Chapter 2

Connecting Climate & First Foods

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2.1 CLIMATE IMPACTS TO THE PACIFIC NORTHWEST REGION

Heavy rains & rain-on-snow

More severe drought and heat

Frequent wildfire and smoke

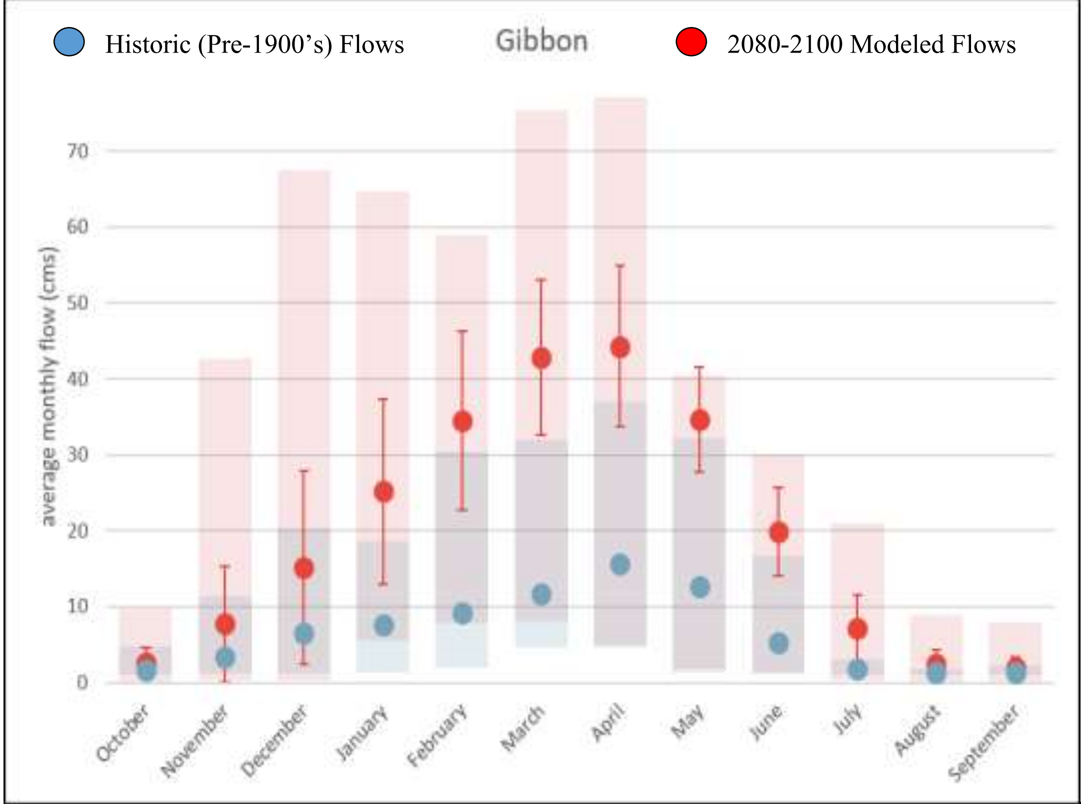
Global heating will impact each ecoregion differently. In the Pacific Northwest (PNW), climate change projections show the primary impact will be warmer winters, affecting seasonal precipitation and regional hydrology. These impacts can be organized under three main categories:

- Winter precipitation is more likely to fall as rain instead of snow, or as rain-on-snow events that shift river seasonal cycles;
- Increased frequency and severity of summer drought situations that place co-management of water in conditions of conflict;
- Increased risk of unintentional and catastrophic wildfire, both from fires close to home and far away, as smoke impacts large regions.

A shift in the way precipitation falls on the landscape has profound effects on the life that depend on that water. **Figure 2.1** shows modeling projections of the Umatilla River's hydrology shift under future conditions, conducted by CTUIR OIT GIS specialists Scott O'Daniel and Bethy Rogers-Pachico (2019).

- Historic weather pattern data was input into statistical modeling programs, and was projected to the end-of-century (2100) using several global climate change action scenarios, called RCP's. Measurements of water conditions were taken at the Gibbon water gage on the Umatilla Indian Reservation (UIR) Eastern Boundary.
- The points in blue show the historic hydrology of the river, with the expected peak flows occurring March to May, as snow in the mountains slowly melts and filters into streams and tributaries. The points in red show the statistical modeling of basin flows for the years 2080-2100.
- These future flows are seen to be increased in intensity, with an extremely wide margin of variability. There is a shift of peak flows into the winter to December instead of from March and April historically.
- Error bars demonstrate the confidence intervals of each data point, and red and blue shading illustrates the variability that exists at each point. As we see, not only do future projections of the river

Fig 2.1: CTUIR OIT "Future Flows of the Umatilla River Basin" Model



increase in winter flows, but there is also a large scale of variability in these estimates, showing that flows in the river could differ dramatically from one year to the next.

This shift has implications for First Foods and reciprocal responsibility that Tribal people have upheld since time immemorial.

2.2 WINTER PRECIPITATION

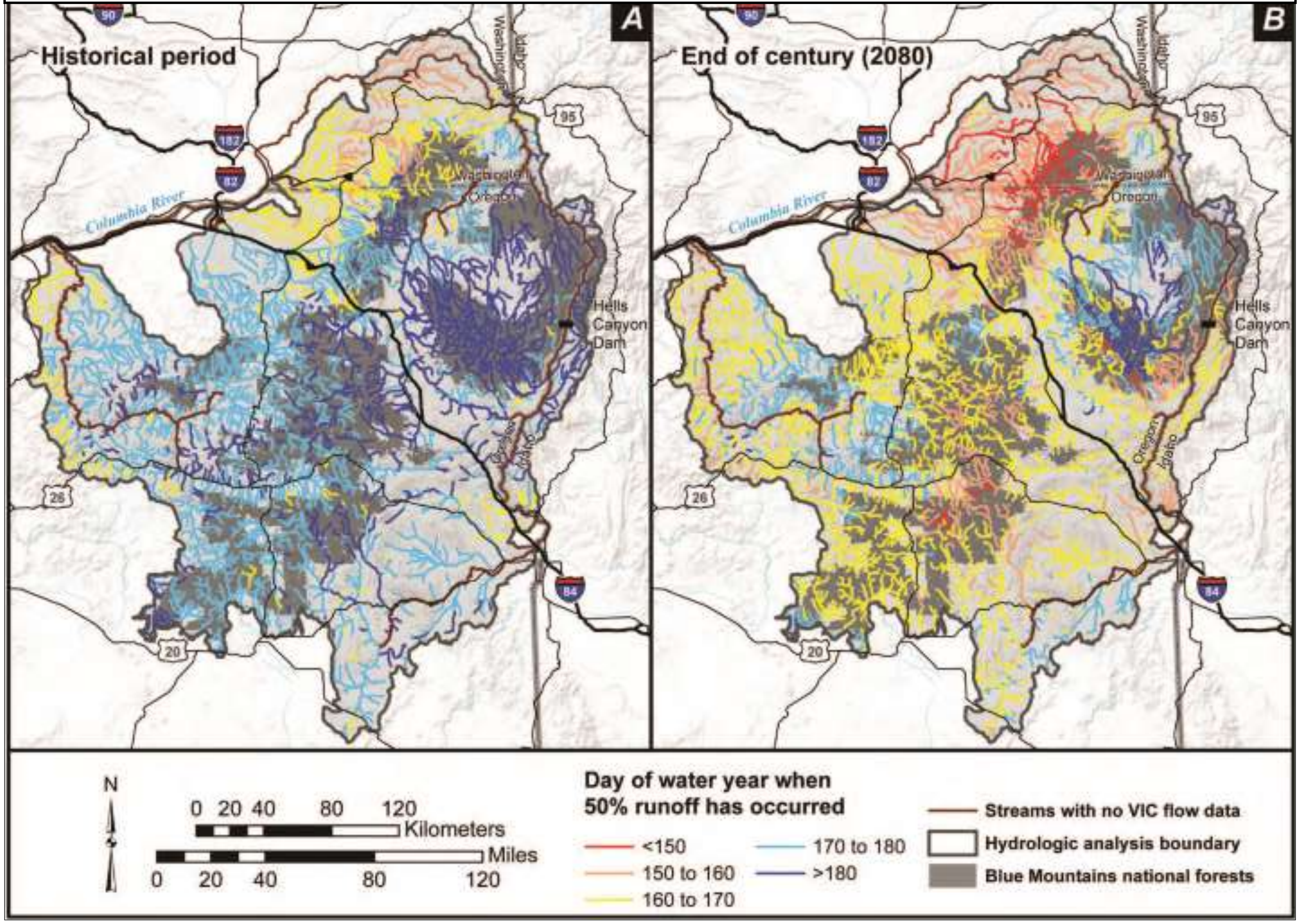
Heavy rains & rain-on-snow

The PNW has a combination of different hydrologic systems, including:

- Rain-dominated systems where high precipitation falls as rain for most of the year (typically coastal locations with warmer winters);
- Snow-dominated systems in high elevation areas that accumulated winter snow pack, which melts slowly as the summer progresses;
- “Mixed rain and snow” systems that have a combination of winter snow and spring/autumn rain.

As winters warm, there will be less intense overall effects on rain-dominated river systems, but large changes in hydrology that depends on snow for summer base flows. The Blue Mountain and Columbia Plateau ecoregions are mid-elevation landscapes dominated by a mixed snow/rain hydrology, where much of the annual precipitation falls as snow in the mountains, and rain at lower elevations, with most rainfall during spring and fall months. **Figure 2.2** shows a number of watersheds within the CTUIR Ceded lands, bordered by the Umatilla, Wallowa-Whitman, and Malheur National Forests as they will be affected by changing seasonal precipitation (Clifton et al 2018). This map measures “days of the water year when 50% runoff has occurred” within historical period on the left side,

Figure 2.2: Blue Mountains Comparison of Historic and Projected End-of-Century Measure of Snow Pack Melt

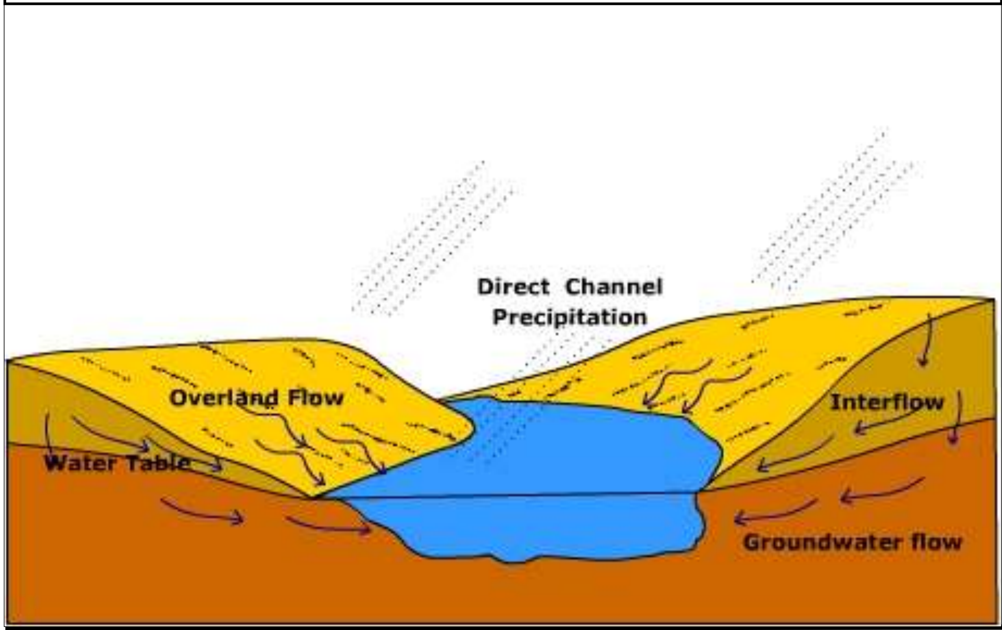


and in a modeled future of 3˚C (5.4) of warming by 2080 on the right. If the "water year" begins in October, then the stream colors indicate how long into this time period it is when half of the stored water has been released.

- Red indicates less than 150 days into the year (before February),
- Orange indicates 150-160 days (early to mid-February);
- Yellow indicates 160-170 days (early March);
- Light blue indicates 170-180 days (mid-March);
- Dark blue lines indicate greater than 180 days (late March and beyond).

On the left in the historical period, much of the Blue Mountain watersheds retained their snow pack into the spring, with the majority of streams showing 50% runoff in 170 to 180 days or greater, into the March month. On the right in the 2080 projection, this is reversed; many of the watersheds are predicted to lose half their runoff in under 170 days, some as early as before February in the northern Walla Walla River basin (Clifton et al, 2018). This illustrates the magnitude of change warming winters will have on snow pack accumulation and stream flow.

Figure 2.3: Precipitation Becomes River Base Flow in Three Ways



More severe drought and heat

2.3 SUMMER DROUGHT

Under historic conditions, precipitation falls in winter months as snow in the higher elevations, and remains until warming weather in spring caused the snow to melt slowly over the season. This slow melt would infiltrate into the soil, and travel through pores and aquifers to ultimately reach the rivers and streams as "base flow." **Figure 2.3** illustrates how rainfall at higher elevations ends up in river systems in three ways (ThePhysicalEnvironment.com):

- Direct channel precipitation: water is added as rain falls directly on rivers and streams;
- Overland flow: water is added as "runoff" moving across the top of the soil;
- Interflow: water percolates into the shallow water table or deeper groundwater flow, and moves through soil pores out into river channels.

Rainfall (as opposed to snowfall) is more likely to be added as overland flow, and creates greater potential for associated soil erosion due to heavy rainfall events. This also reduces opportunity for water to be added as interflow, reducing the amount of water that is passively released into rivers during dry months. Lower quantities of this river base flow means this water becomes hotter, especially in combination with extreme heat events during these same months. This creates concerns about harmful algal growth, reduced dissolved oxygen, and lethal temperature limits for aquatic species.

Figure 2.4 illustrates the severity of these two impacts on Pacific Northwest watersheds (USGCRP 2014). Colored dots indicate the degree of change in summer (July to September) stream flow projected by mid-century (2040). Additionally, color gradients display the reduction in snow pack runoff that will result. This ranges from light brown at an increase of 5%, to dark brown indicating a reduction of 50%. In this map, CTUIR Ceded lands are likely to experience moderate decreases in snow pack runoff, estimated at 10-20% reduction, though more severe loss of snow pack is projected for much of CTUIR's traditional use areas (USGCRP 2014).

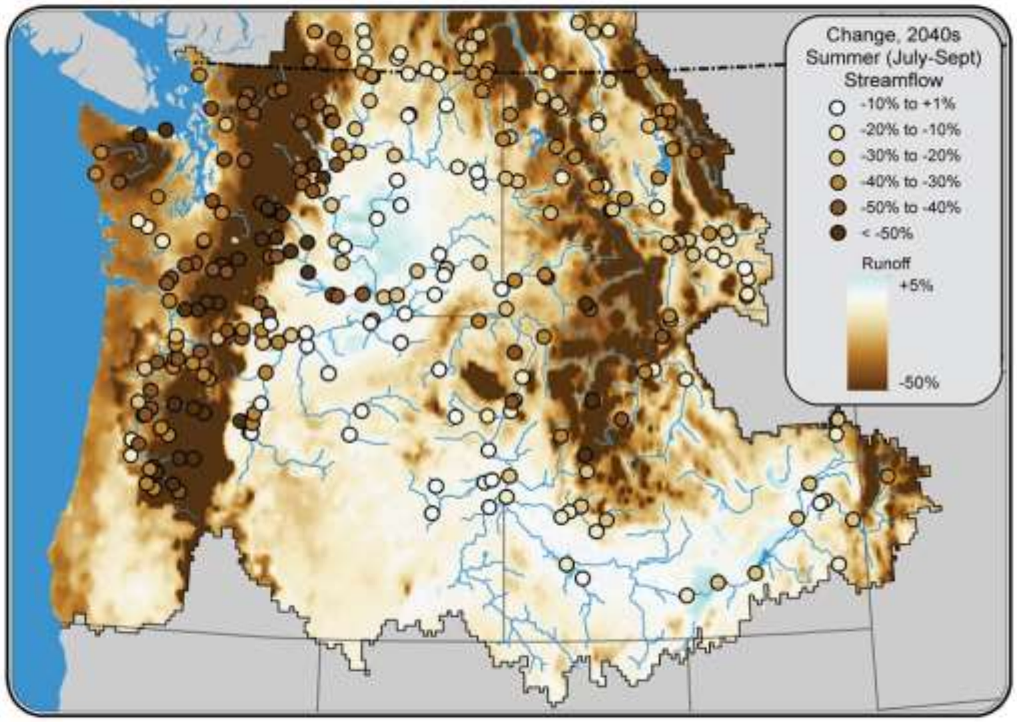


Figure 2.4: Projected Reduction in Summer Streamflow and Snow Pack Runoff

2.4 WILDFIRE & SMOKE RISK

While the Columbia River Plateau ecoregion is adapted to periodic fire, and requires low intensity fires to keep habitats healthy, climate change will increase the frequency and intensity of fires beyond what is beneficial. Warm winters have the potential to benefit the growth and spread of invasive grasses with high fire fuels capability. Grasses take advantage of wet conditions in spring to put on biomass before becoming dormant ahead of summer heat, creating a heavy vegetation load for potential wildfire ignition. Summer drought also creates water stress for trees and large shrubs that require soil moisture throughout the season. Stressed trees are also more susceptible to insect and disease infection.

Frequent wildfire and smoke

Figure 2.5 illustrates areas burned between 1984 and 2008 (24-year period) in orange, and areas affected by insects or disease between 1997 and 2008 (11-year period) in brown. Often these two forest impacts compound each other to worse the severity of each event. Insect and disease outbreaks often follow wildfires where trees are weakened, resulting in tree mortality, and creating increased fire

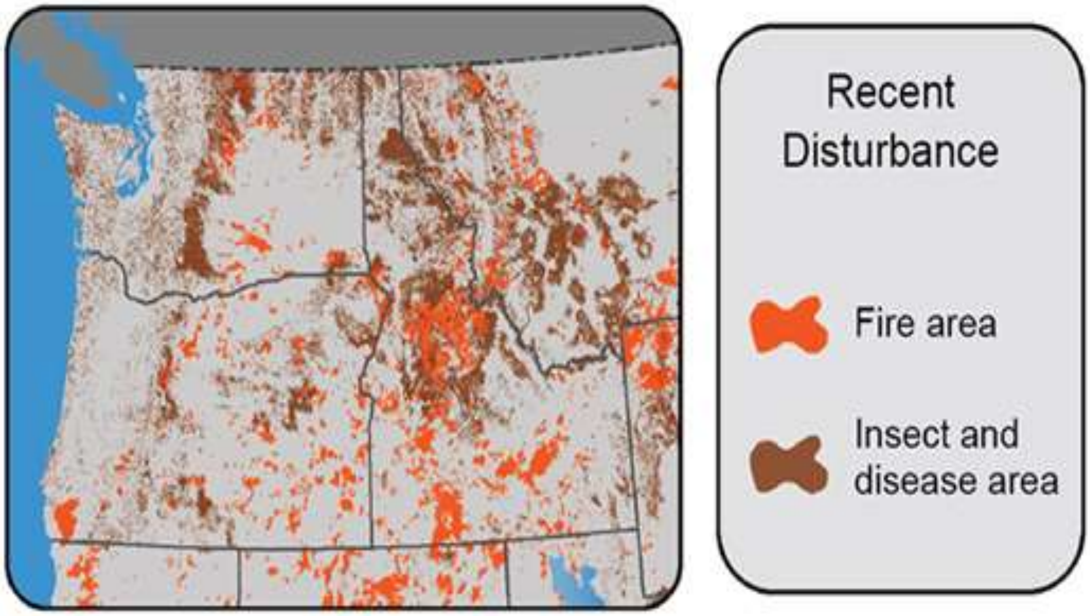


Figure 2.5: Fire Disturbance and Associated Insect and Disease Pressure on PNW Forests

risk (USGCRP 2014).

Combined with federal fire suppression policy and criminalization of Indigenous cultural burning over the last century, the vegetation fuel load in many Pacific Northwest forests creates a higher risk of facilitating the spread of catastrophic wildfire.

Figure 2.6: Projected Increases in Areas Burned in the PNW with 1.8˚F (1˚C) of Warming

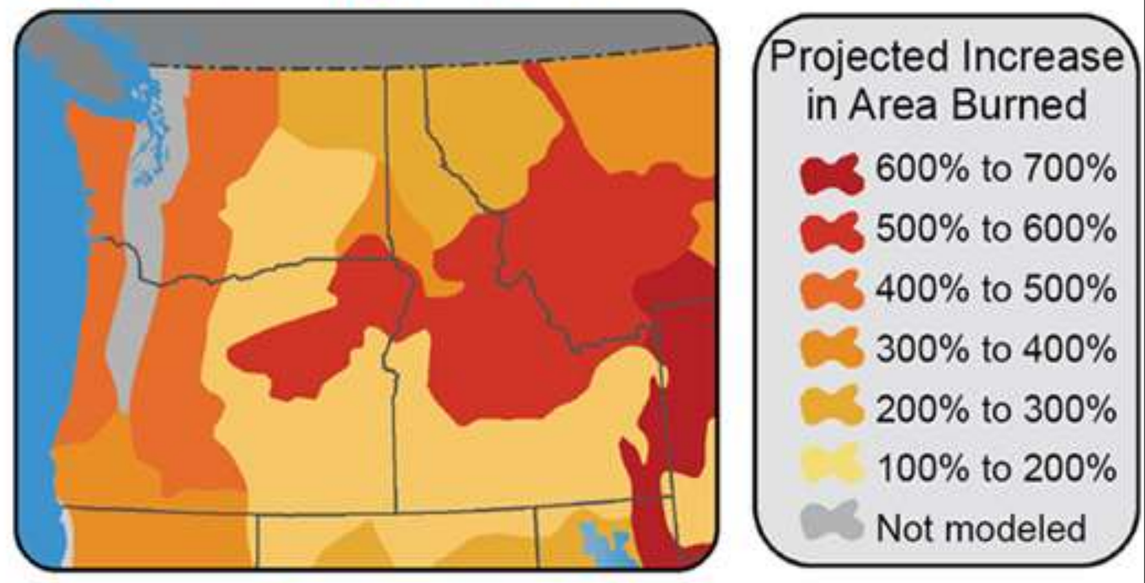
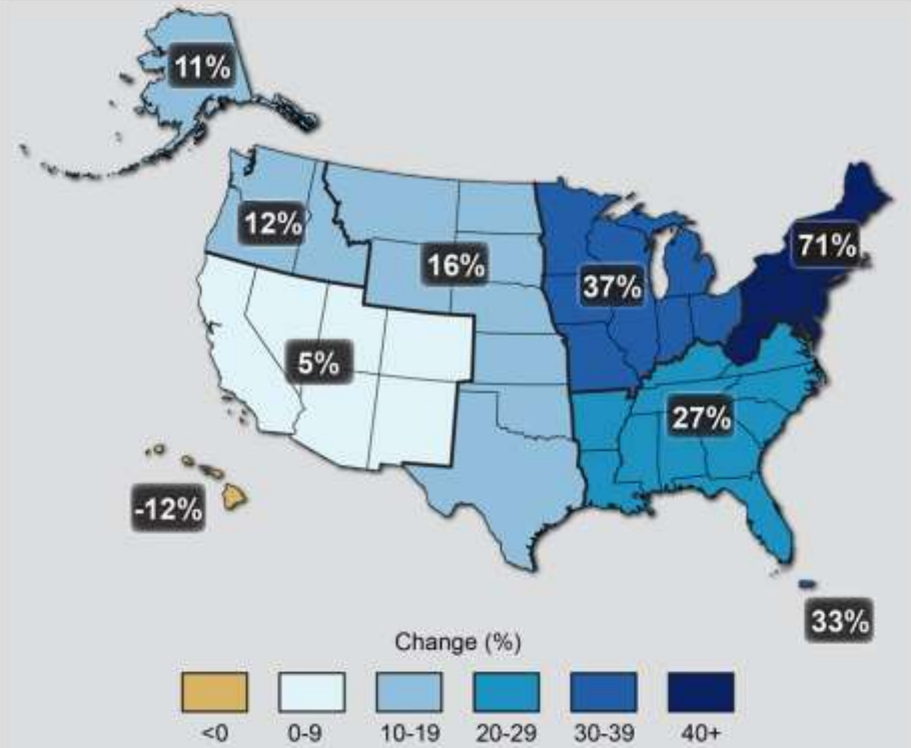


Figure 2.6 maps projections for fire risk in a 1.8˚F (1˚C) warmer future. Much of CTUIR's Ceded and traditional use areas are expected to experience 400-700% risk increase within forested lands, and a 100-200% increase within grassland habitats (USGCRP 2014). Wildfire poses serious risk to infrastructure, public safety, wildlife and plants, and to air quality through the smoke generated. Forest stocking density rates of trees can be managed to reduce the spread of predatory insects, with selective thinning to remove weak and crowded trees can increase the distance between individuals to prevent rapid transmission. Indigenous cultural burning is also being utilized on public and reservation lands, as CTUIR Range, Agriculture, and Forestry (RAF) Program works with various agencies to conduct prescribed burns.

Figure 2.7: Observed Change in Very Heavy Precipitation in U.S.

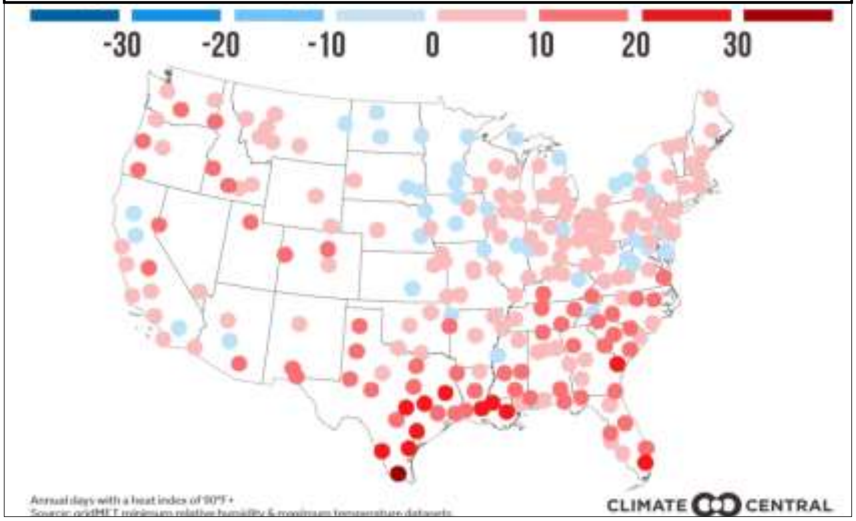


2.5 COMPOUNDING FACTORS

Warm air holds more water, thus seasonal storms will carry more force, and move more slowly. Heavy precipitation is categorized as 1 inch or more of rain or snow in 24 hours. While the Pacific Northwest is likely to experience less intense increases in heavy precipitation (both in the form of rain and snow) than other parts of the United States, higher rainfall during humid seasons creates problems of flooding, landslide, and soil erosion into sensitive and unprotected waterways. **Figure 2.7** provides an overview of how regions across the United States are expected to experience changes in heavy precipitation (NCA USGCRP 2014). An increase of 12% in heavy precipitation events is small compared to Southern, Midwestern, and

Northeastern increases, but still has the potential for devastating impacts to the region's resources, economies, and communities.

Figure 2.8: Changes in Number of Days of Extreme Heat

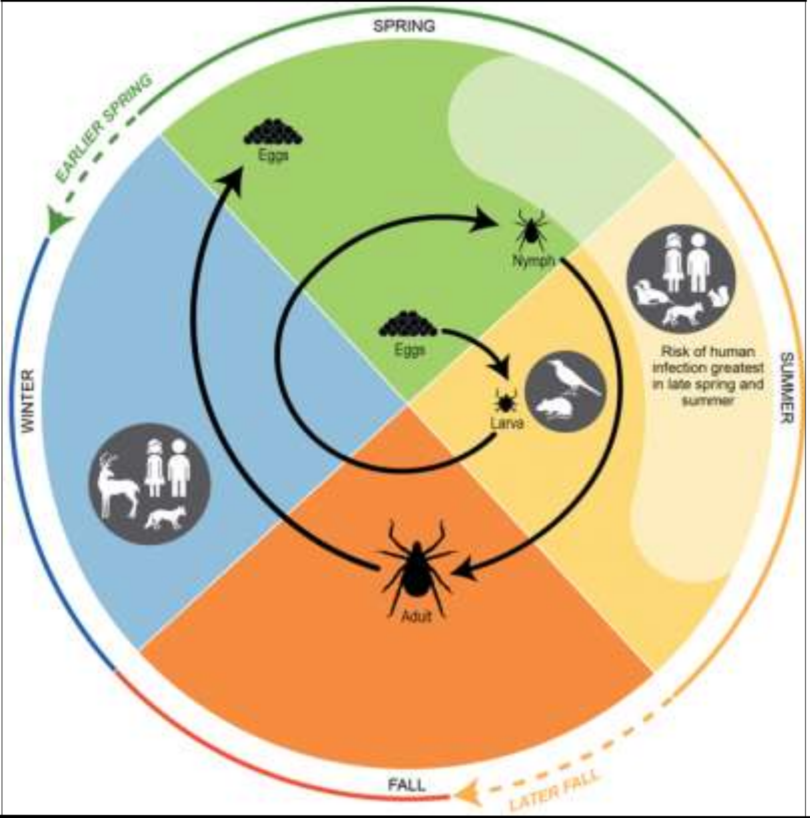


Annual days with a heat index of 90°F+
Source: gridMET minimum relative humidity & maximum temperature datasets

Extreme heat is categorized as temperatures over 90˚ F for one or more days. The frequency, intensity, and duration of these events is highly likely to increase under climate change. Heat is a concern for many reasons, and can be deadly for a number of demographics of people who are particularly vulnerable. Heat can cause additional complications for those with pre-existing medical conditions like diabetes and cardiac illness. Prolonged exposure can also be dangerous for those who lack areas of refuge or access to cooling, such as outdoor workers, and those without housing. Heat can also stress animals, trees, and large shrub species, especially when coupled with long periods of drought, and has even melted some kinds of infrastructure.

Figure 2.8 illustrates the change in frequency of extreme heat events across the United States since 1979 (Climate Central, 2019). Dots in the blue gradient represent areas that have experienced a decrease in frequency of hot days; dots in the red gradient are areas that have experienced increases in frequency of hot days. The Pacific Northwest has experienced 10-30% increase in frequency of extreme heat, with the burden of adaptation falling disproportionately on those without existing adequate access to cooling.

Figure 2.9: Lifecycle Expansion of Predatory Insects



Predatory insects also benefit from warming winters. Both native and non-native populations are very likely to increase, as fewer will be culled by freezing temperatures over sustained periods of time in the winter. Warm winters, wet springs, and hot summers benefit the growth and reproduction cycles of many predatory insects like ticks, pine beetles, and mosquitos.

Figure 2.9 is a stylized illustration of the lifecycle of a blacklegged tick (*Ixodes scapularis*) (Beard et al 2016). Warming conditions are likely to prolong seasons of reproduction, resulting in higher densities of these insects. These insects create hazardous safety concerns for trees and wildlife, as well as a quality of life and health issue for humans and pets; also many are vectors for serious disease. Proliferation of these insects can restrict access to First Foods harvest opportunities, as well as negatively impact the health and abundance of First Foods themselves.

2.6 OCEAN ACIDIFICATION

While CTUIR is not a Tribe that relies directly on coastal resources, many First Foods and their habitats do depend on anadromous fish migration that bring marine nutrients inland to riverine ecosystems that rear them. Salmon and Pacific Lamprey are the best examples of this interconnection between river and coastal ecosystems, as these species spend their juvenile years in inland freshwater streams, and migrate to the ocean to grow big in nutrient-rich marine waters. When these fish return home to freshwater streams, their bodies decompose and return these accumulated nutrients to river systems. **Figure 2.10** provides a map of the ways in which salmon enrich inland ecosystems through their yearly decomposition on these landscapes (National Park Service). Because of this integral connection to coastal resources, CTUIR does have justification for concern over climate impacts to ocean acidification. Oceans have currently absorbed much of the carbon dioxide that has been released, but this changes the ocean water's chemistry as a result.

Figure 2.10: Marine Nutrients Return to Inland Ecosystems

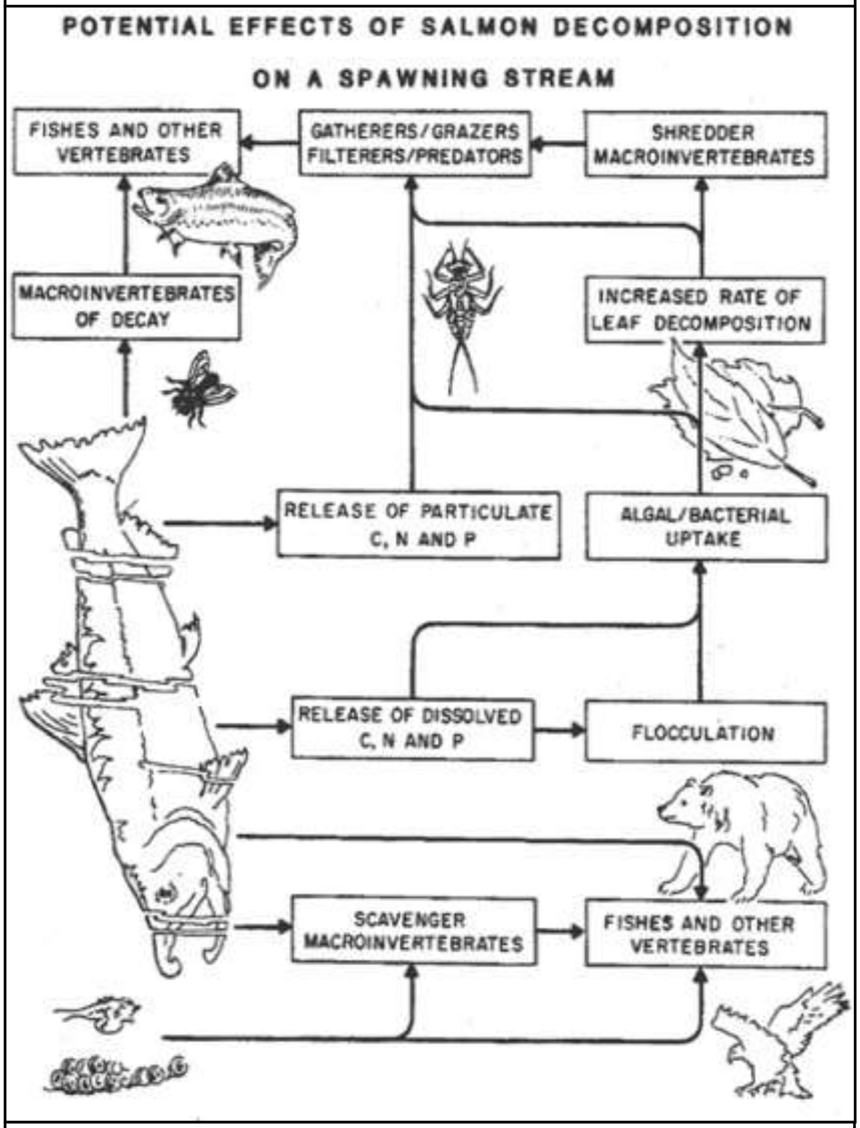


Figure 2.11 provides evidence of this changing chemistry monitored at an ocean research site in Hawaii (HOT 2021). Since 1980, the Pacific Ocean has experienced a 0.1 decrease in pH (becoming more acidic). While this might not sound like a large change, in a 40-year period of time, the Pacific Ocean experienced a 30% increase in acidity (NOAA 2021).

Acidification is a harm to marine ecosystems by threatening the availability of carbonate (HO-_3^{2-}) that comprises the protective shells of many organisms, including phyto– and zooplankton which are foundational in coastal food webs.

Figure 2.11: Changing pH (Vertical Axis) of Pacific Ocean Waters

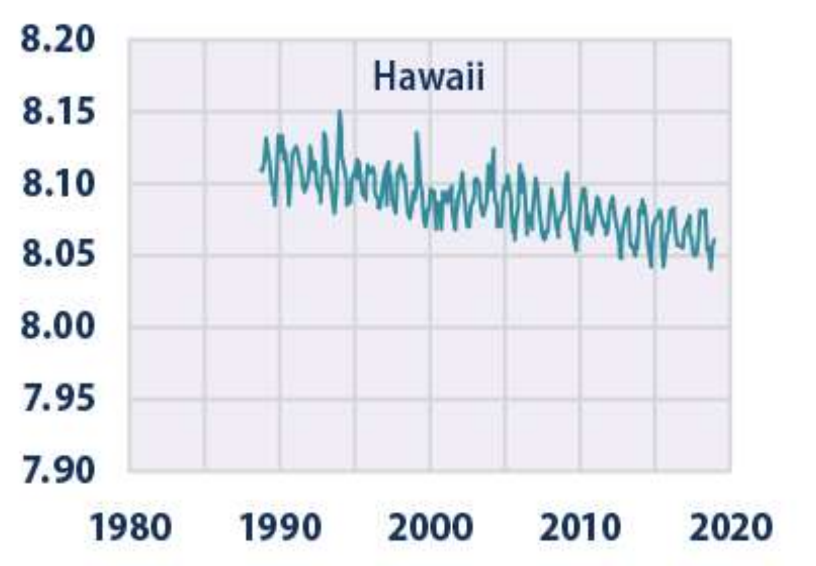


Figure 2.12 illustrates the impact of ocean acidification on marine ecosystems; this diagram was sourced from “Into the Salish Sea” (https://intothesalishsea.org/the-most-insidious-threat-to-our-ocean/) (2021). Because Salmon connect river and ocean environments together, inland Pacific Northwest Tribes like CTUIR have a responsibility to be engaged with coastal management policy to protect and preserve these connections.

2.7 UNKNOWNS AND FEEDBACK LOOPS

There are a number of elements in predictive modeling whose effects are so-far unknown; some of these have the potential for disastrous consequences for climate adaptation.

Breakdown of Atmospheric Circulation Patterns
Atmospheric circulation patterns like the jet stream, Pacific Decadal Oscillation, and El Nino/La Nina occur in response to air temperature and moisture content, and are responsible for driving established

Figure 2.12: Ocean Acidification Threatens Marine Ecosystems (from Into the Salish Sea)

seasonal patterns. As air warms globally, the predictability of these patterns is disrupted, and result in unexpected weather events.

Extreme cold events, known as "polar vortexes," are the result of decay in established atmospheric circulation patterns that keep polar air closely circulated above the Arctic. As polar vortexes become more likely to occur, cold air is pushed further south into Canada and the United States, making it more likely that some places will see more extreme cold than they have historically experienced. A recent example occurred in Texas, February 2021, as record low cold temperatures and snow fell on unprepared residents in the southern U.S. Electrical grid failures left over 10 million people without electricity for days (Busby et al 2021).

Alternatively, the unpredicted heat event that occurred across the Pacific Northwest in June and July 2021, as a "heat dome" that reached 116°F (47°C) in Portland, OR, enveloped the region for over a week, and killed more than 1,000 people in the Pacific Northwest (Neal et al 2022). This event was estimated to be a 1-in-1,000 year event (Neal et al 2022) though disruption of atmospheric circulation patterns may bring additional surprises.

Changing Glacial Albedo

Albedo is defined as the reflectivity of an object; light colors have greater reflectivity than dark colors. This has implications for global heating: loss of glacial ice decreases reflectivity and increases absorption. As polar ice melts due to warming, white glacial ice that historically reflects solar radiation is converted into open ocean or dark terrain, which absorbs light and heat. As more glacial ice is lost around the world, the faster the rate of heating will pick up in a harmful feedback loop (Rutherford et al 2017).

Oceanic Methane Hydrates and Melting Permafrost

Beneath the Arctic Ocean, frozen methane hydrates make up a significant amount of total mobile carbon sources on Earth, and are only stable under a narrow temperature range (Ruppel and Kessler 2017). These gas hydrates are also present in marine soils and permafrost areas in terrestrial regions around the Arctic. As these northern regions warm, hydrates dissociate from their frozen state and become mobile in waters and atmosphere. Methane is an incredibly potent greenhouse gas, with 84 times the heating potential of carbon dioxide over a 20-year period (Abdel-Shafy and Mansour 2018). Thus methane hydrate dissociation presents another feedback loop: more carbon is released as these soils warm (Knoblauch et al 2018). Many factors including depth and strength of the gas hydrate storage and the permeability of soils, and modeling is ongoing.

Earth's Shifted Axis

Even astronomical factors can affect rates of warming and effects of change. Recent studies have reported that Earth's axis has shifted as a result of a number of factors, predominantly melting glacier ice caps and pumping of groundwater causing redistribution of water on Earth. Climate changes heighten demand for consumptive water and places pressure on groundwater resources to meet needs of global communities (Deng et al 2021). This shift in Earth's axis is likely to have some effect on how life functions, though there is much that is still unknown.

2.8 CTUIR CLIMATE CHANGE VULNERABILITY ASSESSMENT

Assessing priorities is a typical approach to climate planning, and ideally engages affected communities in facilitating informed conversations around impacts and planning. As part of a 2013 BIA Tribal Resilience grant awarded to CTUIR, a Vulnerability Assessment was conducted in 2015 to assess Tribal community priorities and perform downscaled climate modeling for the Umatilla Indian Reservation.

Climate Projection Modeling

Climate projections are generated from statistical modeling that examines historic data and performs thousands of iterative likelihood scenarios that account for increasing carbon dioxide levels. These resulting models demonstrate likely scenarios for changings in climate, tracing different predictive outcomes based on optimistic or pessimistic visualizations of our human activities. There are standard recognized climate modeling scenarios, and many have short hand names to easily compare across disciplines.

- **Representative Concentrated Pathway (RCP)**: RCP 4.5 demonstrates a future where societies have worked to radically reduce current carbon emissions, whereas RCP 8.5 demonstrates what is likely to happen if societies continue to carry on with “business as usual,” making little or no attempt to curb our carbon emissions.

- **IPCC Scenario Families**: International modeling scenarios illustrate different future approaches to energy and development. Many projections use the A1B scenario, which assumes a future where rapid economic growth, and global population peaks in mid-century and declines thereafter, with the rapid introduction of new and more efficient technologies that are balanced between fossil fuel and renewable energy sources.

- **Degrees of Warming (˚C/F)**: These projection scenarios are based on overall global temperature increases. 1˚C (1.8˚F) is a level of warming that is almost sure to occur, with current efforts aimed at curbing a 1.5˚C (2.7˚F) and 2˚C (3.6˚F) global temperature rise, while 3˚C (5.4˚F) increase or more is not outside the realm of possibility.

Figure 2.13 provides a quick overview of the modeling that was done by the Oregon Climate Change Research Institute (OCCRI) for the CTUIR ceded lands as part of the CTUIR Climate Change Vulnerability Assessment (2015). Downscaled monthly Coupled Model Intercomparison Project V5 (CMIP5) was used to compare historical and climate modeled seasonal patterns. Overall, warming temperatures, increased days of extreme heat, and changes to precipitation were predicted. This information was then used to conduct a vulnerability assessment workshop, where participants ranked the sensitivity and adaptive capacity of key items of concern.

Key Items of Concern, Sensitivity, and Adaptive Capacity

As part of the Vulnerability Assessment, a working group was convened periodically over the course of 6 months to discuss potential climate change impacts to the region, and how that might affect Tribal resources. These were distilled into Key Items of Concern (KICs). These were used to frame the group discussions at the one-day workshop in which community and staff were asked to participate. In small groups and individually, workshop participants were asked to assign sensitivity and adaptive capacity of KICs.

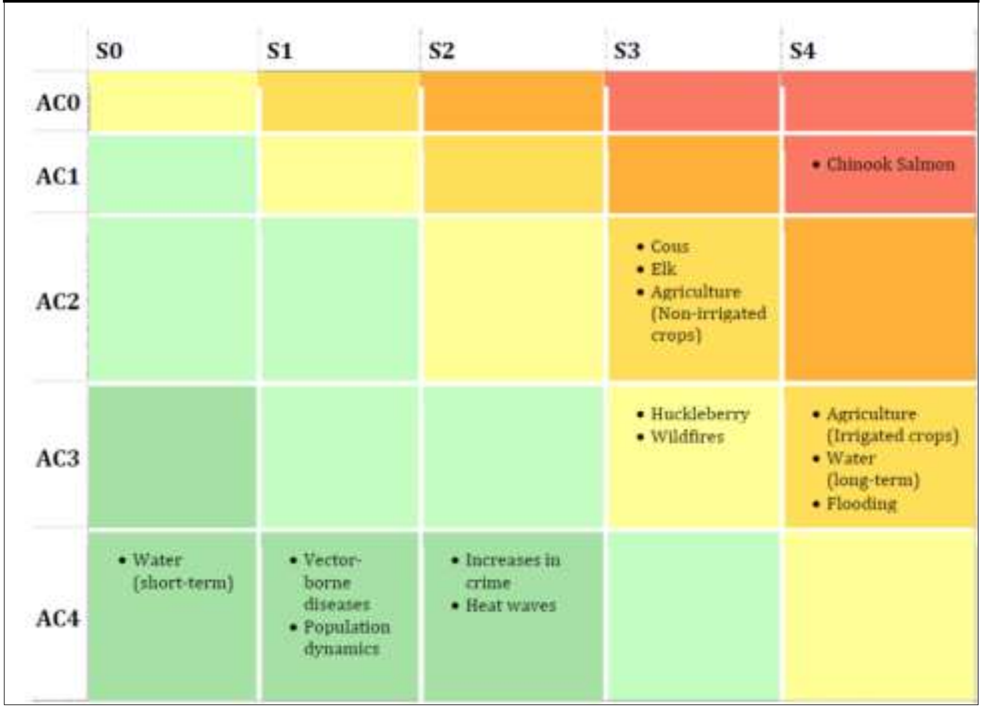
- **Adaptive capacity**: a score of AC1 means that a KIC has very low ability to change its conditions (example: resident freshwater mussels), compared to a score of AC5 (example: elk are able to migrate readily).

Figure 2.13: CTUIR Vulnerability Assessment Summary of MACA Modeling

Avg Monthly Temperature	Max Temperature	Days over 90˚ F	Emissions Scenarios	Precipitation
+ 5 to 12˚F	Summer + 2 to 10˚F	Doubled by 2050 From 13 to 26 days	Present to 2050: RCP 4.5 & 8.5 are same	Little overall change
By End Century (2070-2100)	Winter +1 to 8˚F	Tripled by 2100 From 13 to 39 days	2050 to 2100: RCP 8.5 is more severe	Drier summers with reduced snow

- **Sensitivity**: a score of S4 would indicate a very sensitive KIC (example: Salmon are impacted by waters temperatures of 68˚ F).

Figure 2.14: Vulnerability Assessment Key Items of Concern (KICs) for CTUIR



	S0	S1	S2	S3	S4
AC0					
AC1					• Chinook Salmon
AC2				• Cous • Elk • Agriculture (Non-irrigated crops)	
AC3				• Huckleberry • Wildfires	• Agriculture (Irrigated crops) • Water (long-term) • Flooding
AC4	• Water (short-term)	• Vector-borne diseases • Population dynamics	• Increases in crime • Heat waves		

Figure 2.15 above shows the ranking of various KICs as they were scored according to their sensitivity and adaptive capacity (CCVA 2015).

- Chinook Salmon are colored in red in the top right corner of the matrix, indicating that they are very sensitive to changes in water quality and quantity, and very limited in their ability to migrate from one stream to another.

- Cous, Elk, and Huckleberries were ranked as sensitive to changes, but slightly more able to adapt;

- Non-First Foods KICs like Agriculture, Flooding, and Long Term Water Use were thought to be sensitive, but could be adapted to suit a changing climate.

- Other KICs like Vectorborne Illness, Population dynamics, and Short Term Water Use were not sensitive and could be easily adapted to the projected climate impacts.

This provides a Tribal staff and community-based snapshot of the perception of climate risk and where adaptation will need to occur. To inform the Climate Adaptation Plan, follow-up interviews were conducted with a number of event participants, to identify report strengths and opportunities to improve these approaches. Hindsight considerations centered around relative scale that participants placed on ranked adaptive capacity as compared to number values assigned. Some expressed resistance to the idea of prioritizing one First Food species or KIC over another, contradicting the inherently integrated idea of Tamanwit.

For more detailed information on this report and it's findings, please read the CTUIR Climate Change Vulnerability Assessment (2015); https://ctuir.org/departments/natural-resources/climate-adaptation/climate-projection-resources/ctuir-climate-change-vulnerability-assessment-2015/

2.9 IMPLICATIONS FOR REGIONAL POLICY DECISIONS

Because of this regional interconnectedness, any policy decisions must consider implications of climate adaptation actions not just to immediate environments, but also the needs of those that are connected to them by a longer chain. This also has implications for international policy, since migratory fish spend much of their lives in internationally regulated oceans, and different nations have varied responses to climate change, invasive species management, and overharvesting issues.

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CTUIR Tribal fire crews on break while working on the Yakama Nation Wildfire in 2021