IMPACTS OF CLIMATE CHANGE ON THE KARUK TRIBE

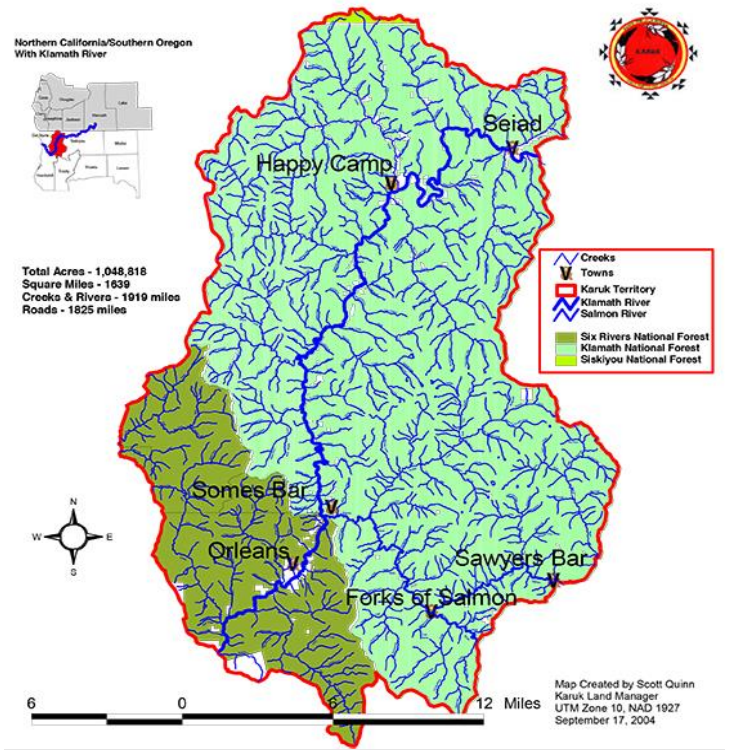
Self-described as "fix the world people," the Karuk Tribe has relied on fire and ceremony to manage their lands since time immemorial. The threats of climate change, acting alongside non-climate factors, are an opportunity for the Tribe to return to traditional management, which includes the use of 22 key cultural indicator species to gauge ecosystem health and to guide appropriate action.

Background

The Karuk Tribe is a federally recognized Tribe comprised of Karuk araráhih (upriver people) located along the Klamath River in the northwestern corner of the state, in Humboldt and Siskiyou Counties. The Karuk Tribe is one of the largest tribes in California with 3,744 members and 5,271 descendants (Karuk Tribe Enrollment Department).

Since time immemorial, the Karuk have lived in the Klamath-Siskiyou Mountains in the mid-Klamath River region of northern California (Figure 1). With an Aboriginal Territory that includes over a million acres, the ancestral Karuk people 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.

Figure 1. Map of Karuk Aboriginal Territory



Source: Karuk Tribe
Climate Vulnerability Assessment, 2016

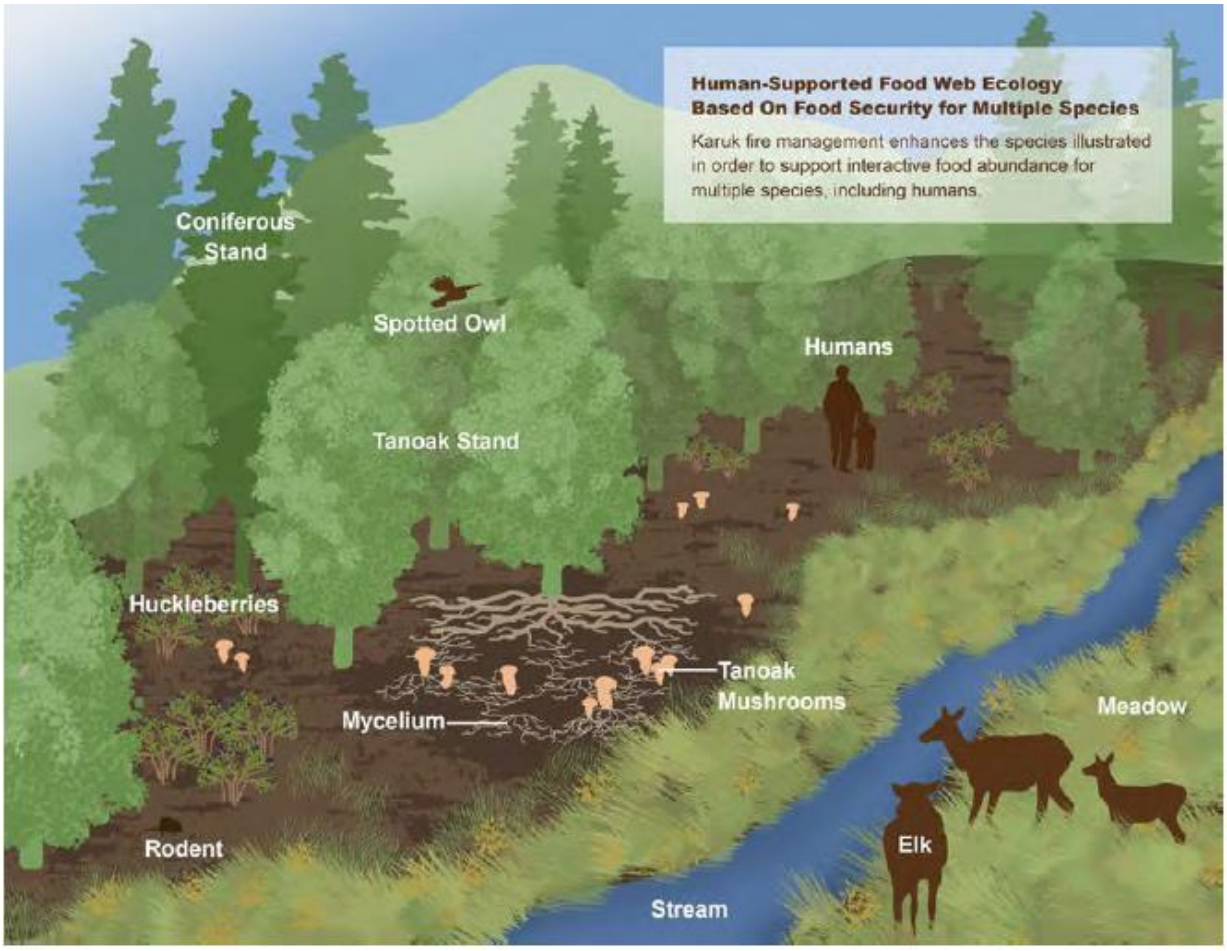
The Karuk People have historically been wealthy from tending of the land. Traditional ecological knowledge provides the Karuk with foods—including acorns, salmon and deer—and fibers such as hazel, willow, and bear grass which they use as materials for their well-known basket-weaving skills. Medicinal plants were also abundant. This rich and diverse cultural landscape was made possible through the use of fire and ceremony.

The mid-Klamath ecosystem has co-evolved with the Karuk people and culture over millennia. Multiple species of importance to the Karuk people play vital roles as cultural indicators for appropriate human actions within the Tribe's system of traditional management. For countless generations, Karuk people have observed the behavior of particular plants and animals to understand ecological dynamics, and have used this 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.

Karuk culture is directly reliant on fire as a tool to manage the environment for cultural sustenance and well-being. 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 is necessary for the maintenance of cultural resources. Fire is especially critical for restoring grasslands for elk, managing food sources including tanoak and black oak acorns, maintaining quality basketry materials, producing smoke that shades the river for fish, and more. 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 the frequent occurrence of relatively low intensity fire from human and natural ignitions for more than the past 1,000 years. Karuk's use of fire has been central to the evolution of the flora and fauna of the mid-Klamath (see Figure 2).

Gold mining started on the Klamath and Salmon Rivers around 1850, ushering in Settler Colonialism for the region and its devastating effects to the people and land. The Karuk People have always resisted Settler Colonialism, whether through armed rebellion as with the 1855 Red Cap War, legal action and protests such as the G-O Road Struggle and the Un-Dam the Klamath Campaign. The longstanding human-ecological relationships and practices have been interrupted by European settlement and its consequences: attempted genocide, displacement, resource extraction and 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, collective memory and the land itself.

Figure 2. Karuk Cultural Burning Produces Species Abundance



Source: Karuk Climate Adaptation Plan, 2019
(Credit: Figure courtesy of Kirsten Vinyeta)

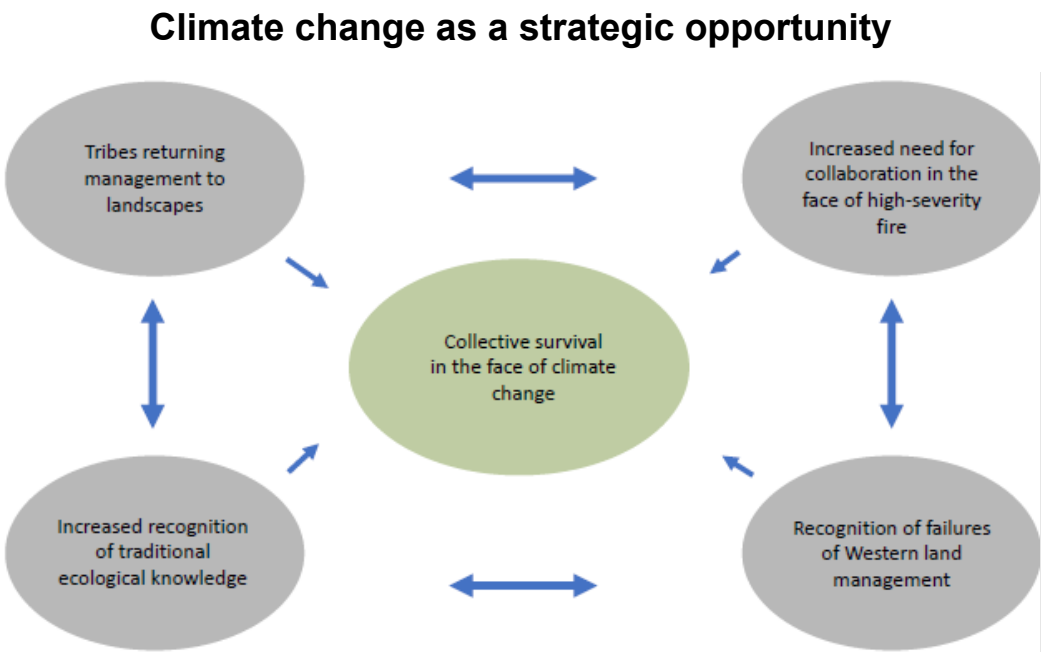
Karuk Tribe and Climate Change

Within Karuk aboriginal territory, the effects of climate change are immediate and occurring now. Climate change poses a threat not only to the Klamath ecosystem, but also to Karuk culture, which is intimately intertwined with the presence, use and management of cultural use species. The Karuk are fortunate to retain relationships with hundreds of species they consider their relations: foods, medicines and fibers that are embedded within cultural, social, spiritual, economic and political systems, and daily life. Impacts to such culturally significant species in the face of climate change thus have more direct impacts on the Karuk people than on communities that do not have such intimate connections in the natural world. Part of the increased vulnerabilities Karuk people face as the climate changes are a direct result of the strength of these connections. For example, the loss of acorn groves that have been family gathering sites for generations is much more than an economic impact. In addition, the social justice challenges that have impacted the Tribe since European influx are ubiquitous today in the form of low economic opportunity and restricted access to traditional

cultural resources, employment, schools, food sources, medical facilities, and emergency evacuation routes in this remote area.

Climate change is viewed by the Karuk as 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. The impacts of the changing climate interact with existing ecological stressors such as water diversions and fire suppression.

Figure 3. Diagram illustrating how Tribes can lead efforts toward collectively addressing climate change



Source: Karuk Climate Adaptation Plan, 2019
(Credit: Sara Worl)

Nevertheless, the crisis posed by climate change presents a strategic opportunity for tribes to retain cultural practices and return traditional management practices to the landscape, and for all land managers to remedy inappropriate ecological actions. There is increasing recognition of the importance of indigenous burning as an ecosystem component and restoration technique. Traditional ecological knowledge, the need for collaboration in addressing high severity wildfire, and a recognition of the failures of Western land management, have combined to create an exciting political moment in which tribes are uniquely positioned to lead the way toward collective survival in the face of climate change (see Figure 3). 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.

The Karuk people have long been part of the ecosystem. Adapting to climate change is about restoring human responsibilities and appropriate relationships with species and ecosystem processes. Karuk tribal knowledge regarding the use of fire can be utilized to manage cultural resources, promote biodiversity, and mitigate catastrophic wildfires, thereby protecting public as well as tribal trust resources. 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 carbon emissions, and a reduction in high severity fires could result in a reduction in forest emissions.

The Tribe's adaptation approach to climate change centers around the revitalization of Karuk cultural management, the restoration of traditional fire regimes, the reduction of 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. Utilizing Karuk Traditional Ecological Knowledge alongside western science, climate adaptation will center on the revitalization of 22 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 Change and Its Impacts

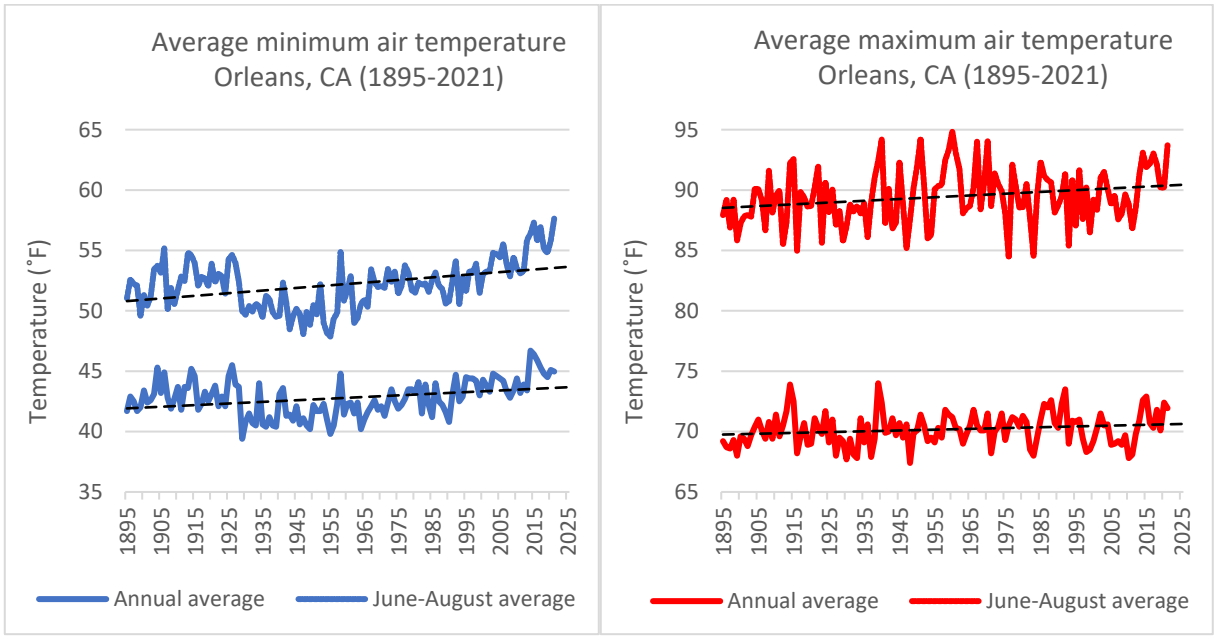
Trends in the Pacific Northwest Region of the United States include rising air temperatures, changing patterns of precipitation, and associated changes in snowpack, soil moisture, length of growing season, fire behavior and more. Similarly, the mid-Klamath region of California has experienced warming, changes in precipitation patterns, increased droughts, increased frequency and severity of wildfires, and disease and pest outbreaks in forests. Observed changes and impacts are summarized below. Unless otherwise stated, the Karuk Climate Adaptation Plan is the basis for the information presented (Karuk Tribe, 2019).

Changing Temperature Patterns

Air temperatures have been increasing in California over the past century (see Air Temperature indicator). Common measures of air temperature include annual average air temperatures, nighttime summer and winter minimum temperatures, number of days per year that exceed 86 degrees Fahrenheit, number of frost-free days (a measure of the length of growing seasons), and measures of extreme heat events. Both across California and in the North Coast region specifically, these temperature increases have been greatest in the summer months. Minimum nighttime temperatures have been increasing faster than either maximum daytime highs or average temperatures. Not only are there overall increases in air temperatures across these measures, but more variable temperature patterns are observed. Future projections in temperature-related metrics are presented in the Adaptation Plan.

Temperature data for Orleans, California are presented in Figure 4. Warming trends are evident. Notably, minimum temperatures, which occur at night, have risen at more than twice the rate of maximum temperatures. Temperatures during the warmer months rose at a faster rate compared to yearly rates: maximum temperatures for the months June through August warmed almost 2.2 times faster than maximum temperatures averaged over the year, and minimum temperatures for June through August warmed more than 1.6 times faster (PRISM 2021).

Figure 4. Average Temperatures at Orleans, CA.



Source: PRISM, 2022

The Adaptation Plan reported the total number of days above 86°F as 49.8 days for 1971-2000, and the number of days without freezing temperatures as 282.5 days. For the period between 1991 and 2020, these have increased to an average of 99 days/year above 86°F and 340 days/year above freezing (32°F) (PRISM, 2021).

Warmer temperatures have been associated with changes in hydrology, including decreased snowpack (particularly at low elevation sites), earlier snow melt and spring runoff, decline in total runoff occurring in the spring, rising river and stream temperatures, and increased variability in streamflow. These changes have occurred in conjunction with changing precipitation patterns, discussed in the next section.

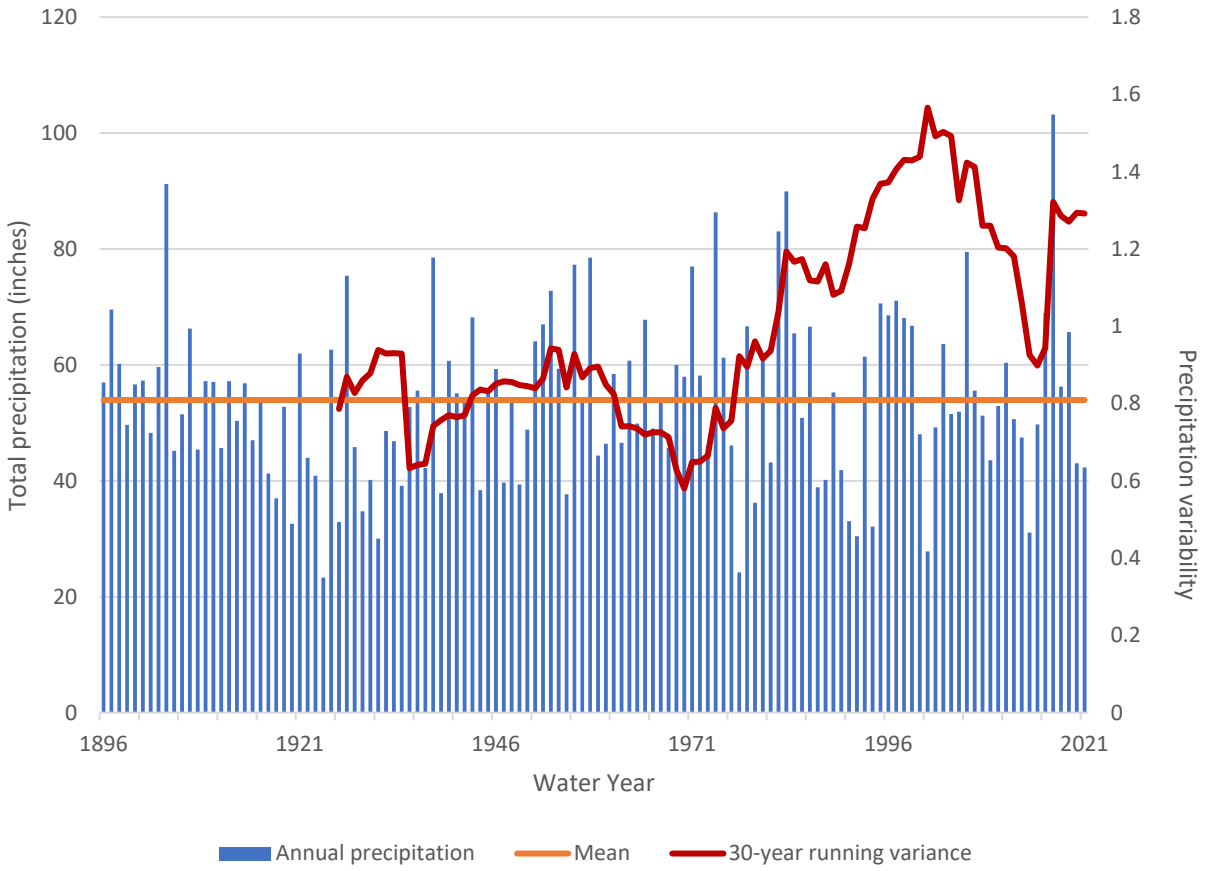
In addition, warmer temperatures may increase the spread of tree diseases (such as sudden oak death) and pest infestations (such as bark beetles); delay autumn migrations of certain species such as black-tailed deer; increase fire risk as vegetation dries with reduced soil moisture and increased evapo-transpiration. Rising temperatures also pose health concerns, including heat stress and heat-related deaths, respiratory

effects from increased pollution and pollen, and from food and water contamination, particularly from toxic algae.

Changing precipitation patterns and drought

Precipitation patterns 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. Annual precipitation measured by water year in Orleans, California, is presented in Figure 5. Year-to-year precipitation is highly variable, while showing no trend in the annual amount over time.

Figure 5. Annual precipitation at Orleans, CA



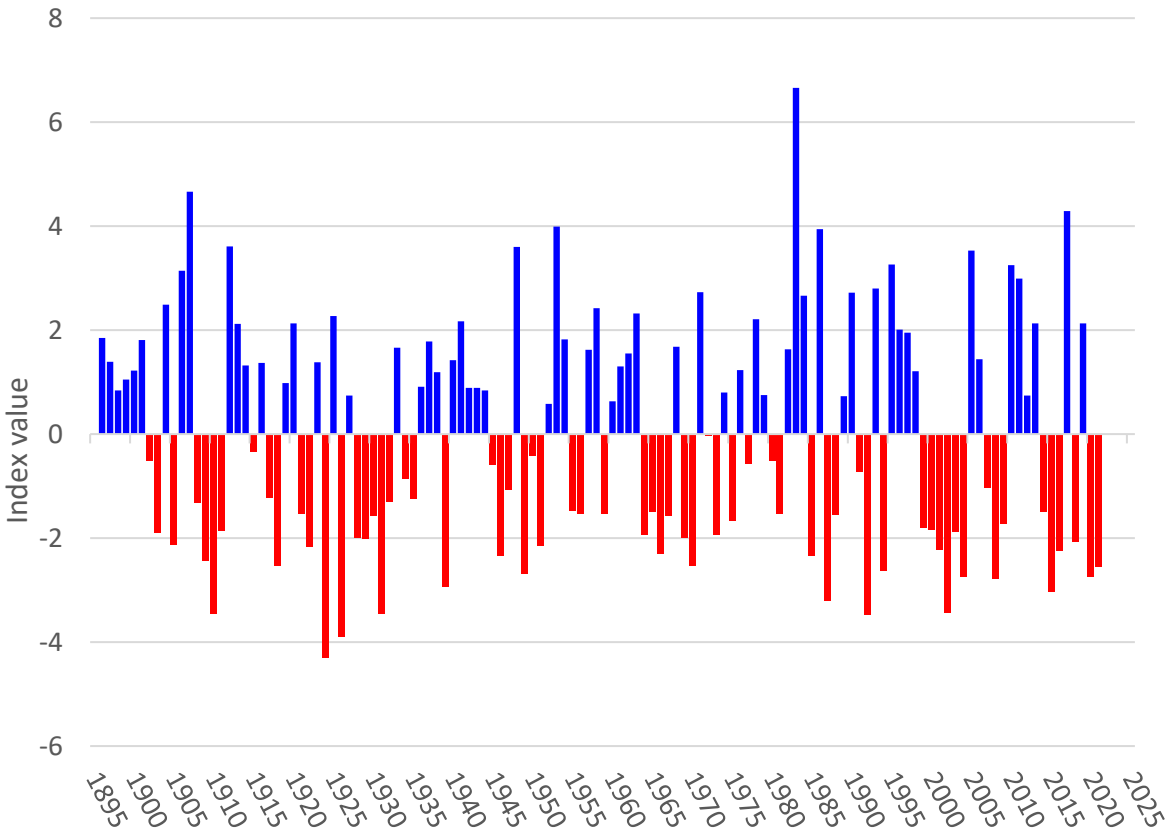
Source: PRISM, 2022

Warmer winter temperatures result in more precipitation falling as rain instead of snow. For the North Coast as a whole, the average spatial extent of snow on April 1st has declined from 60 to 50 percent at elevations above 3,000 feet between 1951-1980 and 1981-2010, with the greatest loss of snow occurring in the Klamath-Siskiyou Mountains. In Karuk Aboriginal Territory, the average snow water equivalent (a measure of

snowpack) on April 1st between 1971-2000 was 10.3 inches. This is predicted to decline significantly by the end of the century.

Figure 6 presents a commonly used metric to track drought, the Palmer Drought Severity Index. The index reflects relative dryness based on readily available temperature, precipitation and soil water content data. Positive values (blue bars) denote wet years; negative values (red bars), dry years. Values below -3 represent severe to extreme drought. Twelve of the last twenty years were dry, with two severely dry years in 2002 and 2015.

Figure 6. The Palmer-Drought Severity Index showing drought patterns at Orleans, CA (1895-2021)



Source: WRCC, 2022

Changing patterns of precipitation, along with warming, translate into decreasing flows and increasing stream temperatures. Prolonged drought will generally reduce stream flows, and may cause permanent streams to become intermittent. Flows in the Salmon and Klamath Rivers are projected to decline, while stream temperatures are projected to increase, affecting habitat for aquatic species such as salmon. Low summer base flows exacerbate toxic algae bloom conditions, and increase the likelihood of tribal members' exposures to the toxin microcystin through contact with contaminated water or consumption of food and water.

Less precipitation – particularly in the form of snowpack – can lead to vegetative stress, for example weakening sugar pine. Drought will lead to more severe wildfires and their cascading impacts on habitats in the region. There is concern that less predictable and reduced precipitation may constrain windows to apply fire.

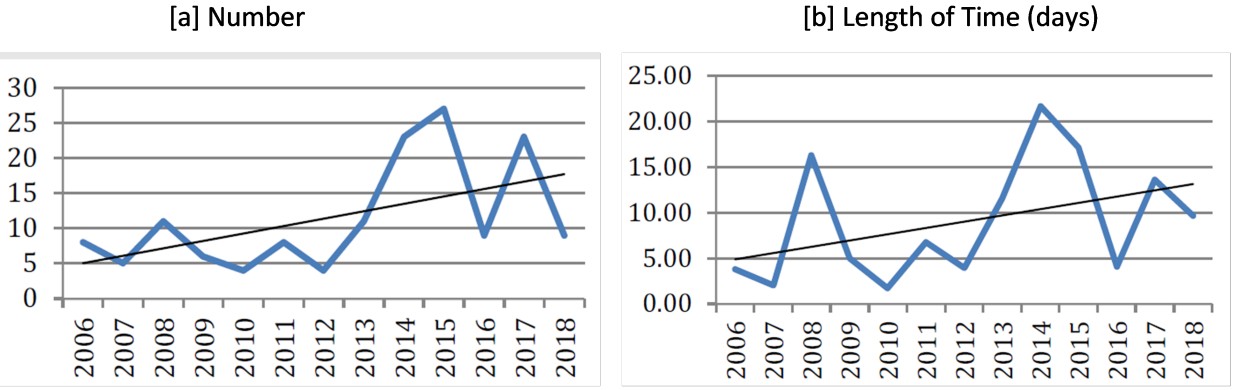
Changing patterns of fire behavior

The Klamath Basin has experienced increasingly frequent, large-scale, intense fires in recent years as a result of both climate change and increased fuel loads resulting from federal land management practices and the cessation of indigenous burning. Invasive species such as scotch broom, star thistle, Himalayan blackberry, non-native grasses and many others are well established within Karuk Aboriginal Territory, adding to the fuel load. Many of these invasive plant species exacerbate fire behavior through the production of long flame lengths.

Changing patterns of fire behavior are among the most pressing of the local dimensions of climate change within Karuk Aboriginal Territory. As shown in Figure 7, the number and length of time of fire weather watches or "red flag warnings" between 2006 and 2018 in the two fire zones that make up the Territory have increased. A Red Flag Warning is issued for weather events which may result in extreme fire behavior that will occur within 24 hours

The increasing frequency of high severity fire threatens individual species, alters the habitat, and disrupts ecosystem dynamics. Fires cause direct mortality to plant and animal species, reducing the availability of food sources; they consume snags and logs used by woodpeckers for nesting, roosting, and foraging. Fires during the flowering and fruiting season may affect harvest and plant reproduction. Trees stressed by fire injury are susceptible to bark beetle and other insect infestations which, in turn, can increase future fire severity.

Figure 7. The [a] number and [b} duration of fire weather watches/warnings, Fire Zones 204 and 280.



Source: Karuk Tribe, 2019

Fire suppression actions have produced adverse impacts. The firefighting tactic of "burning out" along the fire lines creates areas of very high severity fire. Timber fallers often intentionally cut chinquapin and black oaks preemptively because they may have cavities in which fire can smolder; these cavities are important habitat for Pacific fisher. In the immediate aftermath of high severity fires, activities such as salvage logging and associated road building can impact forest stands.

High severity fires in the Klamath region pose immediate health implications during emergency situations, as well as impacts on physical and mental health from smoke exposure. Exposure to smoke is strongly associated with increasing respiratory symptoms which tend to occur during the fires; the deterioration of existing respiratory diseases, hospital admissions, and deaths from respiratory causes impact the Tribal community.

Fires also impact critical tribal infrastructure including the electrical grid, transportation systems, water supply, communication systems, and emergency services.

Impacts on human health and well-being

The Klamath River and its tributaries, forests, grasslands and high country are essential for the cultural, spiritual, economic and physical health of Karuk people. Among the physical health impacts of warming temperatures are: heat stress (many homes do not have air conditioning systems, and those that do are at risk of power outages); increasing rates of asthma and allergies due to increased particulate matter and pollen; and food and water contamination from toxic blue-green algae. Increased residence time of water in the Copco and Iron Gate Reservoirs in the mid-Klamath basin due to drought and low summer flows create ideal growing conditions for the algae (Microcystis aeruginosa) that produces microcystin, a liver toxin. Exposures to the toxin can occur through consuming contaminated water and traditional foods, recreation, bathing or cleansing, and ceremonial activities. The World Renewal Ceremonies in which the medicine man traditionally bathes and drinks Klamath River water overlaps annually with the highest levels of microcystin.

There are serious negative health consequences of smoke inhalation. Large-scale, high severity fires burn much longer than traditional cultural burns, leading to more significant health impacts. In addition to smoke exposures, other potential health concerns include disrupted access to emergency vehicles and to medical care. Poor visibility during periods of thick smoke creates hazardous conditions for air craft operations for firefighting as well as for emergency medical transport. Additional damage to important gathering sites can occur from firefighting tactics. 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 as well as cultural and subsistence activities are disrupted. Irritability or "cabin fever" can set in when people need to stay indoors for prolonged periods.

Biophysical changes across the landscape – including those related to climate change – have affected access to many important food, fiber and medicinal resources. Salmon, acorn, elk, deer, berries and teas are among the traditional foods that are vitally important to the Karuk people, and their consumption prevents diet-related diseases such as diabetes and heart disease. About 50 percent of tribal members in Karuk Aboriginal Territory secure food by hunting, fishing or gathering; 40 percent reported climate and availability as barriers to acquiring sufficient healthy quantities.

Access to an intact natural environment and participation in one's culture are widely recognized as vital for psychological well-being. Cultivating, harvesting, processing, preserving and consuming traditional foods and medicines provide the framework for the Karuk eco-cultural socialization process and religious belief. These practices perpetuate Karuk traditional ecological knowledge and confirm Karuk occupancy on the land. Sharing food is a social obligation, and food related activities strengthen intergenerational relationships within families and the community. Such activities include the Pikyávish ("Fix the World") Ceremonies which are carried out to ensure abundant harvests and restore social and personal balance, and the First Salmon Ceremony, which invokes the spring salmon run.

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 ecological change and denied access to management. Karuk Tribal members have expressed grief, shame, stress and powerlessness from the loss of species, and from their inability to manage the ecosystem in accordance with their cultural practices and spiritual responsibilities. The cultural impacts of climate change are just the latest in a long thread of stressors affecting the mental and emotional health of the Karuk araráhih. 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 (Karuk Tribe, 2019). Many tribes and tribal organizations are turning to traditional healing practices to restore mental health and spiritual well-being to their communities.

Impacts on vegetation and wildlife

As described above, climate change is altering habitat conditions in Karuk territory. As a result, the biodiversity of ecosystems is threatened. The impacts of climate change are compounding those resulting from non-climate related stressors such as dams, fire suppression, and timber harvesting.

Karuk land management reflects a culture-centric perspective on vegetation zones, organized by elevation bands with different timing and purpose in relation to fire management: low elevation forest below the zone of smoke inversions; middle elevation forest within the zone of smoke inversions; and high elevation forest above the elevational gradients in which smoke inversions occur. Additional habitat zones are riverine, riparian, grasslands and wet meadows. These seven habitat zones are

experiencing climate change related impacts that include: changing patterns of precipitation, increasing temperatures, decreasing winter snow pack, changing fire behavior, increasing frequency of high severity fires, drought, and species invasions.

While different habitat zones face distinct threats in light of the changing climate, it is important to recognize their connections to one another. For example, wet meadows supply water to lower elevations where tanoak stands are critical winter foraging habitat for elk who are in turn needed to sustain wolf populations. Each habitat zone is influenced by fire regimes, which have been altered by fire exclusion practices. Fire regimes impact the tanoak stand dynamics of low elevation forests which help shape riparian and riverine habitats. Fire management has shaped the structure and composition of middle elevation forest zones, and has been used to lower stream temperatures.

This section summarizes the impacts of climate change on vegetation and wildlife in the seven habitat zones, as described in the Karuk Adaptation Plan. Certain plant and animal species of importance to the Tribe play vital roles as cultural indicators to guide appropriate human actions. Many species occur across multiple zones, or move across zones seasonally. These 22 cultural indicator species are mentioned in the relevant habitat zone discussion in this section. The Appendix describes each species, organized by habitat zone. More details can be found in the Karuk Adaptation Plan.

Low elevation forests

The low elevation forest habitat lies below the elevational zone (roughly 500-3,000 feet) in which smoke inversions form within Karuk ancestral territory and homelands. This habitat zone is characterized by the presence of tanoak trees (xunyê'ep), and contains an abundance of other species of direct importance for Karuk food, fiber and medicine. Species in this zone are also important for their use as clothing, regalia, and implements, as well as for their role in shaping ecosystems and in informing where and when to burn. The cultural indicator species in this elevation zone are tanoak (xunyêep), tanoak mushrooms (xáyviish), elk (íshyuux), huckleberry (púrith), pileated woodpecker (iktakatákaheen), and wolf (ikxâavnamich). The presence of these cultural indicator species – particularly plentiful tanoak mushrooms and abundant tanoak acorns – is an indicator of balanced ecosystem process and function.

Tanoak forests face primary climate threats from increasing temperatures, decreasing precipitation, lower soil moisture, increased frequency of high severity fires, and expanding forest pathogens such as Phytophthora ramorum, which causes sudden oak death (SOD). The SOD pathogen – which has destroyed millions of oak and other trees and caused twig and foliar diseases in other plant species across California since the 1990s – and other lethal invasive forest pathogens can increase fire danger in coming years.

The composition and overall stand structure of low elevation tanoak forests are the direct result of their long-term intensive management by Karuk people through the use of fire. Frequent fires have traditionally been used to limit the encroachment of competing shrubs and conifer species, providing the open structure that is important for many other species including madrone, white oak, princess pine, pileated woodpeckers and elk. Today, these low elevation forests 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 these stands, meadows are non-existent, conifers such as Douglas fir encroach upon oaks, huckleberries are highly dense but without berries, and elk are not present. Other non-climate stressors to tanoak forests include firefighting activities that can damage the tanoak's mycelium net, as well as salvage logging and associated road building following high severity fires.

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.

Middle elevation forest

The middle elevation forest zone is characterized by the elevational band (roughly 2,500 to 4,500 feet) in which smoke inversions form. Species occurring within this cultural management zone are important for Karuk people as a food source and for use in regalia. Pine roots and needles are used in basket making and are represented in ceremony as the tree of life. The cultural indicator species in this habitat zone are chinquapin (sunyíthih), black oak (xánthiip), pacific fisher (tatkunuhpíithvar), porcupine (kaschiip), and black tailed deer (púufich).

Middle elevation forests with black and other oaks, chinquapin, Douglas fir, hazel, and gooseberry would traditionally be burned every five to seven years. Federal fire management over the past century has led to declines in black oaks and other fire-dependent species and facilitated the growth of conifers, leading to the alteration of the structure and composition of this forest zone and making it vulnerable to high severity fires. A century of fire exclusion and a changing climate has impacted the practice of setting fires on Offield Mountain with the full moon in August as part of the World Renewal Ceremonies. This practice reduced the potential for high severity, high impact events, protecting the village sites below. August fires also cooled riverine systems at the peak of summer temperatures, triggering upstream salmonid migration and cooling the system for fish runs already in the river.

Changing patterns of precipitation and temperature, increased frequency of high severity fire, and species invasions, especially from forest pathogens such as the sudden oak death pathogen (*Phytophthora ramorum*), are climate-related threats for this habitat zone. Forest pest dynamics that appear to be driven or enhanced by climate change in the Klamath Region include the fir engraver beetles that are associated with Shasta Red Fir mortality and *Phytophthora ramorum*.

When it comes to restoration of cultural fire regimes, sites with the combination of huckleberry, chinquapin, and black oak are key sites for management. While sugar pine is often seen at higher elevations, it can occur in middle elevation zones. Sugar pine in this zone is a key indicator of cultural vegetation characteristics, denoting places for management. In ancestral practice, sugar pines were the most prized ignition source, especially because of their yield of pitch and needles. The presence of pines in specific landscapes shows human management. In many cases these remnant pine stands are located in areas central to landscape/resource specific ignition patterns (Tripp, Watts-Tobin and Dyer 2017).

High elevation forest

High elevation forests occupy the zone above which smoke inversions form. It is also defined as forests above the chinquapin band and extending into the high country (defined elsewhere as montane and into the subalpine zone). Processes within this habitat zone are critically important to the health of other parts of the ecosystem. Like their lower elevation counterparts, the high elevation forests within Karuk ancestral territory and homelands are biologically rich and incredibly species diverse. Key Karuk foods and cultural use species in this zone include the sugar pine, gooseberry and beargrass (which especially occurs towards the coast where fog is present). The shrub form of chinquapin may be found at these elevations. Karuk cultural burning enhances species in the high elevation forest zone, making nutrients available in soils, releasing the seeds from sugar pine cones, stimulating growth and flowering of beargrass, and minimizing fuel loads to protect from high severity fires. Cultural burning at roughly five- to ten-year intervals across the landscape creates multiple 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 traditionally used fire to tend this habitat zone. Burning in these areas often occurs along trail networks, targeting meadow areas and patches of particular food and cultural use species such as huckleberry. Some foods, fibers and medicines of particular importance in this zone are wild onion, beargrass, huckleberry, princess pine, Oregon grape, and sugar pine. Much of Karuk high country is under wilderness designation, with fire suppression as a primary intervening stressor; logging is also a stressor.

High elevations forests are being impacted by changing patterns of precipitation and temperature, and the resulting changes in snowpack, soil moisture levels, and fire frequency and seasonality. While this forest zone benefits from regular low severity fire, high severity fires can, in the long term, convert the forest to brush fields. Species invasions and forest pathogens including White Pine Blister Rust and Port Orford Cedar Root Rot are also of concern. Using fire in high elevation forests is critical for getting back to historic fire regimes and an overall manageable, fire-safe system, particularly in

light of the increasing pressures from decreased snowpack, drought, and fungal pathogens.

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. One example is the construction and operation of observation stations or "lookouts" to detect and report fires beginning in the 1920s. Some of these were constructed on tribal sacred sites used as prayer seats, thus affecting tribal land use practices, especially traditional setting of fires at culturally significant habitats. In other instances, the use of bulldozers to create fire lines has destroyed not only physical tribal artifacts, but also the vegetation mosaic of the ridge system which had served as an archive of land stewardship and part of cultural knowledge. The Tribe has lost the ability to learn from the ancestors and the land.

Wet meadows

Karuk ancestral territory and homelands contain a number of wet meadow systems scattered throughout the higher elevation forest and high country. The cultural indicator species for this zone is the leopard lily (Mahtáyiith).

Climate related drivers including changing patterns of precipitation, temperature, fire and species invasions are the dominant threats to these systems. Wet meadows are a highly threatened ecosystem with a severely reduced range due in particular to fire exclusion. In the absence of fire, the encroachment of conifers into wet meadows leads to a cycle in which the water table drops, the meadow dries up, and the drier soils become more conducive to Douglas fir and other hardwood trees that were formerly excluded by high soil moisture. Numerous wet meadows within Karuk ancestral territory and homelands are being lost through this process, especially at the middle to high elevations. Non-climate stressors to wet meadows include channelization from grazing, as well as the introduction of invasive species from grazers.

Wet meadows not only provide critical habitat for many species of importance – including bear, trailing blackberry, Mariposa and Panther lilies, wild turnip, and multiple kinds of Indian potatoes (e.g. Brodiaea coronaria) – they are critical for hydrologic, ecological and fire dynamics across the landscape, especially in lower elevations. Wet meadows supply water and provide higher summer base flows and cold water to lower elevation riverine and riparian systems; for example, the Haypress meadow complex supplies cold water to the Wooley, Ti, Irving, Stanshaw, and Sandy Bar watersheds.

Riverine systems

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 main stem Salmon River, and many key tributaries. Species from riverine systems hold significant cultural or spiritual significance and provide over fifty percent of the calories and protein of traditional Karuk diets. They are also important for food, culture and ceremonies. The

cultural indicator species for the riverine zone are spring Chinook salmon (Ishyá'at) and Pacific lamprey (akraah).

Riverine systems are especially at risk due to changing patterns of precipitation, increasing temperatures, and decreasing winter snow pack. These changes directly impact stream flow and water temperatures. Elevated stream temperatures can cause fish mortality, support fish pathogens and diseases, and enhance the suitability of the habitat for non-native fishes.

Non-climate stressors that threaten riverine systems result from non-Tribal management actions, including: dams (such as Iron Gate) that trap sediment, block access to cold water habitats, and stop processes that shape habitat and cool water downstream; fire suppression, which has removed the cooling effect of smoke on river waters during critical periods for Chinook fall migration and spawning; and water quality impairments from agricultural inputs, fire retardants, logging activity and others

Riparian systems

Riparian areas – lands along water courses and water bodies – are key sites for many food, fiber and medicinal species of importance to Karuk people.

Species from riparian systems serve as indicators of healthy systems; they signal when management steps, including burning, need to be taken. The riparian zone cultural indicators are the Pacific giant salamander (púfpuuf), aquatic garter snake (asápsuun), beaver (sahpihnîich), and yellow-breasted chat.

Riparian habitat is threatened by changing patterns of temperature, precipitation, fire behavior and species invasions. Prolonged drought, which reduce stream flows, may cause permanent streams to become intermittent; increasing temperatures may dry forest floors, thus reducing the area of moist refugia in the terrestrial riparian zone; more severe winter or spring rains may cause flooding events that increase siltation and alter aquatic riparian habitat structures; and warmer climates may increase the spread of diseases and increase the susceptibility of amphibians and other species to diseases. 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. The health of riparian habitat zones is important for the functioning of riverine and forest systems.

Grasslands

Grasslands, also known as prairies or glades, historically occurred in mid to upper montane areas on ridges, in both large and small patches. Until about 1850, grasslands were so extensive they covered nearly one-fifth of California. Today a majority of the grasslands that once existed within Karuk Aboriginal Territory have disappeared due to lack of fire. Frequent burning is required to maintain the open prairie structure. Burning prevents conifer encroachment and enhances conditions for key food species, such as

many of the species known as Indian potatoes (tayiith). The presence of Indian potatoes indicates where the Tribe traditionally burned and managed grasslands. Traditional Karuk knowledge about grasslands is still being recovered.

Grasslands have been historically significant for many species of broad-leaved herbs, native annual and perennial grasses, insects, birds, mammals, reptiles, and amphibians. Among these are important Karuk foods such as elk, as well as iris and other grasses used for twine, and Indian potatoes. Indian potato and bumblebees are the two cultural indicators for this habitat type.

With the changing climate, drought and species invasions are a particular concern in this habitat type. Probably the main non-climate stressor to grasslands comes from their severely reduced range due to fire exclusion and from the transport and spread of non-Native species. Grazing is another key intervening stressor for grassland systems.

Summary

Karuk araráhih have co-evolved with the mid-Klamath ecosystem and its diverse landscapes since time immemorial using multiple species of importance as cultural indicators for various traditional management practices. The Tribe has managed the landscape with controlled burning for countless generations, however the policy of fire suppression at the state and federal levels interrupted these practices and ultimately led to greater wildfire risk. The effects of fire suppression and other non-climate stressors – notably the construction of dams and logging – along with a changing climate, have altered habitat conditions and disrupted ecosystem process in Tribal territory. The Karuk Tribe and its Natural Resources Department are actively working to understand, adapt to, and mitigate the effects of climate change. As the landscape and cultural indicator species are impacted by the effects of that changing climate, the Karuk people will continue to adapt using the environmental stewardship knowledge collected over countless generations of Karuk araráhih to protect their landscape, resources, culture, and the health of their people.

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Appendix. Karuk Cultural Indicator Species by Habitat Zone

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. Cultural and ecological information is retained today in ceremonies, stories, collective memory and the land itself. Today, the Karuk Tribe is centering on the revitalization of 22 focal species, described below, as cultural indicators for human responsibilities and necessary human management actions in the face of climate change. The descriptions and images are taken from the Adaptation Plan.

Low elevation forest

Source: Karuk, 2016

Xunyêep (Tanoak, Lithocarpus densiflorus) is an ecologically, culturally, and economically important species. Tanoak acorns (xuntápan), a staple food for Karuk people, traditionally constituted a high percentage of the calories and protein of their diets. 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.

The most critical environmental factor determining the fate of tanoaks is fire. Another factor is the spread of the sudden oak death pathogen, which increases in warmer and wetter environments.

Púrith (Evergreen Huckleberry or Vaccinium ovatum) is an important Karuk food source with many nutritional and health benefits. Púrith is a slow-growing, shade-tolerant

understory shrub that is most abundant in forests with a higher level of canopy cover. Flower and berry production increases with light and soil moisture where forest gaps have been produced by moderate disturbance related to fire, timber harvest, or thinning. Infections by the sudden oak death pathogen (Phytophthora ramorum), while not lethal, produce lesions that reduce their suitability for tribal use. The infections may also prompt land managers to remove infected plants to protect tanoak stands. Warmer and wetter environments are likely associated with increased spread of the pathogen, and the lack of cultural fire appears to increase púrith's vulnerability to the disease.

Huckleberry is a cultural indicator for when and where to burn. Burn timing is indicated by the burn timing of tanoak acorn, which is in turn related to insect management. Emerging scientific studies indicate the presence of chinquapin may be a sign as to where one should burn for huckleberry. The Tribe defines púrith as a key cultural indicator of socio-ecological resilience of sustainable harvest and landscape management to ensure food security for both humans and animals that consume huckleberry.

Xáyviish (Tanoak Mushroom, Tricholoma magnivelare) is prized as a traditional food and medicine. It is also highly prized in the global market, making it vulnerable to overharvest by outsiders. 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. In addition to rainfall, this mushroom requires low temperatures, and a pattern of warming and cooling. Tanoak mushrooms are connected to tanoak trees, elk, huckleberry, deer, wolf and chinquapin and other species in complex ways. The presence of plentiful tanoak mushrooms is an indicator of treatment success from the standpoint of soil impacts and host tree retention.

High-severity fires burn or destroy mycelial mats, preventing them from fruiting into harvestable mushrooms and compromising the 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 depend on may be less available in forests with repeated high-severity fire.

Xáyviish is threatened by logging machines, which have damaged or severed the mushroom's mycelium, and harvesting of the mushrooms for economic gain. This species serves as an important indicator of responsible human use. While Karuk tradition emphasizes reproductive success by picking mushrooms with at least 50 percent of the veil open to assure the release of spores, and allowing access by other species before human use, economic gain is maximized when the mushrooms are picked with their veils closed.

Iktakatákaheen (Pileated Woodpecker, Hylatomus pileatus) is seen as an ecosystem engineer that creates cavities that can then be used by up to 20 species of birds and mammals. It also promotes nutrient cycling in the forest through its excavations. The

process of harvesting the species for regalia is intricately tied to land management. The largest woodpecker in North America, Iktakatákaheen typically resides in older deciduous or mixed deciduous-coniferous forests. High severity fires consume snags and logs used by pileated woodpeckers for nesting, roosting, and foraging, and reduce insect populations as well as nut and berry sources that are vital to the woodpecker diet.

Íshyuux (Roosevelt Elk or Cervus occidentalis) are important for their use as food, clothing (hides), regalia, and implements, as well as for 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. The reproductive needs for elk are an important cultural indicator for management. Íshyuux require a mosaic landscape that combines open areas for foraging, and forested areas for cover. Much of the habitat for winter range and calving is now overgrown with mid-mature dense stands and plantations due to fire exclusion. Following a mixed (moderate to high) severity burn in a riparian area in 2015 (in the West Simms unit), elk moved in and started calving in it almost immediately. Differences were significant between the cultural prescribed fire and impacts of an adjacent wildfire.

Ikxâavnamich (Wolf, Canis lupus) once inhabited Karuk territory, but by the 1920's were decimated by Euro-American hunting, trapping and poisoning. It is likely to make a return to California as a result of federal protections. The wolf is important to Karuk tribal spiritual practices and ecosystem stability. Intricate relationships exist between wolves and other species in the low elevation forest zone, including elk, deer, tanoak, huckleberry, chinquapin and tanoak mushroom. 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. To succeed as a pack, wolves need large, remote areas free from much human disturbance.

Middle elevation forest

Source: Karuk, 2016

Tatkunuhpíithvar (Pacific Fisher, Pekania pennant) has experienced significant declines in Karuk territory. The fur of tatkunuhpíithvar is traditionally used in Karuk regalia. It is well represented in world renewal ceremonies as the quiver that carries the arrows used to wake up the world. Tatkunuhpíithvar represents the need for balance among dense and open habitats with large fire scarred growth hardwoods. It prefers hardwood forests with significant canopy cover, with large trees and snags where it converts large cavities into a den. The species is currently facing habitat losses due to habitat changes resulting from both climate and non-climate stressors: fire management, high severity fires, insects and pathogens, logging, and rodenticide poisoning from marijuana farms.

Sunyíthih (Chinquapin, Castanopsis chrysophylla) is an evergreen member of the beech family that can grow quite tall and live up to 500 years. Also known as a high elevation species, its presence at other elevations indicates places where one may want to treat for huckleberry. The nuts of sunyíthih are important to the Karuk traditional diet and also provide food to many bird and mammal species. 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. Sunyíthih provides important cover for birds and small to medium mammals. Fisher and martens may use them for their natal dens. Diseases and insects have little impact on giant chinquapin, although it is susceptible to heartwood-rotting fungi such as Phellinus igniarius; the filbert worm (Melissopus latiferreanus) may impact reproduction. Chinquapin has recently been identified as a host of sudden oak death pathogen.

Kaschiip (Porcupine, Erethizon dorsatum) are critical food sources for mountain lions and pacific fisher. Kaschiip's quills are used by Karuk people in 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 oak woodlands and reduces conifer encroachment. 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). Weavers reported 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. 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. The porcupine diet consists of herbaceous plants, twigs, and particularly in the winter, coniferous bark and needles. Fires can affect porcupine food sources and habitat, increase the chances of porcupine predation, and kill individuals who are unable to escape.

Xánthiip (Black oak, Quercus kelloggii) occurs in mixed-conifer forests as well as in mixed hardwood forests. In the highly diverse Klamath-Siskiyou area, black oak has many overstory plant associates. 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.

Historically, black oak stands were ignited at a massive scale in February to promote early spring greens and to protect the most susceptible slopes above the villages from excessive fuel accumulation in the summer months. California black oak appear highly adapted and may experience range expansion as a result of predicted increases in temperature and fire activity. High severity fires may destroy acorn bearing stands of black oak that are culturally vital. There is some speculation that increasing temperatures could influence acorn production. Sudden oak death (Phytophthora ramorum) is a major climate stressor for this species and is already impacting black oak in coastal regions.

Púufich (Black Tailed Deer, Odocoileus hemionus) is among the most important traditional Karuk foods and sources of utilitarian and ceremonial items. In 2005, over 65 percent of Karuk households reported hunting púufich for food. The meat, sinew, bones, hide/skin, fur, antler, and hooves have been used extensively for traditional functions. The Deerskin Dance, which is part of Karuk World Renewal Ceremonies, depicts how burning for deer relates to salmon migration and woodpecker habitat and other connections. Deer health and abundance, as well as their movement and habitat selection across the landscape are indicators of appropriate fire management activities. 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.

Smaller patches of high severity fire that maintain more open shrub, fern, forb, and grasses promote higher quality forage and dispersal for deer. By contrast, high severity,

large-scale fire may burn a significant portion of black-tailed deer's home range and reduce cover from predators. Oak groves burned by such fires can reduce deer diets rich in acorns. Existing stressors include agricultural expansion, habitat loss, disturbance of migration, fire suppression, and barriers (such as fencing, roads and reservoirs). Warming temperatures can affect the availability of food sources and alter patterns of seasonal migration. Delayed autumn migrations may leave púufich at greater risk of sudden winter storms and predation. Warming temperatures and increased humidity may increase spread of parasites and bacteria to which púufich are vulnerable.

<u>High elevation forest</u>

Source: Karuk, 2016

Ússip (Sugar pine, *Pinus lambertiana*) occurs in mixed-conifer forests. In Karuk country, it 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. Sugar pine is often viewed as a high elevation species, but when found at other elevations, it serves as an indicator of specific management actions. It 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. Sugar pine groves were family owned and managed for nuts (food), pitch (medicine), and roots (basketry).

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. Today it is rare to find an open grown sugar pine tree that is accessible for nut collection. Trees grown in the open develop differently than woodland grown trees, typically developing full crowns and a wide branch structure with large limbs growing from further lower on the trunk. 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.

Decreased snowpack, earlier spring snowmelt and warmer temperatures threaten the health of sugar pines directly, or make them susceptible to beetle infestations and fungal pathogens. High severity fires can not only decimate individuals and stand, but also limit seed dispersal and establishment in burn areas.

Panyúrar (Beargrass, *Xerophyllum tenax*) is a perennial, subalpine herb that inhabits upper slopes, often near or beneath coniferous forests. Beargrass flower stalks are browsed by ungulates such as deer and elk. It is an important plant species for Karuk basket weavers and regalia makers. Blades are considered best for basket weaving the first year after a fire. Panyúrar is traditionally burned every three to seven 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. Along with other important cultural species including hazel, panyúrar grows back particularly strongly after low to medium intensity fire. A combination of frequently burned beargrass 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. High severity fires can 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.

<u>Wet meadows</u>

Source: Karuk, 2016

Mahtáyiith (Leopard Lily, *Lilium pardalinum* ssp. *Wigginsii*) is the cultural indicator for wet meadows. 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. 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. Fire of varying intensities removes competing shrub and tree vegetation which would promote lily flowering.

Riverine systems

Source: Karuk, 2016

Akraah (Pacific lamprey or eel; *Lampetra tridentata*) are related to humans as a food source, related to fire cycles for their well-being, and related to bears and birds upslope by virtue of taking nutrients back up the hill to feed plant life, similar to salmon. They have a long life cycle in which adults live in the ocean and return to freshwater to spawn. The larvae reside and filter feed in silty or sandy substrates for up to seven years before migrating to the ocean. Adult Pacific lamprey follow the scent of pheromones released by juvenile lamprey (ammocetes), not necessarily returning to their natal river systems. This highlights the importance of ammocete habitat in the Klamath, which depends on sediment deposition and fire processes to create favorable conditions. The Scott River, the largest source of fine sediment to the main stem Klamath above the Trinity River, is a snow pack driven river system that is threatened by climate change. Furthermore, Iron Gate Dam has cut off the sediment supply to the upper Klamath River.

Ishyá'at (spring Chinook salmon, *Oncorhynchus tshawytscha*) is a key cultural indicator sensitive to stream temperatures. Their presence is an indicator of both riverine and forest habitat quality. Fresh, cool water temperatures are critical to Ishyá'at, as are spring to early summer high water flows they need to reach summer holding areas, to access spawning grounds, and to reproduce. Climate change and changing weather patterns such as drought cycles and high severity storm events have had direct implications on the species. On the Klamath, "spring creeks" that originate in volcanic terrain are perfect for production of juvenile salmon because of their stable flows and cold water temperatures year-round. However, nearly all spring creeks on both the Klamath and Shasta are locked up behind dams.

Riparian systems

Source: Karuk, 2016

Púfpuuf (Pacific Giant Salamander, *Dicamptodon tenebrosus*), while not a Karuk food source, is central to Karuk culture. They are a keeper of water that is critical to life. In Karuk beliefs, púfpuuf is a spiritual being who transformed into a salamander to monitor spring and creek water quality and quantity. Their presence is indicative of a healthy riparian and aquatic fresh water ecosystem. Púfpuuf is perhaps the most important cultural indicator for identifying the need for emergency management actions. Karuk traditional practitioners report that if púfpuuf is in peril, we are on the verge of system collapse, and the immediate application of fire is recommended to lower acutely high air and water temperatures.

Asápsuun (Aquatic Garter Snake, *Thamnophis atratus*) is a cultural indicator of healthy aquatic and riparian systems. As fire regimes are restored in Orleans and the Black Mountain area, paying attention to this species may become more important. Asápsuun is an aquatic snake that uses water for both foraging and protection. 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. With climate change, increased temperatures may dry forest floors and reduce moist refugia for this species in terrestrial habitats.

Sahpihnîich (Beaver, *Castor canadensis*) alters ecosystems in ways that benefit other species. 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. Habitat destruction and degradation, and a lack of riparian vegetation (their food sources) are climate change-related threats to the species. Restoring historic fire regimes will benefit sahpihnîich by promoting the growth of riparian vegetation, and reducing the threat of high severity fires. Sahpihnîich can play a role in drought mitigation by storing water and maintaining areas of open water. Their dams can moderate stream temperatures, reduce peak flows in flooding events, create complex aquatic habitats for many other species, trap suspended sediment, and restore incised streams to more complex channel and ponds systems.

Yellow-Breasted Chat (*Icteria virens*) is a migratory bird that nests in the spring. In Karuk stories, it is welcomed as the true harbinger of spring. Karuk culture says the chat is tied to the responsibility of humans to realize that something has to be done about fire. The return of the chat and other birds to nest is a signal to stop burning. Chats are numerous in Northwestern California, with the highest densities found along the Klamath and Trinity Rivers. The chat depends on riparian areas, especially sandbars, with willow trees. It nests in dense thickets, and uses larger trees as singing perches. A return of cultural burning at proper intervals will maintain riparian willow and cottonwood habitats. Maintaining riparian floodplain habitat by discouraging channelization of streams will also benefit chat. Chat may also be susceptible to changing wind conditions along migration routes to and from the

tropics. The yellow feathers of its breast have traditionally been a part of tribal regalia.

Grasslands

Source: Karuk, 2016

Tayiith refer to a variety of geophytes (including *Brodiaea* spp., *Dichelostemma* spp., *Triteleia* spp., *Calochortus* spp., *Lilium* spp., and *Fritillaria* spp.) commonly called Indian potatoes. The Karuk people harvest their bulbs and tubers for consumption. *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. Historically, species of Indian potato grew thick as grass in certain valleys in California. Karuk and other Native Californians 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. Burn timing in regard to this species needs to be refined to account for harvest timing and invasive species.

Bumblebees (*Bombus* and other genera) are important within grassland habitats in Karuk Aboriginal Territory. While bees require grassland habitat which is fire dependent, the specific relationships between bees and fire is less well understood. Loss and fragmentation of grassland habitat, as well as grazing, reduce nesting and foraging habitat quality for bees This is a species for which more traditional knowledge and scientific attention will be beneficial in the changing climate.