



Karuk Climate Adaptation Plan



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This Climate Adaptation Plan is a living document and modifications will be essential in the face of ongoing climatic changes, the increasing engagement of Karuk people in traditional knowledge and management activities, ongoing research developments and policy opportunities.

Cover Photo Jenny Staats

LIST OF ABBREVIATIONS

<i>BIA</i>	<i>Bureau of Indian Affairs</i>
<i>CALFIRE</i>	<i>California Department of Forestry and Fire Protection</i>
<i>CalTrans</i>	<i>California Department of Transportation</i>
<i>ECRMP</i>	<i>Eco-Cultural Resource Management Plan</i>
<i>FLN</i>	<i>Fire Learning Network</i>
<i>MKWC</i>	<i>Mid Klamath Watershed Council</i>
<i>NGOs</i>	<i>Non-governmental Organizations</i>
<i>PG&E</i>	<i>Pacific Gas and Electric Company</i>
<i>SRRC</i>	<i>Salmon River Restoration Council</i>
<i>TEK</i>	<i>Traditional Ecological Knowledge</i>
<i>USFS</i>	<i>United States Forest Service</i>
<i>WKRP</i>	<i>Western Klamath Restoration Partnership</i>

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Executive Summary

- Within Karuk ancestral territory on the mid Klamath, the effects of climate change including changes in precipitation patterns, decreased snowpack increasing droughts, increasing frequency and severity of wildfires, and disease and pest outbreaks are immediate and occurring now.
- Climate change is one of the most dramatic and widespread impacts the modern world has faced and attempting to come to terms with the data and implications can be daunting. Indigenous people are disproportionately impacted by the changing climate.
- Fortunately, tribal and non-tribal peoples around the world are engaged in efforts to halt fossil fuel production, move to renewable energy and transportation systems, document the current impacts from climate change, and plan for the future. This Climate Adaptation Plan is one such example.
- The Klamath River and its tributaries, forests, grasslands and high country are **essential for the cultural, spiritual, economic and physical health of Karuk people.**
- While the changing climate poses serious threats for Karuk culture, sovereignty and all life on earth, it is perhaps most productively viewed as an opportunity to assert and expand Karuk traditional practices, tribal management authority, sovereignty and culture.
- Karuk people have long been part of the ecosystem. Climate adaptation is about restoring human responsibilities and appropriate relationships to the natural world.
- **Climate adaptations for species and** habitats center around the revitalization of Karuk cultural management, the restoration of traditional fire regimes, reducing impacts from intervening factors, the expansion of Karuk tribal management authority and capacity, community engagement and public education, increased interjurisdictional coordination, and expanded research and monitoring.
- Adaptations discussed here utilize a combination of western science and Karuk traditional ecological knowledge and center on 22 focal species **cultural indicators** as potential cues for human responsibilities across seven habitat management zones.

- The climate planning work of the Karuk is unique for its central and detailed focus on fire, its attention to restoring human responsibilities and traditional ecological knowledge, and its parallel emphasis on collaboration, public education and policy advocacy.
- The federal government has a primary trust responsibility to Indian Tribes as reaffirmed in 2014 by [Secretarial Order 333-5: Federal Trust Responsibility to Federally Recognized Indian Tribes and Individual Indian Beneficiaries](#) (Sec. Order 3335-Jewell 2014). The Department of Interior further acknowledged in [Secretarial Order 3289](#), this responsibility includes the duty to protect lands from the impacts of climate change (USDI 2009).
- This Karuk Climate Adaptation Plan was developed following the Karuk Climate Vulnerability Assessment which was completed in 2016. The Plan details climate impacts and potential adaptations for Karuk species and habitats, human health, critical infrastructure, tribal programs and tribal sovereignty and management authority.
- In the mid-Klamath region specifically, many goals in the Forest Service's own management plan can be best achieved through collaboration and restoring Karuk tribal management.
- Utilization new and existing Tribal authorities including those from the 2018 Indian Energy Act regarding the integration of Tribally approved plans into Forest Plan Revision, and the 2018 Farm Bill extending Good Neighbor Authority to Tribes.
- While major resources are needed for climate adaptation, there are also many easier steps that can significantly alter how the changing climate will impact Karuk tribal members and cultural resources, as well as tribal management authority and sovereignty.
- Wherever possible adaptations are provided at three scales: adaptations for acute emergency conditions (e.g. lethal stream temperatures), strategies for longer term restoration of landscape scale traditional management, and adaptations in the form of robust restoration activities to enhance ecosystem resilience.
- Physical health impacts of climate change include heat stress, increasing rates of asthma, food and water contamination, and diet related diseases in the face of reduced access to traditional foods.

- Mental health dimensions of climate change include stress and anxiety related to wildfires, food insecurity, smoke and emergency events, and cultural and spiritual impacts of ecosystem decline and species loss.
- Immediate adaptation needs involve increased coordination with other departments, development of emergency management program, smoke monitoring, and expansion of individual and community cooling centers and air purifying resources. Long term adaptation needs involve planning for increased occurrences of physical and mental conditions.
- Climate impacts in the form of flooding and increasing frequency of high severity fire are already impacting **critical tribal infrastructure** including electrical supplies, transportation routes, water systems, communication systems and emergency services that supply daily and emergency needs for the Karuk tribal community and tribal programs. These impacts will increase as climate stressors intensify and entities who supply critical services experience greater pressure in the face of regional fire activity and flooding. Increased community self-sufficiency, backup systems and emergency preparedness will be critical for community well-being.
- Given that Karuk communities have historically received lower prioritization for roads, powerlines, communication and other forms of infrastructure maintenance, increased advocacy, coordination and collaboration with these entities will be essential adaptations moving forward. Powerlines pose an immediate threat as a source of ignition for wildfires in areas that have high fuel loads due to fire suppression. This plan includes an in-depth adaptation for electrical infrastructure in the form of 104 proposed prescribed fire treatment units totaling 4,862 acres, along 41 miles of power corridor around the communities of Somes Bar and Orleans.
- The changing climate creates situations that infringe upon **Karuk management authority and political sovereignty**.
- Adaptations for expanding Karuk sovereignty and management authority in the face of climate change include revitalization of cultural indicators for fire applications, utilizing and developing expanded Federal compacting authorities, increasing outreach and coordination with agency and NGO partners, expanding public education and outreach, continuing coordination with University partners for research and monitoring, and possible development of Air Quality and Climate Adaptation Programs.

- Climate change is happening on such a large scale that it can appear to be a natural force, even as we know it results from the emissions and build-up of carbon dioxide and other climate gasses in the atmosphere. Ultimately, climate change is the product of unsustainable Western land management practices and the rise of political and economic systems for which indigenous people hold little to no responsibility. In this context, the crisis posed by climate change is also a strategic opportunity not only for tribes to retain cultural practices and return traditional management practices to the landscape, but for all land managers to remedy inappropriate ecological actions, and for enhanced and successful collaboration in the face of collective survival.
- The Karuk Tribe's work on restoring traditional fire regimes holds the potential to inform both climate adaptation and mitigation efforts, given that wildfires themselves generate emissions, and a reduction in high severity fires could result in a reduction in forest emissions.
- This is a living document that will necessarily evolve over time as information and needs develop

INTRODUCTION: Climate Change as a Strategic Opportunity

Within Karuk ancestral territory on the mid Klamath, the effects of climate change are immediate and occurring now (Butz and Safford 2010 and 2011, Vander Schaaf et al. 2004, Olson et al. 2012, Damschen et al. 2010, Harrison et al. 2010). Responding to these impacts and simultaneously anticipating future impacts is a challenging task. Climate change is one of the most dramatic and widespread impacts the modern world has faced and attempting to come to terms with the data and implications can be daunting. Fortunately, we are not facing it alone. Tribal and non-tribal peoples around the world are engaged in efforts to halt fossil fuel production, move to renewable energy and transportation systems, document the current impacts from climate change, and plan for the future. This report is one piece of that effort. The [Karuk Department of Natural Resources Strategic Plan](#) notes that

"Since time immemorial, the Karuk have lived in the Klamath-Siskiyou Mountains in the mid- Klamath River region of northern California. With an Aboriginal Territory that includes an estimated 1.38 million acres, the ancestral people of the Karuk resided in more than one hundred villages along the Klamath and Salmon Rivers and tributaries. Thriving with a subsistence economy supported by rich natural endowments and a strong culture-based commitment to land stewardship, Karuk environmental management has shaped the region's ecological conditions for millennia. Through carefully observing natural processes, the Karuk have developed traditional management regimes based on a landscape-level ecosystem approach. Self-described as "fix the world people", the Karuk continue ceremonies that restore balance and renew the world."

Today, the task of *fixing the world* involves dealing with new threats to both riverine and "upslope" forest or broader landscape habitats and species in the face of climate change, as shifting and increasingly variable precipitation patterns impact stream flows, snowpack, river temperatures and fire regimes (Butz et al. 2015, Melillo et al. 2014, Karl et al. 2009, Spies et al. 2010, Lata et al. 2010, Fettig et al. 2013, Wimberly and Liu 2014, Mote et al. 2014).

Tribes have been key leaders in responding to climate change through both so-called mitigation —efforts to stop further climate change— and adaptation —developing responsive measures for coping with the unfolding ecological and atmospheric changes. Tribes can often be found leading the way in climate change policy, strategy and resistance by participating in the political process, engaging in

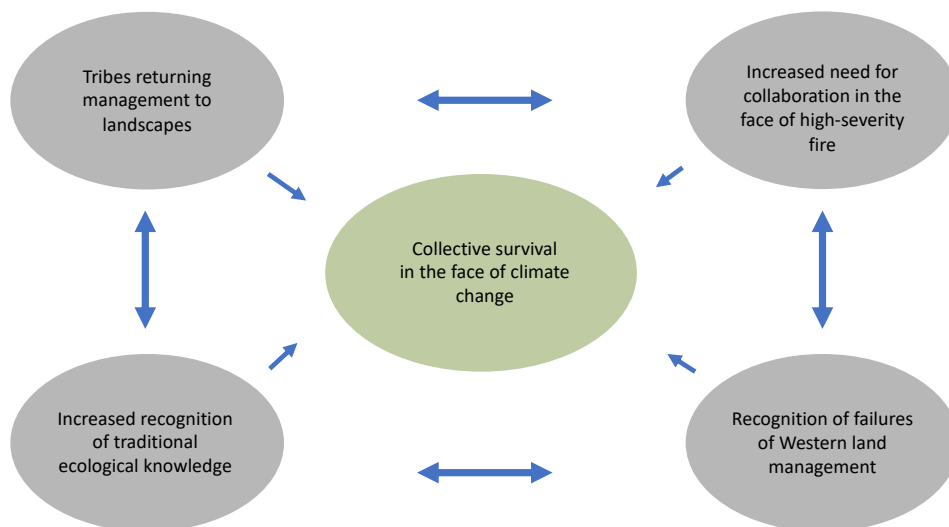
sustainable land stewardship, and being at the forefront of many climate change activism efforts. The Karuk Climate Adaptation Plan was developed following the Karuk Climate Vulnerability Assessment which was completed in 2016. The climate planning work of the Karuk Tribe is unique for its central and detailed focus on fire, its attention to restoring human responsibilities and traditional ecological knowledge, and its parallel emphasis on collaboration, public education, and policy advocacy. The Karuk Tribe's work on restoring fire regimes holds the potential to inform both climate adaptation and mitigation efforts, given that wildfires themselves generate emissions (McMeeking et al. 2006, Langmann et al. 2009). A reduction in high severity fires through the restoration of the region's traditional low-moderate severity fire regimes could result in a reduction in forest emissions.

Climate change results from the emissions and buildup of carbon dioxide and other climate gasses in the atmosphere. These emissions are the result of political and economic systems organized around fossil fuel combustion. Ultimately, climate change is the product of unsustainable Western land management practices and the rise of political and economic systems for which indigenous people hold little to no responsibility. Native American tribes face amongst the most significant climate impacts. The National Climate Assessments describe how tribal climate impacts are "compounded by a number of persistent social and economic problems," and indigenous adaptive responses "occur against a backdrop of centuries-old cultures already stressed by historical events and contemporary conditions" (Bennett et al. 2014, p. 298).

Fortunately, in the face of the changing climate, many ecologists, fire scientists and policy makers, Native and non-Native alike have turned to indigenous knowledge and management practices with renewed interest and optimism in the hope that they may provide a much-needed path towards both adaptation and reducing emissions (Williams and Hardison 2013, Martinez 2011, Raygorodetsky 2011, Vinyeta and Lynn 2013, Whyte 2013, Wildcat 2009). In the context of climate change, Karuk tribal knowledge and management principles regarding the use of fire can be utilized to reduce the likelihood of high severity fires and thereby protect public as well as tribal trust resources (Norgaard 2014). In particular, there is increasing recognition of the importance of indigenous burning as an ecosystem component and restoration technique. In this context, the crisis posed by climate change is also a strategic opportunity not only for tribes to retain cultural practices and return traditional management practices to the landscape, but for all land managers to remedy inappropriate ecological actions, and for enhanced and successful collaboration in the

face of collective survival. There has been recent recognition of the validity of traditional ecological knowledge and the use of fire to manage for cultural resources, promote biodiversity, and to mitigate catastrophic wildfires. This recognition coupled with the need for collaboration in the face of high severity wildfire (e.g. [FLAME Act of 2009](#), [Western Regional Strategy Committee 2012](#)), and recognition of the failures of existing Western scientific perspectives and management approaches focusing on single commodities and single species management, have combined to create an exciting political moment in which tribes are uniquely positioned to lead the way. In the mid-Klamath region specifically, many goals in the Forest Service's own management plan can be best achieved through restoring Karuk tribal management.

Figure 1: Climate change as a strategic opportunity



CHAPTER ONE: Climate Trends for Karuk Aboriginal Territory

- *Climate trends in Karuk Aboriginal Territory include changing patterns of precipitation, temperature and fire behavior, an increase in species invasions, pests and pathogens and changing species distributions. The region also experiences indirect impacts from ocean acidification and sea level rise.*
- *Climate stressors interact with existing ecological stressors including water diversions, dams, and fire suppression.*
- *By the end of this century the number of days over 86°F is expected to double, the growing season is expected to increase by 75 days, the number of days with very high fire danger to increase by 12 days, and the total soil moisture is expected to decrease by 2 inches.*
- *While broader trends are well established, future climate conditions will be highly variable at the local scale, and for individual seasons.*

Ongoing and future ecological outcomes of climate change in the Mid Klamath region of California include changes in precipitation patterns, increased droughts, increased frequency and severity of wildfires, and disease and pest outbreaks (Butz et al. 2015, Garfin et al. 2014, Mote et al. 2014). Changing patterns of temperature and precipitation, decreased snowpack, earlier snow melt and spring runoff, decline in total spring runoff, and increased variability in streamflow have already been observed within Karuk Aboriginal Territory, and these trends are expected to increase (Butz et al. 2015). Additional notable trends within the mid Klamath basin include drier autumn weather (produced in part by the presence of high atmospheric pressure systems, see Swain 2018), the extension of fire seasons, shifting fog and wind dynamics, and an expansion of insect pests, forest and riverine pathogens and invasive species (some of which may or will be refugee species). Future snowfall in the 6,000-10,000 foot elevation range is predicted to decrease by 22-93% across California by 2100.

While specific temperature, precipitation, fire, and other aspects of the changing climate play out differently across regions of the United States and globe, trends occurring in Karuk aboriginal territory are a function of global atmospheric processes and congruent with both broader trends and global climate models. The Fourth National Climate Assessment (2018) notes that the Pacific Northwest Region has warmed 2°F since 1900 (May et al 2018). California's Fourth Climate Assessment (2018) details trends in rising air temperatures and changing patterns of precipitation, and the associated changes in snowpack, soil moisture,

length of growing season, fire behavior and more. In their report "Climate Change in the Northwest," Dalton et al. (2013) note: "For the last 30 years, temperatures averaged over the Northwest have generally exceeded the 20th century average. During 1895–2011, the Northwest warmed by about 0.7 °C (1.3 °F)" and "During 1901–2009 the number of extreme high nighttime minimum temperatures increased in the Northwest" (xxii). Figures from the National Academy of Sciences indicated a projected average temperature increase of up to 3.5–4.5 °F for the Klamath region in the next 50 years (as compared to the period of 1971–1999) (Garfin et al. 2014). Furthermore, among the future trends emphasized is increasing variability in precipitation: "Year-to-year fluctuations in precipitation averaged over the Northwest have been slightly larger since 1970 compared with the previous 75 years, with some of the wettest and driest years occurring in the most recent 40 years" (Dalton et al 2013, p. 4).

Aligning with these larger trends, temperature measurements from Orleans, California, where the Karuk Department of Natural Resources is located, indicate that between 1931 and 2014 average annual air temperatures increased by 2° F (1.1° C) (Butz et al. 2015) and Klamath River temperatures have also increased in the last fifty years. The amount of precipitation that falls as snow within the Klamath basin is also becoming more variable, e.g. the 5 year coefficient of variation for annual precipitation is increasing at all weather stations in the Six Rivers National Forest (Butz et al. 2015). Precipitation for Karuk territory is projected to become more variable, with a trend in snow levels increasing in elevation, resulting in less snowpack and more rainfall. Earlier dates of peak daily flows as well as increases in the proportion of precipitation that falls as rain translates into an increase in flood potential (Butz et al. 2015). Maritime influences are predicted to moderate the influences of more interior warming and drying for the western Klamath region (Butz and Safford 2010 and 2011, Vander Schaaf et al. 2004, Coops and Waring 2001).

Climate projections are consistent across many different models and provide a great deal of information about future scenarios for Karuk Aboriginal Territory, but they are also limited in their specific application due to two issues of scale. First, ***climate projections*** describe long-term atmospheric behavior which are different from ***weather predictions***, the latter of which can be understood as forecasting of short-term atmospheric behavior. Because of this difference in scale, climate projections provide powerful information about what to expect generally (long-term trends in precipitation, temperature, snowpack), but not when specific weather events, or especially extreme events such as flooding, drought or heat waves will occur. Indeed, one key takeaway from climate forecasting across multiple scales is an increase in temperature and precipitation ***variability***. Secondly, these data come from global climate models which are "downscaled" to regionally specific dynamics. See Grantham 2018 for more detailed descriptions of how global climate models are "downscaled" to create regional forecasts. Lastly, it must always be remembered that trends in phenomena such as stream

temperature, fire behavior, pest outbreaks and more are as much a function of past and present management actions as they are of larger scale climatic conditions.

					
Precipitation	Temperatures	Wildfires	Pathogens and pests	Rising sea levels	Ocean acidification

Table 1.1: Biophysical Changes Occurring in Karuk Aboriginal Territory with Examples

Biophysical changes	More variable precipitation, e.g less consistency in the timing of precipitation	Warmer evening temperatures through year	Increasing frequency of high severity fires	Expansion of species not previously here (e.g sudden oak death)	Variable by location, with particular potential impact to estuary juvenile rearing habitat	Impacting food chains, growth of anadromous species
Examples	More extreme precipitation events, e.g droughts and flood events	Reduced winter snowpack as winter precipitation comes as rain rather than snow	Fires season getting longer, fires burning at higher elevations, other changes in fire behavior	More cycles of existing pathogens	Impacts ocean going species such as salmon, lamprey, otherwise impacts on coastal communities greater than inland	Impacts ocean associated species such as salmon, otherwise impacts coastal communities more than inland

Additional forecast data from multiple models assembled by the NW Climate Toolbox provide estimates for future climate conditions within Karuk Aboriginal Territory. Table 2 summarizes a series of these trends for the high emissions scenario, showing data from 1970-2010 as a baseline, model forecast data by the turn of the century, and the total change in value. Figures 1.2-1.3 portray a number of these projections visually, in some cases showing spatial variation across Karuk aboriginal territory. These forecasts are consistent with regional, national and international trends as well as climate models (Bennett et al. 2014, Butz et al. 2015, Coops and Waring 2001, Dalton and Mote 2013, Gafin et al. 2014, Grantham 2018, May et al 2018).

Table 1.2 Summary of Territory Key Climate Forecasts for Karuk Aboriginal Territory
(data from Climate Impacts Group, NW Climate Toolbox high emissions scenario)¹

	Recent Decades (baseline)	By end of Century (2070-2099)	Change
Days over 86 °F	49.8 days	102 days	+ 52.5 days
Jun-August average maximum daily temperature	83.0°F	92.6°F	+ 9.6°F
Annual average daily temperature	52.5°F	60.3 °F	+ 7.8°F
Days in Growing season	176 days	251 days	+ 75 days
Freeze Free Days	282.5 days	344.3	+ 61.8 days
Days of high fire danger	36.5	48.2	+ 12 days
Snow-water equivalent	10.3 in	1.4 in	- 9 inches
Annual Total Precipitation	78.8 in	82 in	+ 3.2 inches
Winter Precipitation (Oct-March)	66.3 in	70.7 in	+4.4 inches
Summer Precipitation (April-September)	12.5 in	11.3 in	- 1.2 inches
Total soil moisture	11.5 in	9.6 in	- 2 inches

Changing Temperature Patterns

The California's Fourth Climate Assessment notes that minimum, average, and maximum temperatures have all been increasing in California over the past century (Grantham 2018). Common measures of air temperature include annual average air temperatures, nighttime summer and winter minimum temperatures, numbers of days per year that exceed 86 °F, numbers of frost free days (a measure of the length of the growing season), and measures of extreme heat events. Across California annual average temperatures have increased by about 1.5 °F in the last century, heat waves have become more common, and spring snowmelt is occurring earlier. Both across California and in the North Coast region specifically these temperature increases have been greatest in summer months. Minimum nighttime temperatures have also been increasing faster than either maximum daytime highs and average

¹ Krosby, M.B., Hegewisch, K.C., Norheim, R., Mauger, G., Yazzie, K., Morgan, H., "Tribal Climate Tool" web tool. Climate Impacts Group (<https://cig.uw.edu/resources/tribal-vulnerability-assessment-resources/>) and NW Climate Toolbox (<https://climatetoolbox.org/>) accessed on [November 12, 2018].

temperatures (ibid). Not only are there overall increases in air temperatures across these measures, but more variable temperature patterns are observed.

At the Orleans, CA weather station, average temperatures have already increased 2 °F in the period from 1931-2014 (Butz et al. 2015). Nighttime temperatures over the same period have increased by almost 4° F (2.2° C) (ibid). Warmer nighttime temperatures have a particularly significant effect on stream temperatures. Butz, Sawyer and Stafford (2015) note “Across the western United States, widespread changes in surface hydrology have been observed since the mid-1900s. These shifts include: decreased snowpack (particularly at low elevation sites; earlier snow melt and spring runoff (by 0.3 to 1.7 days per decade across Western US as a whole) decline in total runoff occurring in the spring (Moser et al. 2009) rising river temperatures (Kaushal et al. 2010), and increased variability in streamflow (Pagano and Garen 2005).

Important indicators of changing temperature include changes in the average annual temperature, change in the average maximum temperature for summer (June-August), the total number of days in excess of 86 °F, and the number of freeze free days, see figures 1.2- 1.3 below. Figure 1.2 indicates an increase of 52.5 days with temperatures above 86 °F by the end of the century, while Figure 1.3 illustrates the forecasted increase in the maximum daily temperature by 9.6 °F in summer months.

Figure 1.2 Forecasted Increase in Days with Temperatures Above 86 F

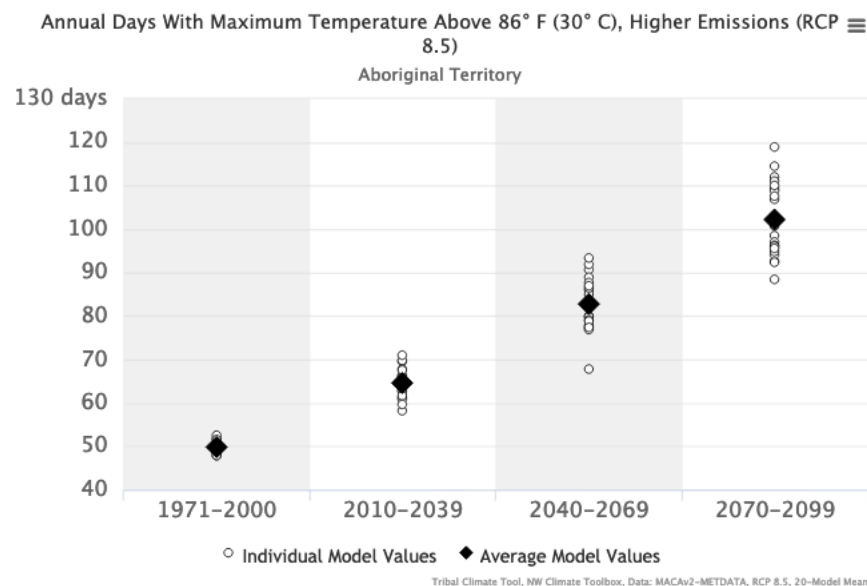
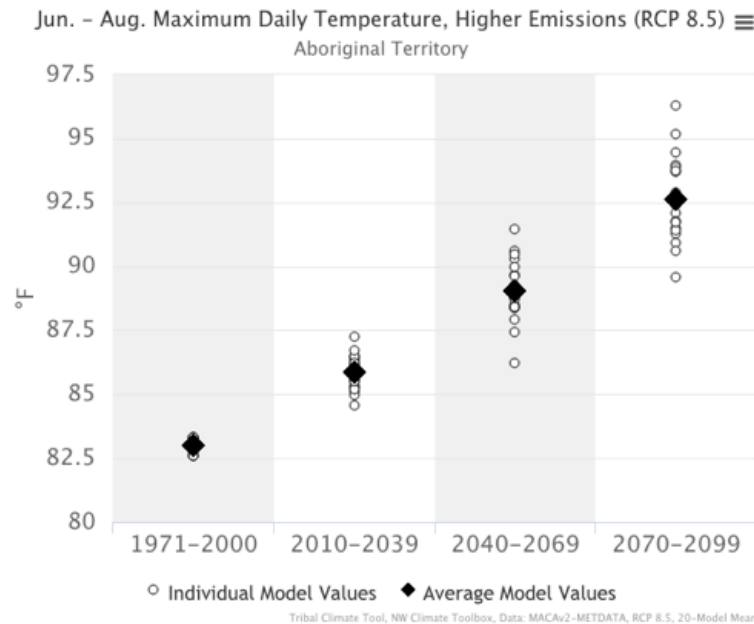
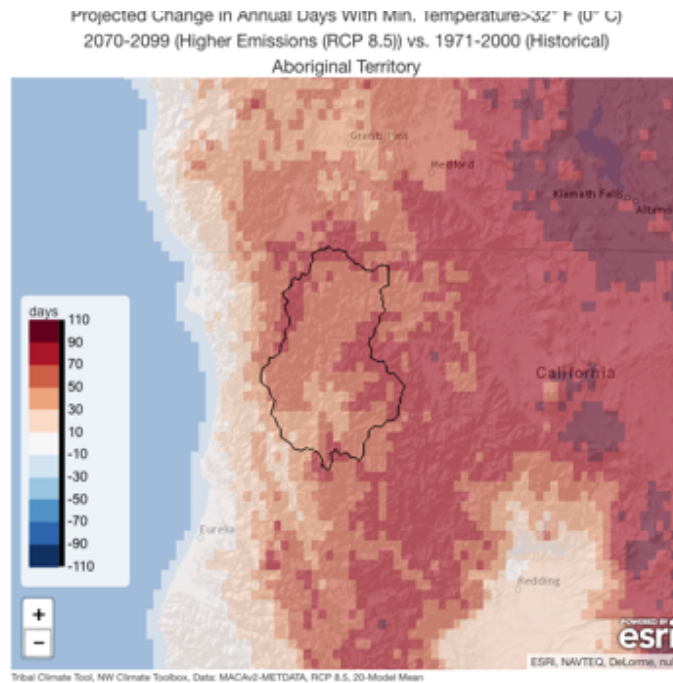


Figure 1.3 Maximum Summer Temperatures for Karuk Aboriginal Territory



As displayed in Figure 1.4 the number of days without freezing temperatures is projected at 344.3 by the end of the century - an increase of 61.8 days.

Figure 1.4 Projected Days Without Freezing Temperatures 2070-2099



Currently the growing season within Karuk Aboriginal Territory is 176 days. With the decrease in frost free days the number of days in the growing season is forecasted to increase by 75 days by the end of the century. All data in Figures 1.2-1.4 from the NW Climate Tool.

Changing Patterns of Precipitation

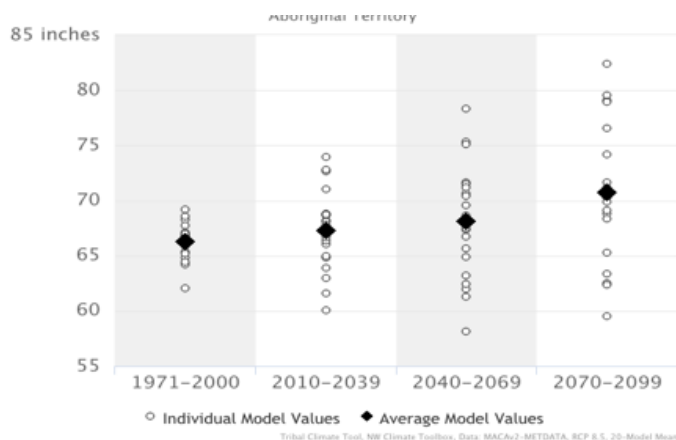
Precipitation patterns too are changing in the Klamath basin and across the Pacific Northwest. Key measures of precipitation include total annual precipitation, timing of winter and summer precipitation, and the total amount of precipitation in individual storm events. Between 2011 and 2017 California witnessed the most severe drought on record. Not only were precipitation records the lowest since first recorded in 1895, but tree ring records suggest this period may be the driest California has been in 1,200 years (Griffin and Anchukaitis 2014). The Fourth California Climate Assessment describes how “The development of a persistent, high pressure system in the north Pacific, coined the “ridiculously resilient ridge” by climate scientist Daniel Swain, is considered to be the primary cause of precipitation deficits during the statewide drought (Seager et al. 2015, Swain 2015)” (2018, 21). Precipitation projects across California as a whole are for increases in the intensity of individual storms (Pall et al. 2017, Prein et al. 2017, Risser and Wehner 2017), a reduction in the length of the wet season (with later onset of Fall rains in the fall and earlier drying in the Spring) and a universal decline in snowpack, even for climate scenarios that suggest precipitation increases due to temperature increases. The California Climate Assessment reports that annual precipitation predictions for the North Coast Region “fall within the range of historical variation with a trend towards slightly higher (2-16%) precipitation across the region by the end of century” (19).

The Assessment further notes that “Paradoxically, the projected rise in the frequency of precipitation extremes is coupled with an expected rise in the frequency of extremely dry years, on the order of 80% across most of northern California (Swain et al. 2018). The coupled rise in the frequency wet and dry year extremes has been termed “precipitation whiplash” and describes a new climate regime for the state characterized frequent, dramatic swings between wet and dry years” (20).

Within Karuk Aboriginal Territory forecasted changes in the annual total precipitation are more modest: with projected increase of 1.2 inches by the end of the century, with the total winter precipitation increasing and total summer precipitation decreasing by about 0.6 inches.

Figure 1.5 shows the forecasted increase in winter precipitation (October -March) by the end of the century using the higher emissions model.

Figure 1.5 Forecasted Increase in Winter Precipitation



The much delayed start to Autumn rainy season in recent years in the Klamath basin has been attributed to the above described atmospheric ridge or “blob”(Swain 2018).

Snow Water Equivalent and Soil Moisture:

The key measure of snow depth is “snow water equivalent.” In Karuk Aboriginal Territory the recent average (between years 1971-2000) Snow Water Equivalent (SWE) at April 1st has been 10.3 inches. The Fourth California Climate Assessment notes that for the North Coast as a whole, Flint et al. (2013), found that “the average spatial extent of snow on April 1st has declined from 60% to 50% within areas exceeding 3,000 feet in elevation between 1951-1980 and 1981-2010, with the greatest loss of snow occurring in the Klamath-Siskiyou Mountains.” The authors predict that “the April 1 extent of snow will decline to 11% by end-of-century and April 1 snow water equivalent will decline from 10.3 inches (1951-1980) on average to 1 inch by end century” (21).

Using data from the NW Climate Tool for Karuk Aboriginal Territory under the higher emissions scenario, the April 1st average snow water equivalent is projected to be 1.4 inches, a decrease of 8.8 inches from the historical value by the end of the century. This projected change in Apr. 1st average snow water equivalent was averaged over the Aboriginal Territory and reported as an average over 10 models of hydrology (See Figure 1.6 below). Implications for reduced snowpack and SWE include reduced potable water availability, stress to aquatic and upland plant and animal species, and changing patterns of fire behavior including increases in fire severity. Furthermore, reduced snowpack and soil moisture influence the onset of fire

season as the ground becomes warmer and drier earlier in the year (Kolian 2015). Total soil moisture between July and September, is projected to decrease by 1.9 inches from the historical value.

Figure 1.6 Projected Changes in Snow Water Equivalent for Karuk Aboriginal Territory by 2077-2099

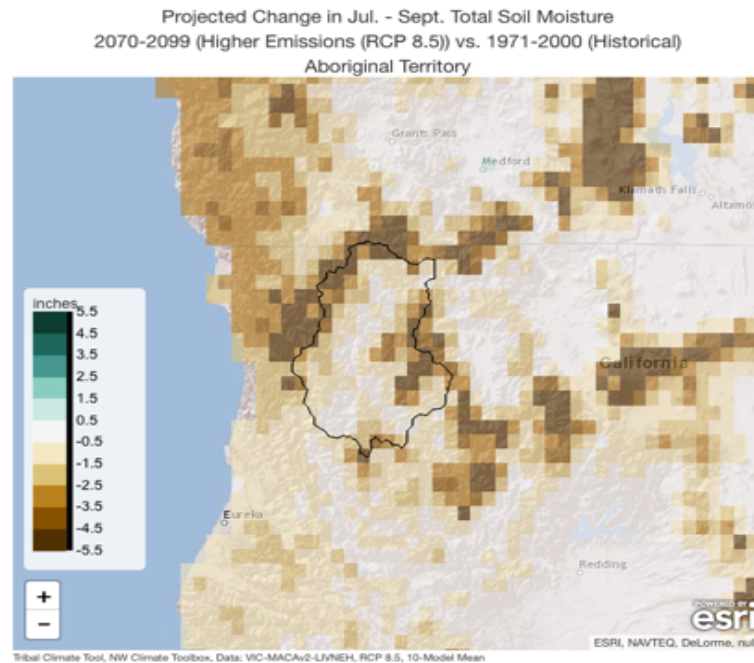


Figure 1.7 Projected Decrease in Summer Soil Moisture within Karuk Aboriginal Territory by 2077-2099

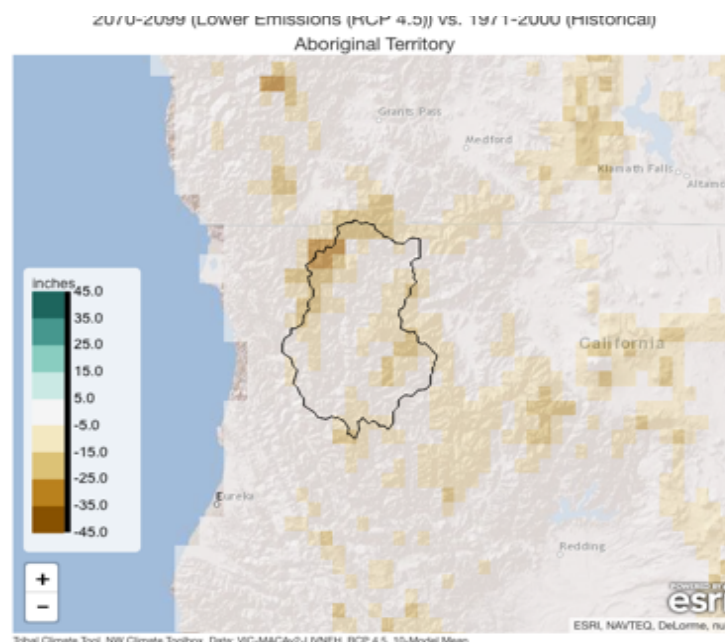
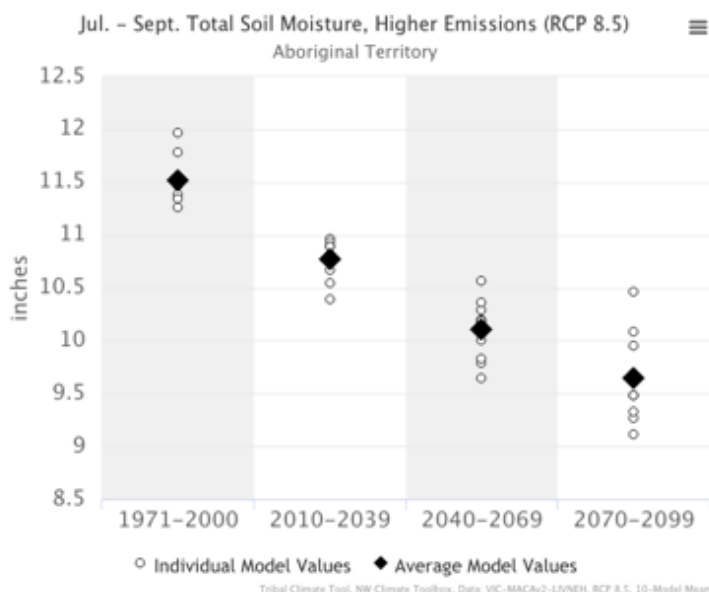


Figure 1.8 below portrays these changes in total soil moisture across three future time periods as compared to the baseline period from 1971-2000.

Figure 1.8 Projected Changes in Summer Soil Moisture Across Three Time Periods

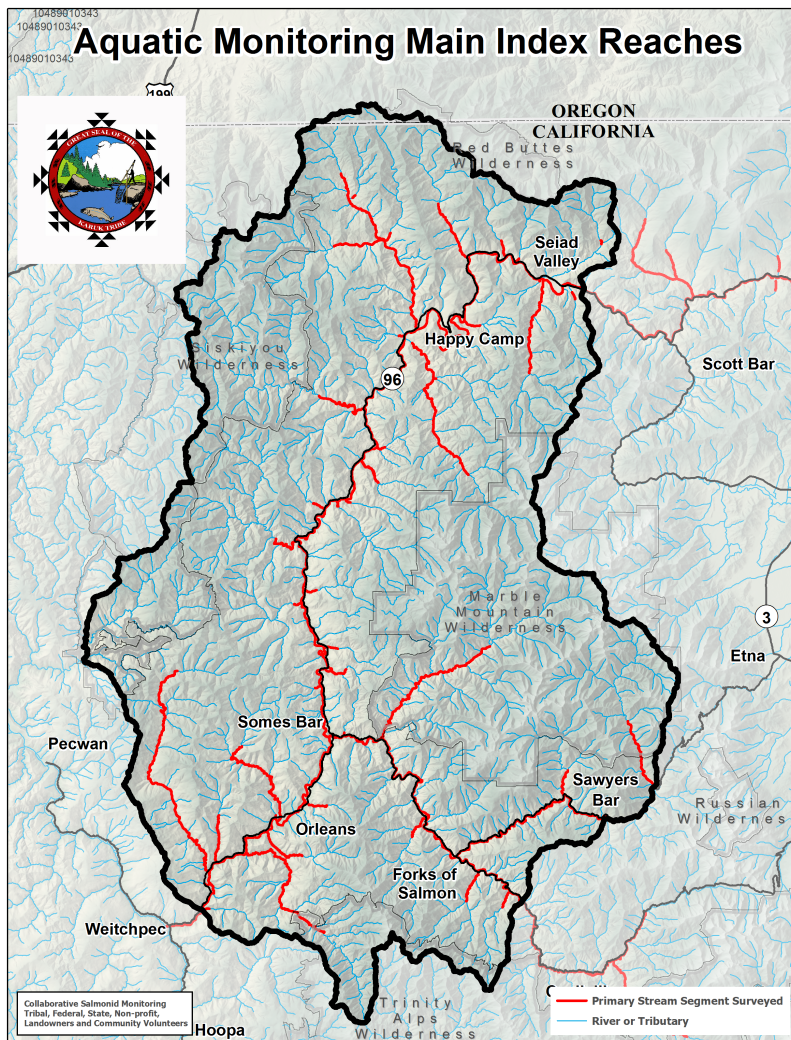


Stream Flow and Temperatures

Changes in patterns of precipitation, temperature, snow water equivalent and soil moisture translate into changing stream temperatures and flows. Stream temperature and flows are highly linked, but the relationships between flows, temperatures and climate warming are a highly complex function of watershed specific geology, groundwater dynamics and both long- and short-term patterns of precipitation temperature and snowpack. Future forecasts for both stream temperature and stream flow tend therefore to be less certain than other climate forecasting efforts. Key measures include total flow and temperature, as well as summer maximum temperatures and minimum summer flows in both tributaries and the mainstem Klamath River. Extent and timing of flood events are also highly relevant.

The Salmon River Restoration Council, Karuk Tribe, Mid Klamath Watershed Council and USFS have conducted long term temperature and flow monitoring in the Klamath Basin. Figure 1.9 indicates areas of the basin with Karuk Aboriginal Territory where monitoring occurs.

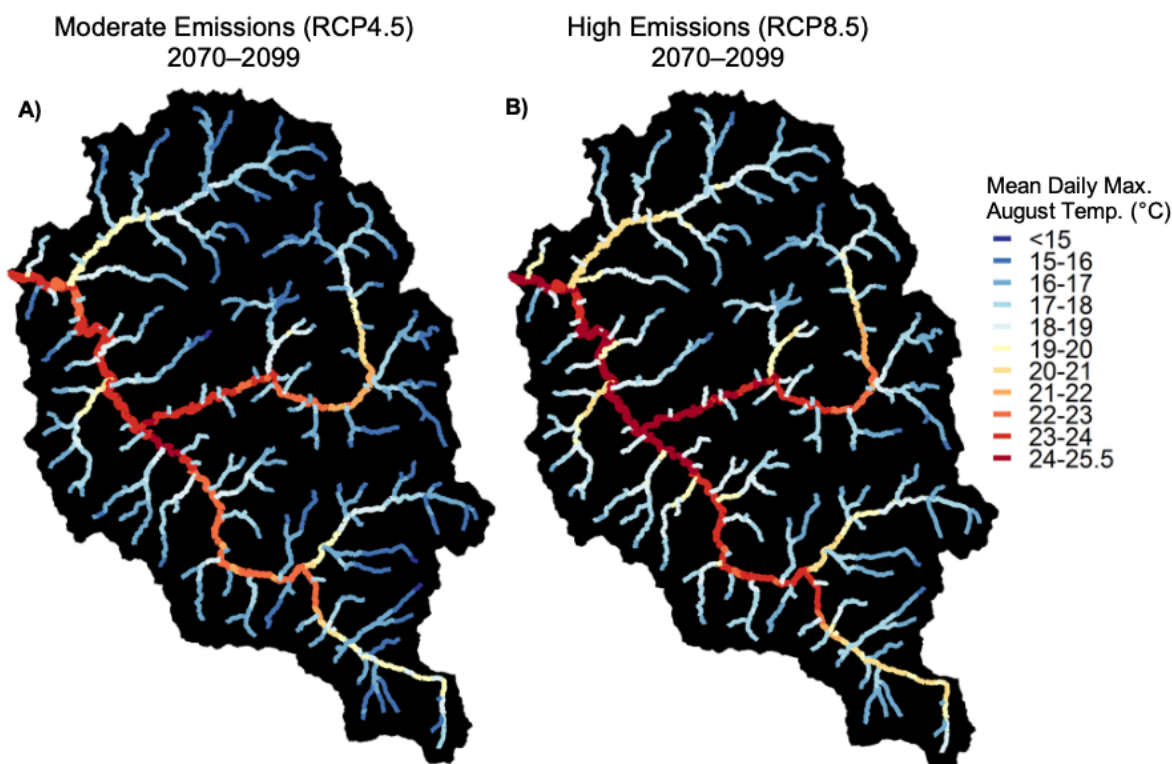
Figure 1.9 Aquatic Monitoring in the Klamath River Basin
(map courtesy of Kenny Suave)



This monitoring data has been utilized in a number of recent climate forecasting efforts. Asarian et al (2019) utilize data from the Salmon River's 20-Year Water Temperature Monitoring Program to evaluate future Salmon River stream temperatures. The authors used predictions from downscaled climate models and hydrologic models to create spatial statistical modeling of stream temperature across the Salmon River basin. Using random forest models calibrated from long-term streamflow stations in coastal California, Grantham et al. (2018) predicted that August stream flows in the Salmon River will decline by 2.35% for each 1°C increase in air temperature from the 1975–1999 baseline (see Asarian et al 2019 for more details). Figures 1.10 and 1.11 are adapted from the Figure 7 in the draft Asarian et al 2019 report so the results presented here are provisional and will likely change. We encourage readers to consult the final draft when it is available. Figure 1.10 portrays their spatial stream-network model predictions

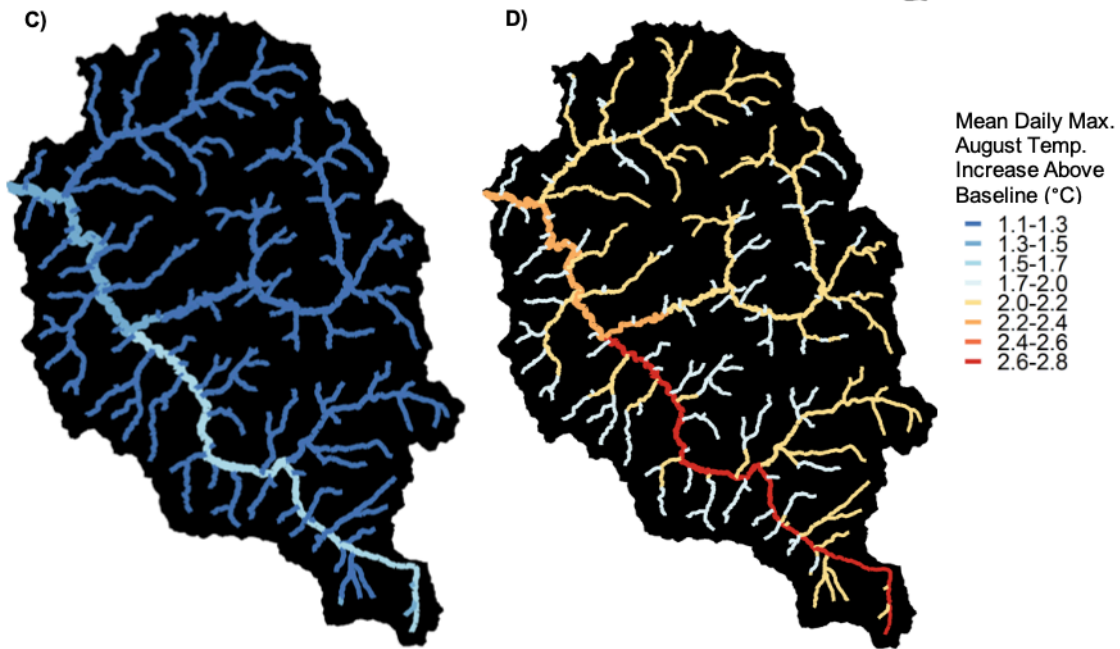
for mean daily maximum stream temperatures for 2070-2099 in the Salmon River sub-basin predicted under a modeled moderate emissions scenario (RCP4.5 shown as A), and high emissions scenario (RCP8.5 shown as B).

Figure 1.10 Forecasted Salmon River Stream Temperatures 2070-2099 (draft maps and data courtesy of Asarian et al 2019)



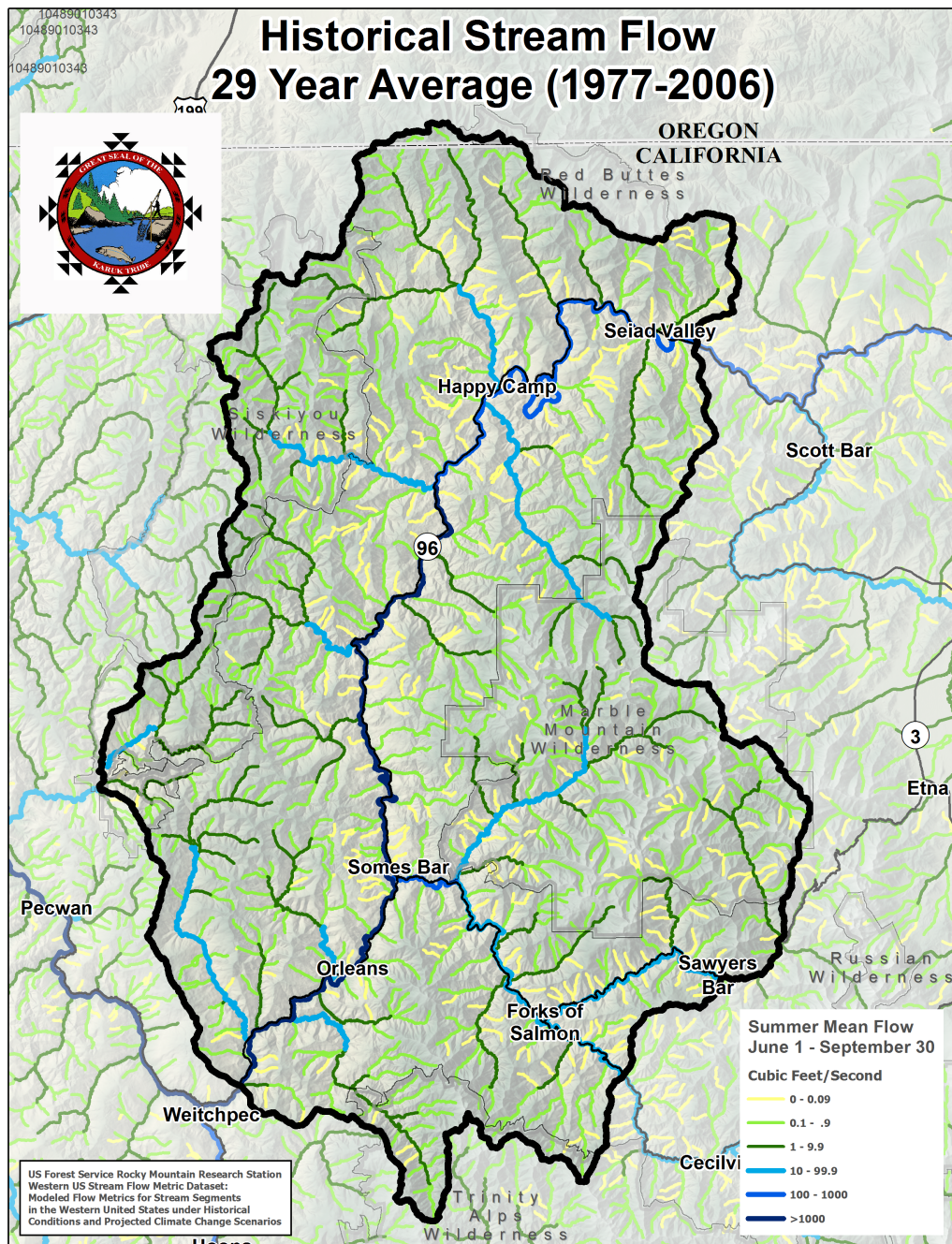
Asarian et al 2019 write that our “spatial models predict that in the 2070–2099 period, mean daily maximum August stream temperatures will warmer than the 1990–2017 baseline by 1.1–1.7°C under RCP4.5 or 2.0–2.8°C under RCP8.5, depending on the reach” and that temperature increases “are predicted to be greatest in the South Fork Salmon River, with lesser increases in the North Fork and mainstem Salmon River. The smallest predicted increases occur in the upper reaches of small tributaries” (10). Figure 1.1 also from Figure 7 in Asarian et al 2019 portrays stream temperature increases between their calculated 1990–2017 baseline and the moderate emissions scenario (RCP4.5 shown as C), and the high emissions scenario (RCP8.5 shown as D).

Figure 1.11 Forecasted Temperature Increases in Salmon River Basin by 2070-2099 (maps and data courtesy of Asarian et al 2019)



Forecasts of both stream temperature and stream flow for the Basin as a whole are less specifically modeled than in above work for the Salmon River watershed. Data from USFS Rocky Mountain Research Station was utilized to provide Figures 1.12-1.14. Figures 1.12 portrays historic summer mean stream flows (June 1-September 30) within the mid-Klamath River and key tributaries (as averaged from 1977-2006) and Figures 1.13 and 1.14 show projected future mean summer stream flows in 2040 and 2080.

Figure 1.12 Historic mid Klamath Basin Summer Stream Flow
(map courtesy of Kenny Suave, data USFS Rocky Mountain Station)



Summer stream flows are forecasted to decrease across the Klamath Basin, Figure 1.13 indicates the predicted decrease in Klamath and key tributaries in cubic feet per second in the coming two decades under the higher emissions scenario.

Figure 1.13 Forecasted Reduction of Streamflow in Klamath River and Key Tributaries by 2040
(may courtesy of Kenny Suave, data USFS Rocky Mountain Station)

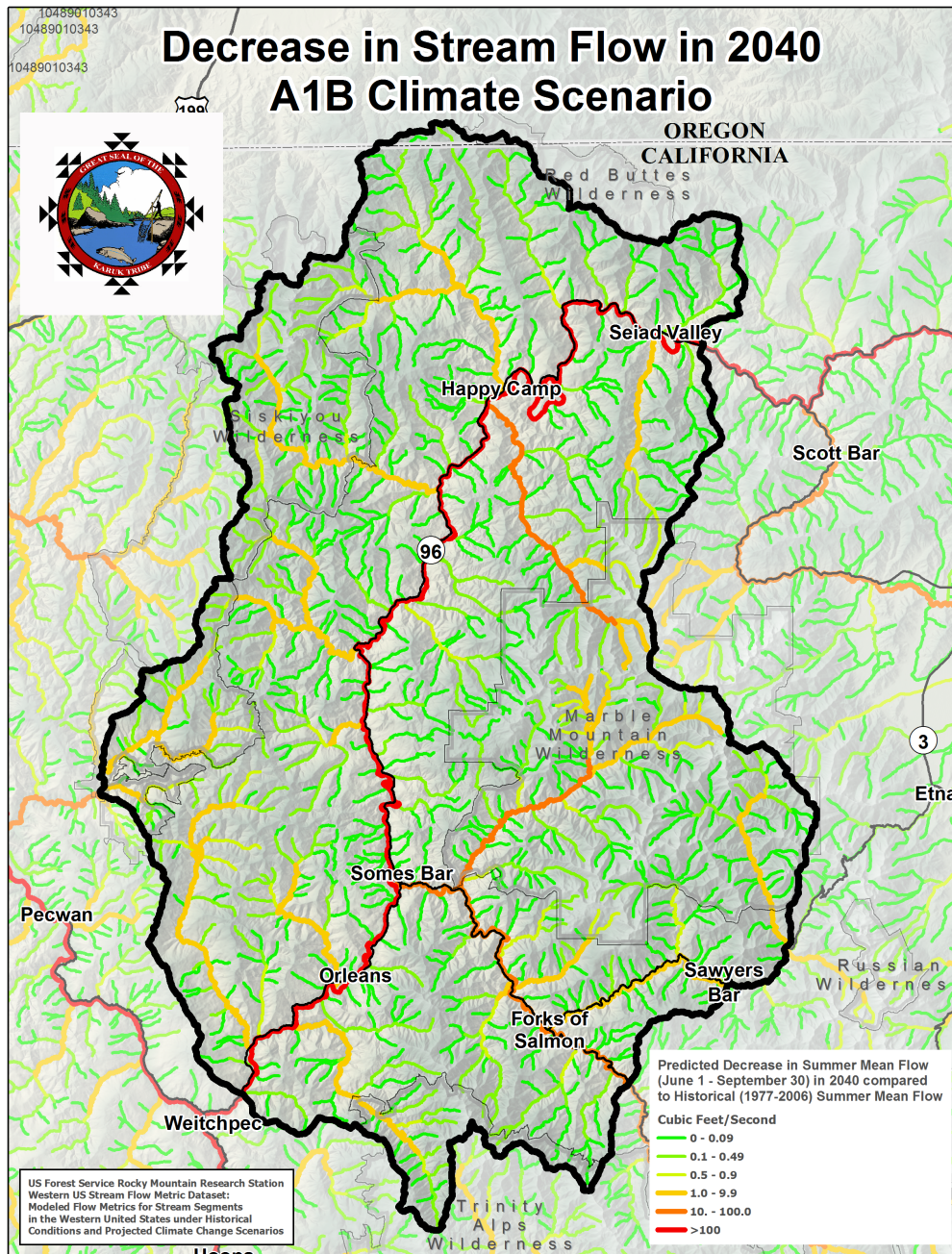
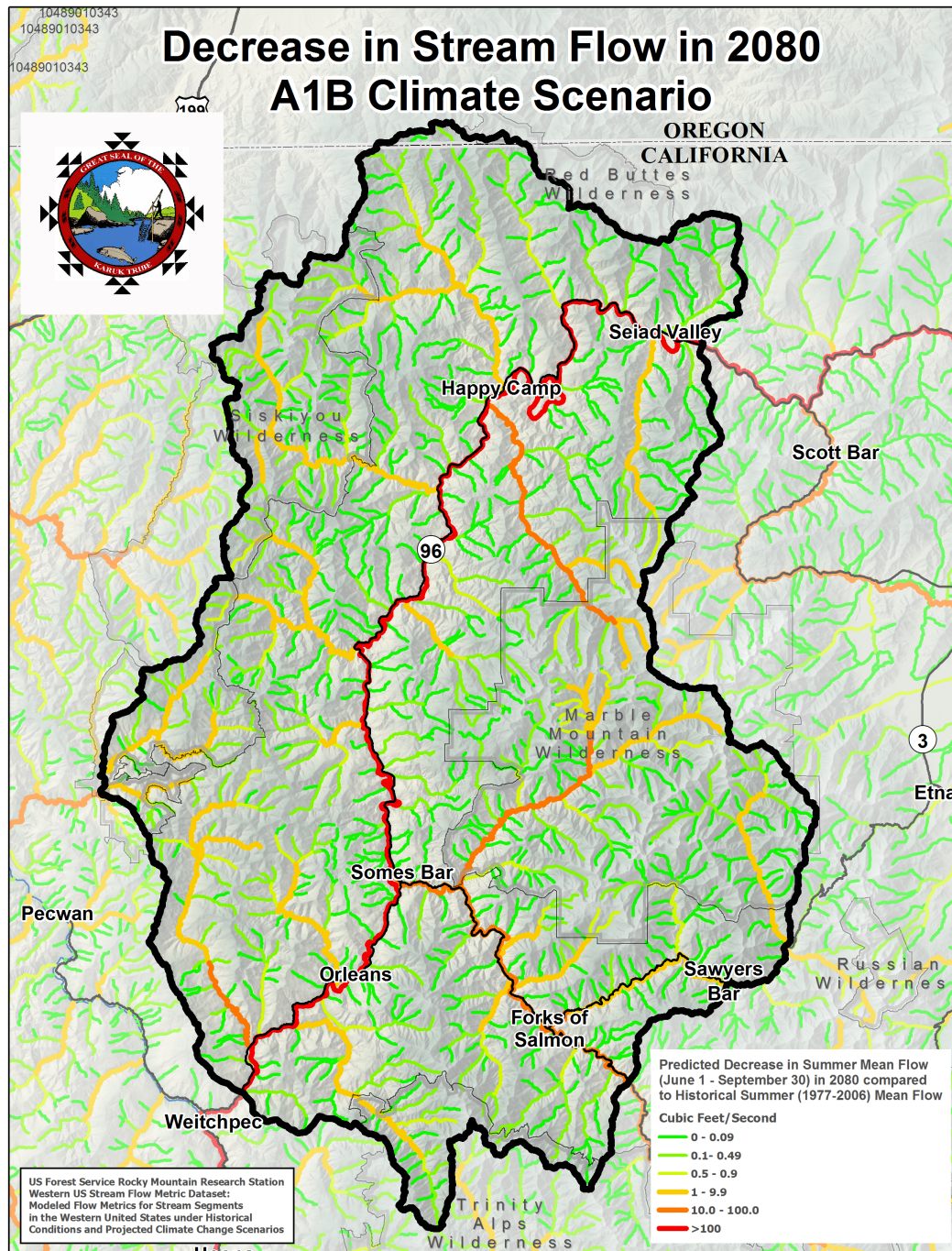


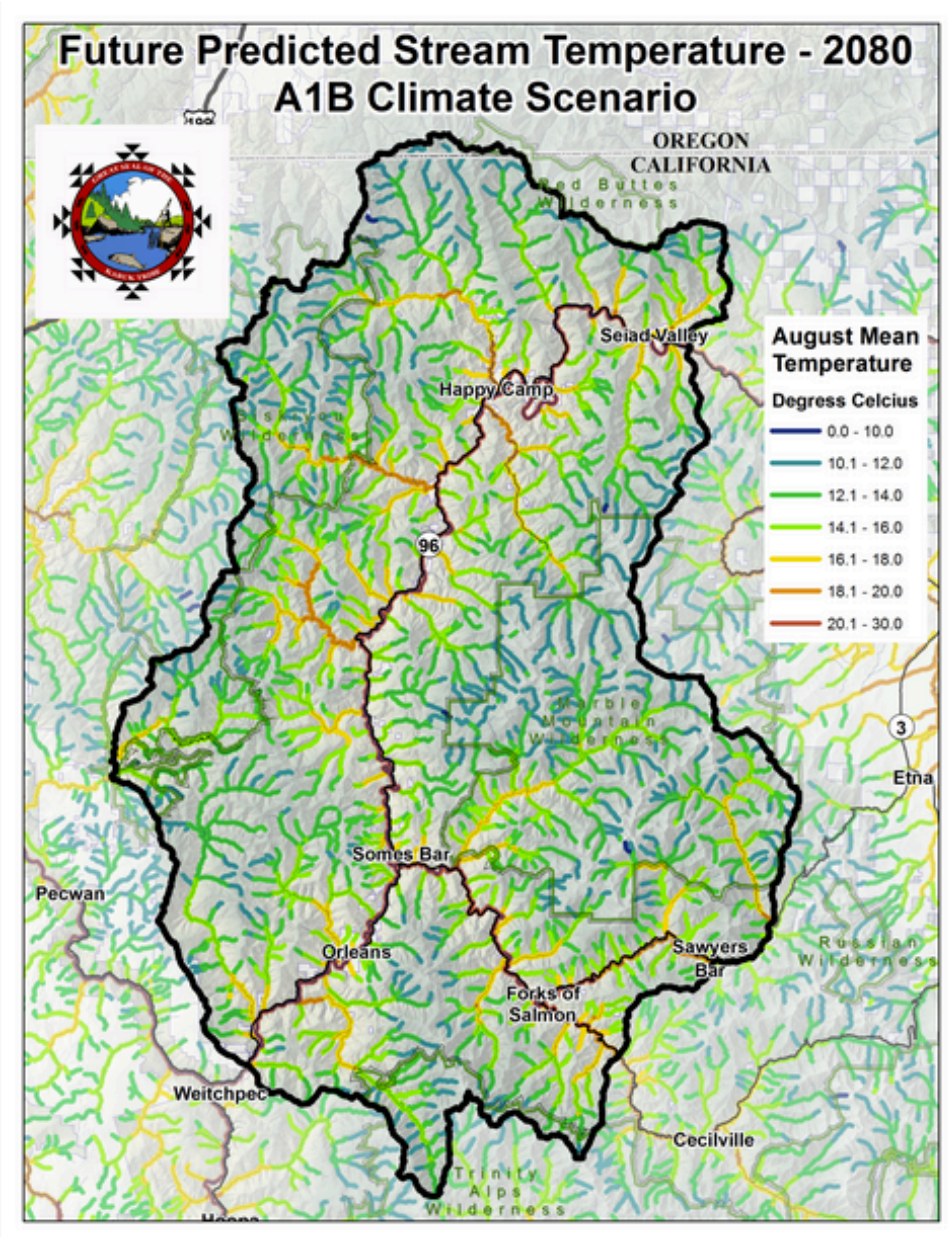
Figure 1.14 indicates the predicted decrease in summer flows for the Klamath and key tributaries in cubic feet per second by 2080 decades under the higher emissions scenario.

Figure 1.14 Forecasted Reduction of Summer Stream Flows Within Mid Klamath Basin 2080
(map courtesy of Kenny Suave, data USFS Rocky Mountain Station)



Stream temperature forecasts also exist for mid Klamath basin, however these data are somewhat complicated as representations average temperatures across tributaries from the headwaters, providing an underestimate of temperatures in key lower sections inhabited by

Figure 1.15 Forecasting of Mid Klamath Basin Stream Temperatures
(map courtesy of Kenny Suave, data USFS Rocky Mountain station)



salmonids. Figure 1.15 illustrates forecasts of future mean stream temperatures in August across Karuk Aboriginal Territory in the year 2080 using A1B climate scenarios.

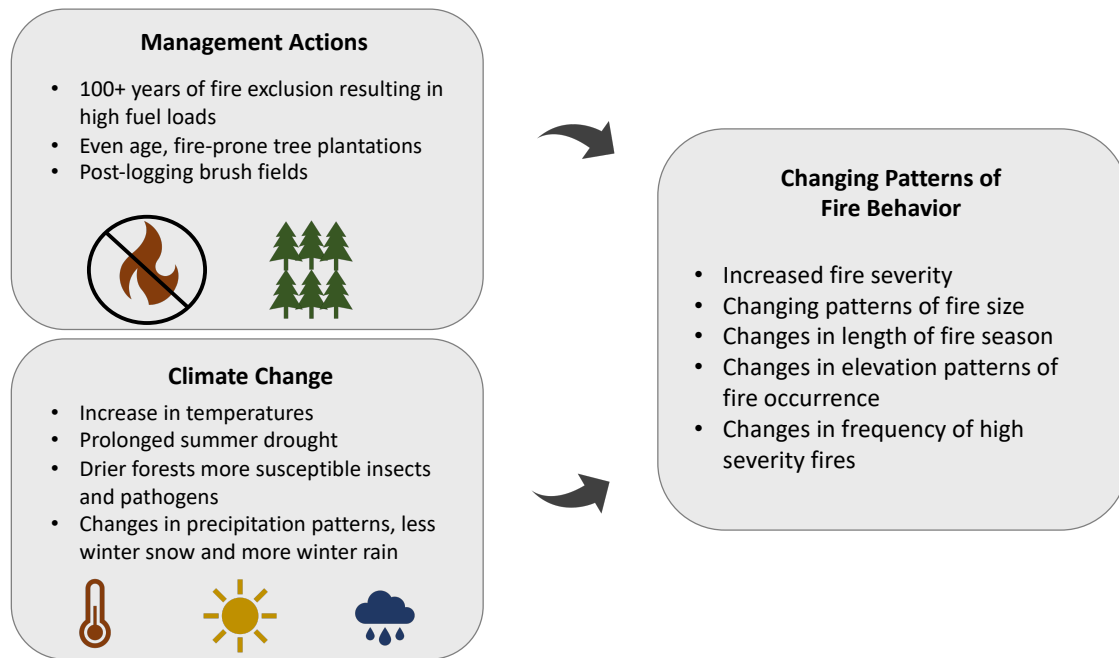
Changing Patterns of Fire Behavior

Changing patterns of fire behavior rank amongst the most pressing of the local dimensions of climate change taking place within Karuk ancestral territory. Due in part to these thousands of years of purposeful fire management, the forests of this region are ecologically dependent on fires that are low in heat production, or “cooler” fires. Western science and traditional ecological knowledge agree that if fire is excluded in these areas for more than 10 to 15 years, the consequences of fire can outweigh the benefits, yet as a result of fire suppression, most forests in the region are missing many fire cycles. Now with the changing climate adding to decades or more of fire exclusion, there is an increasing frequency of high severity fires (Lenihan et al. 2008), Mote and co-authors write:

The largest effects of future climatic variability or change on Northwest forests are likely to arise from changes in fire frequency and severity. Changes in other disturbances, such as wind, insects, and disease, are also possible under climatic change, although the potential character of these disturbances under climatic change is poorly understood. General warming is likely to encourage northward expansion of southern insects, while longer growing seasons are highly likely to allow more insect generations in a season. Forests that are moisture stressed are often more susceptible to attack by insects such as bark beetles and spruce budworm, although the timing and magnitude of effects varies greatly (e.g., Thomson et al., 1984; Swetnam and Lynch, 1993). Interactions between multiple disturbances (e.g., between insects and fire) will be especially important under projected climatic change (2003, p. 71).

Across the state there are increases in the total number of fires. CAL FIRE reports 7,117 wildfires in 2017, compared to an average of 4,835 fires during the preceding five years. The Klamath Basin has experienced a progressive increase in high severity fire in recent years as a result of both climate change and past and present federal land management practices that have led to increased fuel loads (Odion et al. 2004, Miller et al. 2009 and 2012, Taylor and Skinner 2003). In addition to increases in fire severity, there are changing patterns of fire size, changes in the length of the fire season, the elevation patterns at which fires are occurring, and changes in the frequency of these very large hot fires. Note that changes in fire behavior result from a combination of climate change and local management actions. While these patterns of fire behavior are discussed here along with more distinctly atmospheric drivers, they reflect the combination of a century of fire exclusion, the presence of even-age highly fire prone tree ‘plantations,’ post logging brush fields, and changing patterns of temperature and precipitation have led to a series of very large, hot fires within Karuk ancestral territory and homelands (Odion et al. 2004).

Figure 1.16 Factors Contributing to Changing Patterns of Fire Behavior

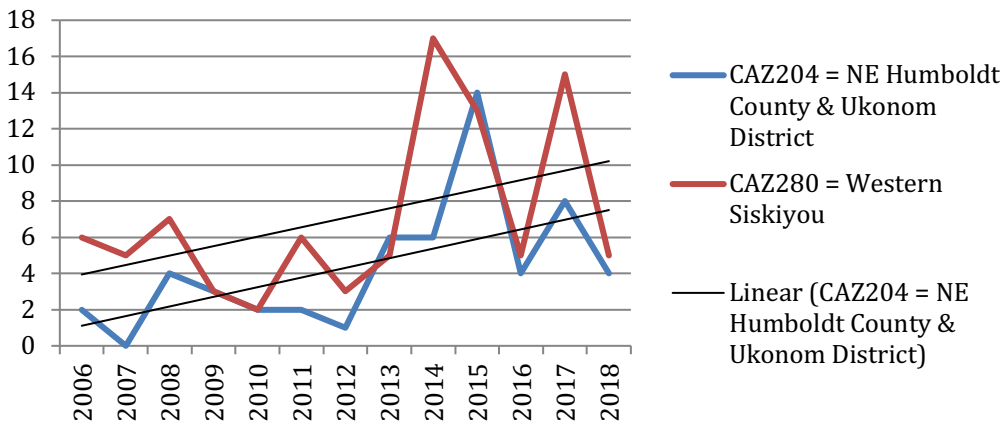


Karuk Aboriginal Territory has experienced large fires every year in the past decade. Data from the NW Climate Toolbox indicate that whereas there have been 36.5 days of very high fire danger for Karuk Aboriginal Territory in recent times, this figure is expected to increase by 12 days by the end of the century, while the number of extreme fire days expected to increase by 6 days by the end of the century.

Karuk Aboriginal Territory spans two fire zones (204 and 280). Figure 1.17 portrays the changing number of fire weather or “red flag warnings in each zone between 2006 and 2018.² Note that the fire season picks up earlier in Zone 204 than it does in Zone 280 and that drought years of 2013-2015 had more red flag warnings.

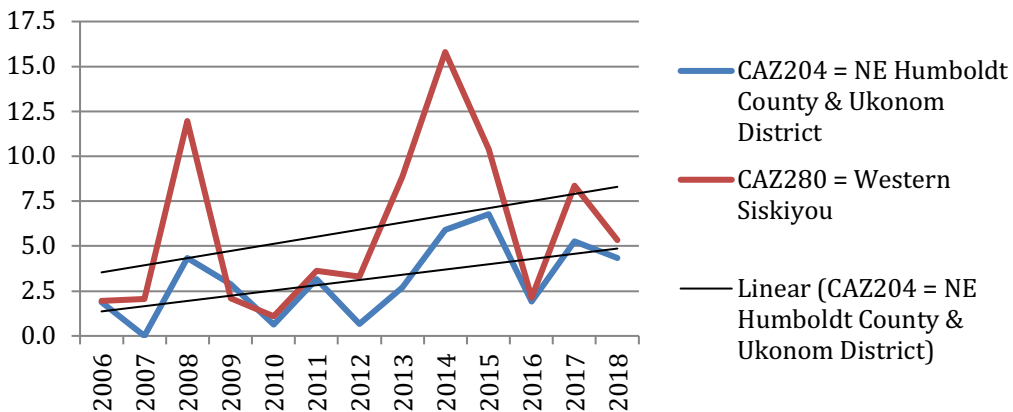
² Graphs courtesy of Jill Beckman. Data from <https://mesonet.agron.iastate.edu/request/gis/watchwarn.phtml>

Figure 1.17 Number of Fire Weather Watches/Warnings Between 2006 and 2018



The length of time (days) that each fire weather warning was in effect also increases over this time period in both zones, see Figure 1.17

Figure 1.18 Length of Time of Fire Weather Warnings in Days



Furthermore, climate change already translates into an increase in the length of the fire season. This is visible in the changing patterns of fire weather warnings throughout the year for the recent past as illustrated in the next set of graphs. During the peak of the California drought, 2014 fire weather warnings occurred in January. This preceded a devastating fire season, as illustrated in Figure 1.18 below portraying the total number of Red Flag Warnings by month for recent fire seasons in both zones.

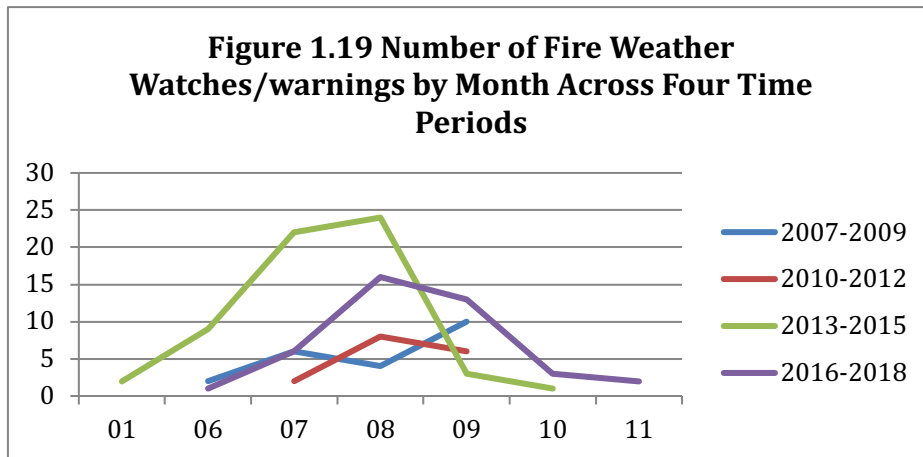


Figure 1.19 indicates the total length of time of red flag warnings (in days) by month for recent seasons (both zones combined).

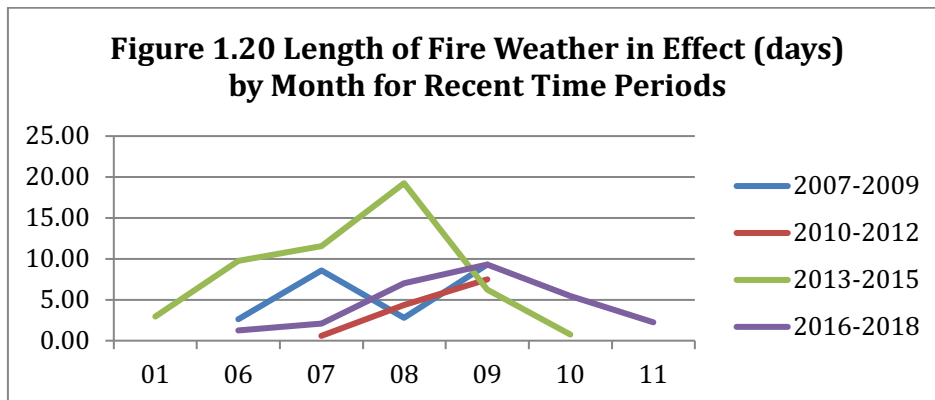
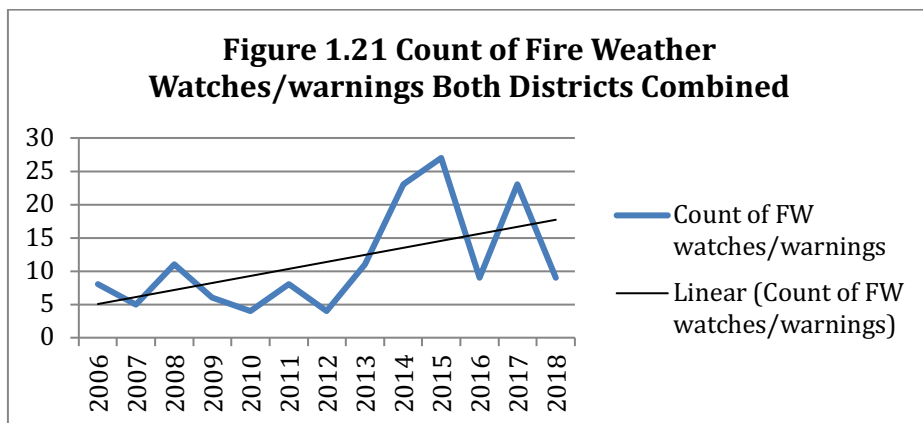
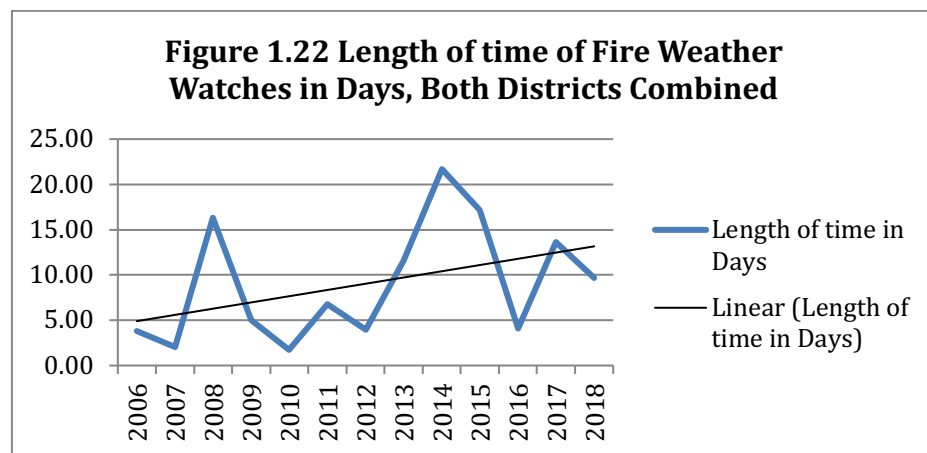


Figure 1.20 indicates the overall increase in the number of red flag warnings for both districts combined between 2006 and 2018.



Lastly, Figure 1.22 portrays the overall increase in the length of time that red flag warnings last for both districts combined across the 2006 to 2018 time frame.



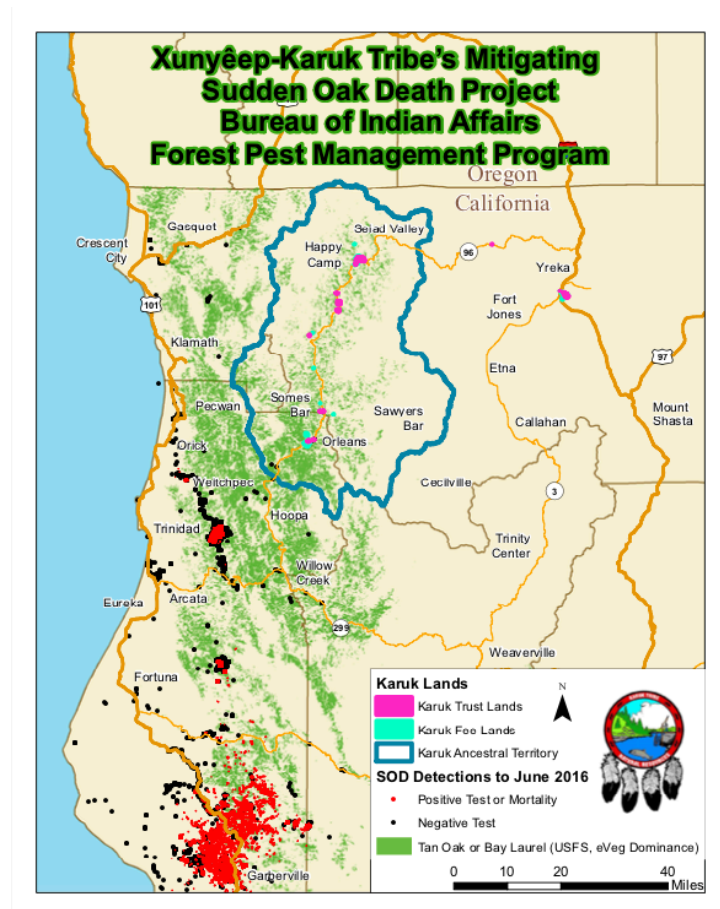
Species Invasions, Pests, Pathogens, and Species Range Expansions

Species invasions, increases in the intensity of pest and pathogen and disease outbreaks and the range expansion of species are additional dimensions of the changing climate that interact with both the changing patterns of precipitation and temperature, increasing frequency of high severity fires and other management actions. Invasive species such as scotch broom, star thistle, Himalayan blackberry, non-native grasses and many others are already well established within Karuk Aboriginal Territory. Many of the abovementioned terrestrial invasives exacerbate fire behavior through the production of long flame lengths. Other forest pest dynamics that are appear to be climate driven or enhanced in the Klamath Region include the fir engraver beetles that are associated with Shasta Red Fir mortality (DeSiervo et al 2018) and *Phytophthora ramorum*, which causes Sudden Oak Death. Other pathogens such as the Goldspotted oak borer have yet to be found in the region but are nonetheless of potential concern.

Within riverine systems a number of invasive species and native and non-Native fish pathogens already pose significant challenges for anadromous and other species of importance to Karuk people (Stocking and Bartholomew 2005 and 2007). The changing riverine environments, produce novel fish–pathogen dynamics that can in tern exacerbate the potential for spread and infection of diseases. Favorable habitats in the form of pathogen thermal refugia will disappear, and these future conditions will further stress native fish, thereby favoring the introduction, establishment, and distribution of invasives (Hellmann et al. 2008; Quiñones and Moyle 2014). Loss of thermal refugia, increased thermal stress, and relative abundance of invasive species may collectively compound the establishment of new and more virulent

pathogens (Chiaromonte, Munson and Trushenski, 2016). Two common fish diseases implicated in the 2002 adult salmon fish kill are *Ichthyophthirius multifiliis* or Ich, a protozoan, and *Flavobacterium columnare* or Columnaris, bacteria under conditions of low flows and elevated river temperatures – conditions forecasted to increase with future climates. A leading cause of juvenile salmonid mortality in the mid Klamath is from the polychaete worm *Ceratomyxa shasta* (Stocking and Bartholomew 2005 and 2007). *C. shasta* habitat may expand with conditions in the changing climate including increased growth of *Cladophora* algal mats (Chiaromonte 2013, Chiaromonte et al 2016). Among the most concerning invasive pathogens impacted by climate change is *Phytophthora ramorum*, which causes Sudden Oak Death (Ortiz 2008, Voggeser et al. 2013). This pathogen is spreading via natural and anthropogenic means and has destroyed millions of oak and other trees, and has caused twig and foliar diseases in additional plant species across California since the 1990s. See Figure 1.22 below

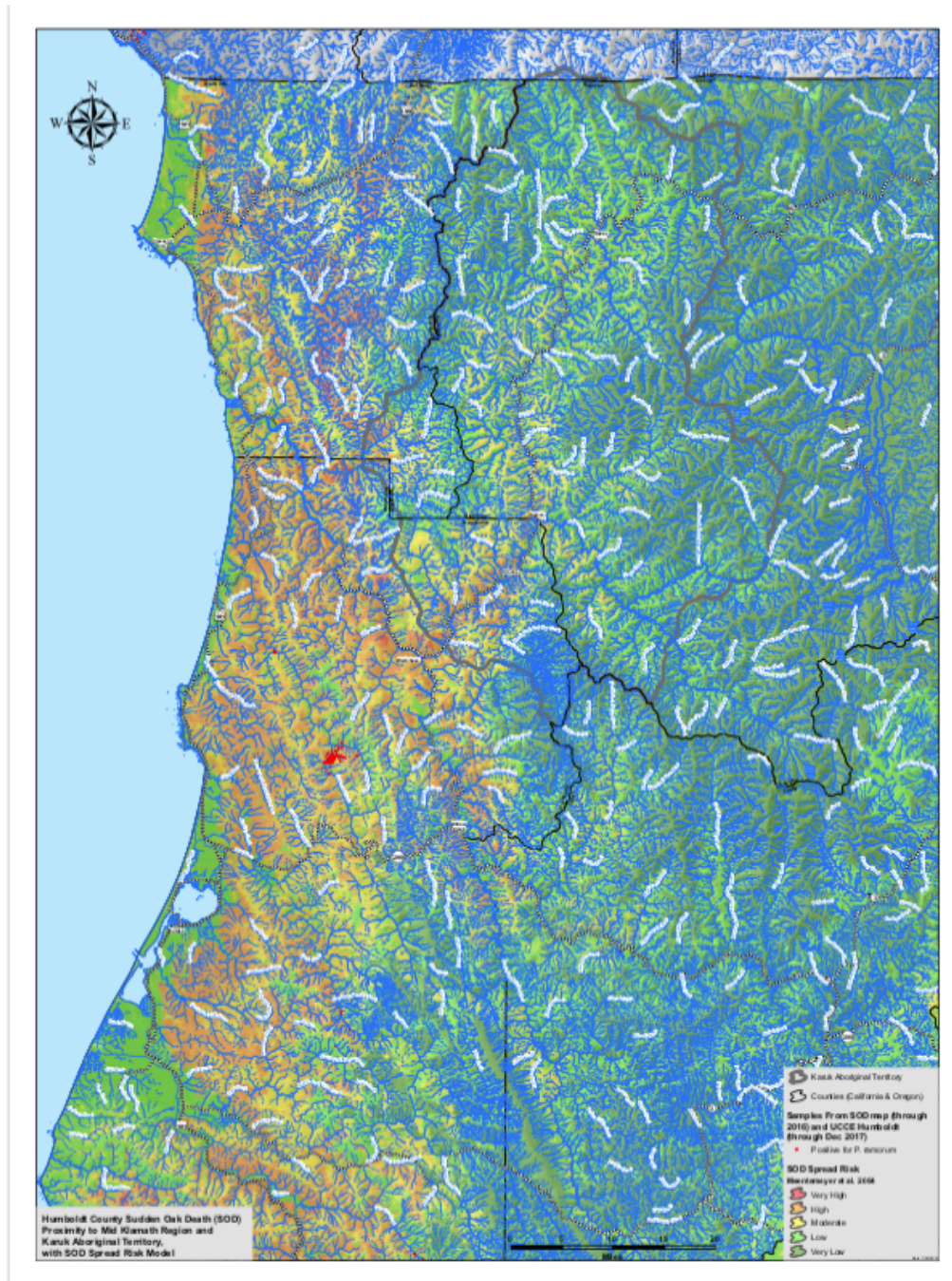
Figure 1.23 Xunyeep-Karuk Tribe's Mitigating Sudden Oak Death Project



Warmer and wetter environments including increased precipitation during spring and early summer are likely associated with increased spread of SOD pathogen (Kliejunas, 2011). As of

December 2018, the nearest *Phytophthora ramorum*, infection site is 13 air miles from the southern boundary of Karuk Ancestral Territory (see Figure 1.23 below).

Figure 1.24 Estimate of Phytophthora ramorum Spread Risk
(map courtesy of Brendan Tweig)



Given estimated annual disease dispersal rates of 2.5 miles or farther, and contiguous suitable habitat between current infestations, infection within Karuk territory is presumed within a few

years. Figure 1.23 indicates an estimate of the spread risk of *P. ramorum* determined by a static model created by Ross Meentemeyer that summarizes the inherent susceptibility of areas to SOD based on their host distributions and climates (map courtesy of Brendan Tweig). Sudden oak death and other lethal invasive forest pathogens hold the potential to increase fire danger in coming years.

Spread of the *P. ramorum* pathogen has been observed to “jump over” areas recently burned leaving no detected infection in the burned area. Conversely, burns in infected areas have shown disease persistence in trees infected prior to burning. These trends suggest that prescribed fire could be more effective as a preventative mitigation than a sanitation treatment.

* * *

The material in this chapter is presented to provide overall context and grounding for the specific adaptations for species, habitats, program capacities and tribal sovereignty in the following chapters. It does not constitute an exhaustive presentation of existing data, climate forecasts or descriptors of dynamics at play. For more detail on climate dynamics, trends and forecasts see California’s Fourth Climate Assessment, the Fourth National Climate Assessment, climate models and data sources listed in the References of this report and scientific papers cited within this chapter.

CHAPTER TWO: There Are Many Ways to Fix the World, Adaptation Goals and General Strategies

- *Restore human responsibilities, revitalize Karuk traditional ecological management*
- *Reestablish traditional fire regimes adapting to modern climate*
- *Enhance ecosystem resilience, reduce intervening ecological impacts*
- *Expand Tribal management authority, sovereignty and program capacities*
- *Strengthen partnerships and increase interjurisdictional coordination*
- *Continue community engagement and public education*
- *Advocate for policy change to increase effectiveness of local strategies*
- *Increase self-sufficiency, system redundancies and backup systems*
- *Expand monitoring of climate, ecological dynamics and adaptive practices*
- *Expand research capacities in support of tribal and community science needs*

This plan centers climate adaptation in Karuk aboriginal territory around the **revitalization of Karuk cultural management, the restoration of fire regimes, and the reduction of negative ecological impacts from intervening factors** such as dams, plantations and water diversions. At a practical level implementing these climate adaptations will require **increased interjurisdictional coordination** and the **expansion of Karuk tribal management authority and sovereignty** as discussed in Chapter Seven. These measures will also enable the necessary expansion of tribal capacity as discussed in Chapter Six. **Community engagement** and **public education** in light of fear of fire, increasing awareness of fire as a necessary and natural process in light of climate change, and expanded research and monitoring will all be vital, see Table 2.1

Restoring Human Responsibilities

The exceptional biological diversity of the mid-Klamath River region Northern California has emerged in conjunction with sophisticated Karuk land management practices, including the regulation of the forest and fisheries through ceremony and the use of fire. Particular places in the landscape such as fishing sites, gathering sites, and

ceremonial grounds hold profound and unique importance for Karuk people. Karuk tribal members have responsibilities to tend to and care for the food and cultural use species they consider as relations. Amongst the activities that Karuk people are supposed to do as their part of the pact is to burn the forest. As Karuk Eco-Cultural Restoration Specialist William Tripp describes

They used to roll logs off the top of Offield Mountain as part of the World Renewal Ceremony in September, right in the height of fire season so that whole mountain was in a condition to where it wouldn't burn hot. It would burn around to some rocky areas and go out. It would burn slow. Creep down the hill over a matter of days until it just finally went out. When it rained it would go out and that's what we wanted it to do.

Karuk management practices have been interrupted by genocide and ongoing presence of non-Native land management practices. In particular the exclusion of fire has led to radical ecological changes including high fuel loads, decreased habitat for large game such as elk and deer, reduction in the quantity and quality of acorns, and alteration of growth patterns of basketry materials such as hazel and willow. Across California the increasing frequency of high severity fire points to the need to re-examine human relationships with fire. Today, with climate change the traditional Karuk task of *fixing the world* involves dealing with new threats to both riverine and “upslope” forest or broader landscape habitats and species in the face of climate change, as shifting and increasingly variable precipitation patterns impact stream flows, snowpack, river temperatures and fire regimes (Butz et al. 2015, Melillo et al. 2014, Karl et al. 2009, Spies et al. 2010, Lata et al. 2010, Fettig et al. 2013, Wimberly and Liu 2014, Mote et al. 2014). In the context of climate change, Karuk tribal knowledge and management principles can be utilized to reduce the likelihood of high severity fires and thereby protect public as well as tribal trust resources (Norgaard 2014). Climate adaptation is an opportunity to restore the human responsibility to other species. In the Cultural Resources Specialist Report (Tripp, Watts-Tobin and Dyer 2017) share the story of how coyote steals fire to illustrate how “People need to work with all the animals, and to manage the landscape from the lowest points to the highest. Care of the environment covers all the plants and animals, and is an obligation for the humans who live there” (p. 3). Tripp, Watts-Tobin and Dyer (2017) emphasize how cultural resources and Traditional Ecological Knowledge “provide a living memory of human use and responsibility in context of place and can help us realize the stories of the past in the formulation of our contemporary future. By reconnecting the human role to the whole

landscape, we can strengthen the spiritual, subsistence and management practices that the place calls the people to perform” (p. 7).

Revitalize Traditional Ecological Management

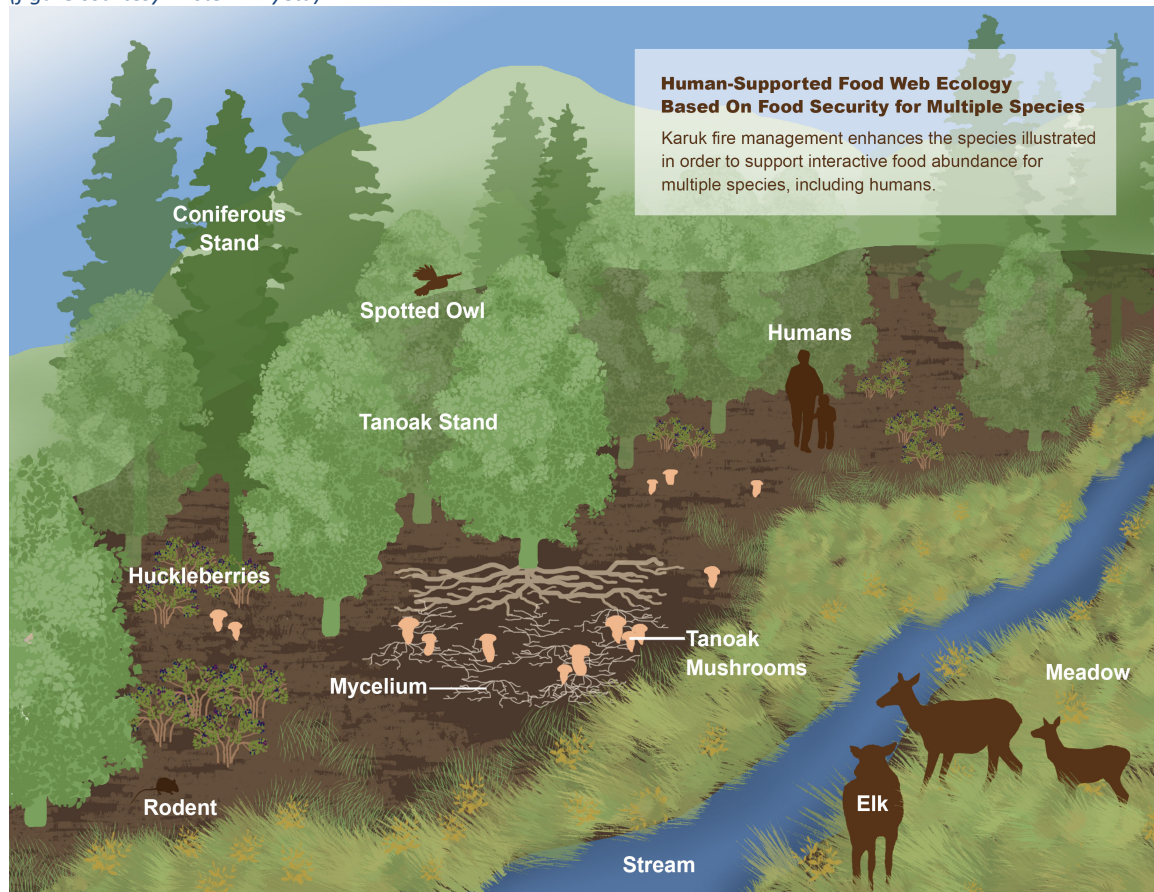
This climate adaptation plan utilizes a combination of western science and traditional ecological knowledge. For countless generations, Karuk people have observed the behavior of particular plants and animals to understand ecological dynamics, and as a guide for necessary human management. Within this system of traditional management, multiple species of importance to Karuk people play vital roles as cultural indicators for appropriate human actions. The return of particular migrating birds signals the timing of the eel run, the appearance of Pleiades in the night sky denotes the time for cultural burning, while the behavior of other species warns of danger. This knowledge gained from attending to the land over generations is inscribed in ceremonies and prayers.

These longstanding social-ecological relationships and practices have been interrupted by genocide and European settlement, including the imposition of non-Native land management policies and ways of understanding the world. While these interruptions have been significant and have taken place over an extended period of time, cultural and ecological information is retained in ceremonies, stories and collective memory. As noted in The Somes Bar Project Cultural Resources Specialist Report (Tripp, Watts-Tobin and Dyer 2017) “This world view establishes a belief system that protects the balance in nature, while remaining rooted in practice and enabling observational knowledge accumulation through intergenerational change” (p. 4). Indicators of prior fire regimes and management systems remain evident also in the landscape. Today, revitalizing the practice of attending to the presence and behavior of other species as cultural indicators to guide human management actions is a necessary step in the face of climate change. As emphasized by William Tripp, Karuk people need to be intimately involved in revitalizing Karuk ecological knowledge practices. This information and approach provides a sideboard using sound cultural management principles for managing the unknown in a changing climate. The climate adaptations in this chapter utilize Karuk Traditional Ecological Knowledge alongside western science, centering on the revitalization of 21 focal species as cultural indicators for human responsibilities and necessary human actions. Focal species represent specific components of the landscape which taken together provide a holistic approach to overall landscape management.

Restoring Traditional Fire Regimes

Karuk People have historically used fire for millennia. While fire can be incredibly dangerous, it is an inevitable part of natural ecosystems, especially in lightning-prone forested areas such as the mid-Klamath. Forested areas in northern California have become adapted to frequent occurrence of relatively low intensity fire from human and natural ignitions for more than the past 1,000 years (Perry et al. 2011, Taylor et al 2016). Karuk use of fire has been central to the evolution of the flora and fauna of the mid-Klamath (Anderson 2005, Lake 2007 and 2013, Lake et al. 2010, Skinner et al. 2006). These fire adapted forests burned in smaller overall areas in mosaic patterns with patches of high intensity fire (Mohr et al. 2000, Skinner et al. 2006, Perry et al. 2011). Fire has long been an important tool to manipulate landscape to patch-scale fires necessary for Karuk cultural sustenance and well-being (Lake 2013). Indeed, Karuk culture is directly dependent on mixed fire severity regimes (Lake 2007, Norgaard 2014). Karuk fire management practices include burning at a specific season, frequency, and intensity at a variety of severities. This frequent, low-intensity fire is linked with various fire-adapted vegetation communities and it necessary for the maintenance of cultural resources. Fire is especially critical for restoring grasslands for elk, managing for food sources including tanoak and black oak acorns, maintaining quality basketry materials, producing smoke that shades the river for fish, and more.

Figure 2.1 Karuk Cultural Burning Produces Species Abundance
 (figure courtesy Kirsten Vinyeta)



Karuk fire regimes generate pyrodiversity by supporting plants that are adapted to low fire severities, extending the burn season, and shortening fire return intervals. The passage of the Weeks Act in 1911 following the Big Burn of 1910, made cultural uses of fire essentially illegal and for the many decades following, less and less burning occurred while more and more vegetation grew. Over a century of policies of fire suppression have created the conditions for the catastrophic, high-intensity wildfires we are seeing today. Warming temperatures and summer droughts further exacerbate these conditions.

In the context of climate change, Karuk tribal knowledge and management principles regarding the use of fire are being utilized to reduce the likelihood of high severity fires. Fortunately, in the face of the changing climate, many ecologists, fire scientists and policy makers, Native and non-Native alike have turned to indigenous knowledge and management practices with renewed interest and optimism in the hope that they may provide a much-needed path towards both adaptation and reducing emissions (Williams and Hardison 2013, Martinez 2011, Raygorodetsky 2011, Vinyeta and Lynn 2013, Whyte 2013, Wildcat 2009). In particular, there is increasing recognition

of the importance of indigenous burning as an ecosystem process and restoration technique.

Enhance ecosystem resilience, reduce intervening ecological impacts

Species, habitats and human communities experience climate impacts in the context of a wide variety of intervening stressors. Any climate related event such as a large flood or wildfire occurs in the context of management actions leading up to the event, during the event and afterwards. Indeed such actions may create larger impacts than the “climatic event” itself. A major approach to climate adaption therefore is to attend to the many intervening non-climate stressors on ecosystems. The Karuk Tribe has long engaged in robust restoration activities including dam removal, road decommissioning , stream restoration, fuels reduction and prescribed burning, correcting water diversions and culvert upgrades and other efforts enhance ecosystem resilience. The importance of these activities has never been greater.

Expand Tribal management authority, sovereignty and program capacities

As a sovereign government, the Karuk Tribe claims jurisdiction over membership, lands and territory including the right to manage air, lands, waters and other resources as specified in the Karuk Constitution. The Karuk Climate Vulnerability Assessment identified major dimensions of tribal vulnerability related to jurisdictional recognition and its results for tribal management authority and sovereignty. Expanding landscape restoration efforts, expanding the use of cultural burning and managed wildfire to maintain appropriate fire frequencies all requires the Karuk Tribe’s ability to exert management authority. There are a number of mechanisms through which this can be done, for example:

- recent expansion of 638 authority for Tribal Forest Protection Act management activities and food distribution programs (USDA) under the Indian Self-Determination and Education Assistance Act,
- the U.S. Department of the Interior, eligibility for tribal nations to exercise Good Neighbor authority for forest management agreements with USDA and states
- the ability to extend tribal land management plans to cover National Forest System Lands under the Indian Energy Act.

Strengthen partnerships and increase interjurisdictional coordination

Responding to the impacts of the changing climate whether in the form of drought, increased high severity fire, flooding or species invasions requires coordination across jurisdictions with multiple federal and state governmental entities. Relationships and collaborations are needed more than ever in light of climate change. Karuk community relies on infrastructure, including roads and utilities (water, power, telephone, internet), most of which are supplied by non-tribal entities who will be under pressure from multiple directions with increases in fire activity and flooding in response to the changing climate.

The Karuk Tribe has been a leader in the Western Klamath Restoration Partnership (WKRPP) – a collaborative that is using traditional ecological knowledge and the cultural use of fire to promote community and forest resiliency. The WKRPP can serve as a model of collaborative land and fire management planning and implementation involving tribal, federal, local partners, as well as non-governmental organizations (NGOs). The crisis posed by climate change is a strategic opportunity not only for tribes to retain cultural practices and return traditional management practices to the landscape, but for all land managers to remedy inappropriate ecological actions, and for enhanced and successful collaboration in the face of collective survival. Partnerships are essential to face the large-scale multijurisdictional challenge of climate change.

Continue community engagement and public education

Wildfires are widely presented in the media as “natural disasters:” dangerous elements of the natural world over which humans have little control. Coupled with the language of climate change, the fear of fire and sense of its inevitability can be overwhelming, leaving people with the sense that there is little that can be done. Nothing could be further from the truth. Whereas the persistence of fire bellies the myth that humans have *control* over nature, humans and fire *have long co-evolved*. Fires can indeed be dangerous, but in mountainous regions prone to lightning strikes such as the Klamath, fire is an inevitable and necessary ecosystem process with which humans have long adapted. Policy potential to support the use of Karuk traditional fire management is limited by fear from the general public and policy makers about fire, as well as by limited public understanding about the fire adapted landscapes that have co-evolved with tribal management. The Tribe has been active in public engagement and education through media productions, speaking to journalists and print media, blogposts, distributing information through networks (e.g., Fire Adapted Communities Learning Network, Western Klamath Restoration Partnership), websites (Karuk Climate Change Projects website), the Tribal website, quarterly newsletter, Facebook and more.

Advocate for policy change

Climate change is rapidly reshaping the legal landscape as changing ecological conditions and political dynamics are generating numerous planning efforts, judicial rulings, policies, and collaborative configurations of state and federal actors (Bronen 2011, Burkett 2011, Kronk Warner 2015, Mawdsley et al. 2009, Ruhl 2009). The changing policy terrain will provide new and emergent opportunities for the expansion of Karuk management such as the recent expansion of 638 authority for Tribal Forest Protection Act management activities coupled with the ability to extend tribal forest management plans to the National Forest System for incorporation into the Forest Plan revision process for the Six Rivers and Klamath National Forests.

The Karuk Tribe plays a leading role in coordinating with state and federal agencies regarding policy development to promote traditional management. It will be important to be prepared for emerging policy formation opportunities and continue communication and collaboration with federal and state partners. A key area concerns gross negligence clauses for prescribed burning. States such as Florida have gross negligence clauses for prescribed burners and land owner rights to burn well established in law. Gross negligence clauses are also appropriate for indigenous communities that need to revitalize their relationship with fire or risk loss of cultural identity.

Increase self-sufficiency, system redundancies and backup systems

As changing patterns of temperature, precipitation and fire behavior affect species compositions, road closures, power outages and other disruptions will also increase. The creation of self-sufficiency and *system redundancies* will be necessary. This adaptation plan emphasizes the need for backup systems, but also strengthening of relationships across the community, and across agencies as a means of strengthening self-sufficiency and creating redundancies. This principle of developing system redundancy as an adaptation approach can be applied to everything from expanding communication backup systems, the acquisition of backup generators for power outages and increasing emergency food supplies, to shifting emphases on a greater variety of traditional foods management to mitigate for years when tanoak acorns or other foods are scarce.

Expand monitoring of climate and general ecological dynamics

Expanded research and monitoring of ongoing climate dynamics and their relationship with other non-climatic stressors will all be vital and are central to the traditional management approach taken in this Plan. Expanded emphasis on monitoring is emphasized throughout the document but is particularly important in Chapter Three

where adaptations for 21 focal species are an outgrowth of the application of a traditional management approach. In this case actions taken on the landscape under the changing climatic conditions will provide direction as to how to proceed. Models produce potential outcomes based on observable trends and can be useful in providing a foundation for action. However, while larger trends are known, dynamics and thresholds for global climate drivers at smaller spatial and temporal scales are less predictable. The scenarios identified in this plan pose starting points for actions, ongoing adaptations will require attention to Karuk cultural indicators.

Expand research capacities

While enough is understood at a broad scale about the changing climate that many actions can be taken now, there are more uncertainties in terms of how impacts will unfold in particular places and times. Tribes, agency partners and other collaborators are at the cutting edge of developing best practices regarding critical issues of species concern such as how to slow the spread of sudden oak death and other forest pathogens, aquatic fish diseases, and more. Expansion of the research capacities of the Píkyav Field Institute will be essential as part of a traditional knowledge approach. University partnerships can bring valuable capacity and expertise to support tribally directed research needs. Table 2.1 summarizes this overall approach to climate adaptation planning with examples.

Table 2.1 Adaptation Implementation Approach Summarized	
Adaptation Strategy	Specific Examples, see also WKRP Plan
Restore historic fire regimes (e.g. traditional management and lightning ignitions)	<ul style="list-style-type: none"> - Eco-cultural: Utilize cultural indicators when, how and where to burn by habitat and resource type - Eco-cultural: Employ strategic stepwise processes to return historic-like cultural fire regimes at landscape scale - USDA FS Shared Stewardship, and Cal. State Fire plan, Policy/authorities that tier to USFS-Karuk Tribe Wildland fire management agreements, TREX, and other approaches for prescribed cultural burning. - Administrative: Develop programmatic NEPA - Governance: Utilize 638 contracting authority for Tribal Forest Protection Act - Admin: Build Integrated Wildland Fire Management Program capacity - Admin: Enable Type 3 Fire Management Team, prescribed fire, cultural burning, managed wildfire training, implementation, and workforce development facility

Enhance ecosystem resilience, reduce intervening impacts	<ul style="list-style-type: none"> - Physical/Infrastructure: e.g. dam removal, road decommissioning and storm proofing, culvert upgrades - Ecological: Increase in-stream flows, thinning of meadows, grasslands, forests
Expansion of Tribal Management Authority	<ul style="list-style-type: none"> - Utilize 638 Compacting/Contracting Authorities - Utilize Stewardship Agreements - Utilize Tribal Forest Protection Act Authorities - Revise and Complete ECRMP with programmatic NEPA coverage - Legal strategies, see knowledge sovereignty report
Expand Tribal Organizational Capacity	<ul style="list-style-type: none"> - 638 Compacting/Contracting Authority - Build Integrated Wildland Fire Management Program capacity - Youth training and workforce development - Expand Facilities identified in Strategic Facilities Master Plan - Grow Endowment for Eco-cultural Revitalization
Continue Community Engagement	<ul style="list-style-type: none"> - News media, Blogs, Facebook, Websites, Conference Presentations - TREX and other field trainings for adaptive practices - Workshops/culture climate camps (seasonal)
Increase interjurisdictional Coordination	<ul style="list-style-type: none"> - Outreach, Joint Projects, Reports - Legal pressure - Local area Operating Plan - Direct Protection agreement with Cal-Fire - Tribal Implementation Plan for Air Quality - Tribal issuance of fire and air quality permits (exemptions-variance/waivers)
Expand Research Capacity	<ul style="list-style-type: none"> - Expansion of Pikiyav Field Institute: University/Agency /Tribal/Organization Partnerships - Grant development/Endowment fiscal sponsorship - Mentoring of Karuk youth and young adults/elder engagement
Conduct monitoring of climate and associated intervening agency impacts	<ul style="list-style-type: none"> - Measurement of ongoing climate developments e.g. seasonal vegetation growth responding to climate stressors. - Monitoring 21 focal species. Include sites on range of habitats - Identify areas of greatest strategic adaptation potential - Map deficit habitats, desired uncharacteristic conditions, engage new technologies

CHAPTER THREE:

Adaptations for Karuk Habitat Zones and Species

- *People have long been part of the Karuk ecosystem. Climate adaptation is about **restoring human responsibilities** and **appropriate relationships** with species and ecosystem processes.*
- *Ongoing mechanisms must be developed to **revitalize traditional Karuk management practices at the landscape level**.*
- *Climate adaptations **must account for stressors beyond climate change that** compound the impacts of the changing climate.*
- *Climate adaptation requires **proactive ecosystem enhancement** to reduce intervening stressors.*
- *Climate adaptation involves **revitalization of Cultural Indicators** for management.*
- ***Emergency measures must be developed for acute scenarios** (e.g. lethal water temperatures, pest and pathogen outbreaks, fire and flooding events).*
- ***Expand research and monitoring** as part of traditional management approach.*
- *This chapter contains specific adaptations for **21 focal species and 7 habitat zones**.*
- ***Climate adaptations must be explicitly built into all Tribal and regional planning efforts**, e.g. WKRP, USFS Plan Revisions.*

Karuk people recognize species in nature as part of an extended ecological family to whom individuals are related and have responsibilities. Leaf Hillman describes this relationship and its associated responsibilities with reference to the Karuk Creation Story and the importance of World Renewal Ceremonies:

“The rocks and the trees and the water and the air, the responsibility that I have, those are real relations. We have not forgotten that we are related and that we have responsibility. And at the same time, we give thanks to those other spirit people for helping to subsist us, and reminding them that we haven’t forgot that we owe them something too. So the renewal is renewing the bonds that exist.”

People have long been part of the Karuk ecosystem. Climate adaptation is about **restoring human responsibilities** and **appropriate relationships** with species and ecosystem processes. This chapter utilizes a combination of western science and Traditional Karuk knowledge and management practices to outline adaptations for species and habitat zones in the face of the changing climate. As noted in The Somes Bar

Project Cultural Resources Specialist Report (Tripp, Watts-Tobin and Dyer 2017) “TEK considerations do not involve single species management, but whole landscape improvement -for the collective benefit of the people, the animals, and the plants. It would not be realistic to analyze and study for all species across the landscape” (p. 4) and “focal species and indicator species served to show interconnections of mutual dependency between one species and another. They provide a rational, coherent explanation of how saving or enhancing one value will contribute to the environment as a whole. Traditional Ecological Knowledge does not focus, as modern regulations tend to, on single species management, but on the health and productivity of the whole” (p. 17).

Some 150 culturally utilized plants are catalogued in “Plants and the People: The Ethnobotany of the Karuk Tribe” (Davis and Hendryx 1991), the Karuk herbarium catalogues over 100 species, but even more are recognized and used. Hundreds of species from salmon and acorns, to tobacco and kishvu’uf provide materials necessary for cultural continuity, spiritual practice and the preservation of traditional knowledge, see **Table 3.1**.

<i>Table 3.1 Multidimensional Importance of Karuk Traditional Foods, Fibers and Medicines</i>	
Basic Sustenance	About 50% of tribal members in Karuk Ancestral Territory secure food by hunting, fishing or gathering Native foods, yet 40% of respondents had climate and availability barriers to sufficient healthy quantities.
Physical Health	Eating traditional foods, especially salmon and acorns, prevents diet related diseases such as diabetes and heart disease. Cultivating and harvesting foods promotes physical and mental health.
Emotional Health	Participating in food related activities strengthens mental health both through contact with nature and engagement with physical activity, and combats low self-esteem associated with intergenerational trauma.
Cultural Practice	Tending, harvesting, processing, storing and consuming traditional foods perpetuates Karuk culture.
Family Structure and Social Relations	Sharing food is a social obligation, food related activities strengthens intergenerational relationships within families and community.
Ceremonial Practice	“Fix the World,” or Pikyávis Ceremonies are carried out to ensure abundant harvests and restore social and personal balance. First Salmon Ceremony invokes spring run, regulates harvest management.
Traditional Knowledge	Tending, harvesting, processing, storing and consuming traditional food perpetuates Karuk traditional ecological knowledge and its practice.
Political Sovereignty	Ongoing actions of tending, harvesting, processing, storing and consuming traditional food confirms Karuk occupancy on the land.

Species of importance to Karuk people are impacted by climate change related stressors including increased drought and temperatures, more variable weather, stronger storm systems, decreased snowpack, flooding, and an increase in invasive species and forest pathogens as outlined in Chapter One, see a summary of these as they apply to habitats and species in **Table 3.2 below.**

Table 3.2 Overview of Key Climate Change Vectors in Karuk Aboriginal Territory	
Vector of Climate Impact	
Changing Patterns of Fire Behavior	<ul style="list-style-type: none"> - Increased frequency and extent of high severity fire - Longer and more variable fire season - Increased total number red flag warnings (e.g. 12 additional days of very high danger by end of century) - More frequent fires at higher elevations
Changing temperature patterns	<ul style="list-style-type: none"> - Increased summer air temperatures (increase of 52.5 days above 86 ° by the end of century) and surface temperatures - Increased nighttime air and soil temperatures, numbers of freeze free days - More variable air and water temperatures (e.g. extreme summer hot, winter cold) - Changing regional and local scale wind patterns, atmospheric high pressure zones
Changing precipitation patterns	<ul style="list-style-type: none"> - More variable precipitation and increase in flooding with rain on snow events and “microbursts” (Polar vortex-North America Jet Stream seasonal intensity) - Decrease in summer precipitation - Higher elevational snowline, more winter precipitation in form of rain - Increase in stream water temperature, decreasing stream flows - Changing timing of runoff (hydrographic intensity and seasonal changes) - Decreased snowpack (snow water equivalent on April 1 to decrease by nearly 9 inches by end of century)
Species Invasions and changing species distributions	<ul style="list-style-type: none"> - Range expansion of forest pathogens such as those associated with sudden oak death, Port Orford cedar root rot, white bark pine blister rust, Wien’s dwarf mistletoe, and forest pests including fir engraver beetles and bark beetles. - Riverine and riparian habitats becoming increasingly suitable for aquatic invaders and aquatic pathogens including the protozoan that produce Ich, the Columnaris, bacteria and the polychaete worm <i>Ceratomyxa shasta</i>. - Intersecting impacts of tree/forest mortality, species composition and fuel loading - Range expansions altering species interactions and relationships

For example, when it comes to air temperature for Karuk Aboriginal Territory, combined data from 20 regional models as compiled and reported through the NW Climate Tool indicate that by the end of the century there will be an increase in the annual average

daily temperature by 7.8 °F °, an increase of 52.5 days with temperatures above 86 °F, and an increase in the maximum summer daily temperature by 9.6 °F. In recent decades there have been an average of 282.5 freeze free days across Karuk territory, but this figure will increase by 61 days by the end of the century.³

Annual total precipitation in Karuk Aboriginal Territory is projected to increase by 3.2 inches by the end of the century, with total winter precipitation increasing very slightly and total summer precipitation decreasing by about 1.2 inches. However, warmer winter temperatures will mean a reduction in the total precipitation coming as snow, and more variable weather will also lead to an increase in flooding. Recent snow water equivalent as of April 1st has been 10.3 inches. By the end of the century this will decrease by nearly 9 inches to 1.4 inches. Whereas soil moisture in the past several decades has averaged 11.5 inches, this is expected to increase by nearly 2 inches by the end of the century. These circumstances translate into an additional 75 days in the growing season by the end of the century. Taken together these circumstances will result in an average of 12 additional days of very high fire danger and 6 additional days of extreme fire danger by the end of the century (ibid).

All these climactic events will affect species and habitats in unique and often unknown manners. Changes in patterns of temperature and precipitation affect the production of tanoak mushrooms, the timing of salmon runs, and the relationships between pollinators and flowering plants in complex ways. Furthermore, while species and systems have long adapted to changing climates, the pace of the changes that are now occurring is unprecedented. While these climate impacts are serious and immediate, they manifest in ways that are complicated and cannot be untangled from ongoing non-climate related stressors such as fire suppression, commercial logging, plantation replanting, dams, water diversions and other forms of habitat destruction, see Table 3.3 below.

Table 3.3: Intervening Stressors and Climate Adaptation Planning
Dams blocking habitat access for salmonid and other species
Dams impacting water quality
Roads and sedimentation
Fire suppression, forestry practices, plantations, timber harvesting
Commercial species harvesting
Ocean conditions (harvest levels, upwelling, currents)

³ Krosby, M.B., Hegewisch, K.C., Norheim, R., Mauger, G., Yazzie, K., Morgan, H., "Tribal Climate Tool" web tool. Climate Impacts Group (<https://cig.uw.edu/resources/tribal-vulnerability-assessment-resources/>) and NW Climate Toolbox (<https://climatetoolbox.org/>) accessed on [January 19, 2019].

Not only does the changing climate hold the potential to negatively affect some species more than others for biological reasons, species that are already at risk or which have more difficulty in adapting will be at greater risk in the event of particular impacts (e.g. flooding). Not only is climate change the result of human activity, humans are integral components of the mid-Klamath ecosystem in very specific ways. Karuk people have shaped the ecology, fire behavior and species composition in their ancestral territory and homelands through traditional management to enhance species of cultural importance (Anderson 2005, ECRMP 2010, Lake 2007). The impact of past and present traditional management on ecosystems is of such magnitude that American Indian land management must be considered part of the reference ecosystem when attempting to restore degraded landscapes (Senos et al. 2006).

Appropriate adaptations for species of importance to Karuk people in the context of climate change do not occur in a vacuum. These adaptations must be understood in light of existing species susceptibilities (e.g. threatened and endangered status, mobility, range limitations), as well as the past, present and future management actions of Tribal and non-Tribal land managers. As noted throughout this adaptation plan, we take an intersectional approach to understanding the above climate change vectors, considering each climate related stressor to Karuk foods and cultural use species in the context of past, present and future management actions of other agencies operating in Karuk Territory.

Following the general adaptation approach of this document, climate adaptations for species and habitats center around the revitalization of Karuk cultural management, the restoration of fire regimes, reducing impacts from intervening factors, the expansion of Karuk tribal management authority and capacity, community engagement and public education, increased interjurisdictional coordination, and expanded research and monitoring. Adaptations discussed here utilize a combination of western science and Karuk traditional ecological knowledge and center on the restoration of ***cultural indicators*** as cues for human responsibilities. Wherever possible adaptations are provided at three scales: adaptations for acute emergency conditions (e.g. lethal stream temperatures), adaptation strategies for longer term restoration of landscape scale traditional management, and adaptations in the form of robust restoration activities to enhance ecosystem resilience, see Table 3.4 below.

Table 3.4 Adaptations for Habitats and Species at Three Scales

1. Adaptations for acute emergency conditions	Smoke cooling to combat lethal stream temperatures, strategic pre/post fire treatment and intergenerational family fire use
2. Strategies for long term landscape restoration	Programmatic NEPA, alternatives to NEPA, exemption of fire management from NEPA. Stable and reliable long term funding sources, competitive wages, highly trained and tribally certified workforce, address habitat deficits
3. Strategies for robust enhancement of ecosystem resilience	Dam removal on mainstem and tributaries, road decommissioning, road storm proofing, plantation, oak woodland, meadow and glade thinning, frequent burning, sustainable resource use

A Return to Use of Cultural Indicators as Basis for Management: Karuk Traditional Ecological Knowledges and Western Science in Tandem

The Karuk Tribe's Traditional Ecological Knowledge (TEK) and belief systems are constructed and preserved in the form of stories, practices, performances and ongoing interactions with the natural world. Among such rituals include our World Renewal Ceremonies, which the Karuk Tribe has practiced since time immemorial. These ceremonies have been passed down for millennia, and are a key part of our local communities' social fabric. They link human practices like fishing, hunting and gathering to responsibility. They also ceremonially align our culture with ecosystem process and function. In our worldview, cultural resources have a life, as do the people using them. Each life deserves consideration when planning projects.

- Bill Tripp, Deputy Director of Eco-cultural Revitalization

As Karuk DNR Deputy Director Bill Tripp describes above, the ecosystem of the mid Klamath region has co-evolved with Karuk people and culture over millennia.

Traditionally, Karuk and other Tribes in this area use fire to manage the landscape. Our traditional management practices prevented the build-up of fuels that could lead to catastrophic fire events as well as managed for healthy stands of acorn bearing oaks, forage for large ungulates, and for other foods, fibers, and medicinal plants. Due in part to these thousands of years of purposeful fire management, the forests of this region are ecologically dependent on fires that are low in heat production, or “cooler” fires. Western science and traditional ecological knowledge agree that if fire is excluded in these areas for more than 10 to 15 years, the consequences of fire can outweigh the benefits. Landscapes should not exceed ten years without fire. Along with this worldview, there is also widespread agreement that areas that have not seen fire in long periods of time will burn eventually and are better off if burned during favorable conditions.

Within this system of traditional management, multiple species of importance to Karuk people play vital roles as cultural indicators for appropriate human actions. For countless generations, Karuk people have observed the behavior of particular plants and animals to understand ecological dynamics, and as a guide for necessary human management. The return of particular migrating birds signals the timing of the eel run, the appearance of Pleiades in the night sky denotes the time for cultural burning, while the behavior of other species warns of danger. This knowledge gained from attending to the land over generations is inscribed in ceremonies and prayers.

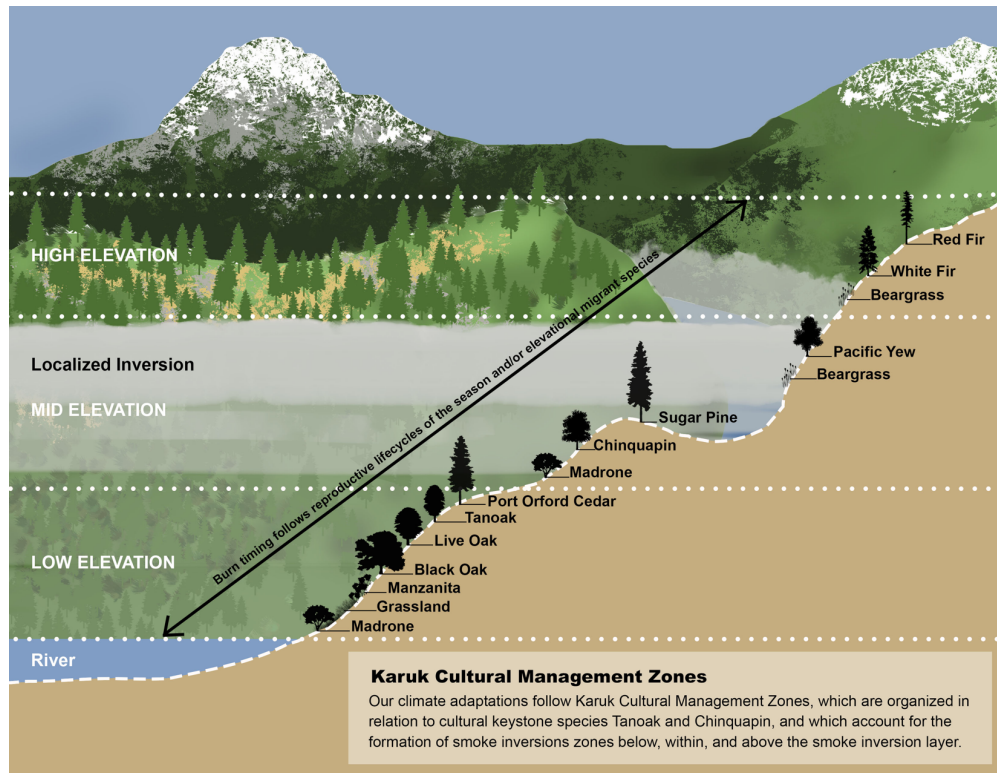
More recently, these longstanding human-ecological relationships and practices have been interrupted by genocide and European settlement, including the imposition of non-Native land management policies and ways of understanding the world. The policy of fire suppression has been especially significant. While these interruptions have been substantial and have taken place over an extended period of time, cultural and ecological information is retained today in ceremonies, stories and collective memory. Indicators of prior fire regimes and management systems also remain evident in the landscape itself. Today, revitalizing the practice of attending to the presence and behavior of other species as cultural indicators of what humans are supposed to do is a necessary step in the face of climate change. The climate adaptations in this chapter utilize Karuk Traditional Ecological Knowledge alongside western science, centering on the revitalization of 21 focal species as cultural indicators for human responsibilities and necessary human management actions. “These species have stories to tell, lessons in terms of how to get back to traditional management. They serve as indicators of relationships, responsibilities and of when and where to burn.” Bill Tripp, Deputy Director of Eco-Cultural Revitalization.

Climate adaptation planning for traditional foods, fibers and medicines begins with a general discussion of seven habitat zones, followed by discussion of 21 focal species that serve as cultural indicators profiled in the Karuk Vulnerability Assessment. The importance of these species is indicated by their having Karuk names. Species were also selected to represent management across a range of habitat and species types (e.g. low and high elevation forest, birds as well as reptiles). The stories from these species point to directions forward, as William Tripp explains, “We need to get out there, take actions and observe. We don’t need to know everything now in order to get it right.”

We use a culture-centric perspective on vegetation zones and organized by elevation bands with different timing and purpose in relation to fire management. Smoke inversions reduce fire behavior and Karuk fire management is organized in three zones relative to the smoke inversion zone. The low elevation forest zone includes species that exist below the zone of smoke inversions (and centered on the cultural keystone species of Tanoak); middle elevation forest are those that exist within the zone of smoke inversions (centered around management of the cultural keystone species of Chinquapin); and High elevation forests and high country are species occurring above the elevational gradients in which smoke inversions. Within this system, elevational migrants are indicators of when to stop burning at one location and move upslope, following receding snows, see Figure 3.1 Seasonality and Elevation Dynamics of Cultural Indicators in Karuk Cultural Management Zones. We also consider habitats of Riverine, Riparian, Grasslands and Wet Meadows, not detailed in this schematic.

Figure 3.1 Seasonality and Elevation Dynamics of Cultural Indicators in Karuk Cultural Management Zones

(illustration courtesy of Kirsten Vinyeta)



Burn timing follows a gradient that tracks the reproductive life cycles of season and elevational migrant species, the calving of elk as well as the nesting of birds. William Tripp describes how the Karuk practice of careful observation is critical to this process. “When the birds come back and nest it is time to move upriver or upslope with your burning.” Fire management occurs working uphill in the Spring along this gradient of reproductive timing. Fire management stops in April when the constellation of Pleiades disappears from the sky and does not resume until mid-June when Pleiades reappears. As noted in The Somes Bar Project Cultural Resources Specialist Report (Tripp, Watts-Tobin and Dyer 2017), “It is told that Coyote had seven wives whom at the time of the great transformation turned into the constellation Pleiades. It is said that when this constellation is not visible (April - June) their spirits come back to earth to help all things through their reproductive cycle. At this time, people were to have the utmost respect for this process by using fire only for the purposes of heating and cooking. In addition to this, place based indicators with some degree of spatial variability extended this time earlier into spring in respect for the reproductive rights of individual species” (p. 4).

In general, the lower elevation zone will have tanoak, and on south facing slopes black oak, madrone, open grasslands and meadows, as well as mazanita. Along ridges of this zone Jeffry pine and some Sugar Pine can be found. On the east side ridges may be Live Oak with larger firs in drainages especially at the head of creeks where they help to retain water. This lower zone can be burned in February, especially in places where black oak is present. While chinquapin is more commonly a middle zone species, its presence in this zone is an indication of places that should be managed for huckleberry. The presence and quality of huckleberry is an indicator for socio-ecological resilience within this lower forest zone.

Middle elevation is characterized by the inversion layer, here madrone, fire, chinquapin and tanoak in the lower portion. Drainages at this elevation may contain Pacific Yew and beargrass. Chinquapin may occur at lower end of transition zone of where inversions set in. Similarly, Ussip or Sugar Pine is common at higher elevations, but where it occurs in this middle zone it is a particularly important indicator. The third cultural management zone occurs above where smoke inversions form. This higher elevation forest and into the high country is characterized by Red and White fir, beargrass and high elevation meadows. Burning occurs in mid June between snow breaks. Summer burning is associated with hunting. Puuf puuf is an indicator for action in this high elevation band. Burning above the inversion zone occurs in the summer. Burning this zone in summer has benefits for hunting and for the winter range of elk.

These dynamics do not fit universally across the landscape, variation by aspect, slope, proximity to fog systems, and past management. This approach ties culture to species and thereby to restoration of ecosystem process and function. Karuk people need to be intimately involved in revitalizing Karuk ecological knowledge practices. This information and approach provides a sideboard for managing the unknown in a changing climate using sound cultural management principles. These inversion zones may be fluctuating with the changing temperature and wind patterns. Monitoring needs to occur regarding dynamics within the zones themselves. While focal species are described in particular configurations and zones, events and activities in one zone affect species across other zones. Furthermore, many species occur in multiple zones. In cases where species are found in “uncharacteristic” elevations they may serve as particularly important indicators for cultural management.

For each habitat zone we provide a general discussion of the climate stressors operating in that zone, discuss how the management actions of federal land managers intersect with the vulnerabilities engendered by these climate change stressors, and provide adaptations. This living document is intended to aid in the revitalization of Karuk traditional management in the face of climate change. This is not a static plan, but a

pathway forward. Information compiled in this chapter reflects a combination of Karuk traditional ecological knowledge and western science. Different habitat zones face distinct threats in light of the changing climate. Some zones have more species emphasized than others, yet while we use the zone approach to highlight the relationships between species in close proximity, it is important to understand that the zones also matter for their connections to one another. For example, wet meadows provide water storage that provides higher summer base flows and cold water to lower elevations zones, while low elevation tan oak is critical winter foraging habitat for elk who are in turn needed to sustain wolf populations. Many species occur across multiple zones, or move across zones seasonally. In such cases profiles are included within the zone for which habitat is most critically limited. Fish are connected through water between elevations zones, but are not physically present in high elevation zones. Water connects Karuk food species (fish) to other landscapes within the Klamath Basin and outside the Basin including the Pacific Ocean. Appropriate adaptations must take such relationships into account. Where less information is presented or fewer species discussed, it does not mean that the zone is of lesser importance. For example, many species have been less emphasized by western scientists, limiting information available for these species. There are relatively more profiles included for riparian and low elevation habitat zones where many species are used directly. Yet the high-country habitat zone is critical for its influence on fire regimes and hydrological dynamics in lower elevations. The grassland zone is historically significant for a number of important species including elk, camas, brodiaea and medicinal forbs. Today a majority of grasslands have disappeared due to lack of burning, and traditional knowledge about grasslands has yet to be withdrawn from the tribal community. Following discussion of each habitat zone we provide adaptation details for particular species occurring in that zone, centering on the lessons that can be learned from that species as a cultural indicator. Many of the profiled species are regalia species that are vital to traditional ceremonies. Many would be considered cultural keystone species.

Adaptation Strategies as Immediate Emergency Mitigation Measures

In some case rapid action will be necessary for species survival, as when riverine systems hit lethal temperatures, or unviable species counts or impending pathogen infection are identified. For example, in 2018 forecasted returns for Fall Chinook were so low that in an unprecedented action the Karuk Tribe suspended all fishing other than for ceremonial use. In recent years the Karuk Tribe was poised to file an emergency drought declaration in response to the presence of dead púfpuuf and the imminent loss of spring salmon as a traditional food source in the Salmon River as described above. Where possible this document points to relevant emergency measures. Development of emergency measures will require expanding tribal management authority, cooperation and collaboration between responding agencies, and a central reliance on cultural indicators for the identification of quick response “trigger points” for needed management actions.

Using Cultural Indicators to Mitigate Acute Conditions

Some cultural indicators are a key mechanism for the identification of needed emergency management actions. Púfpuuf, or Pacific Giant Salamander is of vital importance to the Karuk as it is our indicator for water quality. It has been told to us for countless generations, that if the Púfpuuf is healthy, the water is safe to drink. Conversely if the Púfpuuf is in peril, we are on the verge of system collapse. In 2014, California’s Salmon River, one of the last remaining habitats of Spring run Chinook salmon, warmed to lethal temperatures for these unique fish. An exceedance of 15% mortality of spring run Chinook was observed in the Salmon River Watershed. This die-off was also accompanied by a count of numerous dead Púfpuuf. For Karuk cultural practitioners, the presence of the dead Puuf Púfpuuf was an alarm signal indicating potential for system collapse. Smoke from fires lowers air and water temperatures significantly. Before we could act to address the concern a lightning fire started in the Salmon River drainage which provided temporary relief through smoke shading and reduction of vegetation uptakes which together kept lethal river temperatures in check and the die-off stopped. Had this fire not occurred, staff at Karuk DNR were preparing to use fire in recent fire footprints in a safe manner consistent with traditional cultural practices. Subsequently this fire, in a year with no snowpack, burned at extremely high severity as it ran up Tanners Peak creating a pyrocumulus cloud igniting 22 more fires between there and the Oregon border. Unprecedented fire weather conditions continued throughout this fire year and the Happy Camp Complex went on to burn entire watersheds critical to ESA listed Coho salmon at high severity.

Given that a central adaptation in the face of climate change requires returning to historic fire cultural fire regimes and that all fires produce smoke, a central necessary element of adaptation will require a more informed nuanced public awareness, policy

change regarding human relationships to smoke. There are serious negative health consequences of smoke from both human cultural ignitions and wildfires. However, neither the ecological or environmental justice/health dimensions of smoke are well understood. As communities who have existed with smoke for thousands of years can attest, smoke life fire, is an inherent part of forest ecosystems. Just as public fear of fire has translated into oversimplified and inaccurate understandings of fire, policies that attempt to create smoke exclusion without understanding the different circumstances under which smoke is generated, are not only misguided and ineffective, they result in more hazardous smoke conditions for human health, without producing the ecosystem benefits. There are many kinds of smoke conditions, and many circumstances under which smoke arises. High severity large-scale fires burn for much longer than traditional cultural burning of the past, leading to particularly significant health impacts (Johnston et al. 2016). As noted by staff in the Integrated Wildland Fire Management Program, “With fire exclusion we have a wider pendulum between fires and no fires, between smoke and no smoke, such that when fires occur there may be very large with heavy smoke for periods of weeks at a time.

The reality of smoke as an element of fire prone forest systems, the differences between duration and intensity of smoke according to the different circumstances in which smoke is produced, and ultimately the negative impacts of smoke exclusion policies on human health all need greater attention within air regulations and public discourse. Human generated smoke for ecosystem benefit has overall beneficial health consequences. By contrast, the cause of the smoke conditions most hazardous for human health is fire exclusion. An overgeneralized and erroneous understanding of the relationships between smoke and human health is now producing a situation in which the necessary treatment for hazardous health conditions is itself targeted as the problem. Alarm over smoke and lack of a nuanced understanding by the general public has further produced a situation in which communities in fire prone areas are forced to experience hazardous smoke levels for very extended periods of time.

Emergency measures are exempted from regulation under the Clean Air Act, but this is not the correct way to approach the need for such unregulated action in this sense. A more in depth interpretation of terminology is needed. The Clean Air Act requires that all “anthropogenic” emission sources be regulated. Wildland fires are either considered a “natural” emission source or an “emergency” response depending on if it is to be managed for resource objectives as a natural ignition, or suppressed as a human ignition. The very term “indigenous” infers being “natural” to place. Using fire as an “indigenous management practice” whether it be of lightning, or human origin would take a seemingly “anthropogenic” action and qualify it for consideration as a

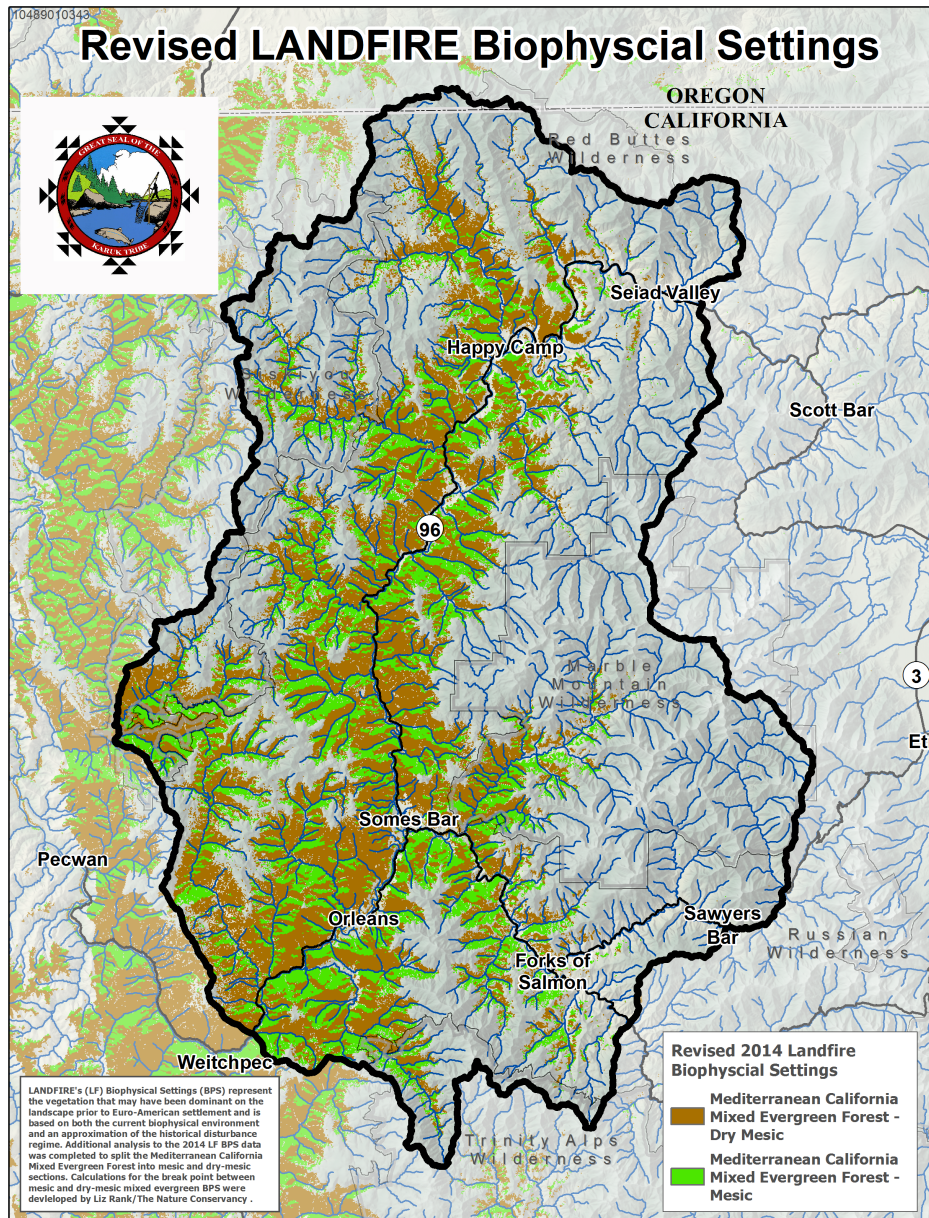
“natural emission.” Smoke cooling of air and water is a natural function of fire process; fire exclusion and suppression of indigenous fire management practices are anthropogenic practices that have contributed to extreme conditions; primary fire related emissions come from fuel loading not ignition sources. Therefore, “indigenous” fire management would be considered a “natural emission source” for the purposes of meeting the intent of the Clean Air Act and enabling such emergency actions as a planned ignition. Developing Tribal Implementation Plan for air quality management for WKRP is also discussed in Chapter Seven on Adaptations for Tribal Management Authority and Sovereignty.

Adaptations for Restoration of Landscape Scale Fire Regimes

Karuk People have used fire for millennia and continue to do so today. As a result, the forested areas in northern California have become adapted to frequent occurrence of relatively low intensity fire from human and natural ignitions for more than the past 1,000 years (Perry et al. 2011, Taylor et al 2016). Evidence of past management exists in what are known as “Cultural Vegetation Characteristics” -- vegetation assemblages that are indicative of historic human use, management, or occupation. Huckleberry, Sugar Pine, Black Oak and Tan Oak are species that commonly understood as evidence past management. Recognition of this baseline of indigenous management is essential for effective climate adaptation. The Kaurk Tribe is working to create measures of past historic conditions to set more appropriate baselines. Amongst such measures has been an adaptation of the “Biophysical Settings” within Landscape Fire and Resource Management Planning Tools known as LANDFIRE.⁴ The Biophysical Settings represent the vegetation that may have been dominant on the landscape prior to Euro-American settlement. It is based on both the current biophysical environment and an approximation of the historical disturbance regime. Figure 3.2 Revised LANDFIRE Biophysical Settings for Karuk Aboriginal Territory (below) portrays an updated 2014 BPS data.

⁴ LANDFIRE is a shared program between the wildland fire management programs of the U.S. Department of Agriculture Forest Service and U.S. Department of the Interior, providing landscape scale geo-spatial products to support cross-boundary planning, management, and operations.

Figure 3.2 Revised Landfire Biophysical settings for Karuk aboriginal territory (map courtesy of Kenny Suave)

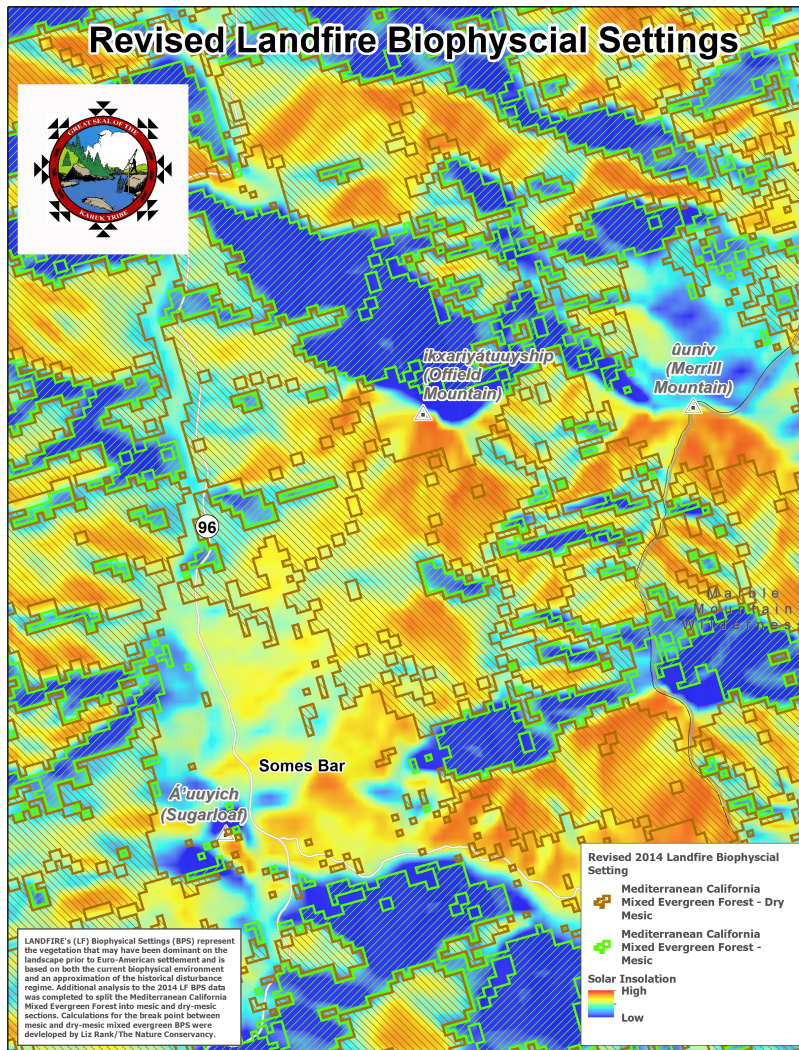


In this figure Karuk GIS technician Kenny Suave split the “mixed evergreen” biophysical setting into dry, mesic and mesic sections based on the work Lix Rank of the Nature Conservancy.⁵ Figure 3.3 indicates the same data including revisions of the solar insolation for the area around Offield Mountain.

⁵ Map units are based on NatureServe's Ecological Systems classification and represent the natural plant communities that may have been present during the reference period.

Figure 3.3 Revised LANDFIRE BPS Settings with Solar Insolation for Offfield Mountain Area

(map courtesy of Kenny Suave)

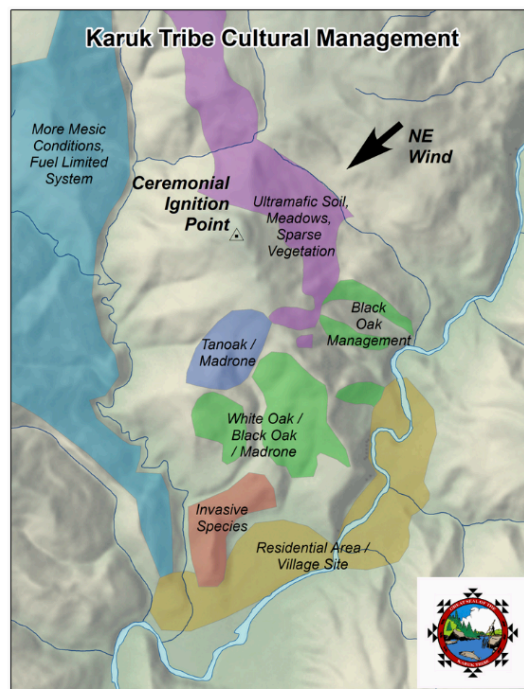


Since time immemorial fires have been set on Offfield and Black mountains with the full moon in August and new moon in September as part of the World Renewal Ceremonies. These ceremonial ignitions from Black Mountain occurred at the time of year when the NE winds begin. These winds can carry fire a great distance. The annual lighting this fire in August sets the stage for a fuel limited fire safe condition to spread when such frequency of fire would make it very difficult to burn at all. August fires also provided

Each BPS map unit is matched with a model of vegetation succession, and both serve as key inputs to the LANDSUM landscape succession model.

protective cooling to riverine systems at the peak of summer temperatures, triggering upstream salmonid migration and cooling the system for fish runs already in the river. In the face of a century of fire exclusion and the changing climate it is not presently possible to put fire on the landscape at this traditional time. However, a combination of geologic features, topography, traditional knowledge coupled with the existence of remnant stands, recent fire footprints and ceremonial ignition sites as information stored in the landscape can be utilized to strategically return fire at the landscape scale, even in the face of 100 years of fire suppression policy. Ceremonial ignition points reflect knowledge and instructions inscribed in the landscape that can be replicated across Karuk territory at appropriate locations. Figure 3.4 below indicates a multi-step sequence through which fire can be returned at the landscape scale, thereby simultaneously providing climate adaptations for low to mid elevation and riverine species, and creating landscape protection for the present-day communities of Somes Bar and Orleans.

Figure 3.4: A Modern Take On Restoring Landscape Level Fire Regimes With Cultural Management



The figure indicates how on the southeast side of Black Mountain existing pockets of Black Oak (shown in green) are remnant stands that can be nudged back towards oak woodland through the use of fire. Black oak is a southerly aspect species that can be maintained with spring (dormant season) burning. While these Black Oak stands are completely encroached by conifers today, the presence of both Black and White Oaks

trying to come back in plantations or burn recent burn scars represents a landscape memory of prior fire regime and ecology. The face of Black Mountain below the ceremonial ignition point is sheltered from a NE wind event, while natural fire breaks exist to the south in the form of serpentine geology (shown in purple), and to the west where a mesic environment is formed by wet shaded, dark canyons (indicated in blue). A fire lit in February in areas of low to mid elevation southwest exposure and restored oak woodland stand characteristics create a fuel limited condition when and shaded fuel break for summer burning activities. Following up with strategic pockets and or areas with presence of invasive species in June should increase the viability of blackline features and favor proliferation of native species over the non-native invasive. Fires lit in August during the ceremonies should go out to where you burned in February and reinforced in June. Burning in August in conjunction with the ceremonies, even during a NE wind event allows for the fire to burn adjacent, yet away from the community, creating a band of fuel limited fire safe conditions around the community of Orleans (shown in tan). This multi-step annual approach of burning in February based on site specific rotation schedules, following up with strategic reinforcing burns (in cured grasses) in June, and conducting ceremonial burning in the World Renewal Ceremonies in August would restore a very large block of land to the historically fuel limited fire regime. This approach serves as a critical climate adaptation measure for lower and middle forest, riverine and riparian habitat zones, and protect the town from dangerous high severity fire activity in the face of climate change.

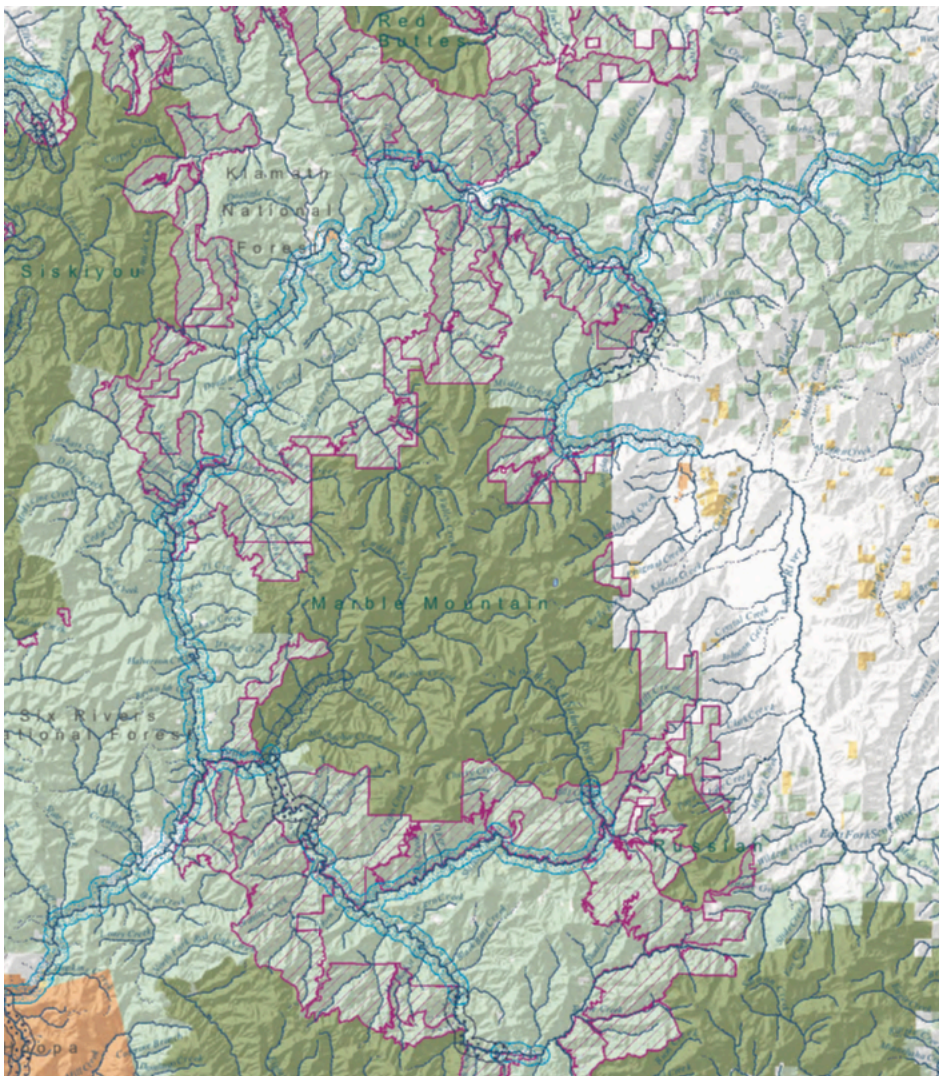
Strategies for Robust Enhancement of Ecosystem Resilience

A primary adaptation measure across each management zone and habitat type concerns strategies for the robust enhancement of ecosystem resilience. Addressing the many intervening non-climate stressors on ecosystems is not only the most immediate and controllable way to buffer against larger system changes, climate related events such as a large flood or wildfire always occur in the context of management actions leading up to the event, during the event and afterwards. Indeed such actions may create larger impacts than the “climatic event” itself. A major approach to climate adaption therefore is to attend to Karuk Tribe has long engaged in robust restoration activities including dam removal on mainstem and tributaries, stream restoration, fuels reduction, prescribed burning, correcting water diversions, road decommissioning, storm proofing and culvert upgrades, thinning of plantations, oak woodland, meadows and glades, sustainable resource use, and other efforts enhance ecosystem resilience. The importance of these activities has never been greater.

In the face of the changing climate, “connected landscapes” with contiguous “habitat corridors” along elevational and other environmental gradients are considered valuable adaptations because they support potential movement of terrestrial species to suitable habitats (Nuñez et al 2013, Olson et al 2012). Such elevational habitat connectivity can prevent the complete loss of suitable habitat for particular species, as well as population fragmentation which decreases population resilience). Figure 3.5 Land Allocation Map Showing Key Habitat Corridors, identifies areas within Karuk Aboriginal Territory that are considered important for elevational habitat connectivity in the face of climate change.

FIGURE 3.5 LAND ALLOCATION MAP SHOWING KEY HABITAT CORRIDORS

(MAP COURTESY OF KIMBERLY BAKER)



These areas, outlined in red, include Grider Creek to Kangaroo Roadless Area which connects the Marble Mountains and Red Buttes Wilderness Areas, the zone from Ukonom Creek to Swillup Creek that connects the Marble and Siskiyou Wilderness Areas, and much of the Salmon River, especially the South Fork Salmon region that connects the high country of the Marble Mountains and Trinity Alps.

Climate adaptations for species and habitats center around the revitalization of Karuk cultural management, the restoration of fire regimes, and the reduction of negative ecological impacts from intervening factors such as dams, plantations and water diversions. At a practical level implementing these climate adaptations will require increased interjurisdictional coordination, the expansion of Karuk tribal management authority, and greater recognition of tribal sovereignty as discussed in Chapter Seven-- utilizing multiple authorities such as recent expansion of 638 authority for Tribal Forest Protection Act management activities (USDA) and the U.S. Department of the Interior, eligibility for tribal nations to exercise Good Neighbor authority for forest management agreements with USDA and states, Indian Energy Act authorities for tribal forest management plans to extend to National Forest System Lands.

These measures, among others, should also enable the necessary expansion of tribal capacity as discussed in Chapter Six Community engagement and public education in light of fear of fire, increasing awareness of fire as a necessary and natural process in light of climate change, and expanded research and monitoring will all be vital (see overview table 2.1 in Chapter 2). As emphasized throughout these overall adaptations are critical given the overall connectedness of activities across the ecosystem (e.g. the importance of meadow restoration for riverine systems, etc). The next portion of the chapter addresses adaptations ore specific adaptations for each habitat type build upon these general adaptation actions.

This Climate Adaptation Plan is a living document and modifications will be essential in the face of ongoing climatic changes, the increasing engagement of Karuk people in traditional knowledge and management activities, ongoing research developments and policy opportunities. In particular, it will be essential to remember in the words of William Tripp “what do we do if the opposite is true?” Climate forecasts call for increasing ***variability of weather*** as has been observed, but as Bill notes “we are supposed to see the start of the next ice-age in my Dad’s lifetime. Even if we move into climate and weather conditions such as cooling that are very different from those we currently anticipate, we still need to be able to build relationships based on Karuk knowledge and fire practice. We need to get people back onto the landscape and learn what is going on. People need to be noticing these things for themselves, this is how we teach and learn in Karuk culture. It is based on observation and practice.”

Riverine Systems

Riverine systems and species are amongst the most critically threatened in the face of the changing climate. Karuk ancestral territory and homelands encompass several hundred miles of riverine habitat along the middle portion of the Klamath river, the lower portion of the mainstem Salmon River, and many key tributaries. Species from riverine systems hold significant cultural and spiritual significance and provide over fifty percent of the calories and protein of traditional Karuk diets. Salmon (coho (achvuun), spring (Ishyá'at) and fall chinook) and other riverine species including green sturgeon (ishxíkihar), lamprey (Klamath and Pacific (akraah), steelhead trout (sáap), otter (amváamvaan), and freshwater mussels (axthah) are important for food, culture and ceremonies.

Riverine systems are especially at risk in the face of changing patterns of precipitation, increasing temperatures and decreasing winter snow pack resulting from the changing climate as outlined in Chapter One. The Klamath River is both a cold water and warm water river system. While salmonids depend upon access to cold water, other non-salmonid species including sturgeon, sucker, dace and lamprey all depend on summer warm temperatures. These species will react to climate change in different ways than salmon. Some of these trends that are particularly relevant for riverine systems are summarized below. For example, data from the NW Climate Tool indicate that while the annual total precipitation is projected to increase by 3.2 inches by the end of the century, total summer precipitation is shown to decrease by 1.2 inches, while the snow water equivalent as of April 1st decreases to a mere 1.4 inches.

	Recent Decades (baseline)	By end of Century (2070-2099)	Change
Days over 86 °F	49.8	102	+ 52.5 days
Annual total precipitation	78.8	82.0	+ 3.2 inches
Total summer precipitation	12.5	11.3	-1.2 inches
Snow Water Equivalent	10.3 inches	1.4 inches	-9 inches

Taken together these climate stressors directly impact stream flow and water temperature within the riverine system. By the end of the century data from the NW Climate Tool under a moderate emissions scenario average August stream temperatures are projected to be dominated by streams with temperatures 57.2-60.8°F and the mainstem of the Klamath projected to reach temperatures between 68 and 71 °F⁶ in August see Figure 3.6 below.

Figure 3.6 Projected Stream Temperatures for Karuk Aboriginal Territory 2077-2099

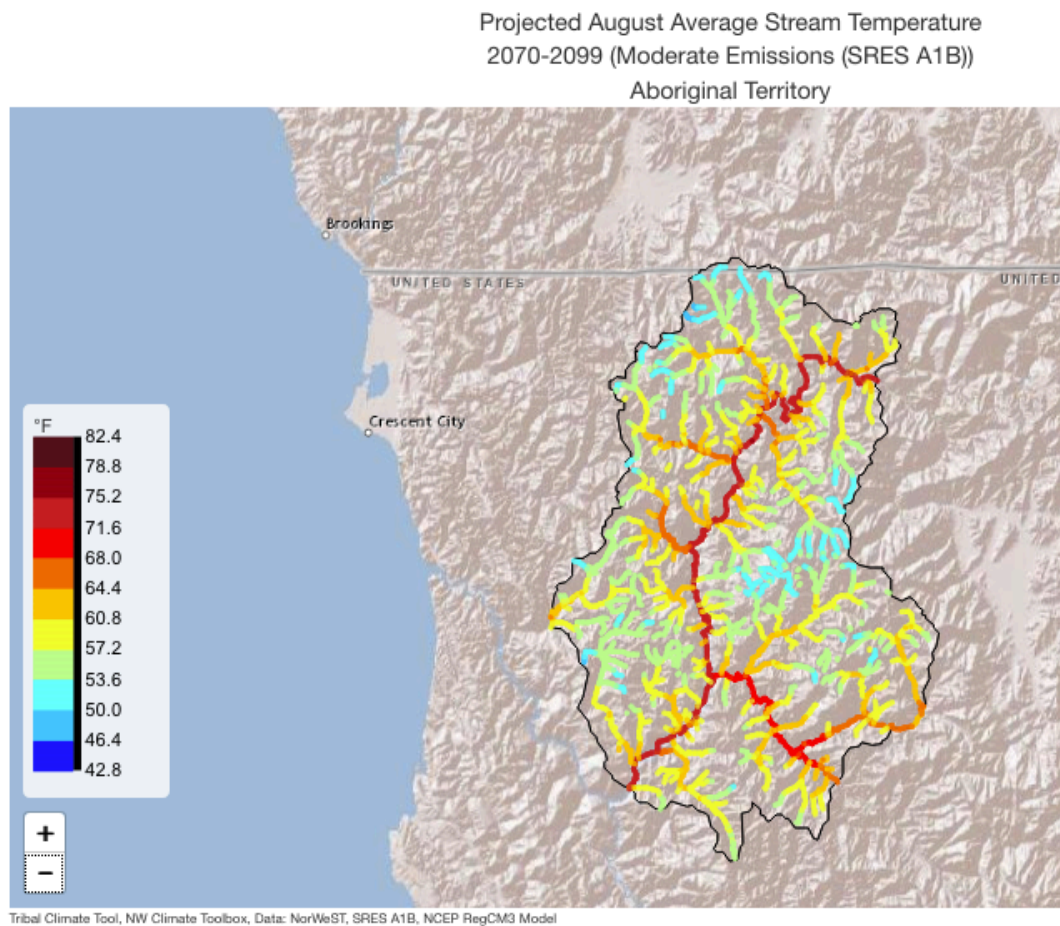
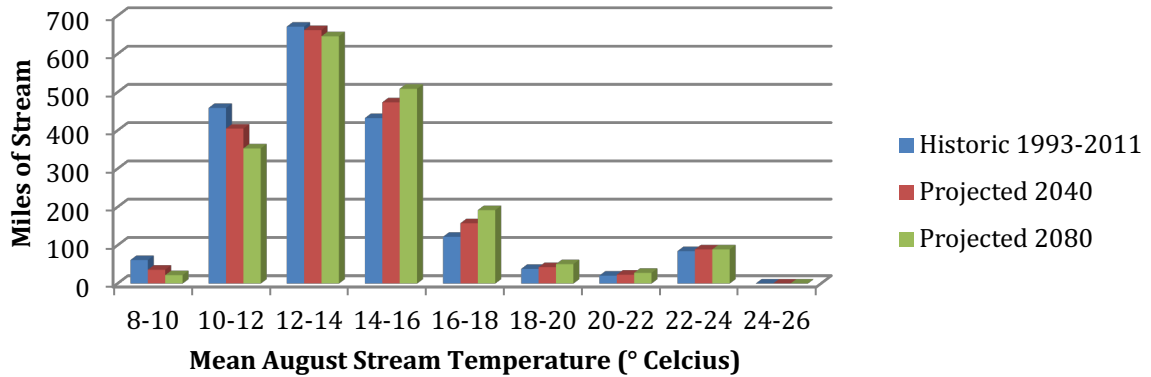


Figure 3.7 from the NW Climate Tool presents historic stream temperatures and future projections in 2040 and 2080 for combined streams across the Klamath Basin.

⁶ Eli Asarian notes that “summaries provided by the NW Climate Tool are somewhat misleading from a fisheries perspective because universe of reaches presented goes all the way up to the headwaters, far upstream of where anadromous fish can access. So the 57.2-60.8 C stat is highly affected by all the upper headwater reaches of the streams, which are closer to the spring sources and have high riparian canopy relative, so are much cooler than the warmer lower reaches of streams downstream where the fish are.”

Figure 3.7 Model Projections, A1B Climate Scenario



Elevated stream temperatures can cause direct mortality of fish, support fish pathogens and diseases, and enhance suitability for non-native fishes (Hitt 2003). For anadromous species, ocean acidification, sea level rise, decreased coastal upwelling and shifts in fog dynamics all impact marine aspects of their life cycle and hence the broader ecosystem health through the connections of these species to upslope forests.

Intervening Stressors to Riverine Systems from Non-Tribal Management

Climate adaptations for riverine systems must encompass the context of actions taken by other agencies operating in Karuk Aboriginal Territory. Riverine systems are already threatened in the mid-Klamath area due to existing non-Tribal management actions that intervene with climate stressors to negatively impact the riverine system. Dams in particular trap sediment and stop geomorphic processes that shape habitat and cool water downstream of the dams. On the Klamath mainstem dams including Iron Gate block access to abundant volcanic spring creeks with cold water habitats that are less influenced by ambient air temperatures therefore are more resilient to climate change. Salmonid access to groundwater fed streams is blocked at Iron Gate Dam on the mainstem of the Klamath and Dwinell Dam located on the Shasta River. Pacific Lamprey ammocetes require large depositions of fine sediments together with dynamic river processes of sediment transport and depositions. Mainstem Klamath dams (Iron Gate Dam and those above) have cut off the sediment supply to the upper Klamath River, therefore ammocetes are not present directly below the dam and provide limited attraction to adults.

Fire exclusion is a second major intervening climate stressor for riverine systems. While high intensity fires may have negative impacts on riverine species, especially in the short term, wildfire is particularly important for shaping the local quality of riverine habitats. In particular, fire suppression has removed the many benefits of fire to rivers and streams including limiting the natural 'disturbance mosaic,' thereby limiting beneficial wood and gravel debris, reducing stream flows and the additional water inputs to streams and rivers after fires. Repeat burns are an essential catalyst for stream inputs like large wood, gravel and sediment. From a physical standpoint, the complex forest structure that results from repeated fire leads in turn to complexity of riverine habitats (Bisson et al 2003). Indeed, the complexity of stream habitats is directly linked to habitat complexity in the surrounding forest landscape (Flitcroft et al 2016 and Bisson et al 2003). This is true in part because fires are a form of disturbance that shapes physical characteristics of upslope forests and riparian environments, including opening canopy and enhancing regeneration (Hessburg et al., 2005, 2007; Perry et al., 2011; Swanson et al., 2011). This disturbance mosaic provides a high diversity of habitat types and gives different species options. Fire suppression has had a direct impact on specific species including salmon and lamprey as well. Pacific Lamprey ammocetes require large depositions of fine sediments and dynamic river processes of sediment transport and depositions. Other intervening impacts include water diversions, water quality impairments from agricultural inputs, fire retardants, logging activity, plantation replanting, and failing roads see Table 3.5 below.

Table 3.5: Intervening Stressors for Riverine Systems
Dams blocking access to sediment flows, stop geomorphic processes shaping habitat and cooling water, access to cold water in volcanic spring creeks, spawning habitat and more
Water quality impacts from dams, fish diseases and pathogens, fire retardants, oad construction and sedimentation etc.
Fire suppression reduces water and debris inputs to riverine systems
Ocean conditions including acidification, decreased coastal upwelling and commercial harvests

Wildfire smoke also relate to fisheries management. Lighting this fire in August thus set the stage for a fuel limited fire safe system in advance of a season with great potential for high severity, high impact events, creating protection for village sites below. August fires also provided protective cooling to riverine systems at the peak of summer

temperatures, triggering upstream salmonid migration and cooling the system for fish runs already in the river. “Stephens and co-authors note that “Particulates produced from annual prehistoric fires were substantial and may have moderated ground sunlight intensity by dispersing incoming radiation to space... Skies were likely smoky in the summer and fall in California before fire suppression.” (Stephens et al. 2007). In the face of a century of fire exclusion and the changing climate it is not possible to put fire on the landscape in all locations at this traditional time. David, Asarian and Lake (2018) outline the relationship between wildfire smoke and river temperatures, observing how wildfire smoke can cool summer river and stream water temperatures by attenuating solar radiation and air temperature by reducing the amount of solar radiation reaching the watershed. Other non-climate stressors on riverine systems that relate to fire suppression include logging and “salvage” logging, replanting, the presence of fire retardants in rivers and lakes, road building, and the creation of fire lines in vicinity of riverine systems. Each fire season hundreds of gallons of phosphorus containing fire retardants are dropped into watersheds both directly into the vicinity of stream systems and onto ridgetops. Impacts to riverine and surrounding forest systems are multidimensional and poorly understood.

*“Particulates produced from annual prehistoric fires were substantial and may have moderated ground sunlight intensity by dispersing incoming radiation to space... Skies were likely smoky in the summer and fall in California before fire suppression.”
(Stephens et al. 2007)*

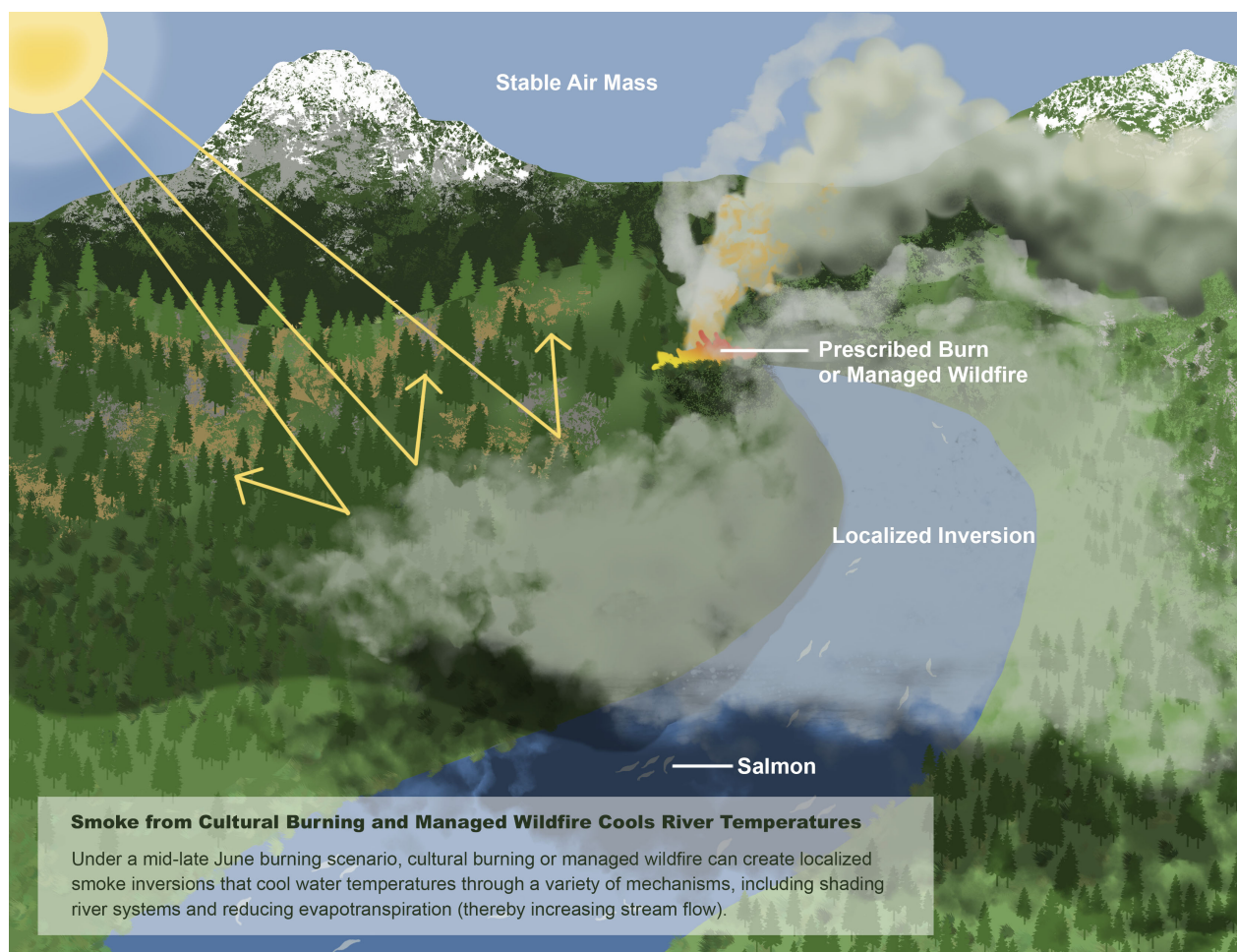
Climate Adaptations for Riverine Systems

Primary adaptation strategies for Riverine Systems include 1) the development of short-term measures to mitigate immediate impacts of acute water temperature events, 2) the restoration of fire regimes on the landscape scale, and 3) engagement in robust restoration activities to restore and enhance ecosystem resilience in the face of intervening factors. Wildfire from both human and natural ignition has been an integral component of the riverine systems in the mid-Klamath region. Fire is particularly important for shaping the local quality of riverine habitats in the face of climate trends. Many riverine species of importance, including salmon, require complex habitats with large woody debris. Fires bring sediments and large woody debris into stream systems critical for both stream productivity and habitat complexity (Arkle and Pilioid 2010 and 2009). Low intensity fires are important for stream flows as they clear out brush that

uptakes water, while high intensity fires are needed to generate debris inputs. High intensity fires may have negative short-term impacts on riverine species, but are nonetheless critically important in the long run, since high intensity fires in particular provide additions of gravel and logs, and generate the canopy opening that form a mosaic of more and less productive stream habitats (Arkle and Pilioid 2010 and 2009, Davis 2016). The most productive mid Klamath salmon streams have burned recently, mostly with high severity fires, e.g. Horse Creek, Seiad Creek, Dillon Creek, Clear Creek, Wooley Creek, and the North Fork of the Salmon River.

The smoke may cool river temperatures during critical warm periods, creating good conditions for fall migration and spawning of Chinook salmon (see detailed discussion below). Figure 3.8 portrays the relationship between smoke and river temperatures.

Figure 3.8 Smoke from Cultural Burning and Managed Wildfire Cools River Temperatures (illustration courtesy of Kirsten Vinyeta)



While figure 3.8 portrays the general relationship, modeling by Aaron David, Eli Asarian and Frank Lake (2018) illustrates more complex dynamics. Figure 3.9: Wildfire Smoke Cools Sumer River and Stream Water Temperatures is adapted from their article.

Figure 3.9 Modeling of Smoke and Stream Temperatures

(diagram courtesy of David, Asarian and Lake 2018)

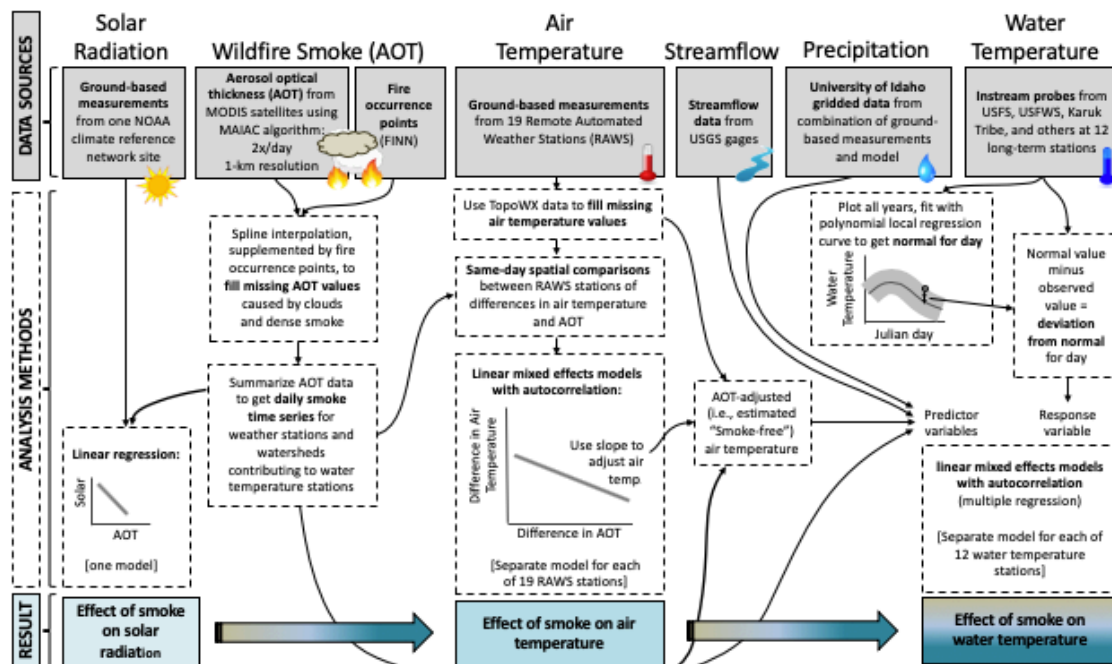


Figure X. Flow chart showing data sources and overview of major data analysis steps used to determine the effects of wildfire smoke on solar radiation, air temperature, and water temperature. For simplicity and clarity, some steps and many details are excluded.

Development of this short-term approach to cool river temperatures in the face of acute triggers requires a return to utilization of cultural indicators for prescribed fire, together with the eventual restoration of August ceremonial fires. In the face of a century of fire exclusion and the changing climate it is not possible to put fire on the landscape in all locations at this traditional time. However, as outlined on Figure 3.1 on p. 60 a combination of geologic features, topography, traditional knowledge, the utilization of recent fire footprints and the existence of remnant stands and ceremonial ignition sites as information stored in the landscape can be utilized as an emergency measure to

strategically return fire at the landscape scale, even in the face of 100 years of fire suppression, thereby simultaneously providing climate adaptations for riverine and other species.

Lastly engagement in robust ecosystem restoration activities is critical, especially dam removal, floodplain and meadow restoration and increased in-stream flow restoration. Other activities including road decommissioning, road storm proofing and culvert upgrades are also beneficial. The removal of mainstem Klamath dams will restore access to cold water in headwaters reaches, re-establish sediment flows and geomorphic processes that shape habitat and cool water downstream of the dams. There are very few mid Klamath spring fed tributaries or "spring creeks." "Spring Creeks" are climate resilient in nature because the ambient air temperature has less effect on water temperature and flows are relatively stable all year round. Spring creeks are perfect for production of juvenile salmon because of the stable nature including year round cold water. However, nearly all spring creeks on both the Klamath and Shasta are locked up behind dams making dam removal a key climate resiliency action needed for salmon. Overall ecosystem adaptations including the restoration of traditional fire regimes, reducing impacts from intervening factors, the expansion of Karuk tribal management authority and capacity, community engagement and public education, increased interjurisdictional coordination, and expanded research and monitoring, listed in Table 2.1 in Chapter Two are essential for riverine systems. Additional specific adaptations for riverine systems are listed in Table 3.6 below.

Table 3.6 Riverine Climate Impacts and Adaptations Overview

Vector of Riverine Climate Impact		Adaptations
Increased frequency of high severity fire	<ul style="list-style-type: none"> - Elevated stream temp in absence of vegetation - Direct species mortality in fire events - Vegetation level change, type level conversions from forest to shrub - Reduction of habitat complexity - Direct contamination of water sources from fire suppression activities, esp. high phosphorus retardants. - Impacts of fire retardants on vegetation throughout watersheds (e.g. ridgetops). 	<ul style="list-style-type: none"> - Return historic cultural fire regimes: Low intensity fires benefit stream flows as they clear out brush that uptakes water, high intensity fires are needed to generate debris inputs. - Expand tribal management authority/program capacity to enable cultural burning and managed wildfire as acute emergency responses. - Policy implementation to significantly reduce amount of retardants, use only non-toxic alternatives and potentially exclude retardant use within key watersheds - Utilize manual fuel breaks so that excessive fire retardant unnecessary to hold lines (also benefits employment) - Increasing local fire capacity making reliance on retardants unnecessary - Additional research on impacts of retardants and alternatives

Changing temperature patterns	<ul style="list-style-type: none"> - Increased air/water temperatures especially in summer - Increased nighttime temperatures - More variable air and water temperatures - Decreased snowpack - Increase vegetation evapo-transpiration 	<ul style="list-style-type: none"> - Dam removal on mainstem Klamath, Shasta and key tributaries with spring creeks to restore access to cold water in headwaters reaches - Re-establish sediment flows and geomorphic processes to shape habitat and cool water downstream of dams. - Restore instream flows, especially for Shasta, Scott and spring fed creeks - Restoring floodplains geomorphically and with vegetation. - Restoring and increasing hyporheic flow, large wood - Enable colder water retention in system, e.g. restoration of meadow systems to maximize ability to maintain water table - Expand tribal management authority and program capacity to enable cultural burning and managed wildfire as long term as well as acute emergency responses. - Restoration/Implementation of cultural indicators for acute trigger events with temperature extremes (e.g. PG salamander/spring salmon mortality) - Return aspects of historical cultural fire regime to reduce vegetation and increase discharge to riverine systems (e.g. reduce fire intolerant tree density across landscape). - In season prescribed/cultural burning in strategic geographic areas to create smoke inversion nearest and to cool down warmer river sections during heat waves/drought. - Expand research/monitoring of climate impacts e.g. key tributaries as cold water refugia, particular species needs including assisted migration - More aggressive actions including assisted migration should be evaluated
Changing precipitation patterns	<ul style="list-style-type: none"> - Decreased in summer stream flows - Changing timing of runoff - More variable precipitation - Increase in flood frequency, intensity and variability, especially winter 	<ul style="list-style-type: none"> - Restoration, ecosystem enhancement (e.g. in-stream flows, habitat restoration, road decommissioning/storm proofing) - Return historic cultural fire regimes to mitigate drought effects on high severity wildfire potential - Research/ monitoring of heat source/sinks to promote cooler water
Species invasions/ Diseases	<ul style="list-style-type: none"> - Increased presence of and interactions with aquatic and riparian invasive species - Increase in fish diseases and pathogens 	<ul style="list-style-type: none"> - Mechanisms to reduce favorable conditions for disease and pathogens including emergency increasing river flows, dam removal. - Increase jurisdictional coordination for eradication and reduction of pathogens and invasive species including emergency measures. - Restore instream flows, especially for Shasta, Scott and spring fed creeks - Expand research and monitoring of aquatic diseases, pathogens and effective policy adaptation responses. - Public Education and prevention of new invasives and to reduce the spread of existing populations
Ocean impacts	<ul style="list-style-type: none"> - Ocean acidification - Sea level rise - Changes in coastal upwelling and currents 	<ul style="list-style-type: none"> - Engage in policy and collaboration regarding ocean conditions

Cultural Indicators for Riverine Systems

Adaptations for riverine systems require a return to utilization of spring chinook salmon (Ishyá'at) and Pacific lamprey (akraah) as cultural indicators for riverine, each of which have long been cultural indicators of particular aspects of the human management responsibility. Due to the connections between riverine and other habitats, cultural indicators in other zones are also key. In particular Púfpuuf or Pacific Giant Salamander is a key indicator for the entire riverine, riparian and forest system. Púfpuuf is discussed under riparian species.

Spring Chinook Salmon / Ishyá'at / *Oncorhynchus tshawytscha*



www.westcoast.fisheries.noaa.gov

Importance As Cultural Indicator

There were once 5 runs of salmon in the Klamath basin. Ishyá'at is among the most critical foods for Karuk people, and is key to overall ecosystem health. Salmon are connected to people as a stable food source that are critical to survival in this place. Ishyá'at spring runs have experienced severe declines as a result of hydroelectric dams, reduced water flows and warmer water

temperatures. Many of the old pictures of Karuk fishermen are trigger net fisheries from platforms built for Spring Run Chinook and were taken during spring water conditions. Loss of population diversity is directly affecting Karuk ability to harvest chinook salmon during other times (spring and early summer) than just the fall dip net fishery in the fall. Like humans, salmon are also connected to fire in many ways, including via mid-summer burning when fires create smoke that blocks sunlight, cooling river temperatures. Ishyá'at are also connected to the forests through spawning and their contribution to forest nutrients. The presence and absence of this species is an indicator of both riverine and forest habitat quality. The most productive mid Klamath salmon streams have burned recently, mostly with high severity fires, e.g. Horse Creek, Seiad Creek, Dillon Creek, Clear Creek, Wooley Creek, and the North Fork of the Salmon River. Reconnecting our relationship with fire reestablish the biological life cycle with strays and some runs may be able to recover. Genetic diversity may not be as it once was, but the evolutionary behavioral process may end up reestablishing over the long haul.

Climate Change, Life Cycle & Habitat

Ishyá'at is a key cultural indicator due to their sensitivity to stream temperature, their connection to the forests and to the Klamath basin as a whole. Fresh, cool water temperatures are critical to Ishyá'at, as are spring to early summer high water flows that Ishyá'at requires to reach summer holding areas, to access spawning grounds, and to reproduce. With a transition from frequent low severity pulse disturbances that provide the necessary inputs for that species, to larger press disturbances that produce more chronic impacts our climate adaptation strategies may need to change. Climate change and changing weather patterns such as drought cycles and high severity storm events have had direct implications on species such as salmon. On the Klamath so called "Spring Creeks" that originate in volcanic terrain are climate resilient because ambient air temperature has less effect on water temperature and flows are relatively stable all

year round. Spring creeks are perfect for production of juvenile salmon because of the stable nature of year-round cold water. However, nearly all spring creeks on both the Klamath and Shasta are locked up behind dams. Dams also block access to abundant volcanic spring creeks with cold water habitats that are less influenced by ambient air temperatures therefore are more resilient to climate change. Salmon access to groundwater fed streams is blocked at Iron Gate Dam and Dwinell Dam located on the Shasta River. This plan gives us a place to be starting from and a platform to recognize when those changes are starting. Overall ecosystem adaptations including the restoration of traditional fire regimes, reducing impacts from intervening factors, the expansion of Karuk tribal management authority and capacity, community engagement and public education, increased interjurisdictional coordination, and expanded research and monitoring, listed in Table 2.1 in Chapter Two, are essential for riverine systems and ishyá'at. Additional specific adaptations for ishyá'at are listed in Table 3.7 below.

Table 3.7 Adaptations for Salmon		
Ecological Outcome	Adaptation Action	Specifics
Increase access to cold water	Remove fish passage barriers, access to cold water, sediment flows, etc. from upper basin and spring creeks	Remove mainstem dams currently blocking access to abundant volcanic spring creeks with cold water habitats as well as re-establish sediment flows and geomorphic processes that shape habitat and cool water downstream of the dams.
	Reduce sediments from road debris -this could increase with future climate scenarios	Culvert/road maintenance, enhancement, especially lower and in particular mid slope roads located in inner gorges, and geologically unstable areas
	Instream flow restoration	Instream flows for Shasta and Scott Rivers
	Restore cultural burning at landscape scale during critical warm water time periods	Conduct Landscape level work, e.g. burning in strategic locations in accordance with traditional cultural management practice timing. Utilize cultural indicators for when burning should occur, develop emergency management protocols, e.g. púfpuuf mortality
Enhance Spawning Habitat	Mainstem Klamath dam removal, tributary enhancement	Access to key spawning and rearing habitat in tributaries behind Iron Gate and Dwinell Dams, enhancement of habitat through returning fire intervals, maintenance and enhancement of habitat in higher producing tributaries
Ocean Conditions/Food Supply	Engage in policy and collaboration regarding ocean conditions	
Monitoring and ongoing Planning	Continue monitoring of this species, evaluate more aggressive actions including transplanting	Relationships between tributary productivity and fire, smoke and river temperatures, fish diseases and pathogens, interactions with invasive species

Pacific Lamprey (Eel) / Akraah / *Lampetra tridentata*



@ Jeremy Monroe, oregonstate.edu

Importance As Cultural Indicator

Akraah is an important food source for Karuk people, harvested during the upstream migration. Lamprey are related to humans as a food source, related to fire cycles for their well-being and related to the upslope through bears and birds through taking those nutrients back up the hill to feed plant life, similar to that of salmon. The start of river fishing for eels is traditionally considered after the dogwoods bloom and extends through the end of the migration. (Karuk DNR 2010). The fire processes on sediment and nutrient cycles in the aquatic system the nutrient cycling that occurs with fire in aquatic systems related to sediment inputs and relationships at that level, particularly when a pacific lamprey is in an ammocete stage. Fire breaks down leaves, branches and forest biomass. This fine material then enters the watercourse where it helps to create the correct ph balance for ammocetes who spend up to seven years subsurface as filter feeders. We know that this species comes in to spawn and die, thereby also impacting tree growth in the upslope forests.

Climate Change, Life Cycle & Habitat

As an adult, akraah is a parasitic species that feeds on various marine and anadromous fish. Adults live in the ocean for a few years before returning to freshwater to spawn in gravel nests. After spawning, adults die, and their eggs hatch into larvae that reside and filter feed in silty or sandy substrates in freshwater for up to 7 years. Eventually, they transform into juveniles that migrate to the ocean, where they develop teeth on their sucking disks and take their adult form. One generation of lamprey occurs over the course of 2-3 generations of salmon. Their life cycle is long and they require fine sediment for their longest life stage—the larval stage (Streif 2008). Pacific Lamprey do not necessarily return to their natal river systems, juveniles migrating out of the Klamath do not always return to the Klamath. Adult pacific lampreys follow the scent of pheromones release by juvenile lamprey (ammocetes). This highlights the importance of ammocete habitat in the Klamath as a factor in the adult population size and access as a food source. Ammocete require large depositions of fine sediments and furthermore require dynamic river processes of sediment transport and depositions. The Scott River is the largest source of fine sediment to the mainstem Klamath above the Trinity River. The Scott River is a snow pack driven river system that is forecasted to

be impacted significantly by climate change. Iron Gate Dam has cut off the sediment supply to the upper Klamath River therefore ammocetes are not present directly below the dam and limited attraction to adults.

Existing stressors for Pacific Lamprey thus include siltation, dams, habitat degradation. Warming riverine temperatures and potential increases in sedimentation depending on future fire regimes pose threats to akraah with the changing climate. Changing stream substrates, decreases in habitat complexity, alterations to flow hydraulics, sedimentation, and temperature changes all negatively affect various life stages of akraah. Pacific Lamprey can exist in temperature range of 41-68 F°. Temperatures over 68 F° are “generally synonymous with stress, tissue damage, and potential mortality” and may “interfere with and create mismatches in the timing of the key seasonal activities of migration, spawning, and embryonic development” (Clemens et al 2017). Akraah utilize a temperature range of 50- 64 F° ° for spawning and 57-66 F° for early development (Clemens et al. 2016). Overall ecosystem adaptations listed in Table 2.1 in Chapter Two are essential for riverine systems and akraah. Additional specific adaptations for akraah are listed in Table 3.8 below.

Table 3.8: Climate Adaptations for Pacific Lamprey

Increased frequency of high severity fire	<ul style="list-style-type: none"> - Elevated stream temperatures - Sedimentation, infilling of pools - Loss of riparian vegetation structure to provide cover can elevate river and creek temperatures (brush fields) 	<ul style="list-style-type: none"> - Removal of mainstem Klamath dams to return sediment transport and flow. - Return historic fire intervals to increase sediment transport vital for ammocetes - Public education and outreach, etc -
Changing Air Temperature Patterns	<ul style="list-style-type: none"> - Increased summer temperatures - Increased stream temperatures - Decreased summer snowpack 	<ul style="list-style-type: none"> - Mitigate by reducing other stressors, dam removal, road restoration, culvert updates - Return historic fire intervals
Changing Precipitation patterns	<ul style="list-style-type: none"> - Decreased in stream flows - Increase in flooding with more rain on snow events - Changing timing of runoff - More variable precipitation 	<ul style="list-style-type: none"> - Mitigate effects with restoration of fire regimes, to re-establish stream flow and sediment, stream structure - Mitigate by reducing other stressors
Species Invasions/Diseases	<ul style="list-style-type: none"> - Potential for increased disease spread and susceptibility 	

Riparian Adaptations

Riparian areas are key sites for many food, fiber and medicinal species of importance to Karuk people. Species of importance in riparian areas as cultural indicators include Pacific giant salamander (púfpuuf), aquatic garter snake (asápsuun), beaver (sahpihnîich), mink (Xanchun'ámvaanich), cedar waxwing (akravsiip), yellow-breasted chat, big leaf maple (saan), and multiple species of willow. Some of these species are also discussed under the section on adaptations for riverine systems and wet meadows. The health of riparian areas is also important for the functioning of riverine and forest systems and the habitat quality for the species within riparian systems are highly vulnerable to a variety of climate stressors including changing patterns of temperature, precipitation, fire behavior and species invasions. For example, whereas soil moisture in the past several decades has measured at 11.5 inches, this is expected to decrease by nearly 2 inches by the end of the century, see Table 3.9 below.

Table 3.9 Relevant End of Century Climate Forecasts for Riparian Systems (NW Climate Tool)

	Recent Decades (baseline)	By end of Century (2070-2099)	Change
Days over 86 ° F	49.8 days	102 days	+ 52.5 days
Soil Moisture	11.5 inches	9.6 inches	- 2 inches
Total summer precipitation	12.5 inches	11.3 inches	-1.2 inches
Snow Water Equivalent	10.3 inches	1.4 inches	-9 inches
Days of extreme fire danger	11 days	17 days	6 days

Prolonged drought will generally reduce stream flows, and may cause permanent streams to become intermittent. Increasing temperatures may dry forest floors and reduce the area of moist refugia in terrestrial riparian zone. More severe winter or spring rains may cause flooding events that would increase siltation and alter aquatic

riparian habitat structures. Warmer climates may lead to increase spread and susceptibility of diseases for amphibians as well as other species in the riparian zone.

Intervening Stressors to Riparian Systems from Non-Tribal Management

Aside from climate stressors, riparian systems are already threatened in the mid-Klamath area by dams, water diversions, species invasions, logging, roads and fire suppression. Sediment from past logging and road building activities, as well as poorly maintained roads has increased stream temperatures in riparian areas. Inputs of fine sediments, alter stream hydrology, may eliminate salmon spawning habitat by filling it in with sediment, and can smother salmon redds, suffocating eggs. Adaptations must take into account how these ongoing stressors intersects with climate stressors. The adaptations for riparian systems must also account for actions taken by other agencies in the context of the changing climate, these especially include actions prior to, during and after high severity fires. During high severity fire events for example, riparian systems face additional threats from firefighting activities. Road building and the use of bulldozers and the cutting of trees are allowed to occur without NEPA process during high severity fire events. While the use of fire retardants is not permitted in riparian areas, accidents occur on a regular basis. Lastly, the longer-term aftermath of high severity fires are increasingly characterized by proposals for salvage logging operations. Here too normal procedures set in place for water quality protections have been waived, reducing protections on riparian systems.

Climate Adaptations for Riparian Systems

Climate adaptations in riparian systems should in general follow the habitat requirements for púfpuuf including terrestrial and aquatic needs, availability of large wood, and seasonality of cultural burning to protect from late summer high intensity fires in riparian areas. Burn plans must be developed in a way that doesn't consume all the large wood near the riparian environment without allowing for recruitment. Primary adaptation strategies for Riparian Systems include 1) the development of short-term measures to mitigate immediate impacts of temperature, sedimentation and firefighting activities in the event of high severity fires, and acute water temperatures especially during summer and early fall, 2) the restoration of fire regimes on the landscape scale, and 3) engagement in robust restoration activities including restoration of flood plains, restoration of in-stream flows, meadow restoration, road decommissioning, road storm proofing and culvert upgrades to restore and enhance ecosystem resilience in the face of intervening factors. Adaptations discussed under riverine and lower, middle and

higher elevation forest systems are also critical for riparian systems. A central cultural indicator for riparian systems is Pacific Giant Salamander or Púfpuuf.

For example, in 2013, California's Salmon River, one of the last remaining habitats of Spring run Chinook salmon and ESA listed coho salmon, warmed to lethal temperatures for these unique fish. An exceedance of 15% mortality of spring run Chinook was observed in the Salmon River Watershed. This die-off was also accompanied by a count of numerous dead púfpuuf. For Karuk cultural practitioners, the presence of the dead Púfpuuf was an alarm signal indicating potential for system collapse. Smoke from fires lowers air and water temperatures significantly. That year, a lightning fire started in the Salmon River drainage which provided temporary relief through smoke shading and reduction of vegetation uptakes which together kept lethal river temperatures in check. Had this fire not occurred, staff at Karuk DNR were preparing to use fire in recent fire footprints in a safe manner consistent with traditional cultural practices. Overall ecosystem adaptations including the restoration of traditional fire regimes, reducing impacts from intervening factors, the expansion of Karuk tribal management authority and capacity, community engagement and public education, increased interjurisdictional coordination, and expanded research and monitoring, listed in Table 2.1 in Chapter Two, are essential for riparian systems. Additional specific adaptations for riparian systems are listed in Table 3.10 below.

Table 3.10 Riparian Climate Impacts and Adaptations Overview		
Vector of Riverine Climate Impact		Adaptations
Increased frequency of high severity fire	<ul style="list-style-type: none"> - Elevated stream temperatures - Potential for direct mortality for Pufpuuf in both forest and riparian system - Fires occurring during avian nesting season can affect reproductive success - Fires can reduce avian habitat (e.g. perching snags) - Sedimentation, infilling of pools - Loss of riparian vegetation structure (brush fields) for Asápsuun - Direct contamination of water sources from fire suppression activities, esp. high phosphorus retardants. 	<ul style="list-style-type: none"> - Restore traditional cultural fire management practices - Tailor fire applications to avoid avian nesting season - Cultural burning at proper intervals to maintain riparian willow and cottonwood habitats (Karuk DNR) - Develop additional species as indicators - Significantly reduce amount of retardant used, use only non-toxic alternatives and potentially exclude retardant use within key watersheds - Utilize manual fuel breaks so that excessive fire retardant no longer necessary to hold lines (also employment) - Increasing local fire capacity so that not needed to rely on retardants - Additional research on impacts of retardants and alternatives

Changing temperature patterns	<ul style="list-style-type: none"> - Increased air and water temperatures, especially in summer - Increased nighttime temperatures - Decreased overall and summer snowpack - Increase vegetation evapo-transpiration 	<ul style="list-style-type: none"> - Return historic fire intervals, however burning prior to the return of Pleiades may be warranted if elevated levels of mortality is witnessed due to high stream temperatures - Enable colder water retention in system, e.g. restoration of meadow systems to maximize ability to maintain water table - Expand tribal management authority and program capacity to enable cultural burning and managed wildfire as long term as well as acute emergency responses. - Restoration/Implementation of cultural indicators for acute trigger events with temperature extremes (e.g. PG salamander/spring salmon mortality) - Return aspects of historical cultural fire regime to reduce vegetation and increase discharge to riverine systems (e.g. reduce fire intolerant tree density across landscape). - In season prescribed/cultural burning in strategic geographic areas to create smoke inversion nearest and to cool down warmer river sections during heat waves/drought. - Expand research/monitoring of climate impacts e.g. key tributaries as cold water refugia, particular species needs including assisted migration - More aggressive actions including assisted migration should be evaluated
Changing precipitation patterns	<ul style="list-style-type: none"> - Decrease in stream flows - Increase in flooding - Changing timing of runoff - Changing timing of runoff may affect prey species and habitats (Chat) - More variable and intense precipitation, flooding, drought 	<ul style="list-style-type: none"> - Mitigate effects with restoration of forests, meadows, etc. - Maintain riparian willow and cottonwood habitats, sandbars (Chat) - Cultural burning at proper intervals to maintain riparian willow and cottonwood habitats (Karuk DNR) - Maintain riparian floodplain habitat by discouraging channelization of streams (Altman 2000) - Research/ monitoring of climate impacts and intervening stressors (Identify heat source/sinks to promote cooler water)
Species invasions/ Diseases	<ul style="list-style-type: none"> - Potential for increased spread and susceptibility to amphibian disease - Cowbirds (for Chat) 	<ul style="list-style-type: none"> - Reduce potential cowbird parasitism by keeping large aggregations of livestock away from riparian areas (Altman 2000)

Cultural Indicators for Riparian Systems

To illustrate adaptations for Karuk species of importance in riparian habitats we provide species profiles for four riparian species of cultural importance: Pacific giant salamander (púfpuuf), aquatic garter snake (asápsuun), beaver (sahpihnîich), and yellow-breasted chat. Each of these species have long been cultural indicators of particular aspects of the human management responsibility. Adaptations for riparian systems require a return to utilization of these cultural indicators.

Pacific Giant Salamander / Púfpuuf / *Dicamptodon tenebrosus*



Californiaherps.com

Importance as Cultural Indicator

In Karuk beliefs, púfpuuf is a spiritual being who transformed into a salamander to monitor spring and creek water quality and quantity. The healthy presence of púfpuuf is indicative of a healthy riparian and aquatic fresh water ecosystem.

Púfpuuf is central in Karuk culture - they're not a Karuk food source, but they are a keeper of water that is critical to our life. Púfpuuf it has its own

prayer in ceremonies related to how humans - as the only species capable of lighting a fire and making sure it doesn't get out of hand - can maintain balance in riparian systems. As a cultural indicator pacific giant salamander is connected to the transitional riparian habitat between the in-stream and the up-slope environments. Some individuals live completely in the water, others live in a mostly terrestrial environment. They're one of the 5 focal species for the Somes Bar Integrated Fire Management Project. It helps teach why we let some places burn differently than others; not letting all places burn in the wildfire environment alone. It needs large wood. When we find them in places of human activity it is our responsibility to make sure that they are safe by moving them to a wet place.

Life Cycle & Habitat

Púfpuuf is a bridging species indicating the human responsibilities to the slope and to the water. Púfpuuf occurs in moist and riparian forests in or near clear, cold streams and rivers, springs, creeks, lakes, and ponds. Population densities are highest in creeks with many large rock/stones and woody material in or under which púfpuuf can take shelter. Larvae are born in water where they swim using an enlarged tail fin and breathe with filamentous external gills. They eventually transform into four-legged salamanders that live on the ground and breathe air with lungs. Some adults retain their gills and continue to live in water (Californiaherps.com 2016).

Existing stressors for púfpuuf include habitat loss, stream temperature increases, and sedimentation that results from logging operations. Clearcut logging limits the ability of Púfpuuf to move across the forest. With climate change increased temperatures may dry forest floors and reduce moist refugia in terrestrial habitats. Prolonged drought may lead to reduced moist refugia for adults and may cause

permanent streams to become intermittent streams, and generally reduce stream flows which could impact aquatic habitat for larval stages. More severe winter or spring rains may cause flooding events that would increase siltation and alter aquatic habitat structures. Warmer climates may lead to increase spread and susceptibility of amphibian diseases.

Púfpuuf is a perhaps the most important cultural indicator for the identification of needed emergency management actions. Karuk traditional practitioners report that if púfpuuf is in peril, we are on the verge of system collapse. Since smoke from fires lowers air and water temperatures significantly, the immediate application of fire (e.g. burning in recent fire footprints if necessary) is a recommended emergency adaptation measure in response to acute water temperatures that may especially be experienced during summer and early fall. This is especially true in between the time Pleiades reemerges in the sky and conditions conducive of producing lightning occurs following years with little to no snowpack. Trigger points based on these conditions can be established based on annual snowpack and elevated water temperatures during this time. The development of additional short-term measures to mitigate immediate impacts of temperature, sedimentation, and firefighting activities in the event of high severity fires is needed.

In the bigger picture, the restoration of fire regimes on the landscape scale is a critical adaptation for this cultural indicator. Burn plans must be developed to protect large wood near the riparian environment. Burning in mid to late June protects púfpuuf habitat from late summer fires that could damage log micro-habitats. Cooperation and collaboration with other federal agencies that also have jurisdiction in the area including, the United States Forest Service, NOAA Fisheries, US Fish and Wildlife Service is fundamental. Consideration for burning green piles during fuels reduction projects may be critical as piles that sit on the landscape too long become occupied habitat that is subsequently burned when this species needs the thermal cover and cannot escape.

Robust engagement in other restoration activities including road decommissioning, road storm proofing and culvert upgrades to restore and enhance ecosystem resilience in the face of intervening factors is critical. Adaptations discussed under riverine and lower, middle and higher elevation forest systems are also critical for púfpuuf and vice versa.

Aquatic Garter Snake / Asápsuun / *Thamnophis atratus*



@ Gary Nafis, californiaherps.com

Importance As Cultural Indicator

For Karuk people, asápsuun is a cultural indicator of healthy aquatic and riparian systems. Aquatic Garter Snake is tied directly into the stories that help us understand what the salamander prayer is and how it is tied to activities such as why we light Black Mountain on fire in August. It is said that the water snake carries that message

out and over the ocean and it comes back with clouds and rain and the water comes back to us. As fire regimes are restored in Orleans and the Black Mountain area, paying attention to this species may become more important.

Climate Change, Life Cycle & Habitat

Asápsuun is a highly aquatic snake that uses water for both foraging and protection. It prefers shallow, rocky creeks and streams in forested or grassy areas. It feeds primarily on amphibians at various life stages, including frogs, tadpoles, newts, salamanders, and salamander larvae. Courtship occurs during the spring, and young are born in late summer to early fall (Californiaherps.com | 2016). In Karuk territory, people have reported seeing fewer and fewer "water snakes," a fact that they attribute in part to the impact of fire suppression on aquatic systems (Lake 2007).

With climate change increased temperatures may dry forest floors and reduce moist refugia in terrestrial habitats. Ectothermic animals may be particularly vulnerable to temperature changes. Prolonged drought may lead to reduced moist refugia for adults and may cause permanent streams to become intermittent streams, and generally reduce stream flows which could impact aquatic habitat for larval stages. More severe winter or spring rains may cause flooding events that would increase siltation and alter aquatic habitat structures. Warmer climates may also lead to increase spread and susceptibility of diseases.

Adaptations for Asápsuun including returning historic fire intervals, riverine and riparian restoration, and reducing other stressors.

Beaver / Sahpihnîich / *Castor canadensis*



@ Ginger Holser, wdfw.wa.gov

Importance As Cultural Indicator

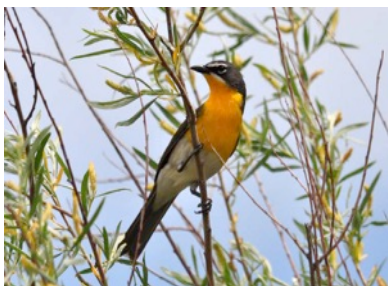
Sahpihnîich alters ecosystems in ways that benefit other species. Beaver dams are known to improve juvenile Coho salmon habitat (Colleen and Gibson 2001). Karuk people value beaver as a teacher of how to intervene in natural processes for the greater good. Sahpihnîich is considered nearly locally extirpated and in need of reintroduction (Karuk DNR 2010). Sahpihnîich constructs dams in lower gradient streams thereby providing the right combination of water depth, velocity and cover for juvenile Coho. Beaver dams raise water level up into the willow layer providing beaver access to food without too much predator exposure while simultaneously providing shelter for the juvenile Coho, salmon and steelhead. The physical infrastructure of beaver dams in floodplain environments helps to slow down and redistribute large wood, potentially building sediment terraces along the watercourse that connects to the terrestrial species when larger flood events occur. Beaver dams attenuate peak flows during flood events, and store more water in the watershed which is beneficial during drought periods. Beaver dams also settle out fine sediments from fires, making them available for distribution on the floodplain, thereby also improving habitat for lamprey and Coho.

Climate Change, Life Cycle & Habitat

Sahpihnîich must possess a stable aquatic system, channel gradients of less than 15%, and a sufficient supply of quality food species. Normally, beavers don't forage further than 300 ft from water, and prefer herbaceous over woody plant material. Prime food species include quaking aspen, willows, alders, and dogwood. The center of beaver activity is the beaver lodge, often constructed in the water or against a bank. (Tesky 1993) Beavers can disperse relatively long distances and are generally not sensitive to changes in disturbance regimes. However, they have a somewhat sensitive life history and are also sensitive to habitat loss or degradation and direct human conflict, such as harvesting. Major potential impacts to sahpihnîich in the face of climate change include habitat destruction and degradation, lack of riparian vegetation for their food sources. Restoring historic fire regimes will benefit sahpihnîich by promoting the growth of riparian vegetation, and reducing the threat of high severity fires.

As the climate changes, sahpihnîich can play a role in drought mitigation by storing water and maintaining areas of open water (Hood and Bayley 2008). Sahpihnîich dams moderate stream temperatures by creating large pools that stratify with cooler water at the bottom which can serve as temperature refugia for fish during the heat of the day, and create a warm top layer for feeding in the mornings and evenings (Hoffman and Recht 2013 in Pollock 2017). Sahpihnîich dams can also result in cooler downstream temperatures (Pollock 2007), reduce peak flows in flooding events (Pollock et al 2003), create complex aquatic habitats for many other species, trap suspended sediment (Green and Westbook 2009), and restore incised streams to more complex channel and ponds systems. There is a lot of current information about and interest in beaver restoration and relocation efforts and methods (i.e Pollock et al 2017).

Yellow-Breasted Chat / *Icteria virens*



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(Awaiting photo permission)

Importance as Cultural Indicator

The yellow-breasted chat is a seasonal migrant that features in Karuk stories in which it welcomed as the true harbinger of spring (Salter 2003). The yellow feathers of its breast have traditionally been a part of tribal regalia. Karuk culture says that birds were put here to watch over humans and let us know when we need to be doing things: doing things right, doing things wrong, doing things in a particular way. We now need to act on a large

level. The chat is tied to the responsibility of humans to realize that something has to be done about fire. The chat is a migratory bird that nests in the spring. When we are burning low, the return of the chat and other birds who have come back to nest, signals that we want to stop burning. Other avian elevational migrants and birds who nest at different elevations and times, should be developed as cultural indicators for fire applications. Humans have burned as they moved up and down with birds for thousands of years. And if we can do this and make that part of the culture of fire use we don't have to stop on Feb 15 because the Spotted Owl is in decline. Instead we will have an indicator that changes as the climate changes. We can either shorten our window or broaden it as the species are telling us.

Climate Change, Life Cycle & Habitat

Chats are numerous in Northwestern California, with the highest densities in the state found along the Klamath and Trinity Rivers. In other areas of they are estimated at about 35% of their historic range (Shuford & Gardali 2008 p 356). This migratory species depends on riparian areas, especially sandbars, with willows. It nests in dense thickets, and uses larger trees as singing perches (Dunn and Garrett 1997). It feeds primarily on insects and wild fruit (Myers n.d.). In California it is a species of special concern (Myers n.d.). It is important to maintain and restore riparian habitats and sandbars. A return of cultural burning at proper intervals will maintain riparian willow and cottonwood habitats. Maintaining riparian floodplain habitat by discouraging channelization of streams (Altman 2000) will also benefit Chat. Chat are susceptible to cowbird parasitism - reduce this risk by keeping livestock away from riparian areas (Altman 2000). Chat may also be susceptible to changing wind conditions along migration routes to and from the tropics (Huang et al. 2017).

Low Elevation Forest: Below Smoke Inversion Zone (Tanoak forest)

Lower elevation forest habitat is defined below the elevational zone in which smoke inversions form (roughly 500-3,000') within Karuk ancestral territory and homelands is characterized by the presence of tanoak trees (xunyê'ep) as cultural keystone species. Not only have tanoak acorns traditionally constituted a high percentage of the calories and protein of Karuk diets (Norgaard 2005), tanoaks are culturally and spiritually significant. Low elevation tanoak forests contain an abundance of species of direct importance for Karuk food, fiber and medicine. These include tanoak mushrooms (xáyvi'ish, commonly known as matustake), princess pine (xunyêpsurukhitihan), pileated woodpecker (iktakatákkahe'en), black oak (xánthiip), port orford cedar, bay (pahiip), canyon live oak (xanputtin), madrone (kusrippan), ponderosa pine (ishvirip), white oak (axveep), huckleberry (púrith), coyote (pihneefich), black bear (virussur), ringtailed cat (tapukpuukanach), gray squirrel (axruuh), and the winter range of elk (ishyu'ux). South facing slopes in this zone will have grasslands, while along ridges Jeffry pine and some Sugar Pine will be found. When found at this lower elevation, Sugar Pine is an indicator for management. Similarly, while chinquapin is more commonly a middle zone species, its presence in this zone is an indication of places that should be managed for huckleberry. The presence and quality of huckleberry is an indicator for socio-ecological resilience within this lower forest zone. In addition to the direct importance of this habitat zone to particular species, the stand dynamics and fire regimes of low elevation tanoak forests significantly shape riparian and riverine health.

Both the composition and overall stand structure of low elevation tanoak forests is a direct result of their long-term intensive management by Karuk people through the use of fire (Anderson 2005, Bowcutt 2013, Karuk DNR 2010, Martinez 1995, Lake 2007, McCarthy 1993). Historically burning pine, hazel and other species was the female role, while burning Live Oak for dipnet hoops, eel hoops, high quality browse for ungulates is the more male role. Frequent fires limit the encroachment of competing shrubs and conifer species (Turner et al. 2011). Low intensity fire favors oaks over conifer species in part because oaks can re-sprout and thereby reestablish after fires. By contrast, competing species such as cedar, fir and pines reproduce with seedlings that will burn up. The open structure of these forests is important for many other species including madrone, white oak, princess pine, pileated woodpeckers and elk. Indeed, as is true for many other California Indians, the majority of species Karuk people use thrive in either open forest conditions or full sun (Anderson 2005,152). At the larger scale, traditional

burning at multiple fire frequencies promotes a mosaic of vegetation types in different stages of response to fires. Fire exclusion has damaged the diversity of resource patches in the landscape causing what had been distinct bands of groupings that were burned in their own cycles to blend together (Lake pers comm).

Tanoak forests face primary climate threats in the form of increasing temperatures, decreasing precipitation, lower soil moisture, increased frequency of high severity fires and especially expanding forest pathogens such as sudden oak death. While low intensity fires are an integral component of the tanoak forest zone, the increasing frequency of high severity fire in light of climate change pose vulnerabilities for individual species and for stand dynamics as a whole. High severity fires consume snags and logs used by pileated woodpeckers for nesting, rooting, and foraging, and reduces insect populations as well as nut and berry sources that are vital to the woodpecker diet, and may cause direct mortality to tanoak mushrooms if reproductive mycelial mats are damaged.

Among the most concerning invasive pathogens for low elevation tanoak forests is *Phytophthora ramorum*, which causes Sudden Oak Death (Ortiz 2008, Voggesser et al. 2013). Warmer and wetter environments including increased precipitation during spring and early summer is likely associated with increased spread of SOD pathogen (Kliejunas, 2011). This pathogen has destroyed millions of oak and other trees, and has caused twig and foliar diseases in additional plant species across California since the 1990s. Sudden oak death and other lethal invasive forest pathogens hold the potential to increase fire danger in coming years (Metz 2017).

Intervening Stressors to Low Elevation Forest

Low elevation tanoak forests within Karuk ancestral territory have been significantly impacted by conifer encroachment, targeted herbicide treatment to reduce competition with conifer plantations, and the past 100 years of fire exclusion. In such stands meadows are non-existent, conifers such as Douglas fir encroach upon oaks, and huckleberries will be highly dense but without berries. Elk will not be present. During fire events tanoak stands may be subject to destruction through firefighting activities such as back burning and the building of fire lines. Fire lines cutting through tanoak stands may damage or destroy the tanoak's mycelium net. In the immediate aftermath of high severity fires activities such as salvage logging and associated road building also impact tanoak stands (although the tanoaks themselves are not the target species).

Climate Adaptations for Low Elevation Forests

scenario Intricate relationships exist between tanoak, huckleberry, chinquapin, tanoak mushroom, deer, elk, and likely wolf, although they are somewhat separated in this plan they need to be understood holistically. By contrast to the above described fire exclusion scenario, having all species present is an indicator of balanced ecosystem process and function. Additional metrics include plentiful tanoak mushrooms and abundance of tanoak acorns. When huckleberries in the mesic mixed evergreen treatment areas are managed to have an abundance of high-quality huckleberries then elk can protect their young. Overlaying the mesic mixed evergreen biophysical setting with low gradient (less than 35% average slope) landscape conditions and where huckleberry are also present should enable identification and prioritization of areas for restoration treatment. This information will allow for identification of the percentage of the landscape needing to be in a desired uncharacteristic condition from that of current condition. Huckleberry in particular are a cultural indicator for when and where to burn. Burn timing of huckleberry is indicated by the burn timing of tanoak acorn which is in turn, relation to insect management. Emerging scientific studies indicate the presence of chinquapin may be a sign as to where one should burn for huckleberry. Figure 3.10 illustrates these components in a Human Supported Food Web.

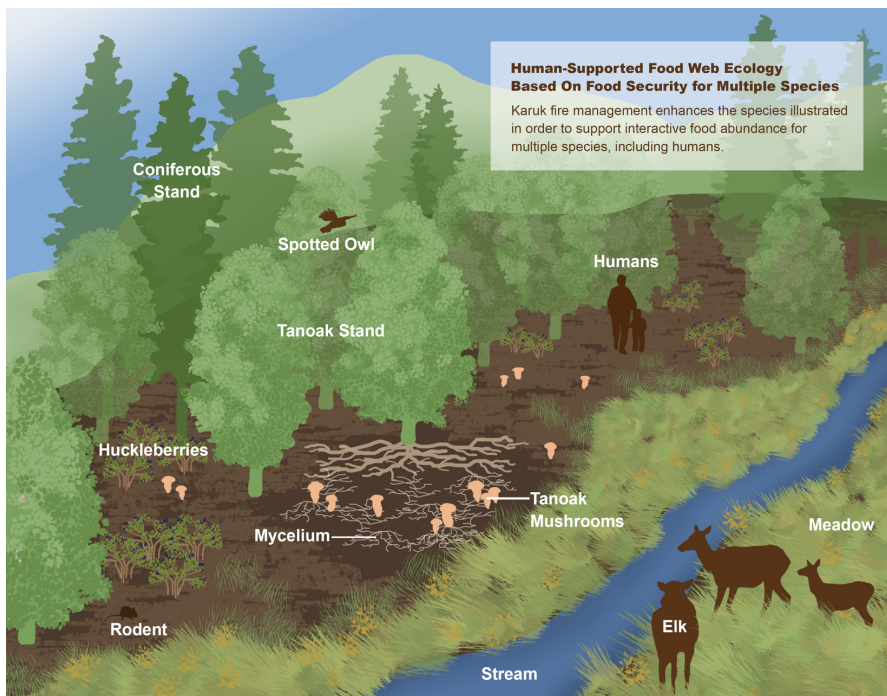


Figure 3.10 Dynamics of human supported food web

(illustration courtesy of Kirsten Vinyeta)

Climate adaptations for low elevation tanoak forests must include landscape level return to historic fire intervals. In the face of a century of fire exclusion and the changing climate it is not presently possible to put fire on the landscape at this traditional time in every instance. However, a combination of geologic features, topography, traditional knowledge coupled with the existence of remnant stands and ceremonial ignition sites as information stored in the landscape can be utilized to strategically return fire at the landscape scale, even in the face of 100 years of fire suppression. Ceremonial ignition points reflect knowledge and instructions inscribed in the landscape that can be replicated across Karuk territory at appropriate locations. Figure 3.4 on p. 68 indicates versions of a multi-step sequence through which fire can be returned at the landscape scale to provide climate adaptations for low to mid elevation and riverine species, and creating landscape protection for the present-day communities of Somes Bar and Orleans. This process can then be replicated and expanded to other communities throughout the western Klamath Mountains and beyond. Climate adaptations for sudden oak death may also include prescribed fire. Hoopa and Yurok tanoak stands that experienced repeated fire were more resilient to the disease over time (Cobb 2017). Other research indicates dramatic differences in disease incidence immediately following wildfire (72 times less likely to be found in burned versus unburned plots in the same area), although it has been shown to steadily recover in the absence of repeated fire, because the disease can survive in hosts not killed by the fire (Beh 2011). See Karuk SOD Plan.

Overall ecosystem adaptations including the restoration of traditional fire regimes, reducing impacts from intervening factors, the expansion of Karuk tribal management authority and capacity, community engagement and public education, increased interjurisdictional coordination, and expanded research and monitoring, listed in Table 2.1 in Chapter Two, are essential for low elevations forests. Additional specifics are listed in Table 3.11 below.

Table 3.11 Low Elevation Forest Impacts and Adaptations Overview

Vector of Climate Impact		Adaptations
Increased frequency of high severity fire	<ul style="list-style-type: none"> - While fire is essential for this forest type, high severity fires consume habitat snags and logs, as well as forage and cover for Íshyuux (elk) - Elk may re-inhabit former high severity patches as conifer and shrub species (browse) are reestablished. - May cause death of Xáyviish (tanoak mushroom) mycelial mats (severe soil burning may extirpate mushroom shiros) - May destroy entire groves of mature-legacy older Xunyêep (tanoak) (former tribal orchards) - Fires during Púriith (evergreen huckleberry) flowering and fruiting season (spring/early summer) may affect harvest and plant reproduction - Xunyêep (tanoak) stands subject to destruction during fire fighting activities, salvage logging post-fire 	<ul style="list-style-type: none"> - Landscape level return to historic fire intervals, frequent use of low intensity fire. - Utilize cultural indicators for burning times, e.g huckleberry and xuntápan (tanoak acorns). - Research: Modeling scenarios to predict vegetation community/habitat type conversion. What vegetation is culturally useful in the new habitat type? - New cultural knowledge and practices keyed into increased availability of post-burn useable species in high severity areas.
Changing temperature patterns	<ul style="list-style-type: none"> - Increased summer temperatures - Increased nighttime temperatures - Decreased summer snowpack - xáyviish requires low temperatures, and a pattern of warming and cooling. (Viess 2016 Hosford et a. 1997) 	<ul style="list-style-type: none"> - Mitigate effects with restoration (maintaining older overstory trees, more open/reduced fuel understory) - Mitigate by reducing other stressors - Return historic fire intervals (promoting drought tolerant/fire adapted vegetation, and heterogeneity of habitats, reducing fuel loads at different scales/aspects and topographic positions).
Changing precipitation patterns	<ul style="list-style-type: none"> - Decreased in stream flows - Increase in flooding (extreme weather, polar vortex (cold)/atmospheric rivers (warm) rain on snow events) 	<ul style="list-style-type: none"> - Design landscape vegetation patterns by aspect, topography, and time since fire to increase snow retention, water use

	<ul style="list-style-type: none"> - Changing timing of runoff - Low fall precipitation in 2018 was associated with low xáyviish harvest 	efficiency/reduced evapotranspiration of vegetation.
Species invasions/ Diseases	<ul style="list-style-type: none"> - Forest pathogens and pests especially <i>Phytophthora ramorum</i>, Sudden Oak Death - Invasive species establishment in burn areas 	<ul style="list-style-type: none"> - Use of fire to reduce spread - Interagency coordination and research regarding strategic use of prescribed fire (see Karuk SOD plan) - Prevent and control Invasive species establishment in burn areas

Cultural Indicators for Low Elevation Forests

Intricate relationships exist between tanoak, huckleberry, chinquapin, tanoak mushroom, deer, elk, and likely wolf, these species are discussed individually but need to be understood holistically. Cultural Indicators of key importance in guiding adaptations in this elevation zone include tanoak (xunyêep), tanoak mushrooms (xáyviish), elk (íshyuux), huckleberry (púrith), pileated woodpecker (iktakatákaheen), and wolf (ikxâavnamich).

Tanoak / Xunyêep / *Lithocarpus densiflorus*



oregonstate.edu

Importance As Cultural Indicator

Xunyêep is an ecologically, culturally, and economically important species. Tanoak acorns (xuntápan) are a staple food for Karuk people and are also vital for many wildlife species. Additionally, the roots of tanoak trees support the growth of another important food, tanoak mushrooms.

Xunyêep is a key cultural indicator for when and where to use fire. There are specific times to burn in a tanoak stand to maximize the quality and abundance of the acorn yield, not only for people but other species including deer, elk and many birds. By using that cultural indicator to tell you when it is time to put fire on the ground, other benefits are achieved as well, e.g. for huckleberry. Some elders have said we should be able to find a five-year pattern in tan oak stands. Every five years we should get a year with big acorns, burning should be aligned to the year prior. Tanoak mushroom has an ectomycorrhizal relationship with tanoak. Decline in tanoak trees results in decreased soil hyphal activity of *Tricholoma* species, disrupting function of these forests (Bergemann, Kordesch, Vansant-Glass, Garbelotto, & Metz, 2013).

Climate Change, Life Cycle & Habitat

The most critical environmental factor determining the fate of tanoaks is fire. Frequent use of low intensity fire is especially important for overall stand structure given that tanoak trees are quite vulnerable to high severity fire. Stands that are clear of underbrush can be burned again without risk of damaging oaks (Hillman 2016, OWIC 2016). Long et al (2017) note that “Tanoak, appear highly adapted and more likely to expand their ranges under the warmer and more fire-prone conditions that have been commonly predicted (Case and Lawler 2016, Coops and Waring 2011). However, warmer and wetter environments including increased precipitation during spring and early summer is likely associated with increased spread of SOD pathogen (Kliejunas, 2011). Treating landscape with fire as a preventative for SOD infection will be especially important along the west side moisture gradient on the west and south of Orleans. Burning these areas is very important to keeping the east zone of our tanoak mixed evergreen biophysical setting intact. It will however be important to collect more information on just how far this disease is capable of moving in a single “jump” as there have been instances witnessed where infection “jumped” over areas recently burned leaving them uninfected.

Tanoak Mushroom / Xáyviish / *Tricholoma magnivelare*



www.shroomery.org

Importance as a Cultural Indicator

Xáyviish is prized as a traditional food and medicine (Anderson and Lake 2013). The tanoak mushroom, also known as the pine mushroom or matsutake, is highly prized in the global market and has at times had very high commercial value, making it vulnerable to overharvest by outsiders (Hosford et al. 1997, Peters and Ortiz 2016). Xáyviish is a critical food source for people and animals, but it also shows us that it can be susceptible to higher intensity fires. Those connections that happen underground in the mycelium chain are not completely understood, the connections between plants and how they communicate and interact with each other is more than humans realize- we need to pay special attention to not be impacting them too much. Impacts to mycelium have been noted as logging machines caused compression from the tracks exposing a severed mycelium layer. It was further observed that mushrooms still grew on the host tree side of the tracks, but didn't grow on other side. There is a need to establish equipment exclusion zones in areas these mushrooms grow to avoid severing or otherwise over-compacting this layer. This species also serves as an important indicator of responsible human use. As with other species having regulated harvest, regulation focuses on expedited human access and economic gain. Karuk traditional cultural regulation focuses on reproductive success, a healthy environment, and access for other species before human use. In the case of this mushroom, picking with veils closed maximizes economic gain, whereas, picking with at least 50% of the veil open assures spore release. The fact that animals that eat them have a better sense of smell gives them the advantage over humans in regard to access.

Climate Change, Life Cycle & Habitat

In Northern California, xáyviish can be found scattered or growing in groups in well-drained soil or duff under tanoak, golden chinquapin, madrone, or pine trees with which it forms a mycorrhizal, symbiotic relationship (Richards and Creasy 1996, Richards 1997, Anderson and Lake 2013). In addition to rainfall, this mushroom requires low temperatures, and a pattern of warming and cooling. (Viess 2016 Hosford et al. 1997). Tanoak mushroom fruiting is a function of relationship between precipitation and temperature, and low fall precipitation in 2018 was associated with low mushroom harvest. Tanoak mushrooms are connected to tanoak trees, elk, huckleberry, deer, wolf

and chinquapin and other species in complex ways. When tanoak mushrooms are plentiful and available it is an indicator of treatment success from the standpoint of soil impacts and host tree retention. Tanoak mushroom has an ectomycorrhizal relationship with tanoak, and a decline in tanoak trees results in decreased soil hyphal activity of *Tricholoma* species, disrupting function and structure of these forests (Bergemann, Kordesch, Vansant-Glass, Garbelotto, & Metz, 2013).

In high-severity fires, Mycelial mats may be burned and destroyed preventing them from fruiting into harvestable mushrooms and compromising survivability of the population. Xáyviish may struggle to repopulate areas if entire stands of host species have been destroyed by high severity fire. Additionally, the moisture and cool temperatures that xáyviish depends on may be less available in forests with repeated high-severity fire.

Roosevelt Elk / Íshyuux / *Cervus occidentalis*



Photo: Kirsten Vinyeta

Importance as Cultural Indicator

Íshyuux are important for their use as food, clothing (hides), regalia, and implements, as well as in their role in shaping ecosystems. The management of elk populations, and the protection and restoration of habitats that elk depend on are of vital importance to the Karuk Tribe. Íshyuux is one of the five focal species in

the Somes Bar Integrated Management Plan. (Karuk DNR 2010). The reproductive needs for elk is an important cultural indicator for management. Humans have learned about the practice of coppicing from animals such as elk. Íshyuux are connected to wolf, tanoak, huckleberry, chinquapin, tanoak mushroom, live oak and deer need to be understood holistically. Much of winter range habitat is now overgrown with mid-mature dense conifer stands and mixed evergreen plantations, much habitat for winter range and calving is lost due to fire exclusion. When Íshyuux were first reintroduced, they moved into private property because that is where people had been keeping things open. As we started seeing less success in fire suppression and wildfires impacting larger areas, some high severity burn pockets started to create more open space. As fires occur, elk herds are splitting and moving off into more places. Presence/absence data and landscape use types can inform us of our progress in regard to winter range and calving habitat restoration and maintenance in the low elevation forest zone. Burning in areas with presence of live oak sprouts in June may be the determining factor in maximizing landscape holding capacity as this would trigger a flush of fresh browse with peak nutrient loading in a time when grasses are curing out and inedible. Browsed live oak sprouts about 5 to 7 years old are then used to make dip net hoops, of which a decline in quality of harvestable quantities would be the indicator for another fire interval on a site-specific basis.

Climate Change, Life Cycle & Habitat

Elk are associated with a mosaic landscape that combines open areas for foraging, and forested areas for cover. They are gregarious animals that navigate in herds year-round. The nature of these herds changes depending on the time of year and the reproductive cycle. Dietarily, elk prefer grasses, followed by forbs, then deciduous browse, and as a last resort, coniferous browse. (Innes 2011). Íshyuux require open space with forage materials close to riparian areas with low gradient and cover and access to water, and

Karuk fire regimes increase landscape holding capacity and population dynamics (see box p. ____). The West Simms unit that burned in the 2015 TREX was a riparian area that was burned at moderate to high severity. Many medicinal plants returned within two years, and elk moved in and started calving almost immediately. Prior to the burn there was no access to food, water or cover for elk. Differences were significant between the cultural prescribed fire and impacts of the adjacent wildfire. The West Simms unit serves as a good example of the benefits that can be achieved as well as the impacts of burning fire excluded forests under moderate conditions.

Using Cultural Indicators at Multiple Fire Severities

The reproductive capacities for elk are an important indicator for management. Karuk fire regimes increase landscape holding capacity and population dynamics. Íshyuux require open space with forage materials close to riparian areas with low gradient and cover and access to water. Much of winter range habitat is now overgrown with mid-mature dense stands and plantations, much habitat for winter range and calving is out of whack with fire exclusion. When Íshyuux were first reintroduced they moved into private property because that is where people had been keeping things open. Fire excluded forests didn't have the habitat dynamics they require.

The West Simms unit burned in the 2015 TREX was a riparian area that was burned at moderate to high severity (a mixed severity burn). Despite initial concern by some about the intensity of that burn, many medicinal plants returned within two years, and elk moved in and started calving in it almost immediately. As William Tripp observes, "Prior to the burn this area was not viable for elk. There was no access to food, water or cover, until we did that burn. And the difference between the prescribed fire that we did for cultural reasons and the adjacent wildfire that burned directly adjacent to that is night and day. And it serves as a good example of why we should get more places to burn under moderate conditions. As fires occur elk herds are splitting and moving off into more places."

Evergreen Huckleberry / Púrith / *Vaccinium ovatum*



www.nwplants.com

Importance As Cultural Indicator

Púrith is an important Karuk food source with many nutritional and health benefits. The berry's high antioxidant content is among the properties that make this plant a medicinal food. Evergreen huckleberry is a key cultural indicator of socio-ecological resistance for successful landscape scale restoration and maintenance, as well as sustainable human use. It is the first one we are attempting to research and define as such in contemporary terms. Púrith is key browse for elk and as such is a useful metric for treatment success. Where present at low elevations, chinquapin indicates places where one may want to treat for huckleberry.

In defining huckleberry as a socio-ecological resilience indicator, we are taking the approach of looking at it through the lens of food security. Food security is typically defined as having an abundant supply of healthy foods for humans. We however added an extra layer into our assessment of this species to include animals. Simply put, huckleberry provides food for birds and other animals. Spotted owls eat rodents. Rodents get food and cover from huckleberry. Too much huckleberry denies the owl access to food. Too little denies food and cover to rodents. Too many rodents cause disease in humans. Humans eat huckleberries and have the capability to manage balanced access and cover for many species. Sustainable harvest by humans can also be defined in this analysis (which will not be complete until after publication of this plan). This sort of research has not been done, but this thought process is foundational in indigenous cultures. We plan to build out this example and replicate it for other species in the interest of refining our view on how we assess indicator species and address sustainable human use and management.

Climate Change, Life Cycle & Habitat

Púrith is an understory shrub is found in coastal forests and mountains of the Pacific Northwest and northern California, and is most abundant in forests that have a higher level of canopy cover. New leaves and flowers emerge in spring, followed by fruit that develops in summer and fully ripens by fall. While this slow-growing, shade-tolerant species depends on a mostly covered understory habitat, flower and berry production increases with light and soil moisture in the presence of forest gaps produced by

moderate disturbance related to fire, timber harvest, or thinning. (Lake 2015). However, an open canopy resulting from high severity fire may reduce the abundance of púrith by creating drier, sunnier conditions in which it may be outcompeted. Fires during flowering and fruiting season may affect harvest and plant reproduction.

The spread of the sudden oak death pathogen (*Phytophthora ramorum*) infects huckleberries (Cobb et al. 2012, Ortiz 2008). Huckleberries seem to be particularly susceptible to infection (Cobb et al. 2012, Ortiz 2008). While the pathogen may not lead to mortality, Long et al (2011) note that “it reduces their suitability for tribal use owing to lesions and may prompt land managers to remove infected plants, especially California bay laurel, to protect tanoak stands” (Swiecki and Bernhardt 2013). The lack of cultural fire also appears to be a disease vector increasing species vulnerability. Warmer and wetter environments including increased precipitation during spring and early summer is likely associated with increased spread of SOD pathogen (Kliejunas, 2011)

Pileated Woodpecker / Iktakatákaheen / *Hylatomus pileatus*



USFS Boise National Forest

Importance As Cultural Indicator

The feathers of iktakatákaheen are used in Karuk regalia (Driver 1939). Iktakatákaheen is seen as an ecosystem engineer that creates cavities that can then be used by up to 20 species of birds and mammals and promotes nutrient cycling in the forest through its excavations (USFS PNRS 2003). It is believed that when

Iktakatákaheen is harvested for use in regalia, the mate should also be harvested lest they would die of loneliness and bad medicine would be made. The process of harvesting such species for regalia is intricately tied to land management. When humans and nature are in sync, there becomes an abundance of some species that then need to be harvested to some degree to avoid population explosions and sharp declines due to food shortages or disease. This species has a lot to teach us and if ceremonial leaders are comfortable releasing certain types of information we should be gleaning from this species, it should be selected soon for more in depth analyses as a socio-ecological resilience indicator.

Climate Change, Life Cycle & Habitat

The largest woodpecker in North America, Iktakatákaheen typically resides in older deciduous or mixed deciduous-coniferous forests. Pileated woodpeckers mate for life, and use large snags and decadent trees to excavate nesting cavities as well as roosts in which the members of the pair roost individually to reduce the risk of predation (Bull et al. 2007). The pileated diet consists primarily of insects (with ants often comprising over 40% of their diet) as well as wild fruits and nuts (USFS PNRS 2003)

Wolf / Ikxâavnamich / *Canis lupus*



@ fws.gov

Importance As Cultural Indicator

Wolves once inhabited Karuk territory, but by the 1920's were decimated by Euro-American hunting, trapping and poisoning. Federal protections have led to an increase in wolf populations and the wolf is likely to make a return to California. Karuk people welcome the return of the wolf as an animal that is important to tribal spiritual practices and ecosystem stability. Intricate relationships exist between wolves and other species in this zone, including elk, deer, tanoak, huckleberry, chinquapin and tanoak mushroom. As a regalia centerpiece in the deerskin dance at Tishawnik, it reminds us of the connections between the use of fire on the landscape and the safety of people in the woods hunting, gathering, pruning, burning and coppicing. Wolf hide used as ceremonial headbands remind us to look at the world through the eyes of the wolf, to teach our young men to protect and care for their families, to not abandon their young, and to honor the leadership of their elders. It also reminds us of the importance to move our burning back and forth across the river and up and down the slopes encouraging rotational grazing of large ungulates and understanding of where the deer, elk, and sub sequentially wolves would most likely be for the purposes of safe human activity across the landscape.

Climate Change, Life Cycle & Habitat

Ikxâavnamich habitat tends to be more prey dependent than land cover dependent. In the West, wolves are known to follow large ungulate herds from their lowland wintering grounds to their upland pastures. Burns that destroy entire stands may force ungulates to seek new forested areas, straining the herd and thus affecting wolves' diets.

Ikxâavnamich creates its own den in meadows near water, rock outcroppings, under tree roots, or even old beaver lodges. Wildfire could kill pups in the den or elsewhere if they lack fast mobility- given the small population numbers, the impact of this loss could be significant. To succeed as a pack, wolves need large, remote areas free from much human disturbance (Snyder 1991).

Grasslands

Grasslands, also known as prairies or glades, historically occurred in mid to upper montane areas on ridges, and in both large and small patches up to low and middle forest elevations, especially on shallow ultramafic soils (Skinner et al 2006; Anderson 2005). Today a majority of the grasslands that once existed within Karuk ancestral territory have disappeared due to lack of fire and traditional Karuk knowledge about grasslands is still being recovered. Place names contain references to species such as wild oats. Grasslands have been historically significant for many species of broad-leaved herbs, native annual and perennial grasses, insects, birds, mammals, reptiles, and amphibians. Amongst these are important Karuk foods such as Elk, as well as iris and other grasses used for twine, and a group of plants known as “Indian potatoes” which include multiple members of the Lilly family, Blue Dicks, White Hyacin, Golden Lantern, Soap Root, Yellow and Globe Lily (Lanctot and Lake ND, Anderson 2005). Anderson (2005) notes the importance of prairies and grasslands for Indian people across California.

Grasslands in particular require frequent burning to maintaining the open prairie structure. Burning prevents conifer encroachment and enhance conditions for key food species, including reducing competition for tubers such as brodiaea and camas and increasing soil productivity by releasing nutrients (Anderson 2005, Stone 1951). Fires enhance the production of bulblets of many of the species known as Indian potatoes. Until about 1850, grasslands were so extensive they covered nearly one-fifth of California (Anderson 2005, 28). Anderson notes “The coastal prairies were burned to produce more food, reduce brush or trees, produce new grass for thatch, drive grasshoppers, enhance cordage materials, and increase forage for ungulates. Indian-set fires modified the grassland to fire-resistant species and expanded the grassland vegetation type (2005, p 167). With the changing climate, drought and species invasions are a particular concern in this habitat type.

Bumblebees of many species are important within grassland habitats in Karuk Aboriginal Territory, these species have been added as cultural indicators for grassland habitats in this adaptation plan. Species diversity in the region is high, Thorp et al (2002) note that “Bumble bee communities in the Klamath Ranges (including the Siskiyou Mountains) of northern California and southern Oregon commonly contain six to a dozen species that often coexist in areas as small as 100 square meters.” The decline of wild bee populations both globally and locally has been of recent ecological concern. While bees require grassland habitat which is fire dependent, the specific relationships between bees and fire is less well understood. Lillie (2011) provides recent local work on

the role of fire in shaping pollinator communities, and also notes that in some cases recently burned areas support higher bee populations, but this is not always the case and relationships are not well understood. Loss and fragmentation of grassland habitat, as well as grazing reduces nesting and foraging habitat quality for many species. This is a species for which more traditional knowledge and scientific attention will be beneficial in the changing climate. Ecologist Frank Lake suggests adaptations to support bees might include the design of landscape vegetation patterns by aspect, topography, and time since fire to increase snow retention, water use efficiency/reduced evapotranspiration of vegetation (Lofland et al 2011). Promote frequent and mixed severity burn patterns among different topographic positions across different vegetation types to enhance and maintain continued early seral shrub and forb plant flowering (linked with native bee life history cycles and foraging/nectar sources) Thorp et al 2002). Table 3.12 below presents summary data for end of year climate scenarios particularly relevant for grassland habitats as compiled by the NW Climate Tool.

Table 3.12 Relevant Grassland Summary Data for Karuk Aboriginal Territory

	Recent Decades (baseline)	By end of Century (2070-2099)	Change
Days over 86 ° F	49.8	102	+ 52.5 days
Annual total precipitation	78.8	82.0	+ 3.2 inches
Total summer precipitation	12.5	11.3	-1.2 inches
Snow Water Equivalent	10.3 inches	1.4 inches	-9 inches

Intervening Stressors for Grasslands from Non-Tribal Management

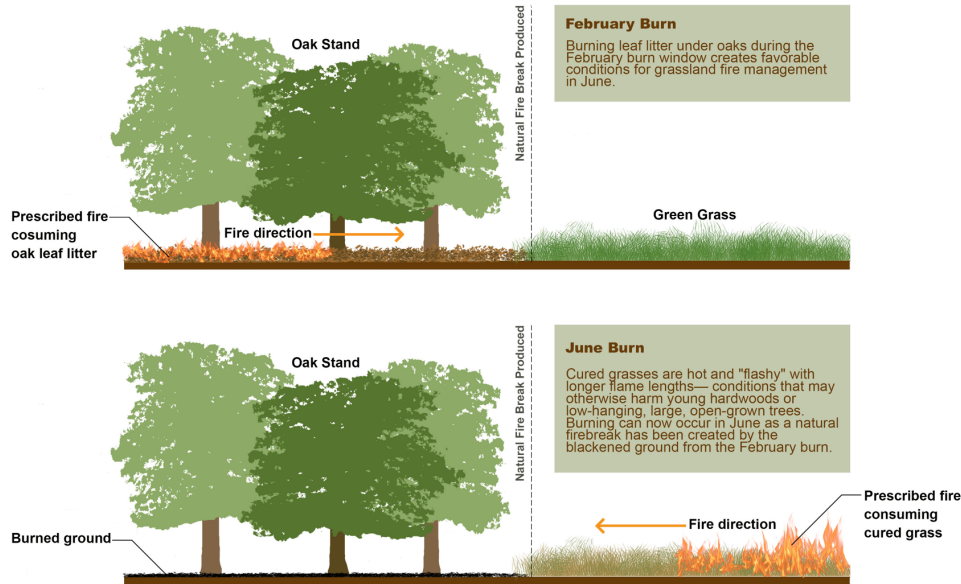
Probably the main intersecting vulnerability to grasslands comes from their severely reduced range due to fire exclusion and from the transport and spread of non-Native species. Anderson writes “in the absence of fire, grassland ecosystems become choked with detritus, and productivity and reproduction fall drastically. Other studies show that grain production in most native perennial grasses dwindles in the absence of some kind of intermediate disturbance, such as herbivory, fire, or flooding. Furthermore, many of the herbaceous plants with edible seeds have high light requirements and grow only in open grasslands or light gaps in forests and shrublands” (2005, 178-179). Grazing is another key intervening stressor for grassland systems.

Climate Adaptations for Grasslands

As with other habitat types, but perhaps particularly so in this case, climate adaptation requires return to historic fire intervals and the revitalization of Karuk cultural practices. Restoration of traditional fire regimes for grassland habitats will require additional species by species research for the eradication and reduction of invasive species, alongside focused attention to Karuk management approaches of action and observation. Attention to specifics regarding which types of grasses (C3, C4) should be burned at different seasonal points (e.g. February, June), how to utilize fire for scotch broom and star thistle along with numerous invasive grasses, outreach to research partners especially grassland ecologists, and mentoring and development of the next generation of cultural practitioners. In particular when looking at southwest low to mid elevation slopes that were historically oak woodland savanna or glades, it will be important to thin conifers, protect young hardwoods at wide spacing (30 -50 yards) and burn frequently. Figure 3.11 illustrates how burning leaf litter in dormant season (February) can be followed by burning dead grass thatch in early summer (June) hardwoods can be promoted. Reducing leaf litter in February fires protects the hardwoods from the hotter flashy grasses that may otherwise harm young hardwoods or low hanging large open grown trees are burned.

Figure 3.11 Cultural Management of Grasslands as Climate Adaptation (Illustration Courtesy of Kirsten Vinyeta)

Cultural Management of Grasslands and Oak Stands: Climate Adaptation in Progressive Scenarios



Overall adaptations including the restoration of traditional fire regimes, reducing impacts from intervening factors, the expansion of Karuk tribal management authority and capacity, community engagement and public education, increased interjurisdictional coordination, and expanded research and monitoring, listed in Table 2.1 in Chapter Two, are essential for low grasslands. Additional specific adaptations for grasslands are listed in Table 3.13 below.

Cultural Indicators for Grasslands

Indian potato (tayiiith) and bumblebees serves as cultural indicators for this habitat type.

Table 3.13 Grassland Climate Impacts and Adaptations Overview

Table 3.13 Grassland Climate Impacts and Adaptations Overview		
Vector of Climate Impact		Adaptations
Increased frequency of high severity fire	<ul style="list-style-type: none"> - High severity patches in formerly prairie/meadow and forest openings that historically supported Indian potatoes may recover populations and promote species diversity (different types). - High severity fire more likely to impact native species and can shift pattern towards invasives. - High severity fires favor ceanothus and manzanita 	<ul style="list-style-type: none"> - Return historic fire intervals (linked with oak woodlands, forest openings, and prairies/meadows). - For south west low to mid elevation slopes that were historically oak woodland savanna or glade, important to thin conifers, protect young hardwoods at wide spacing (30 -50 yards) and burn frequently (3-5 year return intervals). - Burning grasslands in step wise process: leaf litter in dormant season (February) and dead grass thatch in early summer (June) see figure. - Increase seed and cormlet harvesting and reseed/replant in high severity areas that support different Indian potatoes (lilies, other geophytes).
Changing temperature patterns	<ul style="list-style-type: none"> - Increasing air and soil temperatures, especially in summer impacting species composition and invasives - Decreasing snowpack may affect flowering timing, habitat for species such as bumblebees 	<ul style="list-style-type: none"> - Mitigate effects with restoration e.g. conifer management (girdling, thinning). - Promote drought tolerant/fire adapted vegetation, heterogeneity of habitats, reducing fuel loads at different scales/aspects and topographic positions). - Adaptive tribal harvesting/tending practice in sync with soil moisture and phenology/flowering-seeding
Changing precipitation patterns	<ul style="list-style-type: none"> - More high elevation precipitation coming in the form of rain rather than snow - Variable snowpack may also mean that years with increased snowpack 	<ul style="list-style-type: none"> - Mitigate effects with restoration Promote more forest opening, and tree species which hydrologically redistribute deeper ground water and leak it near the surface (e.g. oaks) - Mitigate by reducing other stressors - Utilize available fire windows in wet years to move towards restored fire regimes - Effectively utilize winter burn windows (burn piles in winter, avoid impacts to puuf puuf and other wildlife
Species invasions/ Diseases	<ul style="list-style-type: none"> - Potential range expansion or other interactive effects of Invasive grasses, scotch broom, star thistle, Himlayan Blackberry, cheatgrass, etc - Non-local fire management brings in invasive species 	<ul style="list-style-type: none"> - Utilizing local fire management resources to minimize transport of invasives, esp. cheatgrass - Improve fire crew decontamination - Build invasive management into suppression repair activities as well as BAER and beyond - Increase research and monitoring on invasive species management with fire including burn time effects (e.g. how does June burning of medusa head impacts native species?)

Indian Potato / Tayiith / *Brodiaea coronaria*, etc.



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Importance as a Cultural Indicator

Indian potatoes refer to a variety of geophytes the bulbs and tubers of which are harvested by Karuk people for consumption, including *Brodiaea* spp., *Dichelostemma* spp., *Triteleia* spp., *Calochortus* spp., *Lilium* spp., and *Fritillaria* spp. (Karuk DNR 2010). *Brodiaea coronaria* serves as a good indicator for other Indian potato species, as it tracks soil moisture. Indian potatoes grow in prairies and meadows in a variety of settings.

Climate Change, Life Cycle & Habitat

Historically, species of Indian potato grew thick as grass in certain valleys in California (Anderson 2005). Karuk and other Native California peoples know proper harvesting techniques that further proliferate these species by promoting bulblet production. As with many prairie and meadow species, Indian potatoes have experienced declines as a result of land cover change, fire suppression, and a reduction in the ability of indigenous peoples to steward the landscape (Anderson 2005). Burn timing in regard to this species needs to be refined to account for harvest timing, and invasive species invasions.

Bumblebee / *Bombus* and other general



Importance as a Cultural Indicator

While bees require grassland habitat which is fire dependent, the relationships between bees and fire is less well understood. This is a species for which more traditional knowledge and scientific attention will be beneficial in the changing climate. Refine grassland burn timing in regard to this species.

Climate Change, Life Cycle & Habitat

Ecologist Frank Lake suggests adaptations might include landscape vegetation design by aspect, topography, and time since fire to increase snow retention, water use, reduced evapotranspiration of vegetation (Lofland et al 2011). Promotion of frequent and mixed severity burn patterns among different topographies and vegetation types to enhance and maintain continued early seral shrub and forb plant flowering (linked with native bee life history cycles and foraging/nectar sources) (Thorp et al 2002).

Middle Elevation Forest: Within Smoke Inversion Zone (Chinquapin Band)

The middle elevation forest zone is characterized by the elevational band in which smoke inversions form (see Figure 3.1 On p. 60 and associated text for more description). Species occurring within this cultural management zone are critically important for Karuk people. This middle elevation chinquapin forest habitat (roughly 2,500 to 4,500') is comprised of a number of culturally critical species that contribute important traditional foods and regalia. These include chinquapin (sunyíthih), black oak (xánthiip), saddler oak (yávish), white oak (axvé'ep), live oak (xanpúttip), yew (xupári'ish), port orford cedar, (kúpri'ip), pacific fisher (tatkunuhpíithvar), and black tailed deer (púufich), ponderosa pine (ishvirip), douglas fir (itharip), hazel (surip/aththip), incense cedar (chuneexneeyaach), huckleberry (púriith), jeffrey pine (ishvirip), knobcone pine (ishvakippis) and porcupine (kaschiip).

As is the case with the lower elevation forest, the continued persistence of this forest type is highly dependent on fire and indigenous cultural burning (Anderson 2005, Cocking, Morgan and Sheriff 2012, Lake and Long 2014, Long et al 2016, Long et al 2018, Fryer 2007). The composition and structure of these middle elevation forests are fire adapted. McCarthy (1993) writes that "Black oaks in particular would not have either their present distribution or their frequency without fire, and studies have shown that fire begun by natural causes (i.e. lighting) would not have occurred frequently enough to create that disturbance" (220). Changing patterns of precipitation and temperature and species invasions, especially from forest pathogens are major vectors of climate impacts for this habitat type. Middle elevation forests with black and other oaks, chinquapin, doug fir, hazel, and gooseberry would traditionally be burned every 5-7 years (Lake pers. comm.). Black oak acorns in particular are food for a variety of wildlife and the trees provide valuable pacific fisher denning habitat (North 2012). Intricate relationships exist between tanoak, huckleberry, chinquapin, tanoak mushroom, deer, elk, and likely wolf, although they are somewhat separated in the plan itself they need to be understood holistically. Are tanoak mushrooms plentiful and available? Are the tanoak acorns plentiful and available? These are metrics for success. An indicator of balance where you have all species present without significant over or under population in any species in particular. Evergreen huckleberry serves as a great example of a socio-ecological resistance indicator for successful landscape scale restoration and maintenance in the mesic mixed evergreen biophysical setting. Emerging scientific studies indicate the presence of chinquapin may be a sign as to where one should burn for huckleberry and

associated habitat dynamics. Chinquapin indicates places where one may want to treat for huckleberry. Burn timing of huckleberry indicated by the burn timing of tanoak acorn which is in relation to insect management.

The Somes Bar Project Cultural Resources Specialist Report (Tripp, Watts-Tobin and Dyer 2017) describes Karuk fire management in this key cultural management zone as follows:

These woodlands would usually be southeast to southwest facing, on relatively gentle slope, have relatively open canopy conditions, and would have grasses, forbs, foods, medicines, and fibers among them. These stands are sometimes found on northerly aspects with higher insolation values and make for good fire management features when restored and burned frequently. The people would manage this and adjacent habitats by introducing fire prior to bud set in spring triggering immediate response in ground resources that provide high quality food for animals and people alike. While most other burning is done in early summer though fall, this late winter/early spring practice also provides a valuable teaching component in and near areas of permanent habitation through bringing together elders and youth to teach and learn about the dynamics of fire practice in a low fire risk setting. The conditions in early spring are just right to run fire at low intensity through open canopies covering cured grasses and leaf litter and to enhance the habitat for other animals while reducing vulnerability to overstory trees during in-season fire events. In particular, this habitat is crucial for Elk and for the Pacific Fisher, two of the focal species. These Oak uplands provide crucial connections for the elk between their calving habitat in the woods and their upland summer range. Elk horns are often found in these areas, and they in turn are crucial for management by fire. These habitats provide both browse and the necessary open conditions for Elk to thrive. More research is ongoing about their migration patterns across the landscape. The Fisher, while it burrows in the hardwood and conifer forest, often comes out to forage and rest in the more open conditions provided by Oak woodlands. These habitats provide rodents and other prey for Fisher (p.17).

While this forest band is fire-dependent, stand dynamics and individual species in this forest type face vulnerabilities in light of the increasing frequency. A few species such as deer benefit from high severity fires. Oaks are not highly fire resistant and even mature black oak trees are susceptible to topkill by fire. Black oaks may re-sprout, but it takes time for these trees to reach maturity for acorn production (Cocking et al. 2012, Stephens and Finney 2002).

Sudden oak death (*Phytophthora ramorum*) is a major climate threat for species in the Chinquapin band. Warmer and wetter environments including increased precipitation during spring/early summer is associated with increased spread of SOD pathogen (Kliejunas, 2011). Specific adaptations for this pathogen are discussed throughout this plan.

Intervening Stressors for Middle Elevation Forests from Non-Tribal Management

Federal fire suppression practices that have prevailed over the past century have led to declines in black oaks and other fire-dependent species (Fryer 2007). Under fire suppression coniferous saplings that would normally be eliminated by fire mature into adulthood where they may outgrow and shade the light-dependent species on the chinquapin forest band. During high severity fire events many fire suppression actions create further vulnerabilities to species in this forest elevation zone. Firefighting tactic of “burning out” along the fire lines creates areas of very high severity fire (Lake pers comm). Timber fallers often intentionally cut chinquapin and black oaks during fire suppression activities preemptively because they may have cavities in which fire can smolder. However, such cavities are important habitat for pacific fisher. Black oaks snags are also often fallen in fire lines. Deer benefit even from high severity fires, but if fires are very hot and fire fighters don’t leave any islands of green for refugia, deer may face direct mortality and significant impacts from lack of forage.

Climate Adaptations for Middle Elevation Forests

Restoration of landscape fire regimes is a critically important climate adaptation for middle elevation forests which are highly fire dependent. In addition, fuels reduction appears to reduce the spread of Sudden Oak Death (Cobb 2017). As of 2018 the fuel loading is too severe across much of Karuk Aboriginal Territory for traditional August ignitions. However, using late January early February burn windows in a multi-step process that draws upon ceremonial ignition points reflect knowledge and instructions inscribed in the landscape shows a way forward that can be replicated across Karuk territory at appropriate locations. Assisted migration of low elevation species upslope may be warranted and sub sequentially lower elevation indicators considered in real time as climate change outcomes emerge.

When it comes to restoration of cultural fire regimes, sites with the abovementioned combination of huckleberry, chinquapin, and black oak are key sites for management. While Sugar Pine is often seen as a higher elevation species, this species too is a key indicator of cultural vegetation characteristics, denoting places for management in the face of the changing climate. The Somes Bar Project Cultural Resources Specialist Report (Tripp, Watts-Tobin and Dyer 2017) describes the importance of Sugar Pines and their management:

In ancestral practice, Sugar Pines were the most prized ignition source, especially because of their yield of pitch and needles. Black pitch was indeed one of the most prized monetary resources available. Pine trees in general bridge both the male and female responsibility. Pine roots and needles are also used in basket making and are represented in ceremony as the tree of life. The presence of Pines in specific landscape situations shows human management. In many cases these remnant pine stands are located in areas central to landscape/resource specific ignition patterns. It takes hundreds of years to manage the lifecycle of pine to assure you always have an adequate pitch supply. If these places were not managed for this resource, they would not be found in this pattern on the landscape today (p. 10).

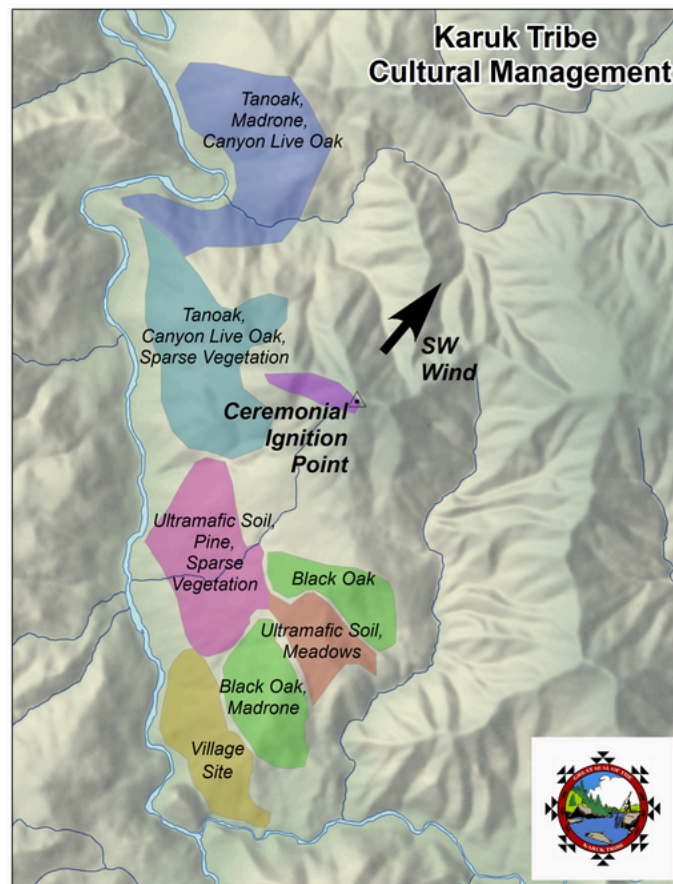
A Multi-Step Approach to Restoring Ceremonial Ignition on Offield Mountain:

Since time immemorial fires have been set on Offield mountain with the full moon in August as part of the World Renewal Ceremonies. Ceremonial ignition in August set the stage for a fuel limited fire safe system in advance of a season with great potential for high severity, high impact events, creating protection for village sites below. August fires also provided protective cooling to riverine systems at the peak of summer temperatures, triggering upstream salmonid migration and cooling the system for fish runs already in the river. In the face of a century of fire exclusion and the changing climate it is not possible to put fire on the landscape in all locations at this traditional time. However, a combination of geologic features, topography, traditional knowledge, and the existence of remnant stands and ceremonial ignition sites as information stored in the landscape can be utilized to strategically return fire at the landscape scale, even in the face of 100 years of fire suppression. On Offield Mountain a combination of geologic, ecological and topographic features can be used as a mechanism to return to this historical fuel limited regime.

Figure 3.11 below indicates a multi-step sequence through which fire can be returned at the landscape scale, thereby simultaneously providing climate adaptations for low to mid elevation and riverine species, and creating landscape protection for the

present-day community of Somes Bar. To the south of the ignition point is a band of conifer encroached Black Oak along the bottom Serpentine areas. Sparsely vegetated areas (shown on map) form a natural fire break together with the ridge coming off Wooley Creek which has seen multiple fires. The presence of plantations indicates that the area was logged, and probably had large trees in the past. Species that would easily burn in February are located there (serpentine if it has whitethorn could burn in February, along with the patches of Black Oak). This zone also may have native grasses which could help carry a fire. Igniting in February would provide protection in advance of ceremonial burn in August. As Bill Tripp notes, “This is a way of protecting a wide range of species we know to be vulnerable.”

Restoration of Ceremonial Burning on Offield Mountain as Climate Adaptation (Illustration Courtesy of Kirsten Vinyeta)



These ceremonial ignition points reflect knowledge and instructions inscribed in the landscape that can be replicated across Karuk territory at appropriate locations.

Cultural Indicators for Middle Elevation Forests

Chinquapin (sunyíthih), black oak (xánthiip), Pacific fisher (tatkunuhpíithvar), black-tailed deer (púufich), and porcupine (kaschiip) are all important cultural indicators in this zone. In addition Sugar Pine (ussip) is often found higher zones, but where it is found here it is a key indicator for management. Overall ecosystem adaptations including the restoration of traditional fire regimes, reducing impacts from intervening factors, the expansion of Karuk tribal management authority and capacity, community engagement and public education, increased interjurisdictional coordination, and expanded research and monitoring, listed in Table 2.1 in Chapter Two are essential for middle elevations forests. Additional specific adaptations for middle elevation forests are listed in Table 3.14 below.

Table 3.14 Middle Elevation Forest Adaptations Overview

Vector of Climate Impact		Adaptations
Increased frequency of high severity fire	<ul style="list-style-type: none"> - Direct mortality of black oak - Direct mortality, destruction of denning habitats, and reduction of habitat connectivity for Fisher - High severity, large-scale fire may burn a significant portion of black-tailed deer's home range, reduce acorn-rich diet, and reduce cover from predators 	<ul style="list-style-type: none"> - Return historic fire intervals: across Karuk Aboriginal Territory in conifer dominant stands there is a landscape memory of past oak woodlands that are trying to come back e.g. in plantations on Offield Mountain - Ratios of dead to live fuels of different species can be used to identify what the burn interval should be. After 5-7 years, ceanothus gets to 50% dead/alive - Return historic fire intervals, structure burning in relation to Fisher as cultural indicator - Public education and outreach regarding impacts to Fisher during firefighting and post fire activities and Fisher, agency coordination
Changing temperature patterns	<ul style="list-style-type: none"> - Increased summer temperatures - Increased nighttime temperatures - Decreased summer snowpack - Increase in temperatures may influence black oak acorn production 	<ul style="list-style-type: none"> - Mitigate effects with restoration - Mitigate by reducing other stressors - Return historic fire intervals - Expand suitable habitat for Fisher wherever possible
Changing precipitation patterns	<ul style="list-style-type: none"> - Decreased streamflows - Increase in flooding - Changing timing of runoff 	<ul style="list-style-type: none"> - Mitigate effects with restoration - Mitigate by reducing other stressors
Species invasions/ Diseases	<ul style="list-style-type: none"> - Sudden oak death (<i>Phytophthora ramorum</i>) - Other forest pathogens and pests e.g gold-spotted oak borer (<i>Agrilus auroguttatus</i>) 	<ul style="list-style-type: none"> - Fuels and fire treatment to open canopy, see SOD plan

Chinquapin / Sunyíthih / *Castanopsis chrysophylla*



oregonstate.edu

Importance As Cultural Indicator

The nuts of sunyíthih are among the various tree fruits that are important to the Karuk traditional diet. Chinquapin is also known as a high elevation species, but when it is found at other elevations it serves as a cultural management indicating places where one may want to treat for huckleberry. The nuts are important to the Karuk traditional diet and also provide food to many bird and mammal species. Whenever chinquapin is found in areas with huckleberry it should be noted on a TEK form and mapped for project planning and mesic mixed evergreen burn unit prioritization purposes.

Climate Change, Life Cycle & Habitat

Sunyíthih is an evergreen member of the beech family that can grow quite tall and live up to 500 years. The tree's fruit ripens the second autumn after pollination, and consists of one to three nuts encased in a spiny bur. Sunyíthih is particularly competitive in dry, infertile sites. On sites with more moisture and fertile soil conditions, disturbance such as fire is necessary to preserve a chinquapin forest component. Rarely does chinquapin occur in pure stands. (OWIC II 2016). Sunyíthih provides important cover for birds and small to medium mammals, and both fisher and martens may use them for their natal dens (Meyer 2012). Diseases and insects have little impact on giant Chinquapin. Most susceptible to heart-rotting fungi such as *Phellinus igniarius* and the filbert worm (*Melissopus latiferreanus*) may impact reproduction. In southwestern Oregon suffers moderate mortality due to infection by *Phytophthora cambivora*; also affected by *Phellinus igniarius* and *Armillaria* spp.” Chinquapin has recently been identified as a host of Sudden Oak death pathogen (Rooney-Latham, 2017).

Black Oak / Xánthiip / *Quercus kelloggii*



@ Michael Yager, fs.fed.us

Importance as a Cultural Indicator

While tanoak acorns are the most prized among Karuk people, black oak acorns are also an important traditional food. Having various acorn sources in the forest ensures dietary diversity and resilience in the event of impacts to any one species. Black oak dominated habitat includes many culturally valued species (Anderson 2007, Long et al. 2016).

Black Oak is traditionally burned in February. Black Oak is a southerly aspect species that can be maintained by fire with spring burning in particular along southerly slopes where there are remnant pockets to promote oak woodland. Historically these stands were ignited at a massive scale in February which promoted early spring greens and left the most susceptible slopes above our villages void of excessive fuel accumulations in the summer months.

Climate Change, Life Cycle & Habitat

Xánthiip occurs in mixed-conifer forests as well as in mixed hardwood forests (McDonald 1990, Long et al. 2016). In the highly diverse Klamath-Siskiyou area, black oak has many overstory plant associates. It is a highly drought tolerant species that reproduces primarily by sprouting from the root crown, but also by acorns (Long et al. 2016, Lininger 2004, Fryer 2007). California black oak, appear highly adapted and may experience range expansion as a result of predicted increases in temperature and fire activity (Case and Lawler 2016, Coops and Waring 2011). In situations where regional precipitation declines, Black oak is expected to experience range contractions, moving upslope or northward (Kueppers et al. 2005, Loarie et al. 2008, in Long et al 2016) however it may be restricted in ability to move in response to climate change due to reliance on animals for seed dispersal (Devine et al. 2012) in Long et al 2016). Note that within Karuk Aboriginal Territory precipitation is not expected to decline, though it will become more variable and precipitation patterns are changing. In the Sierra Nevada less predictable fall rains have shifting gathering windows (Long et al 2016). There is concern that less predictable and reduced precipitation may constrain windows to apply fire (ibid). There is some speculation that increasing temperatures could influence acorn production. Black oaks may increase in woodland types and severely burned areas but decline as a mature tree within mixed conifer forests (Long et al 2016).

Sudden oak death (*Phytophthora ramorum*) is a major climate stressor for this species and is already impacting black oak in coastal regions (Sturrock et al. 2011).

Warmer and wetter environments including increased precipitation during spring and early summer is likely associated with increased spread of SOD pathogen (Kliejunas, 2011) Other forest pests such as the gold-spotted oak borer (*Agrilus auroguttatus*) has killed black oaks in San Diego County and could spread across the range of black oak (Venette et al., in press). Synergistic effects of above stressors likely to cause decline in acorn production, detrimental to Native American harvesters and wildlife (Ortiz 2008, Voggesser et al. 2013) in Long et al 2016).

High severity fires may destroy acorn bearing stands of black oak that are culturally vital. Black oaks may retain post-fire dominance over non-sprouting conifers in high severity burn patches or areas of the landscape. Black oaks may be retained as shrubby, multi-stemmed, low height, growth form

Pacific Fisher / Tatkunuhpíithvar / *Pekania pennanti*



www.fws.gov

Importance As Cultural Indicator

The fur of tatkunuhpíithvar is traditionally used in Karuk regalia. The Pacific fisher has experienced significant declines in Karuk territory. This species is one of the first five focal species selected by the Western Klamath Restoration Partnership. It is well represented in world renewal ceremonies as the quiver that carries the arrows used to wake up the world. It represents the need for balance among dense and open habitats with large fire scared growth hardwoods. The Tribe seeks to conserve current range, promote expansion, and facilitate reintroduction of fisher into the landscape (Karuk DNR 2010). Species such as porcupine are an important food for the fisher, increasing access to food as well as promoting habitat variability will be important for the recovery of this species.

Climate Change, Life Cycle & Habitat

Tatkunuhpíithvar prefers hardwood forests with significant canopy cover, with large trees and snags where it convert large cavities into a den. More open habitats may be used for hunting and foraging. Among the most important prey for fishers is porcupine, a species that has experienced regional extirpation. The reintroduction of porcupine is vital to the successful fisher conservation. (Golightly 2006, Hanson 2013, Karuk DNR 2010). Tatkunuhpíithvar currently face habitat losses due to fire suppression and conifer planting: Shifting forest composition from mixed evergreen to increase in conifers has contributed to a decrease in fisher populations in the Klamath region (Carroll 2005) in Safford 2016). Loss of late successional habitat due to logging and impacts from post fire management activities such as salvage logging reduce potential den trees, coverage for prey species (USFW Draft Species Report 2014 p 62). Rodenticide poisoning from marijuana farms is an additional significant impact (Gabriel et al 2012). Large wildfires occurring earlier into June as seen in recent years may pose additional vulnerabilities to young survival.

Tatkunuhpíithvar habitat in the Klamath-Siskiyou region is already highly fragmented and Fisher are vulnerable to even small losses in habitat (USFW 2014). Climate change is likely to affect Fisher by altering their complex mid-late seral, mixed oak-conifer habitats through increases in disturbances (high severity fires, insects, pathogens), as well as through less predictable and gradual changes in vegetation populations. (USFW 2014, Safford 2016) Fisher are more reliant on forest structure (complex with large cavity forming trees) than on forest

floristics. (Powell 1993; Zielinski et al. 2004a,b, 2006 in Safford 2016). While the projected increase in mixed oak woodlands and decrease in snowpack may favor Fisher, the overall capacity of Fisher to adapt to climate change is limited by their small populations, small range sizes, low reproductive rate, and geographic isolation (Safford 2016, EcoAdapt Assessment 2014). Air temperatures are a key factor determining fisher's resting structures (Weir et al 2004 in Safford 2016), thus Increase in temperatures may force fisher to move to cooler areas, upslope Safford 2016). Increasing air temperatures will likely affect prey species in unknown ways. Increase in drought will lead to more severe wildfires, which may impact both fisher and prey habitats. Climate impacts of disease vectors are uncertain, but if disease affects fisher populations in similar patterns to other mustelids there is the potential for diseases to reduce Fisher populations (USFW Draft Species Report 2014).

Extensive high severity burned landscape may affect fisher hunting and denning opportunities and reduce habitat connectivity. Dens may be destroyed, and fishers killed during fire event. The destruction of large hardwood stands reduces fisher denning habitat. Burned areas may also attract fisher prey and enhance hunting. Fire related adaptations include: a return historic fire intervals; plan burning in relation to Fisher as cultural indicator; and public education and outreach and agency coordination regarding impacts to Fisher during firefighting and post fire activities and Fisher.

Black Tailed Deer / Púfich / *Odocoileus hemionus*



Photo: Dr. Madeline Kalbach, fws.gov

Importance As Cultural Indicator

Púfich is among the most important traditional Karuk foods and sources of utilitarian and ceremonial items. In 2005, over 65% of Karuk households reported hunting púfich for food (Norgaard 2005). The meat, sinew, bones, hide/skin, fur, antler, and hoves have been used extensively for traditional functions. Existing stressors include agricultural expansion, habitat loss, disturbance of migration, fire suppression, barriers including fencing, roads and reservoirs. Intricate rules once set in place for hunting deer are not followed, or even compatible with current state game management. Karuk management of this species includes the use of fire to promote rotational grazing and to draw them away from freshly sprouting basket materials. Tribal management also pays closer attention to allowing for opportunities for reproduction and promoting genetic mixing. Correlations such as how burning for deer relates to salmon migration, woodpecker habitat, and other such connections is held in the Deerskin Dance as part of Karuk World Renewal Ceremonies. Deer health and abundance, as well as their movement and habitat selection across the landscape are indicators of appropriate fire management activities.

Climate Change, Life Cycle & Habitat

Púfich has a home range in response to available resources, often influenced by fire severity burn patterns. Fire created edge habitats (pyro-ecotones) provide opportunities for varied forage as well as cover. The púfich diet is comprised of the tender shoots of various woody species, tree lichens, forbs (particularly in spring and summer), acorns, and fungi. Mating takes place in fall, after which does give birth to one or two fawns in the spring. (Innes 2013). While ungulates have a high dispersal ability and may be able to adapt to climate changes (Schloss et al. 2012), climate stressors coupled with habitat loss and fragmentation could lead to rapid population declines (Bolger et al 2008) in (EcoAdapt Climate Assessment 2017). “Increasing temperatures and reduced snow fall may cause changes in plant phenology and alter patterns of seasonal migration (Walther et al 2002; Bolger et al 2008)” Warmer fall temperatures may delay autumn migrations leaving púfich at greater risk of sudden winter storms, predation. Warmer winters may decrease adult púfich mortality but may increase population densities and result in

poorer body conditions (EcoAdapt Climate Change Vulnerability Assessment Summary). In Wyoming and Colorado, two decades of drought coupled with habitat loss and fragmentation have caused declines in black tail deer populations. Increased spring precipitation may promote rapid growth and subsequent decline of vegetation, resulting in shorter time of high quality forage during female's lactation periods (Inkley et al 2013, Post & Stenseth 1999) Warming temperatures and increased humidity may increase spread of parasites and bacteria to which púufich are vulnerable.

High severity, large-scale fire may burn a significant portion of black-tailed deer's home range, reduce acorn-rich diet, and reduce cover from predators . Oak groves burned by high-intensity fire can reduce deer diets rich in acorns. Extensive high severity burns reduce deer habitat and increase vulnerability to predators. Smaller patches of high severity fire that maintain more open shrub, fern, forb, and grasses promote higher quality forage and dispersal for deer.

Porcupine / Kaschiip / *Erethizon dorsatum*



Gerald and Buff Corsi © California Academy of Sciences

Importance As Cultural Indicator

Kaschiip's quills are used by Karuk people in the production of basketry and regalia. Ideally the quills are harvested via non-lethal methods, and then the porcupine is re-released. Kaschiip has historically held important ecological roles as a species that maintains oaks woodlands and reduces conifer encroachment, and as important prey for the Pacific fisher. The Karuk Tribe aims to restore a healthy

local porcupine population, which may in turn assist the recovery of other habitats and species. (Karuk DNR 2010). Porcupines are critical food sources for mountain lion and pacific fisher. They also aid in hardwood stand development and maintenance. Weavers report seeing many porcupines in black oak stands while gathering as late as the early 1970's. Seeing a porcupine in Karuk Territory today is a very rare event. Though current population estimates are reportedly needed to determine if population augmentation or species reintroduction approach is warranted, presence/absence in managed black oak stands, should be examined closely during project planning to facilitate potential relocation of nuisance animals from adjacent landscapes.

Climate Change, Life Cycle & Habitat

Kaschiip depends on early seral, hardwood/forb dominated, and post-fire habitats in summer, while relying on coniferous stands in winter. During the winter, Kaschiip commonly dens in congregations in rock outcroppings. The porcupine diet consists of herbaceous plants, twigs, and particularly in the winter, coniferous bark and needles. As a result of habitat loss, naturally low reproductive rates, and former Federal and State eradication programs to protect timber harvests, porcupines are now rare in much of California. (Karuk DNR 2010, Lewis 1993, Sweitzer 2012, Yocom 1971).

Reduced vegetative cover resulting from fire may increase chances of porcupine predation. Winter porcupine habitat and diet may be compromised by the burning of entire coniferous stands. High severity burned watershed with little cover or foraging vegetation can reduced porcupine habitat quality. Fires may kill individuals who are unable to escape.

High Elevation Forests/High Country – Above the Smoke Inversion Zone

The forest zone above which smoke inversions form is the third cultural management zone (see Figure 3.1 on p.60 and associated text for more description of these Karuk management zones). High elevation forests are also defined here as those existing above the chinquapin band and extending into the high country (note however that the shrub form of chinquapin may be found at these elevations). The higher elevation portion of this cultural management zone are elsewhere defined as montane and into the subalpine zone (see Taylor et al 2006). Processes within this habitat zone are critically important in relation to the health of other parts of the ecosystem. For example, healthy meadow systems in the high country provide a buffer for flooding, sustaining water throughout the summer and decreasing the potential impacts of erosion in lower elevations. Like their lower elevation counterparts, the high elevation forests within Karuk ancestral territory and homelands are biologically rich and incredibly species diverse. Taylor et al 2006 note “The conifer component of montane forests can be quite diverse and up to 17 conifer species have been identified in some watersheds in the north central Klamath Mountains” (175). Key Karuk foods and cultural use species occurring in this forest type include the Sugar Pine, Gooseberry and Beargrass (which especially occurs towards coast where there is fog). Karuk cultural burning enhances species in the high elevation forest type, making nutrients available in soils, releasing the seeds in sugar pine cones, stimulating growth and flowering of beargrass and minimizing fuel loads to protecting from high severity fires. Cultural burning at roughly 5-10 year intervals across the landscape creates multiple good gathering areas for beargrass.

The high country is key for Karuk cultural and spiritual activity. Especially during summer, families and individuals journey from lower elevation zones to harvest and process foods, materials and medicines, to hunt, fish, and pray. Karuk people have used fire to tend this habitat zone since time immemorial. Burning in these areas often occurs along trail networks, targeting meadow areas and patches of particular food and cultural use species such as huckleberry. Foods, fibers and medicines of particular importance occurring in the higher elevation band country include: kishvuuf, wild onion, beargrass, huckleberry, princess pine, Oregon grape, and sugar pine (at lower portion of this zone). Turner et al (2011) write, “these environments and their plant resources have received little detailed attention in ethnographic literature, and their importance to Indigenous Peoples often remains unrecognized.”

Major vectors of climate change for high elevations forests include changing patterns of precipitation and temperature. With warmer temperatures snowpack will decrease, impacting soil moisture levels and fire frequency and seasonality at higher elevations. Species invasions and forest pathogens including White Pine blister rust and Port Orford Cedar Root Rot are also of concern. While this forest type benefits from regular low severity fire, high severity fires can damage trees and burn duff into soil deep enough to destroy beargrass rhizomes. Damage to forest duff from very hot fires can delay or prevent the re-establishment of beargrass. Mature trees stressed by fire injury are susceptible to bark beetle and other insects which in turn increases future fire severity. In the longer-term aftermath of multiple high severity fires, there is risk of loss of these forest types to brush fields. With repeated high severity fires brush and down woody material can hinder Sugar pine reestablishment and increase risk of repeated high severity fires. The high country is especially vulnerable in light of extended drought and the loss of snow given trends towards greater percentage of precipitation falling as rain. While species in the high country have been adapted to relatively frequent low intensity fire, predicted increases in the frequency of high severity fires pose vulnerabilities to the high country. Historically, this habitat zone was protected from such fires by the presence of snowpack.

Intervening Stressors for High Elevation Forests

Much of Karuk high country is under wilderness designation, with fire suppression as a primary intervening stressor. Karuk Territory formerly had many fire-resistant ridge systems characterized by open grasses, Manzanita and Sugar Pines. Ironically many of the most culturally and spiritually important places throughout Karuk Territory have been the site of particularly intense alteration as a result of fire suppression. These species are present as a result of highly tuned traditional fire management carried out over decades. There is an unfortunate juxtaposition however, of fire suppression activities on sacred sites:

Beginning in the 1920s, fire observation stations, e.g., lookouts, were constructed and fire personnel were placed there to detect and report fires (Jackson pers. com. 2002). Some of these lookouts were constructed on tribal sacred sites used as prayer seats (Alfred pers. com. 1996). Occupation and use of these lookouts or field camps modified tribal land use practices, especially traditional setting of fires near these areas that were culturally significant habitats (Lake, 2007, 274).

Lake's (2007) Interview notes from Karuk tribal member Harold Tripp reinforce this point: "Most of these mountains got their altars destroyed because that's right where the Forest Service put their lookouts" (Tripp, pers. com. 2005). More recently, Dr. Frank

Lake shared the following story by way of illustrating the multilayered impacts that come from non-Native agency actions. Fire resistant ridge systems characterized by open grasses, Manzanita and Sugar Pines result from highly tuned traditional fire management carried out over decades. In 2017 while working as a USFS Heritage natural Resource Advisor Lake was visiting one particular ridge and found evidence of “prehistoric” family camping areas and Manzanita processing sites. From the large open characteristic of the Manzanita he could see that it had grown up under more open conditions. This would have been a site characterized by large open canopy and understory of bunchgrasses. However, over the past decades this ridge, like many others, had been a target of past fire suppression activities. With fire suppression, Douglas fir and other brush species had invaded the site,⁷ but there were a few remnant Sugar Pines as evidence of the prior vegetation characteristics and legacy of prior tribal stewardship. Frank explains:

So now in 2017 the incident management team wanted to put in a fire line on this ridge system, but because there weren’t enough Type I ‘Hot Shot’ firefighter crews available this was done with a bulldozer. So the food processing tools and other artifacts were broken by dozer tracks. The area gets trampled as it is run over by the bulldozer, and firing operation burn out causes heat fracturing of the artifacts. In this way, the legacies of Karuk food and fire stewardship are erased from the land, and replaced by the “safety” needs of the dominant society.

Here not only were the physical artifacts damaged, but the distinct cultural legacy of vegetation mosaic of the ridge system which stands as a cultural knowledge archive of past land stewardship is disappeared. Lake describes these as “third order fire effects” (2007, 343) because there is an erasure of cultural landscape, of particular artifacts, and of the future ability to learn from the ancestors and the land. Lake noted how “Everything gets re-set. You lose not only the biological legacy of the forest structure, or the damage to the stone artifacts, but you have lost the ability to learn and teach in that site. You can no longer take the next generation to that site and say “look, see this is what we did.” Nature is our teacher and we just lost an important instructor.”

While higher elevation forests are less subject to the direct management tactics of other agencies as compared to lower elevation areas the exclusion of indigenous management via the establishment of wilderness areas is relevant. Suppression increases competition, reduces germination, and allows disease to pester in stands. Furthermore, in addition to some logging, firefighting tactics themselves have particular

⁷ These included ceanothus, poison oak, tanoak, madrone and fir that had moved up from the slope below.

negative impacts on species in the high elevation forest zone. For example, Sugar Pines are intentionally cut down preemptively during fire line construction because they “could burn” since these trees form snags and fire can enter their cavities (Lake pers. comm.). If salvage logging takes place after fires, Sugar pines are often targeted as economically valued species. Pine needles can be burned at a time of year when fire is not a threat. If this is done instead of attempting to cut the snags, a fuel limited condition can be established along major ridge systems.

Climate Adaptations for High Elevation Forests

The restoration of landscape level fire regimes relates to the human responsibility in high elevation forests. Landscape scale restoration of fire regimes has an important dimension to the high elevation forests and high country through restoration of mountaintop ceremonial ignition sites as discussed throughout this chapter. In addition, fire management activities are important for species in these regions directly, and as preventative for mismanagement under “emergency” wildfire management scenarios as described above. Details of utilization of January or February burn windows is described in Figure 3.4 on p. 68. In addition, closer coordination with CalFIRE and USFS regarding fire suppression activities in this highly spiritual area is a necessity. Karuk people have long burned for beargrass and other species as they bring fire down from the high country following the ceremonial season in the Fall. Using fire in high elevation forests is a critical for getting back to historic fire regimes and an overall manageable, fire safe system. Restoration of fire regimes in high elevation forests is critical to combat the increasing pressures from decreased snowpack, drought (which will cause decrease in defenses to beetle outbreaks), and fungal pathogens. Depending on the particular snow year, opportunities may arise for early summer burning as well (late June – early July) especially where snow pockets, rock outcroppings and wet meadows encompass high insolation sites with dry combustible fuels available. In some cases, fireline construction may not even be needed except for in short segments interconnecting these natural features. These areas are typically above the elevation where inversions moderate fire behavior during wildfires. Burning these areas in favorable conditions creates a fuel limited condition where experience shows us we will be going to manage the wildfires of the future. A programmatic approach to conducting these activities will be critical. The air quality management approach also needs to change to make this work as in many cases the best time for conducting these burns while achieving objectives such as inversion cooling in the river below would occur during a stable air mass wherein burning in any form is currently limited.

Cultural Indicators for High Elevation Forests Sugar Pine (Ússip) and beargrass (Panyúrar) are important cultural indicators for this elevation. Overall ecosystem adaptations including the restoration of traditional fire regimes, reducing impacts from intervening factors, the expansion of Karuk tribal management authority and capacity, community engagement and public education, increased interjurisdictional coordination, and expanded research and monitoring, listed in Table 2.1 in Chapter Two are essential for high elevations forests. Additional specific adaptations for high elevation forests are listed in Table 3.15 below.

Table 3.15 High Elevation Forest Impacts and Adaptations Overview

Vector of Climate Impact		Adaptations
Increased frequency of high severity fire	<ul style="list-style-type: none"> - Damage to forest duff from very hot fires can delay or prevent the re-establishment of beargrass - Post-fire salvage logging often has negative effects - Brush and down woody material can hinder sugar pine reestablishment and increase risk of reburn prior to trees reaching cone producing age - Higher elevation fires occurring with reduced snow pack 	<ul style="list-style-type: none"> - Use of other cultural indicators related to burn timing in different elevation bands where sugar pine is present - Coordination with air quality management to achieve inversion cooling objectives in stable air masses when burning is currently limited - Return historic fire intervals utilizing ridgetops as ignition sources
Changing temperature patterns	<ul style="list-style-type: none"> - Increased summer temperatures - Increased nighttime temperatures - Decreased summer snowpack - Drought stress weakening sugar pine to other stressors 	<ul style="list-style-type: none"> - Mitigate effects with restoration - Mitigate by reducing other stressors - Return historic fire intervals - Manage tree density in watershed area above meadow by aspect and topographic position to maximize snow pack retention
Changing precipitation patterns	<ul style="list-style-type: none"> - Decreased in stream flows - Increase in flooding - Changing timing of runoff - More high elevation precipitation coming in the form of rain rather than snow - Decreased soil moisture, especially in summer and early Fall 	<ul style="list-style-type: none"> - Restoration of landscape level fire regimes for defense against pests and pathogens in face of increasing drought stress
Species invasions/ Diseases	<ul style="list-style-type: none"> - White Pine blister rust and Port Orford Cedar Root Rot - Mature trees stressed by fire injury are susceptible to bark beetle and other insects increases future fire severity. - Sudden oak death along with other forest pathogens 	<ul style="list-style-type: none"> - Restoration of landscape level fire regimes for defense against pests and pathogens - See also Karuk SOD plan

Sugar Pine / Ússip / *Pinus lambertiana*



www.fs.fed.us

Importance As Cultural Indicator

Ússip is used by Karuk people for ceremonial and subsistence purposes. The snags possess high quality “black pitch” which is not only a traditional form of money, but is also utilized in the ignition of cultural burns (Hillman 2016). Sugar Pine groves were family owned and managed for nuts (food), pitch (medicine), and roots (basketry) (Scheneck and Gifford 1952). Burning for pine bridges male and female responsibilities. The presence of sugar pine is a notable indicator of past fire management actions and may be associated with other culturally relevant information or activity. Ússip are often found in strategic places on ridges where they would have been managed to serve as ignition sources. As described in the Somes Bar Specialist Report, “Pine roots and needles are also used in basket making and are represented in ceremony as the tree of life. The presence of Pines in specific landscape situations shows human management. In many cases these remnant pine stands are located in areas central to landscape/resource specific ignition patterns. It takes hundreds of years to manage the lifecycle of pine to assure you always have an adequate pitch supply. If these places were not managed for this resource, they would not be found in this pattern on the landscape today. Indicators such as this are prevalent in the landscape (Tripp, Tobin and Dyer 2017, p 11). Today it is rare to find an open grown sugar pine tree that is accessible for nut collection. As a future indication of landscape scale fire regime restoration, pine trees with large branches less than 15 feet from the ground and adequate limbs to climb from there will be important. To access cones a pole with a hook on the end is used to climb to the lower branches, then the pole is used to knock down the cones when the nuts are ripe.

Climate Change, Life Cycle & Habitat

Ússip occurs in mixed-conifer forests, and in Karuk country is of particular value when occurring within or adjacent to tanoak or black oak stands. It reproduces via large, heavy seeds held within cones. It can take sugar pines around 150 years to become good cone producers. The seeds are not highly mobile, and unless moved by animals do not stray far from the parent tree. (Habeck 1992, Hillman 2016). Sugar Pine is often viewed as a high elevation species, but when it is found at other elevations it serves as an indicator of specific management actions. Decreased snowpack, drought are expected to cause

decrease in defenses to beetle outbreaks and fungal pathogens. “Early spring snowmelt can lead to reduction in soil moisture, stressing sugar pines (Sheffield 2004).”

High severity patches can limit seed dispersal and establishment in burn areas. Mature trees stressed by fire are susceptible to insect predation. Fire that reaches the canopy can decimate sugar pine individuals and stands. Brush and down woody material can hinder sugar pine reestablishment and increase risk of reburn prior to trees reaching cone producing age.

Warmer temperatures may lead to increased mountain pine beetle outbreaks.

Increased precipitation can increase white pine blister rust infections. Burning when low impacts to root structure can occur is critical, however pine needles can be burned in times when nothing else will burn. Time and energy needs to be dedicated now to Sugar Pine restoration and maintenance actions while also keying in to the other indicators related to burn timing in different elevation bands where sugar pine is present.

Bear Grass / Panyúrar / *Xerophyllum tenax*



@Kirsten Vinyeta

Importance As Cultural Indicator

Panyúrar is an important plant species for Karuk basket weavers and regalia makers. The long blades of grass are among the materials used. Blades are considered best for basket weaving the first year after a fire (Crane 1990, Hummel and Lake 2015, Hummel et al. 2015). Panyúrar is traditionally burned every 3-7 years, especially in the Fall following World Renewal Ceremonies when people bring fire down from the high country. Burning for panyúrar is part of landscape dynamics, and necessary for returning fire intervals across the larger landscape. The burn interval indicator is when there is enough dead material on the ground to carry fire sufficient to top scorch the grass. Burning along ridge systems may be our best line of defense against sudden oak death infection.

Climate Change, Life Cycle & Habitat

Bear grass is a perennial, subalpine herb that inhabits upper slopes, often near or beneath coniferous forests. Flowering typically occurs on a 5-7 year cycle. After fruiting, plants die off but are replaced by vegetative reproduction via rhizomes. Bear grass flower stalks are browsed by ungulates such as deer and elk (Crane 1990, Hummel et al. 2012). Burning for panyúrar is centrally necessary for returning fire intervals across the larger landscape. Along with other important cultural species including hazel, panyúrar grows back particularly strongly after low to medium intensity fire. The fact that this species loves dry sites along this moisture gradient makes it a prime candidate for burning to establish fuel breaks along these important features. A combination of frequently burned bear grass and filtered light through a moderately dense canopy maintains an open understory free of brush and other materials typical of fueling large wildfires. The conditions this type of burning maintains can also promote species like salal and saddler oak which are important for gathering and browse for large ungulates. Burning too hot can make basketry materials brittle. Maintaining large wood and promoting cavity trees during burning helps to maintain habitat for imperiled species (e.g. Humboldt pine martin). Maintaining areas with panyúrar helps to maintain ridge systems in a fuel limited state providing greater assurances that fire management activities as well as those of neighboring tribes do not negatively impact each other. Coordinate areas burned vs areas gathered with neighboring tribes to avoid conflict over treatment responsibility or gathering area.

Wet Meadows

Karuk ancestral territory and homelands contain a number of wet meadow systems which are critical habitat for species in these sites and important for hydrologic, ecological and fire dynamics across the landscape, especially in lower elevations. Wet meadows store water and provide higher summer base flows and cold water to lower elevations zones. The maintenance and enhancement of wet meadows is therefore critical for habitat quality of riverine and riparian species in the changing climate. For example, the Haypress meadow complex supplies cold water to the Wooley, Ti, Irving, Stanshaw, Sandy Bar watersheds. Wet meadows are found scattered throughout the higher elevation forest and high country. Important species occurring in wet meadows include bear, trailing blackberry, Mariposa and Panther lilies, Wild Turnip, and multiple kinds of Indian potatoes (e.g. *Brodiaea coronaria*). Wet meadows not only contain many species of importance, they are important indirectly for their connection to other habitat types. Wet meadows are dependent upon snowpack from upper elevation high country, and in turn provide a steady release of water that gives protection from flooding to forested areas below. Wet meadows are a highly threatened ecosystem type with a severely reduced range due to in particular to fire exclusion. Climate related drivers including changing patterns of precipitation, temperature, fire and species invasions are the dominant threats to these systems.

Intervening Stressors for Wet Meadows from Non-Tribal Management

Wet meadow systems are dependent upon ignitions from human and lightning sources to prevent conifer encroachment. In the absence of fire, the encroachment of conifers leads to a cycle in which the water table drops and meadows dry up. As the soil in formerly wet meadow areas dries out, upland species that cannot have their roots saturated and therefore formerly excluded by the higher soil moisture can now thrive and enter the former wet meadow system as competitors. These drier soils are more conducive to Douglas fir and other hardwood trees which were kept out before, continuing a cycle of transition away from the meadow system. Numerous wet meadows within Karuk ancestral territory and homelands are being lost through this process, especially at the middle to high elevations.

This same cycle of fire suppression, conifer encroachment, changing soil moisture dynamics leading to further encroachment of conifers and other species also takes place around springs, causing springs to dry up. In reviewing plantations in Karuk territory a pattern emerges. Indications of sediment catchment correlates with remnant

grass populations above groups of large stumps just above the initiation point of surface flow in territorial streams. These remnant meadows typically have big leaf maple just uphill. This would indicate that a water source is near the surface at the point of the maple and the large conifers at the base of the sediment slug hold more water toward the surface enabling grasses to perpetuate in areas now planted primarily in Douglas fir and ponderosa pine. It takes a trained eye to notice these distinctions, but where indications of this pattern remain, restoration is a top priority. Other related non-climate stressors to wet meadows include channelization from grazing is a significant problem, as well as the introduction of invasive species from grazers.

Climate Adaptations for Wet Meadows

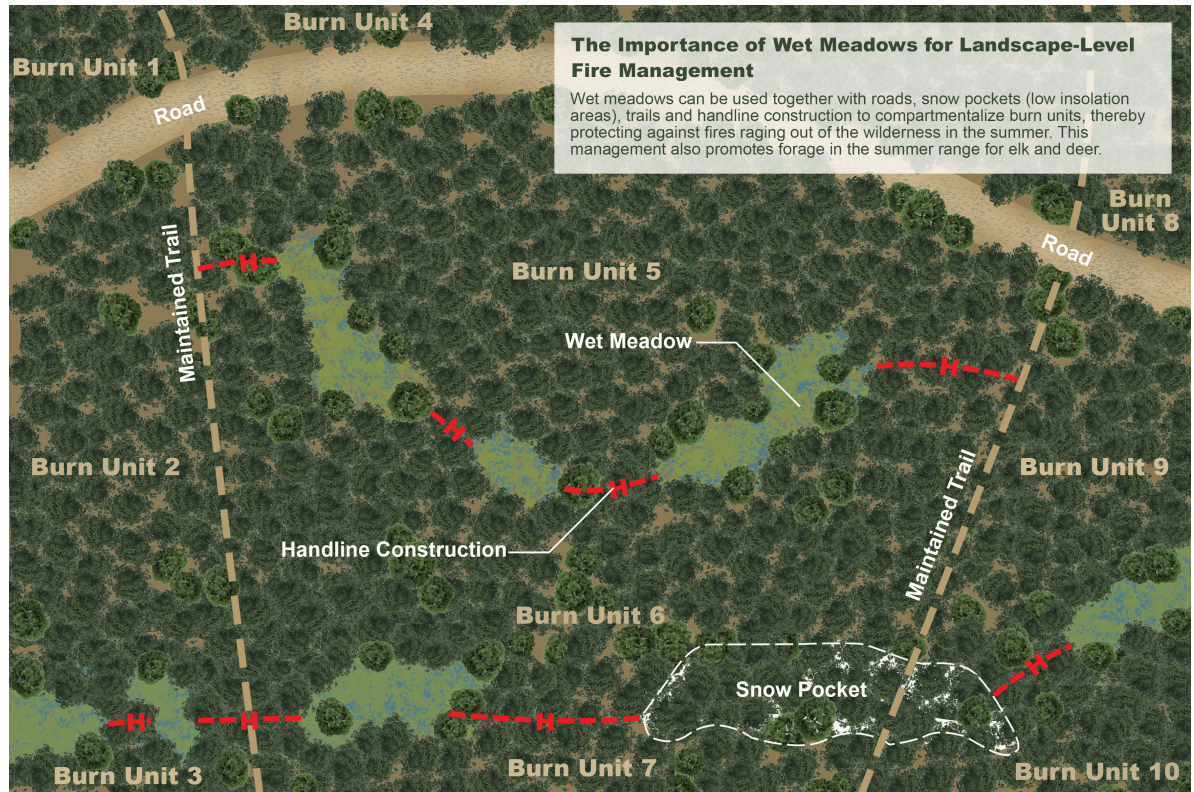
Wet meadow systems are relatively protected from fires due to site moisture. Nonetheless recent observations of fires in Karuk territory indicate expansion of fire into riparian zones where it did not previously occur. While burning is essential for the maintenance of wet meadow habitats, high severity fire could have the potential to cause direct mortality to species under some circumstances. For example, post-fire sediment and erosion can alter geomorphic and hydrologic regimes, causing instability of surface water (creek) networks. In general the maintenance and enhancement of wet meadows is critical for habitat quality of riverine and riparian species in the changing climate. Important activities will include the removal of competing tree and (non-huckleberry) shrub vegetation- this reduced vegetation and fuels promotes lily and meadow/forest edge huckleberry flowering.

A variety of mechanisms to increasing meadow groundwater retention include placing low-profile beaver dam analogues and wood in incised channels. Citizen monitoring efforts are recommended for meadows, as well as assessments of how much meadow area has been lost. Priorities may be placed initially on areas contributing to cold water refugial capacity, but all instances where this pattern is found ultimately warrant restoration action. Restoration strategies to keep wet meadows wet, e.g. placement of wood/trees, brush plugs to stop channelization, active girdling of conifers are a priority climate adaptation for the entire Karuk Aboriginal Territory.

Meadows are also highly important in the entire firescape of Karuk Aboriginal Territory. Another key climate adaptation identified here is utilizing the importance of wet meadows as fuel breaks to control the movement of fire across the landscape and prevent fires that begin in the high country from reaching communities. Figure 3.12 below illustrates a scenario in which wet meadows can be used together with roads, snow pockets (low insolation areas), trails and handline construction to

compartmentalize burn units, thereby protecting against fires raging out of the wilderness in the summer. This management also promotes forage in summer range of elk and deer.

Figure 3.12 The Importance of Wet Meadows for Landscape Level Management (Illustration Courtesy of Kirsten Vinyeta)



Cultural Indicators for Wet Meadows

Leopard Lilly (Mahtáyiith) is the cultural indicator for wet meadows.

Overall ecosystem adaptations including the restoration of traditional fire regimes, reducing impacts from intervening factors, the expansion of Karuk tribal management authority and capacity, community engagement and public education, increased interjurisdictional coordination, and expanded research and monitoring, listed in Table 2.1 in Chapter Two are essential for wet meadows. Additional specific adaptations for wet meadows are listed in Table 3.16 below.

Table 3.16 Wet Meadow Impacts and Adaptations Overview

Vector of Climate Impact		Adaptations
Increased frequency of high severity fire	<ul style="list-style-type: none"> - Decreased functionality of wet meadows to serve as fuel breaks - Post-fire sediment and erosion can alter geomorphic and hydrologic regimes, causing instability of surface water (creek) networks. 	<ul style="list-style-type: none"> - Return historic fire intervals - Public education and outreach - Meadows relatively resistant to fires until converted to conifer, once meadow is wet, conifers cannot survive - Increase water retention/table - Removal of competing tree and (non-huckleberry) shrub vegetation- this reduced vegetation and fuels promotes lily and meadow/forest edge huckleberry flowering - Utilize wet meadows along with other features as fire breaks, reduce need for fire line construction - Enhance functionality of wet meadows as features of fuel breaks
Changing temperature patterns	<ul style="list-style-type: none"> - Increased summer temperatures - Increased nighttime temperatures - Decreased summer snowpack 	<ul style="list-style-type: none"> - Restoration efforts to keep wet meadows wet, e.g. placement of wood/trees, brush plugs to stop channelization, active girdling of conifers - Mitigate by reducing other stressors, e.g. grazing - Restore historic fire intervals post high severity wildfire - Monitor wildlife behaviors pre and post treatment, adapt accordingly
Changing precipitation patterns	<ul style="list-style-type: none"> - Decreased in stream flows - (Channelization from grazing is intervening here) - Increase in flooding - Changing timing of runoff 	<ul style="list-style-type: none"> - Mitigate effects with restoration. Reduce or eliminate grazing. - Mitigate by reducing other stressors, e.g. conifer encroachment - Conduct mountain meadow assessment given that meadows are a significant cold water source, how much has been lost? - Increasing meadow groundwater retention by placing low-profile beaver dam analogues and wood in incised channels
Species invasions/ Diseases	<ul style="list-style-type: none"> - Forest and other pathogens - Specific dynamics with invading species 	<ul style="list-style-type: none"> - Grazing introduces invasive plants

Leopard Lily / Mahtáyiith / *Lilium pardalinum ssp. Wigginsii*

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calphotos.berkeley.edu

Importance As Cultural Indicator

Mahtáyiith is among the most prized bulbs in the Karuk diet. It is dug in the fall and is traditionally cooked in an earth oven like many other bulbs (Schenk and Gifford 1952).

Climate Change, Life Cycle & Habitat

In the Klamath Mountains, leopard lily is found in high country wet meadows, especially on serpentine soils. This rare and endangered herb grows from bulbs that are small and often clustered, and typically blooms in July (CNPS 2016). Fire of varying intensities removes competing shrub and tree vegetation which would promote lily flowering.

CHAPTER FOUR:

CLIMATE HEALTH IMPACTS AND ADAPTATION STRATEGIES

- *The Klamath River and its tributaries, forests, grasslands and high country are essential for the cultural, spiritual, economic and physical health of Karuk people.*
- *Physical health impacts of climate change include heat stress, increasing rates of asthma, food and water contamination, and diet related diseases in the face of reduced access to traditional foods.*
- *There are serious negative health consequences of smoke from both human cultural ignitions and wildfires. However, neither the ecological or environmental justice/health dimensions of smoke are well understood.*
- *Policies that attempt to create smoke exclusion without understanding the different circumstances under which smoke is generated, are not only misguided and ineffective, they result in more hazardous smoke conditions for human health, without producing the ecosystem or human mental and physical health benefits.*
- *Mental health dimensions of climate change include stress and anxiety related to wildfires, smoke and emergency events, and cultural and spiritual impacts of ecosystem decline and species loss.*
- *Immediate adaptation needs involve increased coordination with other departments, development of emergency management program, smoke monitoring, and expansion of individual and community cooling centers and air purifying resources.*
- *Long term adaptation needs involve planning for increased occurrences of physical and mental conditions.*

Human and environmental health are intimately connected. The Klamath River and its tributaries, forests, grasslands and high country are essential for the cultural, spiritual, economic and physical health of Karuk people. Physical and mental health are embedded in ecosystem health and cultural activities. Across North American western land management policies have already compromised the health and abundance of species of cultural importance to tribes, resulting in cultural loss and mental and physical health impacts (Hoover 2013, LaDuke 1999). The changing climate poses a

number of other physical human health risks including increases in the rates of diseases transmitted by food, water and insects, rising pollen production (leading to higher rates

"The cultural impacts of climate change are just the latest in a long thread of what Jacob (2013) calls "soul wounds" imparted upon indigenous communities as a result of colonialism and a capitalist economy."

of asthma and allergies), and increases in both heat related deaths and deaths related to extreme weather events (NAS 2008). For Karuk people traditional foods such as salmon, acorn, elk, deer, berries and teas are vitally important for physical and mental health. As riverine temperatures in the Klamath and tributaries continue to increase, salmon and other cool water dependent species are increasingly at risk. Already dangerously high levels of toxic blue-green algae are also expected to rise with increasing water temperatures. The stresses associated with the impacts of climate change also pose risks for mental health. Physical health or even sheer survival may also be

compromised for indigenous peoples carrying out hunting and gathering activities in changing landscapes. Climate change poses threats not only to physical health, but also to mental health, particularly for people and communities with strong cultural, economic and/or spiritual ties to the land (Cunsolo Willox et al. 2013, McNamara and Westoby 2011). Both access to an intact natural environment and participation in one's culture are widely recognized as vital for psychological well-being. There are multiple mental health stressors associated with climate change including grief and trauma related to species loss, general stress from emergency situations, longer term smoke exposure, workplace stress and cultural loss. Indigenous people in the U.S. already contend with the daunting task of processing centuries of historical trauma resulting from colonialism, a fact that has led to high rates of substance abuse, suicide, and violence within indigenous communities (Maracle 1996, Mokuau 2002, Ross 1998, Smith 2005, Strickland et al. 2006, Weaver 2009).

The cultural impacts of climate change are just the latest in a long thread of what Jacob (2013) calls "soul wounds" imparted upon indigenous communities as a result of colonialism and a capitalist economy. Luckily, many tribes and tribal organizations are turning to traditional healing practices to restore mental health and spiritual well-being to their communities (Jacob 2013, Mokuau 2002, Nebelkopf and Penagos 2005). As climate change progresses, it will be important for tribes to develop or continue to provide culturally-appropriate programs and strong, supportive social networks that can

help tribal members deal with the stresses and mental health impacts associated with the economic, cultural, and spiritual stresses that may be brought on by climate change impacts.

Table 4.1 Karuk Health and Climate Change		
Climate Stressor	Proximate Effect	Health Impact
Increased Air Temperature	Hotter summer days and nights	Heat stress, fatigue, death
	Increased air particulate matter	Increasing allergy and asthma rates
	Algal blooms	Short- and long-term human health impacts from water exposure, food contamination
Increased Fire Activity	Fire Impacts	Direct and indirect physical and mental health impacts from wildfires
	Smoke Exposure	Short and long term physical and mental health impacts including asthma, fatigue, anxiety
Changing Patterns of Precipitation	Road closures as landslides/flooding causes road failure after heavy rains	Reducing access to medical care
Multiple	Loss of species including cultural, ceremonial relations of species	Physical health effects loss of foods
		Mental health effects loss of relations, cultural and ceremonial activities

Health Impacts From Increasing Air Temperatures

As described in Chapter One, end of century temperature forecasts for Karuk aboriginal territory include an increase in the annual average daily temperature by 7.8 °F, a doubling of the total number of days exceeding 86 °F, and an additional 62 frost free days annually. By the end of the century, the maximum daily temperature during the already hot summer months of June through August is projected to increase by 9.6 degrees to an averaged value of 92.6 °F. Figure 4.2 summaries these figures compiled from multiple models in the NW Climate Tool, showing recent past as baseline, end of century figures and total change.

Table 4.2 Summary of Increasing Temperature Trends for Karuk Aboriginal Territory (high emissions scenario, NW Climate Tool).			
	Recent Decades (baseline)	By end of Century (2070-2099)	Change
Days over 86 °F	49.8 days	102 days	+ 52.5 days
Jun-August average maximum daily temperature	83.0°F	92.6°F	+ 9.6°F
Annual average daily temperature	52.5°F	60.3 °F	+ 7.8°F

Serious physical and mental health impacts from increasing temperatures include heat stress during summer months, food and water contamination exposure from algal blooms, and rising rates of asthma and allergies in conjunction with increasing concentrations of air particulate matter. More generally, increasing temperatures combined with other climate stressors to produce overall mental and physical health impacts related to loss of species and ecosystem alteration. As temperatures warm heat stress and heat related deaths are concerns, especially for elders in the already hot summer months. Many homes do not have air conditioning systems, and those that do are at risk for losing cooling systems should power outages occur.

A second health concern directly related to increasing temperatures is rising rates of asthma and allergies as a result of both increasing concentrations of air particulate matter in warmer air and rising pollen production.

A third key health impact from rising temperatures is food and water contamination from toxic algae. Water quality is imperative for access to healthy foods, and necessary for multiple economic, social, spiritual and cultural activities to occur. Toxic blue-green algae are produced in the mid-Klamath basin in Copco and Iron Gate Reservoirs. In the summertime and into the fall, the reservoirs are large, warm, nutrient-rich bathtubs that provide ideal growing conditions for the toxic algae *Microcystis aeruginosa* that produces a liver toxin microcystin. Impaired river water conditions impacts habitat suitability for fish, wildlife, and plants, directly and indirectly affect Karuk psychological and physical health. Karuk people rely on aquatic and riparian habitats of the Klamath River and tributaries for water consumption, bathing/cleansing, food, medicines, materials, and ceremonial purposes. Water quality impacts matter for their impact on species of concern, and on human health from drinking as well as the human health consequences of consuming contaminated traditional foods. Degraded

water quality disproportionately affects the health of Karuk Tribal members through impacts to subsistence, cultural, and ceremonial uses of the River, as well as when contact occurs during recreational activities including swimming. Many ceremonial, funeral, subsistence, basketry, and other family and individual activities involve potential contact with river water during the year. While conducting subsistence or



associated activities Karuk may come into contact with river water by drinking, steaming, or cooking, bathing, using river access points long trails, boating, fishing or hunting or trapping wildlife, gathering plants or plant materials, and collecting rocks to be used for tools or implements. The World Renewal Ceremonies in which the

medicine man traditionally bathes and drinks Klamath River water overlaps annually with the highest levels of microcystin. Subsistence fishermen spend long days in the River fishing for their families, elders, and ceremonies and are exposed to higher levels of microcystin than a recreational user. Freshwater mussels which are a subsistence food for Karuk people can bioaccumulate high levels of microcystin. The already dangerously high levels of toxic blue-green algae are expected to rise with increasing water temperatures from climate change. With changes in precipitation related to climate change, droughts and low summer base flows will increase residence time of water within the reservoirs. This can exacerbate toxic algae bloom conditions.

Health Impacts from Increasing Fire Activity

Temperatures and precipitation changes coupled with increasing presence of invasive species and forest disease mortality and longstanding fire suppression are projected to lead to 12 additional days with very high fire danger and 6 additional days of extreme fire danger by the end of the century (high emissions scenario, CITE). The increasing frequency of high severity fires in the Klamath region poses both immediate health implications from fires in emergency scenarios, and more pervasive physical and mental health impacts from smoke exposure. Deaths and direct physical/health harms related to increasing fire activity are rare but do occur. Also noteworthy are potential health concerns related to disrupted access for emergency vehicles and access to medical care

from road closures both during fires and in the two years following when landslides are more likely to occur.

Health Impacts from Smoke Exposure

There are serious negative health consequences of smoke from both human cultural ignitions and wildfires. However, neither the ecological or environmental justice/health dimensions of smoke are well understood. Smoke from wildfires creates widespread and pervasive respiratory impacts to human health across the community to which clinic staff attempt to respond. Smoke from forest fires consists of carbon dioxide, water vapor, carbon monoxide, ozone, particulate matter, hydrocarbons and other organic chemicals, nitrogen oxides, trace minerals and several thousand other compounds (Lipsett et al. 2008, p. 3). Of these it is actually the particulate matter in smoke from forest fires that is often the most dangerous. In their report on smoke for the state of California Lipsett et al. (2008) note:

...fine particles are linked (alone or with other pollutants) with increased mortality and aggravation of pre-existing respiratory and cardiovascular disease. In addition, particles are respiratory irritants, and exposures to high concentrations of particulate matter can cause persistent cough, phlegm, wheezing and difficulty breathing. Particles can also affect healthy people, causing respiratory symptoms, transient reductions in lung function, and pulmonary inflammation. Particulate matter can also affect the body's immune system and make it more difficult to remove inhaled foreign materials from the lung, such as pollen and bacteria. The principal public health threat from short-term exposures to smoke is considered to come from exposure to particulate matter (p. 4).

Exposure to smoke from forest fires leads to symptoms that “range from eye and respiratory tract irritation to more serious disorders, including reduced lung function, bronchitis, exacerbation of asthma, and premature death.” (p. 3). Respiratory impacts intersect with other health conditions and are especially significant for the elderly and young children. In addition to more acute cases and the concerns of youth and elders who face particular vulnerabilities, thick smoke creates a general background hazardous working conditions for all people living in its vicinity. In 2014 fires burning in the northern edge of Karuk ancestral territory had such hazardous air quality that it was unsafe for people to be outside for over a week. On five of these days, fine particle pollution exceeded local air quality meter measurability. Information gathered in the 2007 and 2008 fires found significantly increased clinic visits to Tribal Clinics during these fires. The Tribe does not currently have dedicated air quality staff, however, there

are research and development needs related to air quality monitoring, as well as education and outreach to the local communities regarding the science behind traditional fire management, policies, and practices as related to effects on air quality.

Affected area residents are isolated and separated by great distances. All too frequently the Karuk Tribal Health Program attempts to respond to smoke hazards across ancestral territory with minimal available resources from outside agencies due to number of fires in the state. The increased frequency of high severity fire thus creates very serious potential impacts to the health of Karuk people given that exposure to outdoor smoke from landscape fires is strongly associated with increasing respiratory symptoms which tend to occur during the fires, but also the deterioration of existing respiratory diseases, hospital admissions and deaths from respiratory causes which cause longer term impacts on not only the health program but of course the Tribal community. Figure 4.2 shows poor air quality from fires.



In addition to more acute cases and the concerns of youth and elders who face particular vulnerabilities, thick smoke creates a general background hazardous working conditions for all people living in its vicinity. As William Tripp notes, “Poor air quality impacts are not limited to respiratory issues. Poor visibility suspends air support for firefighting, but also suspends air transports to hospitals for emergency patients, a problem which we will likely face because of the character of the terrain that these fire fighters are working in.”

As communities who have existed with smoke for thousands of years can attest, smoke life fire, is an inherent part of forest ecosystems. Just as public fear of fire has

translated into oversimplified and inaccurate understandings of fire, policies that attempt to create smoke exclusion without understanding the different circumstances under which smoke is generated, are not only misguided and ineffective, they result in more hazardous smoke conditions for human health, without producing the ecosystem benefits. There are many kinds of smoke conditions, and many circumstances under which smoke arises.

High severity large-scale fires burn for much longer than traditional cultural burning of the past, leading to particularly significant health impacts. As noted by staff in the Integrated Wildland Fire Management Program, “With fire exclusion we have a wider pendulum between fires and no fires, between smoke and no smoke, such that when fires occur there may be very large with heavy smoke for periods of weeks at a time. These circumstances tend to be particularly difficult for (those with) respiratory problems.” Indeed cultural burning is less impacting to human health than the high severity fires that result in its absence. In their work on pyrohealth, Johnston et al. (2016) note this contrast: “While no studies on smoke exposure from traditional indigenous landscape burning exist, the smaller mosaic of patch burning promotes small low intensity fires, which overall produce relatively lower emissions, due to the smaller spatial size and lower fuel loads under such fire regimes” (p. 3). Johnston et al. (2016) further write: “The cessation of indigenous burning, active fire suppression, introduced species, and a warming climate are all contributing to increasingly frequent, large-scale, intense fires in many flammable landscapes. Emissions from large landscape fires can be transported for long distances affecting large and small population centers far from the fires themselves. Smoke episodes from severe landscape fires result in measureable increases in individual symptoms and in population indices of ambulance call outs, admissions to hospital and mortality” (p. 3). The reality of smoke as an element of fire prone forest systems, the differences between duration and intensity of smoke according to the different circumstances in which smoke is produced, and ultimately the negative impacts of smoke exclusion policies on human health all need greater attention within air regulations and public discourse. Human generated smoke for ecosystem benefit has overall beneficial health consequences. By contrast, the cause of the smoke conditions most hazardous for human health is fire exclusion. An overgeneralized and erroneous understanding of the relationships between smoke and human health is now producing a situation in which the necessary treatment for hazardous health conditions is itself targeted as the problem. Alarm over smoke and lack of a nuanced understanding by the general public has further produced a situation in which communities in fire prone areas are forced to experience hazardous smoke levels for very extended periods of time. Fire exclusion is an anthropogenic practice causing high levels of exposure.

Restoration of traditional burning as a mitigation measure needs to be exempt from regulation based on consumption of “natural” (pre-contact levels) fuels accumulations.

Fire and Mental Health

Events connected to the experience of very large fires sometimes called “catastrophic,” and the associated firefighting activities, racism, the struggle to maintain culture and ecosystem decline are each sources of chronic stress. Karuk people consulted for this project vividly described feelings of powerlessness in the face of institutional forces that are working against ecological health, while simultaneously eroding people’s control of their immediate social environment.

Large high intensity wildfires are in and of themselves disturbing events in which people may lose or fear the loss of their homes and important sites in the landscape, and normal home and work routines are disrupted (Amacher et al. 2005; Weisshaupt et al. 2007). When large fires occur, there are significant social impacts at the time of firefighting itself including additional damage to the important gathering sites due to firefighting tactics, mental health impacts of smoke including irritability, the “cabin fever” which can set in when people need to stay indoors for prolonged periods, impacts to cultural and subsistence activities and an enormous mental strain from an awareness that an outside agency is exerting control over decision making which is linked to the intergenerational trauma associated with not being able to legally sustain our culture, causing loss of sense of purpose.

Climate Change, Species Loss and Ecosystem Alteration:

Physical and Mental Health Consequences

Traditional foods and medicines support physical and mental health in multiple ways (Alves and Rosa 2007). Cultivating, harvesting, processing, preserving and consuming Native food and medicine provide the framework for the Karuk eco-cultural socialization process and religious belief. Karuk traditional foods, especially salmon, are higher in protein, iron, omega-3 fatty acids, zinc and other minerals and lower in saturated fats than market foods (Norgaard 2005). Declines in important and highly nutritious traditional food species such as salmon have led to spikes in rates of diabetes and other chronic diseases (Norgaard 2005). Nutritional data show that traditional foods produce stronger hearts, blood and muscle tissue (Jackson 2005).

Biophysical conditions across the landscape have been altered across landscape causing access many important food fiber and medicinal resources. Reactionary policy development by state and federal agencies such as endangered species protections on

one end of the spectrum, to active forest management executive orders on the other, do not adequately consider the needs of indigenous communities. Such actions can consume the time and energy of small tribal agencies trying to “do what is right” and can lead to depression, feelings of despair, and declines in mental acuity. Increased job stress coupled with contemporary work schedules and expected reporting environment leads indigenous people away from practices involving food, fiber, and medicine collection, and in some cases ceremony. This can cause loss of cultural identity and could be considered a form of forced assimilation.

Culture and Mental Health

Land management is a central expression and affirmation of Karuk culture, identity, spirituality and mental and physical health (Lake et al. 2010). Participation in fishing, burning, gathering and other aspects of traditional management holds immense personal and spiritual significance and are central to Karuk identity. Ron Reed describes how participation in these management activities at the heart of “being Indian:”

You can give me all the acorns in the world, you can get me all the fish in the world, you can get me everything for me to be an Indian, but it will not be the same unless I’m going out and processing, going out and harvesting, gathering myself. I think that really needs to be put out in mainstream society, that it’s not just a matter of what you eat. It’s about the intricate values that are involved in harvesting these resources, how we manage for these resources and when.

Traditional management refers to care for the environment, but managers have specific social and cultural responsibilities to their families, to elders and the Karuk community as well. Role strain also comes from the inability to fulfill obligations to the human community such as the ability to provide deer, acorns or other traditional foods.

Finally, there is a level of collective “community stress” which results from a general awareness that Karuk people are denied access to conduct appropriate cultural activities. This too is described as a deeply painful experience for the surrounding community. These emotional impacts of the impaired social and ecological activities that ripple through the community, are thus examples of stressors that proliferate over the life course and across generations (Thoits 2010, 542). At the individual level, Karuk people are observed to experience chronic stressors from threats to meaning systems, identity, role strain and powerlessness in the face of denied access to traditional management. At the collective level racism, the struggle to maintain culture in the face of adversity, and an ongoing sense of genocide are chronic stressors on the community.

If requirements for psychological well-being include control, commitment, support, meaning and normality, one can understand how experiences described by Karuk people in the context of the inability to carry out cultural activities their ancestral lands including hunger, poverty, environmental decline, threats to identity, role stress, and sense of self-efficacy, loss of meaning systems and an underlying and ongoing sense of genocide add up to very significant negative mental health consequences. Mental health is negatively affected by physical health challenges, as well as social sources of stress caused by the absence of any of the above.

The impacts of environmental decline are particularly significant for Native people for a multitude of reasons. As Brave Heart and DeBruyn note, “For American Indians, land, plants, and animal are considered sacred relatives, far beyond a concept of property. Their loss becomes a source of grief” (1998, 62). Recent work on the impacts on climate change for an Inuit community in Labrador, Canada emphasizes emotional dimension of impacts as an important component of health: “it is evident that the emotional consequences of climate change are extremely important to Northern residents. Participants shared that these changes in land, snow, ice and weather elicit feelings of anxiety, sadness, depression, fear and anger and impact culture and a sense of self-worth and health” (Wilcox et al 2013,14). The authors further write that “changes in the land and climate directly impact emotional health and well-being” (14) and coin the term “ecological affect” to describe “the affects that emerge directly from shifts, alterations and fluctuations in climactic or environmental conditions” (17).

In their landmark text Social Causes of Psychological Distress authors Mirowsky and Ross (1989) highlight control as one of five necessary conditions for positive mental health: “feelings of personal powerlessness are an important predictor of psychological distress (Seeman 1959, 1983, Mirowsky and Ross 1986, 1989). Loss of species has profound physical and mental health impacts for Karuk people including the loss of healthy foods in the diet and the profound mental consequences associated with disruptions to ceremonies, cultural practices, meaning systems and daily life. Not only are ties to the natural world particularly strong for many Native people, but there are extensive disruptions of social, cultural and spiritual systems from both ecological change and denied access to management described throughout this report. Indeed, grief from the loss of species, and stress from the inability for Karuk people to manage the ecosystem in accordance with their cultural practices and spiritual responsibilities is expressed vividly in people’s own words in terms of emotions of grief, shame, stress and powerlessness as will be described below. The impact of each of these categories of experiences is underscored by their invisibility and the corresponding lack of legitimacy

or recognition within the dominant culture – what Ken Doka calls “disenfranchised grief” (1989).

Table 4.3 Climate Change and Chronic Mental Health Stressors in Karuk Community

<i>Cultural and spiritual impacts of ecosystem decline and species loss</i>
<i>Stress and anxiety related to wildfires, smoke and emergency events</i>
<i>Individual role strain</i>
<i>Community stress</i>

Adaptations for Karuk Health in the Face of Climate Change

While the physical and mental health consequences of climate change are significant and daunting, the actions of the Karuk Health Program, Karuk Department of Natural Resources and the Karuk Tribe as a whole will make a significant difference in how they manifest. Necessary adaptations for the above health impacts include both short term immediate needs and longer-term structural changes. The Karuk Health program must be prepared for an increase in emergency scenarios, as well as longer term increases in a wide variety of community disease rates. Additional medical staff, especially those equipped for hands on community engagement (e.g. Public Health Nurse) will be needed in clinics as well as for participation in emergency management.

Table 4.4 Adaptations For Karuk Health in the Face of Climate Change

<i>Climatic Event</i>	<i>Proximate Consequence</i>	<i>Impact</i>	<i>Adaptation</i>
Increasing air temperatures	Increased air Temperature	Heat Stress, death	Expand clinic capacity regarding heat stress, e.g. staff training, emergency preparedness resources, capacities to respond to heat stress
			Expand public education regarding heat stress
			Work with Tribal Housing, develop action plans and improvements in housing infrastructure for heating and cooling, e.g. insulating old structures, code and materials updates for new structures
			Expand resources for public cooling centers
			Monitoring and assessment of community needs regarding access to cool spaces
	Algal blooms	Food and Water contamination	Work with DNR water quality and other to advocate for dam removal, reduction in agricultural inputs from upper basin, other water quality
		Exposure with ceremonial,	Improve coordination between medical and water quality monitoring staff

		subsistence, basketry, recreation/cultural activities.	Trainings regarding symptom recognition and treatment
Increase in fire frequency, length of fires	Smoke exposure	Immediate and long-term impacts of smoke exposure	Increase clinic and medical infrastructure to support long term increases in community rates of allergies and asthma
			Revitalize air quality monitoring program, coordinate with clinics
			Tabulate data on smoke related visits, coordinate with air quality monitoring
			Expand HEPA filter distribution capacity; look to permanent installation for all homes in service area.
			Maintain and expand public air centers
			Expand emergency evacuation infrastructure in coordination with other Tribal programs
			Restore historic fire return intervals
	Direct effects of fires	Emergency medical and evacuation needs	Evaluate/expand emergency medical response
Increasing microburst, Increase rain on snow events, aftermath of high severity fire	Road closures from landslides and flooding causes roads to fail after heavy rains reducing access to medical care	Access to medical care cut off	Develop alternate emergency access capacities, e.g. helicopter, boat, ATV
			Emergency Medical Units with backup systems and supplies.
			Develop detailed plan within each clinic, e.g. which patients most at potential risk
			Coordinate with proposed Emergency Management Program
			Public awareness campaigns: encourage and enable patients and community members with severe conditions to have backup supplies
Multiple	Loss of species including cultural, ceremonial relations of species	Mental health stressors in community including drug and alcohol use, self and interpersonal violence	Individual and family counseling services
			Community Programs, expand access to cultural and spiritual activities
			Increase opportunities for community engagement
		Health impacts loss of traditional foods	Coordinate with DNR regarding activities to support species restoration and revitalization of traditional management
			Expand emergency food programs
			Increase medical capacities for diet related diseases

On the whole immediate adaptation needs for Karuk health will involve increased coordination with other departments, development of emergency management program, smoke monitoring, and expansion of individual and community cooling centers and air purifying resources. In addition to this, resolution to societal conflicts will also be critical. Building programs, including the providing of culturally relevant jobs, can only go so far without changing requirements in employment systems. For example, marijuana is legal for recreational use in California; however, federal drug free workplace policies imposed on tribal programs lead to the most impacted losing employment eligibility through pre-employment drug screening. A positive test for marijuana does not prove one is under the influence during working hours. Policy changes regarding will be needed to effectually heal the most impacted as they become ready for change. Long term adaptation needs will involve planning for increased fire frequencies while managing for less impactful events overall. Fire exclusion is anthropogenic practice causing high levels of smoke exposure. Restoration of traditional burning as a mitigation measure needs to be exempt from air quality regulation based on consumption of “natural” (pre-contact levels) fuels accumulations. Consider preparing a Tribal Implementation Plan under the Clean Air Act and assumption of jurisdictional responsibility for our airsheds at the territorial or service area scale.

CHAPTER FIVE: Climate Adaptations for Critical Infrastructure

- Climate impacts in the form of flooding and increasing frequency of high severity fire are already impacting critical tribal infrastructure.
- Climate impacts to **electrical grid infrastructure, transportation routes, water systems, communication systems** and **emergency services** that supply daily and emergency needs for the Karuk tribal community and tribal programs will increase.
- The Karuk community relies on infrastructure, including roads and utilities (water, power, telephone, internet), most of which are supplied by non-tribal entities who **will be increasingly under pressure from multiple directions** due to increases in fire activity, flooding across the region as the climate changes.
- Karuk communities have historically received lower prioritization for roads, powerlines, communication and other forms of infrastructure maintenance.
- Increased advocacy, coordination and collaboration with these entities will be essential adaptations moving forward, together with increased community self-sufficiency, backup systems and emergency preparedness.
- Electrical infrastructure adaptations in light of increasing risk of high severity fire includes 104 proposed prescribed fire treatment units totaling 4,862 acres, along 41 miles of power corridor around the communities of Somes Bar and Orleans.
- The Karuk Tribe should prioritize renewal of the Emergency Management Program

Karuk Aboriginal Territory is mountainous with the primary travel routes and only thoroughfare roads entirely constricted to the Klamath and Salmon river corridors in the far northern part of the state. Throughout Karuk Aboriginal Territory dispersed populations live great distances from emergency services, and individual road closures may completely cut off travel access. Tribal programs and services include a comprehensive mix of health and social services, education programs, housing and energy assistance programs, and extensive natural resource management activities. In the more remote communities of Happy Camp and Orleans, the Tribe is a leading employer, first responder, and sole health care provider for tribal and non-tribal community members.

Climate events in the form of increased frequency of high severity fire, increasing temperatures, more variable precipitation and to a lesser extent species invasions, pose major consequences for critical Tribal infrastructure in the form of electrical grid infrastructure, transportation systems, water supply, communication systems and emergency services. The Karuk Tribe and Karuk community relies on infrastructure, including roads and utilities (water, power, telephone, internet), most of which are

supplied by non-tribal entities who will be increasingly under pressure from multiple directions with increases in fire activity, flooding in response to the changing climate. Tribal functions take place within an infrastructural context that includes power supplied by Pacific Gas and Electric in the Orleans community and Pacific Power in Happy Camp, water systems supplied by local municipalities (Orleans and Happy Camp), phone lines from four separate carriers in addition to private satellite carriers, and highway maintenance by CalTrans and Siskiyou and Humboldt counties. Internet service is also supplied by multiple carriers, including the Tribe. Many homes in the Somes Bar area and Salmon River communities are off grid, operating on standalone systems. Many homes throughout also have stand-alone domestic water systems, with their source many times being in use since times prior to the onset of the 20th century. In addition, the US Forest Service operates over two thousand miles of roads in the region. Community residents and Karuk tribal capacity alike are often significantly impacted by loss of power and especially by disruption in transportation routes. Critical infrastructure is likewise essential for asserting tribal management authority and highly relevant for tribal sovereignty. Climate impacts in the form of flooding and increasing frequency of high severity fires are already impacting tribal infrastructure including roads, electricity, communication and water systems and these impacts will increase. This chapter outlines the need for major resources for climate adaptation, but there are also many easier steps that can be taken that can significantly alter the trajectory of how the changing climate will impact Karuk tribal members and cultural resources as well as tribal management authority and sovereignty.

Karuk people rely on infrastructure, including roads and utilities (water, power, telephone, internet), most of which are supplied by non-tribal entities, and Karuk communities have historically received lower prioritization for roads, powerlines, communication and other forms of infrastructure maintenance due to their smaller population sizes and lack of awareness on the part of these other entities of the unique nature and needs of this remote rural community. For example, even beyond the mountainous terrain and lack of access routes, transportation vulnerabilities for the Karuk Tribal community are further underscored by the fact that the 2014 CalTrans climate assessment for Humboldt County rated Hwy 96 region at “middle point of criticality” for roads in relation to climate change (2014, p. 2). While Highway 96 may not be the most vulnerable road in the county, this categorization is likely to mean that as regional pressures increase in the face of the changing climate limited resources will be distributed to other road systems. Similarly, the criteria for PG & E distribution line maintenance is a function of population size, meaning that local lines have lower maintenance priority

despite the fact that fires from line starts in the Klamath region are likely to be much larger before they can be contained generating impacts across a multistate region. These non-tribal entities will be increasingly under pressure from multiple directions with increases in fire activity and flooding as the climate continues to change. This circumstance underscores the urgent and increasing need for advocacy, public education, collaboration and consultation across tribal and non-tribal jurisdictions in order to maintain and strengthen critical infrastructure essential for tribal functions in the context of climate change.

As emphasized throughout this document, climate stressors are layered on top of existing challenges of this remote area. Social justice challenges have impacted the Tribe since European influx and are ubiquitous today in the way of low economic opportunity, restricted access to traditional cultural resources, employment, schools, food sources, medical facilities, emergency evacuation routes. Already homes and structures along 60 highway miles of Karuk Aboriginal Territory are entirely off the electrical grid. Many households lack either landline telephones or cellular service. These households may rely on satellite phones or voice-over-internet systems or other means of wireless communication that become nonfunctional with a power outage. Many Karuk homes are similarly not served by any municipal water system, relying instead on creeks, individual filtration and UV systems or going without. Table 5.1 provides examples of how climate stressors compound with existing limitations of critical infrastructure including reliance on other entities to impact tribal program capacities.⁸

Table 5.1: Climate Stressors Interact with Existing Limitations in Critical Infrastructure				
Climate induced stressor	Existing Conditions	Existing Stressor	Infrastructure impact	Tribal Program and Community Impact
More variable precipitation, increased flooding	Remote area/reliance on other agencies, e.g. Caltrans	e.g. Culverts in need of updating	Longer or more frequent road closures	Daily routines and emergency access for community
Increased frequency of high severity fires Longer fire season	Century of fire suppression	PG&E infrastructure needing maintenance	Longer more frequent power outage	Tribal staff cannot access work, job sites, carry out responsibilities

⁸ lack of communication infrastructure ready to go when emergency assignments occur should likely be included.

This chapter details present infrastructure conditions and lays out climate adaptations for critical infrastructure in the form of electrical power, roads and transportation systems water supply systems, communication systems and emergency services. This is a living document that will benefit from updating over time.

Electrical Infrastructure

Functioning power lines are vital for daily tribal program operations, community well-being, and other forms of critical infrastructure and emergency services, such as food storage (refrigerators and meat freezers), air conditioning, air filters, phone and internet communication systems. Power is supplied by PG &E in the communities of Somes Bar and Orleans, and by Pacific Power in Happy Camp, Seiad and upriver towns. In this remote community, transmission infrastructure is critically important for energy delivery, emergency services and tribal government functionality. Many households lack either the option of landline telephones or cellular service. These households may rely on satellite phones or voice-over-internet systems or other means of wireless communication that become nonfunctional with a power outage. Homes and structures along 60 highway miles of Karuk Aboriginal Territory are entirely off the electrical grid these residences and supply their own power via generators, micro hydro systems or go without. Community infrastructure including energy grids, water and electrical utilities are built around and adapted for given climate conditions (e.g. wind speeds, expected energy grid demands). Grid outages already occur regularly in Karuk communities as a result of storms, landslides, fires and routine repairs -and these circumstances will increase as the changing climate generates more severe storms, increasing wind speeds, and changing wind directions. Electrical infrastructure is a relatively new factor in Karuk country, with many residents still without a grid connection.

At the same time as they represent a critical form of infrastructure in this remote region, transformers and other electrical equipment are known to be a leading cause of wildfire ignitions across California. Wildfires sparked by power lines and electrical equipment have been the cause of over half the total acreage burned in California in recent years (CALFIRE, 2015, Penn, 2017). As the climate changes, physical and ecological conditions including temperature, precipitation and winds are changing in unprecedented and often not entirely predictable ways. The number of large wildfires and the length of the fire season are increasing across California and powerline fires are expected to increase in the face of changing ecological and atmospheric conditions. At the same time, in this remote mountainous region, protecting critical infrastructure in the

form of functioning power lines is vital for emergency services, food storage (refrigerators and meat freezers), air conditioning, air filters, phone and internet communication systems. Loss of electrical power disrupts government communication and functionality, as well as impacts functionality and communications of emergency responders. Loss of electricity is also a problem during fires as many people rely on air purifiers for smoke management and air conditioning for cooling. Road closures during fire scenarios are not only inconvenient, they may impact escape routes or access for fire personnel. Smoke itself can be a major health issue, causing fatigue even at lower exposure levels. Table 5.2 underscores primary and secondary impacts from powerline ignitions.

Table 5.2: Primary and Secondary Impacts of Powerline Ignitions
(adapted from the California Adaptation Planning Guide Sensitivity Checklist)

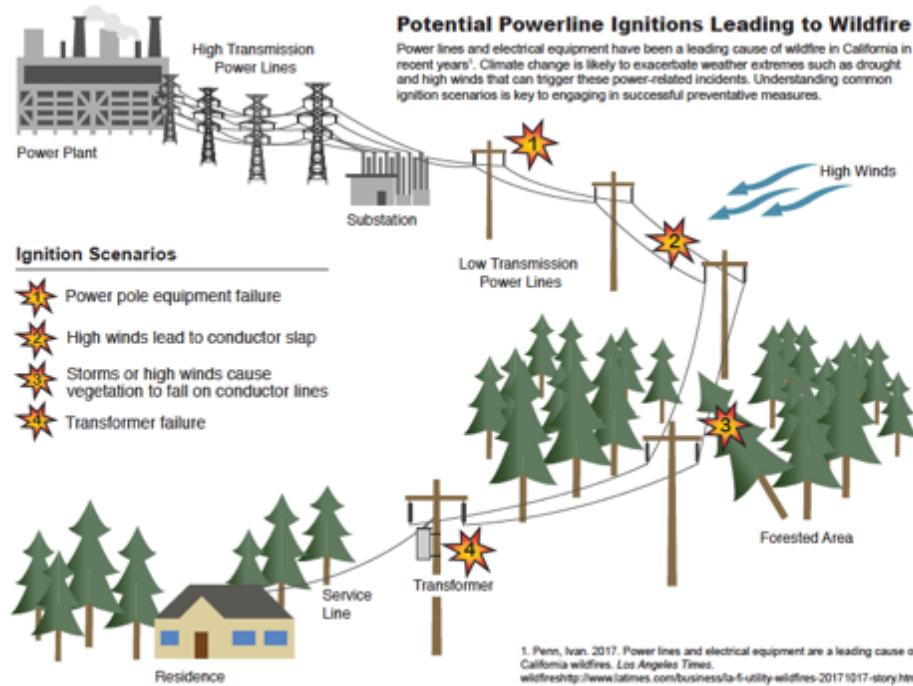
Primary Impact	Secondary Impact
Loss of electrical power	Government functionality and communications
	Emergency functionality and communications
	Household functions (heating, cooling, food storage (refrigerators and meat freezers))
	Community infrastructure (Orleans Community Services District relies on electricity for water treatment)
	Cooling and air purifying for smoke
Road Closure	Loss of transportation access
	Lack of Escape route
	Emergency services cannot access
Smoke	Health impacts
	Fatigue and stress

How Powerline Ignitions Occur

Transferring large amounts of energy from generation sites to households and community buildings involves the transmission of high voltage electricity large distances across the landscape. High voltage transmission lines are stepped down to lower voltage distribution and service lines at power substations to be distributed within communities. Yet distribution and service lines can start or exacerbate fires when trees fall onto lines, when lines contact one another, or when transformers explode. Powerlines can ignite wildfires via multiple mechanisms. These include the mechanical failure of transformers and other equipment, when lines or conductors are close enough together to cause arcing, when unmaintained vegetation comes in contact with a line or when a fallen tree or branch

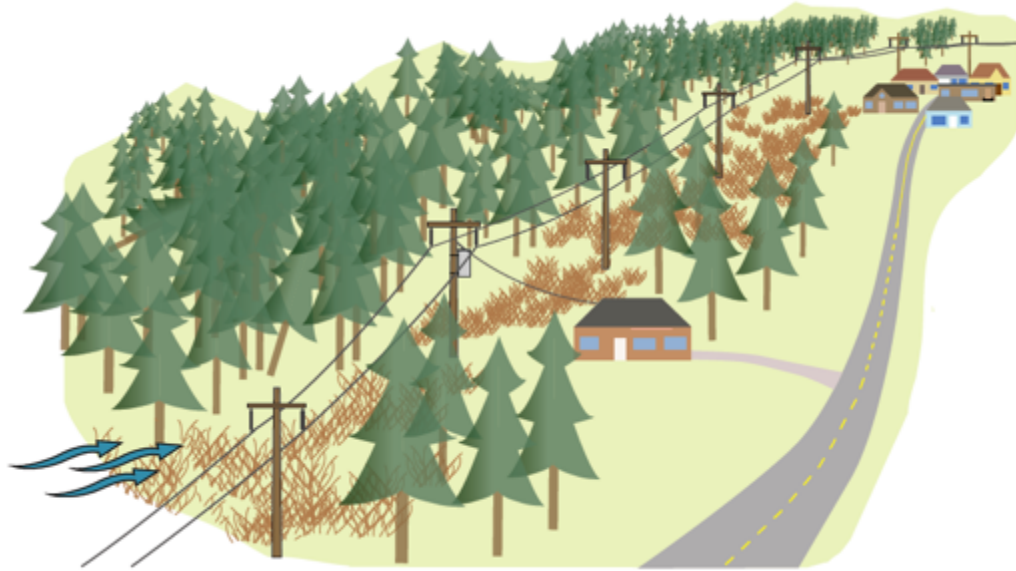
downs a power line. Figure 5.1 illustrates four major categories of power line fire ignition.

Figure 5.1: Potential Powerline Ignitions



Not only are distribution and service lines, transformers and other electrical equipment a source of wildfire ignitions, they can exacerbate existing fires. Once ignition occurs a variety of other factors including availability of fuels for ignition, wind speed, aspect and slope affect whether a fire will spread and how quickly this spread may occur. A third set of factors including presence of homes and other structures, roads and cultural resources affect the consequences of a fire. The presence of trees and shrubs immediately adjacent to the power line that can serve as fuels to carry a fire, the level of vegetation (fuels) in the surrounding forest, wind speeds, topography and proximity to emergency response all shape what will happen next. Figure 5.2 below illustrates a high risk, high consequence scenario with multiple possible ignition sources (powerlines, transformer, power poles, roads) and multiple negative consequences (homes and roads nearby, less maintained power corridor and the community is downwind of the – when a fire occurs it could spread into town). Keeping vegetation cut back or burned in the vicinity of potential ignition sources is of critical importance in preventing dangerous wildfires should a transformer explode, a tree fall onto a distribution or service line or other electrical related ignition occur.

Figure 5.2 Example of High Risk, High Consequence Ignition Scenario



In theory PG&E maintains a 15ft buffer along distribution lines to protect their infrastructure and decrease the risk of fires starts, although not all lines appeared to be maintained and even buffers listed as ‘maintained’ contained significant levels of encroaching brush, adjacent trees and overhanging branches. Buffers not listed as maintained had even higher levels of adjacent fuels. Such conditions are central to the unusually large impact of fires from electrical ignition sources – when fires occur in these remote locations with high fuel loading they can spread rapidly leading to higher damage and making them more difficult to contain. Power line maintenance is costly, but pale in comparison to the alternatives. Insufficiently maintaining lines defers cost onto the community, the Karuk Tribe and fire management agencies. As mentioned above, PG&E criteria for distribution line maintenance are a function of population size despite the fact that fires from line starts in the Klamath region are likely to become much larger before they can be contained. Local distribution lines are currently designated as Tier 2 risk for wildfire as opposed to the highest risk which is Tier 3. Line maintenance frequency is determined based on Tier. Tier 3 ranking is normally applied to higher voltage lines and higher population centers, however it is known that fires from line starts in the Klamath region are much larger before they can be contained, generating impacts across a multi-state region. See Figures 5.3 and 5.4 for examples of fuels near power lines in maintained and unmaintained corridors.

Photo Credit: Kenny Suave



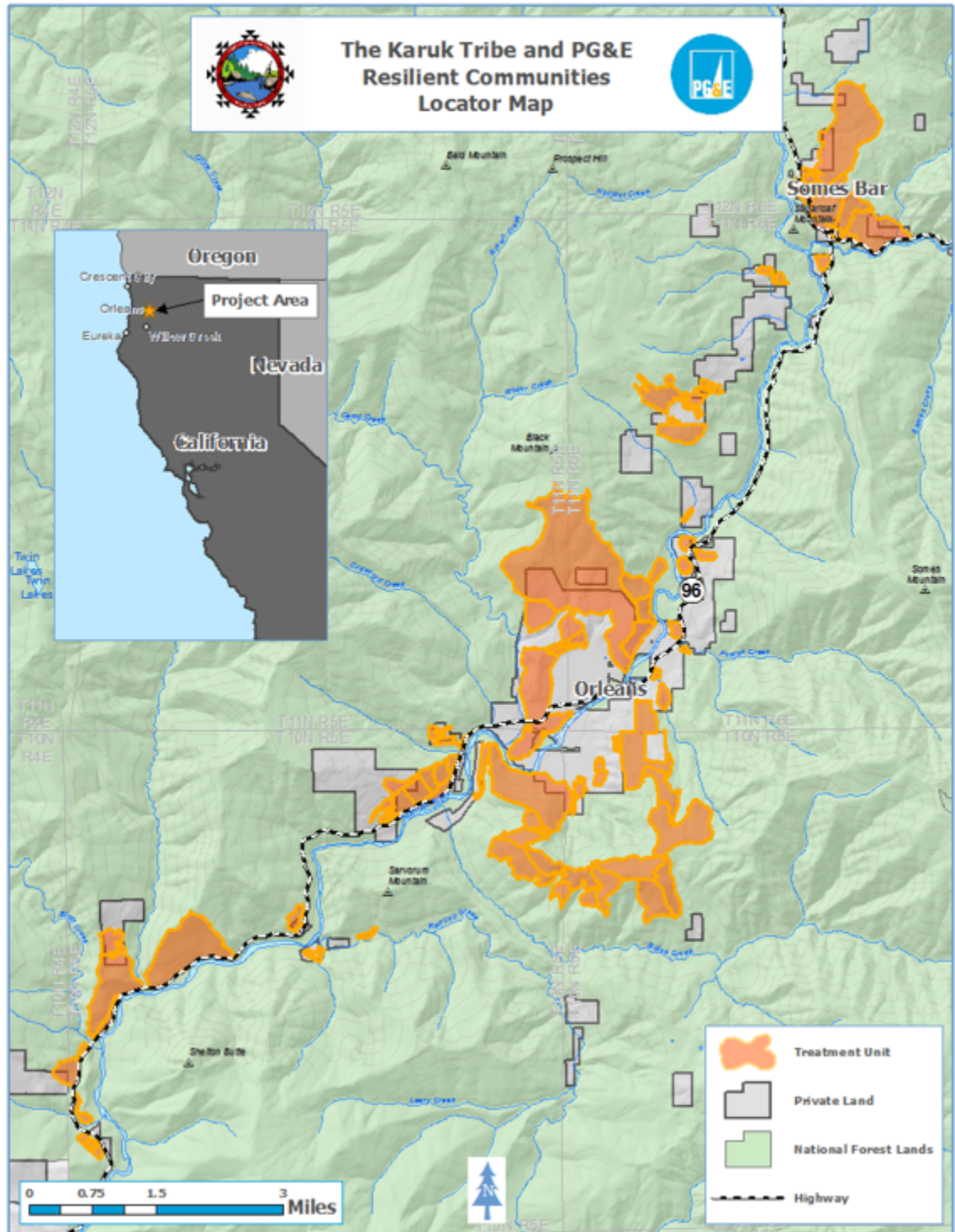
Figure 5.3 Even Maintained Corridors Have Unsafe Levels of Fuels Near Lines

Photo Credit: Kenny Suave



Figure 5.4 Power pole in Corridor Needing Maintenance

Between 2017 and 2018 the Karuk Tribe conducted a detailed adaptation strategy for maintaining critical electrical infrastructure and reducing the risk of powerline ignition in coordination with PG&E through a PG&E Resilient Communities Grant – see full report [Electrical Ignition, Wildfire Risk and Community Climate Adaptation in Northern California](#) for additional details. Climate adaptation, fuels reduction, cultural revitalization, liability reduction and economic employment go hand in hand through this replicable strategy which utilizes a combination of western science and traditional Karuk fire knowledge to establish 104 proposed treatment and prescribed fire units totaling 4,862 acres along 41 miles of PG&E distribution lines in the Klamath River corridor near the communities of Orleans and Somes Bar California in the heart of Karuk Aboriginal Territory (see Figure 5.5 Karuk Tribe and PG&E Resilient Communities Locator Map below). This approach is replicable for collaboration with Pacific Power to secure coverage for communities of Happy Camp and surrounding areas.



In addition to the units themselves, the project outlined additional adaptations regarding wildfire risk reduction from electrical sources, see Table 5.3 below.

Table 5.3 Adaptations for Reducing Wildfire Risk From Powerline Infrastructure	
Immediate Actions	Begin proposed project on 104 units utilizing one or more of proposed funding mechanisms
	Seek partnership with more landowners and establish more units for treatment
	Seek gross negligence liability clauses through state and federal legislation to protect PG&E and prescribed burners from the undue burden of financial liability in regard to achieving community, ecosystem, and infrastructure resilience.
	Reassess PG & E maintenance tier prioritization in light of remoteness and potential for local distribution lines to ignite large-scale fires.
	Develop fire protocols specific to distribution line hazard in wind events including de-energizing lines if necessary.
	Improve distribution line maintenance standards, monitoring and maintenance follow up.
	Resident/customer outreach regarding how household can help maintain vegetation around powerlines and power poles on their properties
Longer Term Actions	Continue maintenance on treatment units over time
	Consider a wide range of proactive responses including placing more powerlines underground.
	As wooden poles are replaced, install steel poles to increase infrastructure resiliency to wildland fire especially in areas slated for frequent prescribed fire.
	Incorporate fire hazard reduction principles in planning future infrastructure projects , including generating energy locally to minimize power failures and transmission hazards.
	Promote micro-grid technologies to help alleviate loss of power when having to shut down portions of grid power while conducting infrastructure protection burns.

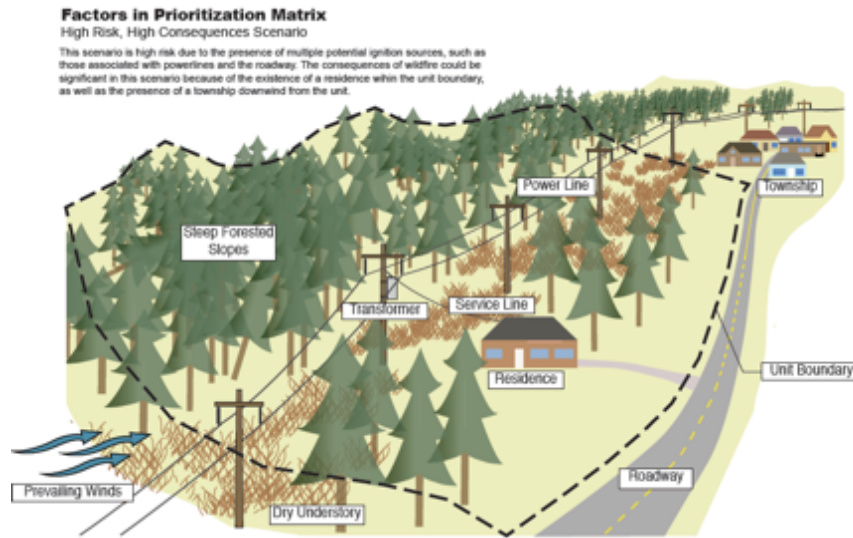
We ranked unit treatment priority using a combination of ignition risk, fuels topography, consequence. In the area around the communities of Somes Bar and Orleans, California we identified five possible ignition sources, three of which are related to electrical equipment (powerline starts, transformer starts, and power pole starts). We then rated the likelihood of ignition from each of these five possible sources as low, medium or high levels according to specific criteria detailed in Appendix D. By combining these three ignition risks we are able to isolate those units for which the possibility of ignition from electrical sources was greatest. Of the 104 total units, 28 ranked high for ignition risk from electrical sources, while 41 were medium ignition risk and another 35 were low. These units ranking high or medium risk can be seen as a liability for PG&E in that there is high risk for an ignition due to PG&E infrastructure, however, they should also be viewed as an opportunity in that they are low hanging fruit for increasing community wildfire resilience and climate adaptation. Lightning and arson ignitions played into the

prioritization in that there is still a risk to energy infrastructure from these other types of ignition potential. Topography matters because steep slopes carry a fire faster, as do slopes that are south facing as these hold less moisture and experience hotter daytime temperatures. Both wind speed and wind directions are also very significant for how fast fires may spread. In the Somes Bar and Orleans area units on a NE/SW axis were of highest priority. The prevailing wind direction is from the southwest, however winds coming from the northeast and heading southwest are often more dangerous because they tend to be dry winds. These northeast origin winds are most frequently associated with “red flag” warnings – conditions under which fire danger is especially high.

In addition to the above, some fires are more damaging than others. Potential negative consequences of fires vary by their location: fires that threaten structures, road access and other community values are generally considered more impactful than those which do not. Table 2 lays out these factors explicitly. This proposed mitigation approach would reduce fire risk and PG&E liability along 41 miles of power corridor in and around the community of Orleans, California by creating prescribed fire/treatment units along the power line corridor and nearby strategic locations. We ranked priority using the criteria specified in Table 5.4 below.

Table 5.4 Evaluating Ignition Risk and Impact Severity	
Ignition Risk	Transformer explosion/malfunction
	Powerline start (multiple possible mechanisms)
	Power pole equipment failure
	Lightning ignition
	Human ignition (roads, vehicle, arson, home start)
Fuels	Level of vegetation maintenance in powerline corridor
	Level of live and dead burnable vegetation in unit
Topography	Steeper slopes carry fire more easily
	South aspect carries fire more easily
	Alignment with strongest winds (NE/SW), and with up canyon winds in summer afternoons.
Community Consequences	Road access for entry or exit
	Homes and other structures directly within unit
	Homes and other structures within 0.25 mile of unit
	Community Value Measures

Figure 5.6 below visually portrays these factors on the landscape for a high risk, high consequence scenario.



Initial and long-term treatment cost calculations were made by evaluating each unit in terms of the number of steps needed to prepare the site for prescribed fire, and the difficulty of conducting these tasks. Before what is known as a broadcast burn can occur, fire lines must be created if they do not already exist. Units without recent fire or other fuels maintenance also require hand thinning of materials into piles and burning of the piles before the broadcast burn can occur. Steep units are significantly more difficult for crews to navigate, and because such units can carry a fire more easily, additional work may need to be done in advance before the broadcast burn can take place. Costs for the initial treatment of project units are displayed in Table 5.5 below broken down according to unit priority (high, medium and low), and sub costs.

Table 5.5: Cost Calculation for Initial Treatment

Unit Priority	Initial Fireline Construction Cost	Initial Hand Treatment Cost	Pile Burning Cost	Initial Prescribed Burning Cost	Total Initial Treatment Cost
High	\$230,850	\$2,218,590	\$891,000	\$1,782,000	\$5,122,440
Medium	\$325,450	\$3,182,220	\$1,278,000	\$1,789,200	\$6,574,870
Low	\$67,500	\$651,135	\$261,500	\$261,500	\$1,241,635
Total:	\$623,800	\$6,051,945	\$2,430,500	\$3,832,700	\$12,938,945

Maintenance costs after the initial treatment are significantly less than initial costs. Prior to fire suppression units in this area (which is close to historic village sites and current communities) was burned on intervals ranging from 1-3 years. The annual maintenance

burning cost on a three-year rotation (i.e. each unit would be burned every third year) is \$810,000, see Table 5.6 below. The treatments shown require environmental planning, leadership and support positions. When additional costs for environmental planning and for leadership and support are included alongside the initial treatment cost the annual cost over a ten-year project period is \$2,379,994 per year.

Table 5.6: Long term Treatment Cost and Average Annual Project Budget

Initial treatment cost		\$12,938,945
Long Term Costs	Annual maintenance burning cost (3-year rotation)	\$810,166
	Environmental Planning	\$3,000,000
	Leadership and Support	\$3,000,000
	Total 10 Year project need	\$23,799,941
Average Annual Project Budget		\$2,379,994

While this figure may appear significant, even the initial treatment cost is less than annual local fire suppression costs in most recent years. By contrast, failure to protect from ignition risk not only creates enormous liability for PG&E, it defers these costs onto the community, the Tribe and fire management agencies. Fires from line starts in the Klamath region are much larger before they can be contained, generating impacts across a multi-state region. For this reason, the suppression costs and liability potential for wildland fires in the area are enormous. Table 5.7 below lists the total costs for fires in and adjacent to the Orleans ranger district for the top three fire years in the past decade. Of course, these are only the direct suppression costs of the fires, and do not include all the additional economic, social, physical and emotional impacts to the community or the negative consequences transferred to the local ecosystem.

Table 5.7: Recent Large Fire Suppression Costs in Orleans/Somes Bar Area

Fire Year	Fires in Orleans/Somes Bar Area	Suppression cost per fire (millions)	Total large fire suppression cost for fire year
2008	Klamath Theater Complex	> \$150	> \$150 million
2013	Dance Fire	\$1.2	\$65.2 million
	Butler Fire	\$39.5	
	Salmon Complex	\$24.5	
2014	Happy Camp Complex	\$86.7	\$86.7 million

While the price tag to conduct this work is not insignificant, a number of funding mechanisms can be employed to easily cover project costs including for example establishing a community strategic investment fund through ratepayer contributions, launching a strategic investment partnership with the Karuk Tribe and/or the Humboldt Area Foundation, or a corporate matching gift program. See full report [Electrical Ignition, Wildfire Risk and Community Climate Adaptation in Northern California](#) for additional details.

Climate Adaptations for Transportation and Roads Infrastructure:

The Karuk Department of Transportation is tasked with constructing and maintaining Tribal transportation facilities exclusively on Tribal Lands. Tribal, state and county transportation facilities are utilized within communities to provide access to general services, education, health services and employment, as well as, ceremonial needs and cultural resource utilization. Karuk Aboriginal Territory is mountainous with high landslide activity and the dominant modern transportation routes almost entirely constricted to the river corridor. Traditional Tribal Transportation facilities are an important part of the transportation system; we recognize the river and tributary corridors, as well as, earthen foot trails as facilities that were principal means of village to village access, ceremonial needs, cultural resource utilization and commerce preceding European influx into Karuk Aboriginal Territory. Today, state highways and county roads that traverse through Karuk Aboriginal Territory are recognized as main access routes to population centers locally and regionally. The three principal Karuk communities of Orleans, Happy Camp, and Yreka span 120 miles of winding river roads along State Route (SR) 96 and SR 263 in the northernmost region of California. Although modern day transportation facilities provide general access, the Karuk people are stewards of this land with the inherent responsibility to pass on knowledge of and access to ceremonial sites, traditional foods and responsible cultural resource utilization.

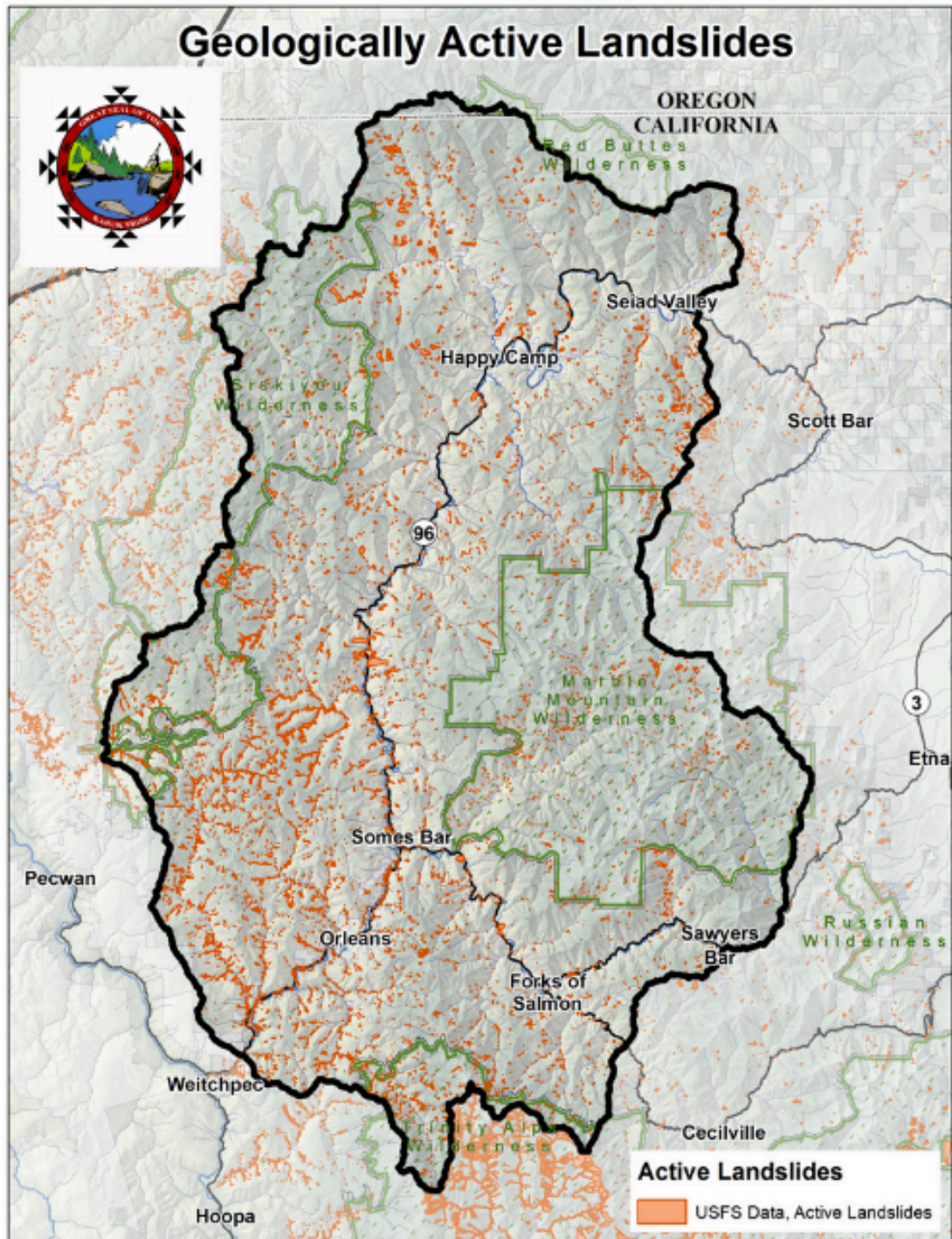
The National Climate Assessment and the Secretary of the Interior have made strong statements concerning the increased vulnerabilities tribes face in the face of climate change. Transportation systems are vitally important to lessen the ubiquitous social justice challenges that have impacted the Karuk Tribe since European influx in the form of low economic opportunity, restricted access to traditional cultural resources,



employment, schools, food sources, medical facilities, emergency evacuation routes. Rural regions are commonly under-served due to their low population sizes. Already daily activities, emergency access, tribal program capacities and management authorities are impacted by disruption in transportation routes, see Figure 5.7. For the Karuk Tribal community, transportation vulnerabilities are further underscored by the fact that the Tribe relies on collaboration and infrastructure support from surrounding non-Tribal agencies. In light of climate

change, these agencies face increased stress from multiple angles, and existing vulnerabilities of rural communities are further intensified. For example, the 2014 Caltrans climate assessment for Humboldt County rated SR 96 region at middle point of criticality for roads in relation to climate change (2014, p. 2). Further, SR 96 is not included as part of the National Highway System, a network of highways that are considered essential to the country's economy, defense, and mobility by the Federal Highway Administration. While SR 96 may not be the most vulnerable road in the county, these categorizations are likely to mean that limited resources will be distributed to other road systems. Geologic instability including slumps and subsidence and

landslides is already enormously high in the area (see Figure 5.8 Geologically Active Landslides below)



Transportation infrastructure is critically necessary for climate adaptation. The Karuk Tribe's Climate Vulnerability Assessment (CVA) identifies potential impacts of climate change on transportation infrastructure as having key impacts for program infrastructure,

for species of concern (e.g. through impacts to roads and sedimentation in aquatic systems), and to political sovereignty through the reduction in management authority when species and programs are negatively impacted. Road closures during wildfire events cut off the community from the outside, potentially affecting escape routes, access to emergency service and food supplies. With increases in both fire and flood activity landslide activity can be expected to increase. In particular, the increased likelihood of high intensity wildfire presents risk to travel throughout Karuk territory both due to direct Forest Service and California Department of Forestry and Fire Protection (CALFIRE) road closures during fire events, and from flooding and landslides in the immediate (e.g. 2 year) aftermath of high intensity fires.

While transportation closures during fires may be relatively short term (in the period of days or weeks), transportation systems are especially vulnerable due to the steep forested topography and the fact that there may be no alternate routes for travel increases the severity of the situation. Road closures during wildfire events cut off the community from the outside, potentially affecting escape routes, access to emergency service and food supplies. In the aftermath of high intensity fires erosion, flooding and landslides frequently cause additional (and potentially longer) closures as increased runoff may cause landslides impacting roadways. Flooding from changing patterns of precipitation (more rain on snow events, more extreme rain events) will also increase.

At the same time as transportation infrastructure is critically necessary for climate adaptation, without proper maintenance, transportation infrastructure is itself a source of increased risk in light of the changing climate. In the aftermath of high severity fires, erosion, flooding and landslides from the fires or from poorly constructed and non-maintained roads occur regularly as increased runoff cause landslides onto roadways. Undersized blocked culverts may cause flooding as upstream flows accumulate behind the culvert. Culvert blockages and subsequent debris flows may in turn damage or destroy main travel routes. When blocked culverts blow out, large amounts of sediment input have in turn serious water quality impacts to the riverine system. Erosion and sediment transport from unmaintained or improperly roads is a leading cause of vulnerability to salmonid species. While some transportation closures may be relatively short term (in the period of days or weeks), the absence of alternate routes increases the severity of the situation. Longer closures do also occur, in March of 2017 Highway 96 between Orleans and Somes Bar and in 2018 the Salmon River Road was closed for several months.

Necessary climate adaptations for Karuk transportation systems are extensive and amongst the highest priority for supporting emergency services, daily and emergency

access/egress of the community, tribal program capacity, tribal management authority and for supporting riverine and riparian habitat impacts. Key activities including maintenance and development of alternative emergency access-egress routes and specific adaptation strategies for routes and areas vulnerable to damage and/or closure from high-severity wildfire and extreme hydrologic events, assessment and evaluation of locations and homes with only one emergency egress-access routes, expansion of equipment, and assessment and expansion of culvert capacities along key slide or flooding areas are all of the upmost importance. Collaboration, coordination and joint projects across tribal and non-tribal jurisdictions will be essential. Work in these areas is underway with additional projects proposed.

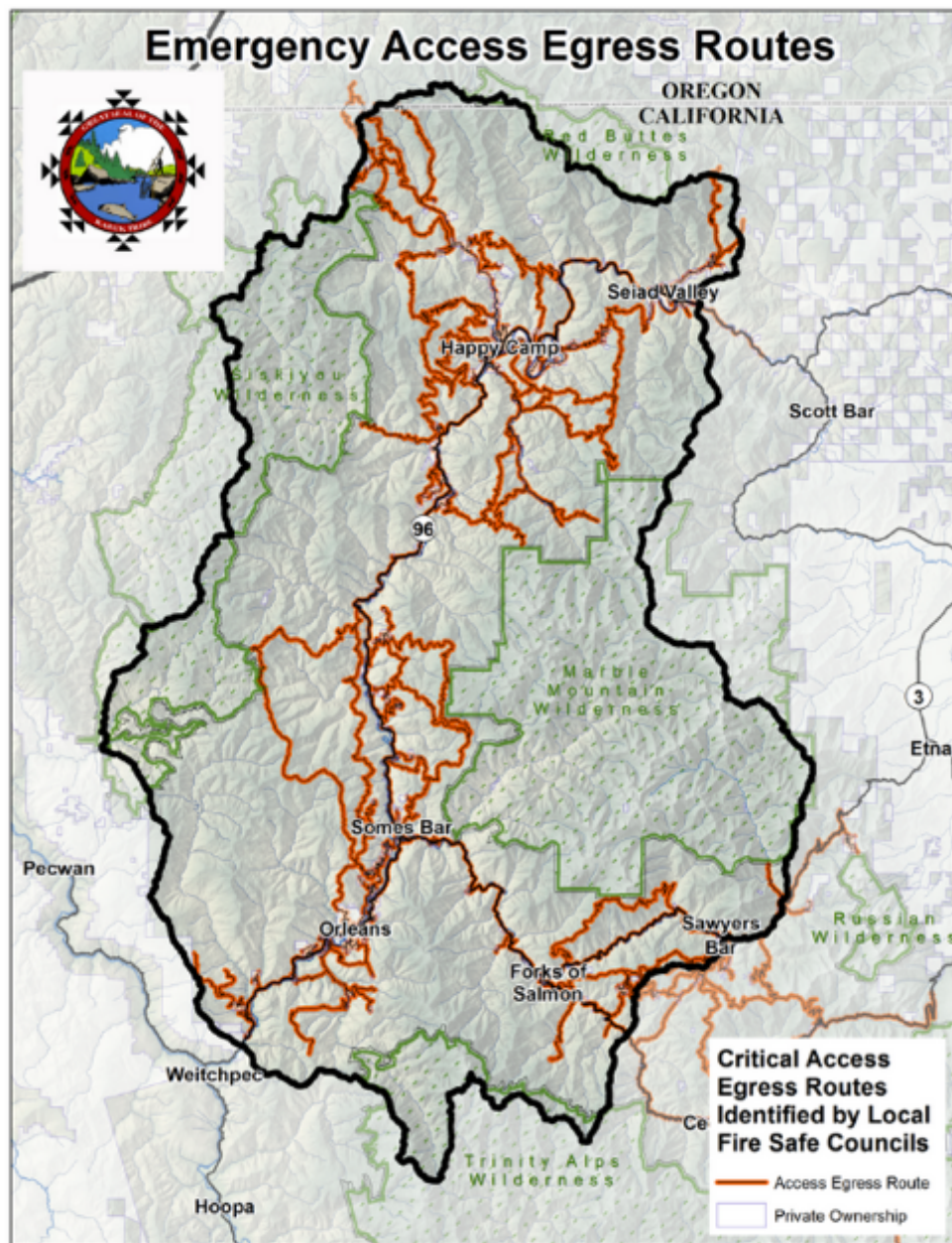
Table 5.8 Climate Change and Transportation Infrastructure Adaptations

<i>Climatic Event</i>	<i>Proximate Consequence</i>	<i>Impact</i>	<i>Adaptation</i>
Increase in fire frequency Increasing microburst, Increase rain on snow events lead to flooding	Road closures from fire activity	Loss of emergency access/egress	Develop in depth plans together with CalTrans, USFS, Humboldt and Siskiyou counties
	Landslides or debris flows following fires cause road closures	Daily and cultural activities disrupted	Increase partnerships, outreach and advocacy
			Road decommissioning
			Culvert repairs and upgrades (currently tend to be done on emergency basis)
	Road closures from landslides, flooding causes roads to fail after heavy rains	Loss of access for staff to site to perform needed operations	Public Education regarding emergency evacuation routes
			Develop Advanced Adaptation Protocols/Plans

Access and Egress

Access and egress within Karuk Territory is already often restricted. Highway 96 is the main travel route through approximately 72 miles of Karuk Aboriginal Territory is subject to numerous landslides (see Figure 5.8 on p.). This highway connects the region to Interstate 5 in the East and to Highway 299 to the southwest. The Salmon River Road begins in Somes Bar, traverses another 31.2 miles of road through Karuk Aboriginal Territory and connecting to CA State Route 3 in Etna, CA, with connections to Interstate

5 and CA SR 299. The Salmon River road is a one-lane route over much of its course with frequent landslide activity, see Figure 5.9 Current Access/Egress Routes below:



The use of further GIS mapping to assessment and evaluation of locations and homes with only one emergency egress-access route, the development of alternative emergency access-egress routes and specific adaptation strategies for routes and areas vulnerable to damage and/or closure from high-severity wildfire and extreme hydrologic events.⁹

⁹ It may make more sense to separate storm events and fire into standalone sections

The maintenance and development of alternative emergency access-egress routes is of top priority. Most of the “alternative” routes indicated in Figure 5.9 above are blocked by snow in winter, depending on snow level and depth. These are also susceptible to landslides, rock falls and fallen trees. In some cases, highly beneficial actions may be relatively simple and inexpensive. For example, currently the Indian Creek/Grayback Road (Forest Service Road 48) which connects Happy Camp and Cave Junction is not maintained in winter. However, as the fire season extends later into winter and begins earlier in Spring this road could be maintained as for emergency access/egress route for Happy Camp. Since road closures due to landslides are predominately on the Hwy 96 corridor from Hoopa to Happy Camp maintaining Bald Hills Road and USFS roads that loop back onto Hwy 96 would be particularly advantageous in bypassing long-term closures.

Climate Adaptations for Water Supply Infrastructure

Access to potable and non-potable water is essential in the community for drinking water non –commercial gardens and orchards, , and for emergency fire suppression response. Municipal water systems are located in Happy Camp and Orleans. A number of additional smaller systems include the Orleans Mutual Water System on Afifharihan Creek (Little Shit Creek) which serves several dozen households, and the Thunder Mountain Water Association on Wilder Creek. An estimated 15-20% of tribal households along the river supply their own water from creeks including those in the township of Somes Bar.¹⁰ These households do their own UV treatment or have untreated water. Climate impacts and potential adaptations for individual household systems are not elaborated here, but individuals using these systems are encouraged to read this material and consider how it may apply. Discussion of systems in Orleans and Happy Camp follow with climate adaptation recommendations (see Table 5.9).

Orleans

The Orleans Community Services District uses Perch Creek as a surface water source. Water is piped about one mile from the inlet and is filtered using a dual filter through sand and silica. This is a gravity-based system providing potable water to the town of Orleans. This intake and treatment system is scheduled to be upgraded in the near future. For the Karuk community in Orleans, roughly 25% of Tribal users are in Karuk Housing, with the remainder of Tribal users in private homes. An estimated ten percent of the total

¹⁰ Confirm Somes Bar systems, school is there. . .

Karuk tribal population living in Karuk aboriginal territory are served by this system. An unknown number of households have access to personal backup systems. The Orleans system has a 100,000 gallon Redwood tank for backup storage (this system currently leaks). However, as 200,000 gallons of water can be used by the community in one day this is very inadequate given the dual water supply and fire suppression potential uses. The Orleans Community Services District has been impacted during past fire events and does not have adequate capacity. During the so-called Dance fire in 2008 an arson fire was responded to by the local community using fire hydrants and the tank was drained very quickly. The town water supply was drained, and the fire could not be put out before an elder's home was lost.

The local water operator can do manual override for treatment system when fires occur which speeds up the delivery time. There is however only one road in and out to access tanks in Orleans. This system is in the process of upgrades. There is a current plan to upgrade to a 300,000 gallon tank. Given the need for double or triple the daily highest use in the case of dual need for fire backup needs are closer to 600,000 gallons minimum. Should a fire occur in Perch Creek sedimentation and debris flows could jeopardize the entire community water system for an extended time period.

Happy Camp:

Water in Happy Camp is supplied by the Happy Camp Community Services district who has had a good working relationship with the Karuk Tribe. Water is drawn from Elk Creek treated with UV or light radiation and also chemical treatment and crosses into town via a pipeline crossing the Klamath River at Indian creek. Currently there is a 1 million gallon holding tank for the community up Elk Creek. As with the Orleans system, fire hydrants hook into the drinking water supply. As with Perch Creek in Orleans, a fire in Elk Creek would threaten the Happy Camp water supply for an extended time period.

Adaptation Recommendations:

Specific notes for each community are provided in addition to the general adaptations listed in Table 5.9 below

Specific Adaptations for Orleans System

- Prioritize fire prevention/safety for Perch Creek
- Install additional 300,000 gallon storage tank for Orleans
- Upgrade to steel tanks

- There is only one road in and out to access tanks in Orleans, upgrade road and initiate fuels treatment to minimize impact from wildland fire along access for water system.
- Ensure bypass treatment option for emergency mode to use for fire suppression. Local water operator can do manual override when fires occur.
- Bury supply lines that are not currently buried.
- Create redundancy by having fire hydrants into a different system than drinking water
- Update distribution system

Adaptations for Happy Camp Water System

- Have backup source of water on west side of Klamath river, in case bridge goes out.
- Create redundancy by having fire hydrants into a different system than drinking water
- Prioritize fire prevention/safety for Elk Creek
- Evaluate need for additional holding tanks.

Table 5.9 Climate Change and Water Supply Infrastructure Adaptations

<i>Climatic Event</i>	<i>Proximate Consequence</i>	<i>Impact</i>	<i>Adaptation</i>
Drought	Reduction in overall water supply	Short term, e.g. seasonal	Additional water storage systems, community planning, rationing, rate increases to promote conservation, etc.
		Long term	May need to develop alternative and backup sources
Increase in fire frequency, length of fire season	Landslides or debris flows in water source drainage may cause water system failure	Drinking water impact	Prioritize fire protection measures including proactive use of prescribed fire in water supply drainages (e.g. Perch Creek in Orleans, Elk Creek in Happy Camp)
			Additional water storage systems, backup tanks
			Develop Advanced Adaptation Protocols/Plan
			Public Education regarding multiple users causing system shutdown
	Increased water demand for fire suppression activities	Fire fighting impact, also as everyone draws on water at same time	Redesign systems to create redundancy
			Additional water storage systems, backup tanks
Increasing microburst, Increase rain on snow events, aftermath of high severity fire	Road closures from landslides/flooding causes roads to fail after heavy rains	Loss of access for staff to site to perform needed operations	Develop Advanced Adaptation Protocols/Plan
			Public Education regarding multiple users causing system shutdown
			Expand backup systems and supplies
			Develop Emergency Management Program
			Develop alternate emergency access capacities, e.g. helicopter, boat, ATV

Climate Adaptations for Communications

Communication is a form of critical infrastructure that is vital for tribal functionality, tribal program capacity, emergency services, as well as for daily community activities. The Karuk Tribe and Tribal communities utilize communication systems via landline and cellular telephone, internet, and some tribal vehicles have radio systems with dispatch in Orleans connecting to Fortuna and Yreka. Each of these forms of communication face serious and intersecting challenges resulting from the mountainous terrain, the remote nature of the region, its limited and often already unpredictable power sources and large area supplied by multiple providers. Where available, phone lines are provided by four separate carriers. In addition, many homes have no cellular or land line option and utilize a variety of private satellite carriers. Homes and structures along 60 highway miles of Karuk Aboriginal Territory are entirely off the electrical grid. Many households lack either landline telephones or cellular service. These households may rely on satellite phones or voice-over-internet systems or other means of wireless communication that become nonfunctional with a power outage. Figure 5.10 indicates the availability of broadband internet within Karuk Aboriginal Territory

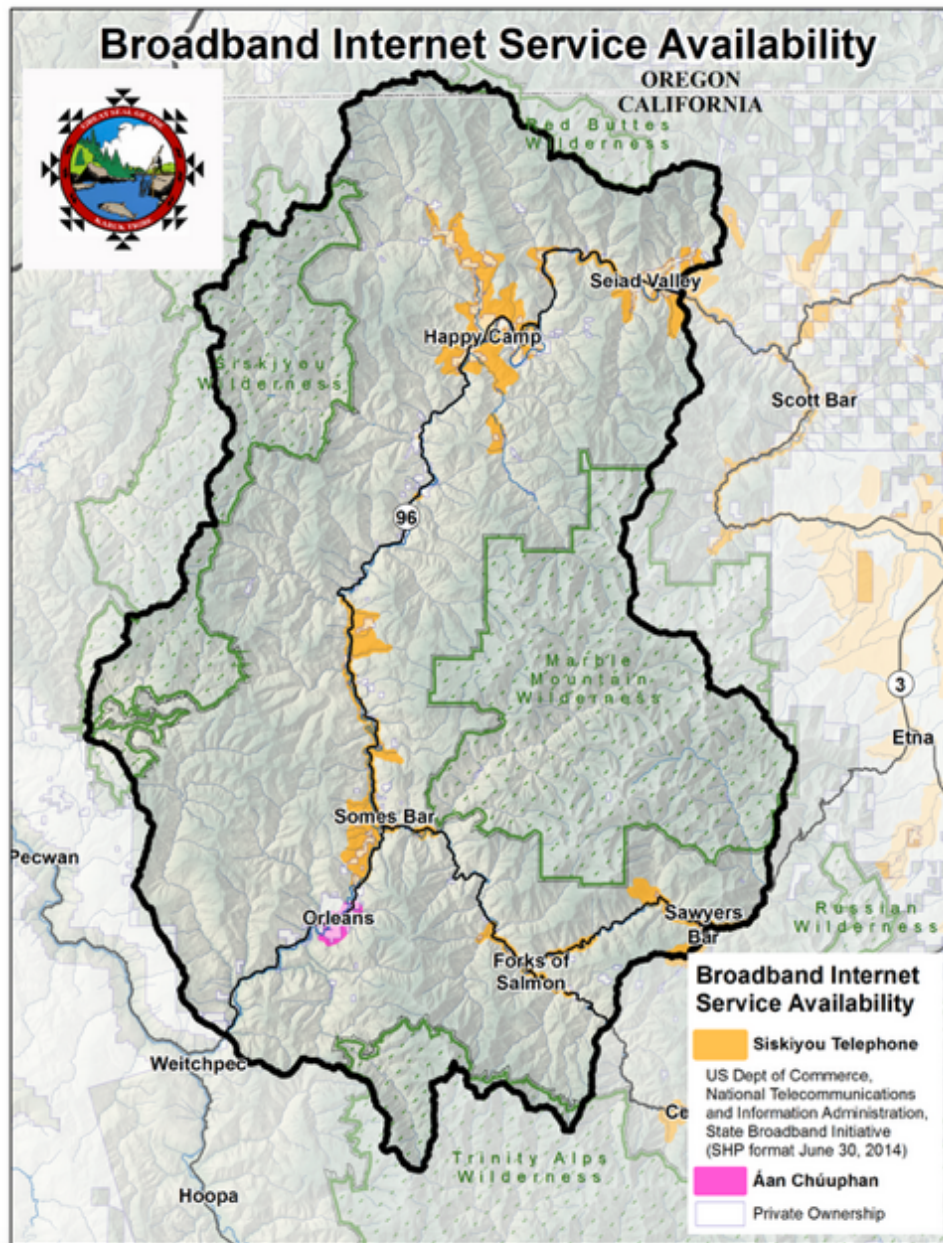
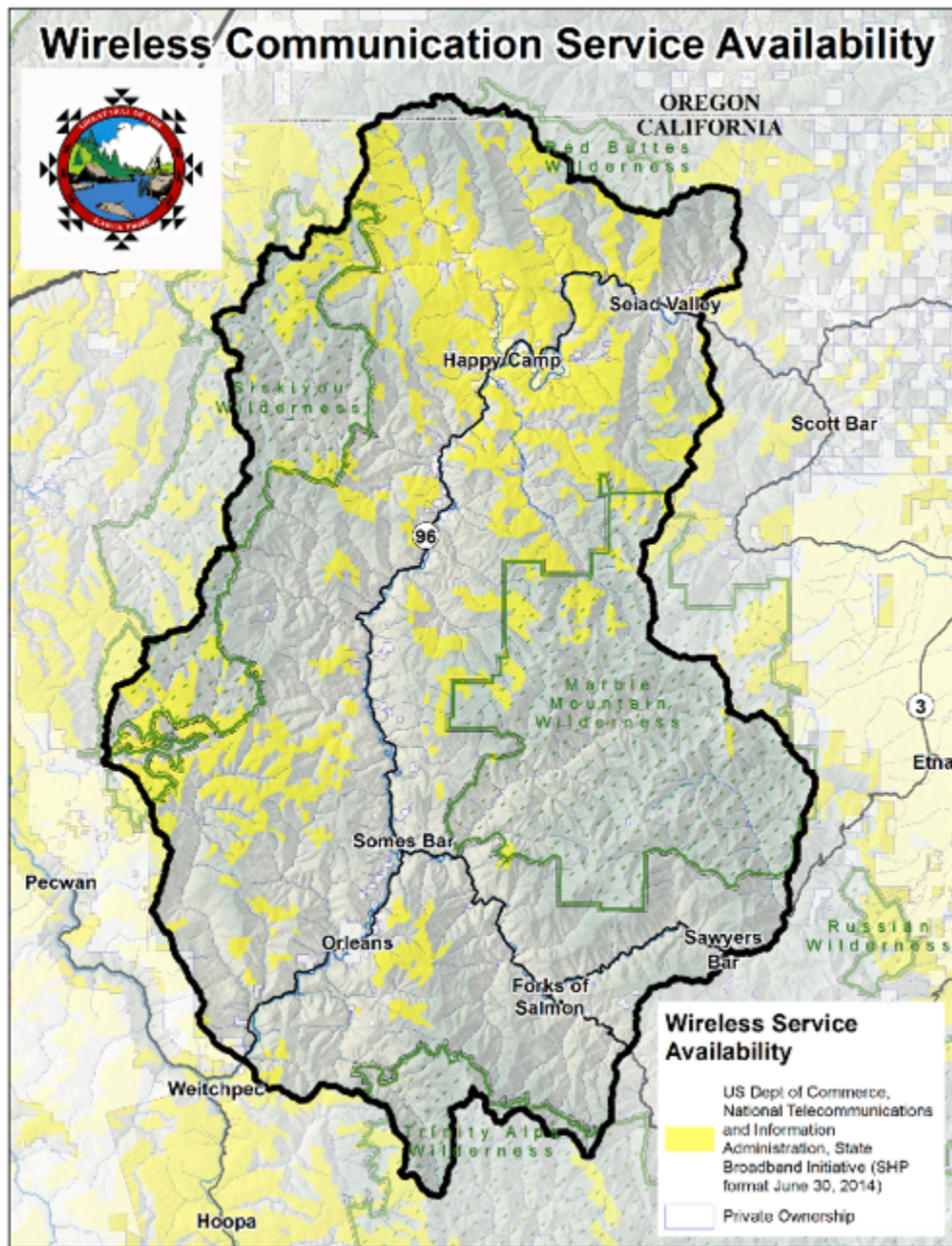


Figure 5.11 indicates the availability of wireless service within Karuk Aboriginal Territory



As noted regarding other forms of critical infrastructure, communication infrastructure is supplied by non-tribal entities who will be increasingly under pressure from multiple directions due to increases in fire activity, flooding across the region as the climate changes. Long term planning, communication, cooperation and joint projects will all be essential moving forward. Given the centrality of communication systems to emergency response, daily tribal program functioning, tribal management authority and the daily routines of the community increasing system redundancies and overall self-sufficiency at

all levels are also essential. Currently the Tribe has backup power systems in Tribal buildings and an emergency communication structure described in the emergency management section that follows. In particular Cellular on Wheels (COW) should be installed in Orleans with direct intertie with fiber to provide expedited emergency communications for both voice and data. The Tribe has an established service area and should be able to provide cellular service in that area regardless of company service areas. Table 5.10 outlines preliminary adaptation recommendations in light of the changing climate.

Table 5.10 Adaptations for Communications Infrastructure
Expand communications backup power potential
Supply each tribal vehicle with a radio system.
Expand repeater system by placing repeater on Horse Mountain so communication with Fortuna is of higher quality.
Below ground fiber optics, this could tie in with putting powerlines underground¹¹
Install Cellular on Wheels (COW) in Orleans with direct intertie with fiber to provide expedited emergency communications for both voice and data.

Climate Adaptations for Emergency Services Infrastructure

Emergency management infrastructure is critical in this remote rural region. Wildfires, extreme summer heat, power outages, road closures and flooding are all familiar circumstances for the Karuk Tribe and community. The community has many formal and informal resources and much basic expertise in responding to situations that other communities have never imagined. Given forecasted increases in summer temperatures, wildfire and flooding activity, the already significant need for emergency management capacity will increase significantly in the coming years. Between 2013 and 2015 the Karuk Tribe had a Department of Emergency Management which supported capacity to manage emergency declarations such as those that enabled deployment of an evacuation center and clean air center, but the program could not be sustained on grant funding. The Tribe has a Hazard Mitigation Plan in place and currently the Karuk Housing Program coordinates emergency management activities for tribal members in housing and for the community at large. Karuk Housing office supplies some emergency management support to the 224 units that are spread between three communities of Orleans, Happy Camp and Yreka. For example, Karuk Housing supports a security officer to care for tenants, stock and supplying residential household size HEPA air purifiers for all Tribal

¹¹ Buried infrastructure is however vulnerable to landslides

housing units, and elder's homes in Orleans have backup generators. This position does not however qualify to be incident commander for a Keeper Team; without an IC a team cannot be deployed. The Housing Office has contracted with the Karuk fire crew to do fuels treatment around structures. The Tribal Housing Program also has a mobile incident command center consisting of a trailer with generator and communication systems, off highway vehicle (UTV), and a jet boat to access houses across the river in the event of road failures during high water. The housing office will finance loans for Karuk tribal members but they must carry fire insurance which is becoming more difficult to secure in the wake of larger California wildfires.

The Karuk Tribe as a whole, supplies dedicated HEPA air purifiers to Tribal facilities, has participated in ongoing collaborations with Siskiyou County Office of Emergency Services, including Preparedness Training and is a member of the steering committee for the Siskiyou County Natural Hazard Mitigation Plan. The community of Happy Camp has an ambulance, for Orleans there is a Volunteer Fire and Rescue, otherwise an EMT paramedic can come from Willow Creek (dispatched from Fortuna). The Headway Building and Senior Nutrition Center serves as warming centers in Winter and cooling centers in Summer.

In the face of increasing frequency of high severity fires the Tribe will face a growing need for direct emergency response, transportation and communication interruptions, power outages and crisis situations regarding short- and long-term management of smoke.

Another area where needs will increase regards flooding. Utilizing a 100-year flood risk (1% flood risk potential) there are 911 structures at risk within Karuk Aboriginal Territory.¹² Figure 5.12 below shows the flood risk map for Orleans. There are 117 structures at risk of a 100-year flood risk in Orleans (1% flood risk potential).

¹² This is using 100 year (1%) flood risk from 3 different sources: Hazus-MH modeling (for Humboldt county); FEMA DFIRM maps (for Siskiyou County); and KBRA EIS, No Action Alternative for the HC community area.

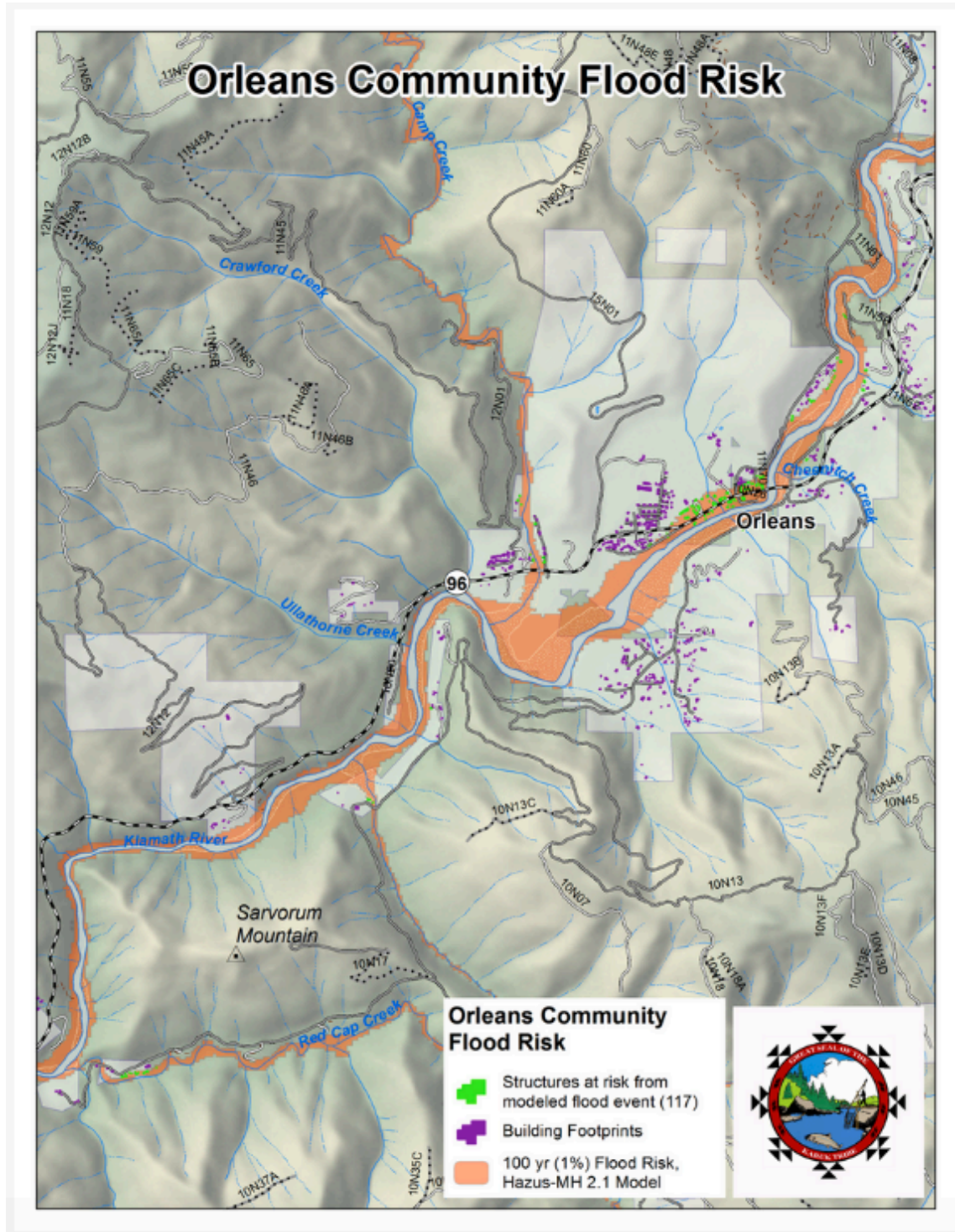


Figure 5.13 shows the Flood risk maps for Happy Camp indicating 433 structures within the 100 year flood zone (1% flood risk).

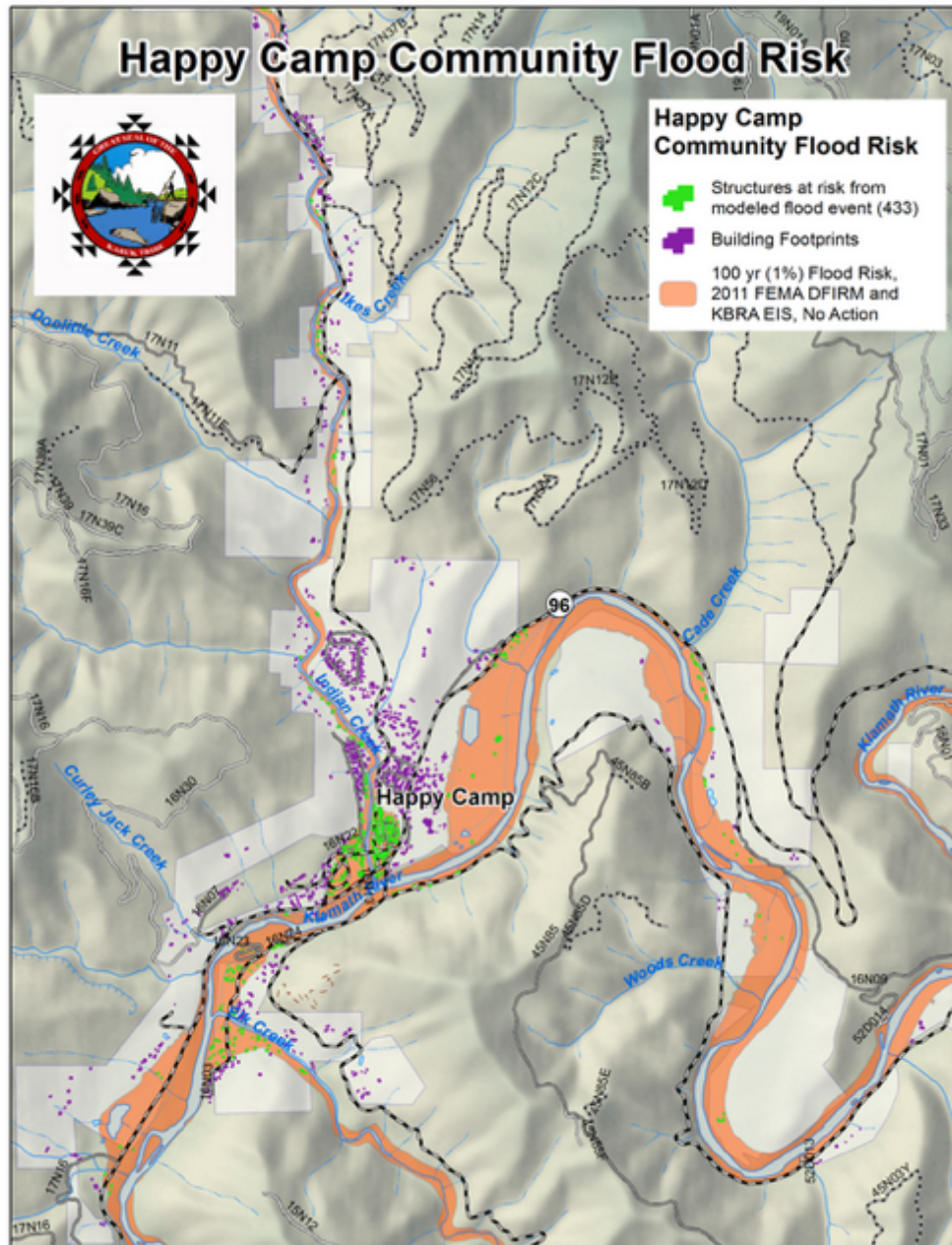


Table 5.11 lays out a preliminary list of potential climate adaptations for emergency preparedness. In addition, the Tribe should continue current efforts including keeping the FEMA Hazard Mitigation Plan updated.

Table 5.11 Climate Adaptations for Emergency Management	
Expand emergency infrastructure	Reestablish a formal Emergency Preparedness Program
	Expand ATV, UTV and jet boat capacities for evacuation for impassible road conditions, Identify and improve helicopter landing zones on remote potentially inaccessible properties.
	Expand radio communications potential in vehicles
	Evacuation centers and support
	Secure additional emergency control centers (e.g. for each community)
Increase Coordination	Develop Emergency and Evacuation plans for each community
	Internal Coordination within tribal programs, e.g. transportation, communication, fire, and especially health
	Coordinate emergency efforts with Law Enforcement in Siskiyou and Humboldt Counties
	Conduct preparedness trainings with law enforcement in both counties
Expand Redundancies and Backup Systems	Strengthen ties with Humboldt County regarding Hazard Mitigation planning, maintain current ties with Siskiyou Co.
	Expand backup generator potential for buildings, tribal housing, all critical infrastructure facilities
	Expand communication backup systems and redundancies
	Medical backup systems in each community and individual households
Strengthen Communication	Expand food and water backup systems in each community and individual household
	Increase external communication potential with radio repeater on Horse Mountain
	Increase internal communication potential with radios in all vehicles, develop radio traffic monitoring, logging and responding protocols
	Work with Forest Service and/or FEMA to get agreement in place to provide cellular and data services in emergency situations
Promote Self Sufficiency	Permanently install COW hookups to fiber line in Orleans
	Traditional foods and subsistence practices
	Gardening and other food provisioning
	Develop solar and micro-hydro electrical power generation, monitor to ensure water utilized generating power is returned to the same stream.
	Use revenue to build Endowment for Ecocultural Revitalization

CHAPTER SIX: Climate Adaptations for Tribal Program Capacity

- *Climate impacts in the form of flooding, power outages, road closures and increasing frequency of storms and high severity fires are already impacting Karuk tribal program capacity by undermining critical infrastructure and increasing workloads.*
- *Many climate adaptations for program capacity require significant resources, yet there are also many smaller actions that can be taken which will significantly alter the future trajectory for Karuk people and focal species.*
- *New mechanisms including expanded 638 compacting authorities relating to food security and forest management can have widespread positive effects for many programs.*
- *Adaptations for Tribal Program Capacity are related to adaptations for critical infrastructure and tribal management authority and sovereignty that are discussed in more detail in Chapters Five and Seven.*

The Karuk Tribe has developed programs, policies and departments to administer services to Karuk people, to carry out tribal jurisdiction as defined in the Karuk Constitution, and to uphold responsibilities to perpetuate our cultural responsibilities and identity. The governmental structure includes nearly twenty departments, programs, and services organized into three service districts. Managing for climate change requires long-term institutional capacity within the Tribe, yet as the Karuk Climate Vulnerability Assessment emphasizes, as increasing fires, flooding and species movements undermine critical infrastructure and increase workloads. Climate impacts in the form of flooding, power outages, road closures and increasing frequency of storms and high severity fires are already impacting Karuk tribal program capacity. The Karuk Tribe is a self-governance Tribe, employing roughly ~231 staff and with an annual operating budget of ~\$37 million. The Karuk Tribe governs tribal trust lands, tribally owned fee parcels and the rights and interests of the tribe and its members/descendants..

Threats to Karuk program capacity resulting from climate change occur in the context of the remote location and specific jurisdictional context of the Tribe as detailed in Chapter Five on climate change and critical infrastructure. The area is remote with a single major highway connecting the 120 miles along the Klamath River. Administrative offices, government operations and the Karuk People's Center are located in Happy Camp, the Department of Natural Resources is located in Orleans and Somes Bar, and the Karuk Judicial System is located in Yreka. Health clinics, education and elders programs, housing authority offices, community

computer centers, tribal court services, and human services/Indian Child Welfare programs are located in each of the three main population centers. The Karuk Climate Vulnerability Assessment detailed general risks to program capacity in light of the changing climate in the form of limited jurisdictional recognition and the challenges of coordinating within multiple federal, state and county jurisdictional overlaps, the constraints of project based funding and specific impacts to program capacity in light of high severity fire events in particular, see Table 6.1 below:

Table 6.1 Climate Impacts to Tribal Program Capacity Identified in Karuk Climate Vulnerability Assessment	
Multiple Jurisdictions and Limited Recognition of Tribal Authorities	Time and energy spent communicating with agencies, responding to actions of other sovereigns
Constraints of Project Based Funding	Inconsistencies in projects, lack of programmatic longevity
	Limited ability of Karuk Tribe to direct proactive culturally appropriate management
	Overall inadequate funding sources
	Inefficiencies and duplication of effort
Impacts to Program Capacities During and After High Severity Fire Events	“Everything stops when there is a fire” added stress and workload in winter/spring leading to burnout
	Emergency management mode
	Infrastructure impacts

The Vulnerability Assessment also discussed specific needs and vulnerabilities of the Transportation Program, Food Security Program, Water Quality Program, Fisheries Program, Watershed Restoration Program, Integrated Wildland Fire Management Program and Health Program. The Karuk Climate Adaptation Plan is organized slightly differently than the Karuk Climate Vulnerability Assessment, containing two additional chapters that focus specifically on tribal program infrastructure – Chapter Four on Human Health, and Chapter Five on Critical Infrastructure. Adaptations for tribal program capacity are related as well to the issue of multiple jurisdictions and limited recognition of tribal authorities that are the subject of Chapter Seven on Karuk Sovereignty and Management Authority. Table 5.8 in Chapter Five outlines how a range of climactic events from increasing frequency of high severity fire, to increasing flooding from

landslides, microbursts translate into a set of circumstances that undermine the capacities of tribal programs. These include transportation disruptions, power and communication outages, and relational feedbacks to mitigation work already performed.

As the climate changes the tasks of responding to and caring for lands, species, waters, etc., becomes increasingly challenging. Beyond impacts related to critical infrastructure, capacity related impacts emerge in effect to the functions and missions of particular programs, especially for those in DNR. This Chapter addresses additional general impacts and adaptations for the DNR the *Watersheds Branch* (Water Quality Program, Fisheries Program and Watershed Restoration Program) and the *Eco-Cultural Revitalization Branch* (Food Security Program and Wildland Fire Program).

Impacts and Adaptations for Food Security Program

The [Karuk DNR Strategic Plan](#) lists the goal of the Food security Program as achieving:

a sustainable food system that results in revitalized traditional ecological knowledge and practices, healthy communities, restored healthy ecosystem, and healthy economy grounded in traditional subsistence . . . Efforts include but are not limited to: measuring and monitoring designated plots in order to document the efficacy of land management techniques on the quantity and quality of food and fiber species; implementing and evaluating events and activities to inform the tribal community on traditional land and resource management, food and fiber harvest, preparation and storage; and improving agro-forestry management to increase supply of traditional foods.

The Karuk Vulnerability Assessment identified general program impacts to the program goal of supporting and enhancing Food Security are presented in Table 6.2 below with potential adaptations:

Table 6.2 Adaptations for Food Security Program Capacity		
Climatic Event	Program Impact	Adaptation
Changing fire behavior, increased frequency of high severity fires, longer fire season, higher elevation fires, etc.	Program staff may be unable to access field sites or offices, creating disruptions to workflow	Advance planning, backup infrastructure for remote work
	Program staff may be pulled from existing program tasks onto emergency projects or fire assignments	Increase staffing, capacity overall and in advance of Increase agency coordination and proactive measures Public education, collaboration and coordination, revitalize fire regimes
	Difficulty in completing tasks due to loss of staff during fire or	Coordinate with other programs to advocate for return to traditional fire regimes,

Changing temperatures, increased heat, changing wind patterns, more variable temperatures	alteration of field sites due to wildfire	working with federal and state agencies to align sport and commercial harvesting activities with traditional management principles and practices, and create tribal laws/ordinances enacting traditional management principles and practices relating to the harvest timing use and trade of traditional food, fiber and medicinal resources, and Identify additional species profiles as outcomes of a changing climate become a reality.
	Difficulty in managing and acquiring, sufficient quantities of particular foods	Coordinate with other programs to advocate for return to traditional fire regimes Increase staffing, agency coordination and proactive measures. Legal measures
Changing precipitation patterns, more flooding, more rain on snow events, decreased summer precipitation	Program staff may need to spend time and energy addressing post fire management actions of other agencies that threaten traditional foods	Increased staffing, proactive planning, invasive species eradication, participate in prescribed/cultural burning activities, increased jurisdictional recognition
	Limited compact funding consumed covering increased operating costs leading to potential loss of key leadership and support staffing.	Outline climate related threats to food security in the interest of utilizing new 638 compacting authority via 2018 Farm Bill
Species invasions, especially sudden oak death	Ecosystem damage may be so extensive that Food Security Division can no longer function	Integrate or separate program functions as necessary

Impacts and Adaptations for Water Quality Program

The Klamath River and its tributaries are essential for the cultural, spiritual, economic and physical health of Karuk people. Water quality is imperative for access to healthy foods, and necessary for multiple economic, social, spiritual and cultural activities to occur. Water quality TMDL standards are set in the context of Karuk subsistence and cultural uses. Water quality impacts matter for their impact on species of concern, and on human health from drinking as well as the human health consequences of consuming contaminated traditional foods.

The [Karuk DNR Strategic Plan](#) notes:

The Water Quality Program conducts monitoring and research along 130-miles of the Klamath River and tributaries. This includes data collection on temperature, dissolved oxygen, sediment, nutrients, phytoplankton, toxins, etc. This data informs state and federal processes and policies. Additionally, the Water Quality management level staff represent the concerns of the Karuk Tribe on Klamath Basin watershed management activities and promote sound water management practices that improve and restore water quality conditions. This program includes a Water Quality Coordinator, Program Project Coordinator and Technicians as

needed. . . the Program also conducts cross-programmatic work that has a direct effect on improving water quality and quantity.

The Karuk Vulnerability Assessment identified general program impacts to the program goal of promoting sound water management practices that improve and restore water quality conditions. These impacts are presented in Table 6.3 below with potential adaptations:

Table 6.3 Adaptations for Water Quality Program Capacity		
Climatic Event	Program Impact	Adaptation
Changing fire behavior, increased frequency of high severity fires, longer fire season, higher elevation fires, etc.	Program staff may be unable to access field sites or offices, creating disruptions to workflow, especially as water samples must be collected at very specific times of day and water samples must be sent via UPS in a timely manner	Advance planning, backup infrastructure for remote work as feasible, development of alternate transportation routes where feasible
	Actions of agencies during fires or other crisis events such as flooding impact species of concern	Public education, collaboration and coordination, revitalize fire regimes
Changing temperatures, increased heat, changing wind patterns, more variable temperatures	Fatigue and respiratory problems from working long hours in smoke during fires	Coordinate with health program to develop proactive measures
	Program staff may need to spend time and energy addressing post fire flooding/ fire management actions of other agencies e.g. impacts to water quality from sedimentation, post fire logging	Increase staffing, agency coordination and proactive measures. Legal measures
Changing precipitation patterns, more flooding, more rain on snow events, decreased summer precipitation	As climatic events impact watershed health more research and water quality monitoring projects become necessary	Coordinate with other programs to advocate for return to traditional fire regimes Increase staffing, agency coordination and proactive measures. Legal measures, collaboration with Universities and other research partners

Impacts and Adaptations for Fisheries Program

Fisheries are vital for the food, health, culture and well-being of Karuk people. Salmon are a staple in Karuk diet. The Karuk as the first peoples of the Klamath Mountains have been the managers of salmon since time immemorial. Our ceremonial practices and principles not only revolve around the life cycles of salmon and steelhead, they historically dictate the harvest seasons for all uses of salmon in the watershed. Contemporary harvest management regulations do not recognize this fact, and in many cases operate in under opposing principles and we have

experienced significant decline in species abundance as a result. The [Karuk DNR Strategic Plan](#) lists the goal of this program as:

...garnering a greater understanding of ecological processes that support fisheries through research and monitoring, as well as enhancing fisheries habitat through restoration activities. Research and monitoring informs practices such as river flow and harvest management.

The Karuk Vulnerability Assessment identified general program impacts to the program goal of garnering a greater understanding of ecological processes that support fisheries through research and monitoring, as well as enhancing fisheries habitat through restoration activities promoting sound water management practices that improve and restore water quality conditions. These impacts are presented in Table 6.4 below with potential adaptations:

Table 6.4 Adaptations for Fisheries Program Capacity		
Climatic Event	Program Impact	Adaptation
Changing fire behavior, increased frequency of high severity fires, longer fire season, higher elevation fires, etc. Changing temperatures, increased heat, changing wind patterns, more variable temperatures Changing precipitation patterns, more flooding, more rain on snow events, decreased summer precipitation	Program staff may be unable to access field sites or offices, creating disruptions to workflow	Advance planning, backup infrastructure for remote work as feasible, development of alternate transportation routes where feasible
	Actions of agencies during fires or other crisis events such as flooding impact species of concern	Coordinate with other programs to advocate for and support the return to traditional fire regimes. Public education, collaboration and coordination,
	Fatigue and respiratory problems from working long hours in smoke during large high severity fires	Coordinate with health program to develop proactive measures. Monitor for indicators of impending fish die off events. Coordinate notifications and follow up monitoring efforts with integrated wildland fire and fuels program, water quality program and food security program staffs
	Program staff may need to spend time and energy addressing post fire flooding/ fire management actions of other agencies e.g. impacts to water quality from sedimentation, post fire logging	Increase staffing, agency coordination and proactive measures. Legal measures
	As climatic events impact watershed health more research and water quality monitoring projects become necessary	Coordinate with other programs to advocate for return to traditional fire regimes Increase staffing, agency coordination and proactive measures. Legal measures,

		collaboration with Universities/ research partners
	Fisheries staff suffer from reduced availability of leadership that are consumed by fire response activities.	

Impacts and Adaptations for Watershed Restoration Program

Karuk ancestral territory contains hundreds of miles of unmaintained and poorly maintained logging roads that pose a threat to watershed processes, water quality, and aquatic habitats via sedimentation. The [Karuk DNR Strategic Plan](#) describes the purpose of the Watershed Restoration Division as “to protect the habitat of anadromous fish by decreasing the sedimentation caused by the road networks within watersheds of critical concern.” The Karuk Vulnerability Assessment identified general program impacts to the Watershed Restoration Program goal of providing safe and reliable transportation facilities as summarized in Table 6.5 below with potential adaptations:

Table 6.5 Adaptations for Integrated Watershed Restoration Program Capacity		
Climatic Event	Program Impact	Adaptation
Changing fire behavior, increased frequency of high severity fires, longer fire season, higher elevation fires, etc.	Program staff may be unable to access field sites or offices, creating disruptions to workflow	Advance planning, backup infrastructure for remote work
	Actions of agencies during fires or other crisis events such as flooding impact species of concern	Public education, collaboration and coordination, revitalize fire regimes
	Program staff may be pulled from existing program tasks onto emergency projects	Increase staffing, capacity overall and in advance of Increase agency coordination and proactive measures
Changing temperatures, increased heat, changing wind patterns, more variable temperatures	Program staff may need to spend time and energy addressing post fire flooding/ fire management actions of other agencies e.g. impacts to transportation e.g. sedimentation or other from fires, post fire logging, etc.	Increase staffing, agency coordination and proactive measures. Legal measures. Build out functional roles of Watersheds Branch as outlined in Strategic Plan. Establish responsible focus areas geared toward adequate coverage of proactive and reactive roles
Changing precipitation patterns, more flooding, more rain on snow events, decreased summer precipitation	Post fire transportation facility maintenance tasks become impediments to implementing	Increased staffing, proactive planning, increased jurisdictional recognition

	regular construction and maintenance schedules.	
	As climatic events impact watershed health more projects become necessary	Coordinate with other programs to advocate for return to traditional fire regimes Increase staffing, agency coordination and proactive measures. Legal measures

Integrated Wildland Fire Management Program

The [Karuk DNR Strategic Plan](#) describes:

The Wildland Fire Program is principally concerned with protecting life, property, and cultural/natural resources from uncharacteristically intense wildland fires. It is the Tribe's intention to achieve this by restoring traditional fire regimes on a landscape scale within Karuk ancestral homelands and implementing restorative forestry practices. An important element of this work is ensuring a well-trained, highly professional local fire and fuels management workforce. It also includes having a collaborative interagency body that can coordinate, communicate, and agree on management methods during wildland fire events, as well as preventive measures including the reintroduction of prescribed and cultural burning throughout Karuk ancestral homelands. This is a large part of the eco-cultural revitalization approach being instituted by DNR, as described in the [ECRMP](#). Currently, this program staffs an Assistant Fire Management Officer/Fuels Planner and Fire and Fuels Operations Specialist, in addition to necessary Squad Bosses, Crew Bosses, and Crew Members, based on seasonal need as funding allows.

Forestlands within Karuk ancestral territory have been severely impacted by extractive timber production, single species management, road building, massive fuel loading, and fire suppression. One dimension of the Integrated Wildland Fire Management Program is to restore natural forest processes and historic forest composition that promote biological diversity and multi-aged ecosystems, with standing dead trees, downed trees, and logs present in riparian zones and streams. These actions can be achieved through management activities such as timber harvest and stand improvements (i.e. thinning), silvicultural treatments, riparian restoration, and prescribed and cultural burning and managed wildfire. The program does not currently have necessary the leadership or capacity to implement the restoration forestry goals relating to the wildland management and restoration forestry, thus more work day to day is carried out with regards to fuels reductions.

The Integrated Wildland Fire Management Program capacity is significantly affected during, immediately after and in the longer-term aftermath of high severity fires. Indeed, the capacity of this program is likely the most affected of any DNR program, see Table 6.6 below.

Table 6.6 Adaptations for Integrated Wildland Fire Management Program Capacity		
Climatic Event	Program Impact	Adaptation
Changing fire behavior, increased frequency of high severity fires, longer fire season, higher elevation fires, etc.	Vehicles/equipment not fully reimbursed	Influence budget models Develop other funding sources
	Increasing fire severity drives suppression-oriented decisions, perpetuating high severity fires	Public education, collaboration and coordination, revitalize fire regimes
	Program staff may be pulled from existing program tasks onto the fire or emergency relief detail	Increase staffing, capacity overall and in advance of Increase agency coordination and proactive measures
Changing temperatures, increased heat, changing wind patterns, more variable temperatures	Program staff may need to spend time and energy addressing post fire flooding/ fire management actions of other agencies that impact watersheds: sedimentation, logging, road building	Increase staffing, agency coordination and proactive measures. Legal
Changing precipitation patterns, more flooding, more rain on snow events, decreased summer precipitation	Staff continuously pulled onto fires, unable to develop capacity and training for proactive projects relating to Wildland Management portion of program.	Increased staffing, proactive planning, increased jurisdictional recognition
	Weakened program capacity slows goal of returning traditional fire management regimes that are needed more than ever in light of climate change and increased frequency of high severity fires.	Increased staffing, proactive planning, increased jurisdictional recognition
Species invasions, changing species ranges	PTSD, fatigue, physical, mental and emotional distress may cause overload and staff turnover	Increased time off, especially before and after fire season more explicit recognition of mental health impacts, specialist support

CHAPTER SEVEN:

Adaptations for Karuk Tribal Sovereignty and Management Authority

- *Potential impacts to and opportunities for Karuk Sovereignty and Management Authority in the face of climate change arise from changing ecological conditions, rapidly shifting policy terrain, agency emergency management mode, and the actions taken by other agencies in responding to climate change. Key adaptations for expanding Karuk sovereignty and management authority include:*
- *Revitalize use of Karuk cultural indicators for land management*
- *Sustain ongoing traditional ecological knowledge production and culture through enhancing presence of Karuk people on the land: e.g. support Karuk cultural practitioners, youth mentoring and youth-elder relationships.*
- *Utilize new and existing Tribal authorities including those from the 2018 Indian Energy Act and the 2018 Farm Bill.*
- *Evaluate potential designation of Karuk Aboriginal Territory, WKRP Planning area, and/or Karuk, Yurok, Hoopa Indigenous Peoples Burning Network as an Indigenous Cultural Landscape*
- *Expand capacities of DNR staff to respond to emergent issues through development of additional funding mechanisms.*
- *Evaluate potential development of Air Quality and Climate Adaptation Programs.*
- *Increase outreach and coordination with agency partners*
- *Expand public education and outreach*
- *Continue coordination with University and agency research partners for tribally designed climate specific research and monitoring.*

As a sovereign government, the Karuk Tribe claims jurisdiction over membership, lands and territory including the right to manage air, lands, waters and other resources as specified in the Karuk Constitution. This jurisdiction is recognized in Article II, Sections 4 and 5 of the Karuk Constitution which states: “The laws of the Karuk Tribe shall extend to:

4. All activities throughout and within Karuk Tribal Lands, or outside of Karuk Tribal Lands if the activities have caused an adverse impact to the political integrity, economic security, resources or health and welfare of the Tribe and its members; and

5. All lands, waters, natural resources, cultural resources, air space, minerals, fish, forests and other flora, wildlife, and other resources, and any interest therein, now or in the future, throughout and within the Tribe's territory."

Ongoing actions of tending, harvesting, processing, storing and consuming traditional food confirm Karuk occupancy on the land. The Karuk Tribe is a self-governance Tribe, employing roughly ~231 staff and with an annual operating budget of ~\$37 million. The Karuk Tribe operates within a complicated cross-jurisdictional terrain in which Karuk management authority is often unacknowledged and misunderstood, contested and/or ignored by a complex slew of agencies including the EPA, USFWS, BIA, NRCS, USFS, California Department of Forestry and Fire Protection (CALFIRE), the State Water Board, and California Department of Fish and Wildlife. The Karuk Climate Vulnerability Assessment identified major dimensions of tribal vulnerability related to jurisdictional recognition and its results for tribal management authority and sovereignty. As cross-species relationships are disrupted by the actions of non-Native land management agencies, so too there is the potential that Karuk political powers and cultural capacities become diminished. In particular, Karuk Aboriginal Territory is located within the National Forest System. The Karuk Tribe has never relinquished custody of these lands; yet a lack of recognized ownership or jurisdiction limits of the Tribe's ability to care for traditional foods and cultural use species, as well as establish and maintain effective tribal programs. Threats to Karuk sovereignty and management authority in the face of climate change arise from changing ecological conditions, the new rapidly shifting policy terrain, agency emergency management mode, and the actions taken by other agencies in the face of climate change.

Recognizing that climate change is simultaneously an atmospheric, ecological and political occurrence, this chapter outlines four overall challenges to Karuk tribal sovereignty and management authority in the face of the changing climate: ecological changes that complicate the utilization of Karuk knowledge, rapidly shifting policy terrain, imposition of emergency management mode, and the actions taken by other agencies in the face of climate change. While each are serious threats, they are and climate change is most productively viewed as an opportunity to assert and expand Karuk traditional practices, management authority, sovereignty and culture. The next section discusses each of these along with key potential adaptations, including the revitalization of cultural indicators for fire applications, utilizing and developing expanded Federal compacting authorities, increasing outreach and coordination with agency partners, expanding public education, continuing coordination with University partners for research and monitoring, and possible development of Air Quality and Climate Adaptation Programs.

Changing Ecological Conditions

Changing ecological conditions including patterns of temperature and precipitation hold the potential to complicate application of Karuk fire practices, in some cases via lack of public perception of their potential utility. Species movement and disappearance have implications for cultural survival and tribal sovereignty, and long-term planning in response to high severity fire may continue to limit Karuk traditional management. Given that Karuk sovereignty management authority are tied to traditional ecological knowledge as a living practice, the radical alteration of the land has potentially dire political consequences. Changing fire behavior, changing seasonality of cultural indicators, new policy regulations, intensification of public fear of fire may each further constrain the feasibility of applying fire in the desired place and time. Expanding the use of cultural indicators, as discussed in connection with initial 21 species potentially serving as cultural indicators for climate adaptation in Chapter Three will be a critical step in revitalizing longstanding traditional practices of Karuk “adaptive management” in the face of the changing climate. The cultural indicator portion of this plan is directed towards this issue specifically. At the same time, maintaining collaboration and coordination with partner agencies will maximize Karuk input into developing policies that might potentially conflict with Karuk management (e.g. air quality regulations, other climate planning efforts). Expanding tribally led research and monitoring will be essential and utilizing relationships with Universities and research partners may be valuable ways to increase capacity. Lastly, public education regarding the ongoing relevance of Karuk traditional knowledge and fire practices as temperature, precipitation and fire behavior changes will be essential to influence the background conditions within which policies will emerge. This will be especially true given the fear surrounding wildfire and public aversion to smoke.

At the heart of the question of changing ecology are issues of time scale. The Klamath system has always been dynamic, but now the ecological shifts caused by climate driven fire effects are outpacing local planning efforts such as those under the WKRP. For example, a large portion of the WKRP landscape has burned since the planning effort began. As new and acute ecological circumstances emerge in the form of extreme river temperatures, fire and flood events or pathogen outbreaks, tribal authority for the rapid and utilization of a wide range of immediate actions is increasingly imperative. Authorities in relation so fire management, smoke regulation and more are essential now.

Traditional Ecological Knowledge as Living Practice in a Climate Changing World

“We cannot predict the future but we can analyze trends. We need to get out there, take actions and observe. We need to get people back onto the landscape and learn what is going on. In looking at this trajectory, TEK indicates we could

find ourselves in an opposite situation. Even if we move into climate and weather conditions such as cooling that are very different from those we currently anticipate, we still need to be able to build relationships based on Karuk knowledge and fire practice. Re-learning from our ceremonies and revitalizing Karuk practices and belief systems should lead us to solutions regardless of the particular way the climate is going. People need to be noticing these things for themselves, this is how we teach and learn in Karuk culture. It is based on observation and practice.”

- William Tripp

Expanding landscape restoration efforts and expanding the use of cultural burning/prescribed fire and managed wildfire to restore and maintain appropriate fire frequencies all requires the Karuk cultural practices of engagement with the land. A key adaptation in the face of changing ecological conditions will be strengthening and supporting cultural practitioners, the mentoring of youth and relationships between youth and elders. [Phase III Western Regional Science-Based Risk Analysis Report](#) developed as part of the National Wildland Fire Cohesive Management Strategy affirms that in the face of continued fire exclusion, Native American cultural identity and traditional ecological knowledge are both at risk (USDA 2012, p. 30). In 1995, fire management comprised approximately 16% of the USFS budget; In 2015, that percentage had reached an unprecedented 50% of the agency's budget (USDA 2015). With these dramatic increases in Forest Service activity and budget directed towards fire suppression¹³, the [Cohesive Strategy](#) has focused on how the prohibition of cultural burning constitutes both an ecological problem and spiritual violation. While people are needed on the land to observe and understand, expanding the application of Karuk traditional knowledge in the face of climate change, requires the ability to assert management authority and tribal sovereignty. In the mid-Klamath region specifically, many goals in the Forest Service’s own management plan can be best achieved through restoring Karuk tribal management.

“As political sovereigns, Tribes are able to practice stewardship and apply traditions, practices, and accumulated wisdom to care for their resources, exercise co-management authorities within their traditional territories, and strongly influence and persuade other political sovereigns to protect natural resources under the public trust doctrine. As signatories to treaties, some Tribes are able to call upon the obligations of the United States to protect their reserved rights to fish, hunt, trap, and gather on FS lands. Tribes that do not have ratified treaties still retain reserved rights. Both treaty and non-treaty Tribes seek to manage off-reservation lands.”

-- Intertribal Timber Council, 2013, p.15

¹³ See the USDA's 2015 Report "[The Rising Cost of Wildfire Operations: Effect on the Forest Service's Non-Fire Work](http://www.fs.fed.us/sites/default/files/2015-Fire-Budget-Report.pdf)," available at <http://www.fs.fed.us/sites/default/files/2015-Fire-Budget-Report.pdf> for details.

This need for a new and active landscape management strategy has specifically been initiated in the context of both wildfires and climate change. As indicated by the Intertribal Timber Council (2013), “Tribal, FS, BIA land managers recognize the importance of active landscape management to reduce the need for and cost of fire suppression. Treating the cause of the problem (overstocking, excessive fuel buildup, etc.) instead of the symptoms (through suppression) leads to more efficient and effective resource management. Implementing these treatments requires a wide range of actions, including timber harvest, biomass utilization, thinning, fuel treatments, and judicious use of prescribed and natural fire” (p. 7).

Changing Policy Terrain – Utilize New and Existing Management Authorities

Expanding the application of Karuk traditional knowledge in the face of climate change, requires the ability to assert management authority and tribal sovereignty. Climate change is rapidly reshaping the legal landscape as changing ecological conditions and political dynamics are generating numerous planning efforts, judicial rulings, policies, and collaborative configurations of state and federal actors (Bronen 2011, Burkett 2011, Kronk Warner 2015, Mawdsley et al. 2009, Ruhl 2009). These collaborations and measures are necessary responses in the face of circumstances that clearly exceed prior jurisdictional boundaries. Yet, since there are still very few comprehensive federal laws applying either to the adaptation to or mitigation for climate change, regional, state, and local efforts have emerged ad hoc. In the absence of an overarching legal framework at the federal level, tribes face potential loss of acknowledgement of their jurisdiction if they are excluded from or cannot keep up with the multiple and rapidly changing dynamics between federal and local actors. Awareness and emphasis on federal tribal trust responsibilities – frequently overlooked in the best of times – are further lost in the midst of this new rapidly shifting policy terrain where the sense of crisis may be further impetus for their negotiation.

Despite these risks, the changing policy terrain clearly provides new and emergent opportunities for the expansion of Karuk management. Several current examples include the Forest Plan revision process for Six Rivers and Klamath National Forests, specific provisions in the Indian Energy Act of 2018, and the recent expansion of 638 authority for Tribal Forest Protection Act management activities (USDA) and the U.S. Department of the Interior through the 2018 Farm Bill.

First, the increased instances of high severity fire will shape the long-term forest planning process. Of immediate importance in this regard is the role that climate change in general and increasing high severity fires in particular will play in shaping the Forest Plan revisions process for both Six Rivers and Klamath National Forests. Now that there is collaboration on the Six Rivers National Forest, their Forest Plan may be revised. This Climate Adaptation Plan needs to be integrated into the new Forest Plan revisions. The

Federal Lands Policy and Management Act of 1976 (FLMPA) states in Sec. 202. [43 U.S.C. 1712] (b); “In the development and revision of land use plans, the Secretary of Agriculture shall coordinate land use plans for lands in the National Forest System with the land use planning and management programs of and for Indian tribes by, among other things, considering the policies of approved tribal land resource management programs.”

Furthermore, the 2018 Indian Energy Act affirms the incorporation of tribally approved management plans into USDA Forest Management Plans. Title II, Section g “Incorporation of Management Plans” on p. 16 of the final Act amended the Federal Power Act such that “In carrying out a contract or agreement under this section, on receipt of a request from an Indian tribe, the Secretary shall incorporate into the contract or agreement, to the maximum extent practicable, management plans (including forest management and integrated resource management plans) in effect on the Indian forest land or rangeland of the respective Indian tribe.”

Secondly, recent expansion of 638 authority for Tribal Forest Protection Act management activities (USDA) and the U.S. Department of the Interior through the 2018 Farm Bill allows tribal nations to exercise Good Neighbor authority for forest management agreements with USDA and states, and recent expansion of Indian Self-Determination and Education Assistance Act 638 contracting authority to the U.S. Department of Agriculture (USDA) for the Food Distribution Program on Indian Reservations. Good Neighbor Authority is a tool stemming from the 2014 Farm Bill that forms a mechanism for cooperative forest management. Essentially, Good Neighbor Authority is a mechanism that enables the Karuk Tribe to collaborate with the USFS (and others) to engage in watershed and forest restoration work across jurisdictions. These two mechanisms can increase funding flow and make way for programmatic NEPA to direct landscape level restoration efforts. Additionally, the 2018 Omnibus Act extended the lifespan of stewardship contracts and agreements to 20-year terms.

However, while promising, even these approaches may provide insufficient responses considering the timeframe of climate change. Alteration of environment policies and tribal exemptions in relation to the application of cultural fire and smoke effects are likely be necessary in light of the rate of ecological shifts now occurring. Existing authorities outlined in the ECRMP including Tribal Clean Air Act Authority may be warranted and should be seriously evaluated. Strategic revisiting should be conducted regarding the range of potential tribal authorities to be utilized. Programs on Air Quality and Climate Change may be warranted as well. For any of this to occur flexible funding mechanisms will be critical for the ability of DNR staff to commit on the ground time as cultural practitioners, engage in strategic policy discussions, develop relationships and respond to priority actions. There is therefore an urgent need for DNR to develop and maintain a flexible pool of funding to support the work of tribal leadership in policy.

Emergency Management Mode

Fear of fire coupled with public ignorance regarding tribal presence, the sophistication of tribal fire knowledge, and tribal trust responsibilities supports a crisis mentality in which emergency actions are taken without considering the long-term implications these actions may have for the Tribe or the ecosystem. The command and control organization of the Forest Service fire response, together with frequent personnel turnover, also limits the ability of Karuk tribal staff to communicate and influence management decisions. Awareness and emphasis on federal tribal trust responsibilities – frequently overlooked in the best of times – can be further lost in the midst of this new rapidly shifting policy terrain where the sense of crisis may be further impetus for their negation. The [Tribal Climate Change Principles](#) reports:

“Over the last several years, more than fifteen climate change committees and working groups have been formed within and among federal agencies. Many of these did not or do not include Tribal representation. Simultaneously, many of the committees that did or do include Tribal representatives only had or have nominal representation” (Gruenig et al. 2015, p. 5).

The continued crisis orientation to fire may shape management decisions, precipitate exemptions in existing regulations on logging and other post fire management activities, and inhibit the ability of the Tribe to conduct cultural burning. Diversion of staff resources and time in the face of these conflicts leaves fewer resources for advancing the positive, proactive directions that are especially needed in light of climate change. Furthermore, as more funding is earmarked for fire suppression, less is available for proactive fire management. Collaboration and coordination with agencies will be even more essential in the times to come, and when these fail legal actions may become important. Additional adaptations to proactively engage this issue include the potential expansion of program capacities in key areas and the possible revitalization of Air Quality Program management and integration of new Climate Adaptation Program functions.

Adaptations for Actions of Other Agencies as Climate Changes

As outlined in the Karuk Climate Vulnerability Assessment many of the actions taken by non-Tribal managers in relation to climate stressors create as much negative impact as climate change itself. Fire suppression activities in particular damage resources, interfere with the ability of members of the Karuk Tribe to perform cultural practices, pulling staff from other responsibilities. Even long after fires have occurred the impacts of these actions, plus additional ones such as salvage logging pose challenges to Karuk sovereignty and management authority. With this adaptation plan in place it asserts tribal management

authority for incorporated in the forest plan revision process. Additional proactive tribal involvement in statewide and national developments regarding wildfire and other climate policies, as well as in collaboration with federal, tribal, state, NGO and local agencies and individuals are all positive adaptations in the face of the potentially harmful actions of others. Continued research attention regarding tribal perspectives and needs, as well as attention to the disproportionate and environmental justice implications regarding the actions of other agencies can be supported via relationships with University partners in legal, policy fields as well as social sciences. Maintaining the Department's Strategic Plan for Organizational and Capacity Development on a 5 year review cycle is a critical step in recognizing adaptations and prioritizing changes in strategic direction. Even with this important document in place, there may be actions by other agencies that require attention. Planning for the unexpected can be difficult, especially in an organization that is primarily grant funded. Building out flexible funding mechanisms will be critical in being able to make adjustments to priority actions in real time. As of spring 2019, only one half of a full time equivalent in flexible funding is available for addressing these things as they arise. With a recent increase in utilizing these funds as match to grants, this time becomes dedicated to task-oriented deliverables. The result is an increasing limit on the amount of funds available to work with collaborative groups addressing bigger picture issues. A flexible pool of funding that is not tied directly to a task, deliverable, or position will become more critical as we continue to grow out our tribal/state relationships. Investing time in building out the Endowment for Eco-cultural Revitalization may be a good way to build the sort of sustainable revenue stream required to address these concerns.

While the changing climate poses serious threats for Karuk culture, sovereignty and all life on earth, it is perhaps most productively viewed as an opportunity to assert and expand Karuk traditional practices, tribal management authority, sovereignty and culture. This chapter has discussed potential adaptations actions to enhance Tribal sovereignty and management authority in light of the changing ecological and policy terrain, including the revitalization of cultural indicators for fire applications, utilizing new tribal authorities including expanded Federal compacting authorities, increasing outreach and coordination with agency partners, expanding public education, continuing coordination with University partners for research and monitoring, development of more flexible funding mechanisms for DNR programs and staff and the possible development of Air Quality and Climate Adaptation Programs.

Table 7.1 below summarizes adaptations for each challenge detailed in this chapter

Table 7.1 Adaptations for Impacts to Karuk Sovereignty and Management Authority		
Changing Ecological Conditions	Changing fire behavior, changing seasonality of cultural indicators	Continue longstanding traditional practice of adaptive management, support cultural practitioners, youth mentoring and youth-elder interactions
	Changing patterns of temperature and precipitation complicate application of Karuk fire practices (or public perception of their potential)	Expand use of cultural indicators
		Development of tribal authorities to enable rapid response in acute scenarios (e.g. lethal stream temperatures, fire events, pathogen outbreaks, etc).
		Maintain collaboration/coordination with partner agencies
		Expand tribally driven research and monitoring, expand relationships with Universities/research partners Public education regarding ongoing relevance of Karuk TEK
Emergency Management Mode	Lack of awareness and emphasis on federal tribal trust responsibilities	Consider expanding program capacities in key areas
		Collaboration and coordination with agencies
	Accelerated protocols reduce possibilities for Karuk input management authority and sovereignty	Consider developing Air Quality Program, Climate Adaptation Program
		Legal and legislative actions
Rapidly shifting policy terrain	Emergent opportunities, expansion of tribal authorities	Be prepared for emerging opportunities by participation in policy formation, communication and collaboration with federal and state partners
	Regulations and planning efforts developed in light of climate change may fail to uphold federal tribal trust responsibilities and/or adequately engage the Karuk Tribe (e.g. EPA ozone rule, USFS climate planning)	Strategic assessment of available tribal authorities, expanded utilization of authorities
		Advocate for policy change especially regarding fire liability and usage, and air quality
		Consider development of new Air Quality Program or Program on Climate Adaptation
		Proactive public education campaigns, e.g. blogs, videos, conference presentations to promote benefits and importance of tribal traditional ecological management in light of climate change Prepare policy statements in advance
		Continue research attention in this area, outreach to University partners in legal, policy fields as well as social sciences
Actions taken by other agencies as climate changes	E.g. fire suppression activities damaging resources, interfere with the ability of members of the Karuk Tribe to perform cultural practices, pulling staff from other responsibilities	Reference Karuk Tribe climate adaptation plan in place e.g. Forest Plan Revision Process
		Involvement in statewide and national policy development, e.g. Forest Plan Revision Process
		Collaboration and coordination with Federal and State agency partners
		Community outreach and public education including collaboration and coordination with watershed councils, local community
		Continue research, outreach to University partners in legal, policy, social sciences and legislative process

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