Chapter 3: Vulnerabilities of Traditional Foods and Cultural Use Species

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As Karuk people, we recognize other species in nature as part of an extended ecological family to whom we are related and have responsibilities. Leaf Hillman, Karuk Tishuniik ceremonial leader & DNR Director, 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.” This worldview has been referred to as “kincentricity” in the academic literature (Martinez 1995, Salmon 2000, Senos et al. 2006).

Acorns and huckleberries harvested in an area burned by prescribed fire.
Photo: Stormy Staats, Klamath-Salmon Media Collaborative

Across the landscape, traditional food, fiber and medicine and especially water are vitally important for Karuk people. Hundreds of species from salmon and acorns, to tobacco and wild celery (kíshvuuf) provide materials necessary for cultural continuity, spiritual practice and the preservation of traditional knowledge systems. 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.

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). Nutritional data show that traditional foods produce stronger hearts, blood and muscle tissue (Jackson 2005). The omega-3 fatty acids found in such abundance in salmon (and anadromous fish such as Pacific lamprey eels) have been linked with a number of significant health benefits including reduced risk of heart attacks, strokes, and Alzheimer's disease, improved mental health and improved brain development in infants (Norgaard 2005). The often strenuous tasks of acquiring traditional food provides exercise that keeps people in good physical condition. Because hunting, gathering, fishing, storing and preparing food are an integral part of daily life and seasonal celebration, traditional food holds great cultural, religious and social meaning as well. These activities also serve as an important social "glue" by bringing people together to work, socialize and pass down values and information from one generation to the next (See Brown et al. 2011, Risling Baldy 2013).. Food is also central to some of the most serious social obligations for Karuk people – hospitality and caring for elders. Overall, the health benefits of eating traditional foods include better nutrient density, the availability of key essential nutrients, physical activity during harvesting, lower food costs, the prevention of chronic disease by consumption of more nutritious food, and "multiple socio-cultural values and traditions that contribute to mental health and cultural morale" (Kuhnlein and Chan 2000, p. 615, Cantrell 2001, Risling Baldy 2013, Fleishhacker et al. 2012).

Table 3.1 Multidimensional Importance of Karuk Traditional Foods, Fibers and Medicines

Basic sustenance	About 50% of tribal members living in Karuk ancestral territory get at least some portion of their food by hunting, fishing or gathering Native foods, whereby limited availability of these foods and the effects of climate change were seen by almost 40% of respondents to be 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 both 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 (Salter 2003, Norgaard 2005).
Family structure and social relations	Sharing food is a social obligation. Tending, harvesting, processing, storing and consuming traditional food strengthens intergenerational relationships within families and across the community (Risling Baldy 2013).
Ceremonial practice	"Fix the World," or Pikyávish Ceremonies are carried out to ensure abundant harvests and restore social and personal balance . (Kroeber and Gifford 1949) First Salmon Ceremony invokes the spring salmon run and regulates harvest management (Swezey and Heizer 1977 cites Powers 1872, Kroeber 1925, Harrington 1932, Roberts 1932, Driver 1938, Kroeber and Gifford 1949).
Traditional knowledge	Tending, harvesting, processing, storing and consuming traditional food perpetuates Karuk traditional ecological knowledge and its practice (Lake 2007, 2013).
Political sovereignty	Ongoing actions of tending, harvesting, processing, storing and consuming traditional food confirms Karuk occupancy on the land (Risling Baldy 2013).

This chapter examines the vulnerabilities to traditional foods and cultural use species in light of the increasing likelihood of high severity fire. Species of importance to Karuk people are impacted by other climate change related stressors that intersect with the vulnerabilities induced by the increasing instance of high severity fire. These other stressors, which include increased drought and temperatures, more variable weather, stronger storm systems, decreased snowpack, flooding, and increase in invasive species, are beyond the scope of this assessment, but may be mentioned here and are also discussed in Chapter One. As noted throughout this assessment, we take an intersectional approach to evaluating vulnerabilities resulting from high severity fire. This approach considers fire related vulnerabilities to Karuk foods and cultural use species in the context of past, present and future fire related management actions. Throughout this assessment we underscore that while high severity fire is a serious and immediate dimension of climate change, Karuk ancestral territory is fire dependent. Humans are ecosystem components and fire is medicine in Karuk culture (see also Wells 2014).

Humans as Ecosystem Components

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 through traditional management to enhance species of cultural importance (Anderson 2005, Halpern 2016, Lake 2007). The impact of past and present traditional management on ecosystems is of such magnitude that some argue, correctly, that American Indian land management should be considered part of the reference ecosystem when attempting to restore degraded landscapes (Senos et al. 2006). "Inhabiting one of the most complex geographical areas of North America, the Karok [Karuk] benefitted from great diversity in flora and fauna. The number of species support by the Klamath Mountain province is reported to be among the highest of any comparably sized region on the [North America] continent" (AITS 1982: 143).

Cultural burning at Tishaniik Ceremonial Grounds. Photo: Stormy Staats, KSMC

Karuk resource management practices, including fire use, increased pyro-diversity of existing ecological communities. “A review of earlier ethnographic work and more recent oral history interviews of tribal elders conducted by the Karuk Tribe and myself [Lake] suggest that tribal TEK encompasses a core area of knowledge about discrete fire events that contribute to landscape fire regimes. Tribal knowledge of fire ecology is closely coupled with subsistence economies, ceremonial practices, and individual or family adaptive strategies. Tribal TEK may also be able to describe how climate and weather influence fire behavior, from the yearly to decadal scale, with generalized understanding of century-scale climate and fire regime changes” (Lake 2013:4).

Karuk fire management is specifically linked to biodiversity (Lake 2013). Anderson (2005) highlights many uses of Karuk cultural burning, including as a means to reduce forest diseases and pests, increase seed and grain production, reduce the fuel load in forests, and enhance the quantity and quality of, and access to food and cultural use species such as oaks, hazel, beargrass, and native tobacco. Karuk fire regimes generate pyrodiversity on the landscape by extending the season of burn and shortening fire return intervals (Lake 2013, Martin and Sapsis 1992). The multitude of foods, materials and other products that come from Karuk environments are in turn evidence of the profound diversity of fire regimes that are required to maintain relationships with hundreds of animal, plant, and mushroom species (Anderson 2005, Lake 2007 & 2013, Anderson and Lake 2013). “For example, drier years have potentially greater fire spread and less resource productivity and required tribal groups to modify fire use and adapt foraging strategies. Tribal seasonal travel and resource strategies were likely linked to differing fire patterns across a range of similar vegetation types, but with each type having been burned at different frequencies. Thus developed a staggering of seral stages of similar vegetation communities across the landscape, differing by time since burn and by severity of burn. A landscape with burns in different years with mixed severities provided greater diversity of seral stages among vegetation types that facilitated tribal acquisition of valued resources" (Lake 2013:12-13)

The vulnerabilities faced by species of importance to Karuk people in the context of high severity wildfire do not occur in a vacuum. These vulnerabilities must be understood in the context 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. Not only does high severity wildfire 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 frequent large-scale high severity fires (Dale et al. 2001). Furthermore, past management actions from logging, road building or fire suppression interact with fire events to influence the level of vulnerability, as do management actions taking during a fire and those that may follow in the long term (Odion et al. 2004). Again, we consider the intersectional dimension of vulnerability to high severity fires in the context of past, present and future management actions.

Since 1910, the activities of the U.S. Forest Service have shaped the ecosystems of the region in different ways. Fire suppression has been a dominant human influence, as have logging, road building, and the replacement of complex forest stands with even age, single species conifer "plantations" (Odion et al. 2010). Logging slash left on the forest floor and fire suppression dramatically increase the risk of high severity fires (Taylor and Skinner 2003). When high severity wildfires occur impacts to ecosystems and species of importance vary dramatically. Because the mid-Klamath region is fire adapted, even high severity fires have many positive dimensions for particular species and in particular time frames. For example, hydrological erosional processes contributing post fire sediment plumes to lower gradient creeks and rivers may smother salmon eggs or reduce fish habitat suitability in the short term if they come at the wrong time of year, but also bring needed woody material and replenish substrate (sand, gravel, rocks) which form longer-term habitat complexity (Wondzell and King 2003). The exact relationships between fire events and species impacts are sometimes debated. In light of the changing patterns of fire behavior, impacts of repeated high severity fire are often unknown. On the whole however, it is clear that while Karuk ancestral territory is adapted to repeated lower intensity mixed severity fires (Perry et al. 2011), the increased frequency of high severity fires creates serious vulnerabilities to the mid-Klamath ecosystem and particular species of importance to Karuk people. Impacts of high severity fire are complex and vary across space and time. We evaluate vulnerabilities at three temporal scales: those that occur during fire events, those occurring in the immediate aftermath of fires and long term vulnerabilities.

When high severity fires occur, they are the subject of additional management actions, usually some form of fire suppression (which has various degrees of success). Activities from back burning to the use of fire retardants are often carried out by agencies who are unaware of the intricate economic, cultural and spiritual relationships Karuk people have with species such as tanoak and madrone trees in the forest, or lamprey in the rivers. Fire suppression actions all too frequently cause further vulnerabilities to Karuk traditional foods, fibers and medicines. And long after fires have ceased to burn, management actions such as re-seeding, sediment control, road building and salvage logging cause further, often long term damage (Karr et al. 2004, Noss et al. 2006). Such activities create lasting impacts on the landscape by bringing in new species (i.e. invasives) that come into direct competition with culturally important Karuk species, increasing the future likelihood of high severity fires (Brooks et al. 2004), increasing sedimentation, and causing vegetation assemblage shifts. Understanding the climate-induced vulnerabilities in relation to high severity fire faced by particular species therefore requires an interdisciplinary multi methods approach that takes into consideration not only biological factors and fire science, but also traditional ecological knowledge and an understanding of the socio-political dimensions of land management in Karuk ancestral territory.

Recognizing that fire influences both individual species and landscape structure, we consider the impacts of high intensity fire on traditional foods, fibers and medicines first with a general discussion of six habitat zones, followed by single page species profiles that highlight how a given species is affected by cultural burning, versus how it is affected by high severity fire, and finally how fire related federal management decisions affect that species' vulnerability. We use a culture-centric perspective on vegetation zones centered on the cultural keystone species of Tanoaks and Chinquapin (see Garibaldi and Turner 2004 for other species). We consider Riverine and Riparian species, Low Elevation Forest (defined as the Tanoak band), Grasslands, Middle Elevation Forest (defined as the Chinquapin band), High Elevation Forest (defined as above Chinquapin but below montane zone), Wet Meadow and High Country (montane and subalpine). This culture-centric zone model corresponds to the ecological model developed by Briles et al.

(2005), but links vegetation to cultural keystone places across the landscape (Cuerrier et al. 2015).

For each habitat zone we provide a general discussion of the influences of fire in the ecology of each zone, describe potential threats in the face of increased fire severity and frequency, and discuss how the management actions of federal land managers intersect with the vulnerabilities engendered by high severity fire in the face of climate change. Where possible, these discussions are supplemented by tables to aid in organizational clarity. Information compiled in this chapter reflects a combination of Karuk traditional ecological knowledge and western science. These different habitat zones face distinct threats in light of increasing high severity fires for particular areas or the larger landscape. Some zones will 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 minimizes flooding in lower elevations, while low elevation tan oak is critical winter foraging habitat for elk who are in turn needed to sustain wolf populations. Where less information is presented or fewer species discussed, it does not mean that the zone is of lesser importance. For example, lamprey are a key food source, but have been less emphasized by western scientists, limiting information available for this profile Peterson Lewis 2009, Miller 2012). . 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 hydrological dynamics in lower elevations. The grassland zone was historically significant for a number of important species including elk, camas, brodiea and medicinal forbs. Today a majority of grasslands have disappeared due to lack of burning (see Skinner 2005), thereby impacting the depth and abundance of traditional ecological knowledge related to grassland habitats (Lake 2013). Restoring fire processes and function is in part about restoring the human responsibility to these species.

Following discussion of each habitat zone we provide an in depth profile for particular species occurring in that zone. Karuk people utilize hundreds of plants and animals for food, fiber and medicine; the species profiled here reflect only a small portion of all those that are culturally and ecologically vital, and were chosen to represent a range of elevation bands, flowering times and dimensions of vulnerability. Many of the profiled species are regalia species that are vital to traditional ceremonies. Many would be considered cultural keystone species (Garibaldi and Turner 2004). To the extent possible, each profile compiles information regarding the influence of cultural burning on the species, as well as the vulnerabilities resulting from the increasing frequency of high severity fire at three scales (during fires, in the immediate aftermath and long term). 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.

What we have outlined below is not intended to be an exhaustive, definitive list, but is instead a starting point meant to illustrate inter-species, inter-habitat, and human/fire relationships—relationships which must be understood in order to formulate a course of action. Some or all of the species listed below may be considered focal, or indicator species in future management practices, or perhaps other indicators will emerge under adaptive management principles. Regardless, the foundational premises and values underlying the ecological management principles and concerns outlined in these habitat and species profiles are of enduring relevance.

It is also important to note that while high severity fire, particularly when occurring in rapid succession, is considered a threat to the eco-cultural health of the region, it also inevitably brings with it some of the same ecological benefits that result from Karuk cultural burning. It is not fire, or even the occasional high severity fire per se, that is the problem, but the repeated occurrence of high severity fire (resulting from climate change) combined with land management practices that not only promote a cycle of increasingly frequent high severity fires, but that also have negative impacts on habitats and species of cultural importance. In this chapter, we tend to highlight the negative implications of high severity fire, while focusing on the benefits of cultural burning practices. However, there are instances in which we also note benefits that may result from high severity fire. It is possible for high severity fire to be detrimental for some habitats and species, while simultaneously benefitting other habitats or species. It is also possible for fire to benefit a species or habitat in one way, while being detrimental in a different way.

Riverine Vulnerabilities

Karuk ancestral territory encompasses 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 (Kroeber and Barrett 1960, Chartkoff and Chartkoff 1975), Salmon (coho (achvuun), spring (ishyat) and fall chinook (áama)) and other riverine species including green sturgeon (ishxíkihar), lamprey (Klamath and Pacific (akraah)), steelhead trout (sáap), river otter (pay saruk/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 (Mote et al. 2003, Barr et al. 2010). Beamish and Bouillon 1993). At the same time, local conditions within riverine and forest systems play a significant role in habitat quality and species vulnerability projections (Isaac et al. 2010). Wildfire from both human and natural ignition has been an integral component of the riverine systems in the mid-Klamath region. Fires are particularly important for shaping the local quality of riverine habitats in the face of climate trends (Hamlet 2011).

Relationships between fire and riverine habitats are complex and vary by species, fire intensity, fire severity and time frame (Isaac et al. 2010, Rieman et al. 2003)). While Karuk use of fire is often noted in relation to forest systems, cultural burning is also critical for riparian and riverine habitats (Lake 2007). 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 Piliod 2009 and 2010). 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 Biswell 1989). 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 habitat mosaic of more and less productive stream habitats (Arkle and Piliod 2009 and 2010, Davis 2016).

Fire influences on riverine systems also vary across time. During fire events reduction in vegetative evapotranspiration often increases stream flow (Biswell 1989). Larger regional or multiple local fires burning during atmospheric high pressure, coupled with river canyon smoke inversions (Robock 1988 and 1991)can be beneficial to spring salmon (see Strange 2010 for cold fronts/clouds similar to the effects of smoke). The smoke may cool river temperatures during critical warm periods, creating better conditions for various fish species and age classes, including fall migration and spawning of Chinook salmon (Lake and Tripp, personal communication, David and Lake 2016). On the other hand, high intensity fires may cause elevated stream temperatures and direct mortality of fish and other species, especially in smaller systems (Hitt 2003).

In the immediate aftermath of high intensity fires (e.g. roughly 24 months) the absence of riparian vegetation that would otherwise provide shade may elevate stream temperatures (Dwire and Kauffman 2003, Isaak et al. 2010, Pettit and Naiman 2007). Post fire debris flows may reduce fish numbers and negatively alter fish habitats (Burton 2005). Yet many of these events are short term, while longer-term impacts of fires include increases in stream productivity and beneficial changes in fish diet (Malison and Baxter 2008 and 2010). Work by Flitcrof et al. (2016) on fire and Spring Chinook habitat quality in stream networks, and work by Isaak et al. (2016, 2010) on stream temperatures examine the complex conditions in which a beneficial 'pulse' disturbance turns into a possibly less beneficial 'press' disturbance. In general, unless species are vulnerable or populations are highly fragmented, populations usually rebound successfully (Rieman et al. 2003).

Over the long run regular fire on the landscape reduces the amount of brushy vegetation (i.e. shrubs and younger vigorously growing trees) withdrawing water from creeks, which affects steam flow and thereby stream temperatures. Post-fire floods can remove fine sediments and provide much needed gravel, cobble, woody debris, and nutrients. Longitudinal studies by Burton (2005) found that fire restores stream habitats, resulting in higher fish productivities than were present pre-fire. High intensity fire in particular leads to larger debris flows and tree mortality (Gresswell 1999). The disturbance mosaic resulting from high intensity fire is like a patchwork quilt of habitats across stages of recovery. This mixed severity burned landscape releases moderated amounts of sediment and water streams through springs and seeps, improving larval habitat for species such as Pacific and Klamath Lamprey. These effects of cultural burning on the riverine system are summarized in Table 3.2 below.

Table 3.2 Effects of Karuk Cultural Burning On Riverine Systems Across Time

Immediate	2-Year	Long-Term
• Smoke from fire may block light from the water's surface and reduce water temperatures. • Reduced vegetative evapotranspiration increases stream flow	• Gravel and wood debris enters aquatic systems following fire and enriches salmon habitat • Increased system productivity as fire releases nutrients into the food chain • Reduction in brush means more water in riverine system	• Patchwork quilt disturbance mosaic provides flood protection • Forest habitat complexity is associated with riverine habitat complexity • Frequent low intensity fire prevents negative impacts of high severity fire
Sources: Soto 2016	Sources: Soto 2016	Sources: Lake 2007, 2010

Vulnerabilities Resulting from Increased Frequency of High Severity Fire

While both high and low intensity wildfires are important to the riverine systems of the mid-Klamath, less is understood about how increase in the frequency of high severity wildfire will impact riverine systems (Flitcroft et al. 2016). Extensive areas of large high severity fires burning across streams, creeks, and rivers can have negative impacts on stream temperatures and can generate fish mortality during fire events, especially in smaller systems. Frequent high severity wildfires can eliminate foliage needed for slope stabilization, leading in turn to more frequent and larger landslides and debris flows, which can degrade fish habitat in the short term by increasing temperatures and more. Aquatic species are particularly sensitive to such habitat disruptions given their dependence on clear, cold water and their limited ability to relocate (Fagan 2002).

Perhaps most importantly, increases in the frequency of high severity fires cause habitat shifts that reduce forested habitats that develop under lower frequency or mixed severity fire regimes and promote the presence of shrub and herbaceous assemblages that thrive under higher frequency fire conditions. Essentially the surrounding forest could shift to an early seral stage that has a higher risk to (re-) burns again and again, unable to return to mature forest condition (burning seed sources before re-establishment of trees). Such a shift of the forests surrounding riverine systems to brush fields would have very serious consequences for river temperatures, species composition and the structure of riverine habitats. From a physical standpoint, the complex forest structure that results from repeated mixed severity fire leads in turn to complexity of riverine habitats (Bisson et al. 2003, Perry et al. 2011). Indeed the complexity of stream habitats is directly linked to habitat complexity in the surrounding forest landscape (Bisson et al. 2003, Flitcroft et al. 2016). 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 and 2007, Perry et al. 2011, Swanson et al. 2011). In the event that forests were entirely or partially converted to brush such forested complexity would no longer exist. Water temperatures would elevate as flows dropped and less shading occurred from vegetation. Warming stream temperatures in turn enhance suitability for non-native fishes (Durham et al. 2003).

Table 3.3 Effects of Increasing Frequency of High Severity Fire in Riverine Systems Across Time

Immediate	2-Year	Long-Term
• Direct heat mortality, especially in small streams • Smoke inversions reduce vegetation evapotranspiration (water use) increasing temporary water yield. They also reduce air and water temperatures, which may benefit aquatic species	• Elevated stream temperatures in absence of vegetation • Heavy sedimentation and infilling of pools may occur as a result of flooding and other post-fire hydrologic impacts Too much sediment is not good for spawning, infilling of pools is bad for rearing.	• Riverine systems evolved with high disturbance, but if high severity disturbance events are too frequent more difficult for system to recover • Riverine systems require forest complexity (not brush fields) for stream complexity.

Vulnerabilities from High Severity Fire Exacerbated by Non-Tribal Management Actions The vulnerabilities riverine systems face in light of the increasing frequency of high severity fire must be understood in the context of actions taken by other public and private land managers prior to, during and after high severity fires. Riverine systems are already threatened in the mid-Klamath area due to existing pre-fire management actions that include a combination of dams, water diversions, water quality impairments from agricultural inputs, logging activity, fire suppression and failing roads. 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 (Gresswell 1999, Noss et al. 2006). 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. A Karuk tribal community member quoted in Peterson (2006) notes: "Ammocoetes that are in the fine mouth of these tributaries aren't getting the kind of hydrograph with the quantity and quality of water that they had historically" (p. 70). Fire suppression has also created vulnerabilities in the riverine system by leading to more frequent and extensive high severity fires (Taylor and Skinner 2003), and the associated vulnerabilities descried above.

During high severity fire events the management actions of federal and state agencies, especially the US Forest Service, may exacerbate vulnerabilities to the riverine system. Detrimental fire suppression activities such as: Fire retardants spill into springs, creeks, rivers and lakes. Road building (opening decommissioned or closed roads), creation of fire lines, safety zones or escape routes(dozer/equipment clearings) in vicinity of riverine systems, excessive felling of mature/old growth trees in riparian areas. After fires, Forest Service management actions including salvage logging sales, limited road building and replanting with conifers which affect riverine health and future high severity fire potential (Dwire and Kauffman 2003, Noss et al. 2006, Stephens and Ruth 2005). These impacts are detailed in Table 3.4 below.

Table 3.4 Effects of High Severity Fire and Intersecting Management Actions Across Time

Prior to Fire	During Fire	After Fire
• Fire suppression alters beneficial wood and gravel debris, and additional water that would normally enter streams and rivers after fire • Suppression-based practices that prohibit cultural burning prevent beneficial smoke from cooling riverine environments	• Fire retardant chemicals that enter aquatic systems may affect the survivability of Chinook salmon, particularly in earlier life stages prior to marine transition • While smoke may benefit aquatic habitat, it may be detrimental to human health • Large scale burnouts in undesirable conditions or implemented in a rushed fashion can increase fire severity	• Salvage logging takes trees that could have otherwise benefitted salmon habitat • Planting conifers in areas that are otherwise naturally reforesting increases future high severity fire vulnerability • The lack of prescription burn planning, and the planting of trees creates and "investment to protect" and perpetuates the suppression paradigm
Sources: Soto 2016	Sources: Dietrich et al. 2012	Sources: Soto 2016, Noss et al. 2006

In order to further illustrate the complex of vulnerabilities high severity fire poses for Karuk species of importance in riverine systems we provide species profiles for spring chinook salmon (áama) and Pacific lamprey (akraah).

Salmon / Ishyáˀat / *Oncorhynchus tshawytscha*
Species Profile -salmon
Pacific Lamprey (Eel) / Akraah / *Lampetra tridentata*
Species Profile -lamprey
Riparian Vulnerabilities

Riparian areas are key sites for many food, fiber and medicinal species of importance to Karuk people. Focal species include (but are not limited to) Pacific giant salamander (puff puff), aquatic garter snake (asápsuun), beaver (sahpihnîich), mink (Xanchun'ámvaanich), cedar waxwing (akravsiip), yellow-breasted chat, big leaf maple (saan), mock orange (xávish), huckleberry (púrith), horsetail (chimchîikar), and multiple willow and fern species including woodwardia (tip-tip) and five-finger/maiden hair ferns. Some of these species are also discussed under the section on vulnerabilities to 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.

Fire is an important component of riparian systems in the mid Klamath and cultural burning in the surrounding forest has key impacts on riparian habitat quality (Lake 2013). The Karuk Draft Eco-Cultural Management Plan outlines how riparian species composition, vegetation structure and hydrology are shaped by the use of fire: "Certain trees and shrubs utilize water more than others, fire affects this relationship (Fites et al. 2006). The distribution of forests, shrubs, and grasslands, affects the process of infiltration from precipitation and resultant levels of evaporation with how those plants utilized water (DeBano et al. 1998). The balance of water in and water out, leading to the amount of moisture in the soil and the quantity and quality of springs is influenced by fire (Biswell 1999:157)" (Karuk DNR 2010). Karuk fisheries biologist Kenneth Brink describes this relationship:

> We did our fire management, which enabled to put more water into the tributaries, say like on a drought year, you take all your understory out, like all these blackberries and stuff would never be here. These alders would not be all big. There might be one or two big ones making a shade instead on all these little suckers. With burning in the past, you didn't see the alder or the willow trees, you had willow brush. All this foliage takes up a lot of water.

Lower intensity mixed severity cultural burning further affects dynamics within riparian systems by releasing nutrients to the soil. Many specific riparian species of importance to Karuk people also benefit from low intensity cultural burning. For example, the Cedar waxwing (a regalia species) needs fire to maintain an open understory along riparian areas for breeding habitat. The yellow-breasted chat is is dependent on willows within cottonwood galleries along riparian sandbars at lower elevations (Lake, pers. comm. Bagne and Purcell 2011). In other cases, frequent fire is necessary to produce specific qualities in plants needed for cultural uses (e.g. straight shoots for basketry Anderson 1999). Beavers benefit from fire in that fire promotes plant species critical for the beaver diet, such as willow, and also affects riparian structure and hydrology in ways that benefit beaver habitat, for example the input of woody debris resulting from cultural burning provides material for dam construction. Beaver are in turn an important component of riparian and riverine systems for the benefits they bring to other species. For example, beaver dams benefit juvenile coho salmon by modifying the velocity, cover and depth of low gradient cold-water refugia.

Effects of Karuk Cultural Burning On Riparian Systems Across Time

Immediate	2-Year	Long-Term
• Reduced vegetative evapotranspiration increases stream flow to riparian system • Rejuvenate flood/disturbance adapted plants between flooding episodes. • Increase human and animal access to forage/post-fire growth.	• Gravel and wood debris enters aquatic systems following fire and enriching habitat for some species • Increased system productivity as fire releases nutrients into the food chain • Reduction of vigorous vegetative growth can provide more water in riparian system	• Water balance of riparian areas benefits from burning in surrounding forest • Frequent low intensity fire prevents negative impacts of high severity fire • Rejuvenate flood/disturbance adapted plants between flooding episodes. • Increase human and animal access to forage/post-fire growth.
Sources: Soto 2016, Lake 2007	Sources: Soto 2016	Sources: Dwire and Kauffman 2003

Vulnerabilities Resulting from Increasing Frequency of High Severity Fire

Moist conditions in riparian areas provide a relative degree of protection from direct mortality as compared to species in forests or grasslands, yet with high severity fires, direct mortality during fires may still occur (Dwire and Kauffman 2003). Large debris flows that occur following high severity fires may also cause direct species mortality. Serious threats to riparian areas may result if increases in the frequency of high severity fires cause habitat shifts that reduce forested habitats which develop under lower frequency or mixed severity fire regimes and promote the presence of shrub and herbaceous assemblages which thrive under higher frequency fire conditions. Such a shift of surrounding forests would have potentially serious consequences for riparian species composition, hydrology and structure. Riparian areas in the context of their landscape setting/position is also important to consider, as wide flood plain willow-cotton wood forest compared to mountain alder-maple/conifer dominated topographically steep areas (see Pettit and Naiman 2007)

Effects of High Severity Fire in Riparian Systems Across Time

Immediate	2-Year	Long-Term
• Smoke inversions reduce vegetation evapotransporation (water use) increasing temporary water yield.	• Elevated stream temperatures in absence ofwater shading vegetation • Heavy sediment from flooding	• Composition, hydrology and structure of riparian systems changed if forests become brush fields

Vulnerabilities Exacerbated by Non-Tribal Management Actions

The vulnerabilities riparian systems face in light of the increasing frequency of high severity fire must be understood in the context of actions taken by other agencies prior to, during and after high severity fires (Dwire and Kauffman 2003, Bisson et al. 2003). Riparian systems are already threatened in the mid-

Klamath area by logging, roads and fire suppression. Fire suppression intersects with climate change to increase the likelihood of more frequent high severity fires (McKenzie et al. 2004). 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 sand, and can smother salmon redds, suffocating eggs (Gresswell 1999, Rieman et al. 2003).

During high severity fire events riparian systems face additional threats from fire fighting activities (Noss et al. 2006). Road building and the use of bulldozers and the cutting of trees are allowed to occur without NEPA process as an "emergency exemption for an act of nature" 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 is increasingly characterized by proposals for salvage logging operations (Karr et al. 2004, Noss et al. 2006). Here too normal procedures set in place for water quality protections have been waived, reducing protections on riparian systems.

Effects of High Severity Fire and Non-Tribal Management Actions Across Time

Prior to Fire	During Fire	After Fire
• Riparian systems already vulnerable due to past actions including dams, water diversions, logging, road building and fire suppression • Increased fuel loading increases risk of higher intensity/severity burning.	• Fire retardants enter aquatic systems • Use of bulldozers, other motorized equipment and large diameter tree falling allowed in riparian area without NEPA process • Logging (tree felling), road building (fire line and water access construction) allowed in riparian area without NEPA process	• Salvage logging, road building leading to sedimentation • Salvage logging, and re-seeding with conifers increase future potential of high severity fires • Reduced ecological connectivity from lowlands to higher elevations
Sources: Dwire and Kauffman 2003	Sources: Noss et al. 2006	Sources: Karr et al. 2004

To illustrate the threats high severity fire poses 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.

Pacific Giant Salamander / Púfpuuf / *Dicamptodon tenebrosus*
salamander
Aquatic Garter Snake / Asápsuun / *Thamnophis atratus*
garter-snake
Beaver / Sahpihnîich / *Castor canadensis*
beaver

Yellow-Breasted Chat / *Icteria virens*
chat
Low Elevation Forest: Tanoak Zone Vulnerabilities

Lower elevation forest habitat (roughly 500-3,000') within Karuk ancestral territory and homelands is characterized by the presence of tankoak 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 fungi: tanoak mushrooms (xáyvi’ish, commonly known as matustake), black trumpets, hedge hogs, fang, and other mushrooms (see Anderson and Lake 2013), herbs:princess pine (xunyêepsurukhitihan), Oregon grape, Yerba Buena-mint, shrubs: huckleberry (púrith), California hazel, mock orange, service berry, ceanothus, ocean spray; trees-, black oak, port orford cedar, California bay (pahiip), canyon live oak (xanputtin), madrone (kusrippan), ponderosa pine (ishvirip), white oak (axveep); animals: pileated woodpecker (iktakatákkahe’en), black-tailed deer, fisher, coyote (pihneefich), black bear (virussur), ringtailed cat (tapukpuukanach), gray squirrel (axruuh), and the winter range of elk (íshyu’ux).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, Halpern 2016, Karuk DNR 2010, Martinez 1995, Lake 2007 and 2013, McCarthy 1993). Frequent fires limit the encroachment of competing shrubs and conifer species (Turner et al. 2011, Perry et al. 2011). Low intensity fire favors oaks over conifer species in part because oaks can re-sprout and thereby reestablish after fires (Hosten et al. 2006, Cocking et al. 2012. By contrast, competing species such as cedar, fir and pines reproduce with seedlings that will burn up (Plumb 1981). The open structure of these forests is important for many other species including madrone, white and black oak, 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, p. 152). At the larger scale, traditional burning at multiple fire frequencies promotes a mosaic of vegetation types in different stages of response to fires. This diversity of food species in multiple phases across the landscape supports food security for Karuk people (Busum 2006, Kimmerer and Lake 2001, Lake 2013). The frequent use of low intensity fire is especially important for overall stand structure given that tanoak trees are quite vulnerable to high severity fire (Bowcutt 201, McDonald and Vaughn 2007). Stands that are clear of underbrush can be burned again with lower risk of damaging mature oaks. Fire exclusion has reduced 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, re ecotones of oak-dominated habitats with more forested or grasslands, see Lake 2013).

Frequent burning also affects the water dynamics within low elevation forests. These relationships between brush, conifer reduction and groundwater are also of critical importance to species in the riverine and riparian zone. Low intensity fire breaks down organic matter, releasing nutrients to the soils where they become available for plant use. Tanoak mushrooms also have a symbiotic relationship with tanoak trees and other species including huckleberry (see Anderson and Lake 2013 for Karuk tanoak forest uses) and make nutrients available across species through their mycorrhizae.

In addition to the importance of frequent low intensity fire for the overall forest structure, frequent use of fire benefits many species in this zone directly (Skinner et al. 2006). McCarthy (1993) writes "In addition to promoting a variable distribution of oaks in the woodland community, the use of fire may positively affect individual trees and their yield" and quotes Scheneck and Gifford (1952) in noting that "Karuk women reported that the trees are better if they are scorched by fire each year. This kills disease and pests" (p. 221). Burning around trees enhances their health and the quality of acorns by reducing populations of filbert weevil and filbert worms (Halpern 2016).. Elk who especially use low elevation tanoak forest in winter, have been described as a "fire-follower" as they benefit from the effects of fire on their food sources (Patton and Gordon 1995). Elk in particular prefer a mosaic landscape that combines open areas for foraging, and forested areas for cover (Long et al. 2008). Pileated woodpecker benefit from the presence of intermediate scales of mixed severity burn patches across the landscape that foster nesting, roosting, and foraging habitats (Bull et al. 2007, Hartwig et al. 2004). Regular burning benefits tanoak mushrooms by minimizing forest duff. This protects the mushroom's mycelium that can otherwise encroach into the duff where it becomes vulnerable to fire (Anderson and Lake 2013). Burning of the mycelium affects not only the mushroom itself, but the nutrient transfer system between tanoak trees and other species including huckleberry (Lake pers. comm., Anderson and Lake 2013). However, for the tanoak mushrooms, cultural burning is a more secondary benefit in that burning benefits the other species with whom the mushroom is a functional cohort. For example, once tanoaks reach 16-18 inches in diameter the production of mushrooms around them increases (Lake 2007).

Effects of Karuk Cultural Burning on Low Elevation Tanoak Forests Across Time

Immediate	2-Year	Long-Term
• Kills encroaching smaller diameter younger conifers • Reduces brush and understory fuel loaing • Promotes grove and acorn health by periodically reducing predatory insect populations • Releases nutrients to system	• Healthy tanoak groves sustained by low intensity fires sustain other culturally vital species and ecosystem health • Increase deer and elk forage quality for understory shrubs, forbs, grasses and ferns.	• Resource patch mosaic leads to food security • Frequent burning prevents high severity fires
Sources: Karuk DNR 2010	Sources: Bowcutt 2013	Sources: Bowcutt 2013

Vulnerabilities Resulting from Increasing Frequency of High Severity Fire
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 poses serious vulnerabilities for this forest type (Bowcutt 2013). High severity fire creates vulnerabilities for individual species and for stand dynamics as a whole. Harrington (1932) quotes "a Karuk woman" "the tanoak is not good when it is burned off, the tree dies. When they are burning, they are careful lest the trees burn (p. 65)." While tanoaks are able to re-sprout after low intensity fire, their thin bark makes them highly susceptible to damage or mortality from hot (higher temperatures and durations of heat) fires. During high intensity or high severity fires the thin bark of this species may heat up and burn quickly leading to damage and scarring of the inner cambium and in turn cause disease and heart rot (see McCarthy 1993 she also cites Plumb and Gomez 1983). Tanoak trees produce a thick smoke when burning which is reported to have negative human health impacts (Lake pers. comm.). High severity fire events may also cause direct mortality to tanoak mushrooms ifreproductive mycelial mats are damaged. 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.

Ultimately the greatest vulnerability from the increasing frequency of high severity fire would occur in the event that tanoak stands (e.g. tribal food orchards) become ceanothus brush fields rather than mixed hardwood woodlands. With repeated very hot fires the structural integrity of tanoak stands might be destroyed. Given that many of these species depends on moisture and cool temperatures provided by shade from larger trees there is concern that high severity fire over time could reset (shift to an alternate vegetation state) the entire system, leading to the replacement of these important food and cultural use species to brush and chaparral. Tanoak stumps may sprout back as a large number of shrubby sprouts that do not produce cover needed to support shade tolerant species such as huckleberry. Without understory these brush stands lack microsite diversity. Brush fields may have be grassy component that can also cause the stand to burn more frequently preventing the return of mature larger diameter, trunked trees. If entire tanoak stands are destroyed by high severity fire, the many other species with which they are interdependent including tanoak mushrooms would in turn also be unable to repopulate given their symbiotic relationships with the oaks.

Effects of High Severity Fire in Low Elevation Forests Across Time

Immediate	2-Year	Long-Term
• Direct mortality of many species including tanoaks • Tanoaks produce thick smoke that is hazardous to human health	• Loss of snags and logs that form habitat for woodpeckers and others	• Lack of microsite diversity • Repeated burning at high severity keeps mature forest from developing • Loss of forests and associated species

Vulnerabilities Exacerbated by Non-Tribal Management Actions

Vulnerabilities to species in the tanoak forest zone in light of high severity fire are magnified by the actions of other agencies prior to, during and after high severity fire events, see Table 3.5 below. Low elevation tanoak forests within Karuk ancestral territoryhave been significantly impacted by the past 100 years of fire exclusion (Skinner et a 2006). Fire exclusion has led to a buildup of fuels and "dramatic increase in the likelihood of high severity fires (Taylor and Skinner 2003). During fire events tanoak stands may be subject to destruction through 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 not the target species).

Table 3.5 Effects of High Severity Fire and Non-Tribal Management Actions Across Time

Prior to Fire	During Fire	After Fire
• Fire exclusion and logging increase risk of high severity fires • Increased fuel loading increases fire risk and ignition potential	• Fire suppression activities including fire lines, cutting of snags and back burning kill tanoaks, madrones and other species of central importance	• Salvage logging damages these forest stands
Sources: Bowcutt 2013	Sources: Bull et al. 2007	Sources: Bull et al. 2007

In order to further illustrate the complex of vulnerabilities high severity fire poses for Karuk species of importance in this elevation zone we provide species profiles for tanoak (xunyêep), tanoak mushrooms (xáyviish), elk (íshyuux), huckleberry (púrith), and pileated woodpecker (iktakatákaheen).

Tanoak / Xunyêep / *Lithocarpus densiflorus*
tanoak
Tanoak Mushroom / Xáyviish / *Tricholoma magnivelare*
mushroom
Roosevelt Elk / Íshyuux / *Cervus occidentalis*
elk
Evergreen Huckleberry / Púrith /*Vaccinium ovatum*
huckleberry
Pileated Woodpecker / Iktakatákaheen / *Hylatomus pileatus*
woodpecker
Wolf / Ikxâavnamich / *Canis lupus*
wolf
Grassland Vulnerabilities

Grasslands also known as prairies historically occurred in mid to upper montane areas on ridges, in both large and small patches up to elevations of 3,280 feet, especially on shallow ultramafic soils (Anderson 2005, Skinner et al. 2006). Today a majority of the grasslands that once existed within Karuk ancestral territory have disappeared due to lack of fire (Skinner 1995, Lake 2013). Traditional. Traditional Karuk knowledge about grasslands has unfortunately also been lost. Yet 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 (Swanson et al. 2014). Amongst these are important Karuk foods and cultural use species such as Elk, Iris and other grasses used for twine, and a group of geophyte plants known as “Indian potatoes” which include multiple members of the Lilly family, Blue Dicks, White Hyacin, Golden Lantern, Soap Root, Yellow Globe Lilly (Lanctot and Lake ND, Anderson 2005, Schenk and Gifford 1952). Anderson (2005) notes the importance of prairies and grasslands for Indian people across California and lists a number of species of importance in these areas:

> “Among the important grass species in California’s coastal prairies were Idaho and red fescues (Festuca idahoensis and F. rubra), California oatgrass (Danthonia californica), and bent grass (Agrostis exarata). Characteristic broad-leaved species were Douglas iris (Iris douglasiana), California buttercup (Ranunculus californicus), and blue-eyedgrass (Sisyrinchium

> bellum). Other species were yampah (Perideridia kelloggii), goldfields (Lasthenia spp.), and tidy-tips (Layia platyglossa). . .

Anderson goes on to note the significance of the diversity of these grassland habitats:

> California's coastal prairies provide a good, well-researched example of how native practices promoted vegetational heterogeneity and high biodiversity. According to the ecologist Mark Stromberg, "The coastal terrace prairies in California and Oregon are the most diverse grasslands in North America. If you count the number of species in a square meter of California's coastal terrace prairie you average 22.6 species—more than the inland prairies of the Midwest, which have between 8 and 12 species" (pers. comm. 2001). (66)

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 geophytes 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, 167). Local traditional knowledge of geophytes was emphasized by Harrington: "But they (Karuk People) knew indeed that where they dig cacomites (bulbs/corms) all the time, with their digging sticks many of them grow up, the following year many grow up where they dig them. They claim that by digging Indian potatoes, more grow up the next year again. There are tiny ones growing under the ground, close to the Indian potatoes" (Harrington 1932:73).

Vulnerabilities Resulting from Increasing Frequency of High Severity Fire
While burning is essential for grassland habitats, high severity fire has the potential to scorch soils. Former prairie-grasslands that have been encroached and colonized by trees develop higher carbon-rich biomass that can burn with detrimental effects to soil productivity. Frequent lower to mixed-severity fires that gradually reduce fuel loading can buffer negative impacts to soil (Neary et al. 1999). The anticipated effects of climate change

on prairie ecosystems involved synergistic distrubances from management and ecological processes (Bachelet et al. 2011).

Vulnerabilities Exacerbated by Non-Tribal Management Actions

Probably the main intersecting vulnerability to grasslands comes from their severely reduced range due to fire exclusion (Skinner 1995). Grasslands are a threatened ecosystem type due to fire exclusion. 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). To illustrate the vulnerabilities high severity fire poses for Karuk species of importance in grasslands we provide a species profile for Indian potato (tayiith).

Indian Potato / Tayiith / Brodiaea coronaria

Indian potato

Middle Elevation Forest: Chinquapin Band Vulnerabilities

The middle elevation chinquapin forest habitat (roughly 2,500 to 3,500') 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 (axvê'ep), live oak (xanpúttip), yew (xupári'ish), port orford cedar (check elevation)   (kúpri'ip), pacific fisher (tatkunuhpíithvar), and black tailed deer (púufich), prince's pine, ponderosa pine (ishvirip), Douglas fir (itharip), hazel (surip/aththip), incense cedar (chuneexneeyaach), huckleberry (púrith), 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, Fryer 2007, Lake 2013, Lake and Long 2014, Long et al. 2016, Morgan and Sheriff 2012). The composition and structure of these middle elevation forests are fire adapted (Skinner et al. 2006). McCarthy (1993) writes that "Black oaks in particular would not have either their present distribution or their frequency with fire, and studies have shown that fire begun by natural causes (i.e. lighting) would not have occurred frequently enough to create that disturbance" (p. 220).

Middle elevation forests with black and other oaks, chinquapin, Douglas fir, hazel, and gooseberry would traditionally be burned as frequently as every 5-7 years (Lake pers. comm. based on Skinner unpublished studies, see also

Pullen 1996 for Karuk burning).). Black oak acorns in particular are food for a variety of wildlife and the trees provide valuable pacific fisher denning habitat (North 2012, Long et al. 2016). Karuk management created a system of temporally staggered “resource patches” in the landscape. Burning promotes the production of a series of resources in the stand over time (Lake 2013). The first spring after fires generates a lush re-sprout of forbs and greens that in turn draw in deer and quail for hunting. As grasses become outcompeted over time, another set of foods and medicines becomes available; this next series of plants draws in a new set of associated species to the forest patch. Two years after the fall burning will be good for the production of basketry materials, after 3 years black cap raspberries will begin fruiting again, whereas bracken fern comes in after 7 or 8 years. At this point the acorns begin to get buggy and the burning cycle is ideally repeated (see Aubrey in Lake 2007 about cultural burning and food plots). In the absence of fire, however, the middle elevation chinquapin forest band is susceptible to encroachment by shade-tolerant conifers (Stuart and Salazar 2000).

Individual species in the chinquapin forest zone also benefit from the frequent occurrence of lower intensity fire. Karuk cultural burning sought to optimize berry production. For example the roughly ten year Karuk burning cycle keeps huckleberry into an optimal intermediate disturbance phase that maximizes production and cover (Lake, pers. comm.). In the absence of fire conifers compete with the oaks for resources. Conifers not only increase fuel loads within the stand, they reduce the crown openings needed for robust oak or other hardwood mast production (Cocking et al. 2012). Chinquapin is dependent on frequent disturbance to retain a competitive foothold in the forest (OWIC II 2016). Animal species in this forest type are also fire dependent. Black-tailed deer depends on a mosaic of burned and unburned habitat (Innes 2013), and pacific fisher benefit from burned landscapes for tribal hunting and foraging (Hanson 2013, Long et al. 2016).

Effects of Karuk Cultural Burning Across Time

Immediate	2-Year	Long-Term
• Burning releases nutrients to soil • Pests are eliminated via low intensity burns that protect acorn-bearing adults • Burning promotes the production of a series of resources in the stand over time. • Reduction of brush increases water to streams	• Cultural burning creates viable conditions for black oak reproduction either via root crown sprouting or acorn seeding, both processes which benefit from fire • Black-tailed deer depends on a mosaic of burned and unburned habitat • Pacific fisher benefit from burned landscapes for hunting and foraging	• Competition from shade tolerant coniferous saplings is eliminated via routine burning, allowing oak stands to endure • Frequent low intensity fire protects mid elevation stands from high severity fire
Sources: Anderson 2005	Sources: Fryer 2007, Hanson 2013	Sources: Fryer 2007

Vulnerabilities Resulting from Increasing Frequency of High Severity Fire

While this forest band is fire-dependent, stand dynamics and individual species in this forest type face vulnerabilities in light of the increasing frequency of high severity fires. A few species such as deer benefit from high severity fires, when the proportion or extent of burn severities (low to high) are diverse. 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). Fisher dens and denning habitat can be decreased when hardwoods are burned or fall down and no longer suitable habitat.

Vulnerabilities Exacerbated by Non-Tribal Management Actions

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 fire resistant diameters with thick enough bark or structure 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. Fire fighting tactic of “burning out” along the fire lines creates areas of very high severity fire (Lake pers comm as Resource Advisor). Timber fallers often intentionally cut chinquapin and black oaks considered “hazard trees’ during fire suppression activities preemptively because they may have cavities in which fire can ignite and then pose a threat to the fire line control capacity. However such cavities are important habitat for pacific fisher (Long et al. 2016). Black oaks snags are also often fallen with fire line construction activities. 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, or literally being burned out of animal safe sites of interior unburned portions of the larger wildfire. To further illustrate the complex of vulnerabilities high severity fire poses for Karuk species of importance in this elevation zone we provide species profiles for chinquapin (sunyíthih), black oak (xánthiip), Pacific fisher (tatkunuhpíithvar), black-tailed deer (púufich), and porcupine (kaschiip).

Chinquapin / Sunyíthih / *Castanopsis chrysophylla*

chinquapin

Black Oak / Xánthiip / *Quercus kelloggii*

black-oak

Pacific Fisher / Tatkunuhpíithvar / *Pekania pennanti*

fisher

Black Tailed Deer / Púufich / *Odocoileus hemionus*

deer

Porcupine / Kaschiip / *Erethizon dorsatum*

porcupine

High Elevation Forest Vulnerabilities

High elevation forest are defined here as those existing above the chinquapin band (note however that the shrub form chinquapin may be found at these elevations -but is this non-producing?). Like their lower elevation counterparts, the high elevation forests within Karuk ancestral territory 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" (p. 175). Karuk foods and cultural use species occurring in this forest type include the Sugar Pine, Port Orford Cedar, Incense Cedar, Green Leaf Manzanita, Saddler oak, Gooseberry, Black Cap Raspberries, Trailing Black berries, Lilies (tiger/Cascade lilies) and Beargrass (which especially occurs towards coast where has fog). Wolf (ikxâavnamich) is also important here.

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 (Hummell et al. 2012).

Vulnerabilities Resulting from Increasing Frequency of High Severity Fire
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 bear grass rhizomes (Hummel et al. 2012). 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 increases future fire severity (Fettig et al. 2013). In the longer-term aftermath of multiple high severity fires, there is risk of loss of these forest types to brush fields (Donato et al. 2009). With repeated high severity fires brush and down woody material can hinder Sugar pine reestablishment and increase risk of repeated high severity fires. Diseases such as white pine blister rust, coupled with fire exclusion also threaten the persistence of sugar pines (van Mantgem et al. 2004).
Vulnerabilities Exacerbated by Non-Tribal Management Actions
Fire fighting tactics themselves have particular 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., obs READ experience). If salvage logging takes place after fires, Sugar pines are often targeted as economically valued species (Sessions et al. 2004).

Sugar Pine/ Ússip / *Pinus lambertiana*
sugar-pine
Bear Grass / Panyúrar / *Xerophyllum tenax*
bear-grass
Wet Meadow Vulnerabilities

Karuk ancestral territory contains a number of higher elevation wet meadow systems which are both critical habitat for species and important for hydrologic, ecological and fire dynamics in lower elevations (below the meadows). Wet meadows are found scattered throughout the higher elevation forest and high country. Important species occurring in wet meadows include black bear, elk and deer (summer), trailing blackberry, Mariposa and Panther lilies, Wild Turnip, and multiple kids 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 meadow systems are dependent upon ignitions from human and natural sources (Dwire and Kauffman 2003, Turner et al. 2011, Lake and Long 2014). In the absence of fire, the encroachment of conifers leads to a cycle in which the water table to drop 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, true fires (Abies spp) and other hardwood trees which were kept out before, continuing a cycle of transition away from the meadow system (Halpern et al. 2010). Numerous wet meadows within Karuk ancestral territory 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.

Vulnerabilities Resulting from Increasing Frequency of High Severity Fire
Wet meadow systems under various climatic regimes, generally are relatively protected from fires due to site moisture (soil and live vegetation). 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 has the potential to cause direct mortality to species. Historically, fire occurrence

at higher elevations was controlled by biophysical parameters (slope position, aspect, soil types, topography) and the fuel loading receptive to ignition and fire spread. Tree and shrub encroachment into meadow can alter the fuel load properties in the soil and above. High severity fires which burn from the forest to meadow transition can increase the depth and persistence of higher severity more lethal fire effects to species associated with meadow habitats

Vulnerabilities Exacerbated by Non-Tribal Management Actions
Probably the main intersecting vulnerability to wet meadows comes from their severely reduced range due to fire exclusion since wet meadows are a generally threatened ecosystem type. Other climate related drivers such as changing patterns of precipitation and temperature are however likely more dominant threats to these systems than the increasing frequency of high severity fires per se.

Leopard Lily / Mahtáyiith / *Lilium pardalinum ssp. Wigginsii*
Leopard Lily
High Country Vulnerabilities

High country is defined as montane and into the subalpine zone where sugar pines drop out (see Taylor et al. 2006). Although the high country may have fewer species used directly for food, fiber and medicine than areas lower down, this habitat zone is nonetheless 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. The high country is key for Karuk cultural and spiritual activity Chartkoff 1983, Wylie 1976). Especially during summer, families and individuals journey from lower elevation zones to harvest and process foods, materials and medicines, to hunt, fish, and pray. Fires are set on Offield mountain (Ma' and Sa'Tue'yee [upper and lower mountain peaks] in particular as part of World Renewal ceremonies in late summer (Kroeber and Gifford 1952). Foods, fibers and medicines of particular importance to Karuk people occurring in the high 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."

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.

Increasing Frequency of High Severity Fire: Vulnerabilities to High Country
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 (Olson et al. 2012). The high country is also vulnerable in light of other climate impacts, especially extended drought and the loss of snow given trends towards greater percentage of precipitation falling as rain (Olson et al. 2012).

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