Current Condition Report for Forest Biodiversity: Lakes Timber Supply Area

APPENDIX 4

Projected Changes in Climate in the Lakes Timber Supply Area (TSA)

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Climate Change Overview

Climate change is expected to affect forest biodiversity in a variety of ways.[1] Climate change can trigger a wide range of biotic responses such as longer-term shifts in plant species composition as forest communities respond to shifting climatic conditions. Some established species may disappear while others may emerge, and in some cases, regime shifts from forest to shrubland or grassland communities may occur. More immediate shifts in forest conditions can be caused by increasingly frequent and severe natural disturbance events (e.g., insects, wildfires, wind) that affect tree and plant communities, the availability of important structural attributes (e.g., large live trees, snags, downed wood), or food sources (e.g., forage, prey) that wildlife use.

Precise predictions of what effects climate change will have on forest ecosystems is challenging due to the complexity of species interactions and uncertainty in forecasting. Extreme weather events are expected to increase over time, and these will have the most significant effects. While we cannot predict when extreme events will occur, we can predict the longer-term changes in average climatic conditions. By investigating how departed future climate conditions are from what is normal, we can infer where the largest risks from climate could be. Areas that will experience the largest departures in climate can be assumed to be at the highest risks of adverse climate impacts.

This assessment focuses on projecting changes in four climate variables associated with the distribution of forest ecosystems, species, and natural disturbance events that shape forest composition, structure, and the availability of habitats. For each climate variable, we include projections for the Spring (March–May), Summer (June–August), Autumn (September–November), and Winter (December–February) seasons as the impact of climate change are projected to vary substantially throughout the year. The climate variables used include:

- Temperature (Temp) – the average temperature in degrees (°) Celsius;
- Precipitation (PPT) – the average precipitation in millimeters (mm);
- Precipitation as Snow (PAS) – the average precipitation falling as snow in millimeters snow water equivalent[2] (SWE mm);
- Climate Moisture Deficit (CMD) – Hargreave's climatic moisture deficit in millimeters per year (mm/yr) which is a temperature-based estimate of potential evapotranspiration.

Temperature and precipitation influence wildlife, tree, and plant species distributions (Hamman and Wang 2006, Mahoney et al. 2018). However, the interaction of temperature and precipitation, and in particular the amount and timing as it affects the water balance, has a greater effect on the distribution of vegetation than wildlife (Mather and Yoshioka, 1968; Stephenson, 1990). Climate Moisture Deficit (CMD) is used to characterize the water balance, as it represents the amount of water by which potential evapotranspiration exceeds actual evapotranspiration. A climate water deficit occurs when more water is removed from the soil through evapotranspiration than is replaced by precipitation. The CMD is also directly related to drought (Delong et al. 2019) and the extent and frequency of natural disturbance events such as wildfire (Parisien et al., 2023; Parks et al., 2018; Wasserman and Mueller, 2023) or insect outbreaks.[3] Precipitation as snow (PAS) is a derived variable that is measured as the snow water equivalent every year (mm/yr). Areas with higher PAS generally have greater snow depths and persistence of snow cover, which is directly related to ecosystem productivity and the distribution of plant and wildlife species.

[1] See: Preparing for climate change - Province of British Columbia (gov.bc.ca) and the report "Adapting natural resource management to climate change in the Cariboo Region: Considerations for practitioners and government staff" caribooen160222.pdf (gov.bc.ca)

[2] Snow water equivalent represents the depth of water (in mm) that would be produced if the snow melted.

[3] provincial_bark_beetle_strategy.pdf (gov.bc.ca)

Climate Projections

Climate variables used in this assessment are from ClimateBC[4] (Mahony et al., 2022; Wang et al., 2016). Climate information from 1961-1990 was used as the reference baseline period, which is commonly used in climate modeling as defined by the World Meteorological Organization (WMO) and the Intergovernmental Panel on Climate Change (IPCC). Climate projections to 2070 were used to represent potential future conditions. Climate projections illustrated in this assessment are an ensemble of eight global climate models (GCM) as recommended by Research Climatologist Colin Mahony with the B.C. Ministry of Forests.[5] Each GCM projects slightly different future conditions therefore the ensemble reflects the average of the GCM projections. Future 2070 projections illustrate the "Shared Socioeconomic Pathway" (SSP2-4.5) that reflects an intermediate greenhouse gas emissions scenario where carbon dioxide emissions continue around current levels until 2050, then decrease but do not reach net zero by 2100, as described by the National Oceanic and Atmospheric Administration (NOAA)[6]. All ClimateBC data was summarized in the ClimR package in R (Daust et al. 2024).

Climate Departure

The magnitude of change in climate conditions that an area may experience, or **climate exposure**, is evaluated by measuring the departure of expected future (2070) climate conditions from the historic interannual variation in climatic conditions measured for the baseline (1961-1990) period. In this assessment, climate exposure is displayed using a ***climate departure score*** that reflects how far the predicted future condition is from the interannual variation observed in the baseline period from the past. A Z-score is used to calculate the climate departure score, with the score representing how many standard deviations away future conditions are projected to be from the mean climate conditions during the baseline period. We interpret that the greater the climatic departure scores, the more likely an area will be severely affected by climate change.

Table 1: *Climate Departure Scores and a Description of Future Climate Compared to the Interannual Variation in Climate Observed in the Reference (1961–1990) Baseline Period.*

Climate Departure Score	Description of the Future Climate
Greater than +3	Exceeding the range of interannual variation observed in the baseline period.
+1 to +3	Above average for the baseline period but within the range.
-1 to +1	Largely within the range of the baseline period.
-1 to -3	Below average for the baseline period but within the range.
Less than -3	Well below the range of interannual variation observed in the baseline period.

4 Home Page - ClimateBC

5 climatena_8modelrationale.pdf (gov.bc.ca)

6 Climate Model – Surface Temperature Change: SSP2 (Middle of the Road) - 2015–2100 - Science On a Sphere (noaa.gov)

Climate Change Projections

Temperature

In the Lakes Timber Supply Area (TSA), future (2070) climate conditions, based on the average of several future scenarios, are projected to become both warmer and wetter (Figure 1 and Figure 2) and generally correspond with previous work completed in the Nadina District.[7,8] The average annual temperature is projected to increase by about 2.4–3.0° Celsius, with the greatest relative change in average annual temperatures in higher elevation Engelmann Spruce Subalpine Fir (ESSF) and Mountain Hemlock (MH) forest Biogeoclimatic zones and alpine ecosystems.

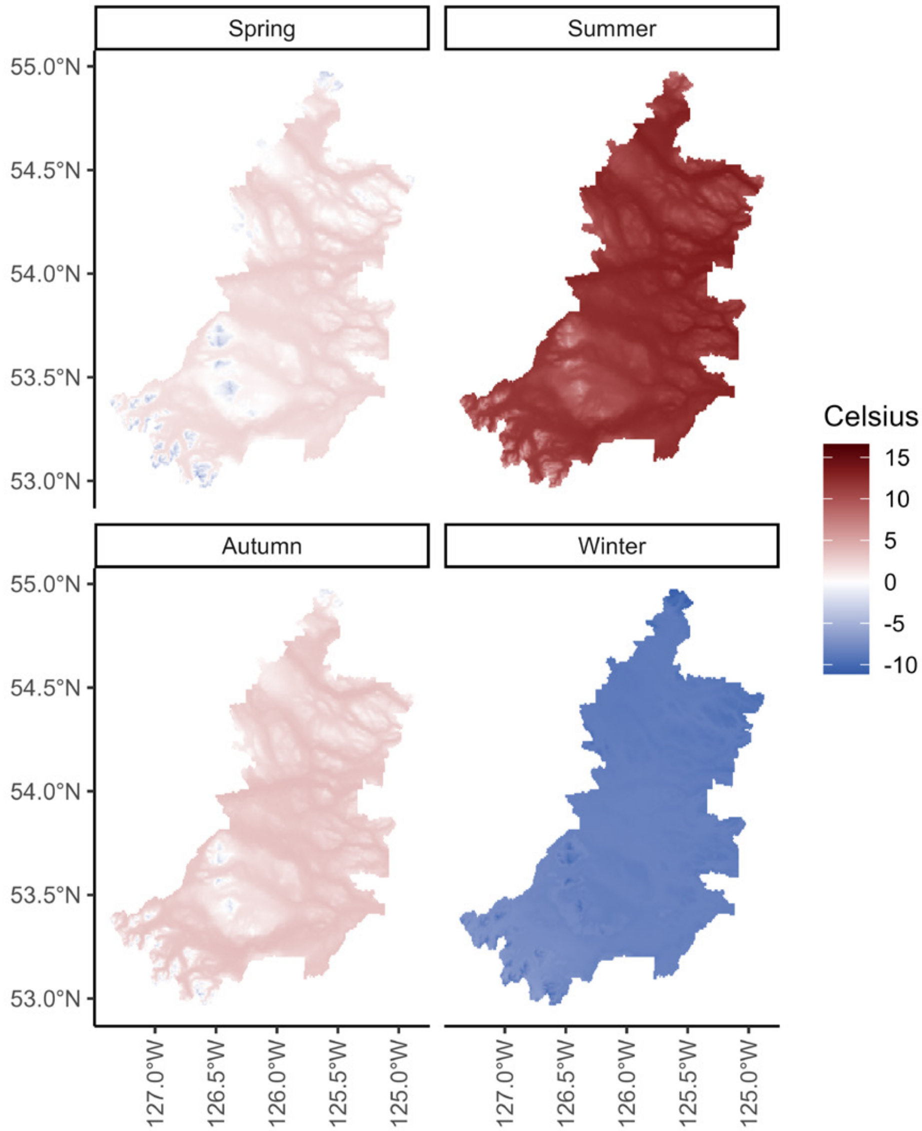

Figure 1: *Average Temperature by Season for the Baseline Period (1961–1990) in the Lakes Timber Supply Area.*

7 Nadina Case Study. Adapting to Climate Change. Dave Daust and Don Morgan.

8 Nadina Climate Change Vulnerability Assessment: Summary of Technical Workshop 1. Impacts on biodiversity. 2010. Dave Daust.

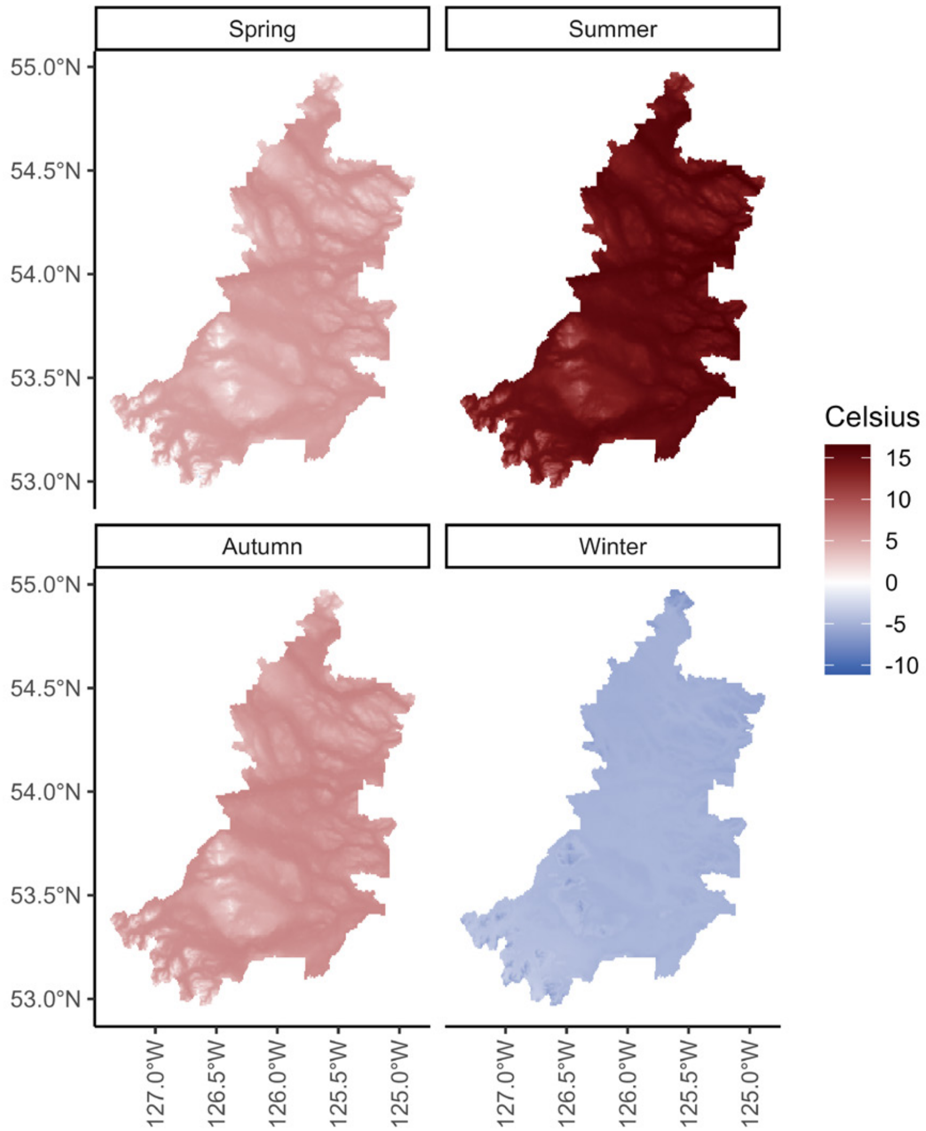

Figure 2: *Projected Future (2070) Average Temperature by Season in the Lakes Timber Supply Area.*

Temperature Departure

Temperature increases are projected to exceed the interannual range for the baseline period with the most significant departures in spring and summer (Figure 3).

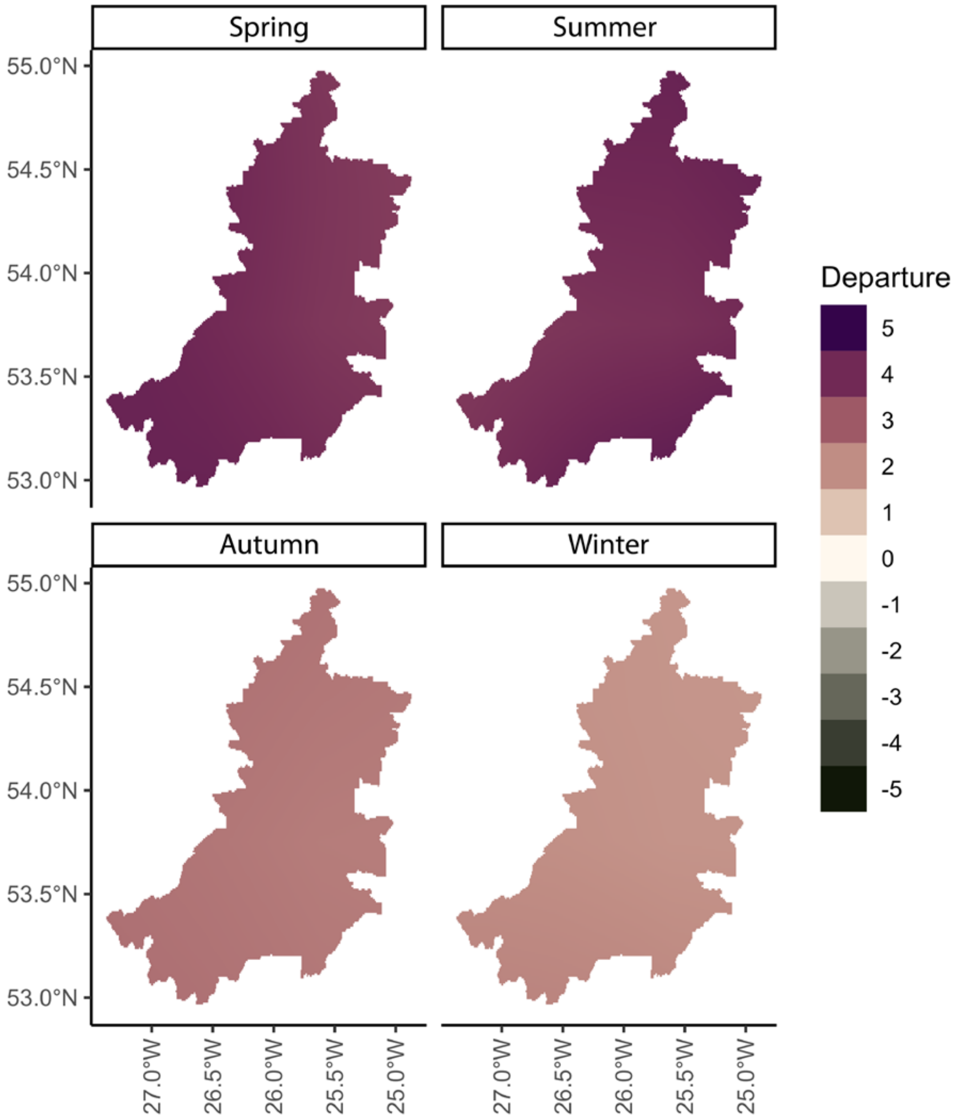

Figure 3: *Estimated Climate Departure Scores Representing the Magnitude in Difference in Average Temperature by Season between the Baseline Period (1961–1990) and the Projected Future (2070) Condition in the Lakes TSA.*

Precipitation

Precipitation is projected to increase by 2070 across the Lakes TSA by about 20–25% relative to the 1961-1990 baseline period (Figure 6). Projected changes range from an annual average increase of 160–190 mm in the Sub-Boreal Pine Spruce (SBPS) and dry and moist variants of the Sub-Boreal Spruce (SBS) Biogeoclimatic zones, and 200 mm in the moist Engelmann Spruce-Subalpine fir (ESSF) ecosystems.

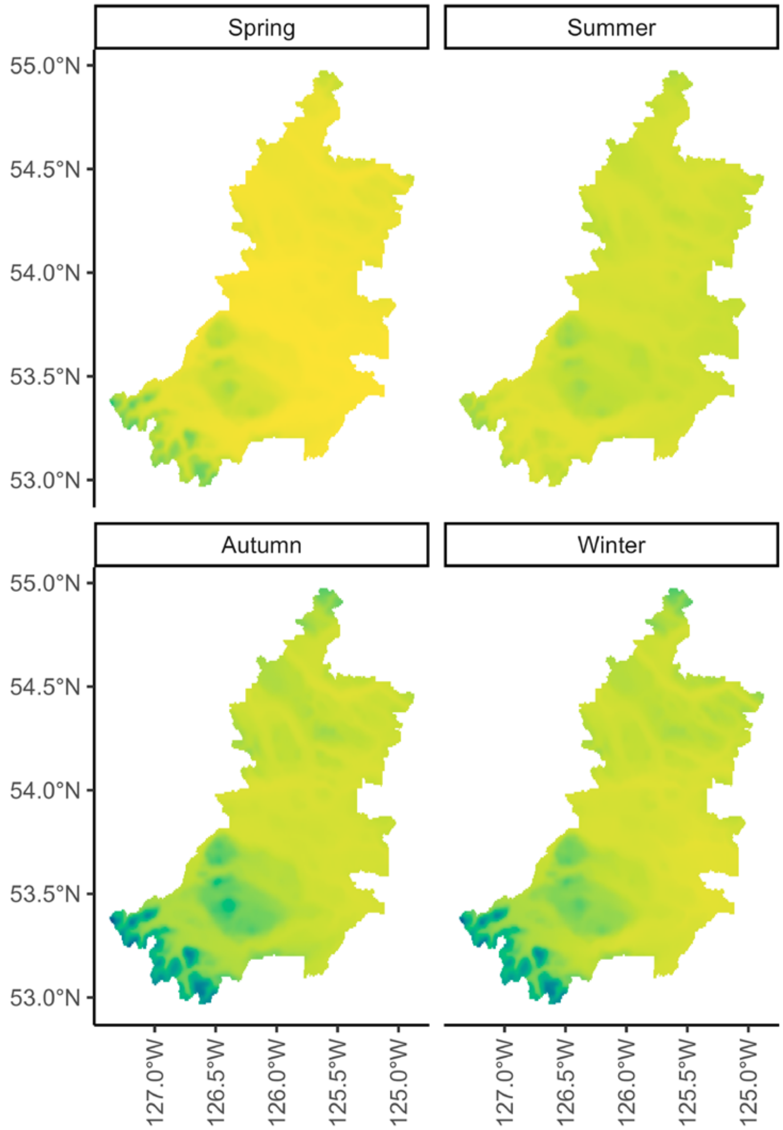

Figure 4: *Average Precipitation by Season for the Baseline Period (1961–1990) in the Lakes Timber Supply Area.*

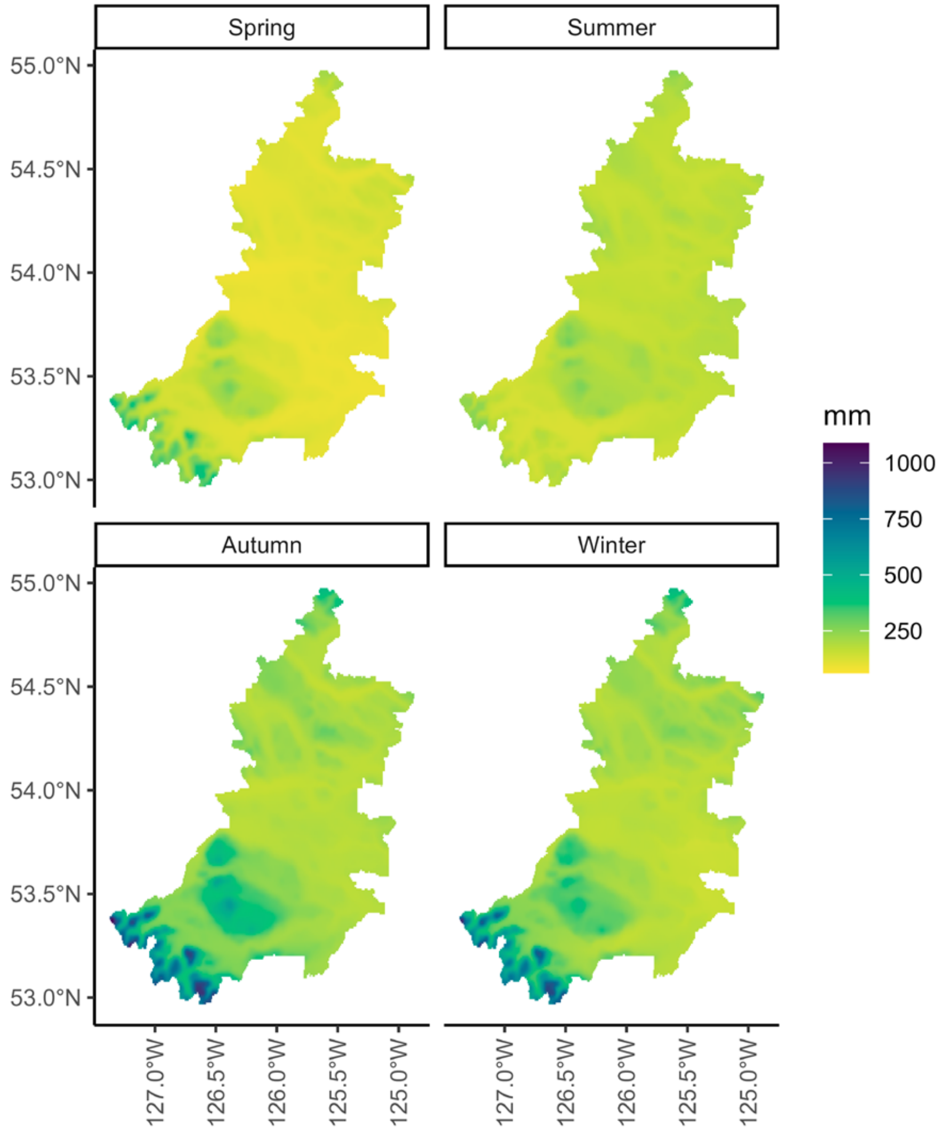

Figure 5: *Projected Future (2070) Average Precipitation by Season in the Lakes Timber Supply Area.*

Precipitation Departure

Changes in precipitation are projected to be well above or exceed the inter-annual range experienced during the baseline period in all seasons but the summer (Figure 6). The spring and autumn seasons are expected to see the greatest increase in precipitation compared to the baseline period.

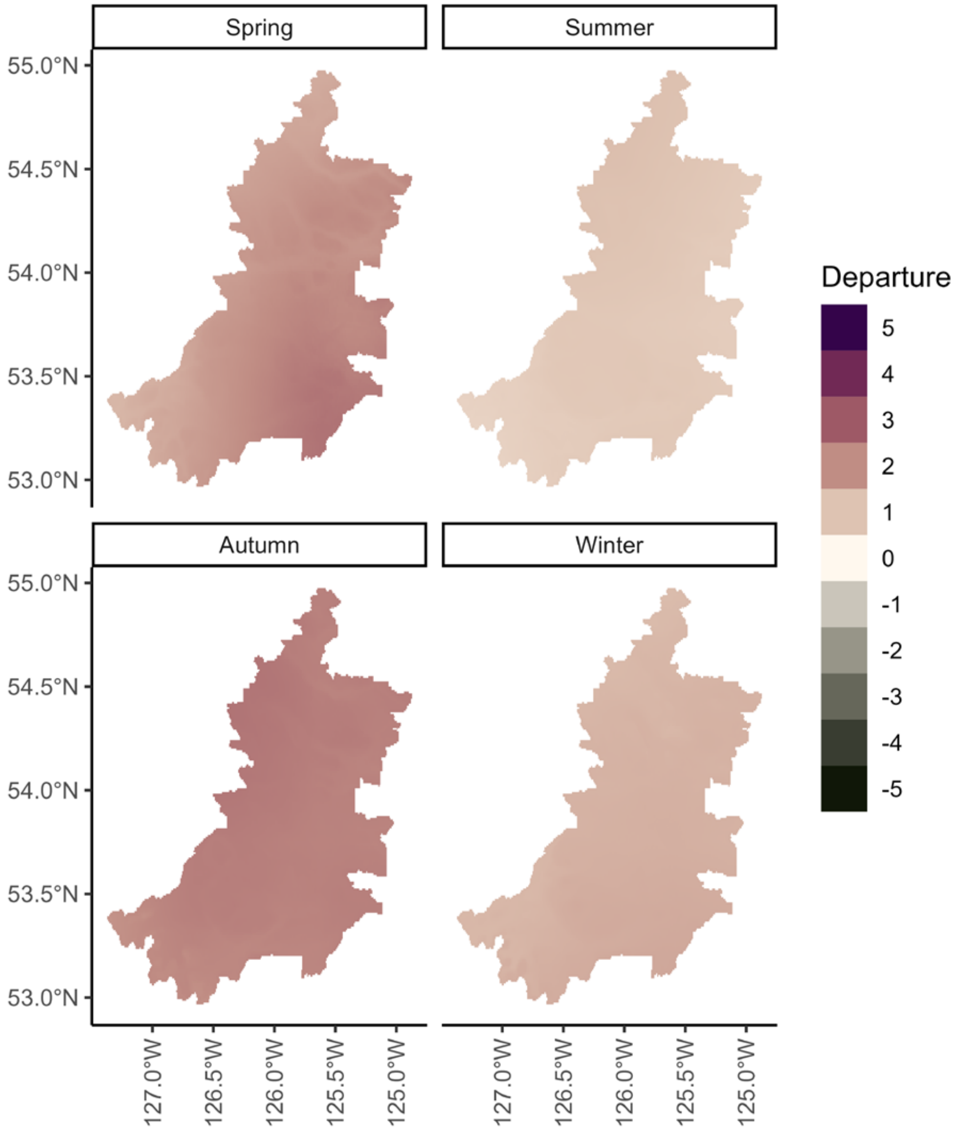

Figure 6: *Estimated Climate Departure Scores Representing the Magnitude in Difference in Average Precipitation by Season between the Baseline Period (1961–1990) and the Projected Future (2070) Condition in the Lakes Timber Supply Area.*

Climate Moisture Deficit

Climate moisture deficit (CMD) is expected to increase slightly overall in the Lakes TSA compared to the baseline period (Figure 7 and Figure 8). Increased CMD is expected particularly in the spring and summer periods, except the wet Engelmann Spruce-Subalpine fir ecosystems, and alpine areas where a slight decrease is expected in spring and autumn.

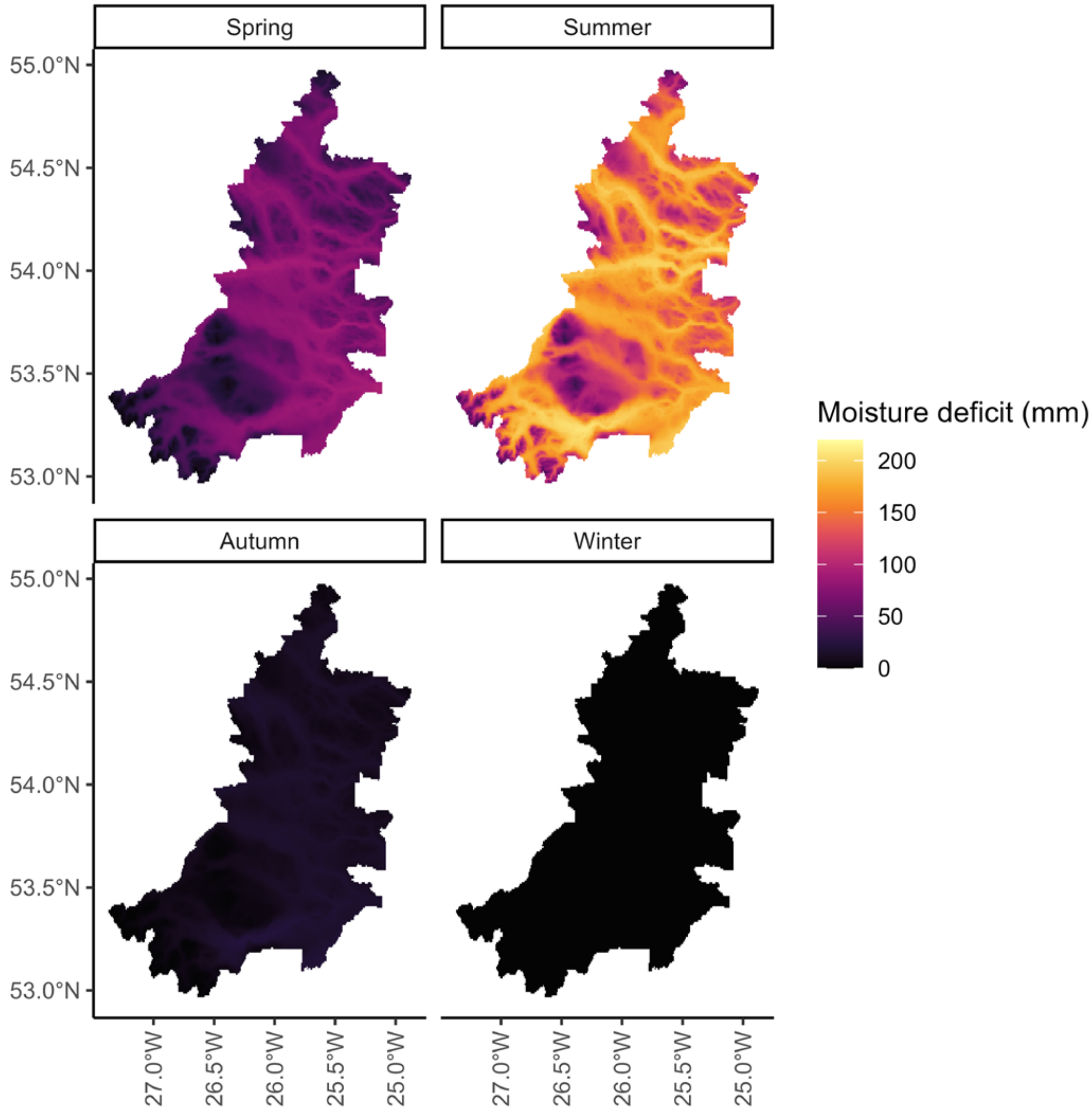

Figure 7: *Average Climate Moisture Deficit by Season for the Baseline Period (1961–1990) in the Lakes Timber Supply Area.*

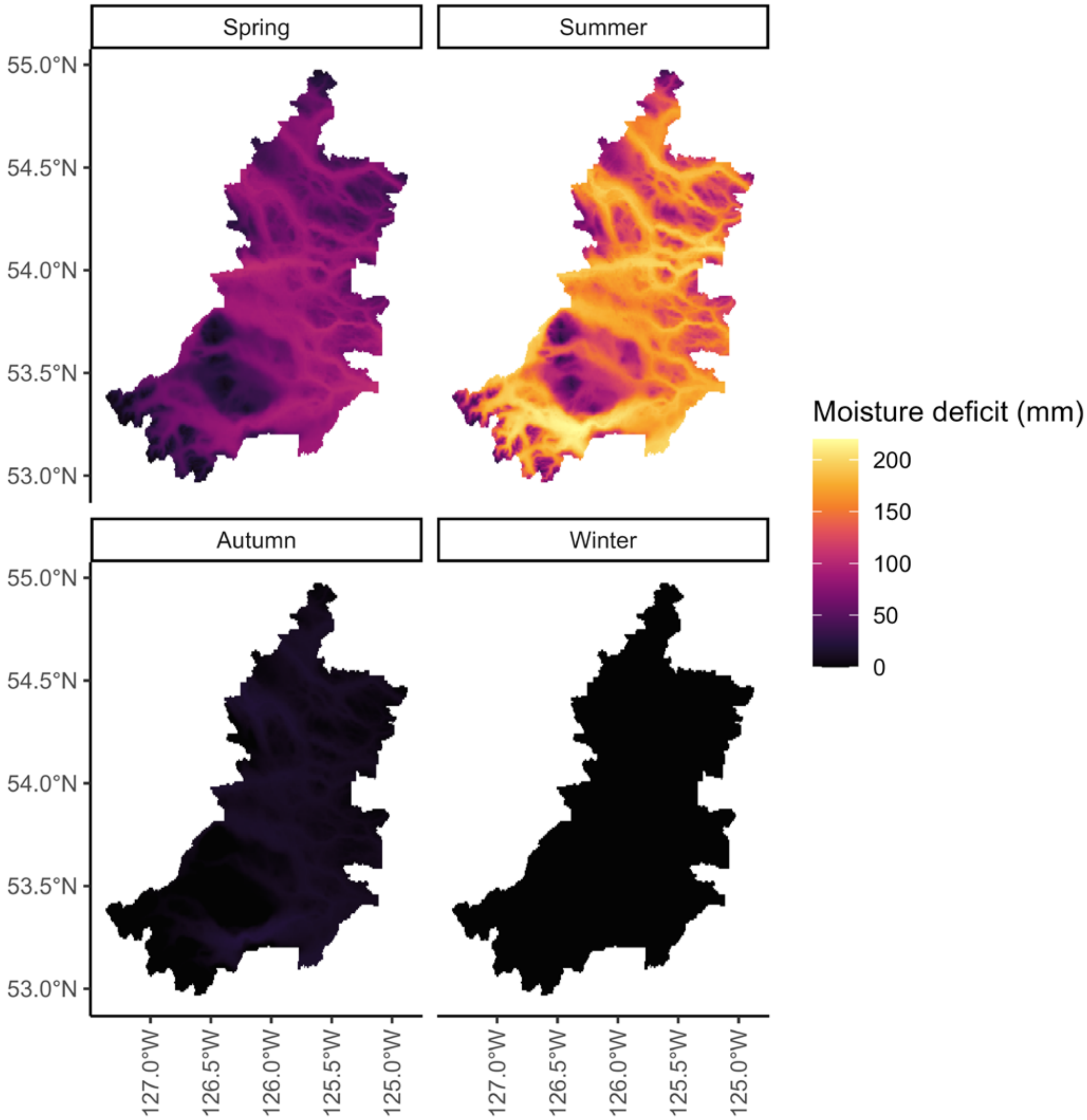

Figure 8: *Projected Future (2070) Average Climate Moisture Deficit by Season in the Lakes Timber Supply Area.*

Climate Moisture Deficit Departure

The increase in CMD in the Lakes TSA is mainly expected to be within the average range of the baseline period (Figure 9). Departure in CMD is expected to be greatest in the drier SBS and SPBS Biogeoclimatic subzone variants.

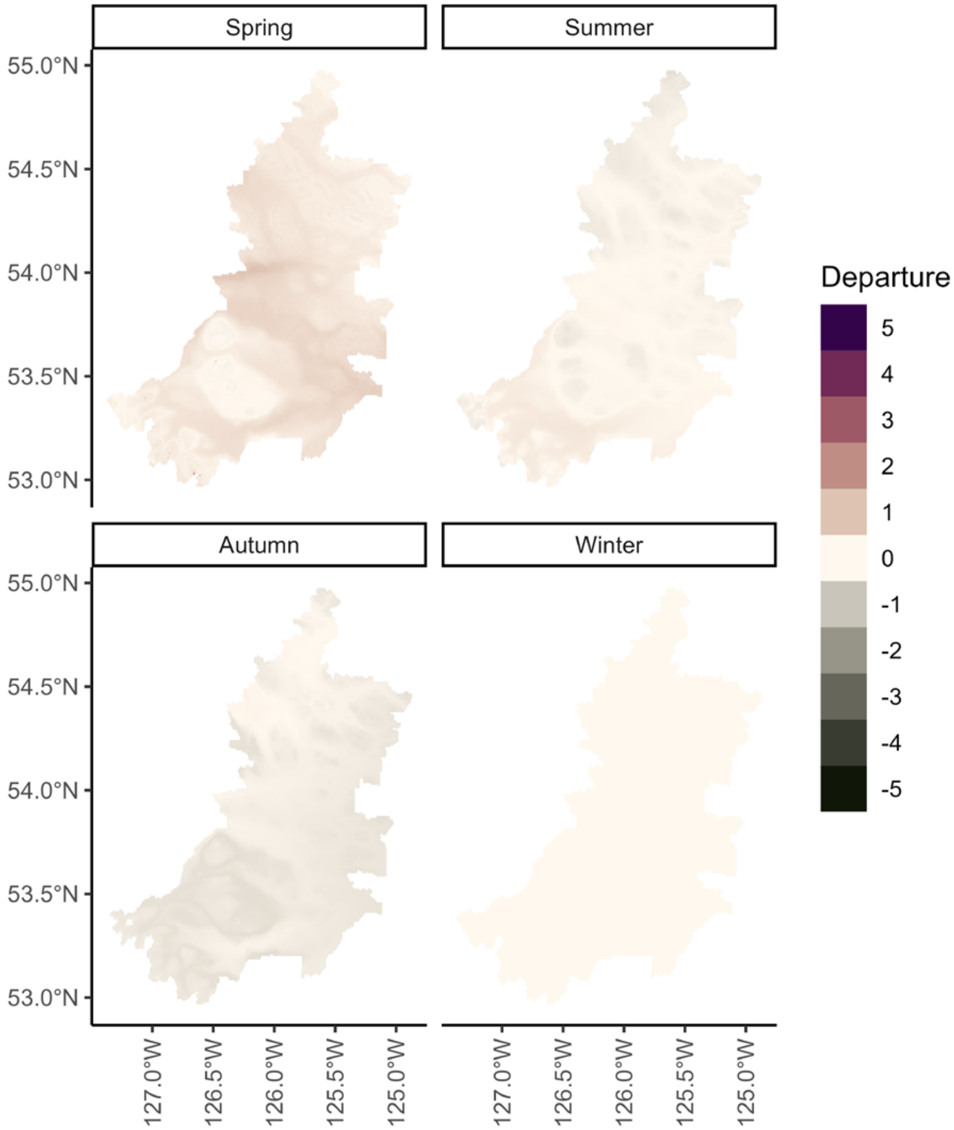

Figure 9: *Estimated Climate Departure Scores Representing the Magnitude in Difference in Climate Moisture Deficit by Season between the Baseline Period (1961–1990) and the Projected Future (2070) Condition in the Lakes Timber Supply Area.*

Precipitation as Snow

Precipitation as snow (PAS) is projected to vary throughout the Lakes TSA with slight increases in some areas and decreases in others. Winter and spring PAS is expected to increase in most ecosystems, while snow falling in summer and autumn is expected to decline (Figure 12).

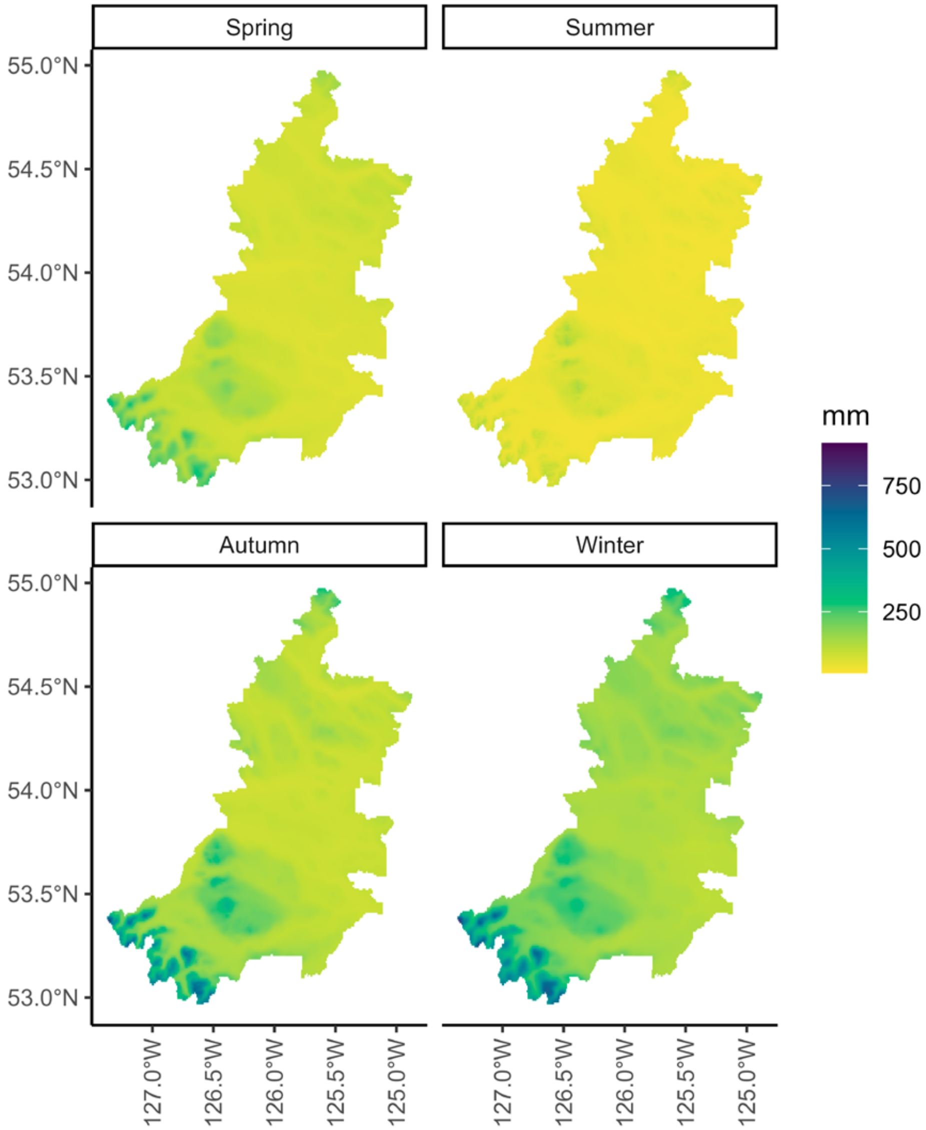

Figure 10: *Average Precipitation as Snow (PAS) by Season for the Baseline Period (1961–1990) in the Lakes Timber Supply Area.*

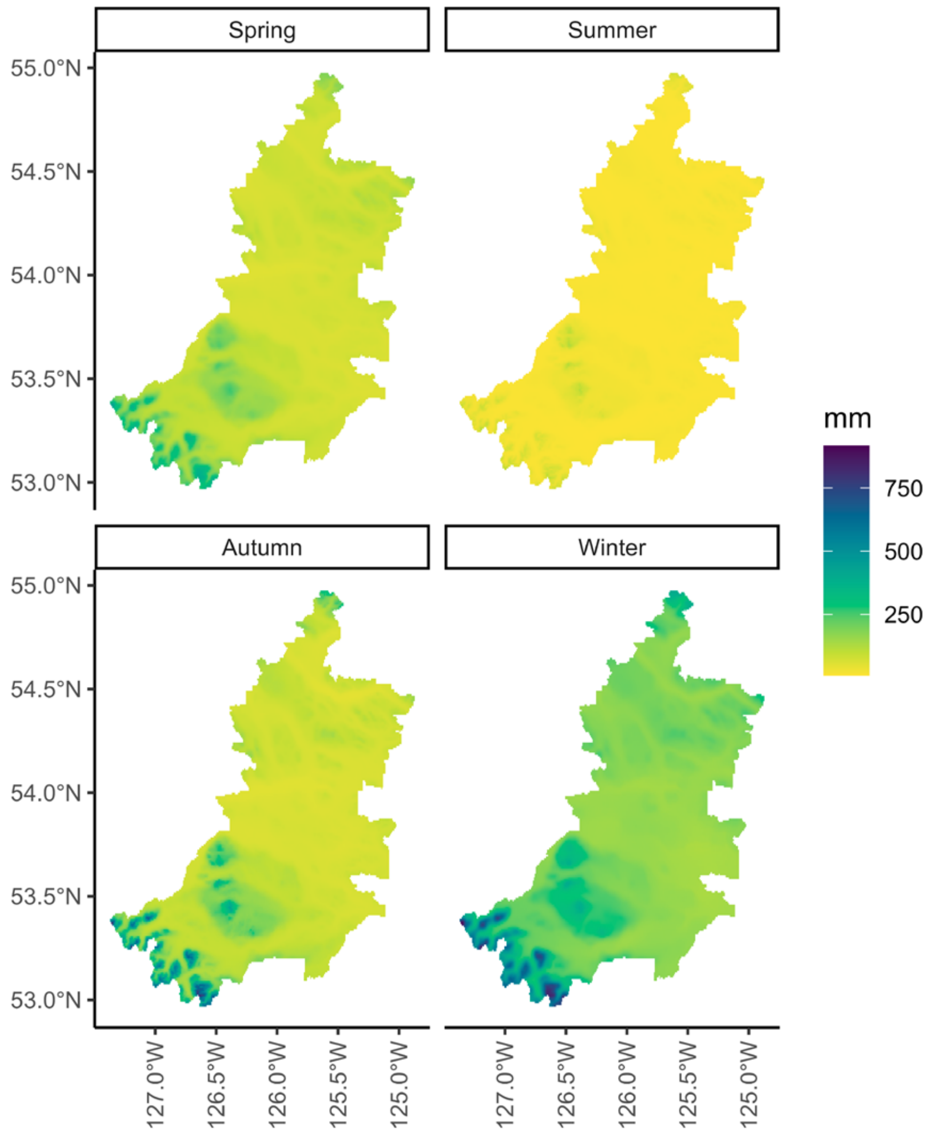

Figure 11: *Projected Future (2070) Average Precipitation as Snow (PAS) by Season in the Lakes Timber Supply Area.*

Precipitation as Snow Departure

Winter and spring PAS is expected to increase in most ecosystems, and largely be within the range to slightly above the range observed in the baseline period. Spring PAS is expected to be within or above the baseline period in most ecosystems, particularly at higher elevations. Snow falling in summer and autumn is largely expected to decline below the normal range for the baseline period (Figure 12).

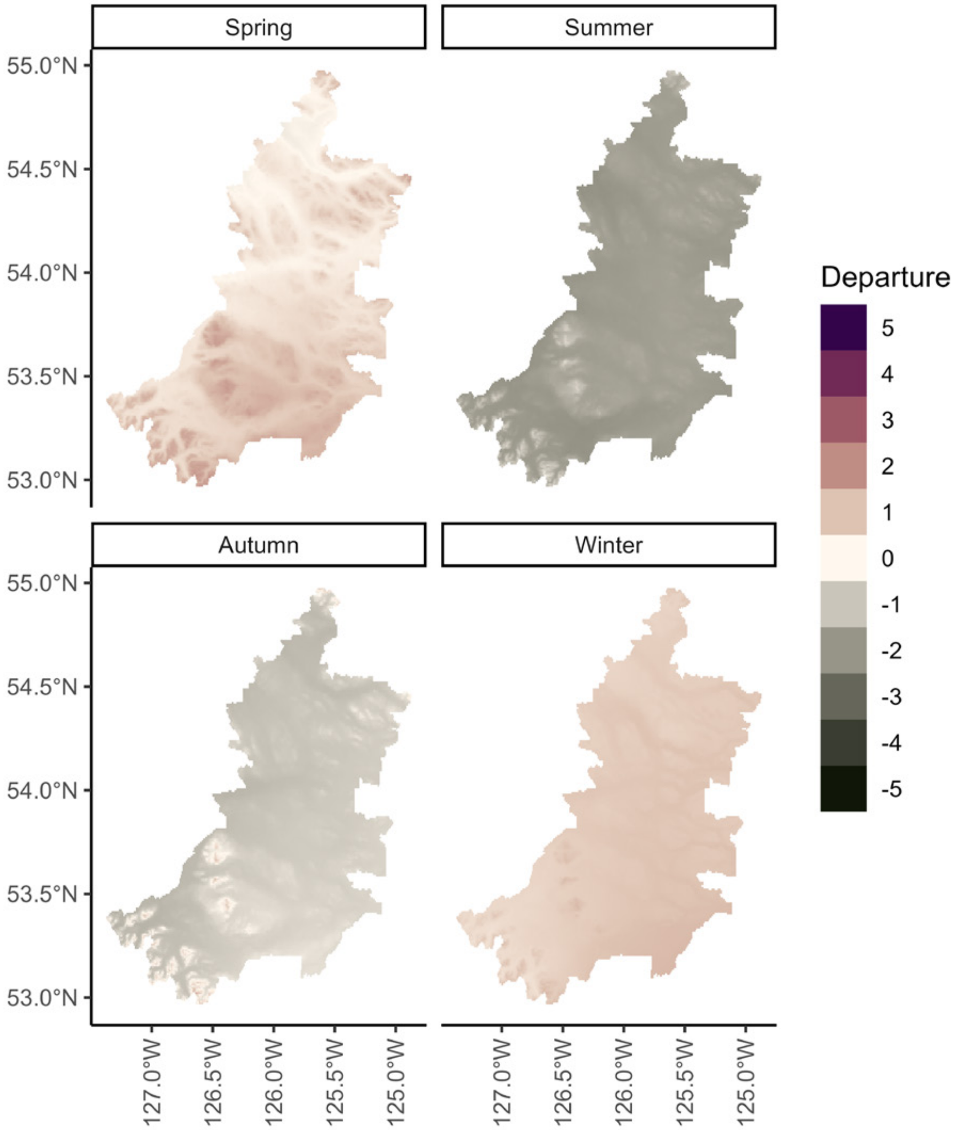

Figure 12: *Estimated Climate Departure Scores Representing the Magnitude in Difference in Average Precipitation as Snow (PAS) by Season between the Baseline Period (1961–1990) and the Projected Future (2070) Condition in the Lakes Timber Supply Area.*

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