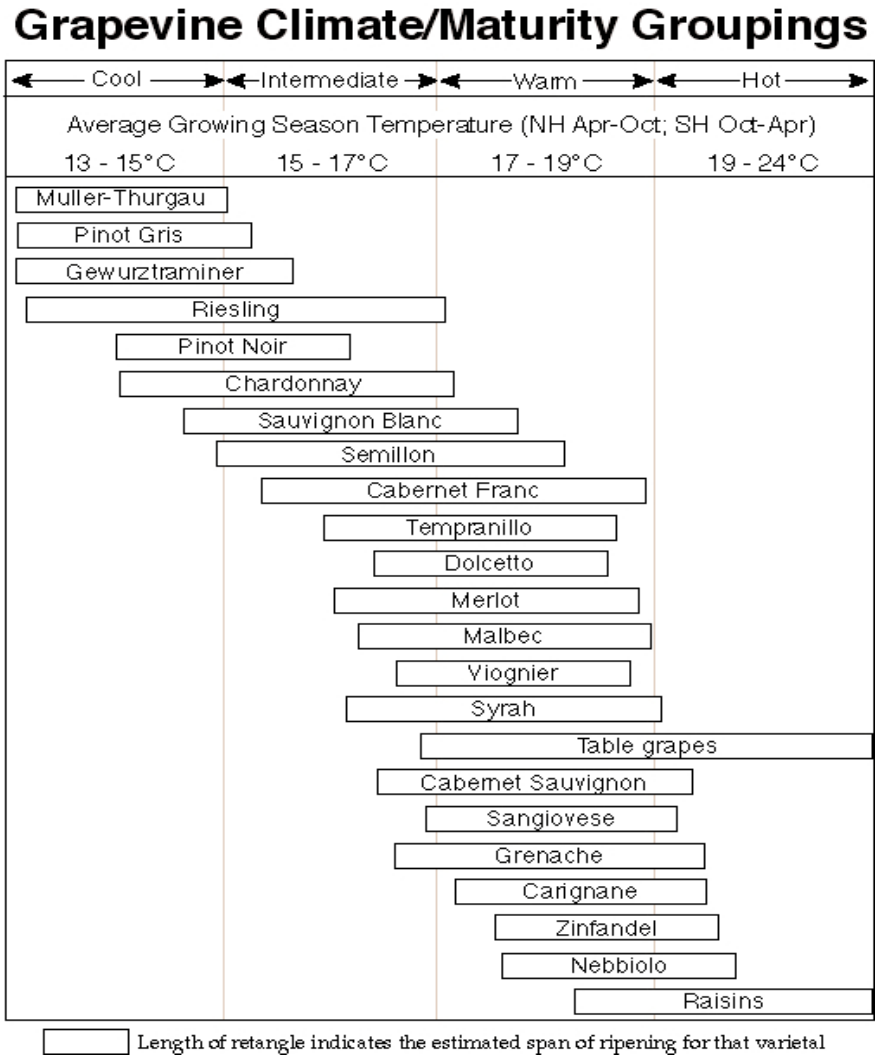


Figure 14. Grape varietal optimum growing seasonal temperatures ranges (Jones, 2003).

buildings, roads, highways and railroads, water and sewage systems, and energy facilities throughout Oregon (Dello and Mote 2010).

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 many 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 snow melt 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 (State of 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).

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 15th District.

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 accompanied by 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.

Even though an urban district may not encompass agricultural areas, individuals living in-district assuredly rely on agricultural productivity from neighboring districts. If productivity in such areas is compromised, the price of food will respond accordingly.

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.

A Timeline for Action:

Based on the projected consequences of a warming climate, International agreements (e.g. UN 2009) have established 2^{o}C as a limit beyond which we should not allow the global temperature to climb. This limit is echoed by the World Bank (2012, 2013, and 2014) and the International Energy Agency (IEA 2009).

Table 1 Carbon Dioxide Emissions and Temperature Consequences

Emissions	Gigatons CO_2 added to atmosphere	Temperature increase
1850 – 2000	**1035**	**0.8^{o}C**
2000 – Now	**440**	**1.5^{o}C**
Emissions Allowed	**825**	**2^{o}C**
Fossil Fuel Reserves	**725**	**3 - 4^{o}C**
Accessible Reserves	**780**	**5 - 6^{o}C**
Additional Reserves	**1280**	**??**

The trends and consequences discussed here are based on readily available data. An overall summary of our global temperature trajectory is depicted in Table 1 (from Quick M 2014). This shows that emissions of greenhouse gases to date have induced a temperature rise and inevitable continued rise totaling 1.5^{o}C to 1.6^{o}C (2.7 - 2.9^{o}F) (Dixon 2001). If we wish to avoid an increase over 2^{o}C the math tells us that we can only allow another 825 gigatons (billions of tones) of Carbon dioxide and equivalent emissions. Given that the current annual rate of global emissions is 37 gigatons (Le Quéré *et al.* 2014) and assuming the 'business as usual'

scenario of accelerating emissions is followed into the future as it has been to date, we will exhaust this budget in about 17 years. Unfortunately, if known and suspected fossil fuel reserves were extracted and burned, the temperature impact would be far in excess of that agreed 2°C upper limit. In relation to shooting beyond 2°C, the World Bank (2012) acknowledged there is: "no certainty that adaptation to a 4°C world is possible."

There can be little doubt that substantial urgency must be attached to addressing this issue.

Contact Senator Elizabeth Steiner Hayward:

Capitol Phone: 503-986-1717
Capitol Address: 900 Court St NE, S-215, Salem, OR, 97301
Email: Sen.ElizabethSteinerHayward@state.or.us
Website: http://www.oregonlegislature.gov/steinerhayward

House District 33: Representative Mitch Greenlick

Capitol Phone: 503-986-1433
Capitol Address: 900 Court St NE, H-493, Salem, OR 97301
Email: Rep.MitchGreenlick@state.or.us
Website: http://www.oregonlegislature.gov/greenlick

House District 34: Representative Ken Helm

Capitol Phone: 503-986-1434
Capitol Address: 900 Court St NE, H-490, Salem, OR 97301
Email: Rep.KenHelm@state.or.us
Website: http://www.oregonlegislature.gov/helm

Literature

Brown L 2006 *Plan B 2.0: Rescuing a Planet Under Stress and a Civilization in Trouble.* W.W. Norton, & Co. N.Y. London 365 pp

Crookston, N. (2014, Nov 18). *Plant Species and Climate Profile Predictions.* Retrieved from US Forest Service- Moscow Forestry Science Laboratory: http://charcoal.cnre.vt.edu/climate/species/

Dalton, M., Motes, P., & Snover, A. (2013). *Climate Change in the Northwest: Implications for Our Landscaps, Waters, and Communities.* Washington, D.C.: Island Press, 230 pp.

Dello, K., & P.W. Mote (eds). College of Oceanic and Atmospheric Sciences, O. S. (2010, December). *Oregon Climate Assessment Report.* Retrieved from Oregon Climate Change Research Institute: http://library.state.or.us/repository/2010/201012011104133/summaries.pdf

Dixon 2001 *Global Warming Commitment: Temperatures Would Rise Even with No Further Additional Greenhouse Gas Increases.* NOAA. http://www.gfdl.noaa.gov/cms-filesystem-action?file=/user_files/kd/pdf/onepageb01.pdf

EPA 2000, June). *Chapter 13: Willamette River Case Study, Progress in Water Quality: An Evaluation of the National Investment in Municipal Wastewater Treatment.* Retrieved from Progress in Water Quality Environmental Protection Agency. An Evaluation of the National Investment in Municipal Wastewater Treatment: http://water. pdf epa.gov/polwaste/wastewater/treatment/upload/2002_06_28_wquality_chap13.

EPA 2012, Mar 6). *Basic Information about Estuaries*. (E. P. Agency, Producer) Environmental Protection Agency.Retrieved Nov 9, 2014, from Environmental Protection Agency: http://water.epa.gov/type/oceb/nep/about.cfm

Fischer, D. (2009, Aug 20). *Rising Ocean Acidity Erodes Alaska's Fisheries*. (S. American, Producer) Retrieved Nov 9, 2014, from Scientific American: http://www.scientificamerican.com/article/rising-ocean-acidity-erodes-alaska-fisheries/

Govtrack.us. (2014). *Govtrack.us*. Retrieved from 5th Congressional District Map: https://www.govtrack.us/congress/members/OR/5#

Hudiburg T, Law B, Turner D, Campbell J, Donato D, Duane M. 2009. Carbon dynamics of Oregon and Northern California forests and potential land-based carbon storage. *Ecological Applications* 19: 163 – 180.

IEA 2009, *World Energy Outlook*, International Energy Agency, Paris, France, 691 pp

Institute for Tribal Environmental Professionals. (2014, Nov 13). *Jamestown S'Klallam Tribe: Climate Vulnerability Assessment and Adaptation Plan*. (I. f. Professionals, Producer) Retrieved Nov 9, 2014, from Tribes & Climate Change: http://www4.nau.edu/tribalclimatechange/tribes/northwest_skallam.asp

Jones, G. V. (2003, November 2). *Cliamte and Terroir: Impacts of Climate Variability and Change on Wine.* Retrieved from Southern Oregon University Environmental Studies: http://www.sou.edu/assets/envirostudies/gjones_docs/GJones%20Climate%20Change%20Geoscience%20Canada.pdf

KTVZ News. (2012, Jun 26). *KTVZ.com*. (K. News, Producer) Retrieved Nov 9, 2014, from Oregon Climate Change: Less Water, More Wildfires: http://www.ktvz.com/news/Oregon-Climate-Change-Less-Water-More-Wildfires/623102

Le Quéré C, Moriarty R. Andrews R, Peters G, Ciais P, Friedlingstein P, Jones S, Sitch S, Tans P, Arneth A, Boden T, Bopp L, Bozec Y, Canadell J, Chevallier F, Cosca C, Harris I, Hoppema M, Houghton R, House I, Johannessen T, Kato E, Keeling R, Kitidis V, Klein Goldewijk K, Koven C, Landa C, Landschützer, Lenton A, Lima I, Marland G, Mathis J, Letzl N, Nojiri Y, Olsen A, Ono T, Peters W, Pfeil B, Poulter B, Raupach M, Regnier P, Rödenbeck C, Saito S, Salisbury J, Schsuter U, Schwinger J, Séférian R, Segcshneider J, Steinhoff T, Stocker B, Sutton A, Takahashi T, Tilbrook B, van der Werf G, Viovy N, Wang Y 2014 *Global Carbon Budget 2014* Earth System Science Data 7: 521-610.

Melillo, J., Richmond, T., & Yohe, G. (2014). *Climate Change Impacts in the Unites States: The Third National Cllimate Assessment.* Retrieved from www.globalchange.gov: http://www.globalchange.gov/what-we-do/assessment

Miller SM, Wofsy SC, Michalak AM, Kort EA, Andrews AE, Biraud SC, Dlugokencky EJ, Eluskiewicz J, Fischer ML, Janssens-Maenhout G, Miller BR, Miller, JB, Montzka SA, Nehkorn T, Sweeney C. 2013, Anthropogenic emissions of methane in the United States. *Proceedings of the National Academy of Science*. 110 (50) http://calgem.lbl.gov/Miller-2013-PNAS-US-CH4-Emissions-9J5D3GH72.pdf

Morris, D. (n.d.). *Agritourism Thrives in Oregon*. Retrieved from Leisure Group Travel: http://leisuregrouptravel.com/agritourism-thrives-in-oregon/

Mote, P., & Snover, A. K. (2014). *2014 National Climate Assessment*. (GlobalChange.gov, Producer) Retrieved Nov 9, 2014, from GlobalChange.gov: http://nca2014.globalchange.gov/report/regions/northwest

NASA Goddard Institute for Space Studies.(2017, July). *GISS Surface Temperature Analysis.* Retrieved from NASA Goddard Institute for Space Studies: https://data.giss.nasa.gov/gistemp/graphs_v3/Fig.A2.gif and http://data.giss.nasa.gov/gistemp/graphs_v3/Fig.D.gif

National Geographic. (n.d.). *Sea Level Rise*. (N. Geographic, Producer) Retrieved Nov 9, 2014, from National Geographic: http://ocean.nationalgeographic.com/ocean/critical-issues-sea-level-rise/

O'Conner, P. (n.d.). *Agriculture in Marion, Polk, and Yamhill Counties.* Retrieved from Worksource Oregon: http://www.bibliopedant.com/rpeBdCSPItPolAC7cKpE

Oregon Department of Fish and Wildlife. (2006, Jan). *Willamette Valley Ecoregion, Oregon Conservation Strategy, January 2006.* Salem, OR: Oregon Department of Fish and Wildlife. Retrieved from Oregon Consersation Strategy, January 2006.

Oregon Environmental Council. (n.d.). *Impacts of Global Warming on Oregon Agriculture*. (O. E. Council, Producer) Retrieved Nov 9, 2014, from Oregon Environmental Council: http://www.oeconline.org/our-work/climate-protection/global-warming-impacts-in-oregon/gwagimpacts

Oregon Forest Resources Insitute. (n.d.). *Trees of Oregon's Forests*. Retrieved from Oregon Forests.org: http://oregonforests.org/content/tree-variety?type=coniferous&forest=Willamette%20Valley

Quick M, 2014 *How Many Gigatons of Carbon Dioxide…?* http://www.informationisbeautiful.net/visualizations/how-many-gigatons-of-co2/

Sinclair, M. (2005). *Willamette River Basin:Challenge of Change.*

State of Oregon. (2012, Feb). *Region 2: Northern Willamette Valley/Portland Metro Regional Profile.* Retrieved from oregon.gov: www.oregon.gov/LCD/HAZ/docs/2.A.ORNHMP12-Reg2Profile.pdf

Toulan School of Urban Studies and Planning. (2011). *ENVIRONMENTAL MIGRANTS AND THE FUTURE OF THE WILLAMETTE VALLEY.* Portland State University.

University of Alaska Fairbanks. (2014, Sept 18). *Ocean Acidification Research Center*. (U. o. Fairbanks, Producer) Retrieved Nov 9, 2014, from University of Alaska Fairbanks: https://www.sfos.uaf.edu/oarc/

UN 2009 *United Nations Framework Convention on Climate Change: Copenhagen Accord*. United Nations, Stockholm, Sweden. http://unfccc.int/resource/docs/2009/cop15/eng/11a01.pdf

USDA National Agricultureal Statistics Service. (2011). *Vineyard and Winery*. Retrieved from Oregon Office of USDA National Agricultureal Statistics Service: http://www.nass.usda.gov/Statistics_by_State/Oregon/Publications/Vineyard_and_Winery/v_2011_final.pdf

USGS 2014 National Climate Change Viewer (NCCV) United States Geological Survey https://www2.usgs.gov/climate_landuse/clu_rd/nccv/viewer.asp.

Vynne, S., Adams, S., Hamilton, R., & Doppelt, B. (2011, Jan). *Building Climate Resiliency in the Lower Willamette Region*. (C. L. Initiative, Producer, & The Resource Innovation Group) Retrieved Nov 9, 2014, from The Resource Innovation Group: http://www.theresourceinnovationgroup.org/storage/Lower%20Will%20Report%201-28-11%20Final%20LoRes.pdf

Weather Underground, Inc. (2014). *Weather Underground Local Climate Change*. Retrieved from Weather Underground: http://www.wunderground.com/climate/

Weaver, C., Cordero, E., Shah, N., DeJoannis, E., Weaver, S., & Ree, J. (2013). *Oregon, District 5*. Retrieved from Congressional Temperature Trends: http://temperaturetrends.org/district.php?district=5&state=OR

Welch, C. (2013, Sep 12). *Sea Change: Oysters Dying as Coast Hit Hard*. (T. S. Times, Producer) Retrieved Nov 9, 2014, from The Seattle Times: http://apps.seattletimes.com/reports/sea-change/2013/sep/11/oysters-hit-hard/

Westerling A, Hidalgo H, Cayan D, Swetnam D, 2006 "Warming and Earlier Spring Increase Western U.S. Forest Wildfire Activity" *Science* 313 no. 5789 pp. 940-943.

Willamette Valley Wineries Association. (2014). *About the Valley*. Retrieved from Willamette Valley Wineries Association: http://willamettewines.com/about-the-valley/

World Bank 2012, *Turn Down the Heat: Why a 4^{o}C Warmer World Must be Avoided*. The World Bank, Washington DC. 84pp

World Bank 2013, *Turn Down the Heat: Climate Extremes, Regional Impacts, and the Case for Resilience.* The World Bank, Washington DC. 213pp

World Bank 2014, *Turn Down the Heat: Confronting the New Climate Normal*. The World Bank, Washington DC. 275pp

WPC IPCC. (2013). *Climate Change 2013: The Physical Science Basis; Summary for Policymakers.* Retrieved from www.climatechange2013.org: http://www.climatechange2013.org/images/uploads/WGIAR5_WGI-12Doc2b_FinalDraft_Chapter12.pdf