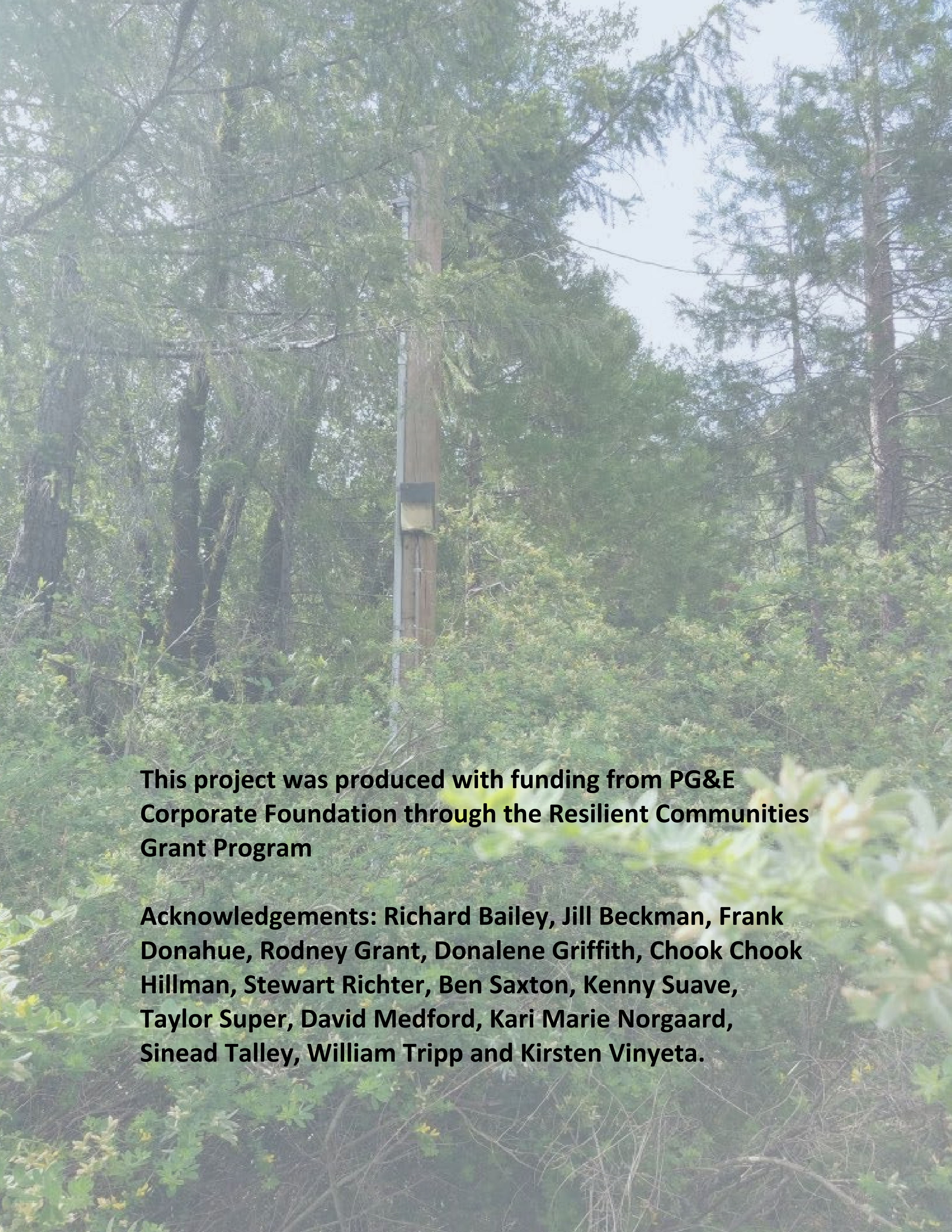
Electrical Ignitions, Wildfire Risk and Community Climate Adaptation in Northern California

PG&E Resilient Communities
August 2018

Karuk Tribe Department of Natural Resources



This project was produced with funding from PG&E Corporate Foundation through the Resilient Communities Grant Program

Acknowledgements: Richard Bailey, Jill Beckman, Frank Donahue, Rodney Grant, Donalene Griffith, Chook Chook Hillman, Stewart Richter, Ben Saxton, Kenny Suave, Taylor Super, David Medford, Kari Marie Norgaard, Sinead Talley, William Tripp and Kirsten Vinyeta.

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Executive Summary

Statewide, California is the hottest and driest since modern record keeping has taken place (Mann and Gleick 2015). Among the most pressing dimensions of climate change in California and the mid-Klamath region specifically is the increased frequency of high severity fire. In this remote mountainous region, powerlines are fundamentally related to community climate resilience. On the one hand, distribution and service lines, transformers and other electrical equipment are a leading cause of wildfire ignitions. At the same time, the protection of critical infrastructure in the form of functioning power lines is vital for emergency services, air conditioning, air filters, phone and internet communication systems. The growing frequency of large fires in the Klamath region also have important impacts including the environmental justice vulnerabilities of the community, local cultural and economic impacts, and the fact that the resulting large fires generate significant carbon emissions. This collaborative mitigation strategy increases disaster resilience in a remote rural mountain area. Fires in the Klamath region tend to be much larger before they can be contained, generating impacts across a multi-state region. For this reason, the suppression costs and PG&E liability potential for wildland fires in the area are enormous. Climate adaptation, fuels reduction, cultural revitalization, liability reduction and economic employment go hand in hand through this replicable mitigation strategy which utilizes a combination of western science and traditional Karuk fire knowledge to establish 104 proposed treatment and prescribed fire units totaling 4,862acres along 41 miles of PG&E distribution lines in the Klamath River corridor near the communities of Orleans and Somes Bar California in the heart of Karuk Aboriginal Territory.

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Across California high intensity wildfires are increasing in frequency and size. This more frequent occurrence of larger, hotter fires is the combined effects of nearly a century of fire suppression and the changing climate. In the Klamath-Siskiyou region of northern California ongoing and future impacts of climate change include changes in precipitation patterns, increasing droughts, increasing frequency and severity of wildfires, and disease and pest outbreaks (Butz et al. 2015, Garfin et al. 2014, Mote et al. 2014). Among the most pressing dimensions of climate change in the study area is the increased frequency of high severity fire (Lenihan et al. 2008, Steel et al 2018). Although the increasing frequency of high severity fire poses many direct and indirect dangers to the local communities, there are also opportunities for proactive action to reduce and mitigate the negative effects. Tribes have been key leaders in responding to climate change through both so-called mitigation —efforts to stop further climate change— and adaptation — developing responsive measures for coping with the unfolding ecological and atmospheric changes. This mitigation strategy for securing community fire safety is one such example.

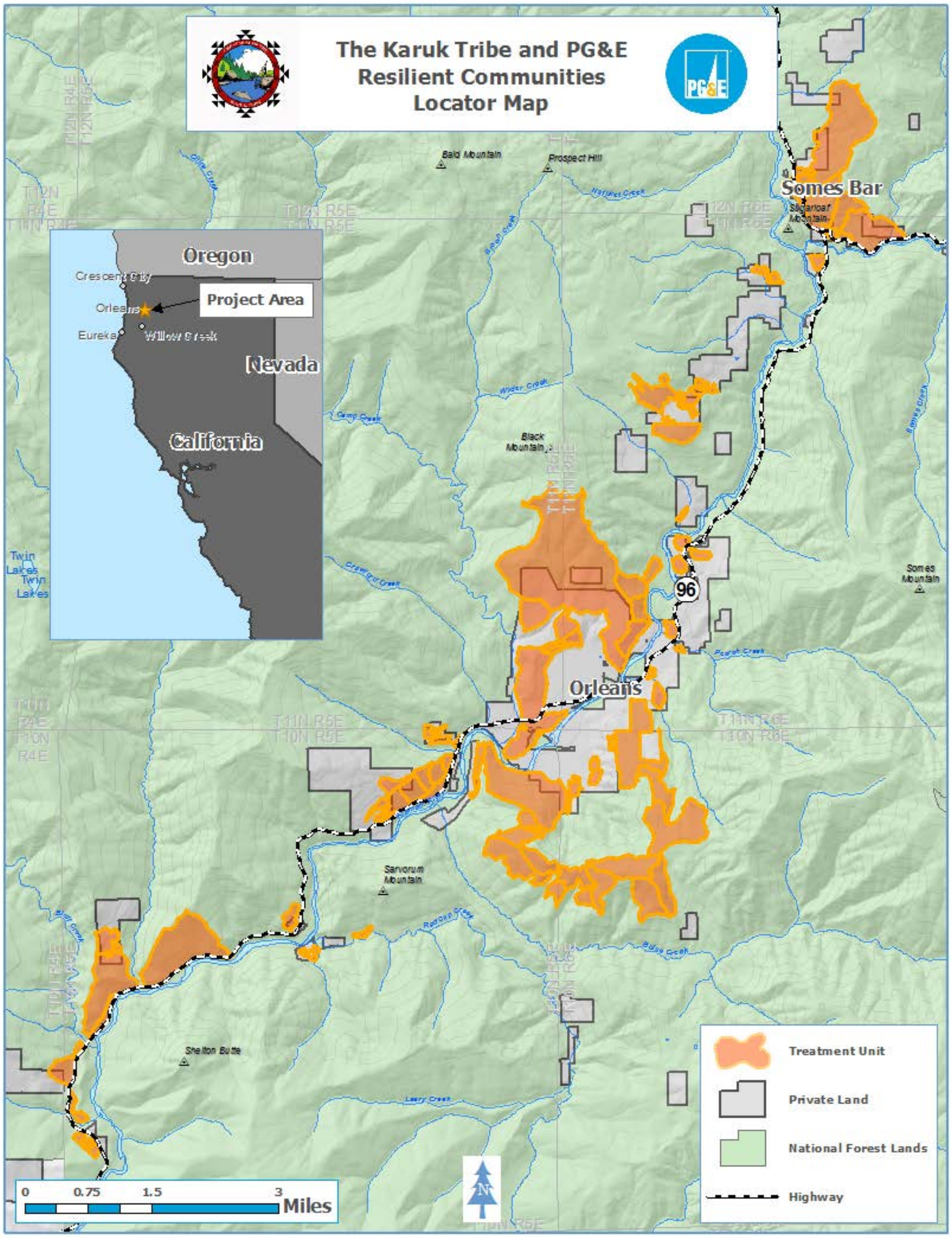
This collaborative mitigation strategy increases disaster resilience in a remote rural mountain area through preventative application of prescribed fire along key areas with high ignition risk. Electrical infrastructure including distribution and service lines and transformers are a leading cause of wildfire ignitions (Penn 2017). Furthermore, there is growing evidence that wildfires caused by power lines and other electrical infrastructure are amongst the most destructive (Collins 2016, Riordan 2014, Miller et al 2017). At the same time, the protection of critical infrastructure in the form of functioning power lines is vital for emergency services, air conditioning, air filters, phone and internet communication systems. Climate adaptation, fuels reduction, liability risk reduction, cultural revitalization and economic employment go hand in hand through this mitigation strategy which utilizes a combination of western science and traditional Karuk fire knowledge to establish 104 proposed treatment and prescribed fire units totaling 4,862 acres along 41 miles of PG&E distribution lines in the Klamath River corridor.

This collaborative mitigation strategy increases disaster resilience through preventative application of prescribed fire in areas with high ignition risk

Site Description: The People and the Place

Karuk Aboriginal Territory includes an estimated 1.048 million acres, in the mid-Klamath River region of northern California, see Figure 1.

Figure 1 Karuk Tribe Locator Map



Karuk people have lived in this place since time immemorial. The Klamath-Siskiyou region is a high point of California's renowned biological diversity -- with numerous endemic amphibians, fish and flowering plants, an abundance of lilies and some of the highest diversity of conifer species to be found worldwide. At the same time, with one third of households earning $20,000 or less for a family of three, and one quarter of households earning less than $10,000/year, Karuk people may be the most disadvantaged community that PG&E serves. Vulnerabilities faced by the Karuk Tribe in the context of high severity wildfire occur in the context of existing susceptibilities, as well as the past, present and future management actions of non-Tribal land managers such as PG&E.

Karuk People have historically used fire for millennia. The passage of the Weeks Act in 1911 following the Big Burn of 1910, made cultural uses of fire essentially illegal and for the many decades following, less and less burning occurred while more and more vegetation grew. Electrical infrastructure is a relatively new factor in Karuk country, with many residents still without a grid connection. Through fire exclusion, the culmination of federal and state law, policy regulation and management practice have significantly contributed to the site conditions upon the greater landscape, while the climate gets warmer and dryer. This is exacerbated by the fact that fire cause remains attached to the ignition while not including the culmination of factors leading to the condition at the time of the event.

The Karuk Tribe is a leader in the Western Klamath Restoration Partnership – a collaborative that is using traditional ecological knowledge and the cultural use of fire to promote community and forest resiliency. This mitigation strategy is part of that effort.

Native American tribes face amongst the most significant climate impacts. The 2014 National Climate Assessment describes how tribal climate impacts are "compounded by a number of persistent social and economic problems," and indigenous adaptive responses "occur against a backdrop of centuries-old cultures already stressed by historical events and contemporary conditions" (Bennett et al. 2014, p. 298). Karuk people may or may not be the most disadvantaged community PG&E serves, but they are likely amongst the proactive with respect to fire prevention. While many are aware of the disadvantages Indigenous people face, there is less awareness of how Native people are leading the way in climate adaptation. On the Klamath, the Karuk Tribe has been a leader in the Western Klamath Restoration Partnership (WKRP) – a collaborative that is using traditional ecological knowledge and the cultural use of fire to promote community and forest resiliency. This mitigation strategy is part of that effort.

Climate Change and Fire in the Mid-Klamath Region

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

Figure 2 Acorns and Huckleberries Harvested in an Area Burned by Prescribed Fire


Photo Credit: Stormy Staats

While fire is a central component of Karuk management and culture, increased frequency of high severity fire poses particular and unique risks to specific Karuk tribal foods and cultural use species on the one hand, and to broader Tribal programmatic goals and activities on the other. Karuk foods, medicines and fibers are embedded within cultural, spiritual, economic and political systems -- the loss of acorn groves that have been family gathering sites for generations is much more than an economic impact.

The Klamath Basin has experienced a progressive increase in high severity fire in recent years as a result of both climate change and past and present land management practices that have led to increased fuel loads (Odion et al. 2004, Miller et al. 2009 and 2012, Steel et al 2018, Taylor and Skinner 2003). On the one hand, fire exclusion and suppression practices, combined with forest management activities (e.g. harvesting older forest, establishing plantations), have increase the density of trees, shrubs, and fuel loading (Odion et al. 2004). Statewide, California is the hottest and driest since modern record keeping has taken place (Mann and Gleick 2015). Climate change, in the form of changes in precipitation (i.e. drought) coupled with increasing temperatures, the spread of forest pathogens and species invasions has increased the susceptibility of California forests to an increasing frequency of higher severity fires. Former frequent mixed-severity fires maintained a bio-physically

The combination of a century of fire exclusion, the presence of even-age highly fire prone tree 'plantations,' post logging brush fields, and changing patterns of temperature and precipitation have led to a series of very large, hot fires within Karuk Aboriginal territory and homelands

mediated diverse landscape of different vegetation types and seral stages. Today, the combination of a century of fire exclusion, the presence of even-age highly fire prone tree 'plantations,' post logging brush fields, and changing patterns of temperature and precipitation have led to a series of very large, hot fires within Karuk Aboriginal territory or homelands (Miller et al 2012, Odion et al. 2004). Fires in the Klamath region tend to be much larger before they can be contained, generating impacts across a multi-state region. For this reason, the suppression costs and PG&E liability potential for wildland fires in the area are enormous.

Species invasions are another dimension of the changing climate that interacts with both the changing patterns of precipitation and temperature, and increasing frequency of high severity fires. Among the most concerning invasive pathogens is *Phytophthora ramorum*, which causes Sudden Oak Death (Ortiz 2008, Voggesser et al. 2013). This pathogen has destroyed millions of oak and other trees, and has caused twig and foliar diseases in additional plant species across California since the 1990s. Sudden oak death and other lethal invasive forest pathogens hold the potential to increase fire danger in coming years. However, there is some evidence that cultural burning and prescribed fire may prevent infection (Moritz and Odion 2005). The Karuk Tribe completed a fire focused climate vulnerability assessment that describes significant risks for Karuk traditional foods and cultural use species, tribal program capacity and management authority during and after high-severity fires. The Karuk Tribe's Climate Adaptation Plan is currently in development.

Climate Vulnerability in Remote Communities

The Karuk community is remote with high poverty, food insecurity and limited infrastructure. Karuk Aboriginal Territory is mountainous with the primary travel routes and only thoroughfare roads entirely constricted to the Klamath and Salmon River corridors. Climate impacts in the form of an increasing frequency of high severity wildfire has the potential to negatively impact infrastructure provided by other entities such as roads, electricity and water systems. Remote communities are uniquely vulnerable in the context of climate change for a number of reasons. In such communities dispersed populations live in greater distances from emergency services, and individual road closures may completely cut off travel access. Furthermore, low population numbers lead many agencies to prioritize other regions for emergency services, and routine maintenance, further exacerbating rural community vulnerabilities.

The Karuk tribal functions take place within a complex infrastructural context that includes power supplied by Pacific Gas and Electric in the Orleans and Somes Bar communities, and Pacific Power in Happy Camp, water systems supplied by local utilities (Orleans and Happy Camp), phone lines from Siskiyou Telephone and private satellite carriers, and highway maintenance by CalTrans and Siskiyou and Humboldt counties. In addition, the US Forest Service operates hundreds of miles of dirt roads in the region. Homes and structures along 60 highway miles of Karuk Aboriginal territory are entirely off the grid.

Community residents and Karuk tribal capacity alike are often significantly impacted by loss of power and disruption in transportation routes.

Community residents and Karuk tribal capacity alike are often significantly impacted by loss of power and especially by disruption in transportation routes. The function of tribal programs also requires reliance on infrastructure, including roads and utilities (water, power, telephone, internet), most of which are supplied by non-tribal entities as noted above. For example, when it comes to communication, many households lack either landline telephones or cellular service. These households may rely on satellite phones or voice-over-internet systems or other means of wireless communication that become nonfunctional with a power outage. Whereas populations in urban areas have multiple alternatives which serve as "redundancy" should power be lost, rural communities are entirely dependent on electrical availability for communication. Transmission infrastructure is thus even more critically important for energy delivery, emergency services and tribal government functionality in this community, as outlined in Table 1 below.

Table 1 Transmission Infrastructure: Functions, Structures and Populations (adapted from the California Adaptation Planning Guide Sensitivity Checklist)

Functions	*Structures*	*Populations*
Energy delivery **Emergency services** **Government continuity**	Residential Government Commercial	Seniors Children Individuals with disabilities, who are chronically ill and/or compromised immune systems People without access to car, telephone or transportation

Because these communities have smaller population sizes they often receive lower prioritization for roads, communication and other forms of infrastructure maintenance, including PG&E corridor maintenance. These conditions underscore the increasing need for collaboration and consultation across tribal and non-tribal jurisdictions. For example, even beyond the mountainous terrain and lack of access routes, transportation vulnerabilities for the Karuk Tribal community are further underscored by the fact that the 2014 CalTrans climate assessment for Humboldt County rated Hwy 96 region at "middle point of criticality" for roads in relation to climate change (2014, p. 2). While Highway 96 may not be the most vulnerable road in the county, this categorization is likely to mean that limited resources will be distributed to other road systems.

Similarly, PG&E criteria for distribution line maintenance are a function of population size despite the fact that fires from line starts in the Klamath region are likely to become much larger before they can be contained. Local distribution lines are currently designated as Tier 2 risk for wildfire as opposed to the highest risk which is Tier 3. Line maintenance frequency is determined based on Tier. Tier 3 ranking is normally applied to higher voltage lines and higher population centers, however it is known that fires from line starts in the Klamath region are much larger before they can be contained, generating impacts across a multi-state region. For this reason the suppression costs for wildland fires are enormous (see Table 2 below which lists the total costs for fires in and adjacent to the Orleans ranger district for the top three fire years in the past decade). These large fires also have important impacts that may not have been previously considered in tier prioritization including environmental justice vulnerabilities of community, local cultural and economic impacts and the fact that the resulting large fires generate significant carbon emissions.

Table 2: Recent Yearly Fire Suppression Costs in Orleans/Somes Bar Area

Fire Year	Total Large Fire Suppression Cost for Year
2008	>$150 million
2013	$65.2 million
2014	$86.7 million

As this table illustrates, it is not uncommon for fires in the area to well exceed $50 million in a single year. Even "smaller" fire years in the local area such as 2015 had costs in excess of 14 million. The deferred costs for this project are currently being borne by the community in the form of loss of life, loss of homes, impact to forests and other ecosystems, health impacts from exposure to hazardous smoke, disruptions to daily life and mental health impacts of all of the above. Although data for these deferred costs is currently unavailable, discussions are starting in regard to building out those datasets so calculating avoided costs for unit invested can be extrapolated.

In addition, the increased likelihood of high intensity wildfire presents risk to travel throughout Karuk territory both due to direct Forest Service and California Department of Forestry and Fire Protection (CALFIRE) road closures during fire events, and from flooding and landslides in the immediate (e.g. 2 year) aftermath of high intensity fires. Highway 96 is the main travel route through approximately 72 miles of Karuk Aboriginal territory. This highway connects the region to Interstate 5 in the East and to Highway 299 to the southwest. The Salmon River Road, beginning in Somes Bar, traverses another 31.2 miles through Karuk Aboriginal Territory and connecting to CA State Route 3 in Etna, and Callahan CA, with connections to Interstate 5 and CA SR 299. The Salmon River road is a one-lane route over much of its course. Closures to both roads due to fire and rockslides are a regular occurrence.

Road closures during wildfire events cut off the community from the outside, potentially affecting escape routes, access to emergency service and food supplies. In the aftermath of high severity fires, erosion, flooding and landslides from the fires or from poorly constructed and non-maintained roads occur regularly as increased sediment cause landslides onto roadways. Blocked culverts may cause flooding as upstream flows accumulate behind the culvert. Culvert blockages from increased sediment may in turn damage or destroy main travel routes. When blocked culverts blow out, large amounts of sediment have in turn serious water quality impacts to the riverine system. Sedimentation from unmaintained or improperly designed culverts and roads is a leading cause of vulnerability to salmonid species. While some transportation closures may be relatively short term (in the period of days or weeks), the absence of alternate routes increases the severity of the situation. Longer closures do also occur, in 2018 the Salmon River Road was closed for several months.

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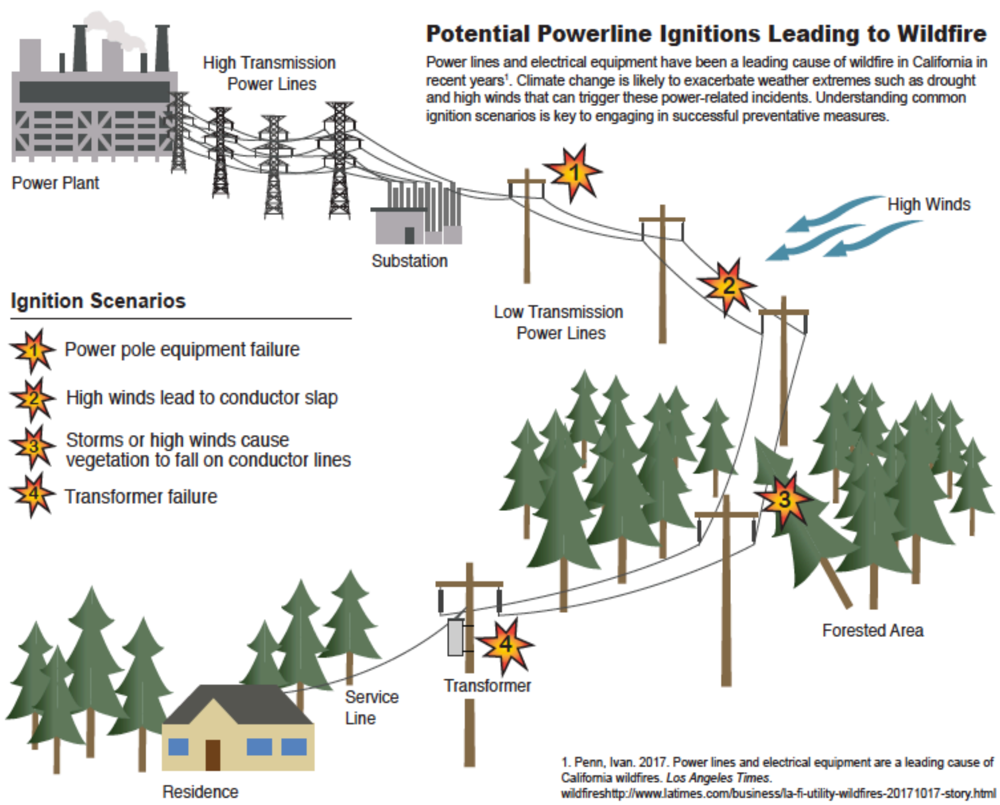
Powerlines, Electrical Ignitions and Wildfire

Wildfires sparked by power lines and electrical equipment have been the cause of over half the total acreage burned in California in recent years (CALFIRE, 2015, Penn, 2017). Transferring large amounts of energy from generation sites to households and community buildings involves the transmission of high voltage electricity large distances across the landscape. High voltage transmission lines are stepped down to lower voltage distribution and service lines at power substations to be distributed within communities. Yet distribution and service lines can start or exacerbate fires when trees fall onto lines, when lines contact one another, or when transformers explode. Powerlines can ignite wildfires via multiple mechanisms. These include the mechanical failure of transformers and other equipment, when lines or conductors are close enough together to cause arcing, when unmaintained vegetation comes in contact with a line or when a fallen tree or branch downs a power line. Figure 3 illustrates four major categories of power line fire ignition.

Figure 3 Potential Powerline Ignition Sources



Not only are distribution and service lines, transformers and other electrical equipment a source of wildfire ignitions, they can exacerbate an existing fires (see Appendix B: How Powerlines Ignite Wildfires for more detail). Once ignition occurs a variety of other factors including availability of fuels for ignition, wind speed, aspect and slope affect whether a fire will spread and how quickly this spread may occur. A third set of factors including presence of homes and other structures, roads and cultural resources affect the consequences of a fire. Figure 4 below illustrates a high risk, high consequence scenario with multiple possible ignition sources (powerlines, transformer, powerpoles, roads) and multiple negative consequences (homes and roads nearby, less maintained power corridor and the community is downwind of the – when a fire occurs it could spread into town).

Figure 4 Example of High Risk, High Consequence Ignition Scenario

The presence of trees and shrubs immediately adjacent to the power line that can serve as fuels to carry a fire, the level of vegetation (fuels) in the surrounding forest, wind speeds, topography and proximity to emergency response all shape what will happen next. Keeping vegetation cut back or burned in the vicinity of potential ignition sources is of critical importance in preventing dangerous wildfires should a transformer explode, a tree fall onto a distribution or service line or other electrical related ignition occur. In theory PG&E maintains a 15ft buffer along distribution lines to protect their infrastructure and decrease the risk of fires starts, although not all lines appeared to be maintained. Field crew observation confirmed that even buffers listed as 'maintained' contained significant levels of encroaching brush, adjacent trees and overhanging branches. Buffers not listed as maintained had even higher levels of adjacent fuels. Such conditions are central to the unusually large impact of fires from electrical ignition sources – when fires occur in these remote locations with high fuel loading they can spread rapidly leading to higher damage and making them more difficult to contain. Power line maintenance is costly, but pales in comparison to the alternatives. Insufficiently maintaining lines defers cost onto the community, the Karuk Tribe and fire management agencies as will be discussed below. See Figures 5 and 6 for example of fuels near power lines in

Figure 5 Even Maintained Corridors Have Unsafe Levels of Fuels Near Lines

Figure 6 Powerpole in Corridor Needing Maintenance

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

In addition to the above risk factors, some fires are more damaging than others. In this case the potential negative consequences of fires vary by their location: fires that threaten structures, road access and other community values are generally considered more impactful than those which do not. Table 3 lays out these factors explicitly. This proposed mitigation approach would reduce fire risk and PG&E liability along 41 miles of power corridor in and around the community of Orleans, California by creating prescribed fire/treatment units along the power line corridor and nearby strategic locations. We established these units and ranked tehir priority using the criteria specified in Table 4 below.

Table 4 Evaluating Ignition Risk and Impact Severity

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

This proposed mitigation strategy is undertaken in coordination with the Karuk Tribe Climate Adaptation plan. Reduction of the risk of fire along distribution and service lines is fundamentally related to community climate resilience on a number of levels. Distribution and service lines, transformers and other electrical equipment are a known source of wildfire ignitions in California – not only are powerlines and electrical equipment a leading cause of fires, but fires from these sources were deemed responsible for over half the total acreage burned in California fires for 2015 (CALFIRE 2015, Penn 2017). Fires from electrical ignition sources are expected to increase in the coming years.

Our assessment evaluated the risk of potential ignition sources near the communities of Somes Bar and Orleans. Of the five potential ignition sources, four were most critical. Lightening is less common in the river corridor than at higher elevations and to the East. Three of the four potential sources (powerlines, powerpoles and transformers) came from electrical infrastructure. At the same time, in this remote mountainous region, protecting critical infrastructure in the form of functioning power lines is vital for emergency services, air conditioning, air filters, phone and internet communication systems. Loss of electrical power disrupts government communication and functionality, as well as impacts functionality and communications of emergency operators. Loss of electricity is also a problem during fires as many people rely on air purifiers for smoke management and air conditioning for cooling. Road closures during fire scenarios are not only inconvenient, they may impact escape routes or access for fire personnel. Smoke itself can be a major health issue, causing fatigue even at lower exposure levels. Table 3 underscores primary and secondary impacts from powerline ignitions.

Table 3: Primary and Secondary Impacts of Powerline Ignitions
(adapted from the California Adaptation Planning Guide Sensitivity Checklist)

Primary Impact	Secondary Impact
Loss of electrical power	Government, non-governmental organization, business and community functionality and communications
	Emergency functionality and communications
	Cooling and air purifying for smoke
Road Closure	Loss of transportation access
	Lack of Escape route
	Emergency services cannot access
Smoke	Health impacts
	Fatigue and stress

Powerline fires are expected to increase in the face of changing ecological and atmospheric conditions. The number of large wildfires and the length of the fire season are increasing across California in the context of climate change. Community infrastructure including energy grids, water and electrical utilities are built around and adapted for given climate conditions (e.g. wind speeds, expected energy grid demands). As the climate changes, the physical and ecological conditions around which human infrastructure is organized including temperature, precipitation and wind conditions are changing in unprecedented and often not entirely predicable ways. While fire is a natural and inevitable part of the ecosystem in mountainous regions, and an integral part of Karuk land management practices, fires from electrical equipment occur within the context of a combination of a century of fire suppression and climate change. Fires occurring under these circumstances are unexpected, and may occur at particularly dangerous times of the year, weather conditions, and locations (e.g. late summer, when high temperatures and low precipitation make for larger hotter fires). By contrast, fires that start from lightning are sometimes accompanied by rain and usually ignites in remote areas, having to back downslope before reaching human habitation. Traditional Karuk fire management happens during intentional conditions -- within fuels that have been previously managed and within select weather conditions and times of the year.

We conducted this project in the wake of the October 2017 fires in North-Central California where a confluence of weather-related conditions including very strong winds resulted in dozens of near simultaneous ignitions across five counties in a 24 hour period. Considered the most devastating series of wildfires in state history, these fires were caused by electric power and distribution lines, conductors and the failure of electrical components in power poles. This infrastructure failure occurred in the immediate context of high winds and very low humidity, new conditions in the changing California climate. Six years of drought followed by a record-setting wet winter meant millions of dead trees on the one hand, while the wet winter spurred significant vegetation growth that then became abundant fuel after record-setting heat during the summer months. CALFIRE reported that five of the 20 most damaging wildfires in state history burned between October and December 2017. Furthermore, climate change already translates into an increase in the length of the fire season. CALFIRE faced 7,117 wildfires in 2017, compared to an average of 4,835 fires during the preceding five years. Fortunately there is much that can be done to mitigate such fire sources. This mitigation strategy is one such example.

Electrical Ignition Risk Potential in the Somes Bar and Orleans Communities

In the area around the communities of Somes Bar and Orleans, California we identified five possible ignition sources, three of which are related to electrical equipment (powerline starts, transformer starts, and power pole starts). We then rated the likelihood of ignition from each of these five possible sources as low, medium or high levels according to specific criteria detailed in Appendix D. By combining these three ignition risks we are able to isolate those units for which the possibility of ignition from electrical sources was greatest. Of the 104 total units, 28 ranked high for ignition risk from electrical sources, while 41 were medium ignition risk and another 35 were low. These units ranking high or medium risk can be seen as a liability for PG&E in that there is high risk for an ignition due to PG&E infrastructure, however, they should also be viewed as an opportunity in that they are low hanging fruit for increasing community wildfire resilience and climate adaptation. Lightening and arson ignitions played into the prioritization in that there is still a risk to energy infrastructure from these other types of ignition potential. Figure 7 (page 26) indicates the units for which PG&E infrastructure poses the primary ignition hazard in need of mitigation in and around the Orleans and Somes Bar community. Vegetation maintenance near lines can pose a hazard for a line should a tree fall, or if ignition should occur, fuel levels affect wither a fire will carry and how quickly it may spread. Figure 8 on page 27 indicates field crew estimates for levels of maintenance on powerline corridors.

While fire is a natural and inevitable part of the ecosystem in mountainous regions and an integral part of Karuk land management practices, fires from electrical equipment occur within the context of a combination of a century of fire suppression and climate change. Fires occurring under these circumstances are unexpected, and may occur at particularly dangerous times of the year, weather conditions, and locations (e.g. late summer, when high temperatures and low precipitation make for larger hotter fires).

Figure 7 PG&E Infrastructure Risk Rating

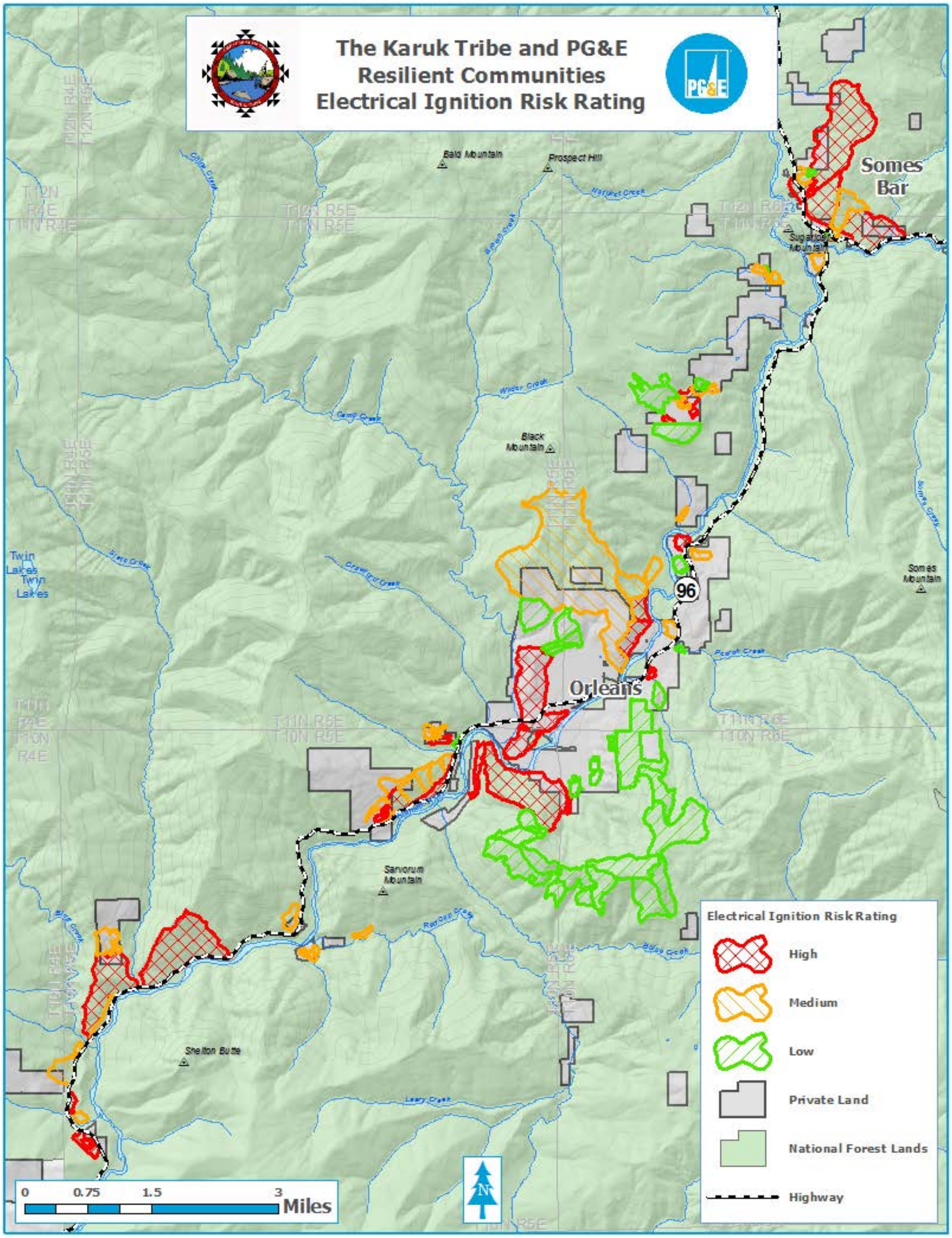
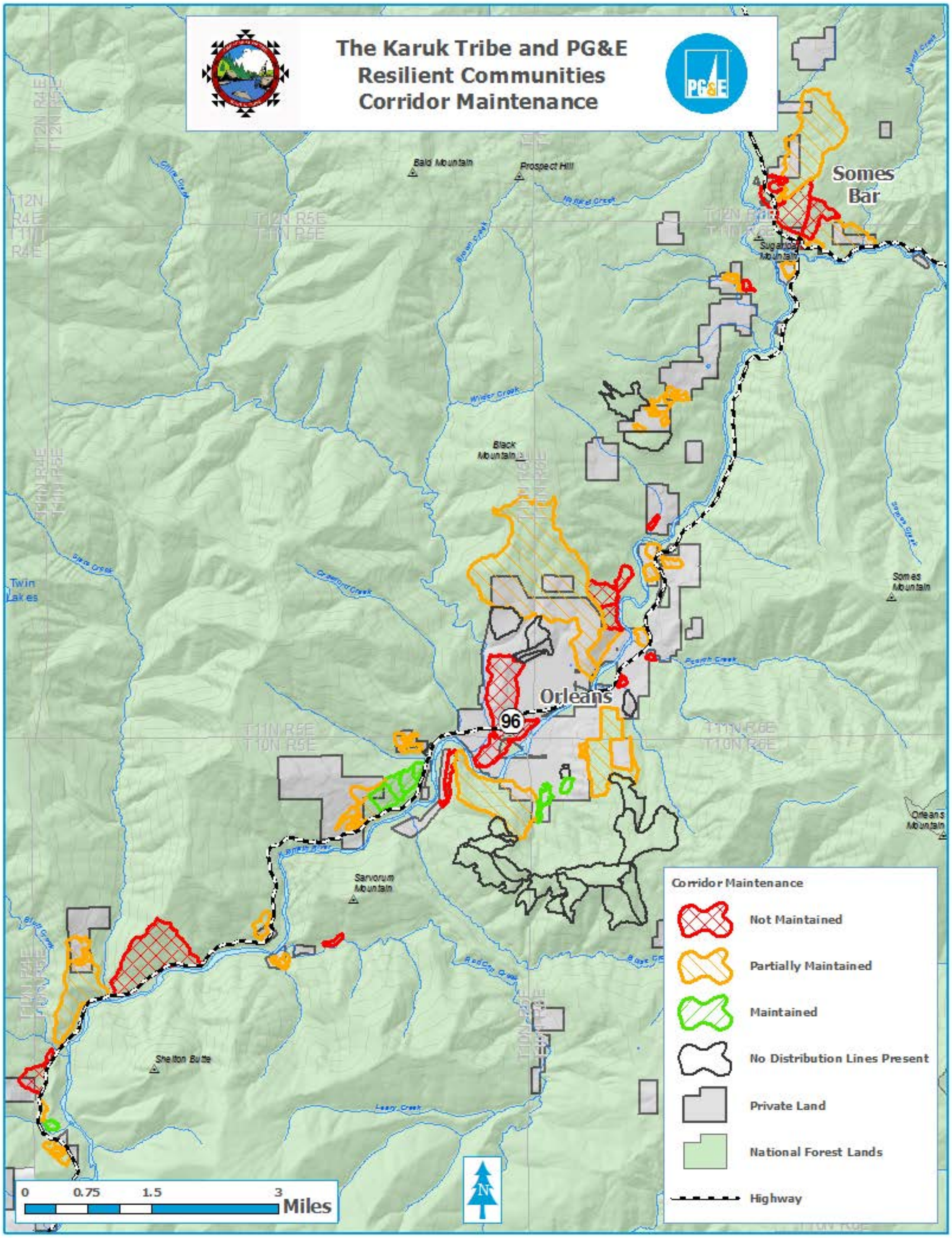
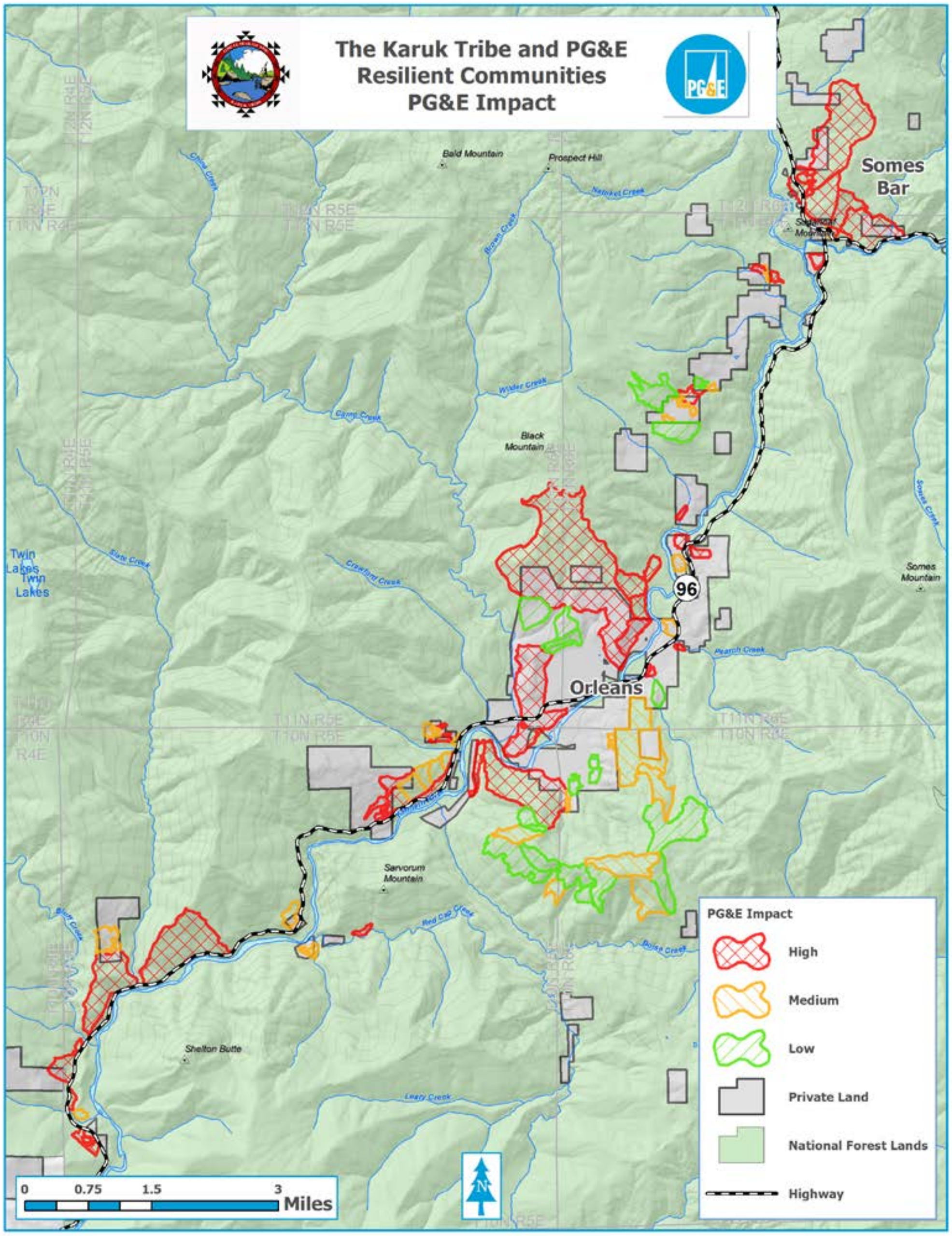


Figure 8 Maintenance Estimates for Powerline Corridors



Taking these two variables together, Figure 9 combines the units with low levels of vegetation maintenance and higher ignition risk from PG&E infrastructure. These are the treatment units for which PG&E infrastructure has most significant risk for community (greatest potential PG&E liability), but also the units with the greatest opportunity for implementing fire safety and community security.

Figure 9 Total PG&E Impact Risk Rating



Changing the Conversation on Fire and Climate Change: From Natural Disaster to Community Resilience and Cultural Revitalization

Wildfires are widely presented in the media as "natural disasters:" dangerous elements of the natural world over which humans have little control. Coupled with the language of climate change, the fear of fire and sense of its inevitability can be overwhelming, leaving people with the sense that there is little that can be done. Nothing could be further from the truth. Whereas the persistence of fire bellies the myth that humans have *control* over nature, humans and fire *have long co-evolved.* Fires can indeed be dangerous, but in mountainous regions prone to lightning strikes such as the Klamath, fire is an inevitable and necessary ecosystem process with which humans have long adapted.

Wildfires are widely presented in the media as "natural disasters:" dangerous elements of the natural world over which humans have little control. Coupled with the language of climate change, the fear of fire and sense of its inevitability can be overwhelming, leaving people with the sense that there is little that can be done. Nothing could be further from the truth.

Climate adaptation, fuels reduction, cultural revitalization and economic employment go hand in hand through this proposed mitigation strategy. In the context of climate change, Karuk tribal knowledge and management principles regarding the use of fire are being utilized to reduce the likelihood of high severity fires. Fortunately, in the face of the changing climate, many ecologists, fire scientists and policy makers, Native and non-Native alike have turned to indigenous knowledge and management practices with renewed interest and optimism in the hope that they may provide a much needed path towards both adaptation and reducing emissions (Williams and Hardison 2013, Martinez 2011, Raygorodetsky 2011, Vinyeta and Lynn 2013, Whyte 2013, Wildcat 2009). In particular, there is increasing recognition of the importance of indigenous burning as an ecosystem process and restoration technique.

In order to protect critical infrastructure in light of increasing risk of high severity fire, we established 104 proposed prescribed fire

Climate adaptation, fuels reduction, cultural revitalization and economic employment go hand in hand through this proposed mitigation strategy.

treatment/burn units[1] totaling 4,862 acres, along 41 miles of power corridor in and around the communities of Somes Bar and Orleans, California. These treatment/burn units ultimately reduce wildfire risk for 409 community structures, with 68 of these structures directly within potential units. Furthermore, 36.7 miles of power line are projected for reduced fire risk by (more than 448 power poles are located directly within treatment units).[2] This potential approach would reduce fire risk on adjoining forested lands. Prescribed fire units along distribution lines are part of the larger prescribed fire planning process of the Western Klamath Restoration Partnership and the Karuk Tribe Climate Adaptation Plan.

Along with prescribed fire as a solution comes transference of risk. Community fire practitioners may be unwilling to assume liability for potentially damaging a power pole, damaging a home, or having an escaped prescribed fire. Liability considerations for prescribed burners are just as dire as those of PG&E in today's legal framework. Initiating a prescribed burn in an unmaintained power corridor, or an area that has had fire excluded for nearly a century is a task that deserves liability protections. States like Florida have gross negligence clauses for prescribed burners, and land owners have the right to burn well established in state law. Gross negligence clauses would also be appropriate for indigenous communities that need to revitalize their relationship with fire or risk the loss of their cultural identity. After all, when PG&E gets sued for an infrastructure ignition, nobody asks the question of who is liable for forcibly removing fire from the hands of indigenous people and settlers alike. One can only imagine how different our situation would be if these practices had been allowed to continue at scale for the past century.

[1] 61 of these have been ground truthed in the course of this mitigation strategy, another 24 units were recently ground truthed through a recent USFS project, while 19 are on private property and have yet to be accessed.
[2] All in all, 41.4 miles of powerline were digitized, 36.7 of these were field verified. The remaining 4.7 miles of line were on private property that could not be accessed.

Project Methods

These 104 prescribed fire units were established through an in depth process of mapping, verifying infrastructure locations, identifying and filed verifying potential burn/treatment units and development of treatment priority matrix and treatment cost estimates. In the interest of replicability, we detail our methods here.

1) Digitizing Distribution Lines

Distribution lines, service lines and poles were initially located through a combination of remote sensing methods, including aerial imagery (google maps/NAIP National Agriculture Imagery Program), and a LiDAR (Light Detection and Ranging or "radar") derived canopy model. Some distribution line and power pole location data was already identified in other projects e.g. preparation for the annual Klamath River Prescribed Fire Learning Exchange (TREX). Most of the distribution lines and smaller power lines off the main line to houses were more difficult to see from imagery especially in heavily forested areas, although some of these locations were visible from LIDAR. Using imagery was useful in locating distribution lines where the corridors are maintained, but where the corridors are unmaintained it is difficult to distinguish the distribution lines. The 2016 NAIP imagery had enough resolution to locate maintained corridors, but was not sufficient quality to see the distribution lines. Google maps imagery resolution is <1 meter enabling staff to map some, but not all of the additional distribution lines.

2) Verification of Distribution Line Locations

Once preliminary maps had been created with the locations of the digitized distribution lines, the crew began to survey the infrastructure to verify digital locations, understand vegetation conditions on the ground, confirm landmarks and accurately map other relevant features. The crew was able to verify the locations of over 80% of the distribution lines. Less than 5% of the distribution lines that were originally digitized did not exist.

Figure 10 Chook Chook Hillman conducts ground truthing

The crew ground truthed maps by physically accessing sites and dropping pins/waypoints in Avenza PDF maps to collect point data. Point data were collected for power poles, power poles with transformers, water tanks, water lines, areas of heavy fuel loading, buried cables and other useful information with regards to the distribution line corridor or potential burn units. Ground truthing the distribution lines locations was a relatively straight forward, although it did involve climbing through and otherwise navigating steep terrain, thick understory vegetation, and private property.

The process of ground truthing also allowed for the collection of data regarding vegetation conditions and potential fire control features for prescribed fire units adjacent to the distribution lines. Thus, field verification of distribution line locations was also part of an initial process of identifying possible burn units, see Figure 10. The crew worked in pairs both for safety and to maximize data collection, especially when verifying distribution lines away from the highway corridor. Field crews were unable to ground truth 4.7 miles of distribution lines located on private property because they were unable to secure access.

As noted earlier, field crews were impressed with the high level of fuels on the ground even in corridors that were classified by PG&E as maintained. In corridors not listed as maintained tree limbs, brush, thick duff and trash were all found in immediate vicinity of the powerlines. Figure 11 below of crew member Richard Bailey crawling through tanoak slash left underneath a distribution line was taken while ground truthing a distribution line corridor. The crew noted several 8-12 inch DBH (diameter at breast height) tanoaks that were felled directly underneath powerlines and left whole on the ground, some limbs were bucked off the stem, but the entire limbs were left behind.

Figure 11 Crew member Richard Bailey crawls through tanoak slash left below powerline

3) IDENTIFICATION OF POTENTIAL TREATMENT/PRESCRIBED BURN UNITS

One hundred and four potential treatment/prescribed fire units were determined using a combination of field verification notes, local knowledge and existing GIS data on potential control features. GIS layers included slope, roads, hillshades, imagery, ownership, building footprints, the digitized distribution lines, wildfire footprints, recent fuels work, elevation contours, the WKRP community prioritization overlay assessment and trails were important information to establish places where prescribed fire control lines could be safely created. Treatment unit boundaries were established by the presence of "control features" -- places where you could put in a hand line to stop a prescribed fire. Most prescribed fire units are bordered by a road on one or more sides, in which case the roads themselves served as a fire control feature. The main control features used were roads, ridges (as a place to install a hand line) or in some cases the maintained distribution line corridor themselves. Where possible existing features e.g. old dozer line (as a wildland suppression control feature) or previous fuels treatments were used to determine treatment unit boundaries/control features.

A 15 foot buffer is ideally maintained along distribution lines as to protect PG&E infrastructure and decrease the risk of damage and fire starts. Not only do few of the units appear to be adequately maintained, this is a very small buffer which should likely be significantly expanded. Figure 12 indicates an example of a relatively well maintained power corridor that still contains plenty of vegetation (fuels) in close proximity to lines. In particular crews observed circumstances with high fuel loading, and other places where fuels had been cut down around distribution lines, but limbs and parts of trees were left on the ground where they posed a hazard.

Figure 12 Even Relatively Maintained Corridor Has Vegetation Close to Lines

Both maintained and unmaintained lines were considered in the development of treatment units. A majority of maintained corridors were used as control features, although all corridors will require more fuels reduction. In order to effectively use these corridors as control features, all ground and ladder fuels would need to be cut, piled and burned in a minimum buffer of 75 to 150 feet around the line. This would accommodate fireline construction to occur a minimum of 35 feet from the line for personnel safety reasons while burning. In the event that the control line would be closer, or transect the corridor, personnel would need to maintain a 35 foot distance from the line while fire moves through. If this is not possible, line segments may need to be deenergized for burning operations. Microgrid technologies may be useful in limiting the amount of time the community may have to go without power in these instances.

In cases where distribution line corridor would be included in a unit, but control features would be a nearby road, handline, and/or recent treatment unit, the entire burn area should be pre-treated (cut, pile, pileburn, clear around poles to bare mineral soil) as an initial entry. Treatment units range from 1.5 -950 acres. A few of the units are relatively flat with an average slope around 15-20%, but due to the terrain many of the units are on average above 20% slope and a few are >50% slope. The units are mainly along the Hwy. 96 corridor between Aikens Creek (near the edge of the Karuk Aboriginal Territory) and Somes Bar.

Some low to moderate priority units were identified at the first site specific ridge capable of suppressing a fire. These are strategic features that do not have power line infrastructure within them, but were included due to access limitations or when treatment directly adjacent to power infrastructure would be insufficient.

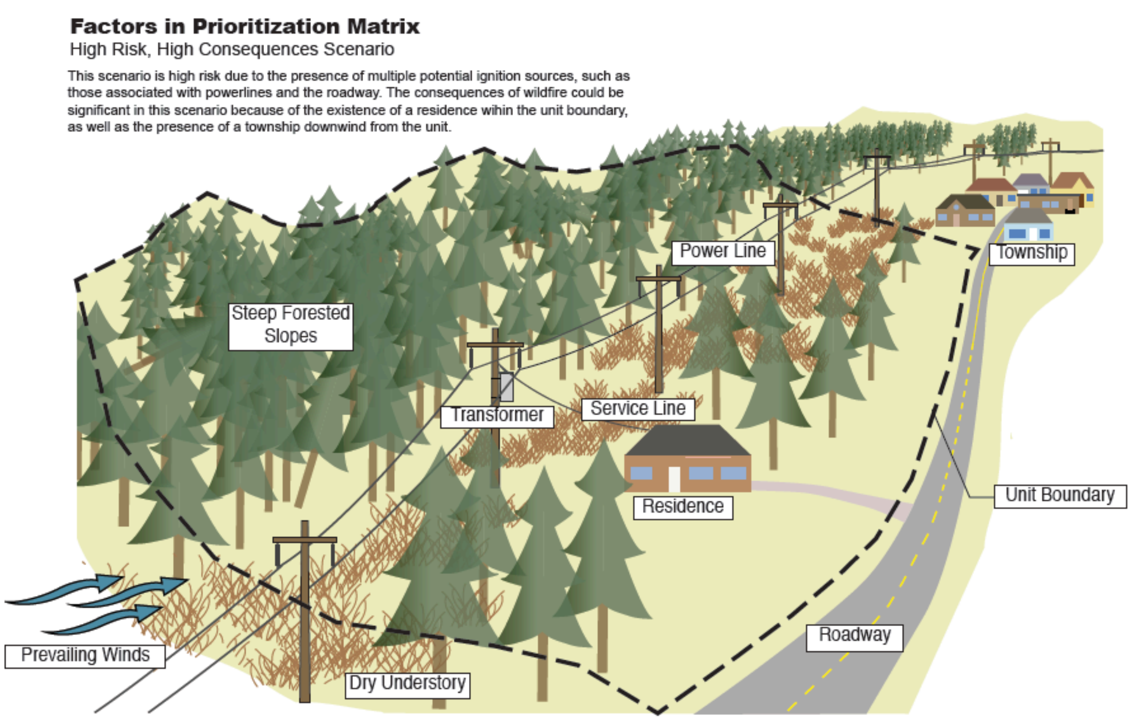
4) GROUND TRUTHING OF TREATMENT/PRESCRIBED BURN UNITS

Next, to confirm the feasibility and appropriateness of potential treatments on the landscape, proposed prescribed fire treatment units ground truthing was led by Natural Resources and/or GIS Technicians and members of the Karuk Tribe Wildland Fire (K1) Crew. In nearly all cases, locations of unit boundaries and fire control features determined with GIS and LiDAR proved to be acceptable on the ground. Where this was not the case, the ground crew made adjustments, most adjustments were made to the locations of the control features to a stronger feature. The crew only had to delete/remove one of the identified treatment units due to slope conditions that would be deemed unsafe to hold a prescribed fire. Crews successfully ground truthed over 80% of the identified prescribed fire units. Landowners could not be contacted, or did not respond after multiple attempts in the remaining units. Crews worked in groups of 2-3 to walk potential unit boundaries and along the distribution line corridor to determine the viability of that particular piece of ground serving as an effective fire control feature. Some of the larger units have over 1000ft of elevation change from the top to the bottom and the boundary and control features themselves are close to a mile long. These longer control features required preparation, route planning, radios for communication/safety, vehicle shuttling and teamwork.

5) Creation of maps showing final proposed fuel break locations & burn units and Prioritization of treatment

Our team worked together to construct a prioritization matrix for unit treatments. Ignition sources, fuel levels, topographic features and community impacts were all incorporated and criteria for low, med and high levels of risk for each element were jointly developed based on our knowledge of the area, ignition risks and fire behavior. Appendix D contains a listing of these categories and specifics. Units with multiple possible ignition sources, units near homes and evacuation routes, and units upwind of town became the highest priority as illustrated in Figure 13 below. In other words, the presence of multiple potential ignition sources from electrical infrastructure as well as roads, and the presence of nearby houses downwind of the potential fire heighten the consequences.

Figure 13 Full Detail of High Risk, High Consequence Scenario



The prioritization matrix evaluated the risk of each unit catching fire coupled with the consequences of such a fire. Each unit was ranked in terms of the risk of ignition, the level of existing fuels, topographic features contributing to fire risk (steep slopes, wind direction), and the potential for negative consequences of fire in the unit (e.g. structures, roads, cultural features).

Ignition sources:

There are five possible ignition sources, three related to electrical equipment (line start, transformer start, power pole start). These five possible ignition sources were each rated as low, medium or high levels of risk according to specific criteria detailed in Appendix D.

Table 5 Criteria Used for Potential Ignition Source Risk Ranking

Potential Ignition Source	
Powerlines	Total length in unit or within 100 ft of unit
Transformers	Total number in unit
Power poles	Total number in unit
Human	Roads, structures, arson potential
Lightning	Ridges, elevation, historic ignitions

Units with multiple potential ignition sources ranked at 'medium' or 'high' received higher total points, and thus higher overall priority for this measure. All units were relatively close to human activity (roads, structures) and thus ranked either medium or high risk for human ignition. Data on ignitions over the past 25 years indicated higher human ignition especially in and around the community of Orleans.

Fuels

Should a fire occur either from a power arc, road or transformer failure, the relative availability of fuels is a key variable for what comes next. In the case of trees or other large vegetative material near power lines, these can also contribute to ignitions, as when a fire or high winds causes a tree to fall into electrical equipment such as powerline. We considered two categories of fuels, the fuel loading within the unit as a whole as assessed via an extensive database of treatment history,[3] and the level of vegetation maintenance along the power corridor as observed by the field crews during ground-truthing efforts. Each variable was rated as low, medium or high risk according to specific criteria listed in Appendix D.

[3] The database is comprised of data we collected from several different publicly available sources, along with some additional site-specific local knowledge/history.

Table 6: Criteria Used for Fuels Risk Rating

Fuels	
Current vegetation maintenance of unit	Karuk Tribe, WKRP, USFS dataset on how recently areas burned or manually treated
Current vegetation maintenance of power line corridor	As observed during ground truthing

Topographic factors including the degree of slope, aspect and wind direction are critical elements in the risk scenario for fires. Fires carry more rapidly on steep slopes, especially in south facing aspects, which tend to be drier. Prevailing winds carry fires quickly. Sites where up-canyon winds are aligned with high ignition risk hold the potential to create quick moving fire that can spread substantially before resources can respond. One element of the changing climatic condition can be increasing wind speeds. Unusually high winds were directly associated with fires across California multiple counties in early fall of 2017. In the Somes Bar and Orleans area prevailing winds come from the southwest and heading northeast, however winds from the northeast are drier and most frequently associated with red flag warnings.

Table 7 Criteria Used for Topographic Factors Risk Rating

Topographic Factors	
Slope	Fires carry faster with greater slope
Aspect	South/Southwest aspect burns at higher intensity, and can carry fire faster, especially when aligned with up canyon winds
Wind	NE and SW winds strongest/most associated with red flag warnings

The final element in our matrix addressed the consequences of fires. The number of structures threatened and the importance of nearby roads as emergency access or for escape (ingress and egress) were each ranked here. In addition we had data on community values ranking of the region that included cultural importance.

Table 8 Criteria Used for Community Consequence Risk Rating

Community Consequences	
Structures threatened	Total number of structures proximate to unit
Roads: ingress/egress threatened	Number of roads adjacent to or within unit
Community Values Overlay	As generated during a series of community workshops

Appendix E contains the unit maps showing specific rankings on each element. Based on this effort, of the total 4,862 total acres recommended for treatment we considered 35 of the units representing a total of 1,782 acres to be in the highest priority for immediate treatment. An additional 54 units comprising 2,556 acres are of medium priority, and fifteen units (523 acres) are the lower priority, see Table 9 below.

Table 9: Total Units and Acres By Priority Level

Priority Level	Total Units	Acres
Highest	35	1782
Medium	54	2556
Lower	15	523

Units will need to be continually maintained once treatment takes place. Especially for units closer to roads and the communities of Orleans and Somes Bar the recommendation is use of prescribed fire every 3-5 years. Intervals should be based on local/traditional knowledge and/or fuel conditions at any given time, which could fluctuate depending on climate and the effectiveness of previous burns, especially while transitioning from fire-suppressed forest types to fire-maintained forest types. Situations will change over time, when high severity wildfire occurs grasses and invasive can become primary vegetation characteristics. In these situations, burning every year or two may be warranted. Next initial and long term treatment cost calculation were made by Karuk Staff David Medford (AFMO) in consultation with Bill Tripp (Deputy Director for Eco-Cultural Re-vitalization) and Kenny Suave (GIS Technician III). Calculations were made using existing basic formulas for a 20-person crew, taking into account unit sizes, and maintenance.

Treatment Costs, Deferred Costs and Potential Funding Mechanisms

Karuk Aboriginal Territory has experienced large fires every year in the past decade. This closing section presents immediate and long-term fuels treatment costs as compared with recent fire suppression costs, and lays out potential funding mechanisms. While costs of treatment can appear high, they are significantly lower than the economically costly and physically devastating alternative of catastrophic fire. It is not uncommon for fires in the area to well exceed $50 million in a single year. As of this writing, the Nachez fire currently burning in the local area has reached 23,000 acres in size and a suppression cost of $30 million. For less that the suppression cost of a single fire year, local investments in the solution can be set in place.

Initial treatment cost calculations were made by evaluating each unit in terms of the number of steps needed to prepare the site for prescribed fire, and the difficulty of conducting these tasks. Before what is known as a broadcast burn can occur, fire lines must be created if they do not already exist. Units without recent fire or other fuels maintenance also require hand thinning of materials into piles and burning of the piles before the broadcast burn can occur. Steep units are significantly more difficult for crews to navigate, and because such units can carry a fire more easily, additional work may need to be done in advance before the broadcast burn can take place. Costs for the initial treatment are displayed in Table 10 below broken down according to unit priority (high, medium and low), and sub costs.

Table 10: Cost Calculation for Initial Treatment

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

Maintenance costs after the initial treatment are significantly less than initial costs. Prior to fire suppression this area was burned on intervals ranging from 1-3 years. The annual maintenance burning cost on a three-year rotation (i.e. each unit would be burned every third year) is $810,000, see Table 11 below. The treatments shown require environmental planning, leadership and support positions. When additional costs for environmental planning and for leadership and support are included alongside the initial treatment cost the annual cost over a ten-year project period is $2,379,994 per year.

Table 11: Long term Treatment Cost and Average Annual Project Budget

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

While this figure may appear significant, even the initial treatment cost is less than annual local fire suppression costs in most recent years. By contrast, failure to protect from ignition risk not only creates enormous liability for PG&E, it defers these costs onto the community, the Tribe and fire management agencies. Fires from line starts in the Klamath region are much larger before they can be contained, generating impacts across a multi-state region. For this reason, the suppression costs and liability potential for wildland fires in the area are enormous. Table 12 below lists the total costs for fires in and adjacent to the Orleans ranger district for the top three fire years in the past decade. Of course, these are only the direct suppression costs of the fires, and do not include all the additional economic, social, physical and emotional impacts to the community or the negative consequences transferred to the local ecosystem.

Fires from line starts in the Klamath region are much larger before they can be contained, generating impacts across a multi-state region. For this reason, the suppression costs and liability potential for wildland fires in the area are enormous.

Table 12: Recent Large Fire Suppression Costs in Orleans/Somes Bar Area

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

While the price tag to conduct this work is not insignificant, a number of funding mechanisms can be employed to easily cover project costs including for example establishing a community strategic investment fund through ratepayer contributions, launching a strategic investment partnership with the Karuk Tribe and/or the Humboldt Area Foundation, or a corporate matching gift program. Table 13 below outlines an example of how PG&E could partner with others to invest in long term solutions through creation of an endowment. An endowment of $50 million would produce $2.25 million annually with an annual payout rate of 4.5% of the total endowment.[4] At these rates the total endowment would grow about 2.5% to 3% per year depending on the negotiated fund management fee (which would be quite low on an endowment this size). Part of the money spend from this 4.5% would also involve information and outreach for leveraging endowment growth, and all of it would be eligible for non-federal match, hence expediting the process of getting to the landscape scale.

[4]This is the percentage rate the Humboldt Area Foundation Currently pays out on endowed funds. If the total fund dropped below $50 million, the amount available for expenditure would drop, or if the HAF board changes the payout percentage, that payout would also change (they just increased it from 4% to 4.5% because of their 10 year average return has been over 8%).

Table 13 Long Term Costs and Funding Mechanism

Initial treatment cost		**$12,938,945**
Long Term Costs	Annual maintenance burning cost (3-year rotation)	$810,166
	Environmental Planning	$3,000,000
	Leadership and Support	$3,000,000
	10 Year project need	$23,799,941
Average annual project budget		**$2,379,994**
Funding Mechanism	Size of Endowment to initiate project, leverage match and begin scaling up	$50,000,000
	Initial Endowed expenditures available annually at 4.5%	$2,250,000

Such an endowment could be created by multiple potential mechanisms. For example, the addition of a small amount to the utility bill of residents statewide would easily cover these costs which are currently disproportionally placed onto the local community. Communities could then be compensated for their efforts – labor which benefits the residents across the state of California through fire risk reduction and reduction of greenhouse gas emissions. A variety of funding mechanisms could be developed to direct funds to the local communities.

A second funding mechanism would be to pilot a strategic investment project with the Karuk Tribe and Humboldt Area Foundation. A strategic investment of $50 million can generate a consistent $2 million a year as an endowment or donor advised fund. With $2 million/year planning, implementation, and maintenance of this mitigation strategy could occur in perpetuity, as well as leveraging additional investments for expanding such efforts to the landscape scale.

A third funding option would be to establish a corporate matching gift program through a platform such as Benevity Causes Portal and promote employee giving that supports strategic investments. For example, Microsoft matches up to $15,000 per year, per employee to non-profit entities. This sort of effort can also grow strategic investments quickly. If 100 employees gifted $15,000 a year, and PG&E matched it, a strategic investment could grow a $45 million fund in 15 years.

With the growing inevitability of PG&E starts in the future, the company would be better served in working toward mitigation up front. Initiating one or more such strategies may be what it takes to gain social acceptance of gross negligence liability clauses for PG&E and prescribed burners alike. Not only could such investments achieve the treatments identified, but it would have a multiplier effect by enabling the local communities to expand their activities to the landscape scale and increase the resource capacity needed to respond to suppression efforts for unwanted fires.

The deferred costs for this project are currently being borne by the community in the form of loss of life, loss of homes, impact to forests and other ecosystems, health impacts from exposure to hazardous smoke, disruptions to daily life and the mental health impacts of all of the above. The growing frequency of large fires in the Klamath region also have important impacts that may not have been previously considered in PG&E maintenance tier prioritization including the environmental justice vulnerabilities of the community, local cultural and economic impacts, and the fact that the resulting large fires generate significant carbon emissions. Although data for these deferred costs is currently unavailable, discussions are starting in regard to building out those datasets so calculating avoided costs for unit invested can be extrapolated. In contrast, this collaborative mitigation strategy decreases PG&E liability and increases disaster resilience in a remote rural mountain area. Climate adaptation, fuels reduction, cultural revitalization and economic employment go hand in hand through this replicable mitigation strategy which utilizes a combination of western science and traditional Karuk fire knowledge.

Recommendations

IMMEDIATE RECOMMENDATIONS

- **Initiate programmatic NEPA/CEQA planning** in order to enable mitigation strategy implementation to take place in high priority units and for maintenance as all units are treated.
- **Orleans/Somes Bar Fire Safe Council incorporation of this project into Community Wildlife Protection Plan** as supplemental addendum to be considered in larger scale WKRP community project planning efforts**.**
- **Incorporation of this project into Karuk Climate Adaptation Plan** to keep at the forefront of Tribal planning and implementation efforts.
- **Incorporate of this project into PG&E Climate Adaptation Plan** to inform and progress further Working Better Together Climate Showcase Communities investments.
- **Allow Karuk Tribe to retain PG&E infrastructure data** in Karuk Tribe's confidential cultural resources geodatabase.
- **Enter line corridors and dispose of concentrations of cut brush limbs and trees by chipping or burning** to reduce flammability and radiant/convective heat potential during wildfire and prescribed fire events. Clean up trash on ground.
- **As wooden poles are replaced, install steel poles** to increase infrastructure resiliency to wildland fire especially in areas slated for frequent prescribed fire.
- **Seek gross negligence liability clauses through state and federal legislation** to protect PG&E and prescribed burners from the undue burden of financial liability in regard to achieving community, ecosystem, and infrastructure resilience.
- **Maintain distribution lines to at least existing standards.**

COMMUNITY FIRE PREVENTION AND CLIMATE ADAPTATION RECOMMENDATIONS:

- **Improve distribution line maintenance standards, monitoring and maintenance follow up.** There is a serious need to decrease fuel loading in the immediate vicinity of electrical equipment. Increase buffer size around powerlines, transformers and electrical equipment from 15 feet to a minimum of 75 feet and adequately maintain buffers. Include treatments relevant to current and expected conditions at the community level and ensure work is being completed to specifications. Employ maintenance interval of 12 to15 years for line corridors outside of burn units specified in this proposal, or in areas that have not burned in 9 to 12 years.

- **Reassess PG&E maintenance tier prioritization in light of remoteness and potential for local distribution lines to ignite large-scale fires.** By considering the high, medium and low priority metrics at the local scale, treatment and maintenance intervals could be frequent in the highest priority areas for the affected community and some degree of mitigation will be in place when the fire comes or line produced starts occur. Local distribution lines are currently designated as Tier 2 risk for wildfire, as opposed to the highest risk which is Tier 3. Line maintenance frequency is determined based on Tier. Tier 3 ranking is normally applied to higher voltage lines and higher population centers, however it is known that fires in the Klamath region are in many cases much larger before they can be contained, generating impacts across a multi-state region. For this reason the suppression costs for wildland fires are enormous. These large fires also have important impacts that may not have been previously considered in tier prioritization including environmental justice vulnerabilities of community, local cultural and economic impacts and the fact that the resulting large fires generate significant carbon emissions.
- **Establish a Working Better Together, Community Strategic Investment Fund** for community-based planning, treatment and maintenance efforts such as those identified herein. While the price tag to conduct this work is not insignificant, a small addition to the utility bill of residents statewide would easily cover these costs which are currently disproportionally placed onto the local community. Communities could then be compensated for their efforts – labor which benefits the residents across the state of California through fire risk reduction and reduction of greenhouse gas emissions. A variety of funding mechanisms could be developed to direct funds to the local communities. With the growing inevitability of PG&E starts in the future, the company would be better served in working toward mitigation up front.
- **Pilot a Working Better Together Strategic Investment project with the Karuk Tribe and Humboldt Area Foundation** to plan and implement initial treatment, monitoring, and maintenance activities identified in this and similar community-based planning efforts in and adjacent to Karuk Territory. A strategic investment of $50 million can generate a consistent $2 million a year as an endowment or donor advised fund. $2 million a year can plan, implement, and maintain this mitigation strategy in perpetuity as well as leverage additional investments for expanding such efforts to the landscape scale.
- **Establish a corporate matching gift program through a platform such as Benevity Causes Portal** and promote employee giving that supports

working better together strategic investments. Microsoft matches up to $15,000 per year, per employee to non-profit entities. This sort of effort can also grow working better together strategic investments quickly. If 100 employees gifted $15,000 a year, and PG&E matched it, a working better together strategic investment could grow a $45 million fund in 15 years.

- **Develop fire protocols specific to distribution line hazard in wind events.** Given the recent importance of high winds in other fires across the state and the expected increase in fluctuation of climate conditions including future higher wind events, we recommend that CalFire and the Karuk Tribe develop fire protocols specific to distribution line hazard in wind events.
- **Promote micro-grid technologies** to help alleviate loss of power when having to shut down portions of grid power while conducting infrastructure protection burns.
- **Consider a wide range of proactive responses** including placing more powerlines underground. Considering the risk and established reality of powerline ignitions in this forested region, and the regional impacts emerging from large scale fires placing powerlines underground is recommended.
- **Implement use of drones** to determine fuels condition along powerlines and confirm that maintenance work has been done to specifications.
- **Perform quality assurance checks** to assure implementation workforce does not leave cut trees/heavy fuels beneath powerlines.
- **Incorporate fire hazard reduction principles in planning future infrastructure projects,** including generating energy locally to minimize power failures and transmission hazards.
- **Collect and synthesize data on deferred costs** and build formulas for calculating avoided costs per unit of investment.
- **Initiate major resident/customer outreach** regarding how households can help maintain vegetation around powerlines and powerpoles on their properties; how to identify potential maintenance issues; who to call to get issues resolved; and the benefits of forest fuel maintenance, including prescribed fire, in and around their communities.

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Appendix A: Key Terminology

Burn /Treatment Unit Identified area where fuels can be reduced to reduce community vulnerability to fire using a variety of methods from manual vegetation removal to cultural or prescribed burning.

Critical Infrastructure Community infrastructure that is integral to community function and safety such as roads, access to electricity, water systems and communication systems.

Distribution lines Distribution lines, distribute power from substation to the transformers.

Hand Line A hand line is defined as a 24 to 36 inch scrape down to bare mineral soil, coupled with a six foot wide brush cut.

Service lines Service lines are lower voltage lines that connect power from the transformers to the house or other structure.

Transformers Apparatus on powerpole that reduces the voltage in the transmission lines to deliver it to individual household.

Transmission Lines Transmission lines are the higher voltage lines that run from substation to substation. These lines no not distribute power to customers. Our project did not involve transmission lines.

TREX- Klamath River Prescribed Fire Training Exchange (TREX) is an annual training event put on by local, regional and national sponsors where 80 to 100 people from all walks of life burn together and learn together. It is greatly expanding Karuk capacity to implement prescribed burns.

WKRP Western Klamath Restoration Partnership (WKRP) Is a collaborative partnership led by the Karuk Tribe, Mid Klamath Watershed Council, Salmon River Restoration Council, and the US Forest Service. The WKRP has established shared values, identified an initial zone of agreement, and begun to build social liscence to restore historic fire regimes on a 1.2 million acre scale.

Appendix B: Field Specific Recommendations

Here we offer more details of the mitigation strategy implementation that may be useful for field crews seeking to replicate our work. Our particular context is a rural community with mountainous and heavily forested terrain.

After digitizing distribution lines field crews identified high priority areas to begin verification of the line locations based on critical branches off the main lines, provision of access to population centers, proximity to other key infrastructure and past history of repeated fire activity (e.g. near highway). Critical areas for our work initially identified included main lies branch across the Klamath River near Red Cap Creek which supplies power to population center in Orleans, main line where it leaves highway at Ullathorne River Access. The latter was emphasized as a site where there has been a history of fires started from that line over last 20 years. Main line crossing of the Klamath River at Ishi Pishi Road was important as in close proximity to the high speed internet line at Wilson Creek. These areas were determined to be places where prescribed fire would be needed as a means for protection. In contrast, there was no need to survey all smaller arterial lines through the town or Orleans because prescribed fire would not be used in these locations, although vegetation maintenance around these lines should remain a priority.

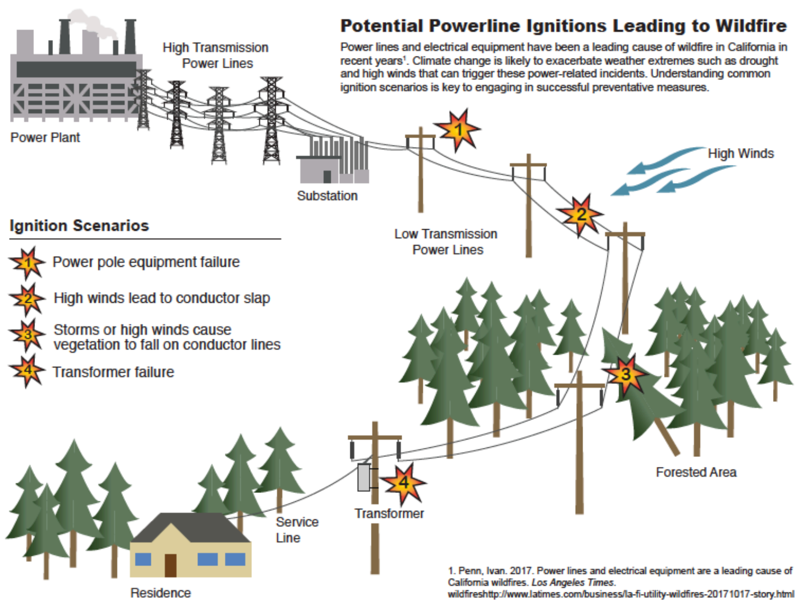
In this phase one of our crews' most significant obstacles was verifying powerline locations on private property. While many landowners were supportive of the work, others expressed confusion and/or suspicion of the project purpose, did not want anyone on their land, or simply could not be reached. Based on our experience we recommend more effort to contact landowners beginning further in advance and using a variety of techniques including mailing informational notifications about the project and asking for access, word of mouth, in person contacts in conjunction with other projects, as well as phone calls.

Terrain: some of the mapped powerlines travel across very steep terrain and across the river, which makes field verifying the power lines locations time-consuming. In cases where power lines were partially buried, our field crew found it more difficult to locate where the lines rise above ground and go to the houses. In this highly mountainous terrain, distribution lines in the vicinity of the highway or roads were relatively easy to ground-truth, in contrast with lines further from road corridors, which were significantly more time-consuming to access.

Other useful suggestions from the crew included the benefits of using radios for communication between individuals on field crew and the office increased productivity when conducting field work. Updated maps helped to identify work completed/to be done, back up/export any data collected on a weekly basis.

Appendix C: How Powerlines Ignite Fires

Powerlines can ignite wildfires via multiple mechanisms. Below the mechanics of four important categories of powerline ignition are explained.



Downed lines:
Unmaintained trees/limbs can fall into powerlines, causing the line to break and hit the ground. Power distribution systems contain protective devices (e.g. fuses, circuit breakers), but these may also fail with the result that many downed lines remain energized and arcing. Arcing downed lines readily ignite nearby vegetation. In cases where an ongoing fire burns into a power corridor, falling trees falling may contact power lines causing further ignition and spread.

Conductor Slap: Although power lines are designed with sufficient clearance between conductors to keep them from contacting one other under normal operating conditions, unusual circumstances may allow line conductors to "slap" together. This so called "conductor slap" creates high-energy arcing and ejects hot metal particles that may burn while falling or ignite vegetation upon contacting the ground. Note that winds that are strong enough to break a power line will spread a fire very rapidly.

<u>Equipment Failure Powerpole:</u> Power line equipment including switches, insulators, and circuits and have hundreds of components, all of which eventually fail. Before total failure they may arc or spark at low levels, or they may produce high-energy arcing or even burns conductors in two, resulting an energized wire on the ground, which provides a ready source of ignition.

<u>Equipment Failure Transformers:</u> Transformers contain hundreds of electrical components that eventually wear out and can explode.

Appendix D: Full Prioritization Matrix, Appendix E: Unit Maps

See Attached Files, these larger files are attached as separate documents.