Overview of Climate-related Changes in the Salmon Valley Region				
Climate Variable	**Historical Changes**	**Direction of Change Expected**	**Seasonal Patterns of Change**	**Confidence**
Air Temperature	In the 20th century, the average annual temperature increased 0.73°C in the Rocky Mountain region of the Pacific Northwest.[1] During the same time period, temperature increases occurred at an average rate of 0.13°C per decade over the entire Pacific Northwest region.[2] More rapid increases have occurred since 1960,[2] and the 1990s were the warmest decade of the 20th century; that trend has continued into the 21st century.[1] From 1895-2015, the average annual temperature was 3.6°C (38.4°F) in the Salmon Valley region.[3]	Within the Pacific Northwest region (an area which includes Idaho and western Montana) climate models predict a temperature increase of 4.0°C by 2100 under the IPCC A1B (moderate/high) emissions scenario, and 2.5°C for the B1 (low) emissions scenario. The range of possibilities is much larger, however (between 1.5°C and 5.8°C for both scenarios combined).[4] The rate of temperature increase is expected to rise over the course of the century. In the A1B scenario, the temperature in the Pacific Northwest is projected to rise 1.28°C by the 2020s, 2.3°C by the 2040s, and 3.9°C by the 2080s (changes are relative to the 1980s).[4]	Temperature increases are projected to be largest in the summer, relative to the other seasons.[2, 4] In the 20th century, temperature increases were largest in the winter (average increase of 0.11°C per decade) and smallest in the fall (increase of 0.06°C per decade).[1]	Temperature is projected to increase according to all of the GCMs under multiple IPCC emissions scenarios. Thus regional warming is almost certain in the future.[4, 5]

Overview of Climate-related Changes in the Salmon Valley Region				
Climate Variable	**Historical Changes**	**Direction of Change Expected**	**Seasonal Patterns of Change**	**Confidence**
Precipitation	From 1925-2015, average annual precipitation in the Salmon Valley region was 45 cm.[3] Over the course of the 20th century, average annual precipitation in this area rose by 10.66 cm, or 24.1%.[1] However, precipitation totals vary widely on both annual and decadal scales, due in part to the Pacific Decadal Oscillation (PDO).[1] The actual amount of annual precipitation received in the Salmon Valley region over the course of the 20th century ranges from a low of 24.7 cm in 1924 to a high of 67.1 cm in 1903.[3]	Precipitation trends are correlated more closely with decadal sources of variability (such as the PDO) than long-term climate trends, making it difficult to detect any trends associated with climate change, and difficult to project how precipitation may change in the future.[6] Within the Pacific Northwest region, an area which includes Idaho and Montana, climate models predict a precipitation increase of only 1-2% by the end of the century. However, the individual models vary widely, with predictions ranging from precipitation decreases of 16% to increases of 20%.[4] The Pacific Northwest will continue to see patterns of precipitation that shift on both an annual and decadal basis, due in large part to the PDO.	Most models project that precipitation in the Pacific Northwest region will increase the most in winter, predicting on average a 9% increase in that season. The models vary however, with predictions ranging from a decrease of 14% to an increase of 42% in winter precipitation.[4]	There is low confidence in predicting precipitation trends in the Pacific Northwest. Although scientists cannot rule out long-term shifts in precipitation amounts and patterns due to climate change, the effect of the PDO is stronger and no strong conclusions can be drawn.[6]

Overview of Climate-related Changes in the Salmon Valley Region

Climate Variable	Historical Changes	Direction of Change Expected	Seasonal Patterns of Change	Confidence
Wildfire	Since the 1980s, the incidence of large wildfires (>400 ha) in the western U.S. has increased dramatically. Wildfire frequency has been concentrated at elevations centered around 2130 m and the greatest increase in large wildfires has occurred in forests of the Northern Rockies. While fire suppression policies have impacted fire regimes in some areas across the western U.S., it has had little impact on the natural fire regime in the Northern Rockies.[7] In Idaho and western Montana forests, fires are most common and intense in years when warm springs with low snowpack are followed by warm, dry summers, and when the Pacific Decadal Oscillation (PDO) is positive (the PDO influences spring temperatures in the northern Rockies).[8]	Fires are already becoming more extensive in the cold and dry forests of the northern Rocky Mountains.[8] Given that climate models predict that the future will have warmer springs, less snowpack, earlier snowmelt, and drier summers, large fires are expected to become more common.[7, 8] Other variables, such as increased insect outbreaks which kill trees and create higher fuel loads, may also affect the size, frequency, and severity of wildfires over the coming century.[9]	Warming springs and the resulting early snowmelt is expected to be a major driver in changing fire patterns in the western U.S.[7] In mid- and high-elevation sites in the Northern Rockies, this dynamic is particularly strong, and accounts for a large percentage of moisture deficits by mid-summer.[8] Drought is also highly associated with severe summer fire seasons in the western U.S., though it becomes a more important factor at lower-elevation sites where drought is more common and severe.[8]	There is relatively high confidence that as air temperatures rise, the frequency and intensity of wildfires will also increase. Temperature alone explains roughly 66% of the variance in the annual incidence of fires in western forests.[7]

Overview of Climate-related Changes in the Salmon Valley Region

Climate Variable	Historical Changes	Direction of Change Expected	Seasonal Patterns of Change	Confidence
Snowpack	From 1963-1996, 62% of annual precipitation fell as snow at an average elevation of 1905 m in Idaho and western Montana; this is equivalent to about 47.32 cm of snow water equivalent (SWE; the amount of water contained in snowpack).[10] While the effect of warming temperatures over the 20th century decreased snowpack somewhat, patterns of increasing precipitation also affected the snowpack in the Salmon Valley region, leading to a slight net increase. From 1916-2003, the SWE in this region increased by just 0-0.5% per year.[6]	Future precipitation patterns are difficult for climate models to predict. For interior, high elevation areas such as the Salmon Valley region, precipitation patterns will influence SWE more than temperature.[6] For lower elevations with marginal snow coverage, warming air temperatures will cause a larger percentage of annual precipitation to fall as rain rather than snow.[6, 10]	Areas with cold winter temperatures, such as the Salmon Valley Region, have a higher percentage of annual precipitation that falls as snow over the course of the late fall, winter, and early spring.[6] Precipitation amounts in this area are highly variable on both annual and decadal scales, explained partly by the Pacific Decadal Oscillation (PDO).[6]	Currently, there is relatively little confidence in predicting annual snowpack because the snowpack in the northern Rocky Mountains is most dependent upon precipitation patterns (poorly predicted), and less so on temperature patterns (relatively well predicted).
Timing of Snowmelt	From 1963-1996, the average date of peak snow accumulation in Idaho and western Montana was April 12th. The average length of the snowmelt season was 88 days, and the average date on which the snow disappeared was July 9th.[10] The average date of peak snow accumulation in the Salmon Valley region did not change significantly during the period 1916-2003. During the same time period, the date on which 90% of snowmelt had occurred shifted 0-5 days later.[10]	Across the western U.S., changes in the timing of peak snow accumulation and 90% melt are a complex function of precipitation and temperature, but the dominant effect is due to temperature trends.[6] As air temperatures increase, especially during winter and spring, it is expected that snowmelt will begin to occur earlier in the season.[6]	Warmer winter and spring temperatures are highly correlated with shifts towards earlier snowmelt and higher percentages of the total streamflow occurring earlier in the year.[11]	Currently, there is relatively little confidence in predicting snowmelt timing trends in the northern Rocky Mountains, which depends upon complex relationships between precipitation (poorly predicted) and temperature (relatively well predicted).

Overview of Climate-related Changes in the Salmon Valley Region

Climate Variable	Historical Changes	Direction of Change Expected	Seasonal Patterns of Change	Confidence
Water temperature	Temperatures of free flowing streams are closely associated to air temperature in the northwest U.S., and air temperature accounted for 82-94% of the variation in stream temperatures of nine northwest streams from 1980-2009. In the same time period, stream temperature increased by 0.01°C per decade.[12] In contrast, the temperature of regulated streams (streams with an upstream reservoir) is more variable and less tied to air temperature. No statistical relationship with air temperature was found in 9 regulated streams between 1980 and 2009.[12] Stream isotherms are lines of constant or equal temperature used to track thermal properties of streams. During the 20th century, it has been estimated that, globally, stream isotherms shifted 1.5-43 km upstream as air temperatures increased by 0.6°C.[13]	Because air temperature and stream temperature are closely related, it is likely that stream temperature will increase over the coming century. In the summer, stream temperatures may warm at rates of 0.3-0.45°C per decade. This would cause a net annual increase in stream temperature of 1.2-1.8°C by mid-century.[12] By the mid-21st century, global stream isotherms are expected to shift 5-143 km upstream if air temperature rises by 2°C.[13]	Warming rates are highest during the summers (0.17°C per decade in free-flowing streams from 1980-2009). Warming trends also occur during fall and winter, while streams tend to cool during spring (decrease of 0.14°C per decade), partially due to snowmelt runoff. Across seasons, there is a net warming of stream temperature.[12]	If low stream flow coincides with high air temperatures, then streams may heat up more quickly than projected. It is not fully understood how stream flow rate contributes to changes in stream temperature.[12] Wildfire can also influence stream temperature by reducing natural vegetation cover and shading over rivers. In addition, human activities such as riparian vegetation removal, discharge from reservoirs and power plants, and runoff have variable effects on stream temperature.[12]

Overview of Climate-related Changes in the Salmon Valley Region

Climate Variable	Historical Changes	Direction of Change Expected	Seasonal Patterns of Change	Confidence
Stream flows (low and high)	From 1980-2009, free-flowing streams in the northwest U.S. have had an average decrease in flow of 2.1% per decade. Regulated streams (which have an upstream reservoir) have had an average flow decrease of 2.8% within the same time period.[12] There have also been significant changes in the timing of the center of the mass of annual flow, which reflects the amount of water flowing during spring high flows. Between 1948-2002, the center of annual flow occurred an average of 10-30 days earlier in the Pacific Northwest and northern Rocky Mountains; however, there were no significant changes in the timing of the onset of spring high flows.[11] This suggests that spring flows have become both shorter and more intense.	As air temperatures increase, especially during winter and spring, it is expected that the center of annual flow will continue to shift earlier in the year.[11] It is also likely that warmer temperatures will result in reduced and earlier spring peak flows, reduced warm season water availability, and late summer low flows.[14]	Free-flowing streams have seen the largest drop in flow during summer and winter months (decrease of 3.5% per decade), while regulated streams have seen the largest drop in flow during spring and winter (decrease of 5.5% and 3.8% respectively).[12] Warmer winter and spring temperatures are highly correlated with shifts towards greater percentages of the total annual flow occurring earlier in the year;[11] this will likely result in shorter and more intense spring flows.	Regulated stream flow is predominately controlled by reservoirs and dams. Provided there is enough water in the reservoirs (a function of the reservoir size and associated snowpack in its watershed), stream flows will be controlled by management choices. Unregulated, snow-fed stream flow is more difficult to predict because it is a function of timing of peak snowmelt (moderately understood) and snowpack accumulation (moderately understood).

Overview of Climate-related Changes in the Salmon Valley Region

Climate Variable	Historical Changes	Direction of Change Expected	Seasonal Patterns of Change	Confidence
Extreme events: Precipitation and flooding	Spring flooding is common as snow begins to melt quickly. When combined with a heavy rainfall, significant flooding can occur, as happened in December 1964 in the Pacific Northwest. Atmospheric rivers, such as the “Pineapple Express” can also produce very high amounts of precipitation and resulting floods.[2] There is less inter-annual variability for extreme events than for annual precipitation amounts. There have been no significant changes in the number of extreme precipitation days over the last century. However, within the 20th century, the 1990s did see higher numbers of extreme precipitation events, with 1996 being the most extreme.[2]	Earlier snowmelt coupled with late winter/early springtime precipitation might increase the risk of springtime flooding.[2] In the Salmon River Valley region, climate models suggest an increase of 0-10 days per year with over 1” of precipitation for 2041-2070.[2]	Although no information is available for the region about the seasonality of extreme precipitation events, it is likely that increases in flooding will take place during the spring as snow melts.[2]	There is moderate to low confidence in predictions for precipitation. Extreme precipitation might be caused by altered atmospheric circulation patterns coupled with increased atmospheric moisture content.[15]

Overview of Climate-related Changes in the Salmon Valley Region

Climate Variable	Historical Changes	Direction of Change Expected	Seasonal Patterns of Change	Confidence
Extreme events: Temperature	In the Salmon Valley region, there was no significant increase in days with a temperature high over 35°C (95°F) between 1980 and 2000. Five of the top 10 years for heat waves in the Pacific Northwest have occurred in the last 20 years, with 2006 having the highest number of heat waves.[2]	Downscaled climate models suggest that extreme heat days in central Idaho will increase up to 300% (days where the high temperature is in the 95th percentile), and will last 3-6 days longer by the end of the 20th century. Similarly, extreme cold days are expected to decrease in frequency.[15]	As temperature is projected to increase most in the summer months, it is likely that extreme heat events will follow that pattern.[2]	It is generally expected that the frequency of extreme hot/cold events will increase/decrease as mean air temperature rises and the loss of snow cover reduces regional ice albedo feedbacks.[15]
Evapotranspiration rates	Warm season evapotranspiration (ET) rates have followed trends in regional precipitation patterns. In early spring, snowmelt is the factor that influences increased ET the most, but by late summer, warmer temperatures are the primary driver of ET.[14]	Warmer temperatures are expected to increase evapotranspiration overall. The date by which 50% of the average ET has occurred will likely shift towards the earlier part of the year,[14] suggesting that ET will increase more during the spring than during summer and fall.	During the spring and early summer, ET will be heavily correlated with snowmelt. During the late summer, ET will be more dependent upon precipitation and temperature.[14]	Currently there is relatively low confidence in projected changes in ET because they are caused by changes in cloud cover/radiation (poorly understood), air temperature/dewpoint (relatively well understood), and water availability (poorly understood). Because of the close seasonal coupling between ET and snowmelt, future projections of ET and runoff in the spring and early summer are likely more reliable than projections for the late summer.[14]

Overview of Climate-related Changes in the Salmon Valley Region

Climate Variable	Historical Changes	Direction of Change Expected	Seasonal Patterns of Change	Confidence
Changes in forest structure and composition	Wildfire, insect outbreaks, and water stress are the biggest stressors for forests in the western U.S.[9] Ponderosa pine and western larch have low survival during drought.[16] Insect outbreaks have already killed trees covering millions of hectares in the western U.S. Dead and dying trees increase fuel loads, contributing to wildfires of greater size and severity.[9]	Changes in soil moisture, which are expected to decease in the drier summer months, may affect tree establishment, growth, cone and seed development, phenology, and disease and fire susceptibility.[16] Increasing frequency and severity of wildfire and other disturbances may advance the rate of change in species composition, as long-lived species are killed and replaced by those that may be better adapted to heat and water stress. Large disturbances may also create forests that are more homogenous, with large even-aged stands and fewer species.[9] Species shifts will occur as temperatures continue to increase, with species generally moving northward and/or higher in elevation.[9]	Tree growth is affected by water stress more than any other seasonal factor.[16] Shorter winters may lead to more severe insect outbreaks, as more life cycles can be completed during the longer warm months.[9]	Forests in the western U.S. are affected by complex interactions between climate and non-climate stressors, making detailed local projections difficult. However, broader patterns within species associations and ecosystems can be mapped onto the landscape with relative confidence.

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