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Summary of Climate Trends and Projections for Jackson County

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This discussion of climate trends and projections focuses on Jackson County, but includes data on recent historic trends for Medford where these are available. Although specific projections for Medford are not available, there is no reason to suspect the pattern would be different from that suggested here for Jackson County as a whole.

As will be seen, in general, the climate projections for Jackson County are largely simple continuations of the trends we are experiencing. The following county-wide discussion is based largely on United States Geological Survey data on trends and projections formulated from NOAA data and 28 climate models. Medford data come from the local NOAA Weather Service office and NOAA websites.

Graphs from the USGS site depict both recent historic trends and projections through the end of the century. The black line represents historic trends represented by the models. The projections illustrate two scenarios. The red lines (Representative Concentration Pathway -RCP - 8.5), represent a scenario that assumes we continue to consuming fossil fuels at the accelerating rate we have exhibited to date, resulting in an accelerating pattern of greenhouse gas emissions. This is often called the Business As Usual (BAU) scenario. Meanwhile, the blue lines (RCP 4.5) assume we do not exhibit quite that trajectory but slow the rate of accelerating fossil fuel use and GHG emissions by about 50%

Temperature

The average temperature in Jackson County rose about 1.5°F during the second half of last century (Figure 1) compared to the mean for that period. Meanwhile, the anticipated BAU average temperature

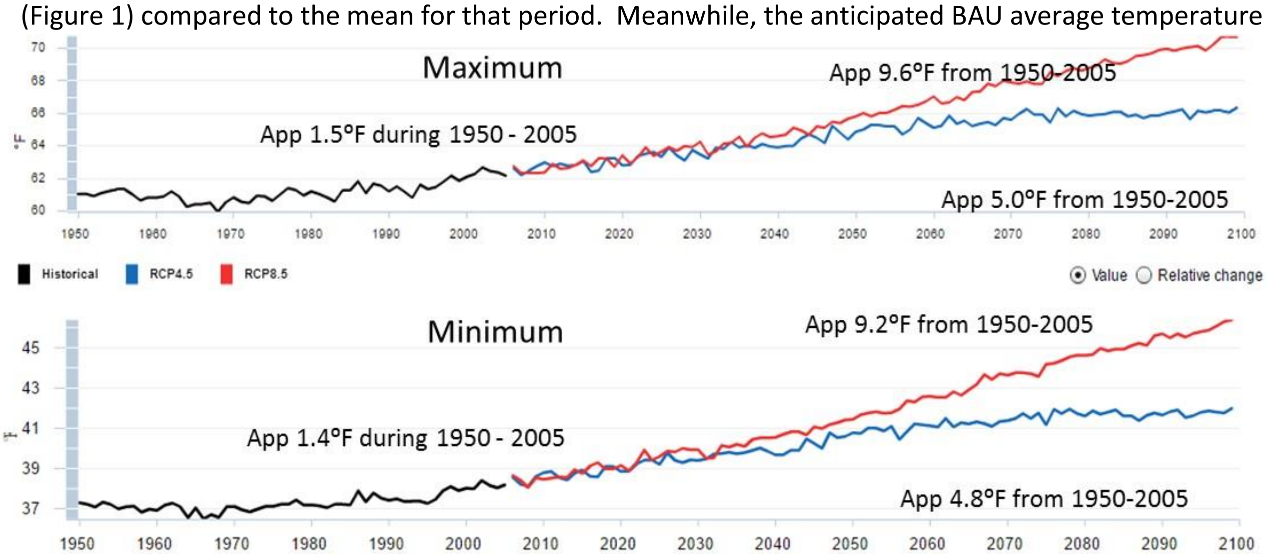


Figure 1. USGS Trends and Projections for Jackson County maximum and minimum temperatures. The Business as Usual projection (red line) suggests an increase across the county of 9.4°F compared to late the 20th Century average. App = approximately.

increase by the end of the century will likely be about 9.4ºF. Projected seasonal temperatures indicate summer and fall will be substantially hotter, with notable increases to 2050 – 2074 and 2090-2099 while winter and spring temperatures will increase, but to a lesser extent (Table 1). By 2100, July will likely experience a month long high close to 95ºF.

	1950 – 2005 Ave	2050 – 2074 Ave	Increase	2090 – 2099 Ave	Increase
Winter	36.48	41.28	4.83	44.05	7.73
Spring	45.90	50.45	4.55	53.19	7.95
Summer	63.63	70.47	6.83	74.75	11.77
Fall	50.73	56.72	6.00	60.29	9.73

Table 1. Projected Temperature and increases for the periods 2050-2070 and 2090- 2099 and increases from the late 20th Century (1950 – 2005) average. Data from USGS.

The historic trend for Medford (Figure 2) exhibits a parallel pattern to the county as a whole discussed above. Including temperature data from the recent years of 2014 and 2015 the trend exhibits a century increase of over 2ºF, slightly above the county trend.

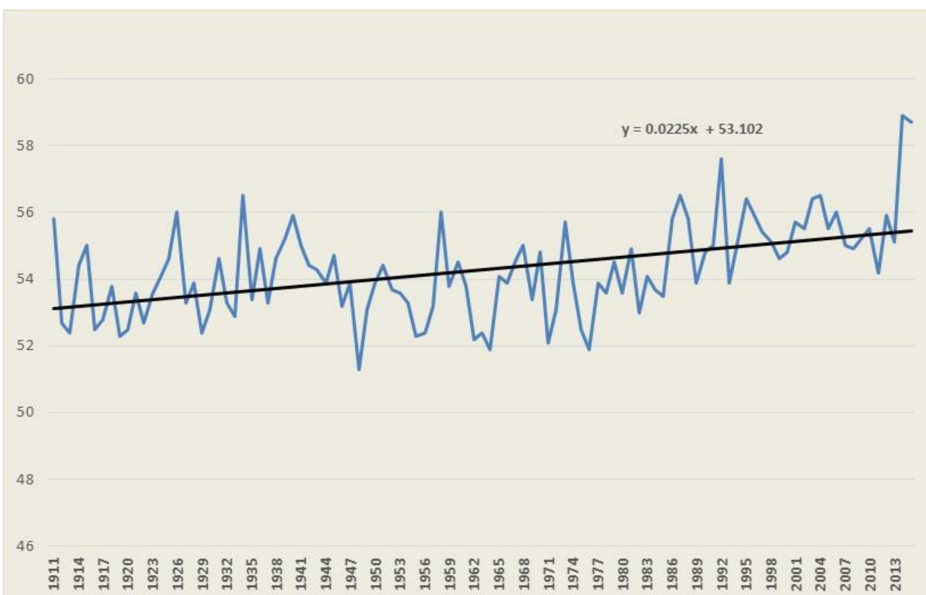


Figure 2 NOAA Historic Temperature trend for Medford through 2015 shows a rise of 2.25ºF per century.

The trend in days over 100°F in Medford is presented in Figure 3. This shows much variability but an increase from 7 to 11 days. By the end of the century, this value is likely to increase to some 45 days although these are not necessarily expected to be consecutive days (Melillo *et al.* 2014).

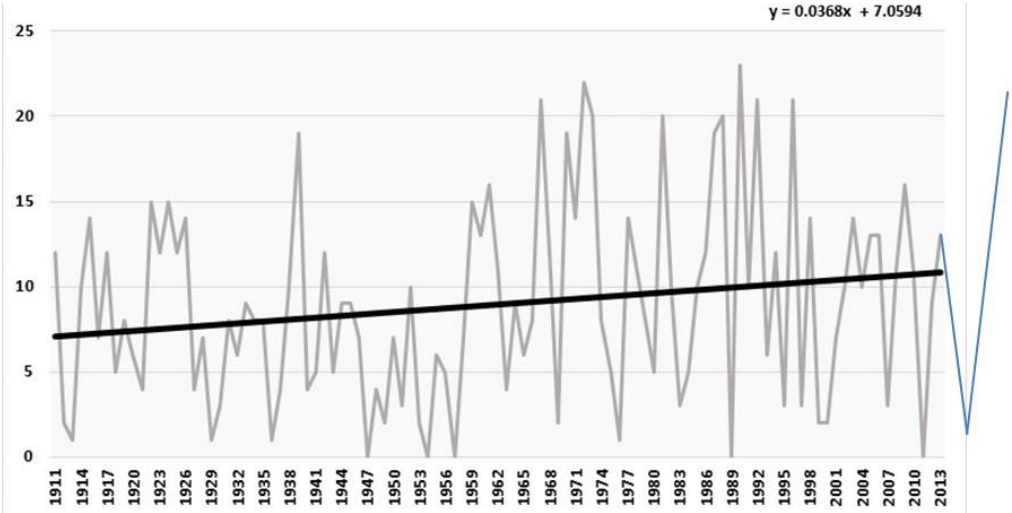


Figure 3. Number of days over 100°F during the last century

Precipitation (including Snowfall)

The historic precipitation pattern for Jackson County has been variable though this pattern is imposed on an overall trend that remains flat (Figure 4). The projection, meanwhile, indicates the annual variability will increase (with wet years likely wetter and dry years likely dryer) but again no overall increase or decrease (Melillo *et al.* 2014).

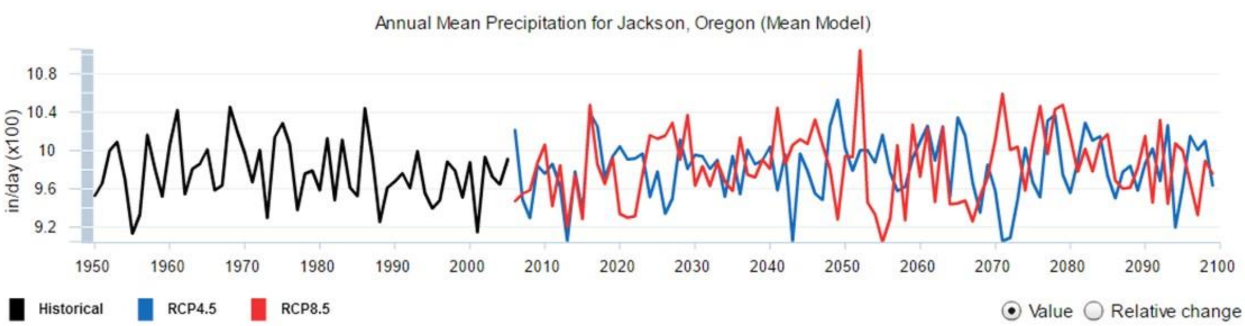


Figure 4. The Jackson County precipitation trend and projections from the USGS.

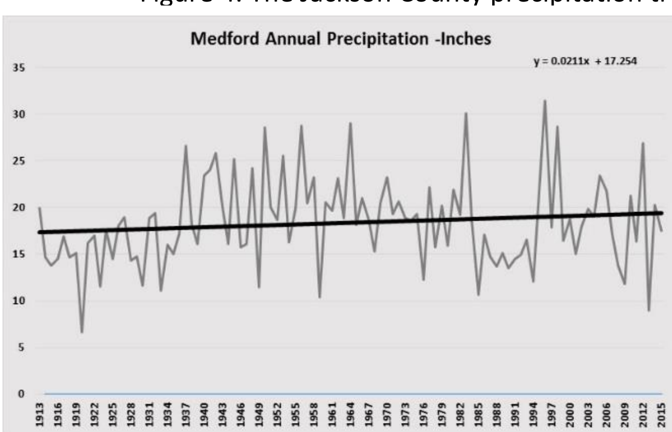


Figure 5. Precipitation trend for Medford.

The precipitation trend for Medford is presented in Figure 5. This shows a historically slight but probably insignificant increase.

Two additional features of the regional (Pacific Northwest) precipitation trend are relevant: seasonal and intensity patterns. In the future, winters are likely to be somewhat wetter, and summers dryer, with spring and fall remaining unchanged (Melillo *et al.* 2014). Additionally, the current trend wherein precipitation falls increasingly as heavy downpours rather than light drizzle will likely continue and become more severe – inducing more frequent flooding, soil erosion, and landslides without replenishing soil moisture as effectively (Melillo *et al.* 2014).

Meanwhile, the trend in snowfall alone (measured and projected in terms of Snow Water Equivalent, SWE) will likely continue declining as it has done since the 1970s (Figure 6). This means declining snowpack, particularly relevant at high elevations since precipitation falls lower as rain rather than

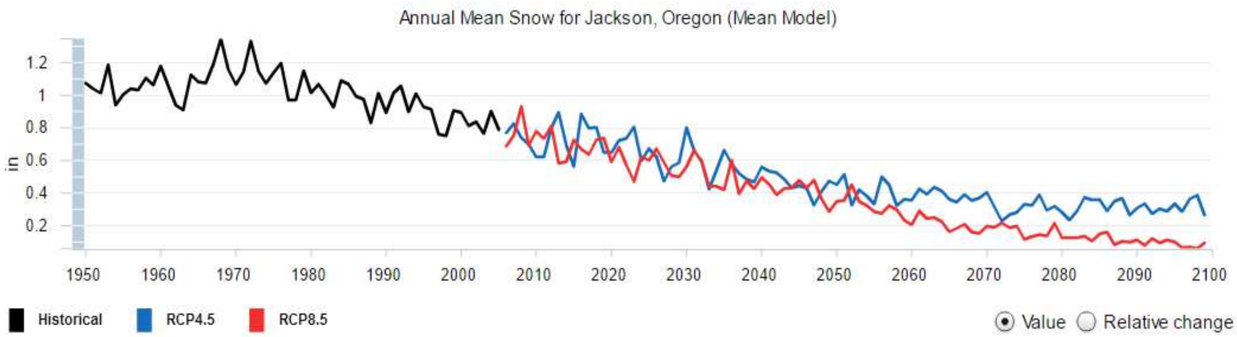


Figure 6. Snowpack, as snow water equivalent, trend and projections for Jackson County

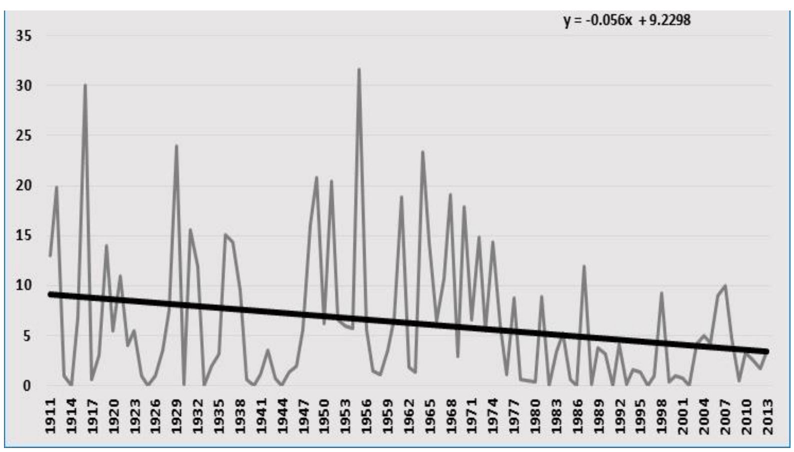


Figure 7. The snowfall trend in Medford through the last century.

higher as snow. By the end of the century, the BAU scenario indicates SWE will be 10-20% of the late 20th Century average with many years experiencing no snowfall. The historic trend for Medford (Figure 7) shows a parallel drop from the 1970s. Meanwhile, snowfall has been declining at Crater Lake since the 1930s (Figure 8). If this trend continues as expected, it is likely to impact Lost Creek Lake storage and Rogue River flow.

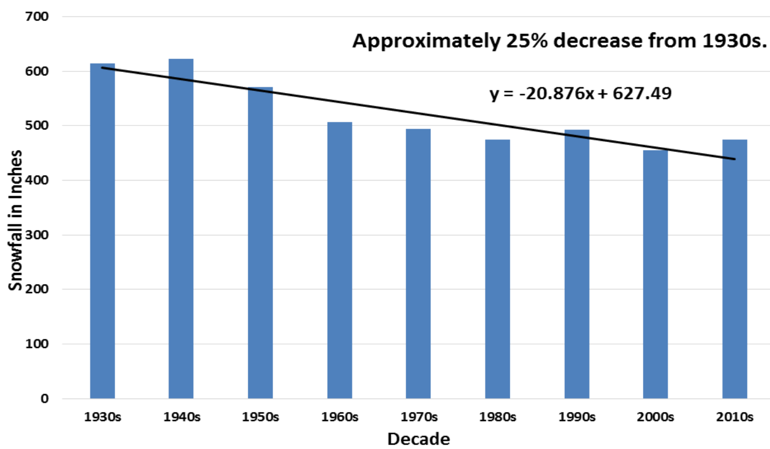


Figure 8. Crater Lake snowfall trends from the 1930s

These trends, combined with that of spring arriving earlier, are likely to have several critically important impacts discussed below.

Temperature and Precipitation Trend Consequences

Evaporative deficit measures the actual evaporation (of available moisture) compared to the potential evaporation (assuming unlimited moisture). When this value is negative, soils dry out. In Jackson County, this value has been rising since the 1970s, and is expected to continue to rise by an estimated 133% by the end of the century (Figure 9).

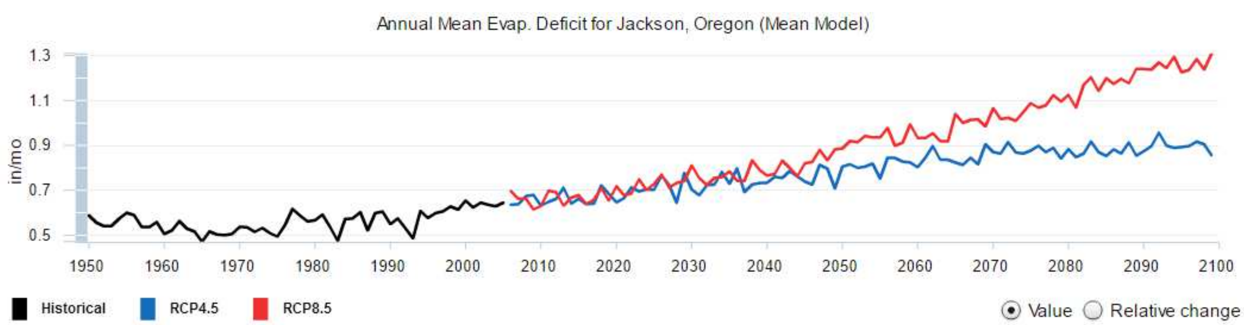


Figure 9. Evaporative Deficit trend and projections for Jackson County

Not surprisingly, the result is reducing soil moisture in Jackson County (Figure 10). Already declining, soil moisture is expected to decline some 20% through the century.

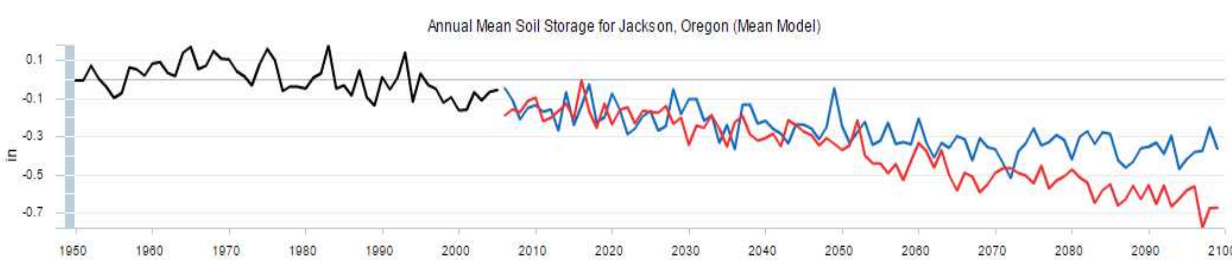


Figure 10. Soil moisture storage trend and projections for Jackson County

Potential Impacts

A reasonable consequence of this set of temperature, precipitation, snowpack, and evaporative deficit trends is drought. An analysis of drought potential for the Western states (Ault *et al.* 2014) suggest that this region has a 40% – 50% chance of experiencing an 11-year drought, with a 20% – 50% chance of experiencing a 35-year mega-drought.

As growing season temperature rises, snowpack dwindles, and spring snowmelt arrives earlier, soils will likely dry out more extensively during summer, with the region anticipating substantially higher wildfire risk. Indeed, these are exactly the factors that correlate with higher fire risk (Westerling *et al.* 2006). Marlon *et al.* (2012), among others, suggest that the region is experiencing a substantial fire deficit as a result of climatic changes. Meanwhile, Melillo *et al.* (2014) argue that only a 2.2°F temperature increase will result in a 300% increase in area burned. In addition to the recreational and economic losses, increased wildfire risk brings greater health risks from smoke and micro-particulates.

The impact of the array of climate trends anticipated for the region are troubling. The combination suggests serious problems for agriculture, forestry, and natural systems because these are all profoundly influenced by the combination of temperature and precipitation patterns that the global warming trend influence globally and regionally.

Should the variables discussed above change to the extent suggested by the projections, the region will experience considerable changes. It is recommended that we understand the potential impacts, do whatever we can to avert them, and simultaneously manage our biological systems in such a way as to help them adapt to the changes that are a consequence of the emissions already released.

Natural, Agricultural and Forestry Systems

Several decades ago, R.H. Whittaker (1970) developed a chart (Figure 11) depicting the distribution of the world's natural systems (biomes) in relation to average annual temperature and precipitation. The distribution of biomes around the world is determined largely by these two variables, acting in combination with soil characteristics. The message is that if these variable are modified, even minimally for biomes on the edge of current

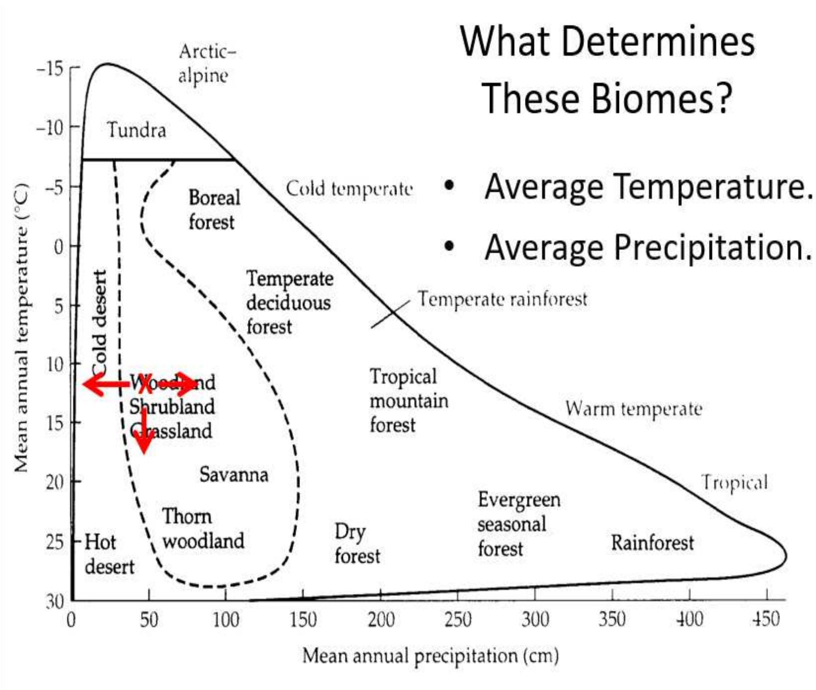


Figure 11. Whittaker 1970 chart depicting biome distribution in relation to temperature and precipitation

conditions, the survival of current biomes and the species of which they are composed will likely be severely undermined to the point of their being eliminated at least regionally and maybe globally.

The relevance of threat to these natural systems posed by a changing climate is not limited to the loss of biodiversity (native flora and fauna / wildlife), our outdoor recreation areas, critical watersheds, and valuable resources such as forests; it also has direct relevance to us. This is because human agriculture is dependent on exactly the same two variables that control the success of biomes. The best illustration of this is the fact that the American grain belt down the central bank of states of the U.S. exists where the natural biome of grassland / prairie historically existed. Thus, if we compromise natural biomes, we also compromise our agriculture, and our commercial forestry.

By modeling future conditions globally under different atmospheric greenhouse gas concentration scenarios, Williams and Jackson (2007) illustrated the problem clearly (Figure 12). They explored future carbon dioxide concentrations of 850 and 550 ppm (parts per million) compared to the historical (pre-industrial revolution) concentration of about 280 ppm and the current concentration of about 400 ppm. The concentrations they chose represent where we might reach during this century according to the

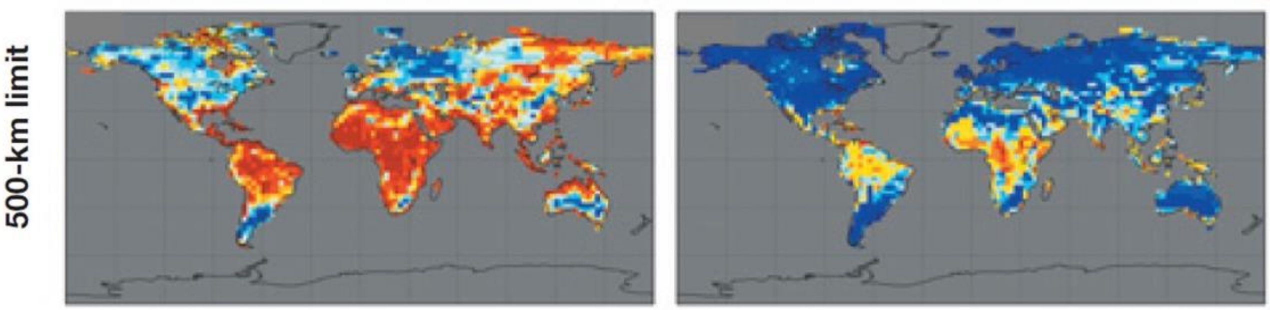


Figure 12. Williams and Jackson (2007) depictions of future biome survival probability under two atmospheric carbon dioxide concentration scenarios (L 850 ppm; R 550 ppm)

BAU scenario (850 ppm) compared to the scenario comprising a reduced emissions trajectory (550 ppm). Areas that are red indicate there is no possibility that biomes will find a suitable location within the designated distance, while blue areas indicate a probability of 100%. Among the questions they posed was: is there anywhere, within 500 kilometers (about 300 miles) of their current location, that current biomes might find conditions appropriate? This value is a reasonable generalization for biomes since native flora and fauna have a limited capacity for dispersal to locations at great distance from that currently occupied. This distance is controlled by the dispersal capacity of propagules (seeds and juveniles). Additionally, human activities and infrastructure (agriculture, cities, roads etc.) now present barriers to the natural dispersal potential of species.

It is critical to appreciate that the carbon dioxide concentrations are not themselves the cause of the pattern. Rather it is the global warming and climate change consequences of those concentrations that drive the projections. What these authors suggest is that under the 850 ppm scenario most of northern (tropical / sub-tropical) South America and Africa will be devastated. Biomes of the coastal Southwestern and Southeastern United States and northern and southern Australia are similarly threatened as are the biomes of much of Asia. Additionally, note the threat to the grassland biomes and the grain belt of the Central United States. See below for a discussion of potential impacts on Southern Oregon forest species and agriculture.

The impact of future conditions on forests is of particular concern in SW Oregon. Westerling *et al.* (2006) identified warming during the growing season and timing of spring snowmelt as two variables that correlate with increased wildfire activity. As would be expected, warmer summers and earlier spring snowmelt correlate with high fire years since these lead to dryer conditions during late summer and fall.

Rehfeldt *et al.* (2006 and http://charcoal.cnre.vt.edu/climate/species/) evaluated the impact of future conditions on the viability of western tree species. As an example, the current and future viability and range for Douglas fir and Ponderosa pine in Oregon are presented in Figures 13 and 14. The color represents viability from 0.5 (yellow) through 0.75 green) to 1 (red). Both species are projected to exhibit range contraction in this region. The maps show the current scenario on the left and the future scenario, 90 years from now, on the right.

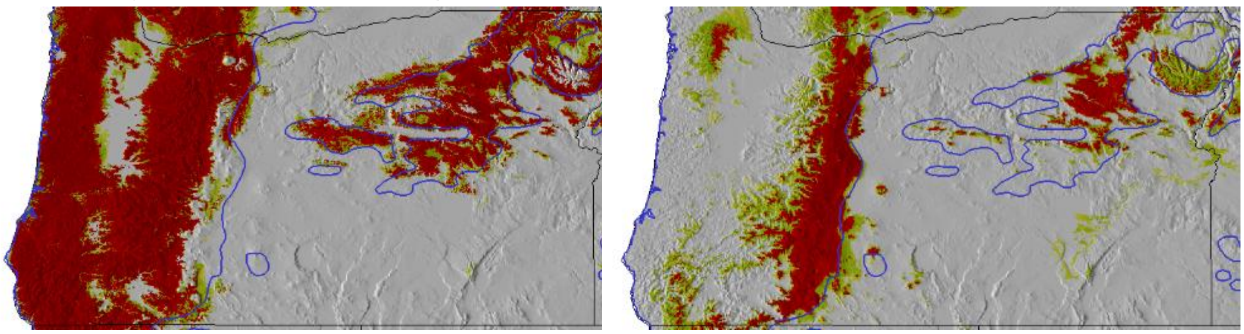


Figure 13. Douglas fir distribution and viability through 21st century.

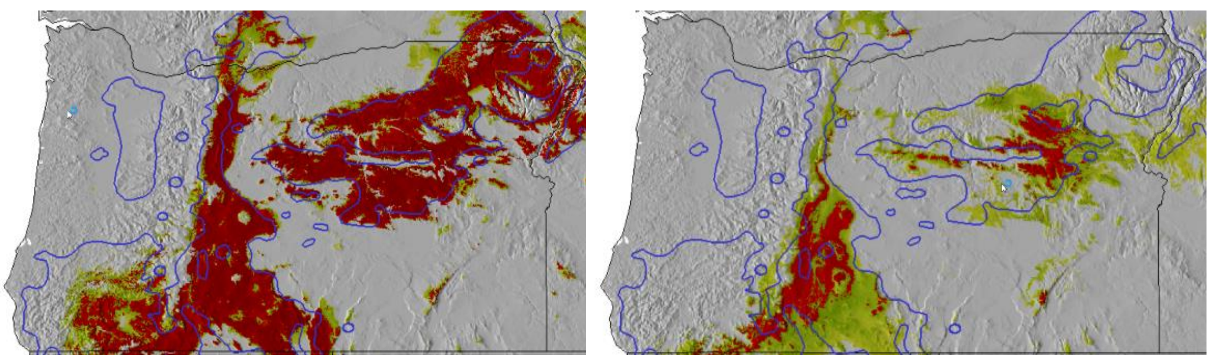


Figure 14. Ponderosa pine distribution and viability through the 21st Century:

In addition, according to Rehfeldt's models, by late century Oregon will be outside the range of the Lodgepole pine.

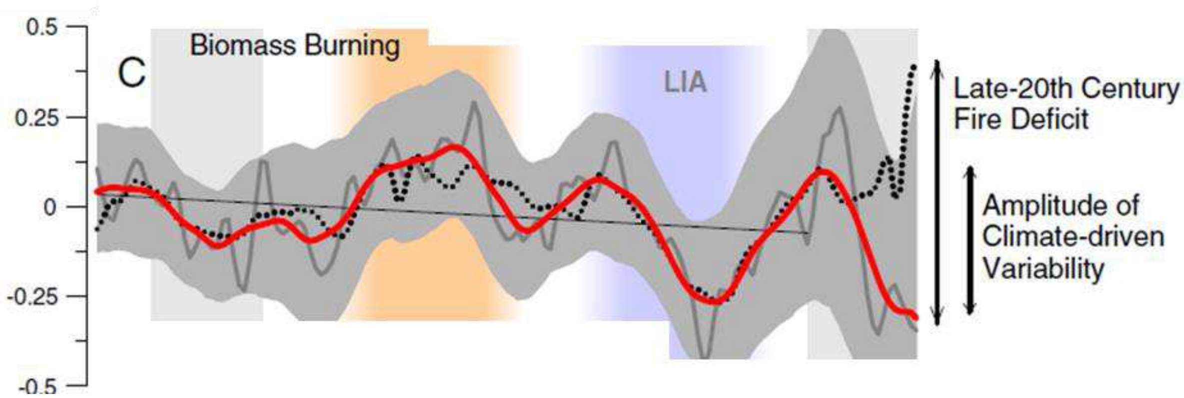
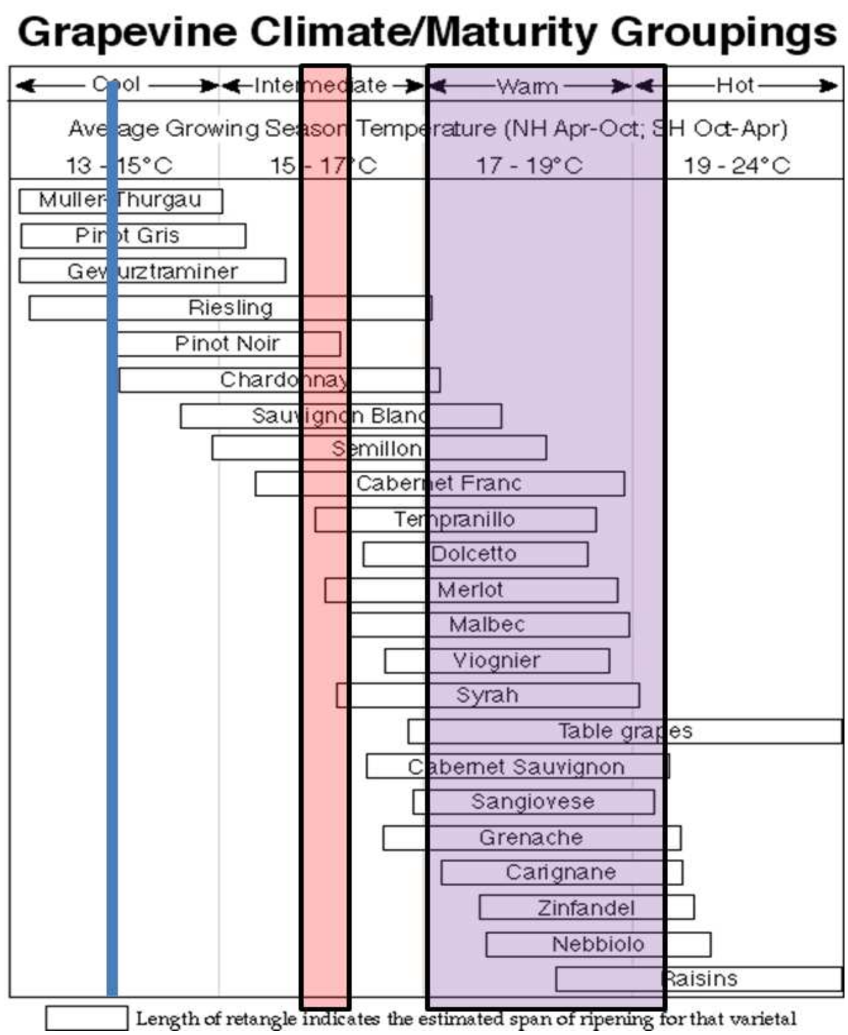


Figure 15. Relative changes in biomass burning in the Western United States for the past 3,000 years indicating the current fire deficit.

Given that many of the climate trends reported above can be traced back to the 1970s, it should be no surprise that the wildfire season in the Western states has expanded some two and a half months since that time. Data from the Interagency Fire Center indicate that the number of wildland acres burned has increased over this period. Climate central http://www.climatecentral.org/western-wildfire-trends), meanwhile, reports that both the number of western acres burning and the size of western fires has been increasing since that period. However, analyses that include earlier decades and centuries yield a slightly different perspective (Marlon *et al.* 2012, for example), report (Figure 15) that we are currently experiencing an unusually low level of biomass burning. In fact, given the temperature and drought conditions present in the western forests, these authors conclude, that we are experiencing a profound fire deficit. Meanwhile, studies of burn scars in tree trunks reveal that the historical natural fire return interval (average period between natural fire events in a location) through much of the Rogue Basin was less than a decade (Metlen *et*

Figure 16. Optimal growing season temperatures for grape varietals typical of the Rogue Basin. Blue: 1960 – 1999 actual average temperature, Pink - 2035-2045 projected temperature; Purple 2075 – 2085 projected temperatures. Modified from Jones (2006).



al. 2016). This represents a marked difference from current trends since the imposition of fire suppression, when the fire return interval has lengthened to between 40 and 10,000 years (Metlen *et al.* 2015). With climate change, the tendency will be to return in the direction of the earlier fire return intervals as wildfires occur much more frequently.

Regional Agriculture

Two examples will illustrate the potential impact of these climate trends on our local agriculture: grapes and pears.

Figure 16 depicts the growing season optimum temperatures for wine varietals grown in Southern Oregon (Jones 2006). On this, the late 20th Century growing season actual temperature average are superimposed for the growing season (blue), the 2035-2045 projected average (pink) and the 2075-2085 projected average (purple). The chart suggests the wisdom displayed by vintners who have adjusted to warming through the century by adopting warmer growing season varietals. Unless extreme temperatures are achieved, warmer grape varietals can protect the wine industry. The pattern among grape varietals where colder season varietals are being and will be further compromised can be generalized to other local agricultural crops.

While the warmer conditions during the growing season are one potential problem facing crop production, another is the absence of a sufficient number of chilling hours during winter when the temperature is between 32 and 45 degrees F (about 800 hours for Bartlett pears). This is particularly a threat for perennial crops. While warming winters are not yet sufficient to pose problems for the spring development of pears, with continued warming, this could become a concern in the future.

Freshwater Resources

The impact of the changing climate on our freshwater systems should also be considered. As Myer (2013) reported, the water quality in many of our streams is already compromised. Depleted flow and warming water can only make matters worse – threatening our iconic fish species and the health of our waters for irrigation and consumption. Warmer waters provide

Figure 17. Outline image of S. Oregon and California indicating future Medford climate possibilities. Map: http://www.netstate.com/states/maps/images/ca_outlinebord.gif

reduced oxygen availability and more rapid development conditions for water and vector borne wildlife and human disease organisms.

Health

The direct and indirect effects of these climate trends on human health are also noteworthy (OHAPHD 2014, USGCRP 2016) Not only do the warming trend and heat waves themselves impose substantial direct and indirect threats, but also the impact of the changing climate on wildfires and diseases should be considered. Micro-particulates released during forest fires can compromise the young and elderly as well as those with respiratory disease and those working outside. Meanwhile, general warming will likely increase the development rate of vectors of plant and animal pathogens and encourage their range expansion north and to higher elevations. Warming waters will likewise probably increase the threat posed by water-borne diseases. Individuals who earn their living outside will be particularly vulnerable to these trends.

A Living Reference Point

By mid-century, it is suggested the Medford climate (Figure 17) will resemble that currently experienced by Redding, CA (Mote 2015) with a July average high of 96.8^{o}F and an average January low of 38^{o}F (http://www.bestplaces.net/climate/city/california/redding). Meanwhile, by 2100 Medford summer is likely to experience the current climatic conditions in Delano, CA (near Bakersfield) (http://www.climatecentral.org/news/summer-temperatures-co2-emissions-1001-cities-16583 with 10 inches of annual rainfall, 0.1 inches of annual snowfall, an average July high of 99.9^{o}F, and an average January low of 36^{o}F (http://www.bestplaces.net/climate/city/california/delano).

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