Precipitation

Chapter 2—Precipitation Impact Study for Spokane, Washington

Chapter Summary: This chapter examines precipitation under projected future climate change in the Spokane area. The chapter focuses on potential climate impacts on dryland wheat farming due to the crop's direct reliance on precipitation and economic importance to the region.

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Key Findings:

1. In recent decades, the Spokane region has observed a slight increase in precipitation during the fall, winter, and spring months, and a slight decrease in precipitation during the summer months.
2. The timing and volume of precipitation in the Spokane region is not projected to dramatically change over this century.
3. Precipitation projections for Spokane for this century show a slight increase in annual precipitation, with a slight increase in precipitation during the fall, winter, and spring months, and a slight decrease in precipitation over the summer months. However, these projections do not preclude the existence of periodic future droughts due to low precipitation levels.
4. The Spokane region will continue to meet the precipitation timing and volume requirements for dryland wheat production.
5. During the 2015 drought, drought loss claims filed for wheat in Spokane, Adams, Whitman, and Lincoln Counties totaled a combined $22 million.

Recommended Resilience Action:

- **Planting Techniques**— There are several steps farmers can take to minimize the compounding effects of climate change to our agricultural community. Current efforts to minimize erosion in our region, including no-till and direct seeding planting techniques as well as re-establishing stream and field buffers, will become even more important in the future.

Climate Data Story—Dryland Wheat Farming

In the Inland Pacific Northwest, dryland farming dominates much of the landscape. In 2018 alone, Washington dryland farmers produced 153 million bushels of wheat, making the state the fourth largest wheat-producing state in the nation, with the second highest average yield per acre, according to the Washington Grain Commission. All told, dryland wheat is Washington's third largest commodity and accounts for nearly $691 million in production value for the state (**Washington Grain Commission 2019**). Dryland wheat farming is also dependent solely on precipitation for all of the moisture required for crop growth, maturation, and productivity.

This relationship to precipitation makes dryland wheat ideal for studying how projected future changes to precipitation could impact dryland farming in the Spokane region. Dryland wheat production requires 8–25 inches of precipitation during the fall, winter, and spring, and benefits from relatively dry summer months (**Schillinger et al., 2012**). Historically, the majority of Spokane's annual precipitation has fallen during the winter and spring months. This trend is expected to continue under both the lower emissions scenario (RCP 4.5) and the high emissions scenario (RCP 8.5). Under both scenarios, precipitation projections for Spokane show a slight increase in annual precipitation, a slight increase in precipitation during the fall, winter, and spring months, and a slight decrease in precipitation over the summer months. According to future climate projections tracked in the Climate Toolbox, the Spokane region will continue to meet the precipitation timing and volume requirements for dryland wheat production. Independent research has also concluded that dryland winter wheat production in the Pacific Northwest could see increased yields under both the rising temperatures and the rising atmospheric carbon dioxide levels expected under both RCP 4.5 and RCP 8.5 (**Stöckle et al., 2014**; ***Fourth National Climate Assessment, Chapter 24 2018***).

Historically, however, dryland wheat farming has not been immune to the effects of drought. To better understand how drought might impact dryland wheat farming in the Spokane area, CIRC examined drought-associated insurance loss claims for wheat filed from 2001 to 2015 across the 24-county region of the Inland Pacific Northwest, a region that includes Spokane County and nearby Adams, Whitman, and Lincoln Counties (**Seamon et al., 2019a**).

In 2015, wheat insurance loss claims filed across the Inland Pacific Northwest totaled $240 million for all damage causes, of which losses attributed to drought accounted for 56%. In Spokane, Adams, Whitman, and Lincoln Counties in 2015, drought loss claims filed for wheat totaled a combined $22 million (**Seamon et al., 2019b**).

The drought conditions during 2015 provide a potential analog for future droughts in terms of both precipitation and temperature. The year 2015 is an ideal analog in this sense because the year saw near-normal precipitation levels but with temperatures similar to those projected for the middle decades of this century (**Marlier et al., 2017**). While the 2015 drought and its effect on wheat and insurance loss claims is not a clear guide to how dryland wheat might be affected in the future, it does raise the possibility that dryland wheat farming might be more susceptible to certain climate conditions than previously estimated.

Larger Context—About Precipitation Projections

Precipitation projections have less confidence to them when compared to temperature projections. As such, precipitation projections experience greater levels of uncertainty associated with them (**Rupp et al., 2017; *CIRC "Precipitation"2019***). ***Figure 1*** shows the projected annual precipitation simulations for the Pacific Northwest United States to the year 2100 for both the lower emissions scenario (RCP 4.5) and the high emissions scenario (RCP 8.5). Note: there is little difference between the two scenarios as far as projected precipitation is concerned.

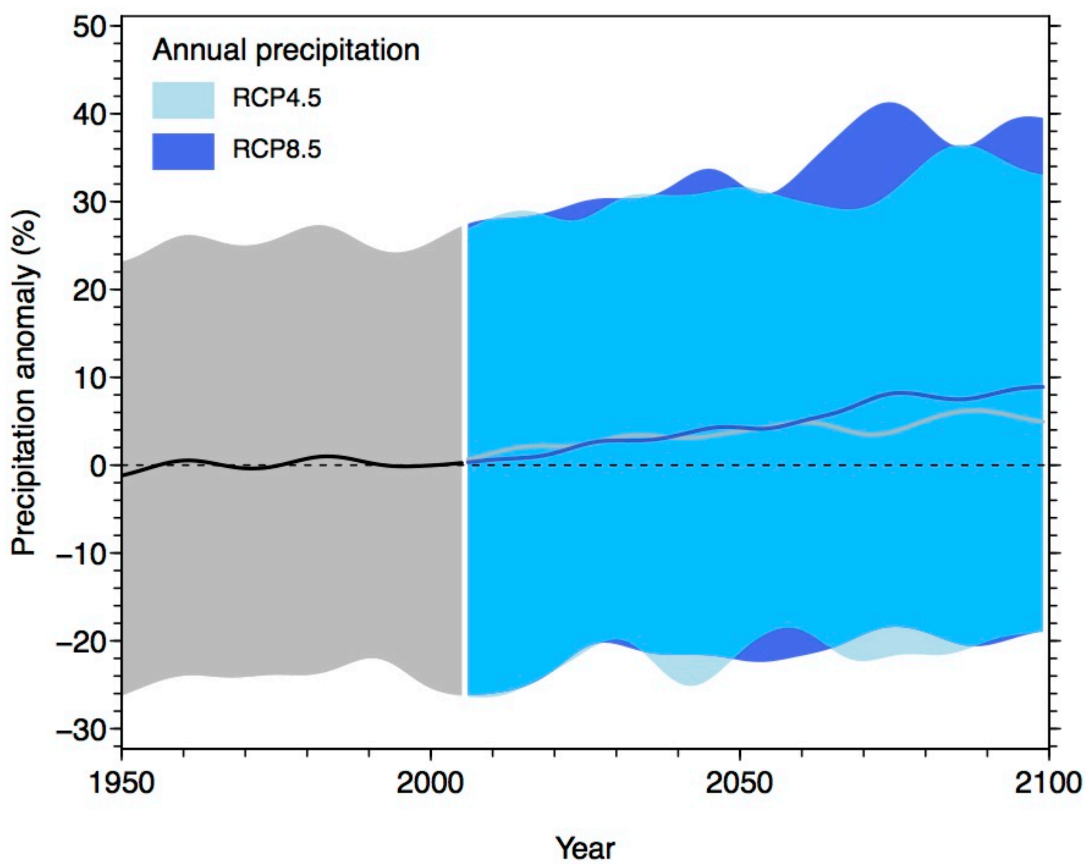

Figure 1: Annual precipitation projections for the Pacific Northwest to the year 2100 for both the lower emissions scenario (RCP 4.5) and the high emissions scenario (RCP 8.5). The dashed zero line represents average annual precipitation for the Pacific Northwest United States for the historical baseline period 1950–2008. The gray section represents simulations of the historical period; the black line represents the multi-model mean from those simulations. The light blue band represents the spread of results from RCP 4.5; the gray line represents the multi-model mean from those results. The dark blue represents the spread of results from RCP 8.5; the dark blue line represents the multi-model mean from those results. Source: Rupp et al., 2017/CIRC "Precipitation" 2019 (https://pnwcirc.org/science/precipitation).

Local Context—Precipitation Not Projected to Change Dramatically

While the uncertainty associated with precipitation projections remains high, the model results used for this report can lead us to some reasonable conclusions. The first is that the timing and volume of projected precipitation in the Spokane region is not projected to dramatically change over this century. However, precipitation should not be considered alone (see ***Discussion—Why Precipitation Should Not Be Considered Alone***). When precipitation is considered along with temperature increases, several climate impacts come to light, including decreased mountain snowpack (see the ***Snow*** chapter of this report), changes in the timing and flows of local streams and rivers (see

Streamflow), and increased likelihood of wildfires (see ***Fire***), which is expected to increase due to projected temperatures gains as well as projected declines in summer precipitation.

Analysis—Geography, Data Tools, Inferences & Limitations, Emissions Scenarios, Multi-model Means, Variables, Time Frames, Climate Data Story, and Additional Analysis

Geography: Precipitation trends for the Spokane Region were evaluated using tools available in the Climate Toolbox (Toolbox), a product of The Pacific Northwest Climate Impacts Research Consortium (CIRC). For all Toolbox tools used, the location of Spokane, Washington was set at 47.66 º North, 117.43º West. Toolbox data has been downscaled to a grid cell resolution of 2.5 miles. This 2.5-mile resolution limited the degree of detail our team could obtain.

Data Tools: Our team downloaded figures from the following tools in the Toolbox:

- Future Time Series Tool (https://climatetoolbox.org/tool/Future-Time-Series)
- Historical-Climograph Tool (https://climatetoolbox.org/tool/Historical-Climograph)
- Historical Climate Tracker Tool (https://climatetoolbox.org/tool/Historical-Climate-Tracker)
- Future Boxplots Tool (https://climatetoolbox.org/tool/Future-Boxplots)

Inferences & Limitations: The greatest limitation to our analysis was the uncertainty associated with precipitation projections. (See ***Larger Context*** and ***Projected Future Precipitation—Overall Trends*** above).

Emissions Scenarios: Our team chose to focus on results from the high emissions scenario (RCP 8.5) for our analysis of projected seasonal differences in precipitation. This was done to streamline our analysis and in order to be consistent with the other chapters of this report. We also chose to use RCP 8.5 on its own because, as the authors of the ***Temperature*** chapter of this report put it, RCP 8.5 is "understood by the climate community to be the scenario that most closely resembles our current emissions trajectory." However, we did perform an analysis to see if there were any notable difference between precipitation projections under the lower emissions scenario (RCP 4.5) and the high emissions scenario (RCP 8.5). We found no discernable difference between the two scenarios as far as annual and seasonal precipitation projections were concerned.

(Note: RCP 4.5 isn't the *lowest* emissions scenario used by climate researchers. RCP 2.6 is the lowest emission scenario considered in climate models. However, because the collective global emissions pathway has very likely veered off course from that modeled under RCP 2.6, RCP 2.6 is no longer used as the low emission scenario pathway. Since RCP 4.5 is lower than RCP 8.5, this report has adopted the standard used by many in the climate research community: *lower* to describe RCP 4.5 and *high* to describe RCP 8.5, rather than *lower* and *higher* to describe the two scenarios.)

Multi-model Means: The data and figures that make up this analysis represent the mean resulting from the 20 global climate models (GCMs) used by the Toolbox to create its future climate projections. Using a multi-model mean as opposed to the results of single model is generally accepted as best practice by climate researchers. However, the mean does not show the full spread of results from the 20 GCMs used. In other words, actual future climate conditions, when we get to them, might lie either above or below the multi-model mean.

Variables: Our analysis examined the following variables using the following tools.
- *Mean monthly precipitation and minimum/maximum temperatures* (Historical-Climograph Tool)
- *Summer (June–August) precipitation* (Historical Climate Tracker Tool)
- *Annual precipitation* (Historical Climate Tracker Tool; Future Time Series Tool)
- *Seasonal precipitation* (Future Boxplots Tool)

Time Frames: This analysis examined recent historical precipitation for the years 1981–2010 and 1979–2018. Projected annual changes were examined to year 2100 and compared to the historical baseline period 1950–2008. Projected annual and seasonal changes were further examined using the following time frames: early century (2010–2039), mid-century (2040–2069), and late century (2070–2099). Future projections were compared to the historical baseline 1971–2000.

Climate Data Story: Our climate data story for this section focused on potential climate impacts on dryland wheat farming due to its economic importance to Spokane's regional economy and its direct reliance on precipitation. A climate data story is defined by CIRC as "a narrative outlining climate facts and impacts specific to your community" **(Mooney et al., 2019)**.

Additional Analysis: This chapter includes an additional analysis provided by CIRC that examines the relationship between the 2015 drought and insurance loss claims for wheat filed by farmers in the Inland Pacific Northwest during 2015.

Historical Climate—Seasonal Precipitation Trends

Variables: *Mean Monthly Precipitation*; *Minimum/Maximum Temperature*

Finding: Historically, the majority of Spokane's annual precipitation has fallen during the fall, winter, and spring months.

Justification: From 1981 to 2010, the average annual precipitation in Spokane, Washington was 17.6 inches, according to the Historical-Climograph Tool (***Figure 2***). This data represents a simulated historical climate that was created using historical data. To check this data against location data, our team examined data collected at the Spokane International Airport. The National Weather Service station at the Spokane International Airport recorded an average of 16.6 inches for the same time period (**NOWData 2019**). Inclusion of more recent years' data raises the average annual precipitation to 18.4 inches for 1979–2018 in Spokane (***Figure 3***).

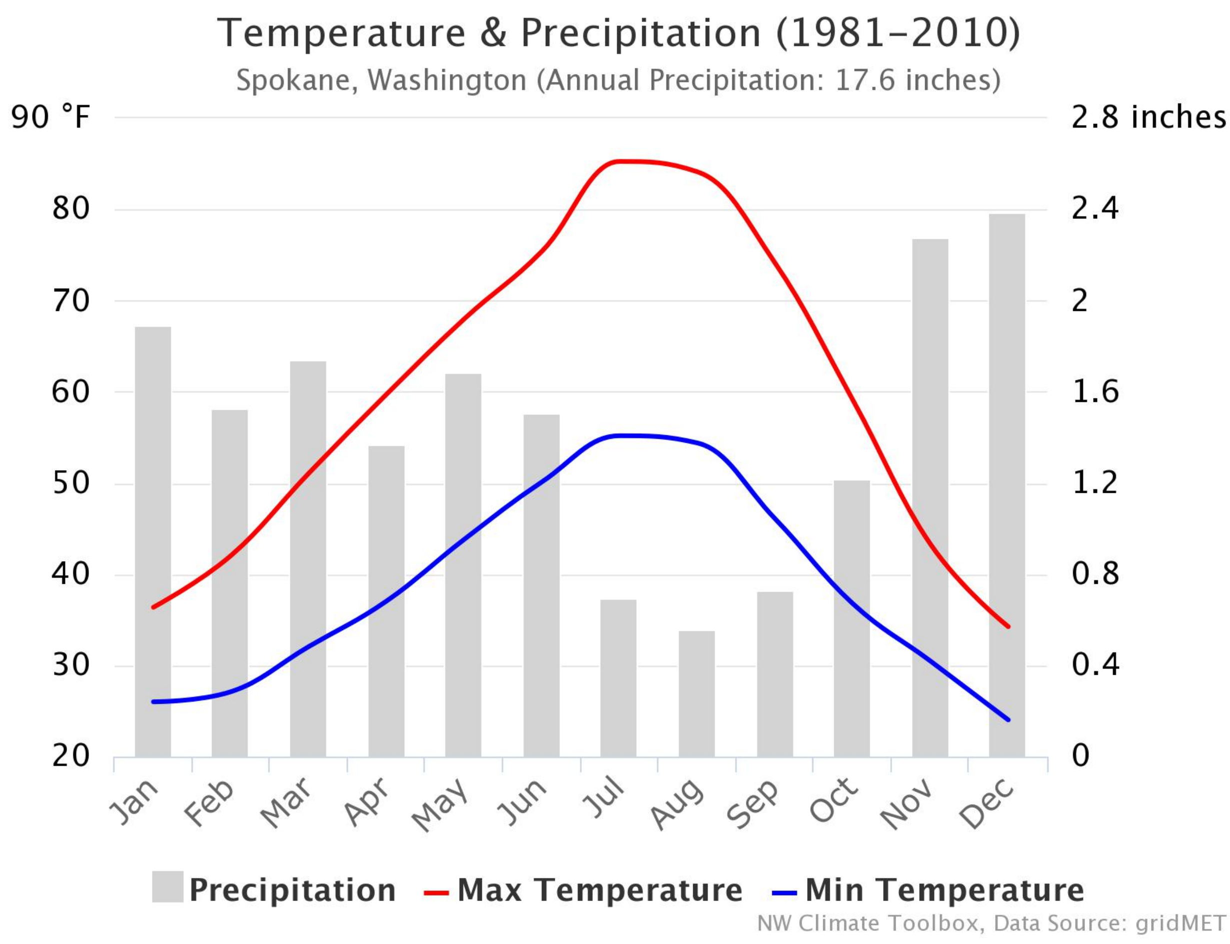

Figure 2: Mean Monthly precipitation measured in inches and minimum/maximum temperatures measured in degrees Fahrenheit for the years 1981–2010. Source: Historical-Climograph Tool (https://climatetoolbox.org/tool/Historical-Climograph), The Climate Toolbox.

Historical Climate—Recent Seasonal Precipitation Trends

Variables: *Annual (January–December) Precipitation*; *Fall (October–December) Precipitation*; *Winter (January–March) Precipitation*; *Spring (March–May) Precipitation*; *Summer (June–August) Precipitation*

Finding: In recent decades, the Spokane region has experienced a slight increase in annual precipitation, a slight increase in precipitation during the fall, winter, and spring months, and a slight decrease in precipitation during the summer months.

Justification: If we further examine historical precipitation data for Spokane, several trends can be seen in the available data. The Historical Climate Tracker Tool shows a prevailing trend in recent years (1979–2018) of increasing annual (January–December) precipitation (+1 inch per decade) (***Figure 3***).

Examined seasonally, the Historical Climate Tracker Tool shows a trend of increasing precipitation in the fall (October–December) (+0.5 inch per decade) (***Figure 4***), winter (January–March) (+0.6 inch per decade) (***Figure 5***), and spring (March–May) (+0.4 inch per decade) (***Figure 6***). From 1979 to 2019, Spokane has also seen a trend of decreasing summer precipitation (June–August) (- 0.1 inch per decade) (***Figure 7***).

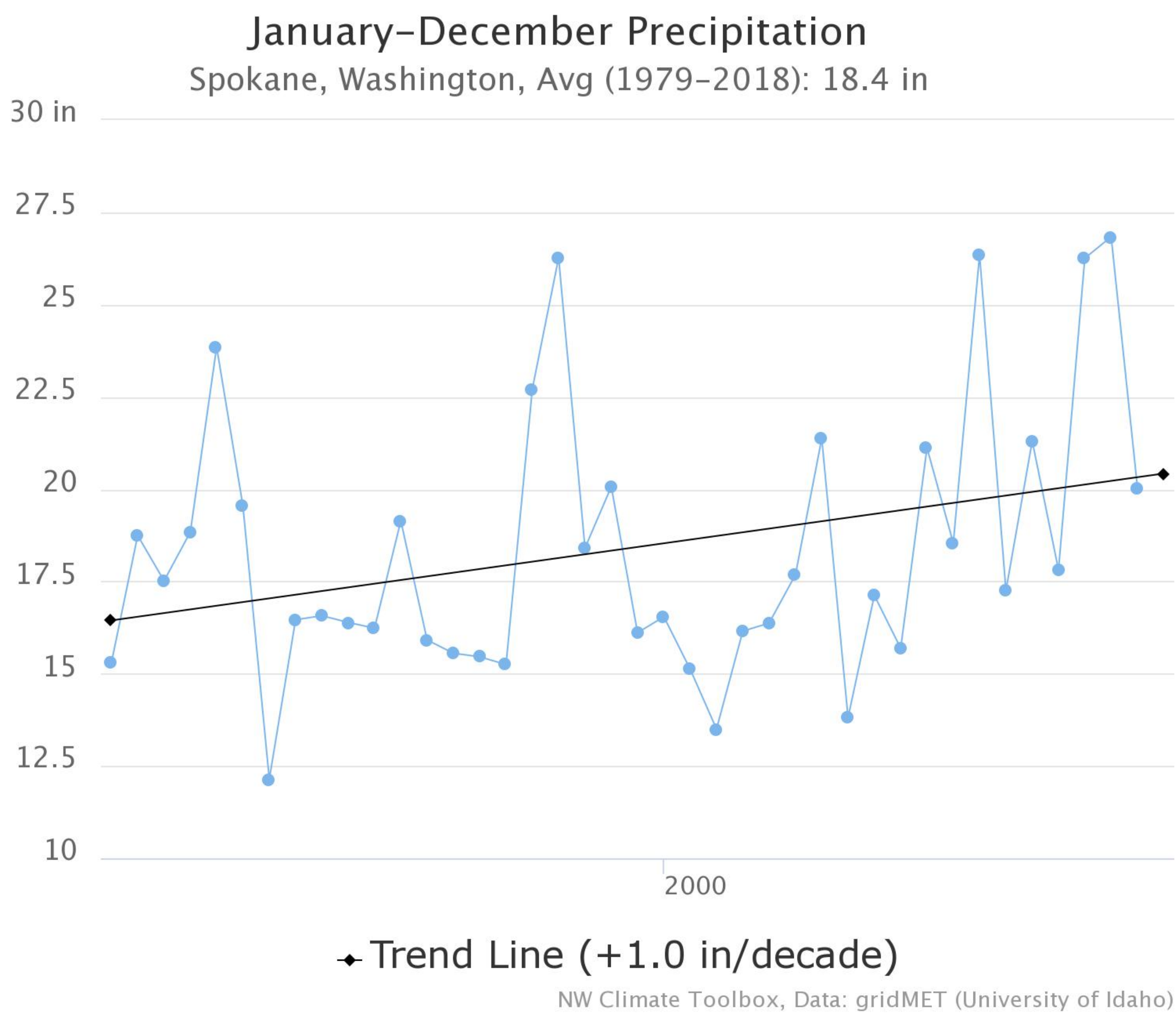

Figure 3: Annual (January–December) precipitation (in inches) for Spokane, Washington for the years 1979–2018 with trend line. Source: Historical Climate Tracker Tool (https://climatetoolbox.org/tool/Historical-Climate-Tracker), The Climate Toolbox.

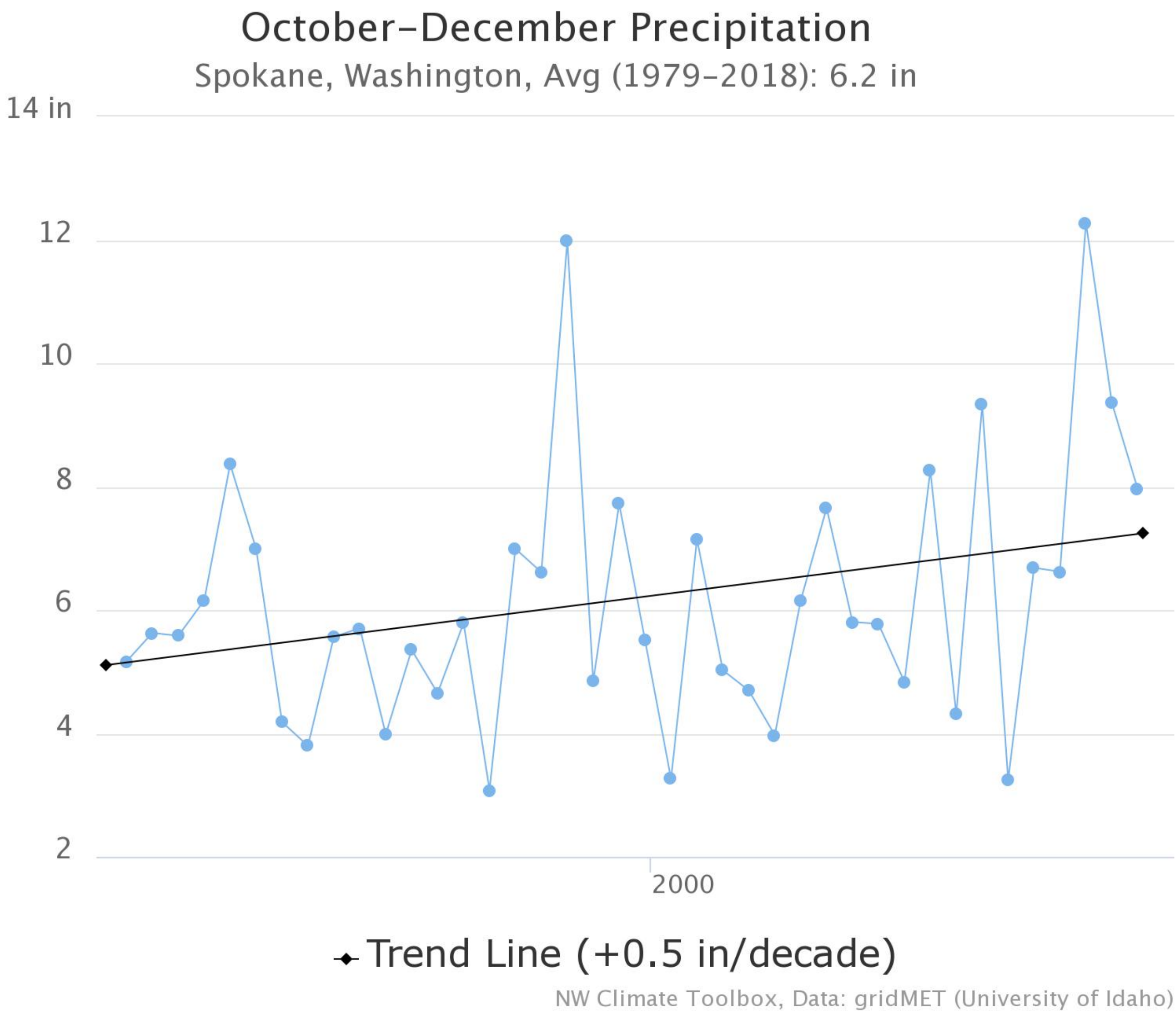

Figure 4: Fall (October–December) precipitation (in inches) for Spokane, Washington for the years 1979–2018 with trend line. Source: Historical Climate Tracker Tool (https://climatetoolbox.org/tool/Historical-Climate-Tracker), The Climate Toolbox.

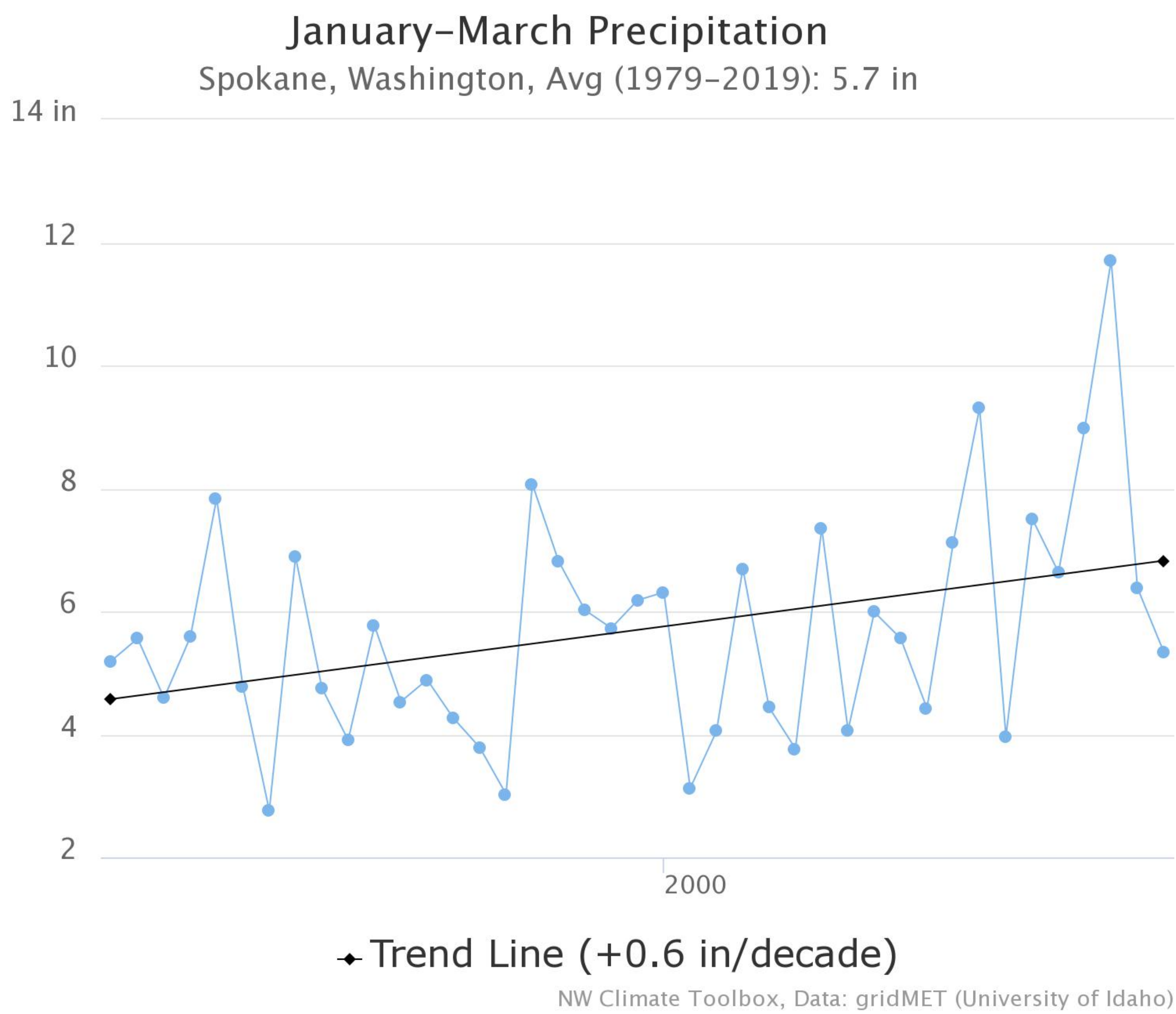

Figure 5: Winter (January–March) precipitation (in inches) for Spokane, Washington for the years 1979–2019 with trend line. Source: Historical Climate Tracker Tool (https://climatetoolbox.org/tool/Historical-Climate-Tracker), The Climate Toolbox.

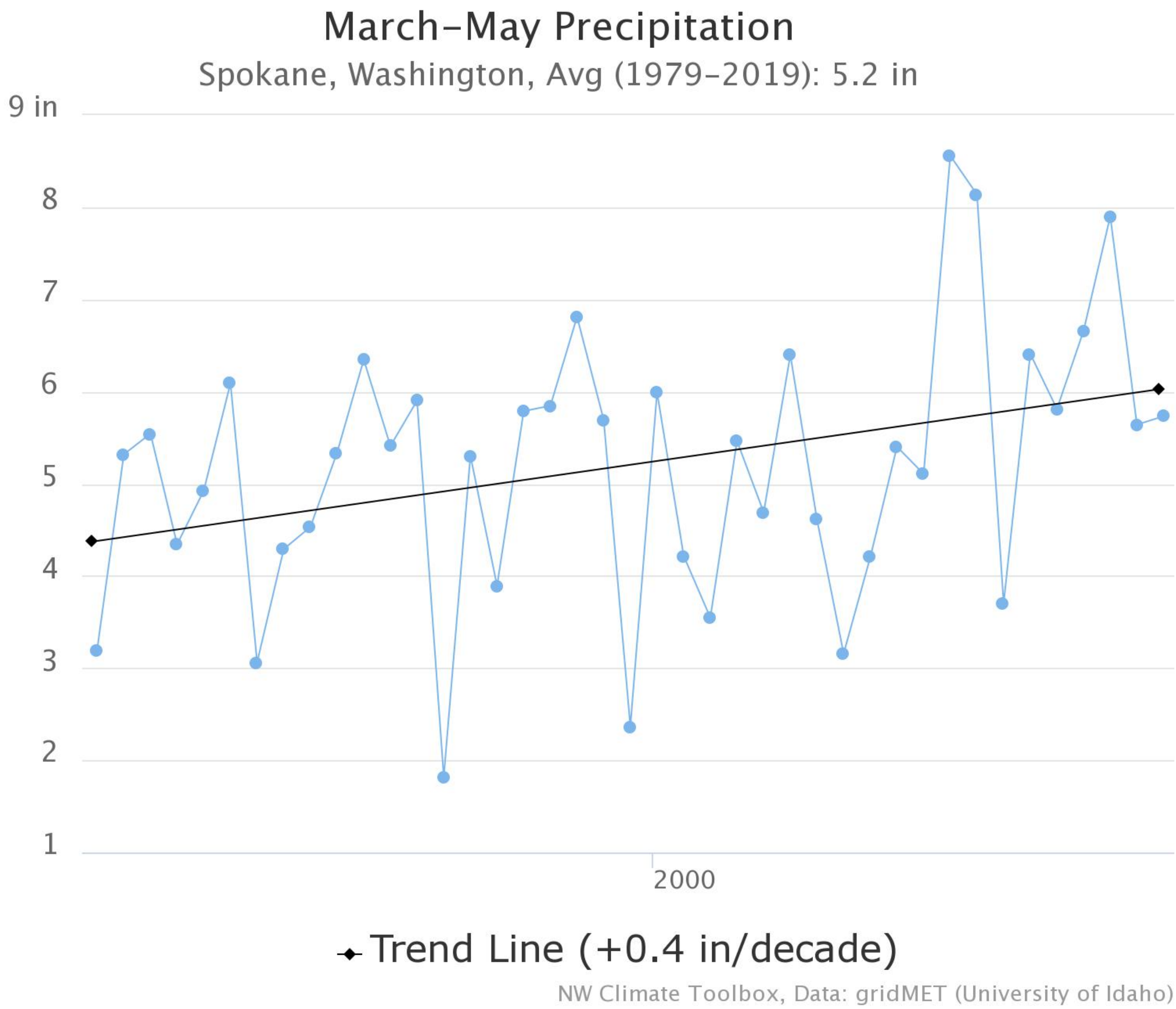

Figure 6: Spring (March–May) precipitation for Spokane, Washington for the years 1979–2019 with trend line. Source: Historical Climate Tracker Tool (https://climatetoolbox.org/tool/Historical-Climate-Tracker), The Climate Toolbox.

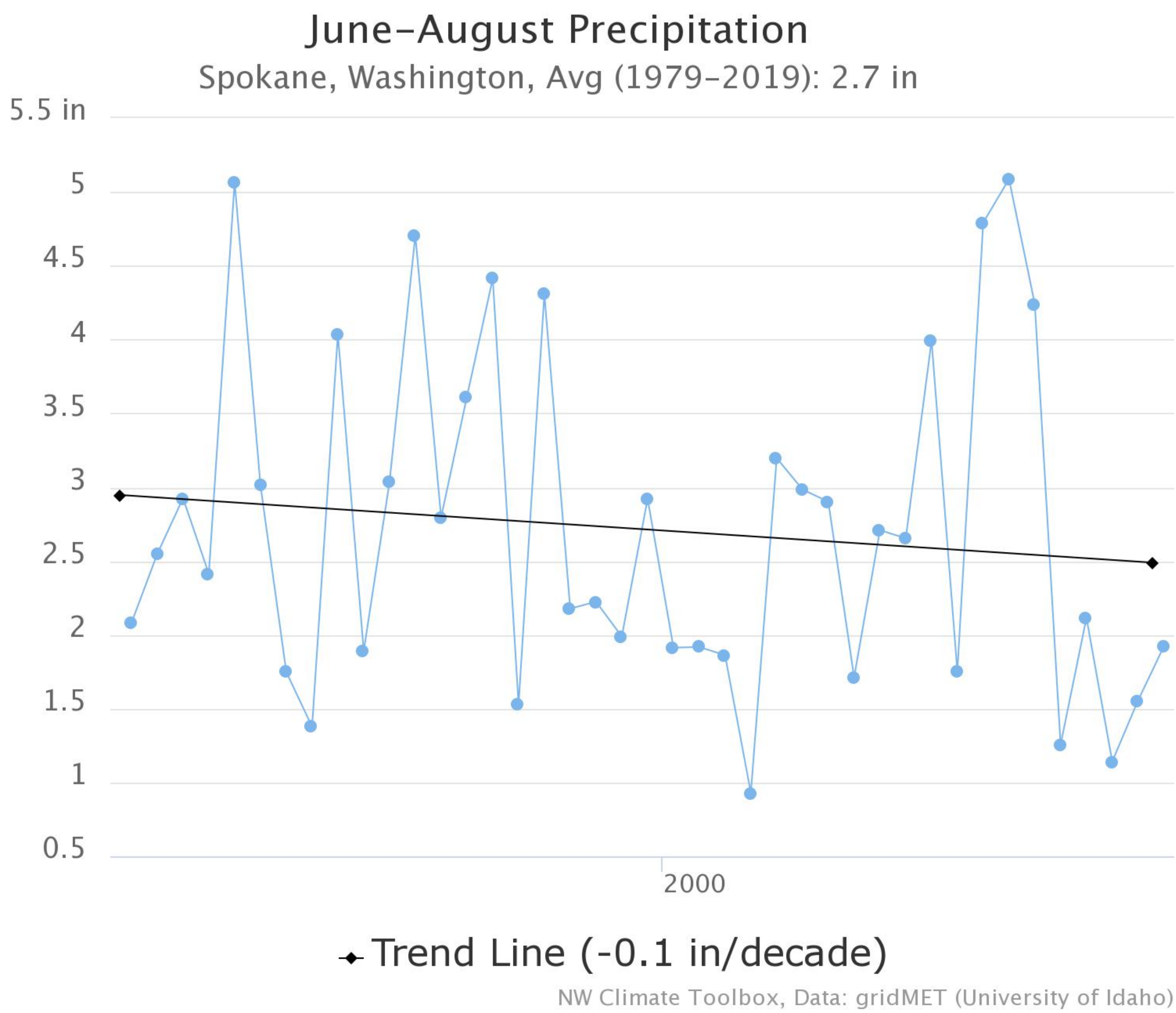

Figure 7: Summer (June–August) precipitation for the years 1979–2019 with trend line. Source: Historical Climate Tracker Tool (https://climatetoolbox.org/tool/Historical-Climate-Tracker), The Climate Toolbox.

Projected Future Climate—Annual Precipitation Trends

Variables: *Annual (January–December) Precipitation*

Finding: There is little difference between the lower emissions scenario (RCP 4.5) and the high emissions scenario (RCP 8.5) in terms of annual precipitation projections for Spokane.

Finding: Projected future annual precipitation for Spokane under both the lower emission scenario (RCP 4.5) and the high emissions scenario (RCP 8.5) is not expected to deviate significantly from historical levels. In other words, the annual volume of precipitation is not projected to change dramatically under future climate change.

Justification: Precipitation projections generally have less confidence to them than temperature projections. An analysis by the Pacific Northwest Climate Impact Research Consortium (CIRC) suggests that the higher variability in precipitation projections for the Pacific Northwest United States is due to several factors (***Rupp et al. 2017***). The impact of greenhouse gas emissions is less direct for precipitation than for temperature. For instance, the higher emissions scenario (RCP 8.5) produces more warming than the lower emissions scenario (RCP 4.5) yet the precipitation projections are similar for both scenarios (***Figures 8*** and ***9***). Interannual precipitation variability is also rather high and generally larger than the magnitude of projected changes (***Rupp et al. 2017***). Precipitation projections for the Pacific Northwest show disagreement between global climate models (GCMs) about whether precipitation will increase or decrease under a warming climate. At the same time, the multi-model mean from these projections tends not to deviate significantly from what was normal historically. ***Figure 8*** shows projected average annual (January–December) precipitation for Spokane (measured in inches) to year the 2100 for the lower emissions scenario (RCP 4.5). ***Figure 9*** shows projected average annual (January—December) precipitation for Spokane (measured in inches) to the year 2100 for the high emissions scenario (RCP 8.5). The gray and blue lines in the figures represent the multi-model mean of 20 GCMs used to create the projections. Projected future precipitation is shown in blue. The bands of blue represent the spread of results from the GCMs. Three things can be understood from these figures:

1. There is little to no difference in projected precipitation levels between the two scenarios. For instance, the projected average annual precipitation for the year 2099 is 19.6 inches under RCP 8.5 and 19.0 inches under RCP 4.5.
2. The projected future multi-model mean for both scenarios shows slight increases above the historical values. For instance, the historical mean is 17.6 ″ while the end of century projections for both scenarios are only slightly above that mean (19.6 ″ for RCP 8.5; 19.0 ″ for RCP 4.5). This means the region might be trending slightly wetter under climate change.
3. The spread of the climate projections (represented as the blue band) can be found both above and below both the historical multi-model mean and projected future multi-model mean. This result is harder to interpret. However, if you consider CIRC's above-mentioned analysis, this likely implies two things:
    a. There is disagreement among the models about whether Spokane will get wetter or drier under climate change;
    b. Natural variability, as annual and interannual changes in precipitation (i.e. abnormally wet and abnormally dry years, and abnormally wet and abnormally dry seasons) will continue to be a key climate factor in the region's future.

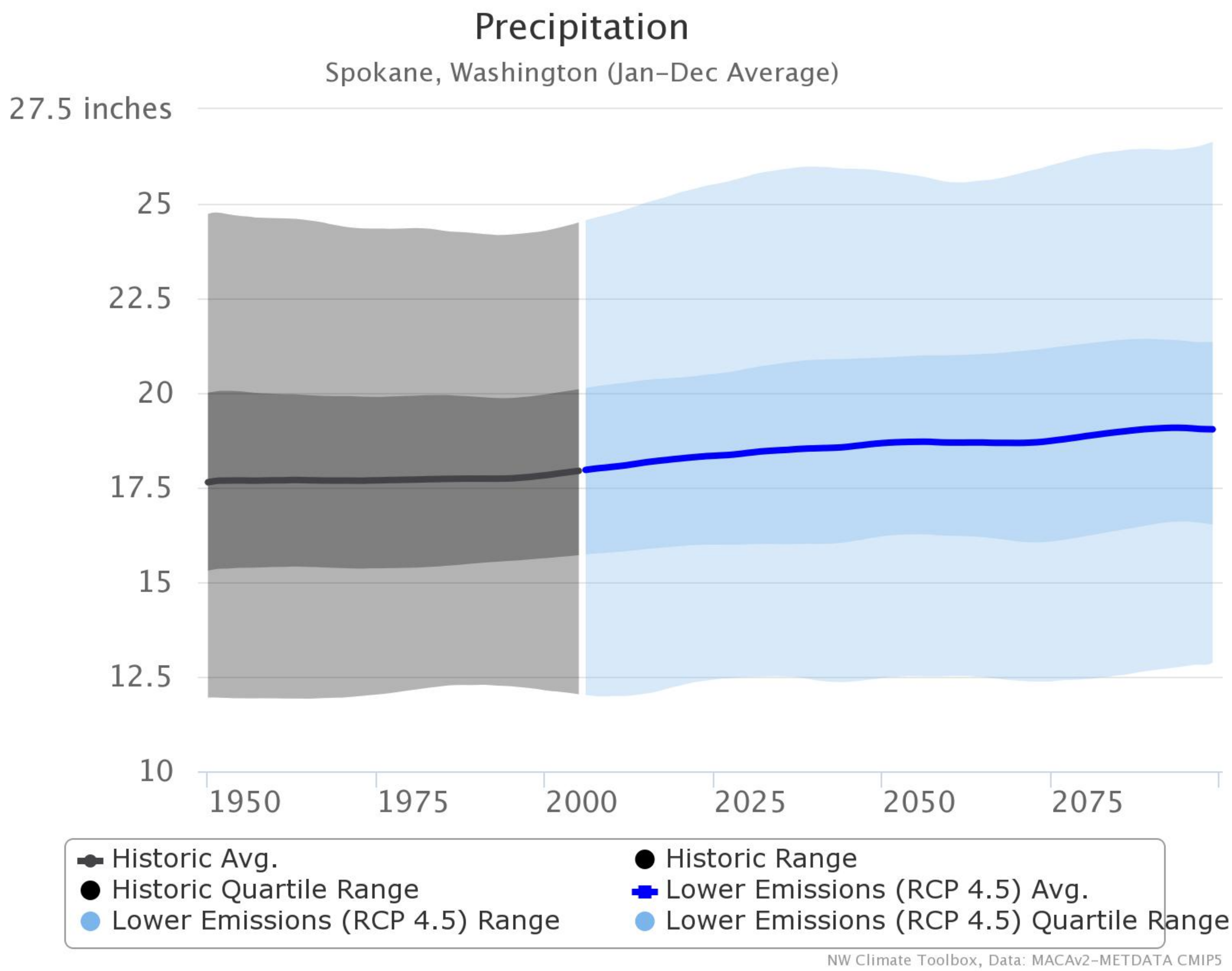

Figure 8: Projected annual (January–December) precipitation in inches for Spokane, Washington to the year 2100 for the lower emissions scenario (RCP 4.5) shown in blue. The lines represent the multi-model mean of 20 downscaled global climate models. The solid bands (blue and gray) represent the spread of results from the 20 models used to create this projection. The gray band represents a historical simulation of the years 1950–2005. The black line represents the multi-model mean for the historical simulation. Projected future precipitation is represented in the blue line (the multi-model mean) and the blue band (the spread of results from the 20 models). Source: Future Time Series Tool (https://climatetoolbox.org/tool/Future-Time-Series), The Climate Toolbox.

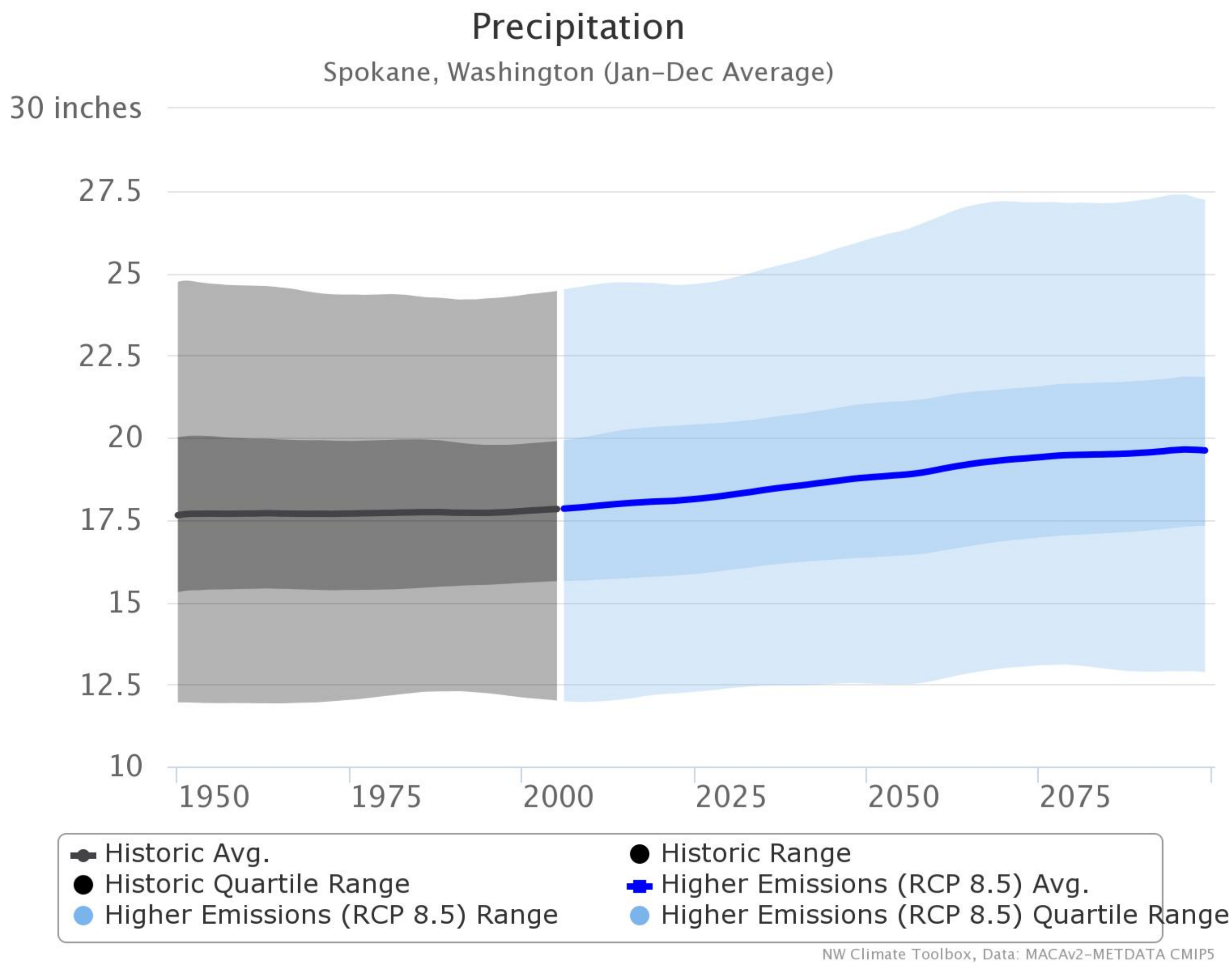

Figure 9: Projected annual (January–December) precipitation in inches for Spokane, Washington to the year 2100 for the high emissions scenario (RCP 8.5) shown in blue. The lines represent the multi-model mean of 20 downscaled global climate models. The solid bands (blue and gray) represent the spread of results from the 20 models used to create this projection. The gray band represents a historical simulation of the years 1950–2005. The black line represents the multi-model mean for the historical simulation. Projected future precipitation is represented in the blue line (the multi-model mean) and the blue band (the spread of results from the 20 models). Source: Future Time Series Tool (https://climatetoolbox.org/tool/Future-Time-Series), The Climate Toolbox.

Projected Future Climate—Seasonal Precipitation Trends

Variables: *Annual (January–December) Precipitation*; *Winter (December—February) Precipitation*; *Spring (March—May) Precipitation*; *Summer (June–August) Precipitation*

Finding: Precipitation projections for Spokane show a slight increase in annual precipitation, with a slight increase in precipitation during the fall, winter, and spring months, and a slight decrease in precipitation over the summer months.

Justification: This section of our analysis looks at projected seasonal precipitation. Because we found no substantive difference between the lower emissions scenario (RCP 4.5) and the high emissions scenario (RCP 8.5) as far as annual precipitation projections were concerned, our seasonal analysis examines RCP 8.5 alone. To examine projected seasonal precipitation, we used the Future Boxplots Tool available in the Climate Toolbox.

The boxplots shown in ***Figures 10–14*** display the results of 20 global climate models statistically downscaled to the Spokane region. The boxplots each contain 90% of the variance or values within the box. The results of each of the 20 global climate models are represented by the individual points. The multi-model mean is indicated by a solid bar. Over all, precipitation projections for Spokane show a slight increase in annual (January–December) precipitation (***Figure 10***), a slight increase in fall (September–November) precipitation (***Figure 11***), winter (December–February) (***Figure 12***), and spring (March—May) (***Figure 13***), and a slight decrease in summer (June–August) precipitation (***Figure 14***).

Projected 20-model mean annual precipitation (***Figure 10***) for the 30-year time periods early century (2010–2039), mid-century (2040–2069), and late century (2070–2099) are 18.2 inches, 19″, and 19.6″, respectively, compared to 17.7″ for the historical baseline (1971–2000). Projected 20-model mean summer precipitation (***Figure 14***) are 2.7″ early century, 2.6″ mid-century, and 2.4″ late century, compared to 2.8″ for the historical baseline (1971–2000).

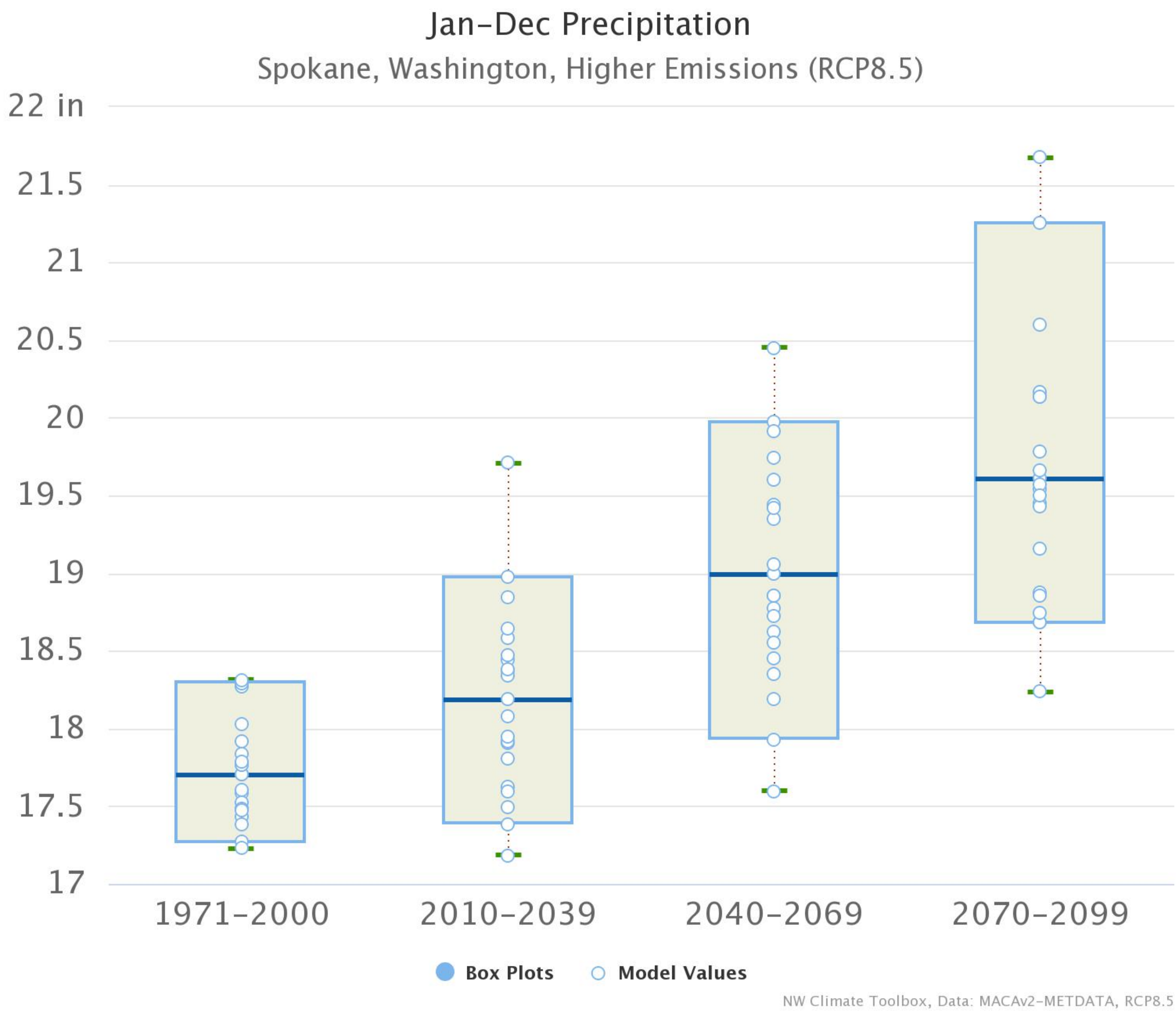

Figure 10: Projected Future annual (January–December) precipitation (in inches) for Spokane, Washington for the simulated historical period (1971–2000) and projection future periods (2010–2039, 2040–2069, and 2070–2099) under the high emissions scenario (RCP 8.5). The results of each of the 20 models used in the analysis are represented by individual points. The multi-model mean is indicated by solid bars. Source: Future Climate Boxplots Tool (https://climatetoolbox.org/tool/Future-Boxplots), The Climate Toolbox.

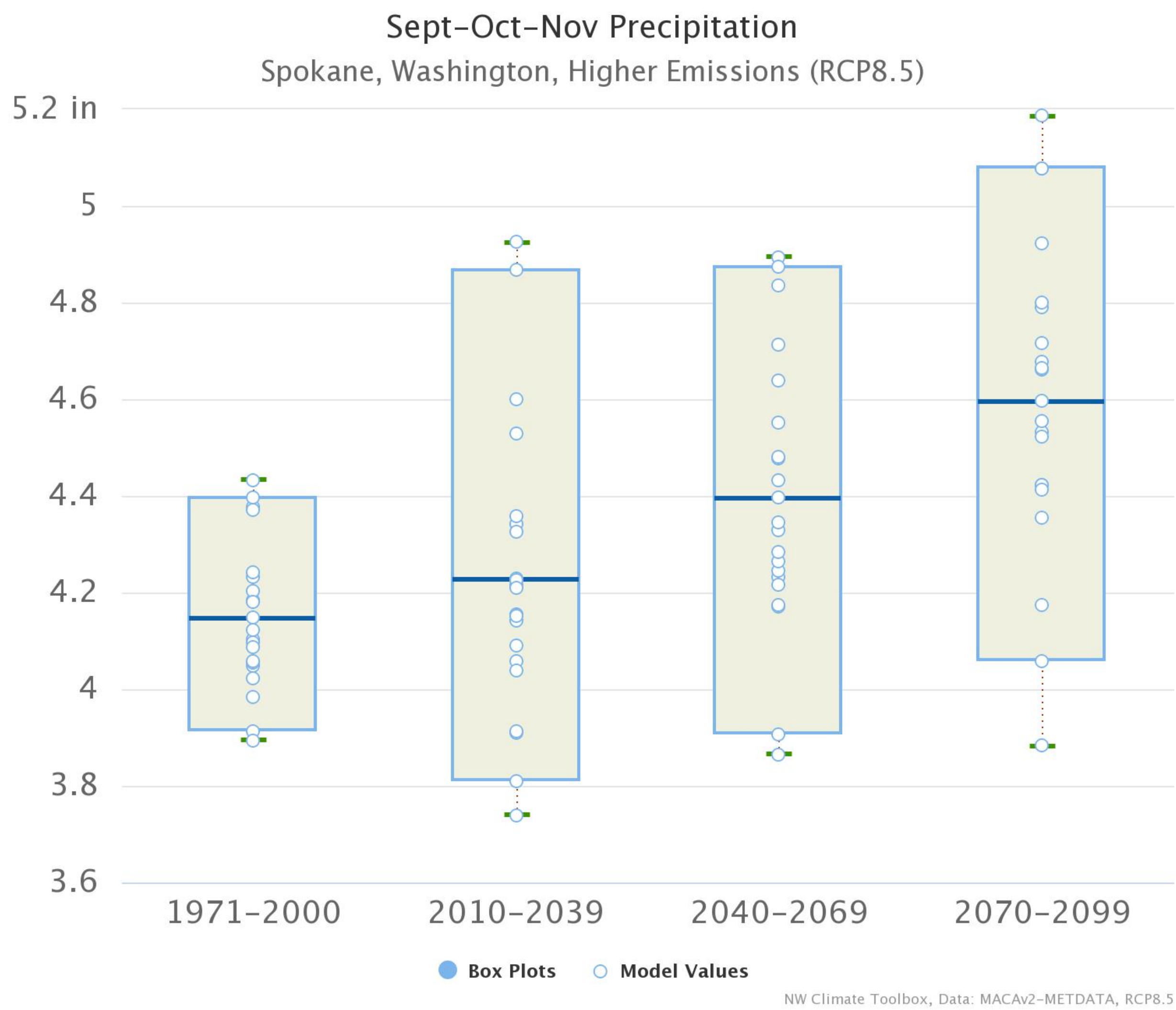

Figure 11: Projected future Fall (September—November) precipitation (in inches) for Spokane, Washington for the simulated historical period (1971–2000) and projection future periods (2010–2039, 2040–2069, and 2070–2099) under the high emissions scenario (RCP 8.5). The results of each of the 20 models used in the analysis are represented by individual points. The multi-model mean is indicated by solid bars. Source: Future Climate Boxplots Tool (https://climatetoolbox.org/tool/Future-Boxplots), The Climate Toolbox.

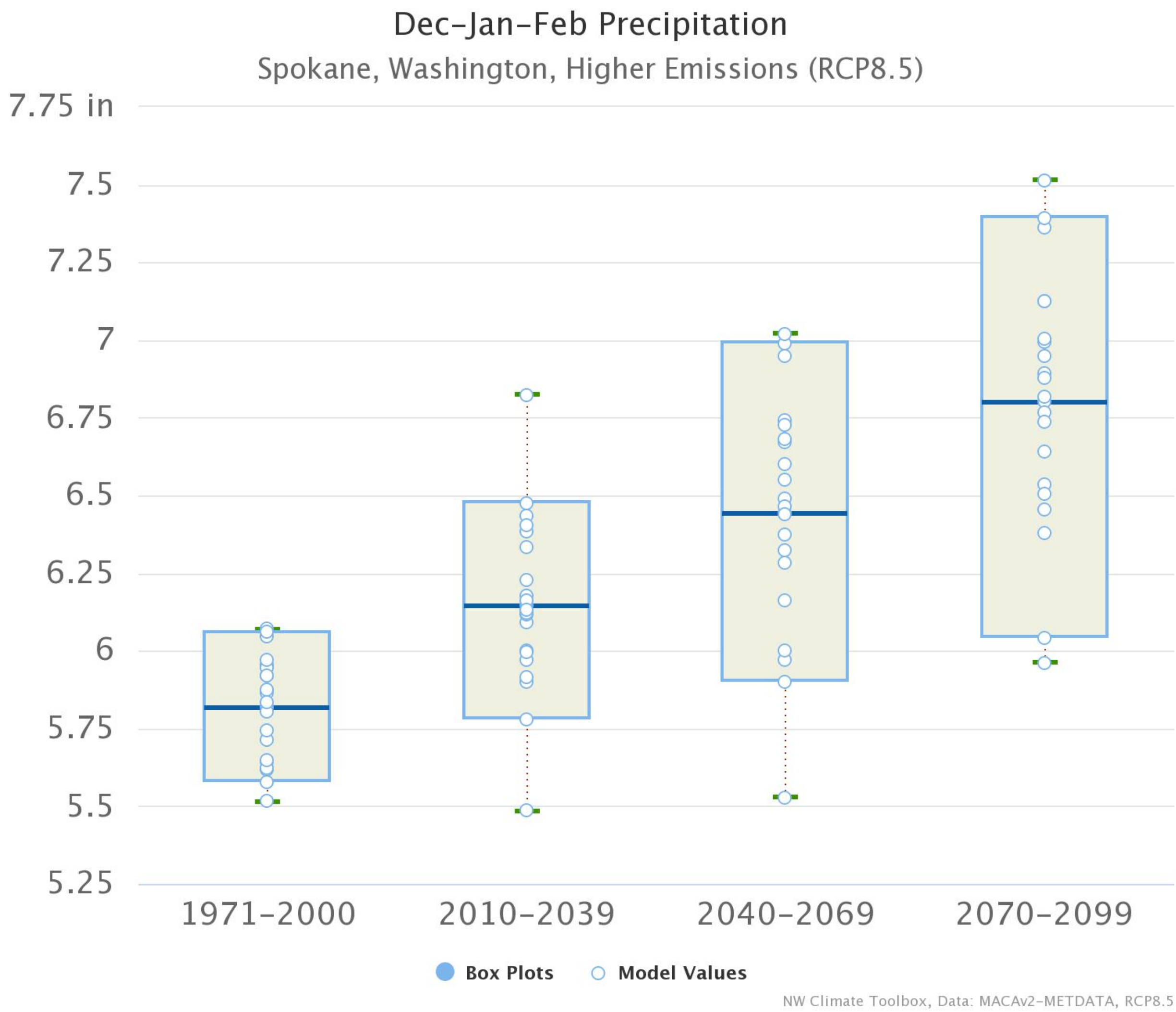

Figure 12: Projected Future winter (December—February) precipitation (in inches) for Spokane, Washington for the simulated historical period (1971–2000) and projection future periods (2010–2039, 2040–2069, and 2070–2099) under the high emissions scenario (RCP 8.5). The results of each of the 20 models used in the analysis are represented by individual points. The multi-model mean is indicated by solid bars. Source: Future Climate Boxplots Tool (https://climatetoolbox.org/tool/Future-Boxplots), The Climate Toolbox.

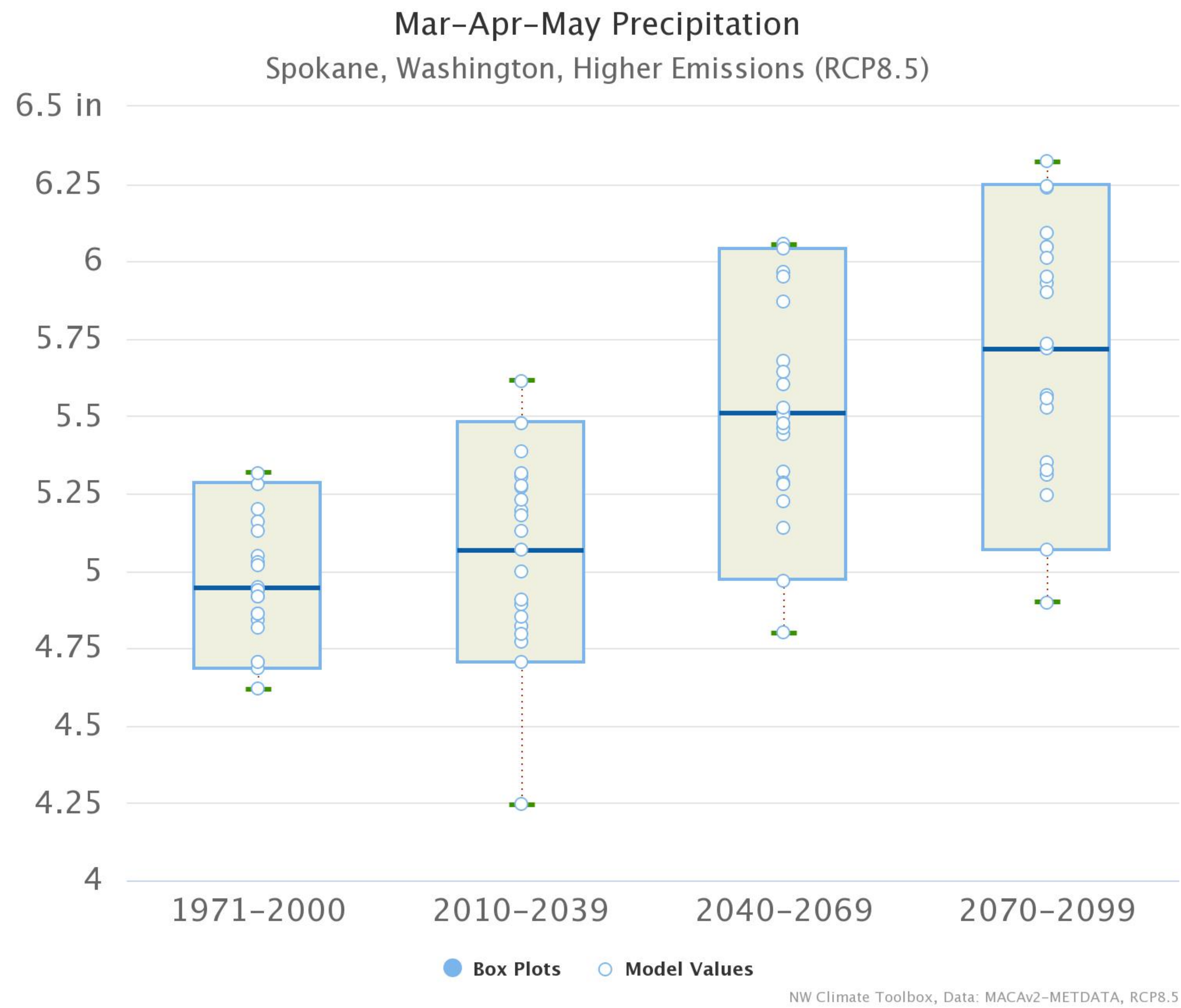

Figure 13: Projected Future spring (March—May) precipitation (in inches) for Spokane, Washington for the simulated historical period (1971–2000) and projection future periods (2010–2039, 2040–2069, and 2070–2099) under the high emissions scenario (RCP 8.5). The results of each of the 20 models used in the analysis are represented by individual points. The multi-model mean is indicated by solid bars. Source: Future Climate Boxplots Tool (https://climatetoolbox.org/tool/Future-Boxplots), The Climate Toolbox.

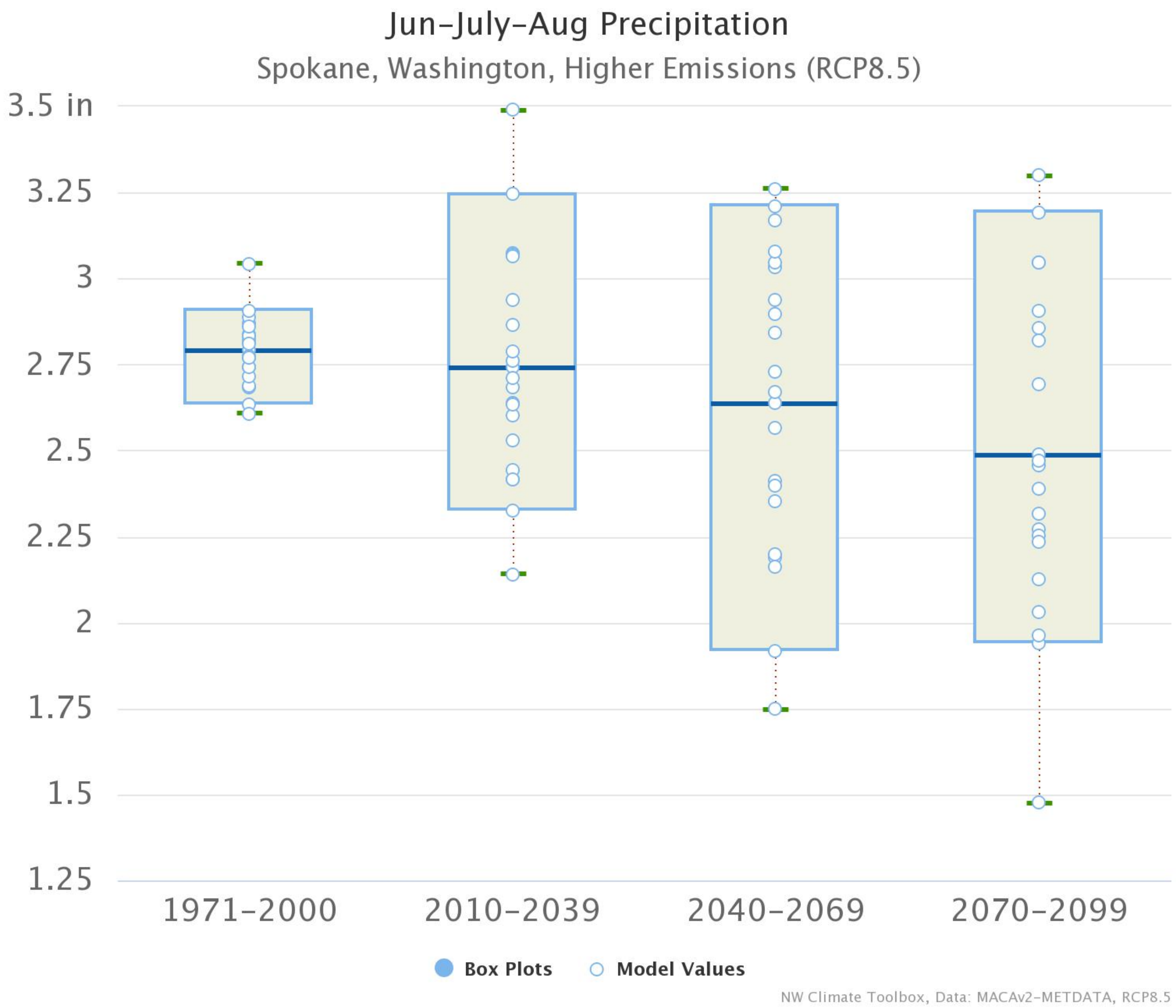

Figure 14: Projected future summer (June–August) precipitation (in inches) for Spokane, Washington for the simulated historical period (1971–2000) and projection future periods (2010–2039, 2040–2069, and 2070–2099) under the high emissions scenario (RCP 8.5). The results of each of the 20 models used in the analysis are represented by individual points. The multi-model mean is indicated by solid bars. Source: Future Climate Boxplots Tool (https://climatetoolbox.org/tool/Future-Boxplots), The Climate Toolbox.

Conclusion—Dryland Wheat Farming is Viable Under Future Climate Change

The seasonal timing as well as the annual and seasonal volume of precipitation in the Spokane region is not expected to dramatically change over this century, according to our analysis. This means that the Spokane region will continue to meet the precipitation timing and volume requirements for dryland wheat production as outlined by the Washington Grain Commission. However, as discussed above, compared to other climate variables, such as temperature, the precipitation projections have much greater levels of uncertainty associated with them. Natural variability in the form of especially wet and especially dry years and seasons is also likely to continue in the future. Put simply, our analysis does not preclude the existence of periodic future droughts due to low precipitation levels.

Discussion—Why Precipitation Should Not Be Considered Alone

When precipitation is considered with other climate variables, such as temperature, several other potential impacts to agriculture become apparent. While there is evidence to suggest that dryland wheat farming in Washington State may see higher yields due both to rising temperatures and rising CO2 levels at least through the middle of this century (**Stöckle et al., 2014**) (***Fourth National Climate Assessment, "Chapter 24: Northwest," 2018***), other crops might not benefit from rising temperatures. For instance, warmer winter temperatures are expected to lead to precipitation falling more as rain and less as snow, particularly at the lower elevations. This is important for some crops because winter snow cover can provide an insulating effect protecting dormant crops from freezing temperatures (***Aase and Siddoway 1979***).

Additionally, as the ***Snow*** and ***Streamflow*** chapters of this report describe, the shift in precipitation from snow to rain during the fall, winter, and spring months is expected to alter the timing of streamflow in the region and is likely to impact the amount of stored water available for irrigated agriculture. Without large increases in storage or conservation, the decline in spring snowpack will tax summer irrigation and water resources. However, this is likely to be a larger problem in other parts of the Pacific Northwest rather than Spokane (***Fourth National Climate Assessment, "Chapter 24: Northwest," 2018***). In the farmlands surrounding Spokane, direct irrigation from the Spokane River is limited. Most agriculture in the region is dryland farming and is not irrigated.

Recommended Resilience Action

It is with the above analysis in mind that we recommend the following resilience action:

- **Planting Techniques**—Current efforts to minimize erosion in our region, including no-till and direct seeding planting techniques as well as re-establishing stream and field buffers, will become even more important in the future.

Additional Analysis: Insurance Loss Claims for Wheat and the 2015 Drought

Author: Erich Seamon, University of Idaho, Pacific Northwest Climate Impacts Research Consortium (CIRC)

Finding: During the 2015 drought, wheat insurance loss claims across the Inland Pacific Northwest totaled $240 million for all damage causes, of which drought loss accounted for 56% of these claims.

Finding: During the 2015 drought, drought loss claims filed for wheat in Spokane, Adams, Whitman, and Lincoln Counties totaled a combined $22 million.

Justification: As noted above, several studies suggest that dryland wheat farming in the Pacific Northwest may see higher yields due both to rising temperatures and rising CO2 levels (**Stöckle et al., 2014**) (***Fourth National Climate Assessment, Chapter 24 2018***). Precipitation projections for Spokane also suggest that dryland wheat farming will receive adequate amounts of precipitation in the future, according to the above analysis. However, these projections do not preclude the occurrence of periodic droughts.

To better understand how drought might impact dryland wheat farming in the Spokane area, CIRC examined drought-associated insurance loss claims for wheat filed from 2001 to 2015 across the 24-county region of the Inland Pacific Northwest portion of the United States (***Figure 15***), a region that includes Spokane County and nearby Adams, Whitman, and Lincoln Counties (**Seamon et al., 2019a**).

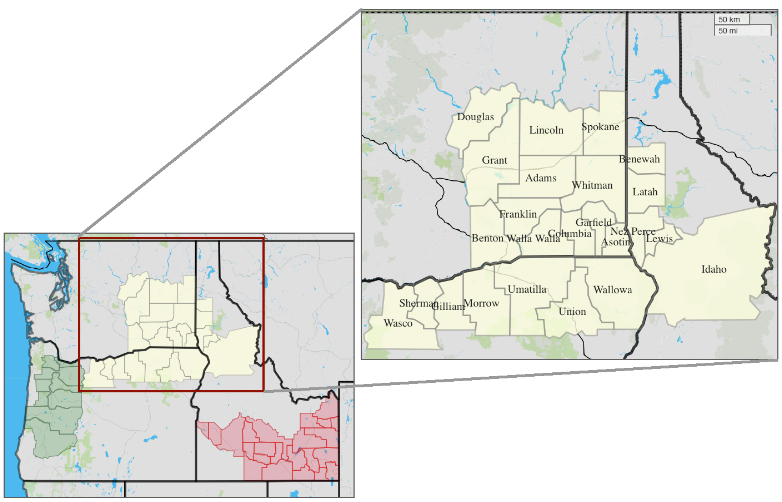

Figure 15: Pacific Northwest (PNW) agricultural regions, which include the Willamette Valley (green), the Southern Idaho Valley (red), and the study area for this analysis, the Inland Pacific Northwest (yellow).

CIRC's analysis highlights the drought conditions that occurred across the Inland Pacific Northwest in 2015. Because climate conditions during the 2015 drought look similar to projected future climate conditions for the Pacific Northwest generally (**Marlier et al., 2017**), drought conditions during 2015 are used in this analysis as an analog for understanding potential future drought impacts on dryland wheat in the Spokane region. In particular, CIRC found a clear relationship between drought conditions during 2015 and drought-associated insurance loss claims filed during 2015.

Over 90% of US farmers have agricultural crop insurance. Nationwide, over 2.8 million crop insurance claims were filed from 2001 to 2015. Crop insurance is especially important when climate-related events, such as droughts, extreme heat, or cold weather, affect crops and, as a result, impact a farmer's livelihood (**Christiansen et al., 1975**; **Diskin 1997**; **Miranda and Glauber 1997**).

During the 2001–2015 period examined by CIRC, insurance losses associated with wheat accounted for over $1.4 billion in claims across the 15-county region of the Inland Pacific Northwest, including over $700 million in claims due to drought. During the 15-year period, the years 2009 and 2015 standout (***Figure 16***).

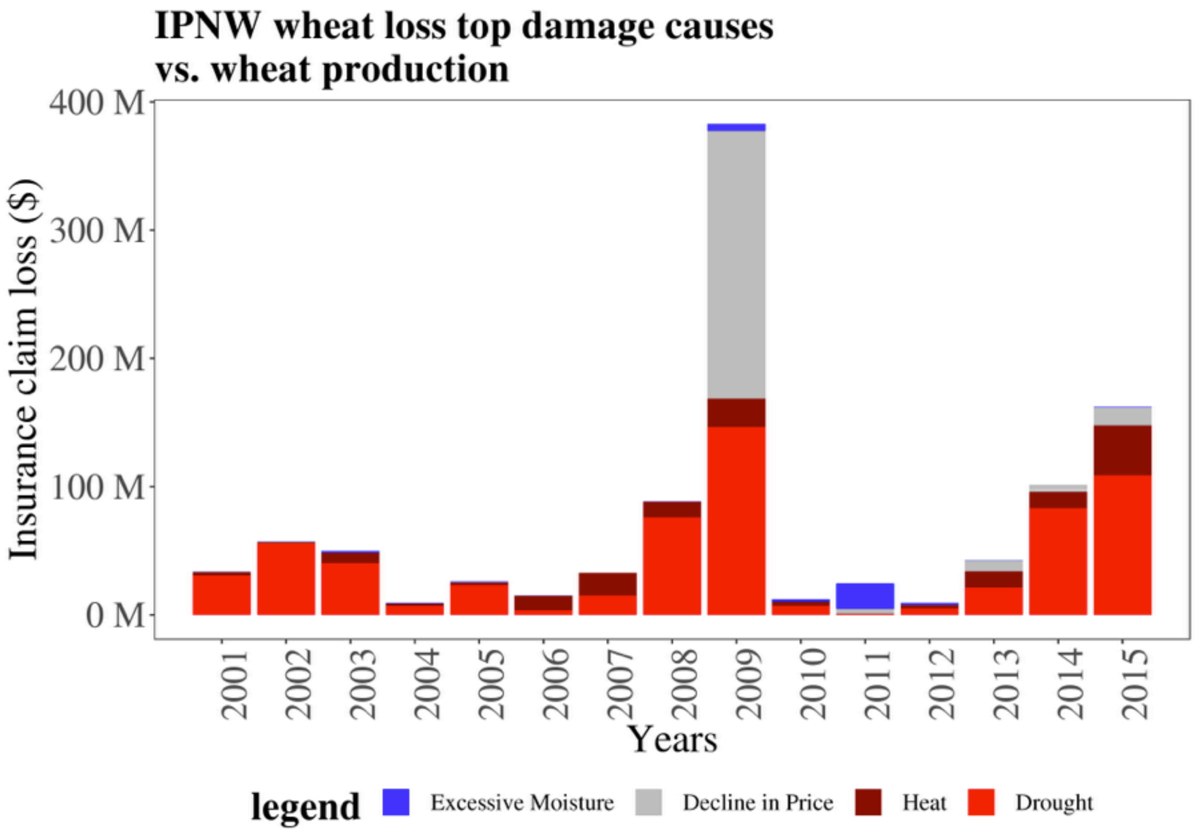

Figure 16: Comparisons of wheat insurance loss from 2001 to 2015 for the Inland Pacific Northwest, comparing causes of loss (excessive moisture, decline in price, heat, and drought). Note the peak years of 2009 and 2015.

Both 2009 and 2015 were peak years for filed insurance loss claims for wheat, and both years saw a large number of claims for drought. However, 2015 was the only year of the two that experienced regional drought conditions (**Seamon et al., 2019a**). This suggests that the Great Economic Recession of 2008/2009 and the associated drop in wheat prices may have played a role in farmers' decisions to file insurance claims for losses due to drought (**Seamon et al., 2019a**).

The year 2015 was clearly a drought year. Precipitation levels during 2015 were slightly below normal. However, temperatures during 2015 were warmer than normal (**Mote et al., 2015**). By late June 2015, much of the Inland Pacific Northwest was categorized as being *Abnormally Dry* or experiencing *Moderate* to *Severe Drought*, according to data collected at the time by the U.S. Drought Monitor (***Figure 17***) (**U.S. Drought Monitor 2019**).

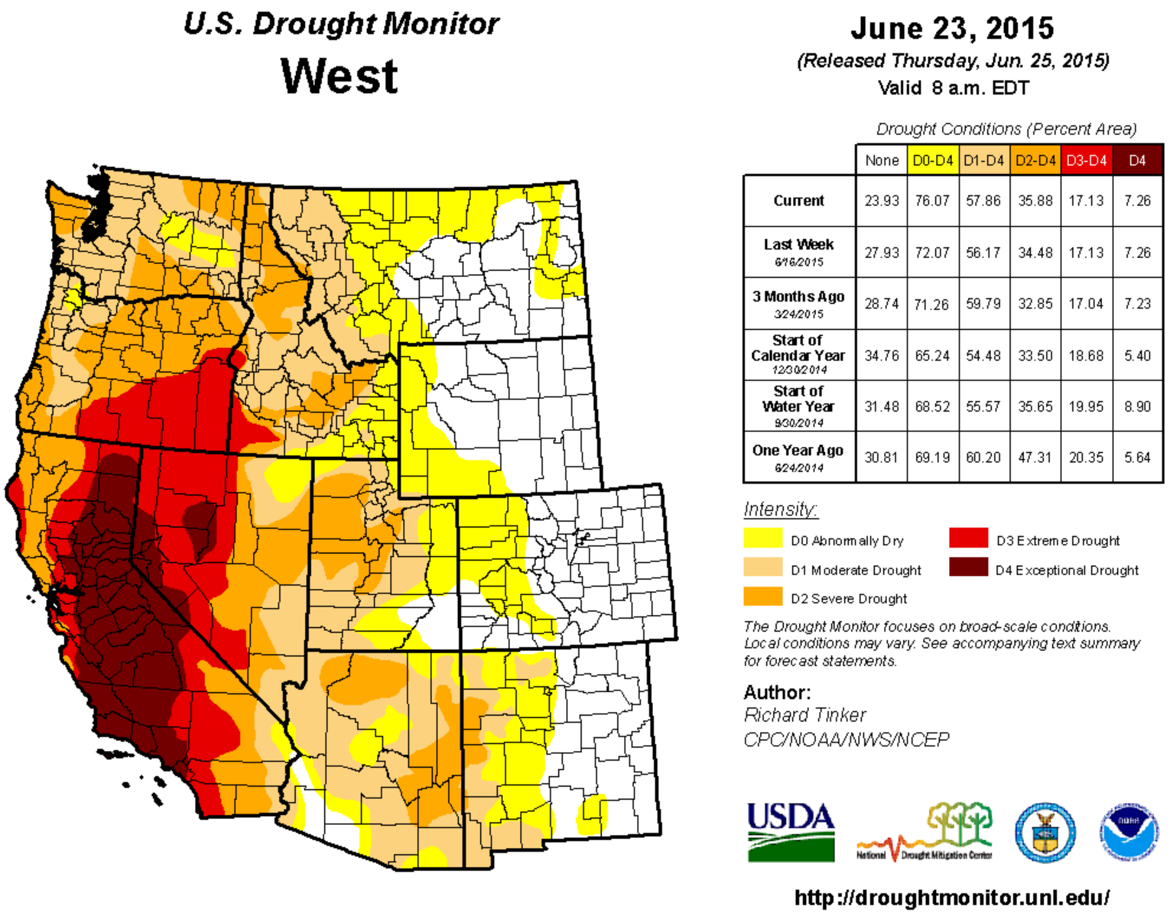

Figure 17: Drought conditions for June 23, 2015 across the western region of the United States. Much of the Inland Pacific Northwest was placed under the categories Abnormally Dry, Moderate Drought, and Severe Drought, according to the US Drought Monitor.

Wheat insurance loss claims across the Inland Pacific Northwest for 2015 totaled $240 million for all damage causes, of which losses attributed to drought accounted for 56% of that total (**Seamon et al., 2019b**). In Spokane, Adams, Whitman, and Lincoln Counties, drought loss claims for wheat filed in 2015 totaled a combined $22 million. ***Figure 18*** provides a comparison of drought and heat loss claims filed in the four counties for the years 2001–2015.

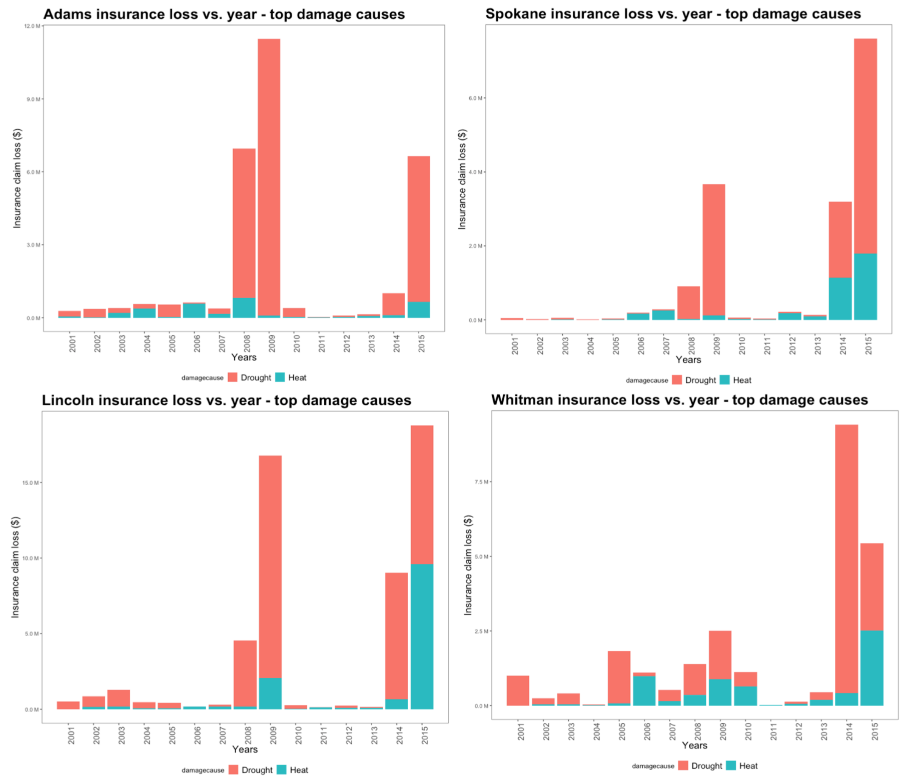

Figure 18: A comparison of drought and heat loss claims filed in Spokane, Adams, Whitman, and Lincoln Counties for the years 2001–2015.

The drought conditions during 2015 provide an analog for future droughts in terms of both precipitation and temperature. Future precipitation projections for Spokane and the Inland Pacific Northwest generally are not expected to vary significantly from current patterns in terms of the timing and volume of precipitation. The year 2015 is an ideal analog in this sense because the year saw near-normal precipitation levels across the region. Temperatures during 2015 also look quite similar to temperatures projected for the middle decades of this century (**Marlier et al., 2017**). Third, is the relationship between wheat drought claims made by farmers and drought conditions at the time of those claims.

A statistical analysis performed by CIRC examined the relationship between insurance loss claims and multiple variables, including commodity prices, temperature, precipitation, evapotranspiration, and the Palmer Drought Severity Index (PDSI). CIRC's analysis revealed a clear relationship between drought claims and PDSI, a climate variable that is used as a proxy for soil moisture. PDSI is commonly used in agriculture and incorporated into the US Drought Monitor. CIRC's analysis indicated that PDSI was the most important factor in predicting total seasonal wheat/drought insurance loss claims. This pattern was especially clear in the drought-prone counties of eastern Washington (**Seamon et al., 2019b**). While the 2015 drought and its effect on wheat and insurance loss claims is not a clear guide to how dryland wheat might be affected in the future, it does raise the possibility that dryland wheat farming might be more susceptible to certain climate conditions than previously estimated.

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