

Spring 2010



Gresham Climate Futures Report

Climate Preparedness in the
Lower Willamette Subbasin

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About SCI

Sustainable Cities Initiative (SCI) is a cross-disciplinary organization at the University of Oregon that seeks to promote education, service, public outreach and research on the development and design of sustainable cities.

Our work addresses sustainability issues across multiple scales, from the region down to the building, and emerges from the conviction that creating the sustainable city cannot happen within any single discipline. SCI is grounded in cross-discipline engagement as the key strategy for solving community sustainability issues. We serve as a catalyst for expanded research and teaching; market this expertise to scholars, policymakers, community leaders, and project partners; and work to create and sponsor academic courses and certificates. Our work connects student passion, faculty experience, and community need to produce innovative, tangible solutions for the creation of a sustainable society.

About SCY

The Sustainable Cities Year Initiative is a 'partnership' with one city in Oregon per year where a number of courses from across the University focus on assisting that city with their sustainability goals and projects. The Sustainable Cities Year faculty and students work with that city through a variety of studio projects and service learning programs to: 1) provide students with a real world project to investigate; 2) apply their training; and 3) provide real service and movement to a local city ready to transition to a more sustainable and accessible future.

About Gresham

With just over 100,000 people, Gresham is the fourth largest city in Oregon. It is bordered to the west by Portland, the largest city in the state. Gresham is home to the Mount Hood Jazz Festival and is known as "The City of Music". It is close in proximity to the Columbia Gorge National Scenic Area and Mount Hood, the highest point in Oregon. Gresham has a wide variety of neighborhoods including the Civic Center, known for its active transportation network, rapid transit connections and residential, commercial and retail mix.

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Project Intent

The Climate Futures Forum for the City of Gresham is part of a larger report being developed for the entire Lower Willamette Subbasin. Participants focus on natural and community systems to develop a whole-systems approach to addressing and preparing for climate change. This process will support the City of Gresham in preparedness planning and help gain a better understanding of the anticipated effects of climate change. For access to the Lower Willamette Subbasin report, visit <http://climlead.uoregon.edu/node/136>.

Involved Faculty Members

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Table of Contents

I.	Executive Summary	7
II.	Introduction	9
III.	Purpose and Overview	11
IV.	Systems Addressed in Climate Futures Forum	13
V.	Climate Change Projections for Gresham	15
VI.	Consequences for Natural Systems and Recommendations for Preparation Strategies	27
VII.	Consequences for Community Systems and Recommendations for Preparation Strategies	30
VIII.	A Vision for Gresham's Future: An Action Plan for Preparedness	35
IX.	Conclusion	38
	Bibliography	39
	Appendices	41

The City of Gresham in northern Oregon has many community and natural resources. This report outlines how those resources can expect to be affected under changing climate conditions and establishes recommendations for preparedness planning.

Many of the impacts of climate change can already be seen across the globe, from increased precipitation and drought, to more extreme temperatures that affect the daily lives of individual communities. Experts agree that even if significant reductions in greenhouse gases were to occur, the stabilization of climate systems will still take decades to establish.

This project is the result of the Climate Futures Forum hosted by the Climate Leadership Initiative (CLI). The objective of the forum is to gather area experts from a variety of backgrounds together to discuss the potential impacts of climate change and to begin to establish recommendations for preparing locally for those changing conditions. Participants used climate projections to identify likely changes to natural (aquatic and terrestrial), built (infrastructure), economic (agriculture, forestry, business), and human (health, education, emergency services) systems.

By using various climate models to predict the effects of climate change, the Oregon Climate Change Research Institute (OCCRI) has established regional climate projections that help inform preparedness planning. In Gresham, temperatures are expected to rise an average of 3°-5° Fahrenheit in winter months and 10°-15° Fahrenheit in summer months by the end of the century. Climate models also show an increase in precipitation in fall and winter months with reductions in spring and summer, inviting the increased possibility of flooding and drought. Vegetation models indicated a shift in growing conditions combined with changes in streamflow, increasing the potential for invasive species and shorter growing seasons. Below are the recommendations established by some local experts for how to help prepare for these likely climate changes:

Terrestrial and Aquatic Systems: Recommendations for natural systems include addressing species management and protecting existing habitats. Species should have habitats large enough for natural processes to occur. As such, the Threatened, Endangered and Sensitive (TES) species management system should be revisited as a means for protecting these natural systems.

Human Systems: Ensuring that populations' health and safety are important focuses of the human system recommendations. Establishing communication systems to alert the population of dangers in their living situation (e.g. boil alerts, poor air quality days, and the location of cooling centers) will help build preventative safety measures into the community. Residents are encouraged to learn about growing their own food and learning where to get products locally in the event of isolation from an extreme event.

Built Systems: Building resiliency to the built systems in Gresham includes recommendations for increased renewable energy systems, more water storage options to decrease the risk of contamination to an entire system, encouraging relocation of individuals living in flood- or fire-plains, and developing fire protection plans to ensure safety under changing conditions.

Economic Systems: Increasing energy efficiency from renewable sources, particularly during peak weather events, will help cut back on costs of coal generated power. Urban farming measures were recommended as an area of policy development in order to encourage adaptation behavior and increase self-sufficiency.

The establishment of climate preparedness planning will help strengthen Gresham's resiliency to climate change as projected by climate models of OCCRI. This document will help outline in more details the expected impacts and additional recommendations for ways to prepare, adapt and build resiliency within the community to better understand climate change.

The Intergovernmental Panel on Climate Change (IPCC) declared in 2007 that there is “unequivocal” evidence that the earth’s atmosphere and oceans are warming (IPCC, 2007). Their research uncovered a number of potential factors causing this warming; primarily the generation of carbon emissions and other greenhouse gases from human sources, which are overloading the system and causing the changes. Because of the existing build up of emissions in the atmosphere, even if immediate action is taken to aggressively reduce global carbon emissions, Oregon and the Northwest can still expect to see average annual temperature increase around 3-4° F by mid century (IPCC, 2007). The Northwest has already experienced a 1-1.5° F average annual temperature increase over the last century (Mote 2004).

Potential consequences of this temperature increase as well as changes in precipitation patterns include severe weather events (e.g. extreme heat, extreme cold, droughts, and floods), increased disease outbreaks, reduced stream flow, and impacts on biodiversity. Gresham is among the many cities in Oregon proactively discussing plans for reducing or preparing for risks associated with climate change in order to build resiliency. Solutions to climate change include behavioral changes and modifying or adapting systems, both of which can be difficult for large populations to adopt. Additionally, many cities, counties and states do not contain the resources (financial or human capacity) to make significant changes. This, however, can be addressed through community engagement and discussion of multi-pronged approaches and co-benefit analysis for implementing new programs.

Definitions to know:

- *Mitigation:* In this report refers to the reduction of or lessening the seriousness of climate affects;
- *Preparation/Adaptation:* Proactively reduce the vulnerability of a community to negative impacts of climate change;
- *Resiliency:* Building capacity of systems to recover from the climate change impacts they cannot withstand;

(Climate Leadership Initiative Institute for Sustainable Environment, 2009 and Barr et al, 2010)

Objective

The Climate Leadership Initiative (CLI), a partnership between the Resource Innovation Group, a 501(c)(3) non-profit organization, and the University of Oregon’s Institute for a Sustainable Environment, developed a systems thinking model to engage communities in conversations and planning for climate change. They work across sectors to create multidimensional solutions for the potential problems facing the area. CLI’s “Climate Futures Forums” (CFFs) engage stakeholders across natural (e.g. landscape, streams, and biodiversity), human (e.g. emergency response, health care, education), built (e.g. transportation, irrigation, communications infrastructure and buildings), and economic (e.g. forestry, agriculture, manufacturing, tourism) systems in assessing what the likely local impacts are for their particular sectors and helping participants develop strategies and policy recommendations to prepare for climate change.

By using local, downscaled climate projections and engaging local stakeholders in community forums, cities and counties are able to establish proactive responses to climate change. The ultimate goal of the program is to support local governments, organizations, agencies, individuals and communities as a whole in developing and implementing strategies to build resiliency to climate change.

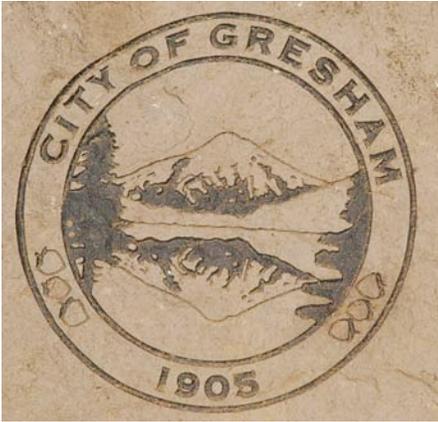
Sustainable Cities Initiative (SCI)

As part of the 2009-2010 Sustainable City Year program of the SCI, Gresham partnered with the University of Oregon to create a plan for a more sustainable future. This report outlines one of the SCI projects, a set of actions and recommendations for the city to begin addressing climate preparedness as part of their yearly city assessments. Downscaled climate data, provided by the Oregon Climate Change Research Institute (OCCRI) and the expected impacts and recommendations, which came from the Gresham workshop participants, can be used as a starting point for establishing long-term plans for climate change preparedness and risk management.

Gresham Climate Futures Report

In this report, prepared for the City of Gresham and the Sustainable City Year program, climate change preparedness will be discussed as it pertains to the City of Gresham and the Lower Willamette Subbasin. The report begins by giving an overview of climate change and this project. Next, this report will discuss the various systems (natural, human, built, and economic) that are focused on throughout the report. It will next discuss the future climate projections for the city of Gresham. With this background established, the report then goes through the specific impacts and recommendations provided by local experts regarding climate change preparedness necessary for each of the previously described natural and community systems. Finally, the report concludes with a vision of Gresham for the future as well as an action plan for the city to begin preparedness planning for the impacts of climate change.





This report, prepared for the Sustainable Cities Initiative and City of Gresham, is also part of a larger report being prepared for the Lower Willamette Climate Futures Forum project of the University of Oregon's Climate Leadership Initiative. The purpose of the program is to encourage preparedness planning around the impacts associated with climate change. By encouraging organizations and communities to plan ahead, stronger resilience can be established to address the impacts of climate change.

The Climate Futures Forum process supports local stakeholders and decision makers in assessing local climate projections, identifying potential impacts to local systems, and developing recommendations for climate preparedness. The program intentionally incorporates cross-sector collaboration in the process as climate change often spans the realm of natural, human, built, and economic systems. The process has been completed in the Rogue, Upper Willamette, and Klamath River basins; more information on climate preparedness can be found at: <http://climlead.uoregon.edu/node/9>. This report provides an overview of the process and results for Gresham, Oregon. It is part of a larger report that will reflect on a series of workshops that occurred throughout the Lower Willamette Basin in 2010. (Other workshops that were part of this forum include Portland [February 24, 2010], Oregon City [April 7, 2010] and Cornelius [April 9, 2010]). Participants (see Appendix A) at the April 15, 2010 Gresham workshop provided expertise and experience in a wide variety of sectors and were able to establish a set of community-specific recommendations to implement short-term and long-term preparedness strategies as well as identify ways to implement changes at low cost.

As part of the Sustainable City Year, the City of Gresham was interested in incorporating the recommendations of the Lower Willamette on a local level, ensuring their future plans include climate preparedness. As a host city of the Climate Futures Forum, many of Gresham's leaders were able to participate in the conversation, lending a certain level of locality to the forum and to future planning within the Lower Willamette Subbasin.

Evidence of Global Climate Change

Greenhouse-gas emissions from human activities are among the primary causes of the Earth's atmospheric warming to levels not experienced in the last 10,000 years (IPCC, 2007 and USGCRP 2009). Experts agree that as temperatures rise, resulting changes in climate patterns can be expected to impact communities (plant, animal and human) that rely on them. While projecting annual temperature change is next to impossible, climate scientists are able to make long-term projections for future change using models based on the laws of physics and various scenarios for future greenhouse gas emissions (IPCC, 2007). These changes in temperature are already having global consequences including:

- Increased precipitation levels and storm severity (USGCRP, 2009);
- Increased sea surface temperatures since 1961 of 0.2°F and significant ocean acidification (USGCRP, 2009);

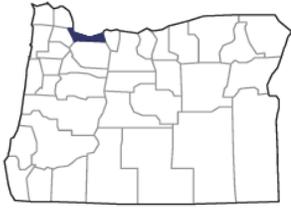


- An 8-inch rise in sea level following 2,000 years of little change (USGCRP, 2009); and
- Decreased Arctic sea ice of 20% since the 1950s (Curran et al. 2003).

Climate Change Preparedness

Even if significant efforts are made to reduce greenhouse gases and carbon emissions in the earth's atmosphere today, experts project that the stabilization of the climate systems will take decades, if not centuries, to occur. On the other hand, if emissions worldwide are not addressed soon, there is the possibility that a threshold (or "tipping point") may be passed and the opportunity to address climate change may never come (IPCC, 2007). Communities like Gresham, Oregon can take action now in order to prepare for climate changes in the future while also reducing the risk and severity of outcomes expected for the area.





The city of Gresham sits within Oregon's smallest, yet most densely populated county, Multnomah. With over 710,000 people in residence, Multnomah County is known for its arts and culture, outdoor recreation and as a leader of the green and sustainable movement.

As this program takes a whole-systems approach, below is a description of the four systems that were discussed during the forum process: natural, human, built and economic. (Cultural systems are also considered, but are not specifically described in this report.)

Natural Systems



Natural systems include aquatic and terrestrial species and habitats, water quality and quantity, and invasive plants. According to Oregon Water Quality Index scores, the Lower Willamette Subbasin, within which Gresham sits, ranks fairly low in water quality. Air quality ranks within the requirements of the Clean Air Act, but has been under surveillance due to previous violations. Invasive exotic plant and animal species do exist within the Subbasin, namely: English ivy, reed canary grass and Himalayan blackberry along

with the northern squawfish, black crappie, white crappie, largemouth bass, smallmouth bass, and walleye (City of Portland, n.d.). Species identified as Endangered or Threatened in the region (due to invasives, loss of habitat, and other causes) include the Lower Columbia River Chinook salmon (threatened, 1999), Columbia River chum salmon (threatened, 1999), Lower Columbia River coho salmon (threatened, 2005), Lower Columbia River steelhead (threatened, 1998; reaffirmed, 2006) (ODFW, 2006), Yellow-breasted Chat, Acorn Woodpecker, Lamprey, Western Painted Turtle, and the Northwest Pond Turtle.

Human Systems

Human systems includes social services, public health, education, and emergency services. Education near Gresham includes a number of private and public universities, community colleges and technical institutes. It is estimated that 88% of people 25 years of age or old have high school degrees or higher while 31% have a bachelor's degree or higher (City Data, 2010). The city has an emergency preparedness system in place in the event of a disaster with information on what to do and how the city communicates with residents during the event. In



partnership with Federal Emergency Management Authority (FEMA) and organizations like the Centers for Disease Control and Prevention (CDC), government and private agencies have worked to prepare for, respond to and recover from a wide range of potential emergencies and disasters such as the H1N1 virus outbreak, extreme heatwaves and flooding events (OEM, 2010). Public Health systems within Multnomah County and the Lower Willamette Subbasin include clinics, hospitals, food safety, disease response and monitoring, immunizations, and healthcare for citizens within the area.

Built Systems



Built systems include transportation and communications infrastructure, homes, buildings, water supply and power supply. Portland General Electric (PGE) and PacificCorp (referred to as Pacific Power in Oregon) largely provide utilities in Gresham. Northwest Natural is the main provider of natural gas for heating. Water services are provided by the City and are managed by Clean Water Services. The mass transit transportation system in, out, and within the city is well connected. The largest airport in the state, Portland International Airport (PDX), rests just outside the city limits. Further, public transportation within the city limits is provided by TriMet, including the Metropolitan Area Express [MAX] light rail system, serving the greater Portland area as well as Gresham. Nearby, Amtrak provides rail service connecting to Seattle and Los Angeles out of downtown Portland.

Economic Systems

Major economic sectors in the city include agriculture, forestry, retail, tourism, commercial fishing, and healthcare. Multnomah County is known for its vegetables, melons, potatoes and sweet potatoes in addition to fruits, nuts, and berries. There are roughly 30,000 acres of farms providing just shy of 40% of the agricultural employment (e.g. farming, fishing, and forestry) in the county (Census of Agriculture, 2010). Aside from the agriculture, Multnomah County provides many opportunities for outdoor recreation to tourists from all over the world. The City of Gresham has a historic downtown for tourists to explore in addition to golf courses, a center for the arts, numerous city parks, and the Springwater Corridor (a former rail line that has been converted for bikers, walkers, and skaters).



Understanding what actions should be taken to prepare natural, built, human, cultural and economic systems for climate change is challenging. The Earth's climate and ocean systems are too complex to be simulated in a laboratory experiment or reactor. Therefore, climate scientists use global climate models to estimate how climate change might affect conditions in mid- and end-of-century (Climate Leadership Initiative, 2009). Climate models incorporate the physical laws and chemical interactions of the Earth. Future conditions are calculated based on different "scenarios" (or estimations) of future greenhouse gas emissions, policies and regulations that would limit emissions, technological improvements, and behavioral changes (for the scenarios selected in this project, please see below).

In order to test the climate models, they are backcasted against observed data to see how well they "predict" the past. While each of the inputs to the models are the same, they vary in their level of detail and manner of interpretation. This results in some differences in outputs and uncertainty as to which future scenario is most likely to occur (and therefore the importance of running multiple models). The difference in detail and interpretation that leads to this uncertainty is due to processes and feedbacks between different parts of the Earth's climate system that are not fully understood. However, by comparing a group of climate models, it is possible to project a credible range of possible future conditions.

Most climate models are created at global scales, but are difficult to downscale to local or regional scales because the more localized they become, the greater the chance of errors and uncertainty. However, managers and policymakers need regional and local data that reflect how climate change will impact their region in order to plan and develop policies. The Oregon Climate Change Research Institute (OCCRI) has adjusted global model results to local and regional scales to support this effort.

The Intergovernmental Panel on Climate Change (IPCC) uses approximately 27 models to make global climate projections. The models are developed by different institutions in different countries around the world and are subject to different interpretations.

OCCRI has selected the following models for use in the Lower Willamette Subbasin project:

- PCM1: The Parallel Climate Model, developed through a collaboration of United States federal agencies.
- CSIRO-MK3: Developed by the Atmospheric Research Office in Australia.
- HadCM3: Developed by the Met Office, the national weather office for the United Kingdom.
- MIROC (MC1): A Japanese model used for the MC1 vegetation models (shown in results for fire and vegetation projections).

These models were selected because they use temperature and precipitation forcing agents including changes in greenhouse gas emissions, aerosols, water vapor and cloud cover, solar radiation, and changes in land use to represent possible future conditions.

To further refine these projected futures, the IPCC has developed a range of scenarios under which climate models are run. These scenarios, as described in the IPCC's Special Report on Emissions Scenarios (SRES)¹, describe different futures for greenhouse gas emissions, land use, and agricultural practices based on global policy decision-making. For this report, two scenarios were selected to model how different futures might play out:

¹ For more information on SRES, visit: http://www.ipcc-data.org/ddc_envdata.html

- A1b: The business as usual scenario (for which current global emissions are actually exceeding) that presumes continued growth in economies, population and technology, and reliance on mixed energy sources.
- B1: The 'greener' emissions scenario, which suggests emissions increasing slightly in the coming decades but then falling to lower than current levels by 2100 due to deployment of low carbon energy and transportation systems.

Model outputs were converted to local scales using local data on recent temperature and precipitation patterns. The MC1 vegetation model provides information on possible future vegetation types and wildfire patterns.

The utility of the model results presented in this report is to assist public and private entities envision what the conditions and landscape may look like in the future and the potential magnitude and direction of change.

It is important to note that the scenarios described in this report utilize the best available information. However, they are not predictions. Instead, they should be considered possible outcomes. Actual conditions may vary quite substantially from those depicted in these scenarios. Readers are therefore urged to focus on the range of projections and the trends they suggest, as opposed to relying on the outputs of a single model or on a particular number.

Outputs of our climate models (PCM, CSIRO, and HadCM) and the vegetation model (MC1) include projections for changes in temperature, precipitation, percent of landscape burned, suitable vegetation types and distribution, snowpack, and streamflow. A historical baseline of 1971-2000 was used in order to make comparisons of projections for the 2040s (2030-2059) and 2080s (2070-2099) (scientists use thirty year time slices, or averages, to account for interannual and interdecadal variability). Stream data is for 2020s and 2040s, due to data availability. The results present a range of different possible future conditions in the Lower Willamette, including Gresham. Unforeseen circumstances such as uncertainties about chemical reactions or international policy to drastically reduce greenhouse gas emissions, may result in a future different than has been projected.

Climate change projections are provided as bar graphs, charts and spatial maps to demonstrate the results of the modeling using a variety of visualizations that may be useful for different decision-making groups. Samples for each factor are available in Appendix B - a full set of modeling results is available at <http://climlead.uoregon.edu>.

The modeling results come from the global modeling results available from the IPCC Fourth Assessment Report. Implications for the Pacific Northwest are based on the twenty global climate models analyzed by Mote and Salathé (2009). For historical baseline, 800m PRISM 1971-2000 climate grids were used to apply to the analysis and 'downscale' the data.

Temperature

The overall trend for temperature shows warming for the entire Lower Willamette by the end of the century. The most intense warming of 10-15° F is in summer (Figure 1). Warming is also most intense along the Interstate 5 corridor (running through the most populated area of the Basin). There is also warming during the winter months (Figure 2), but less extreme than in the summer (about 3-5° F). In the B1 scenario, there is still warming, but warming is less severe in the summer months (Figure 3) compared with the higher emissions scenario, and minimal in winter (Figure 4).

Figure 1 - "Business As Usual" (A1b) Summer Temperature Projections - HadCM3

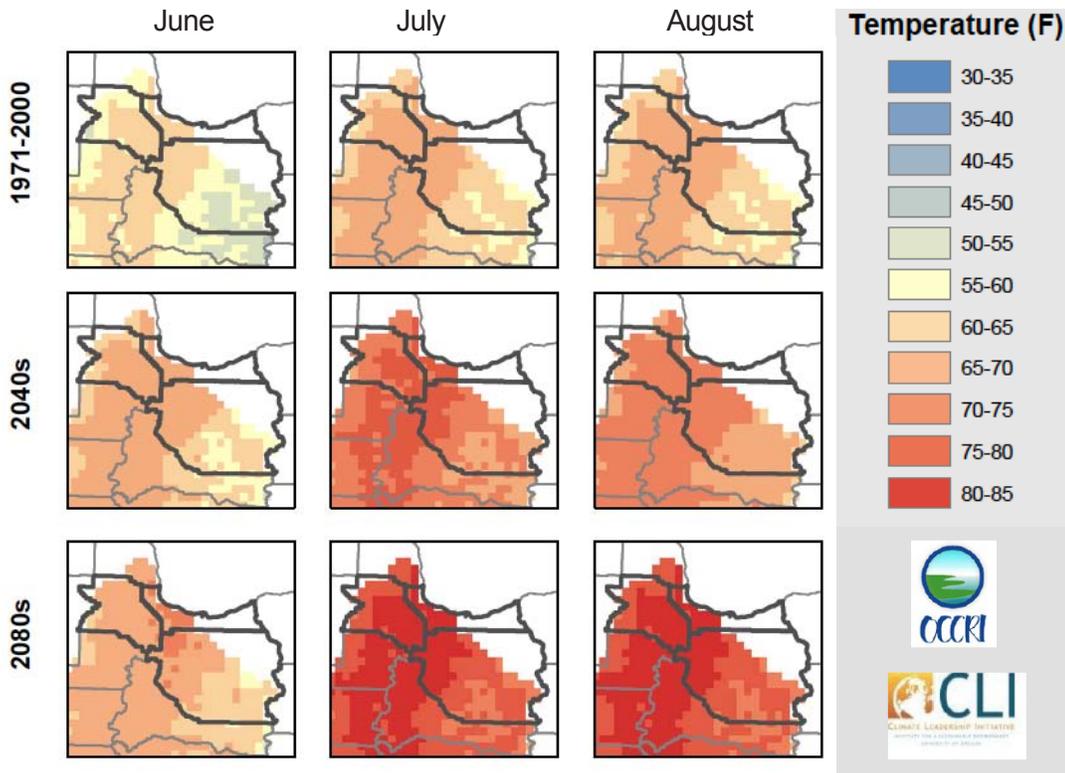


Figure 2 - "Business As Usual" (A1b) Winter Temperature Projections - HadCM3

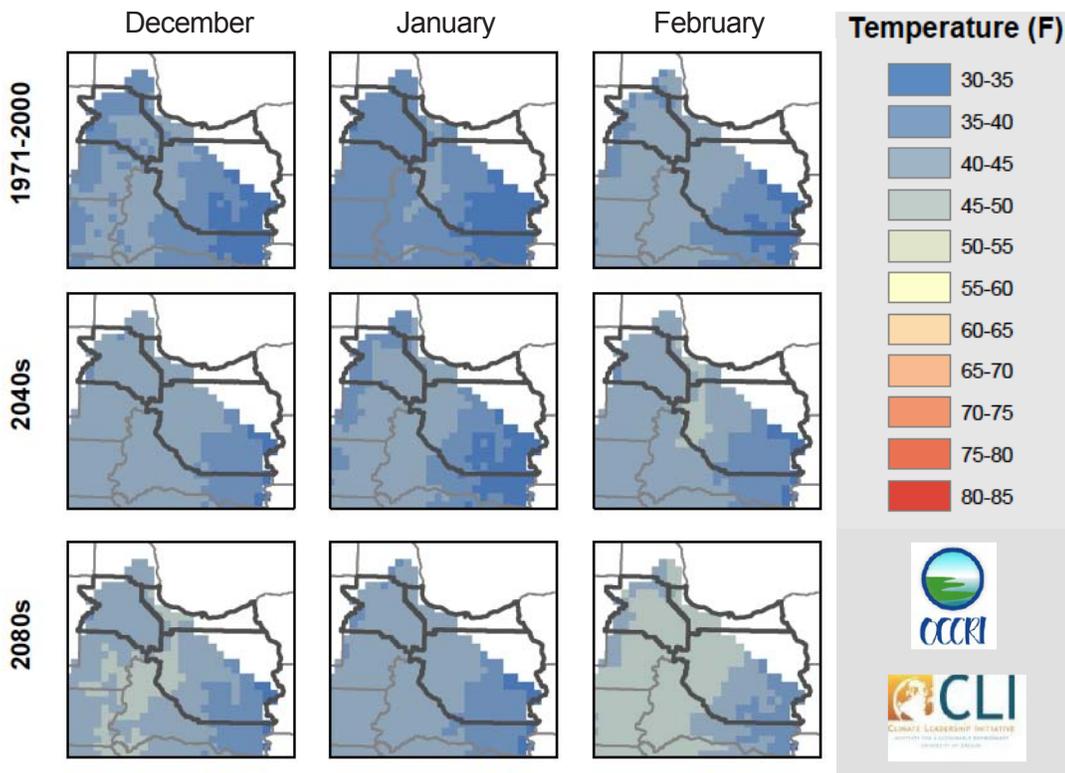


Figure 3 - "Green Scenario" (B1) Summer Temperature Projections - HadCM3

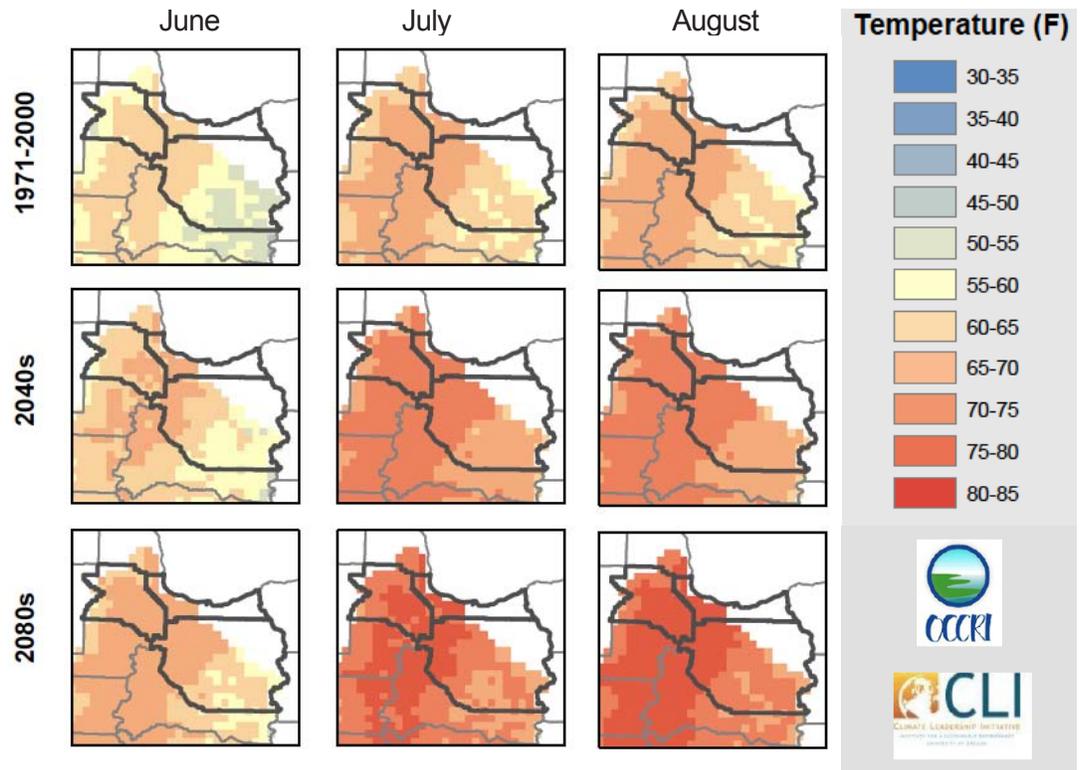
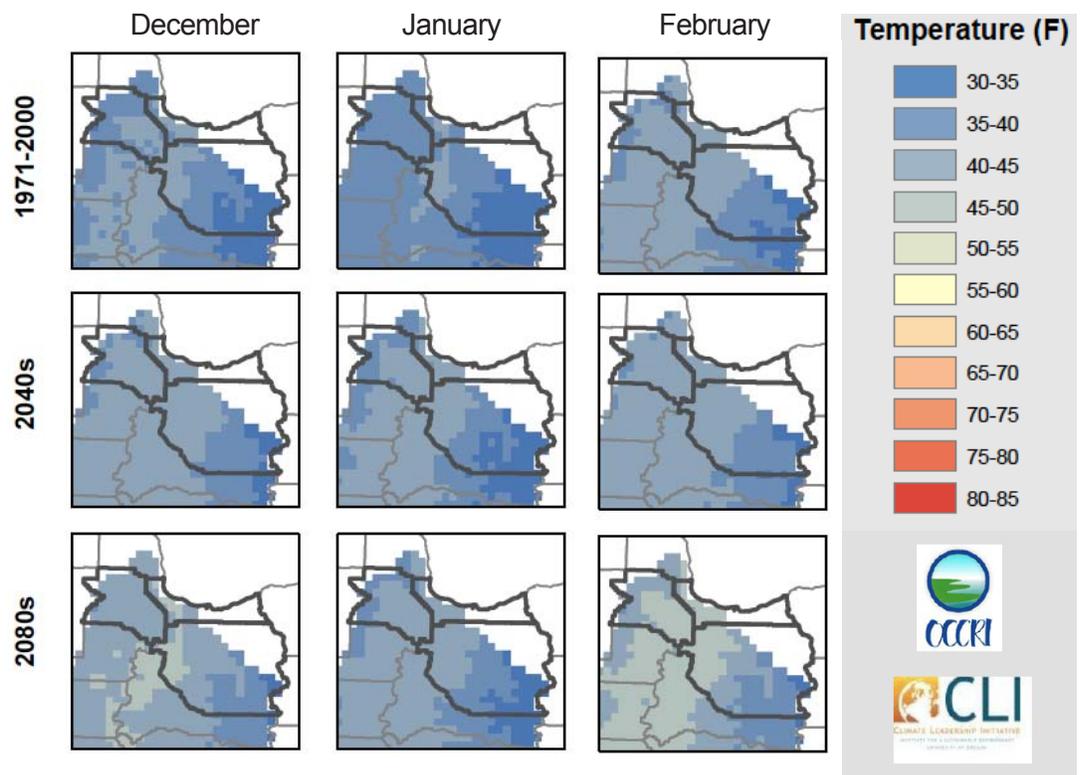


Figure 4 - "Green Scenario" (B1) Winter Temperature Projections - HadCM3



Precipitation

Precipitation is one of the variables most difficult for climate models to project, particularly for the Pacific Northwest. For the mid-century A1b scenario, an increase in precipitation is seen in the winter for all models (Figures 7 & 8 - minimal for PCM1), with the least change in the spring, and mixed results in the summer (Figures 5 & 6 - only shown through mid-century). HadCM shows severe drought in the summer, while CSIRO and PCM1 show a slight increase in precipitation. For the fall months, the models project mixed results in precipitation. In the 2080s, the CSIRO and PCM1 models show an increase in precipitation for most of the year. HadCM projects a slight reduction in the spring and drought in the summer, but not as severe of drought as shown (Fig 6) in the 2040s.

Figure 5 - "Business As Usual" (A1b) Summer Precipitation Projections - CSIRO3.5

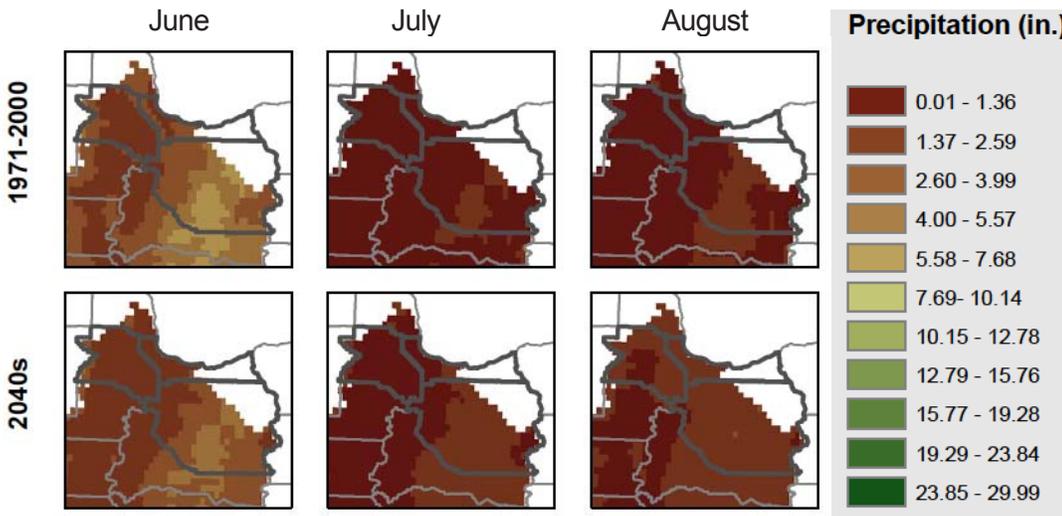


Figure 6 - "Business As Usual" (A1b) Summer Precipitation Projections - HadCM3

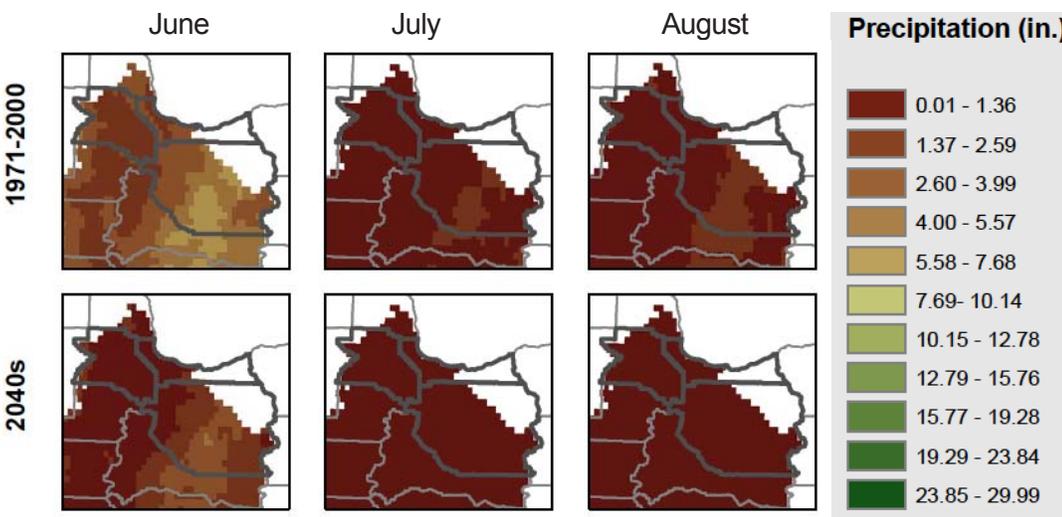


Figure 7 - “Business As Usual” (A1b) Winter Precipitation Projections - CSIRO3.5

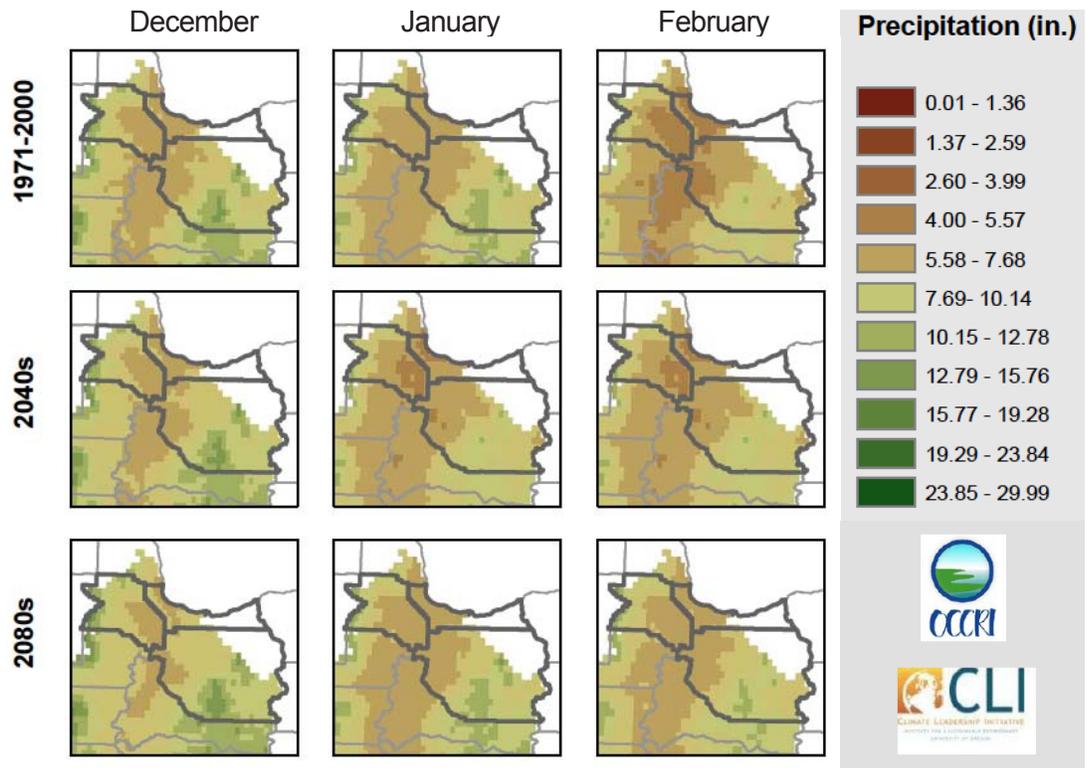
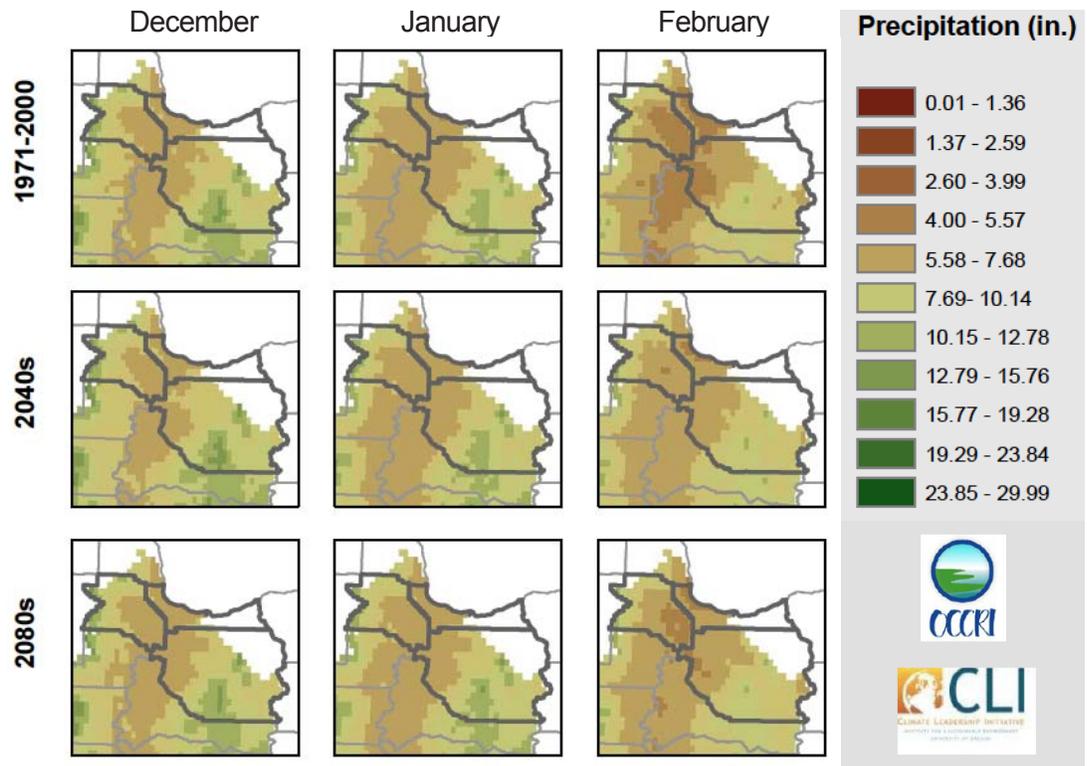


Figure 8 - “Business As Usual” (A1b) Winter Precipitation Projections - HadCM3



For the B1 scenario, the models produced mixed results for winter, with no change in the HadCM (Figure 12), a slight increase for CSIRO (Figure 11 - except a decrease in late winter) and increases in the first half of the century, then decreasing for PCM1. The models were in better agreement for summer, with the HadCM3 (Figure 10 - only shown through mid-century) and PCM1 showing a decrease. The same was true for CSIRO for the latter half of the century, but the model showed decreases for the early part of summer and a bit of an increase in later summer for mid-century (Figure 9 - only shown through mid-century).

Figure 9 - "Green Scenario" (B1) Summer Precipitation Projections - CSIRO3.5

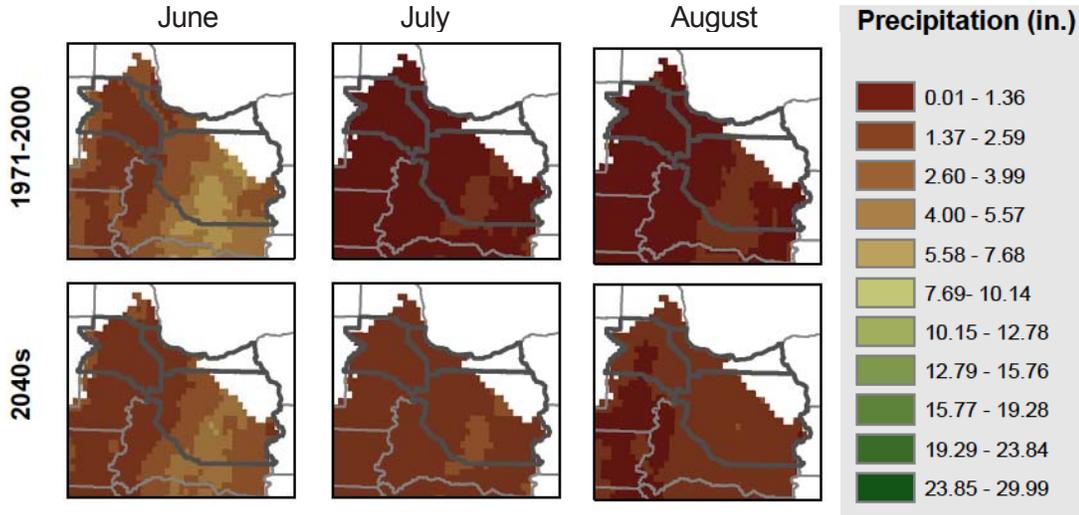


Figure 10 - "Green Scenario" (B1) Summer Precipitation Projections - HadCM3

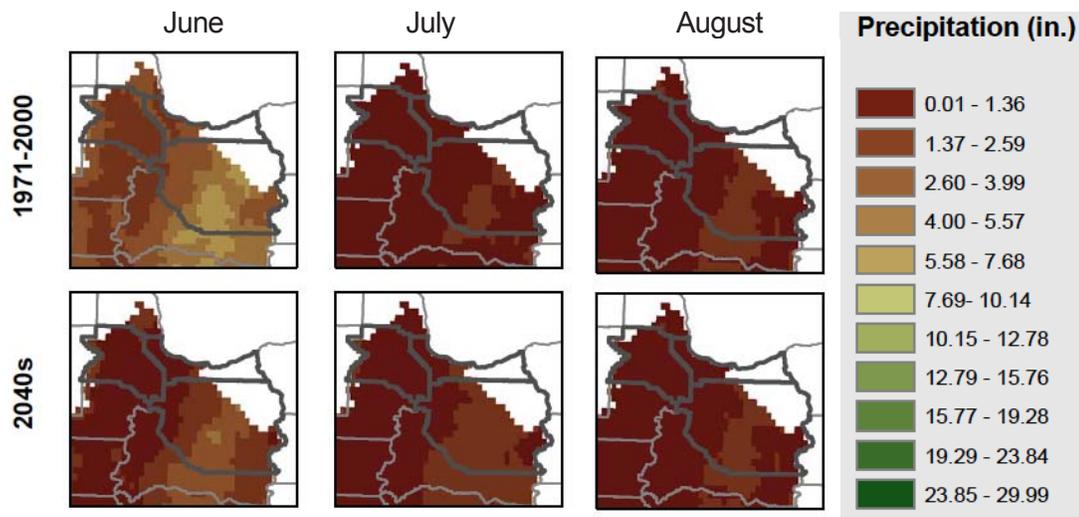


Figure 11 - “Green Scenario” (B1) Winter Precipitation Projections - CSIRO3.5

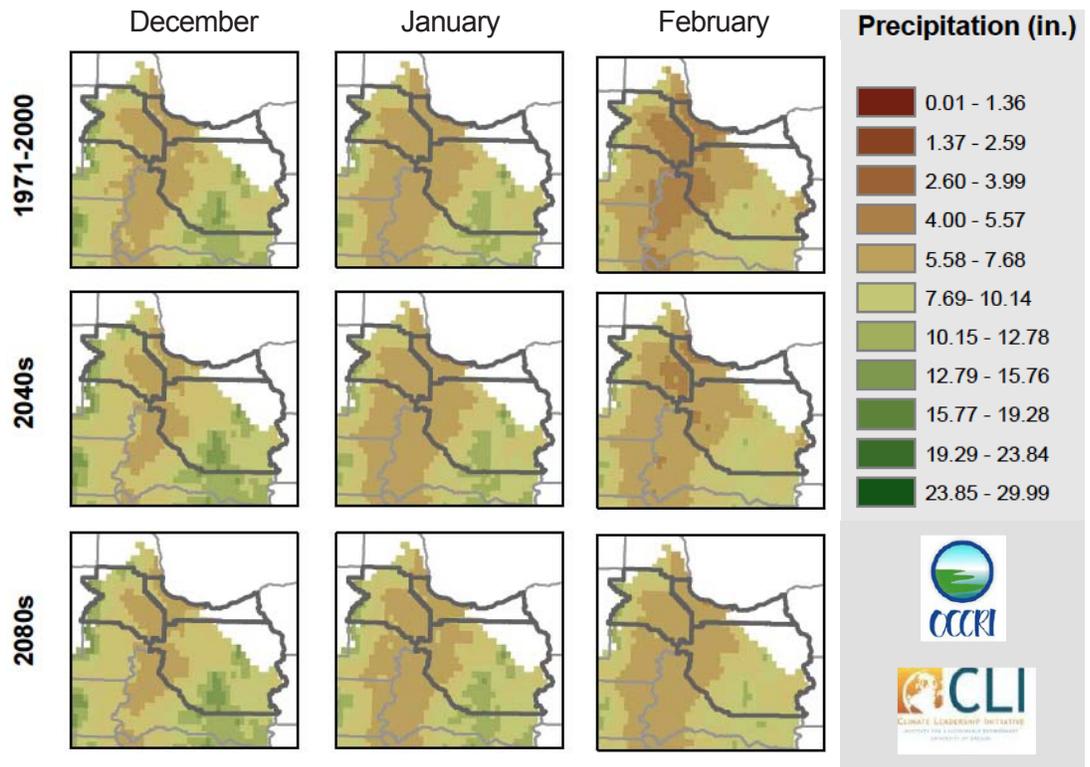
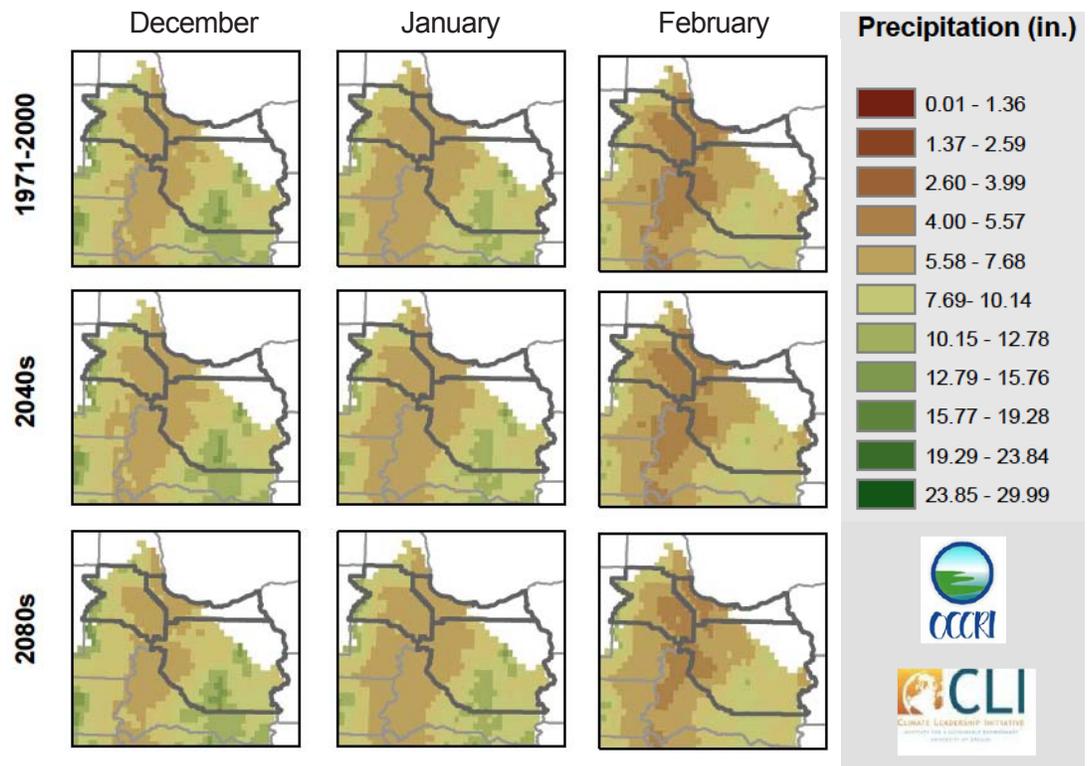


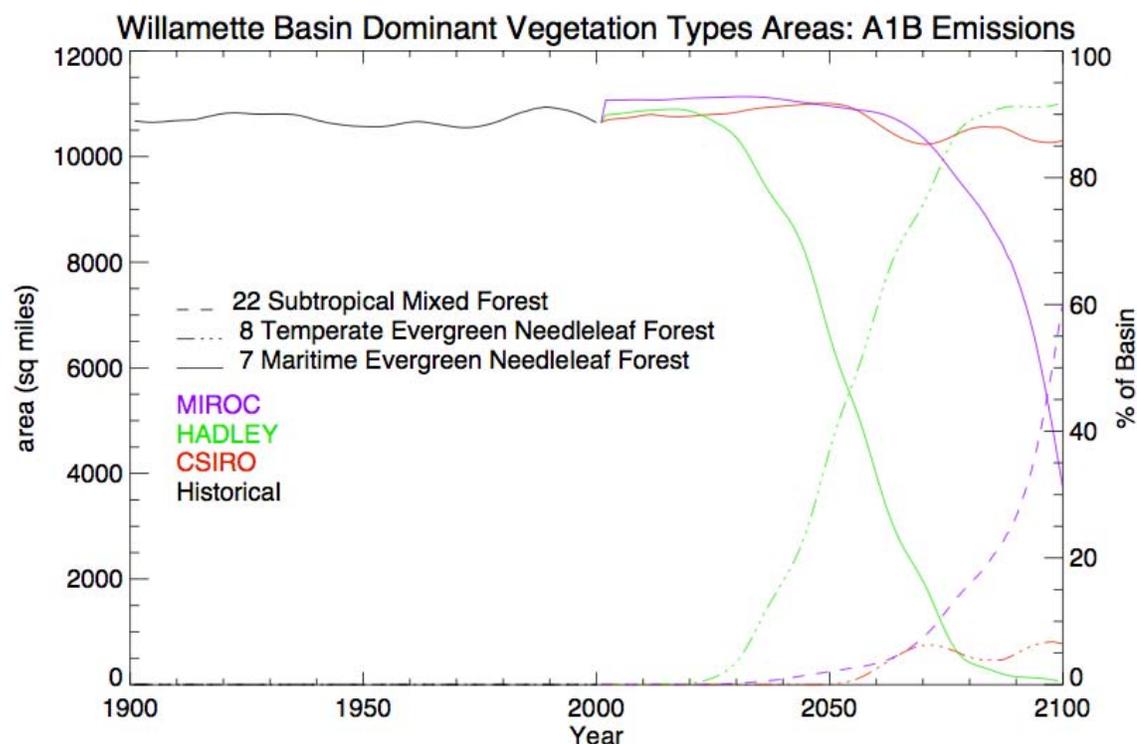
Figure 12 - “Green Scenario” (B1) Winter Precipitation Projections - HadCM3



Vegetation

For Maritime Evergreen Needleleaf species, the HadCM and MIROC models project a significant decline, with near disappearance by the end of the century. CSIRO also shows a decline, but not as severe as the other models. HadCM shows a rapid increase in Temperate Evergreen Needleleaf species, replacing Maritime species. MIROC and CSIRO also project an increase in Temperate Evergreen species, but not as rapidly as HadCM. Subtropical Mixed Forest species also increases slightly in abundance, with rapid increase after mid-century under the MIROC model, but less change for HadCM and CSIRO. (Data provided by Ray Drapek, Pacific Northwest Research Station.) A large portion of the vegetation change in the Northwest is expected to be attributed to increased fires, leading to a transition and dominance of other species (Figure 13).

Figure 13 - Dominant Vegetation Type Projections with “Business as Usual” (A1b)



Acres Burned

The fire projection maps (Figures 14 and 15) show percent of area in each grid cell (8km) projected to be burned for the entire Willamette Basin (note, counties for the Lower Subbasin could not be overlaid, but Gresham is nearest the northeast corner in the images). Under both scenarios, HadCM projects a greater proportion burned with almost 2% of each grid cell burned by 2080. MIROC and HadCM show an increase in intensity of areas burned, especially under the A1b scenario and for the Lower Willamette Subbasin.



CSIRO, which tends to be a wetter and cooler model, shows less change in proportion burned. (Data provided by Ray Drapek, Pacific Northwest Research Station.)

Figure 14 - Percent of Area Burned Projections in Willamette Subbasin (A1b Scenario)

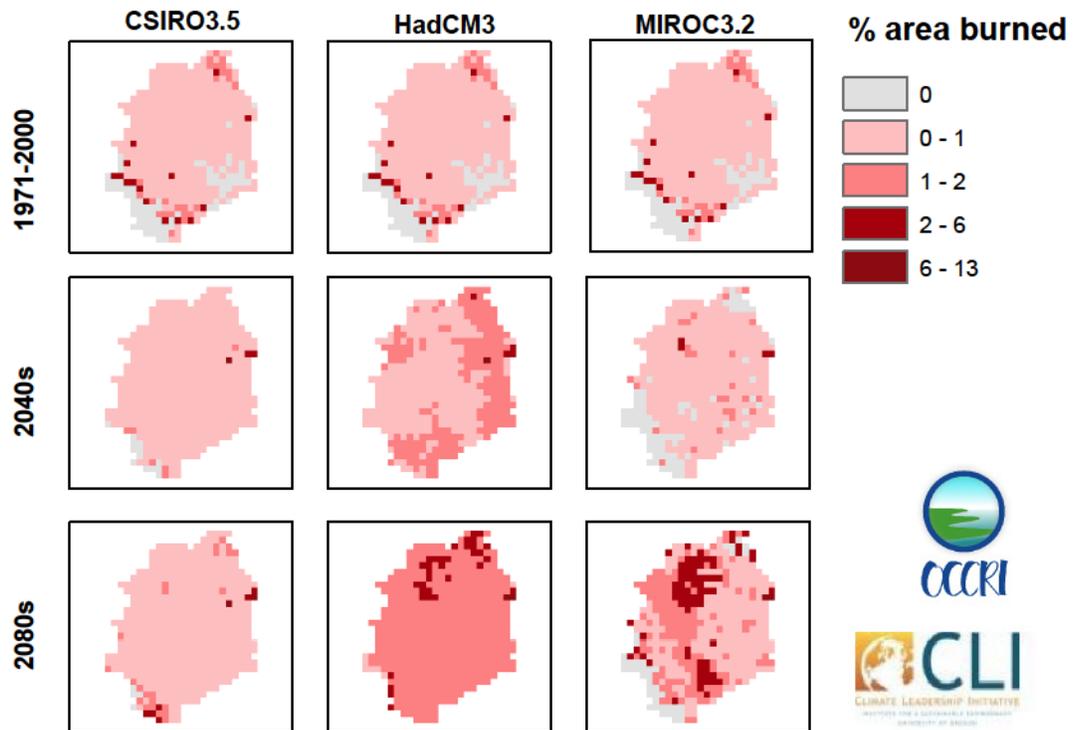
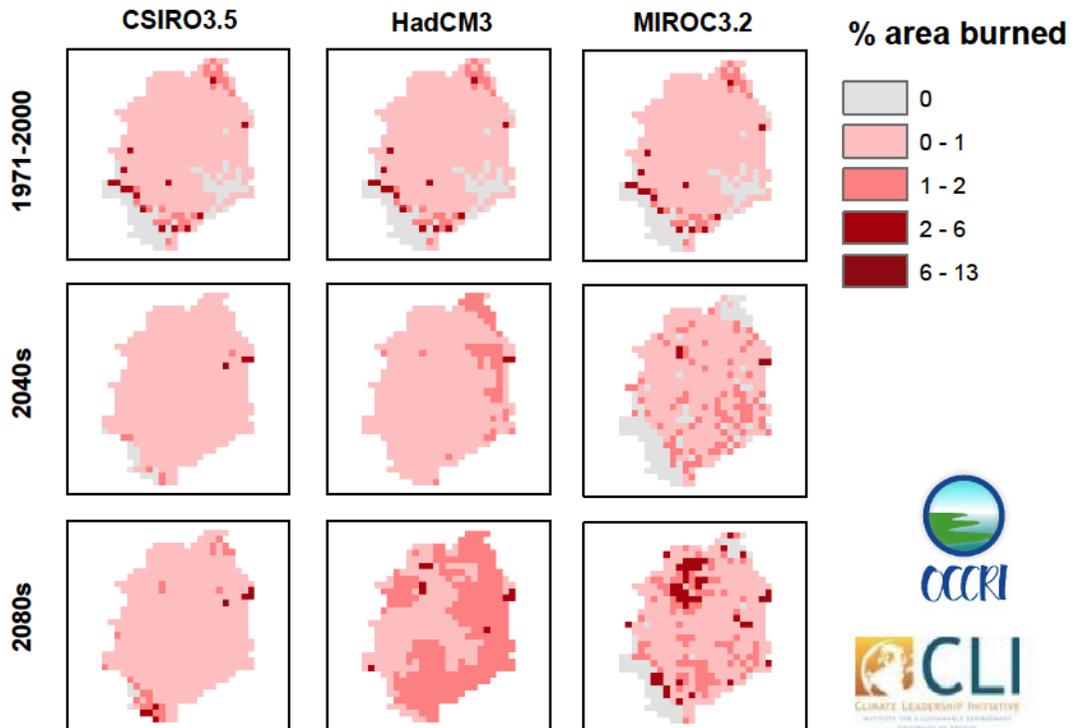


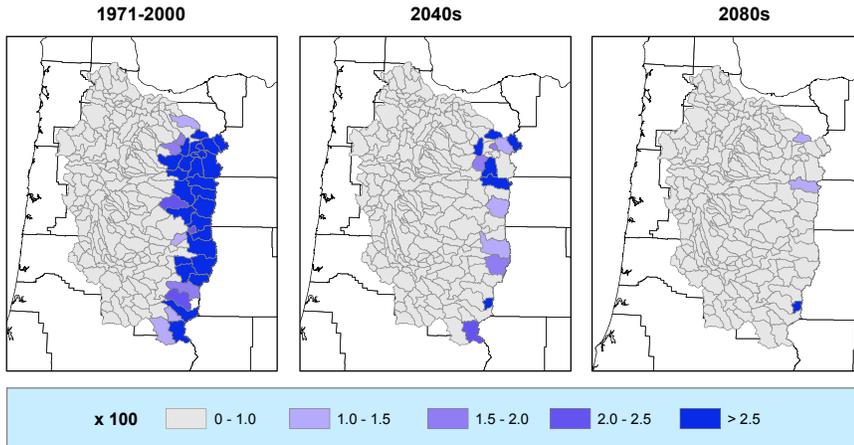
Figure 15 - Percent of Area Burned Projections in Willamette Subbasin (B1 Scenario)



Snow Water Equivalent

Under the A1b scenario, the model (Figure 16) projects a severe decrease in snow water equivalent with near disappearance (greater than 80% loss) by the end of the century. (Data provided by Heejun Chang, Portland State University.)

Figure 16 - Mean Projected Changes in Snow Water Equivalent (A1b Scenario)



SRES a1b

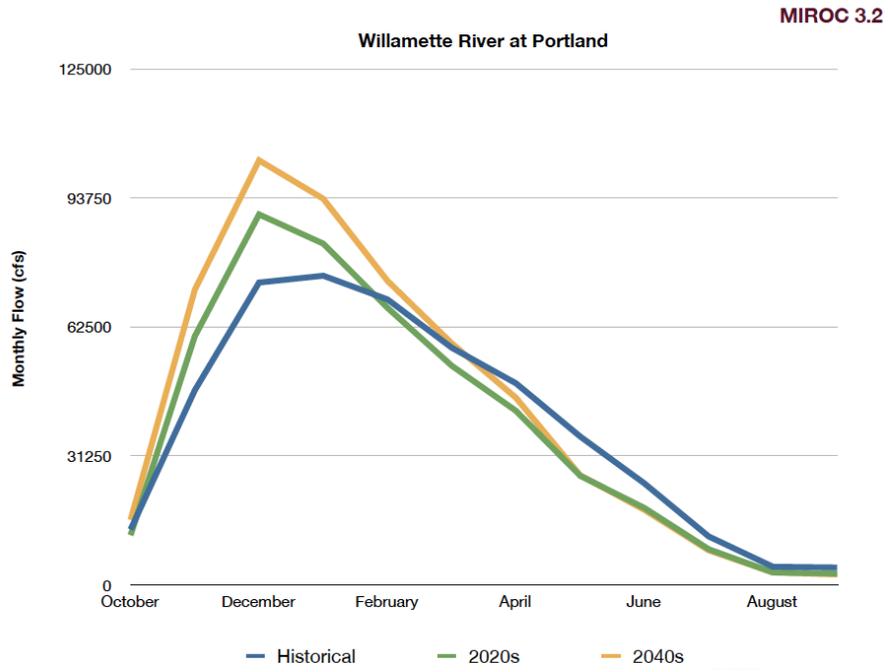
Streamflow

Projections show that streams are likely to become flashier in the winter and early spring— that is, higher high flows and more frequent and severe flooding, and lower low flows with more streams going dry – due to temperature, more precipitation falling as rain, groundwater and storm severity changes. All three models show a slight increase in winter flow, with a



moderate decrease in historical summer flows. Figure 17 shows the expected flow of the Willamette River discharge into the Columbia through the first half of the century. Flow is expected to increase during the winter (expected with increased rain events and less snowfall) and more rapidly decrease through the spring and summer (with less expected snowpack).

Figure 17 - Monthly Flow Projections for the Willamette River at Portland



VI. Consequences for Natural Systems and Recommendations for Preparation Strategies



Projections for climate change are expected to create many shifts in natural ecosystems and species. Regional experts provided the information below during a one-day workshop in Portland. While many of the identified impacts and recommendations were generalized across the Lower Willamette, those most applicable to Gresham are listed below. Natural resource experts identified impacts to natural systems focusing on aquatic and terrestrial habitats and species. Individuals made projections for natural systems consequences using their collective understanding in the fields of science, natural processes, habitats, plants and animal species. They also made recommendations for ways to help reduce the severity of impacts and help ecosystems become more resilient.

Aquatic Habitat and Species

Impacts to Aquatic Systems

Increased precipitation may result in more frequent and severe flooding to the area. Flashier flooding increases erosion, soil loss and the introduction of pollutants draining into streams will also degrade riparian areas over time.

An increase in temperature will likely impact water quality as stream conditions will play host to algae blooms and fall prey to nutrient loading. For species with temperature gender determination, like the Western Pond Turtle and Western Painted Turtle, a change in sexual diversity is expected as the ratio of male-to-female shifts (more females with warmer temperatures). Aquatic species may be affected by the loss of habitat and refugia as wetlands may dry or even desiccate during summer months, streams may experience a reduction in flow, and the overall biodiversity of aquatic species will decline.

Recommendations for Aquatic Systems

While impacts to aquatic systems pose detrimental concerns, there are opportunities to help create resiliency and protect both habitats and species. The key recommendations provided by natural systems experts are:

- Protect floodplains;
- Increase/restore the complexity of streams; and
- Protect genetic diversity and recovery opportunities for fish.

Each of these recommendations provides an opportunity to help build resistance and resiliency to the impending climate change impacts. Protecting floodplains supports the need to create and maintain deep water and off-channel habitats. The loss of complexity in streams has depleted habitats of many aquatic species, but by increasing complexity and protecting cold refugia, those species will better survive climate change.

Terrestrial Habitats and Species

Impacts to Terrestrial Systems

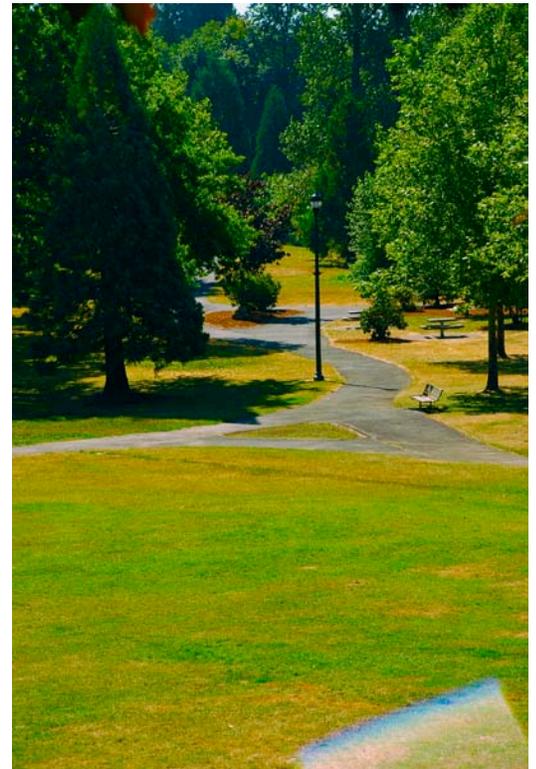
Under warming conditions and drier terrain, there is an expectation that wildfires will increase in areas surrounding the Gresham community. This will create increased periods of smoke affecting human and animal communities. Moreover, changes in wind patterns could alter seed dispersal as well as increase the chances that smoke is distributed over larger areas, affecting air quality. With increased fires, ecosystems will be less resilient against invasive species, which colonize after such events. Considerations for habitat and refugia were also discussed, noting that amphibians that rely on soil and ground cover may experience habitat loss. Additionally, species like the northern spotted owl may be unable to find suitable habitat while their current habitat is further fragmented and vegetation conditions shift.

Recommendations for Terrestrial Systems

In order to prepare terrestrial systems for climate impacts, natural resource experts identified the following as key recommendations:

- Restore natural fire regime to reduce fuel build up;
- Use a landscape scale approach to conservation; and
- Plant more trees to reduce heat island effect in urban areas.

It is recommended that the city restore the natural fire regime with consideration for days that will least impact human health. Additionally, fire prone areas should be limited in their growth and if infrastructure does exist, it should be fire-proofed. The landscape scale approach integrates efforts happening at a localized level to help protect habitat.



Both Terrestrial and Aquatic Habitats and Species

Impacts to Both Terrestrial and Aquatic Systems

An increase in extreme weather events (e.g. increased precipitation events and heat waves) is expected to impact areas like Gresham, Oregon. While precipitation will create problems of flooding and soil erosion, extreme heat can cause heat island effects for cities with disproportional amounts of heat-absorbing materials (e.g. concrete and asphalt).

The Lower Willamette Subbasin can expect changes in stream flow and subsequently potentially detrimental reductions in ecosystem services. An example might be the ability of the Willamette Basin to store necessary amounts of water for citizens in the area, affecting both drinking water, sewage, and stormwater treatments. Pollination may also be disrupted, having negative impacts on economic sectors.

Species will likely be negatively affected by climate change as well. Migration patterns and habitats can be expected to change according to the shift in weather. While some species will remain longer due to warmer winter weather, others may become more common creating competition for prey and vegetation. These changes can have considerable impacts on the historical timing of the food web and its reliance on specific food diversity at particular times of the year.

Opportunities for Both Terrestrial and Aquatic Systems

With the expected increase in fires, certain species like woodpeckers, olive-sided flycatchers and nighthawks may benefit from the succeeding increase in insects. This could also affect their habitat and living range as conditions change. As water temperatures rise, warm water species will thrive in the welcoming habitat. Species that thrive in ever changing conditions and are easily adaptable are expected survive fine under changing climate (e.g. bald eagles, crows, coyotes and some types of owls).

Recommendations for Both Terrestrial and Aquatic Systems

Due to the observations that climate change has the potential for negative and positive impacts, recommendations for both terrestrial and aquatic systems are largely focused on protecting existing habitats and addressing species management. In order for this to happen, a consideration of new or revised policies that protect habitats should be considered; this would replace the existing framework that only focuses on endangered species. These habitats should be large enough for natural processes to occur. In order to maintain the species in these habitats, the Threatened, Endangered and Sensitive (TES) species management process should be reviewed and reconsidered in order to prepare for species that may migrate away from or to the Lower Willamette Subbasin.

Heat Island Effect

Heat Island describes the effect that urban areas, which tend to be built up, are likely to have hotter temperatures than neighboring rural areas. Particularly during seasons of increased temperatures, heat island effect may increase energy use and the need to monitor for extreme heat conditions (EPA, 2010).

VII. Consequences for Community Systems and Recommendations for Preparation Strategies



Gresham can expect climate change to impact the built, economic and human systems (collectively referred to as “community systems”) as a result of climate change. Experts within these community systems joined together at the April 15th Gresham Climate Futures Forum to discuss potential impacts and recommendations for climate change preparation. The consequences and recommendations outlined in this section of the report are summarized from the Climate Future Forums meetings and do not necessarily reflect the findings or positions of the City of Gresham or its staff.

Human Systems

Impacts to Human Systems

Given that the Pacific Northwest is projected to experience consequences less severe than other parts of the country and world, cities like Gresham can expect to see an influx of climate refugees seeking both permanent residence and temporary shelter. With additional people to serve, social services will be stretched beyond capacity and social networks will diminish or weaken as communities become strapped for service provisions.

While the city currently boasts of a cooperative emergency management system, the ability to sustain such services for extended periods of time may become more difficult. For example, public health experts estimated that only 15-20% of homes in the Lower Willamette Subbasin have air conditioning, making a significant portion of the people vulnerable to heatwaves. Populations such as the elderly, lower income, those with pre-existing conditions (e.g. asthma), individuals with mobility constraints, language barriers, homelessness, and children all are at risk of heat related adversities. Additionally, extreme weather events can adversely affect the mental health of the population. The stress implications and lack of access to health services during extreme events can have negative implication for those with mental health problems, and those at risk of developing them.

Gresham’s water supply comes primarily from Bull Run. Because the majority of the City’s water is sourced from one location, the implications for a failed system can be detrimental, including potential E. Coli outbreaks, impacted water quality, and potential sewer backup. The population is also at risk of vector-borne disease spreading due to the extreme weather changes (e.g. heavy rains, followed by temperature increases). Mosquitoes and ticks are amongst the vectors that may carry infectious diseases (such as West Nile Virus and Lyme disease, both of which are currently uncommon in the Northwest) harmful to individuals in Gresham.

Recommendations for Human Systems

In order to prepare and respond to these climate change impacts, there are number of potential adaptive and mitigating measures that can be taken. Experts recommended that a map of the water systems with clear lines of where water lines run, and who is connected to what areas is created in addition to an information system that can support information dissemination during an emergency (e.g. boil alerts, access to cooling centers). Essential services should also be relocated out of potential flood- or fire-plains. Communication systems (using multiple means and languages) that help people know where safe water is or how to respond in an emergency) will help keep the community healthy. Because Gresham is tied so closely to Bull Run, it was also recommended that smaller storage tanks be considered in order to spread out the responsibilities centers, decreasing those affected should one water source become contaminated.



Preventative healthcare is also an essential measure for mitigating health problems during an event. By ensuring the population is healthy at the onset of an event, there are higher chances for their continued health throughout. As a measure for supporting this system, education forums can be used to teach the community members about the importance of taking care of themselves and knowing the signs of when they need a doctor or healthcare professional. Particularly during heatwave events, educating communities about checking in with vulnerable populations (such as the elderly), making sure people know where cooling centers are, and training community-based organizations on emergency response mechanisms will significantly improve response measures.

In order to build resiliency, residents are encouraged to learn about gardening and growing their own food. Creating a local food movement or an urban farming movement to encourage community gardening and help build a local food supply can be essential in the case of an emergency when food transportation systems may be disrupted or in the case of food-borne disease outbreaks. While these recommendations help support the population in the event of an emergency situation, they also builds social capital and networking opportunities to help the community really understand what role they play and how they can work together.

Built Systems

Impacts to Built Systems

Considerations for built systems and the potential impacts from climate change will be significant for areas like Gresham. There was growing concern among the forum participants that there is not enough “forward thinking” happening within the city, that each action is taken as a response to a condition instead of in preparation for impending conditions. As such, discussions around transportation, water infrastructure management, fire protection and housing were key focus areas.

Bike lanes were a concern for the transportation infrastructure present in the city of Gresham. With few lanes, safety of riders and access to safe routes has growing implications for the city. With increased rainfall, bike lanes and driving lanes may be impacted by weather events or severe flooding, reducing the ability of bikers to get around the city.



With houses being built in very close proximity to water and the potential for increased flash flooding events, the resilience of these homes and neighborhoods is significantly reduced. Moreover, as water systems are incredibly complex and interconnected, and public water infrastructure is aging, drinking water could be affected by an extreme event and access to clean water will be increasingly difficult.

Neighborhoods will need to consider the implications of increased wildfires. As the summer weather has potential to create increased drying in the area, wildfires may impact the integrity of neighborhoods causing displacement of large groups of people.

Gresham is served by Portland General Electric for power supply, which relies on hydroelectric power generation for a portion of its energy supply. With decreased stream flow in the summer months (due to reduced snowpack and changes in precipitation patterns), as well as an increase in energy consumption for air conditioning with warmer temperatures, hydroelectric power systems may be strained and an increase in coal for energy may occur. In addition, transmission lines may be threatened by increasing summer temperatures as well as wildfires.



Recommendations for Built Systems

Building resiliency into the existing systems will be important for climate preparedness. Experts identified the following as key recommendations for preparation:

- Increase community-based renewable energy systems within neighborhoods and homes;
- Build water storage options to spread responsibility centers and improve infrastructure;
- Provide incentives for people to move off the floodplain or fireplain;
- Develop fire protection plans to ensure safety under changing conditions;
- Plant trees and minimize parking surfaces to reduce heat island effect; and
- Create incentives for home insulation to increase energy efficiency.

Looking into future planning initiatives, it was recommended that mixed experience housing is developed to support active community engagement. These new developments (ie. “Twenty-minute neighborhoods” where everyone can walk to essential services within twenty minutes) should have access to grocery stores, exercise pavilions to increase physical activity and community gardens for food security included in future infrastructure planning. Creating benchmarks for reaching these goals will be important for understanding the progress made towards a more climate resilient built environment.



Economic Systems

Impacts to Economic Systems

According to local experts, the majority of businesses in the region are small, which means there is a concern that they will have the most trouble recovering from a climate change event (i.e. flooding, wildfire). There is an additional concern that water and transportation systems are in need in repair and will only worsen as climate change becomes more severe. Community members acknowledge that capital may not be available to provide for infrastructure needs. Also, they have begun to ask the questions surrounding how people will pay for this and understand that this may lead to higher taxes. Experts highlighted that certain areas where there are businesses, homes, and transportation paths may be susceptible to landslides due to heavy precipitation events, thus having a detrimental economic impact.

Agriculture and food production are also concerns of economic preparation. Climate change will negatively affect local crop and seedling production due to increased fuel costs, vector management costs (e.g. mosquito abatement), water availability, decreased nursery resources, and crop temperature needs. As temperatures rise, we can expect to see a decrease in productivity and nutritional value and an increase in insects; thus, some crops will be destroyed as a result and farmers will be spending more resources on vector control. Moreover, costs may ensue in order to deal with invasive plant species (i.e. knotweed). Lastly, types of crops may change as temperature increases shift planting and harvesting seasons.



The cost of living and price of housing may increase due to increased migration of people from areas hit by more severe climate events. Many residential and commercial buildings rest within floodplains and may become more susceptible to flooding and wildfires as well as temperatures change. Increased temperatures will also lead to increased use of energy for cooling (and higher utility bills) in the warmer months. The potential destruction of these buildings will greatly impact the economy as the need arises to replace or find alternate resources for those who once inhabited or used those spaces. As a result, insurance rates may increase with risks of floods and wildfires. Water rights issues and the projected increase in the cost of water may also occur due to increased demand and scarcity under climate stressed conditions.

Mt. Hood Community College will be impacted in their enrollment as a result of increased population. Moreover, a change in educational demands may result in a need to adapt their coursework to meet the needs of industries of the future (i.e. shift to a green economy).

Preparation in Action

Gresham has begun preparing for a sustainable future by considering micro-hydro power generating turbines at its wastewater treatment plant, developing a City Operations and Facilities Sustainability plan, and increasing renewable solar energy generation at City Facilities and within the broader community.



Recommendations for Economic Systems

Jobs will likely increase from the many recommendations mentioned throughout this report; building rain gardens and hiring electricians, training insulation installers and construction teams to build efficient homes, instructing scientists to test habitats and asking social workers to support refugees. Accommodations for urban farming were recommended as policy level changes that might be necessary to adapt to climate change.

Capital investment is recommended in order to transition away from coal generated power to renewable energy. This may increase the cost of electricity to the rate payer. Energy efficiency and conservation measures need to be increased and can economically benefit residential and commercial rate payers. Another recommendation, though the science is not clear and is a bit controversial, is harvesting algae for energy in the region.

VIII. A Vision for Gresham's Future: An Action Plan for Preparedness



The impending outcomes of climate change have resulted in the city's efforts to plan for unfavorable outcomes. The Climate Futures Forum intentionally brought together a number of individuals across many sectors in the community, in order to discuss the impacts and recommendations for how Gresham can move forward in planning for climate preparedness. Their recommendations are only the beginning of the changes needed in order to reduce the effects of climate change and increase resilience of the community and population.

Participants described what their community would like in 40-50 years if it were truly a model of climate resiliency. This vision can be used as a goal for the City of Gresham to strive for as they consider taking action on climate preparedness:

From an aerial viewpoint, one sees diverse shades of green. There is extensive vegetation, green along roads, green roofs on homes and buildings, and broad riparian areas

that expand into the rural environment. A native and functional tree composition is widespread, and provides ground level shade. The natural floodplains and disturbance regimes, such as fire, have been restored. Macroinvertebrates and pollinator populations are diverse and abundant. River channels are diverse, and connected, with stream barriers minimized. The groundwater system is robust, yields vibrant forests, and there is an extensive spring system. Children are swimming in the rivers once again, as are the beaver populations that are rebuilding natural dams. Salmon are returning to the urban areas. Communities are vibrant, diverse, accommodate human population growth, and have a robust local economy. Metro has adopted urban and rural reserves to allow for a working landscape and the urban landscape is integrated with the natural landscape. Different components of society and stakeholder groups are cooperating, and scientists are communicating with decision makers to provide the tools needed to make effective decisions. Overall, the precautionary principle has been applied and incorporated into long-term planning.

Approaches to Preparedness Planning

The following excerpts were taken from the forthcoming: *Building Climate Resiliency* by the Climate Leadership Initiative at the University of Oregon. To access the report, go to: <http://climlead.uoregon.edu>. The report is expected for release in Fall 2010.

- I. *Organize a Climate Preparedness Team:* The best way to begin building climate resiliency is to bring together a team of experts (e.g. scientists, policy analysts, community stakeholders and policy makers) to join together and create an action plan for the city of Gresham.
- II. *Identify Key Variables That Are High Priority For Your Community:* Many of the impacts and recommendations described in this report can be used as a starting point for identifying key issues for Gresham. Secondly, identify management goals already in place in Gresham (e.g. water quality standards, air quality standards) that are established to support these systems.

- III. *Identify Key Processes:* This step requires identifying processes that significantly influence the issues and systems in Gresham. Initially, it may be adequate to consider processes such as:
- Surface air temperature (seasonally)
 - Precipitation quantity and timing (seasonally)
 - Snowpack and the timing of runoff
 - Frequency and intensity of storm events
 - Frequency and duration of droughts or heat waves
- IV. *Identify Major Disturbance Regimes:* List the major disturbance events that shape your community. This is an important step because traditional disturbances that produce minimal long term or mostly localized consequences might be greatly exacerbated by climate change. A disturbance can be thought of as anything that causes disruptions to the community. Ecological disturbances include droughts, floods, disease outbreak, and fires (all of which are threats to Gresham under current climate projections). Human interventions such as dam building, excessive timber harvest, or the establishment of protected areas can produce major disturbances.
- V. *Map 'Behavior-Over-Time':* To assess the vulnerability of the community it is important to develop a sense of how core natural processes, disturbance regimes, and key management responses and practices have shaped your community over time. For example, the Climate Preparedness Team might try to map how temperature, rainfall, snowpack, storm events, and fire patterns have affected Gresham. Then, to the extent possible, chart the human responses that occurred to these events (e.g. were additional dams or water storage facilities built after a particularly long drought?). These historic profiles and timeline help reveal the long-term dynamics of the system and will allow the group to identify patterns and effectiveness of responses. Once this has been done, try to determine if any areas, systems or issues stand out as a priority for building resistance and resiliency. Are there responses to avoid? What other lessons learned seem important?
- VI. *Identify Critical Thresholds That Have Been Crossed:* The “behavior-over-time” charts should provide a starting point for determining whether thresholds have been crossed. A critical threshold is the point at which sudden or rapid change occurs that flips processes, structures, or species into a new unwanted condition or causes unacceptable risks or losses to your system.
- VII. *Identify Likely Future Critical Thresholds:* Now try and determine how close Gresham might be to new thresholds that, if crossed, would push the city into new undesirable conditions.
- VIII. *Examine Climate Impact Scenarios:* Now it is time to consider the possible future shifts brought about by climate change. The goal of this step is to identify how changes in the Earth’s climate systems might add additional stresses to the slow and fast moving factors that were identified as potentially reaching a tipping point for reaching their threshold. Using the local data, identify the impacts to both natural and community systems. In doing so, also identify potential opportunities (e.g. new business opportunities).
- IX. *Assessing the Risks:* Once the likely consequences of climate change are identified, it is time to determine the level of risk that exists for each of the potential impacts. One way to do this is the use a standard risk assessment matrix; assessing the probability of the impact occurring combined with the consequence of the impact should it occur.

- X. *Determine if Climate Risks Are More or Less Important Than Non-Climate Risks in Gresham:* Some decisions are directly driven by the need to manage climate risks. However, for many decisions, climate risks are just one of many risks to be considered. Consider what priorities were set at the beginning of process and decide which actions are reasonable and attainable.
- XI. *Determine the Priority of Risks That Require a Climate Preparedness Response:* Having determined what are important climate risks to consider, it will now be time to prioritize those risks. Consider what resources are available to address the risks, and over time which risks can be addressed.
- XII. *Develop and Implement Your Preparedness Response:* Once the team has identified their priorities, it is time to identify strategies associated with reducing each risk. What forming strategies, consider feasibility and costs for implementation.



IX. Conclusion



If climate change conditions and risks are not addressed, there are potentially high costs that can accrue for communities, like Gresham, should no action be taken (Climate Leadership Initiative and Oregon Climate Research Institute, 2009). The impacts of climate change (e.g. higher temperatures, shifting precipitation patterns, reduced snowpack levels and shifting species) will have significant affects on the transformation of natural systems in Gresham as well as affecting the city's community systems (human, built, and economic).

Gresham, Oregon has already taken the first steps toward a more sustainable and climate resilient future, building the capacity of the city to effectively make these important changes. Taking steps now to prepare for likely consequences of climate change will help each of the systems within the city to be better prepared for the future. Though many of the climate projections are negative, there are other opportunities that may arise out of the systems changes as well. Creating a more climate resilient city will help build social capital and local networks throughout the city.

It is recommended that the city of Gresham involve the entire population in the planning for a more resilient community. By joining the community together, creativity and resources can be better utilized to plan and prepare for the impending changes in climate.

Bibliography

- Barr, B.R., Koopman, M.E., Williams, C.D., Vynne, S.J., Hamiton, R. and Doppelt, B. (2010). "Preparing for Climate Change in the Klamath Basin". Available at: http://climlead.uoregon.edu/sites/climlead.uoregon.edu/files/reports/KlamCFFRep_5-26-10finalLR.pdf
- Census of Agriculture. (Retrieved June 2010) Retrieved from: http://www.agcensus.usda.gov/Publications/2007/Online_Highlights/County_Profiles/index.asp
- Clean Water Services. (Retrieved June 2010). Retrieved from: <http://www.cleanwaterservices.org/>
- City Data. (Retrieved June 2010). Gresham, Oregon. Retrieved from: <http://www.city-data.com/city/Gresham-Oregon.html>
- City of Portland. (Retrieved June 2010) "Willamette Watershed Characterization Report". Web. Retrieved from: <http://www.portlandonline.com/BES/index.cfm?c=31806>
- Climate Leadership Initiative and Oregon Climate Change Research Institute. (2009). "Projected Future Conditions in the Lower Willamette River Subbasin of Northwest Oregon: Clackamas, Multnomah, and Washington Counties". Available at: <http://climlead.uoregon.edu/node/136>
- Climate Leadership Initiative Institute for Sustainable Environment. (2009). "Preparing for Climate Change in the Upper Willamette River Basin of Western Oregon: Co-Beneficial Planning for Communities and Ecosystems". Available at: http://climlead.uoregon.edu/sites/climlead.uoregon.edu/files/reports/willamette_report3.11FINAL.pdf
- Curran, M.A.J., Ommen, T. D., Morgan, V. I., Phillips, K. L., & Palmer, A. S., (2003). "Ice Core Evidence for Antarctic Sea Ice Decline Since the 1950s". *Science*, 302, 5648, 1203. Retrieved from Climate Crisis Coalition: www.climatecrisiscoalition.org. University of Washington Climate Impacts Group.
- Environmental Protection Agency [EPA]. (Retrieved July 2010). "Heat Island Affect". Retrieved from: <http://www.epa.gov/heatisld/>
- Gresham Chamber of Commerce. (Retrieved July 2010) http://www.greshamchamber.org/about_attractions.php
- Gresham Emergency Preparedness. (Retrieved July 2010) <http://greshamoregon.gov/city/city-departments/governance-and-management/emergency-management/template.aspx?id=5916>
- Gresham City Public Transportation. (Retrieved July 2010) <http://greshamoregon.gov/live/getting-around/template.aspx?id=3114>
- Gresham City Utilities. (Retrieved July 2010) Retrieved from: <http://greshamoregon.gov/city/city-departments/finance-and-management/utilities/>
- IPCC –Intergovernmental Panel on Climate Change. (2007). "Climate Change 2007: Synthesis Report". Contribution of Working Groups I, II, and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. R.K. Pacharui and A. Reisinger, eds. IPSS, Geneva, Switzerland. Web. Retrieved from: www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_synthesis_report.htm

Mote, P.W. and Salathe, E.P. (2009). "Future Climate in the Pacific Northwest". Retrieved from: <http://www.cses.washington.edu/db/pdf/wacciach1scenarios642.pdf>

OEM –Multnomah County Office of Emergency Management. (n.d.) Retrieved from: <http://www2.co.multnomah.or.us/Public/EntryPoint?ch=5a6c7845ebd96010VgnVCM1000003bc614acRCRD/>

ODFW –Oregon Department of Fish & Wildlife: Frequently Asked Questions for the Oregon Lower Columbia and Willamette Salmon and Steelhead Recovery Planning Stakeholder Teams (2006). Retrieved from: http://www.dfw.state.or.us/fish/CRP/docs/upper_willamette/faqs_for_lcr-uw_stakeholder_teams_update_june_06.pdf

Oregon State Archives. (Retrieved June 2010) Retrieved from: <http://arcweb.sos.state.or.us>

USGCRP –U.S. Global Change Research Program. (2009). "Global Climate Change Impacts in the United States". T.R. Carl, J.M. Mellilo, and T.C. Peterson, eds. Cambridge University Press. Web. Retrieved from: www.globalchange.gov/whats-new/286-new-assessment-climate-impacts-us

Appendix A: Gresham Climate Futures Forum Participant List

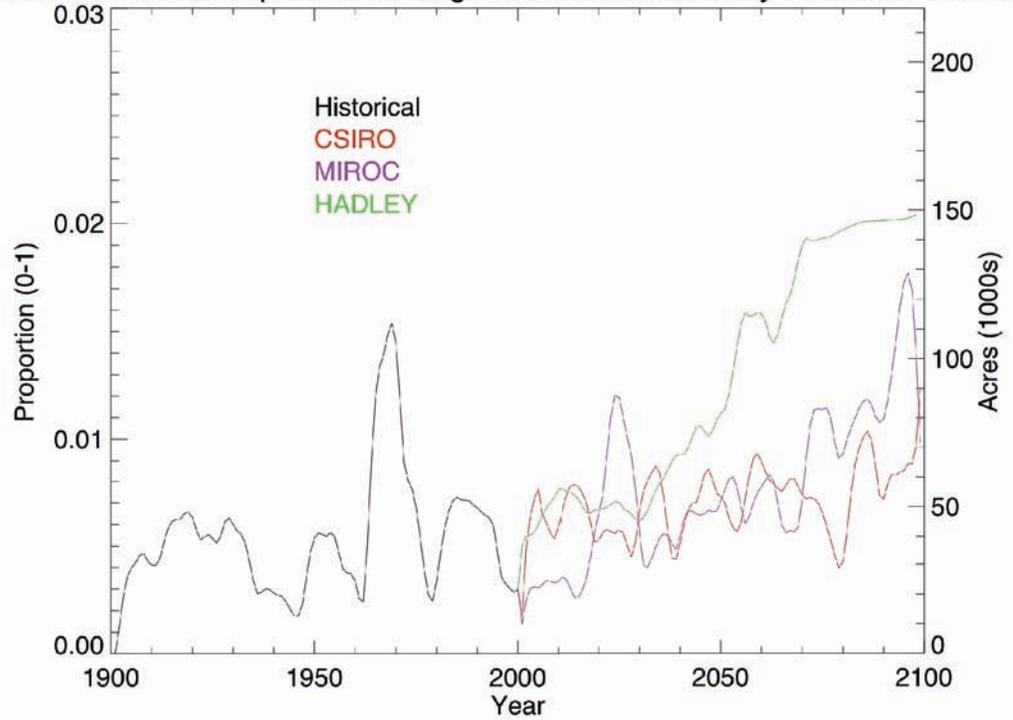
Kathryn Blau
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Nicole Cousino
Tiffany Danielson
Paul Eckly
Kim Ellis
Jesse Engum
David Farmer
Meg Fernekees
Scott France
Kristin Greene
Thomas Griffith
Eric Hesse
Sheila Holden
Liz Hopkins
Aireen Joven

Betty Kaplan
Kathrine Kelley
Tom Kloster
Mark Knudson
Dan Layden
Kaitlin Lovel
Tim Lynch
John Mermin
Melanie McCandless
Jane MacFarland
Susan Millhauser
Anne Nelson
Barbara Progulske
Bob Progulske
Dave Rouse
Sara Schooley

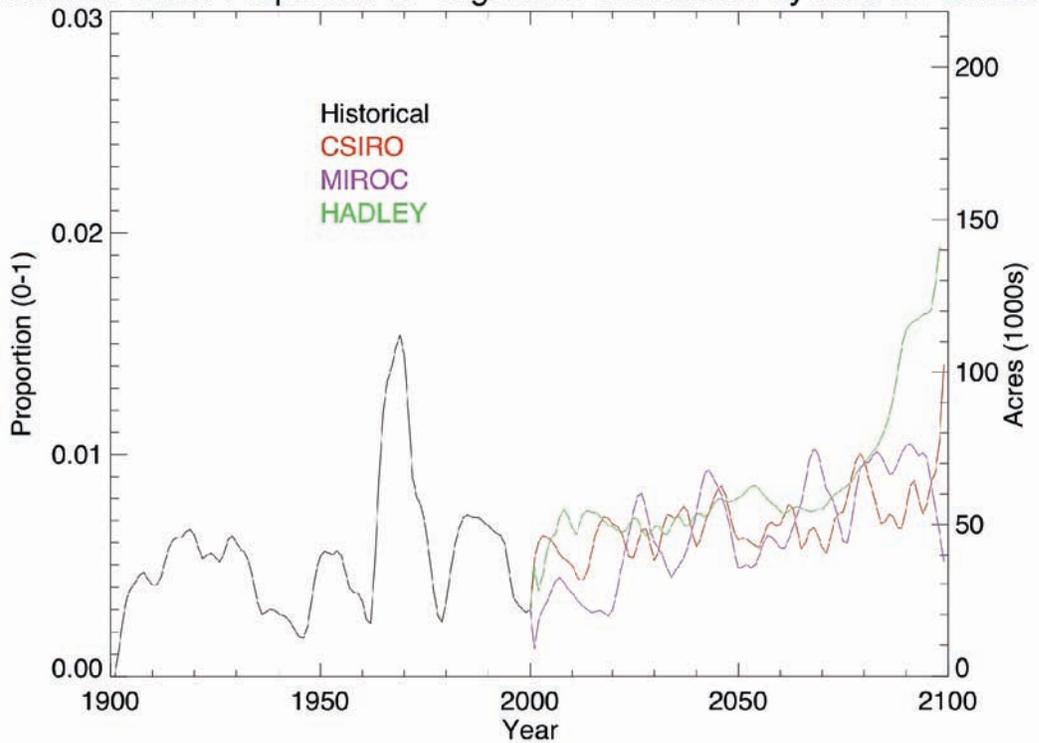
Jamie Stamberger
Lori Summers
Kimberly Swan
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Matthew Wiener
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Scott Jury
Cyd Cannizzaro
Jonathan Harker
Lorna Stickel
Coral Conant
Jamie Stephenson
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Jason Okuly

Appendix B: Sample Modeling Results

Willamette Basin Proportion Of Vegetation Consumed By Fire: A1B Emissions



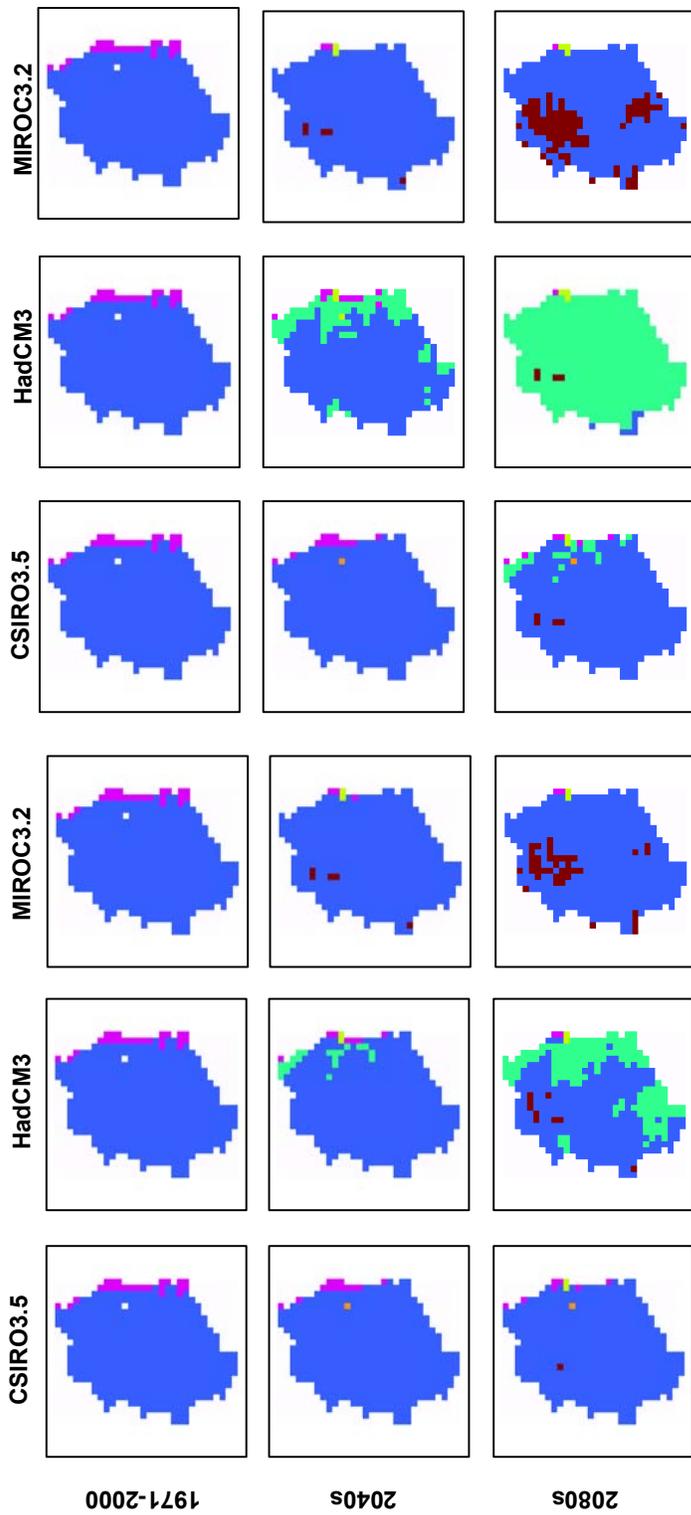
Willamette Basin Proportion Of Vegetation Consumed By Fire: B1 Emissions



Predominant Vegetation Type

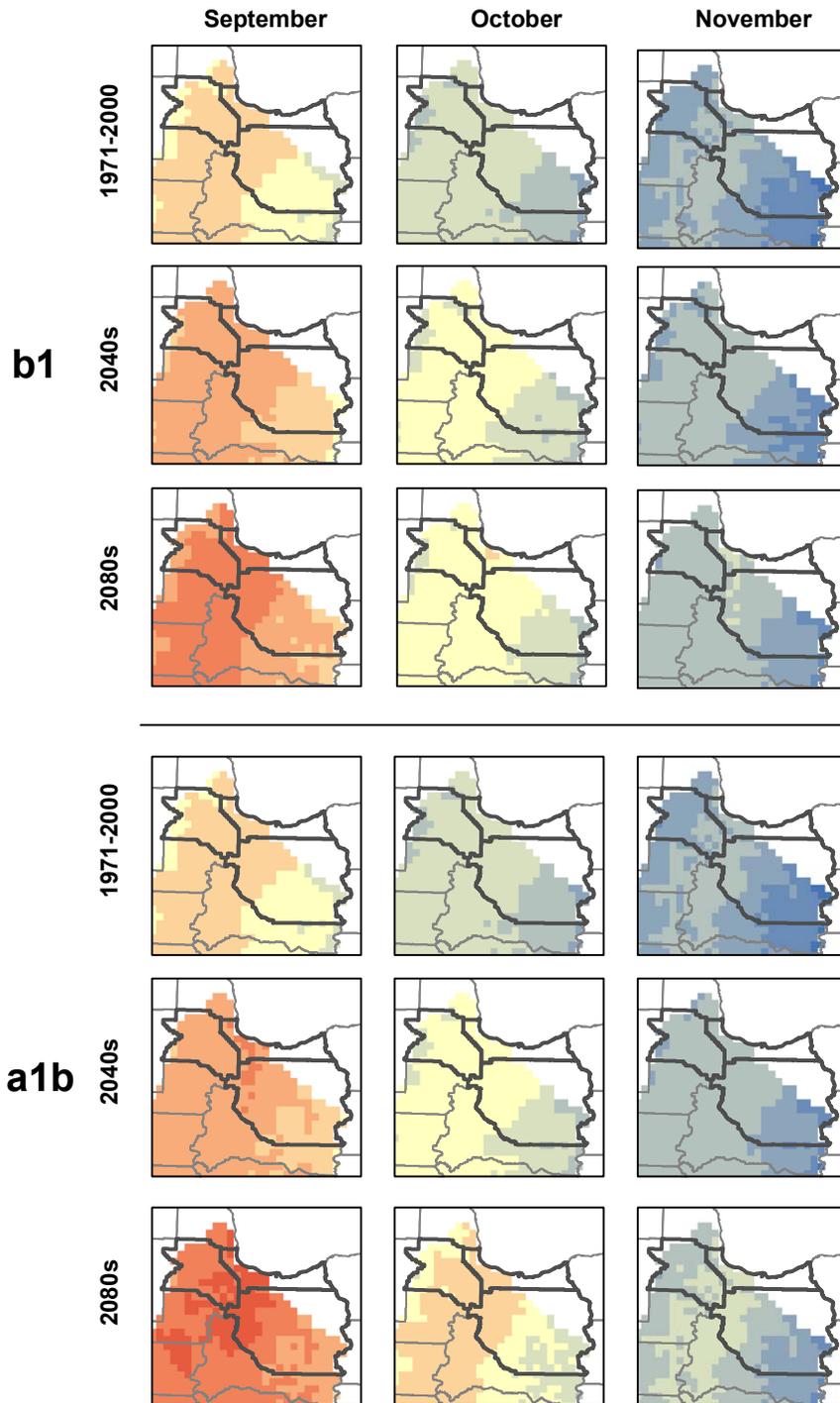
a1b

b1

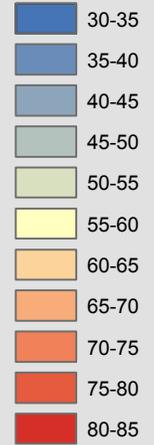


Fall

HadCM3

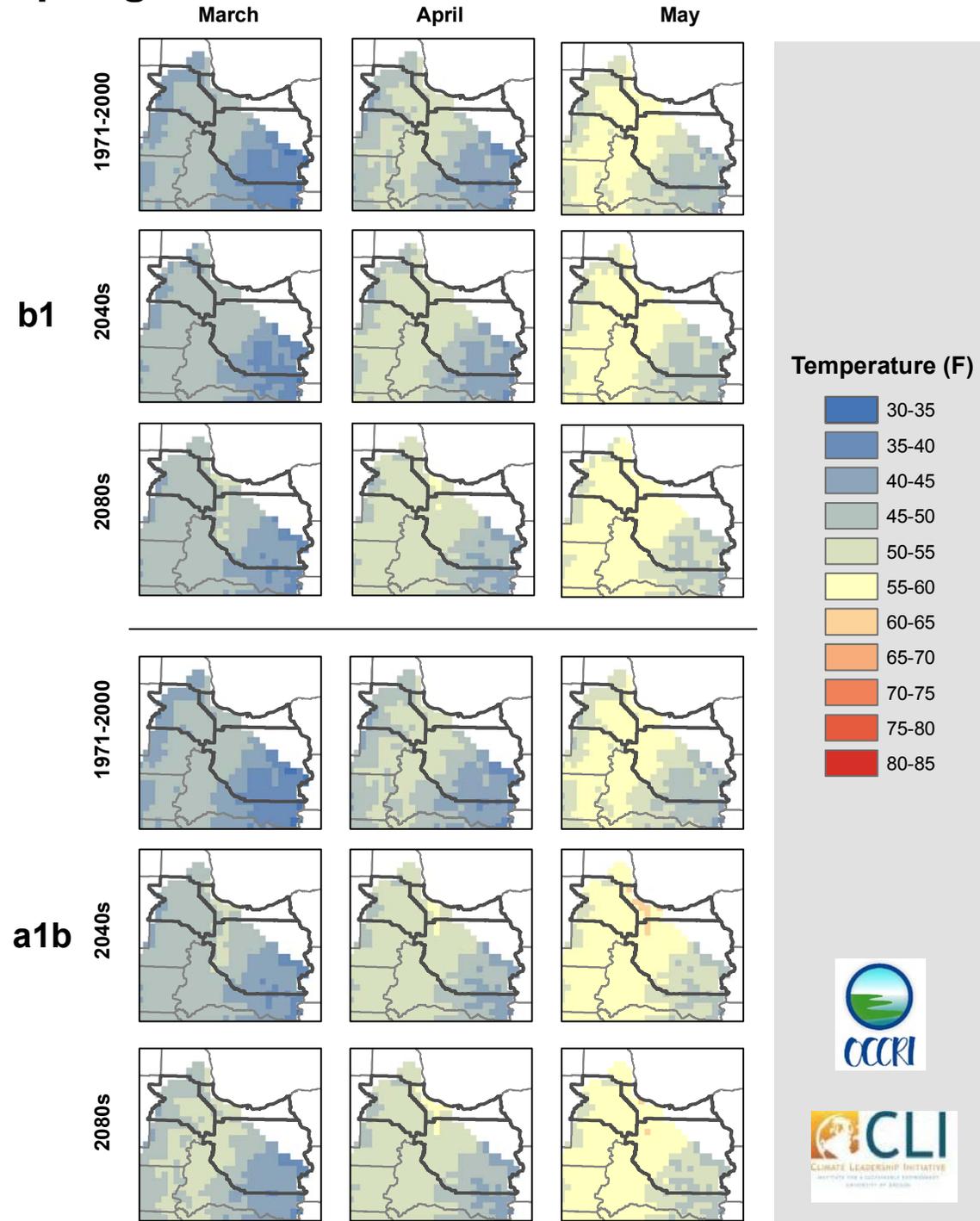


Temperature (F)



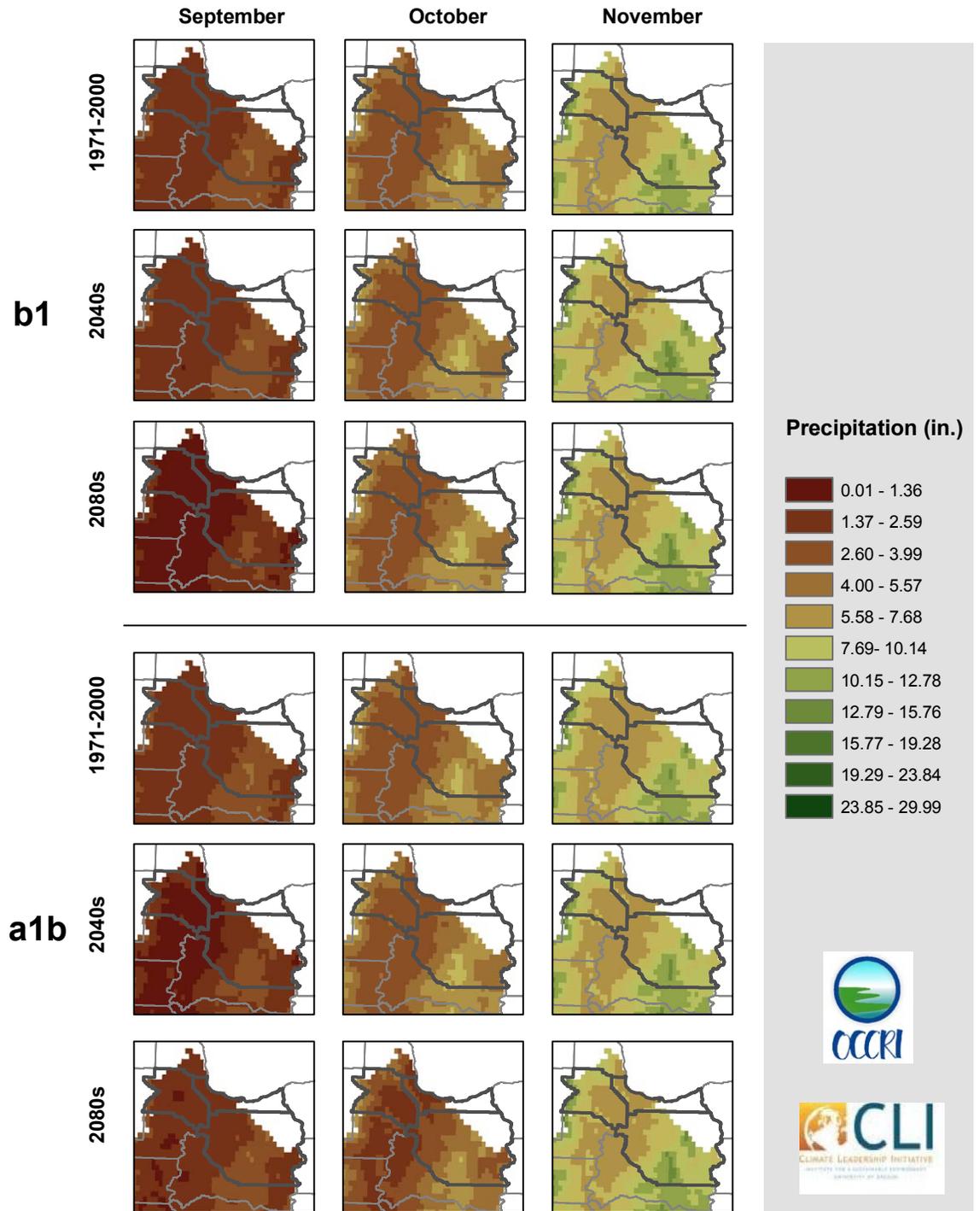
Spring

PCM1



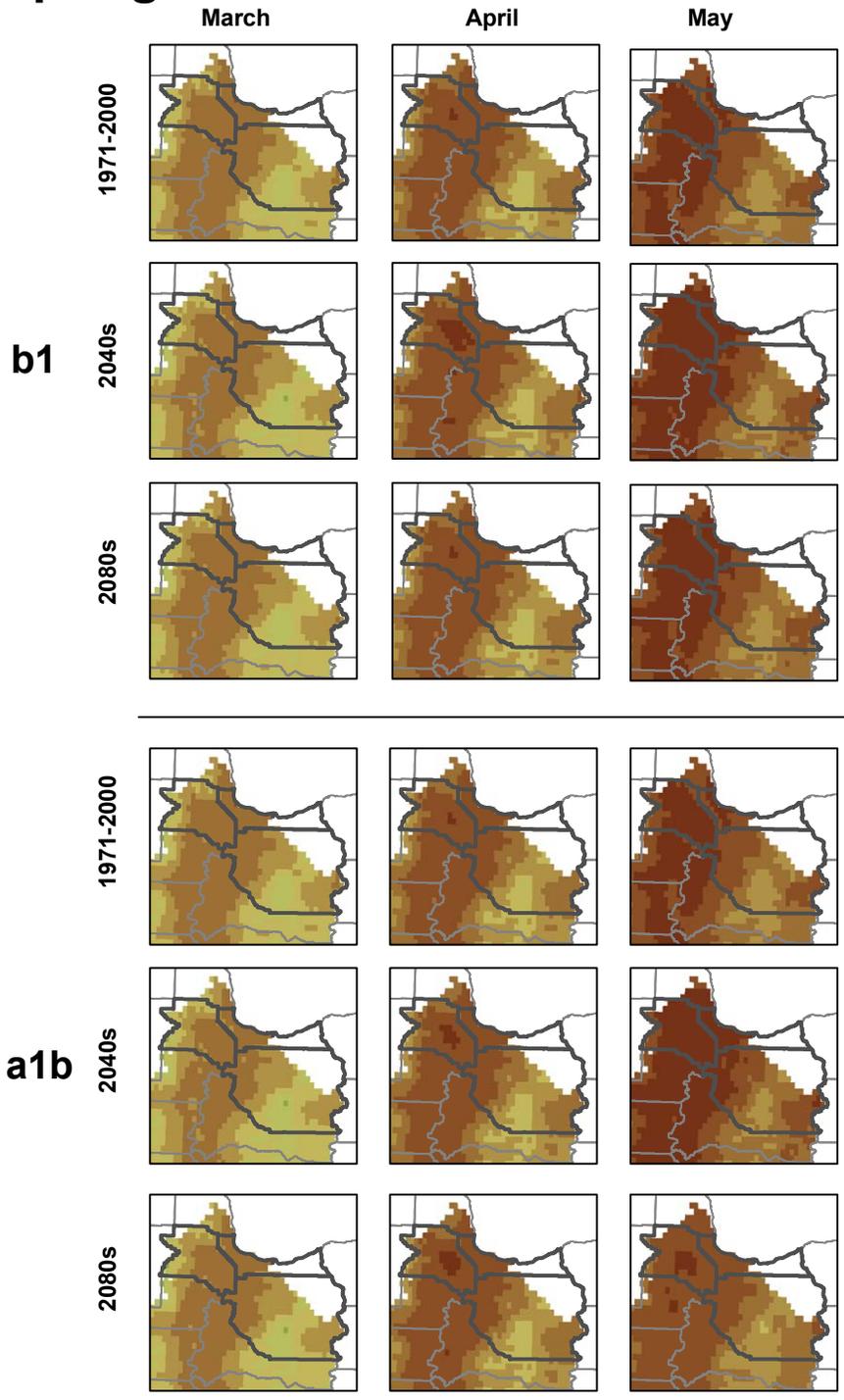
Fall

CSIRO3.5



Spring

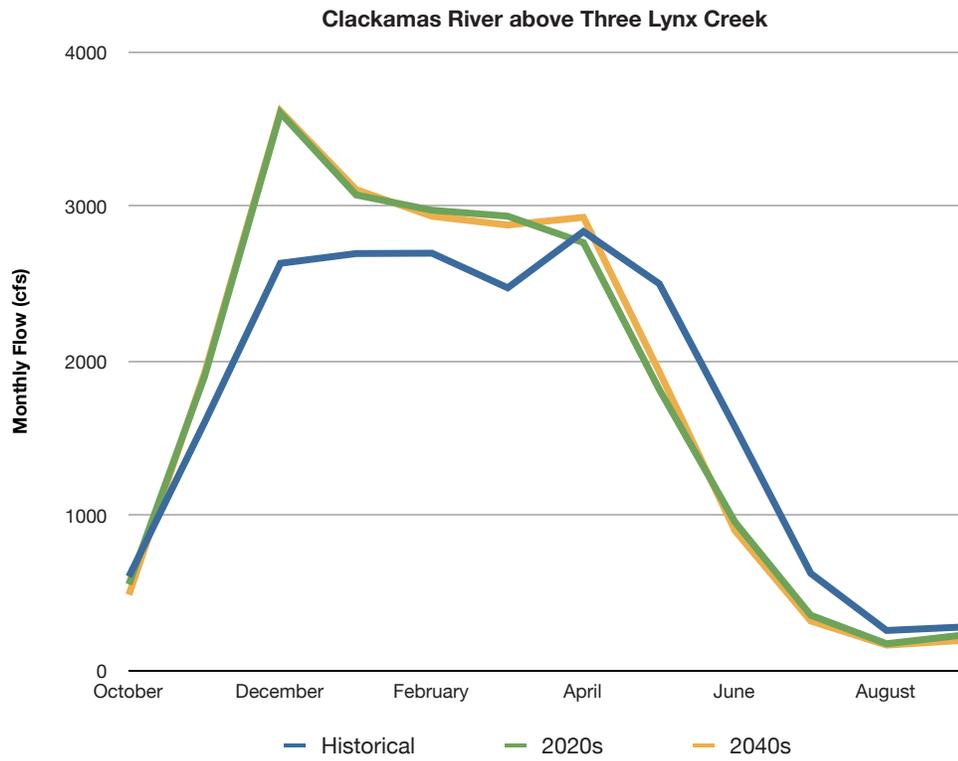
HadCM3



Precipitation (in.)



HadCM3



PCM1

