Fire Risk Reduction on Vineyard Sites
Best Management Practices

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INTRODUCTION

Since 2015, many large and destructive wildfires have occurred in the north coast wine country. Vineyard properties have suffered from direct loss of houses, wineries and other buildings as well as vines. Many tons of winegrapes have been left unharvested as they are tainted by wood smoke from large wildfires.

There are two primary reasons for the increase in the frequency and intensity of recent fires – climate change and long-term suppression of fire. California's Mediterranean climate has a six-month period without substantial rain when vegetation dries out and becomes more fire prone. Droughts greatly exacerbate this condition as do summer temperatures increased by climate change. Over time climate change will further increase summer temperatures and drought increasing fire risks.

Fire is a natural process especially in Mediterranean climates. Frequent, low-intensity fire removes leaf litter, underbrush and small trees from the forest floor and reduces ladder fuels, or the dead branches on the lower 10-15 ft of trees. Low intensity fire reduces fuel loads and the likelihood of a high intensity fire. But fire suppression over the past hundred years in California combined with increased drought and high temperatures has brought high intensity wildfires that are very large and difficult to put out.

In general, when looking at your property assume that it can and will burn. The Best Management Practices outlined here provide a number of methods for managing for fire, protecting buildings and creating safety measures for workers.

FIRE CONDITIONS IN SONOMA COUNTY

Much of Sonoma County is covered in fire prone vegetation and the majority of lands in Sonoma County are not managed to reduce fire risk. Figures 1-3 depict general vegetation types in Sonoma County including agriculture and urban areas. Table 1 lists the acres of each vegetation type. Hardwood forest, conifer forest and grassland are the primary natural vegetation types. Many agricultural and urban areas are adjacent to or surrounded by natural vegetation.

Annual Grasses and Forbs

Annual grasslands in California are dominated by annual nonnative European grasses such as brome (Bromus sp.), wild oat (Avena sp.), dogtail (Cynosurus sp.), barley (Hordeum sp.), ryegrass (Lolium sp.) and others (Crampton 1974). Invasive plants such as yellow star thistle (Centaurea solstitialis) and black mustard *(*Brassica nigra) are common in grasslands.

In some locations native perennial bunchgrasses such as needlegrass (Nassella sp.), fescues (Festuca sp.), Ca. oatgrass (Danthonia sp.) can be found. Native forbs and wildflowers in grasslands include: wild hyacinth (Brodiaea sp.), mariposa lily (Calocortus sp.), indian paintbrush (Castilleja sp.), tidy tips (Layia sp.), Ca. poppy (Eschscholzia californica) and others. Native forbs and grasses tend to germinate after fires when built up biomass is cleared away (Hervey 1949, Marty 2002). Some species have fire adaptations. For example, lupines and some clovers produce hard seeds that germinate after fire. Soap plant (Chlorogalum pomeridianum) can resprout from its bulb following fire The seeds of filaree species (Erodium sp.) are awns that drill into the ground and withstand fires.

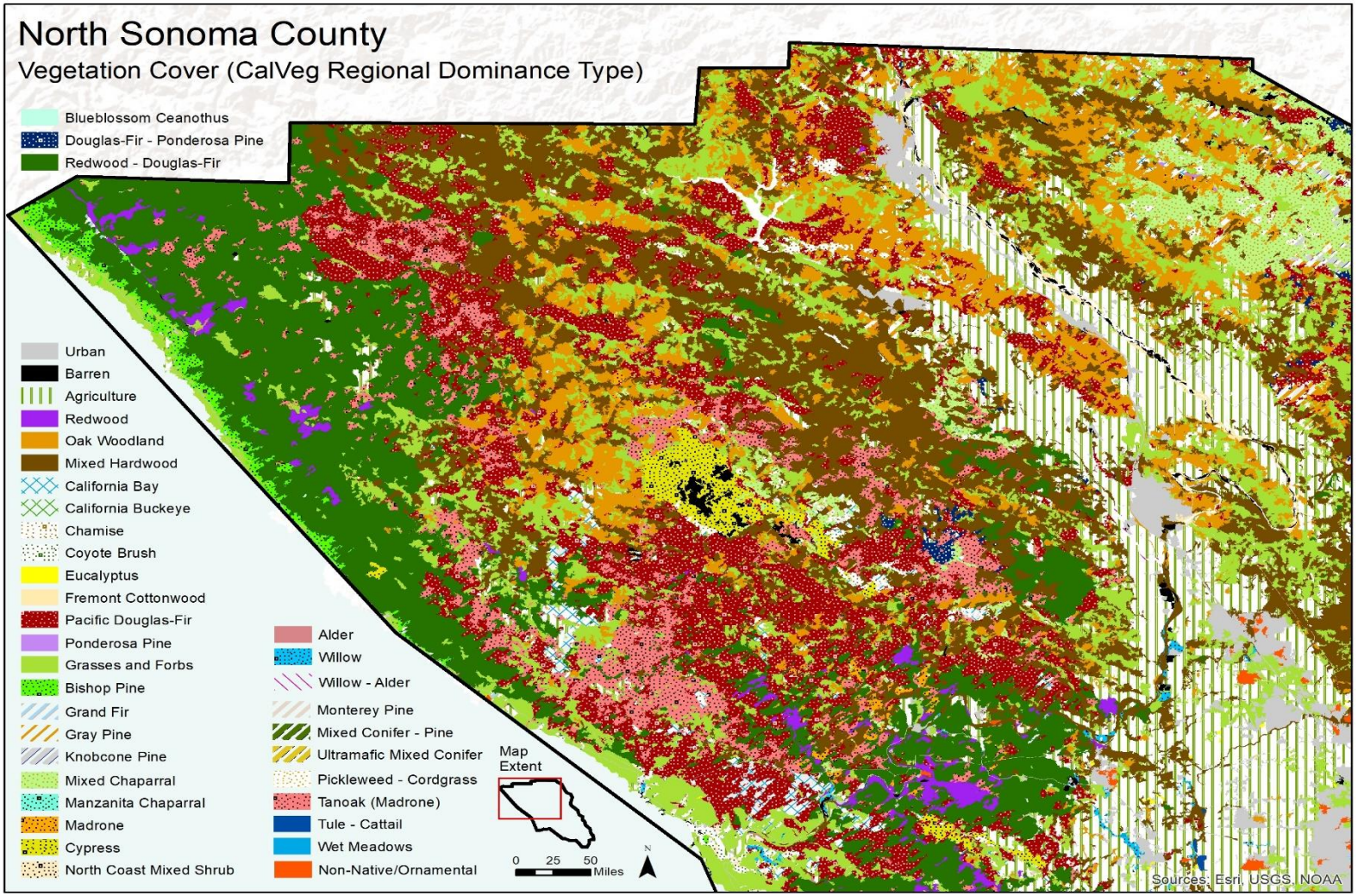


Figure 1. Vegetation types of northern Sonoma County

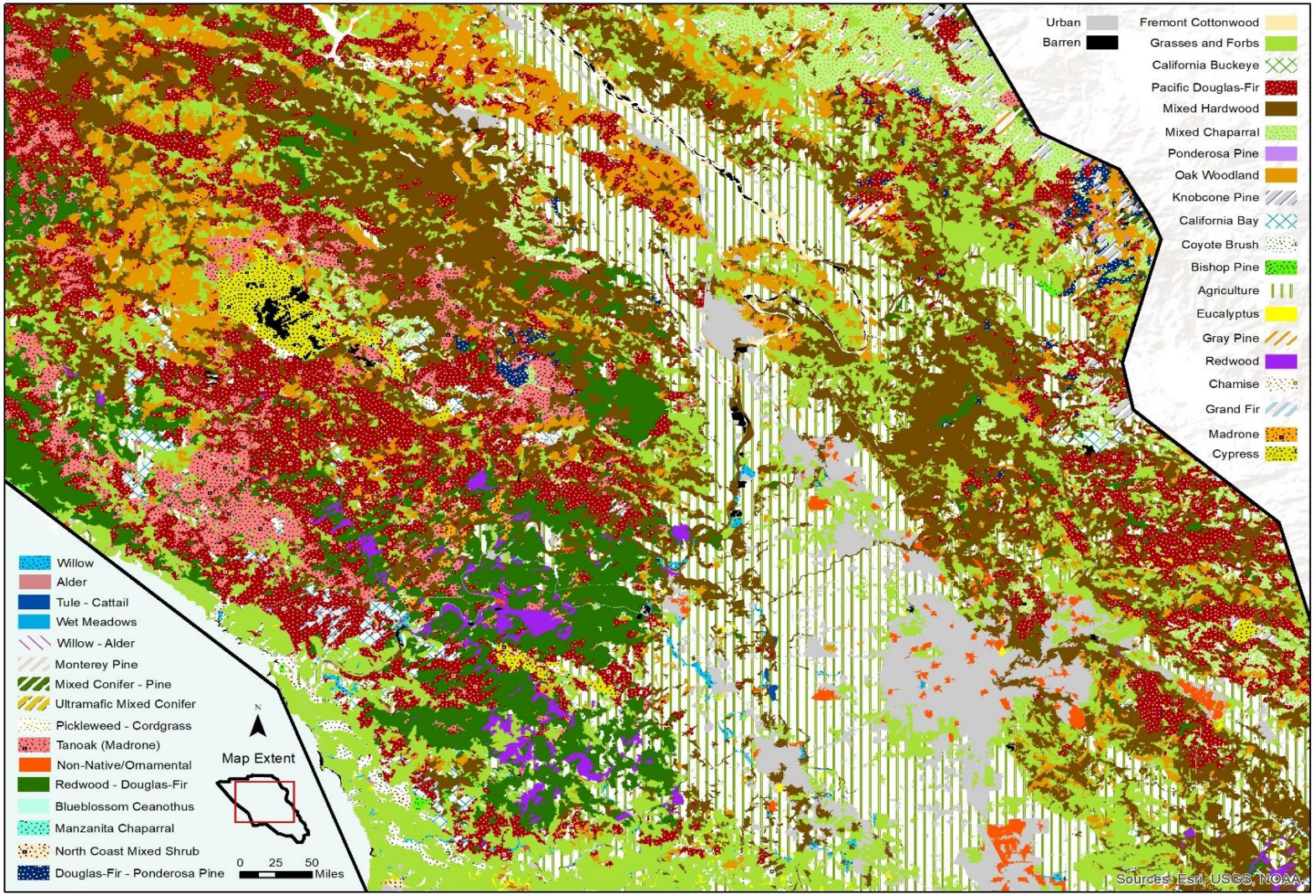


Figure 2. Vegetation types of middle Sonoma County

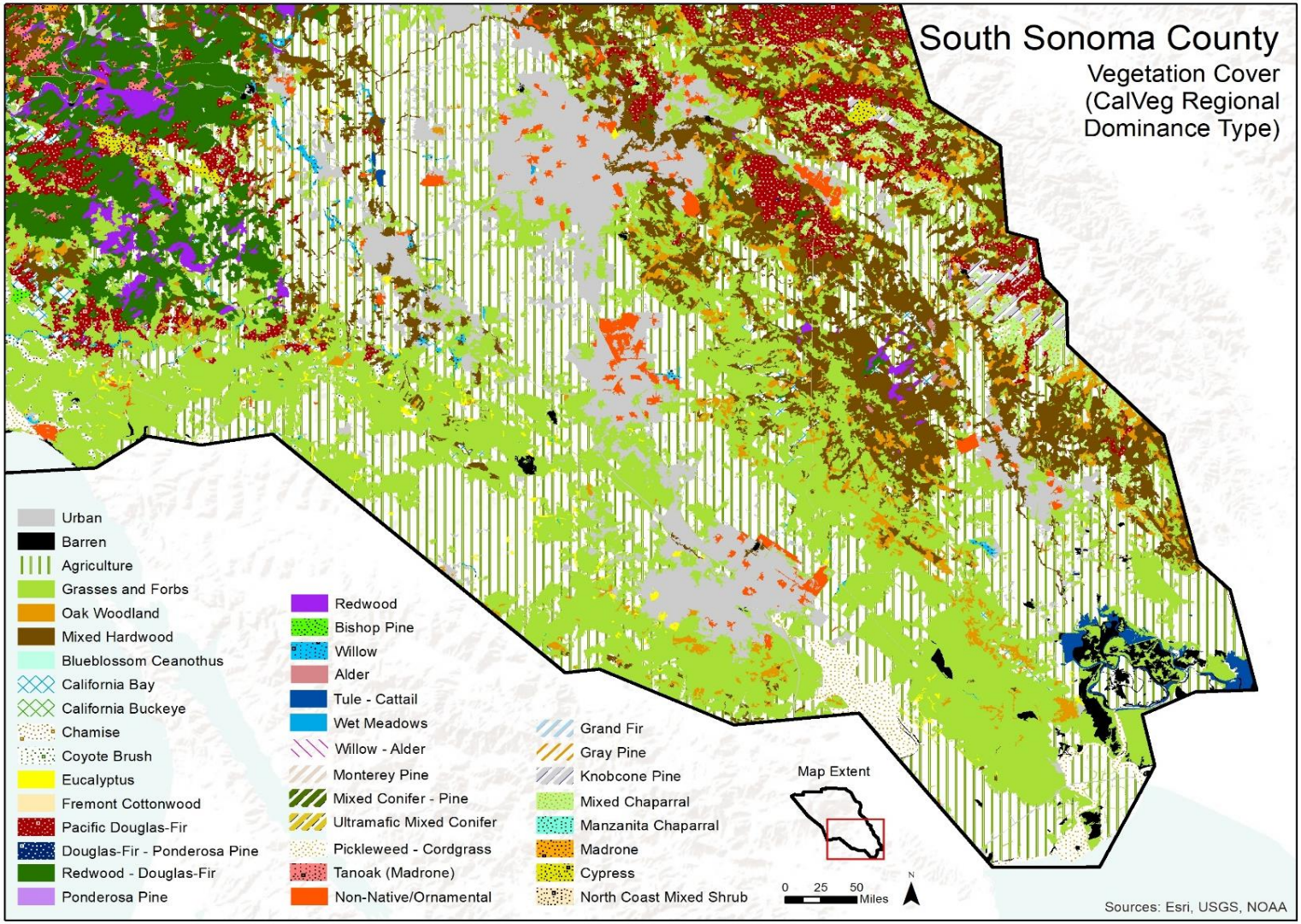


Figure 3. Vegetation types of southern Sonoma County

Table 1. Vegetative cover (CALVEG Regional Dominance Type)		
Vegetation Group	**Regional Vegetation Type**	**Acres**
Urban	Urban/Developed (General)	40,423.17
	Urban-related Bare Soil	11,161.40
Agriculture	Vineyard - Shrub Agriculture	9,221.42
	Orchard Agriculture	8.82
	Flooded Row Crop Agriculture	556.19
	Pastures and Crop Agriculture	51,038.06
	Agriculture (General)	107,511.65
Barren	Barren	7,006.47
Coyote Brush	Coyote Brush	3,689.98
Blueblossom Ceanothus	Blueblossom Ceanothus	9.86
Chamise	Chamise	4,566.18
Mixed Chaparral	Lower Montane Mixed Chaparral	33,576.12
	Upper Montane Mixed Chaparral	230.85
	Manzanita Chaparral	6.20
	Scrub Oak	3,200.58
North Coast Mixed Shrub	North Coast Mixed Shrub	453.16
Oak Woodland	Coast Live Oak	20,237.67
	Canyon Live Oak	6,419.29
	Oregon White Oak	37,802.50
	Black Oak	3,171.73
	Valley Oak	527.94
	Interior Live Oak	1,433.12
	Blue Oak	427.37
Madrone	Madrone	1,712.26
Mixed Hardwood	Coastal Mixed Hardwood	286.65
	Riparian Mixed Hardwood	4,558.50
	Interior Mixed Hardwood	137,872.30
	Montane Mixed Hardwood	35,850.88
California Buckeye	California Buckeye	25.54
Tanoak and Madrone	Tanoak and Madrone	26,157.23
California Bay	California Bay	7,461.52
Grasses and Forbs	Annual Grasses and Forbs	204,796.65
	Perennial Grasses and Forbs	628.07
Wet Meadows	Wet Meadows	97.44
Pickleweed - Cordgrass	Pickleweed - Cordgrass	5,780.65
Tule - Cattail	Tule - Cattail	1,723.15
Cypress	Monterey Cypress	94.53
	McNab Cypress	5,125.69
	Sargent Cypress	1,108.98
	Pygmy Cypress	113.55

Table 1. (cont.) Vegetative cover (CALVEG Regional Dominance Type)		
Mixed Conifer - Pine	Mixed Conifer - Pine	568.44
Ultramafic Mixed Conifer	Ultramafic Mixed Conifer	8.03
Pacific Douglas-Fir	Pacific Douglas-Fir	101,482.74
Douglas-Fir - Ponderosa Pine	Douglas-Fir - Ponderosa Pine	3,381.73
Gray Pine	Gray Pine	3,804.44
Bishop Pine	Bishop Pine	4,170.68
Ponderosa Pine	Ponderosa Pine	140.99
Monterey Pine	Monterey Pine	180.89
Grand Fir	Grand Fir	141.71
Knobcone Pine	Knobcone Pine	4,731.66
Redwood - Douglas-Fir	Redwood - Douglas-Fir	98,568.52
Redwood	Redwood	8,040.91
Alder	White Alder	140.44
Alder	Red Alder	101.74
Fremont Cottonwood	Fremont Cottonwood	1,314.85
Willow	Willow	822.31
	Willow (Shrub)	808.47
Willow - Alder	Willow - Alder	195.01
Eucalyptus	Eucalyptus	1,586.73
Non-Native/Ornamental	Non-Native/Ornamental Conifer	31.21
	Non-Native/Ornamental Grass	4,976.91
	Non-Native/Ornamental Hardwood	11.47
	Non-Native/Ornamental Conifer/Hardwood	303.73
	Non-Native/Ornamental Shrub	148.49

Chaparral

Chaparral is made up of evergreen, hard leaved and close growing shrubs and small trees. The leaves on the shrubs are oriented vertically to reduce overheating. Shrubs in chaparral are fire adapted. Chaparral is associated with Mediterranean climates and often grows on shallow rocky slopes at elevations of 900-4500 ft where 9 to 29 inches of rain falls yearly. Fire will kill all above ground growth (Figure 5). Fires are typically high intensity in chaparral due to the oils in the shrubs. Following a fire an ephemeral flora of annuals will grow in the first year from the seed left in the litter of the chaparral since the last post fire bloom. Some of these species will spend 95% of their lifetime as a dormant seed waiting for a post fire bloom. About 20% of the post fire flora sprout from bulbs, corms or rhizomes and go dormant once the canopy of larger shrubs shades them out. In addition to these herbaceous plants there are subshrubs such as toyon (Heteromeles arbutifolia), and mountain mahogany (Cerocarpus betuloides) and others that germinate post fire and will persist for up to 10 years, produce large amounts of seed and then die as they are shaded out by larger shrubs. The seed will remain viable and may stay dormant for up to 115 years and still germinate (Keeley et al 2003).

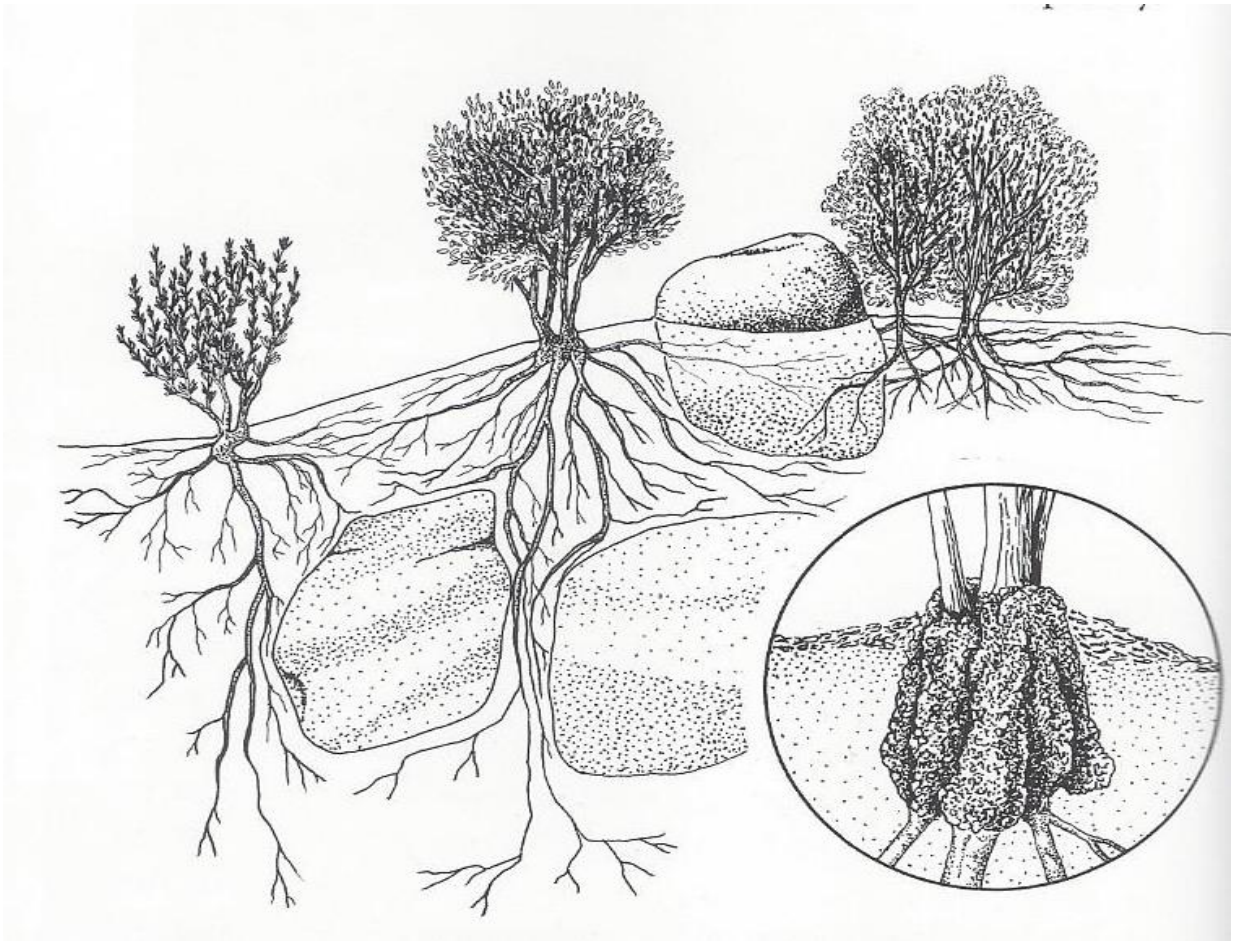


Figure 4. Root systems of chaparral plants hold the soil. Chamise (left), manzanita (middle) and Ceanothus (right). The inset is a root crown/burl in a chamise shrub. From: Quinn and Keeley 2006.

Figure 5. Chaparral shrubs and hardwoods following 2013 fire on Mt Diablo.

Figure 6. Post fire stump sprouting of chamise.

Figure 7. Regrowth of scrub oak 10 years after fire on Mt Diablo.

For the larger shrubs most will have a root crown or burl (Figure 4) The burl will start sprouting very soon after the fire (Figures 6 and 7). Chaparral shrubs also produce seeds which build up in the litter and will sprout after a fire. The seeds require a fire to break the hard seed coat and allow germination. These seedlings need full sun and can tolerate severe summer dryness and heat. Looking across expanses of chaparral there are typically large patches of shrubs of the same age and size representing the regrowth following a fire intermixed with patches of much larger shrubs that are unburned. Figures 5-8 show a 2013 fire on Mt Diablo in Contra Costa County and the regrowth of chaparral and hardwood trees after the fire.

There is no old growth chaparral as this vegetation type is fire dependent for seeds to germinate and established shrubs to resprout (Quinn and Keeley 2006, US Forest Service 2018, Reeves 2006, Fryer 2012, League 2005, Howard 1997, McMurray 1990, Howard 1993, Hauser 2007). In the absence of fire, chaparral shrubs can get old enough to die creating large holes in the canopy and areas where invasive plants may get established. However frequent fires (2-10 years) can result in the transition of chaparral to grassland. The seedling and resprouting shrubs cannot grow large enough to survive another fire.

Three types of shrubs dominate chaparral – chamise, manzanita and Ceanothus:
Chamise (Adenostoma fasciculatum) has small one-half inch or less dark green needlelike leaves (Figure 8). Chamise flowers in early February and resprouts quickly after fire. Chamise tends to grow at lower elevations and on south facing slopes (Quinn and Keeley 2006).

There are many species of Ceanothus, also called blue blossom or California lilac. This shrub flowers in winter and produces small fruits that explode in the summer heat and distribute seed.

Manzanita (Arctostaphylos sp.) is widely distributed in California and is the longest-lived chaparral shrub. It tends to grow on higher slopes and ridgetops. Manzanita flowers in winter and produces fruits that are eaten by many types of wildlife. The digestive effects of the animal's gut on the fruits makes the seed germinate better. Sprouting species are well adapted to frequent fires, but still need 20 years or more between fires to fully recover (Sugihara et al. 2006).

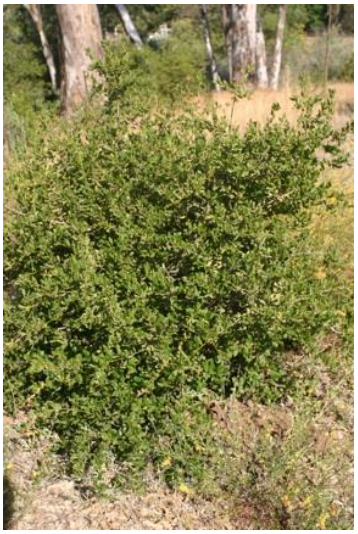
Scrub oak (Quercus berberidifolia) termed "chaparra" by Spanish explorers is the primary tree species in the chaparral and is widely distributed in California. Scrub oak is evergreen with small leaves with spiny margins. This plant flowers from March to May and resprouts following fire. Often scrub oak will grow underneath the shrub canopy and stay as a stunted sapling. Then following a fire this species can resprout and reach a height above, or at the shrub canopy level.

Oak Woodland and Mixed Hardwoods

Oak woodland includes a variety of oak species that vary in distribution with slope, aspect, soil and water availability. All of these species are somewhat fire resistant and all resprout from their root crown (stump or burl) when fire kills above ground growth (Pavlik 1991, Fryer 2007a and b, Fryer 2012, Gucker 2007, Howard 1992a, c and d, Steinberg 2002, Tollefson 2008). Acorns germinate quickly and in large numbers on the burned mineral soil following a fire.

Oak woodland species in Sonoma County include (Figure 9):
Coast live oak (Quercus agrifolia) is an evergreen oak that favors north facing slopes, canyon bottoms, streams and locations with deep soils. Coast live oak has very hard bark that resists burning

Chamise flowering in the spring



Scrub oak

Ceanothus flowering in the spring

Greenleaf manzanita

Ceanothus flower

Manzanita flower

Figure 8. Plants of chaparral.

Coast live oak

Canyon live oak

Blue oak

Post fire sprouting valley oak

Black oak

Ca. bay laurel

Ca buckeye

Figure 9. Plants of oak woodland and hardwood forest

Figure 10. Stump sprouting oak with a post fire infestation of invasive French broom.

Figure 11. French broom understory in oak woodland increases fire risk

Interior live oak (Quercus wislizeni) is also an evergreen oak and covers valley bottoms, canyons and hillsides.

Blue oak (Quercus douglasii) can be deciduous or evergreen depending on available soil moisture and is the most drought tolerant oak. It occurs in particularly hot and dry locations and is very slow growing.

Canyon live oak (Quercus chrysolepis), also called golden oak, is an evergreen oak that lives in ravines and along creeks.

Black oak (Quercus kelloggii) has large deciduous leaves and occurs in ravines along stream and on rich soils.

Oregon white oak (Quercus garryana) is widespread and deciduous with fairly large leaves.

Valley oak (Quercus lobata) needs abundant moisture and occurs on valley floors, ravines and along creeks. This species is deciduous.

Ca. bay laurel (Umbellularia californica) is the only native California tree in the avocado family and is evergreen with highly scented leaves. This species occurs along creeks, in ravines and on hillsides.

Ca. buckeye (Aesculus californica) has large sprigs of white flowers and segmented leaves. Buckeyes lose their leaves in late spring and become dormant to avoid the effects of summer drought.

Mixed hardwood forest consists of oak woodland species intermixed with Douglas fir, a conifer.

There are a number of invasive nonnative plants that invade burned lands particularly hardwood and conifer forests. Figure 10 shows a burned hardwood forest where French broom (Genista monspessulana) has invaded and is nearly as large as the stump sprouting growth of the oak trees. French broom is highly flammable and this invasion creates a dense understory of flammable vegetation in future fires (Figure 11). French broom produces abundant seed that remains viable for years and will allow for rapid re-establishment after the next fire. Other invasive nonnative species in burn areas are Scotch broom (Cytisus scoparius) and Spanish broom (Spartium junceum)**,** gorse (Ulex europaeus), yellow and purple star thistle (Centaurea solstitialis, Centaurea calcitrapa) black mustard (Brassica nigra) and European grasses.

Conifer Forest

There are a number of conifer tree species that occur in various associations with other trees, with chaparral or in single species stands (Figure 12).

Conifer species in Sonoma County include:
Douglas fir (Pseudotsuga menziesii) can withstand moderate fires but will die after a crown fire. Its seeds germinate best on mineral soils in full sun. Douglas fir has corky bark that has low heat conductivity to resist low and moderate intensity fires

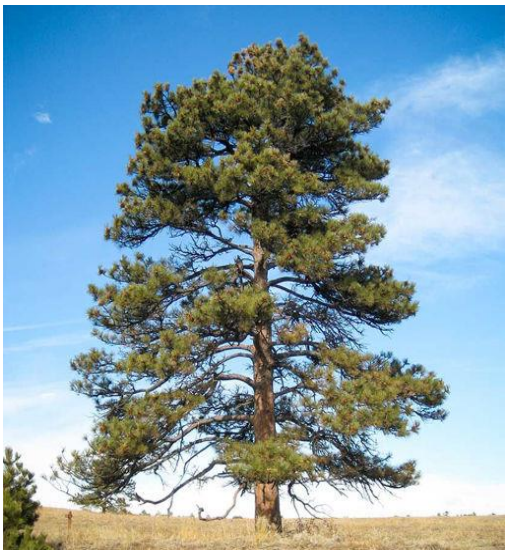
Grey pine (Pinus sabiniana) occurs with hardwoods and chaparral and can grow on serpentine soils. This species has pendent cones with seeds dispersed by animals, gravity and wind (Howard 1992e).

Knobcone pine (Pinus attenuata) grows on nutrient poor soils including serpentine and is often found in pure and even aged stands regrown after fires. The cones of this species are serotinous and dependent on fire to open and disperse seeds (Howard 1992b).

Ponderosa pine (Pinus ponderosa) grows on well drained, non-serpentine soil and will be killed by crown fires, but not moderate fires (Fryer 2018). This species has thick bark to resist moderate and low intensity fires.

Coastal redwoods (Sequoia sempervírens) only grow in the coastal fog belt from central California to southern Oregon. They require continuous moisture and will sprout following fire from epicormic buds underneath the bark (Griffith 1992).

Sargent cypress (Cupressus sargentii) is a fire dependent species that grows in widely scattered, isolated groves and as part of many vegetation types. Sargent cypress often grows on serpentine soils. Many trees die in larger fires. Fire opens cypress cones releasing seeds resulting in the growth of dense thickets of new cypress (Esser 1994).



Ponderosa pine

Coastal redwood

Douglas fir cones

Knob-cone pine

Grey pine cones

Grey pine

Sargent cypress

Sargent cypress

Figure 12. Conifer trees.

NATURAL FIRE REGIMES

In California's Mediterranean climate there is little to no rain from May/June to Oct./Nov. The long, dry hot summer leaves vegetation desiccated and easily burned. Several years of drought increases the dryness of vegetation and its flammability (Barrett et al. 2010).

Prior to human settlement lightning was the main ignition source for fires. Lightning in the coastal ranges comes from monsoons that move north out of the American Southwest bringing afternoon thunderstorms (Adams and Comrie 1997). Although not common, these types of storms can occur for up to 10-20 days per summer season. The fires started by these lightning storms could have burned for months until put out by rainstorms.

Fire has been a major factor in landscapes in California for millions of years (Sugihara et al. 2006). California vegetation evolved adaptations to these natural fire regimes. Native American tribes in California managed the landscape using fire to protect their villages, improve plant collection and hunting areas and to favor the growth of food plants (Heizer and Whipple 1972). Fires were set annually in certain areas (Anderson 2005).

Nineteenth century loggers burned cut over conifer forest land once logging was complete. This action cleared slash and logging debris and created grassland for livestock grazing (Sugihara et al. 2006).

In 1905 the U. S. Forest Service began the practice of widespread fire suppression in national forests. State and local fire authorities adopted the same approach in 1924. Fires were put out quickly. Over time this practice resulted in the buildup of large fuel loads (Sugihara et al. 2006).

Historic Fires

Figures 13-15 depict the extent and locations of fires larger than 5000 acres mapped by CAL FIRE since 1973. Table 2 lists the size of the fires on the map. More recent fires from 2017-2020 vary greatly in size from those of prior decades.

These recent, larger fires were spread by high erratic winds, high temperatures and low relative humidity. Relative humidity, or the moisture content in the atmosphere, and wind velocity affect fuel moisture. Low relative humidity changes moisture content in living plants and water diffusion in dead fuel increasing the amount of fuel available to burn and the intensity of the fire. In drier conditions the coarseness (larger particle size of fuel vs. fineness or smaller particle size) of the fuel that can burn increases. High wind speeds cause high fire spread rates and increase the intensity as well as the size of the fire. Due to decades of fire suppression, fuel loads in much of Sonoma County are high.

These recent fires are not only larger than fires in prior decades, they also burned for a long time and were spread by high wind events. Future fire conditions are likely to be similar to the past few years rather than the conditions of prior decades.

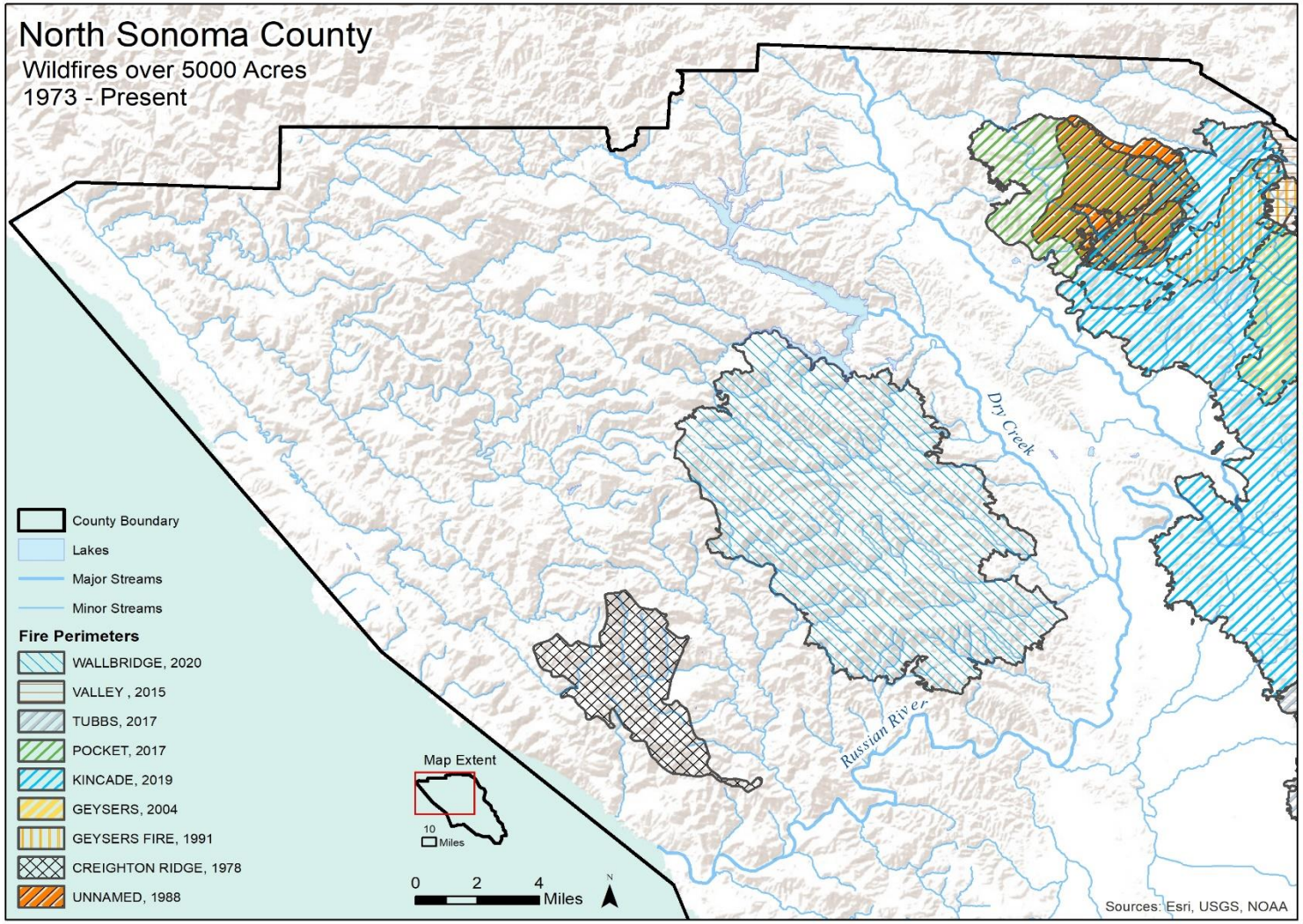


Figure 13. Perimeters for wildfires over 5000 acres since 1973 northern Sonoma County. From CAL FIRE

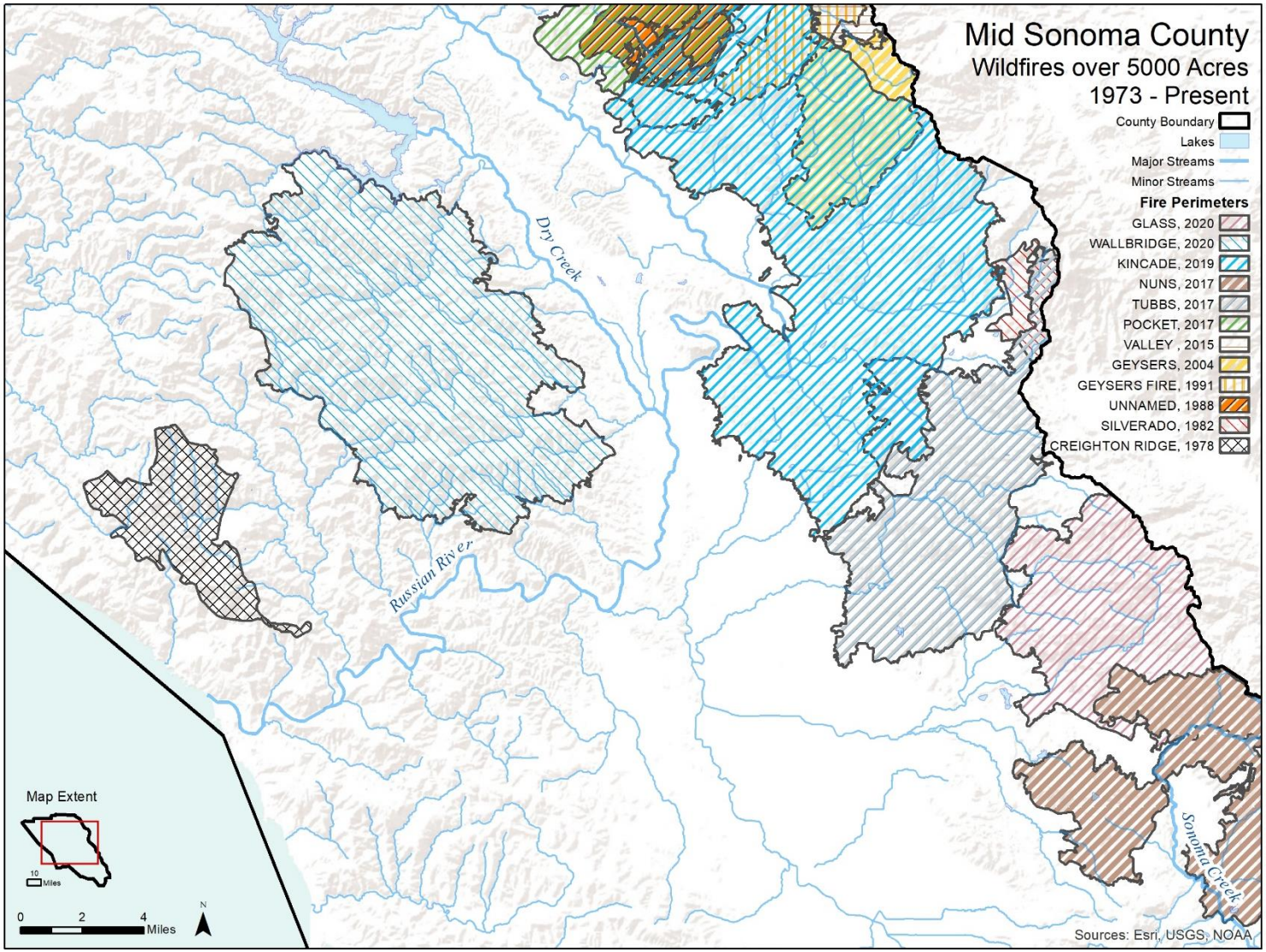


Figure 14. Perimeters for wildfires over 5000 acres since 1973 middle Sonoma County. From CAL FIRE

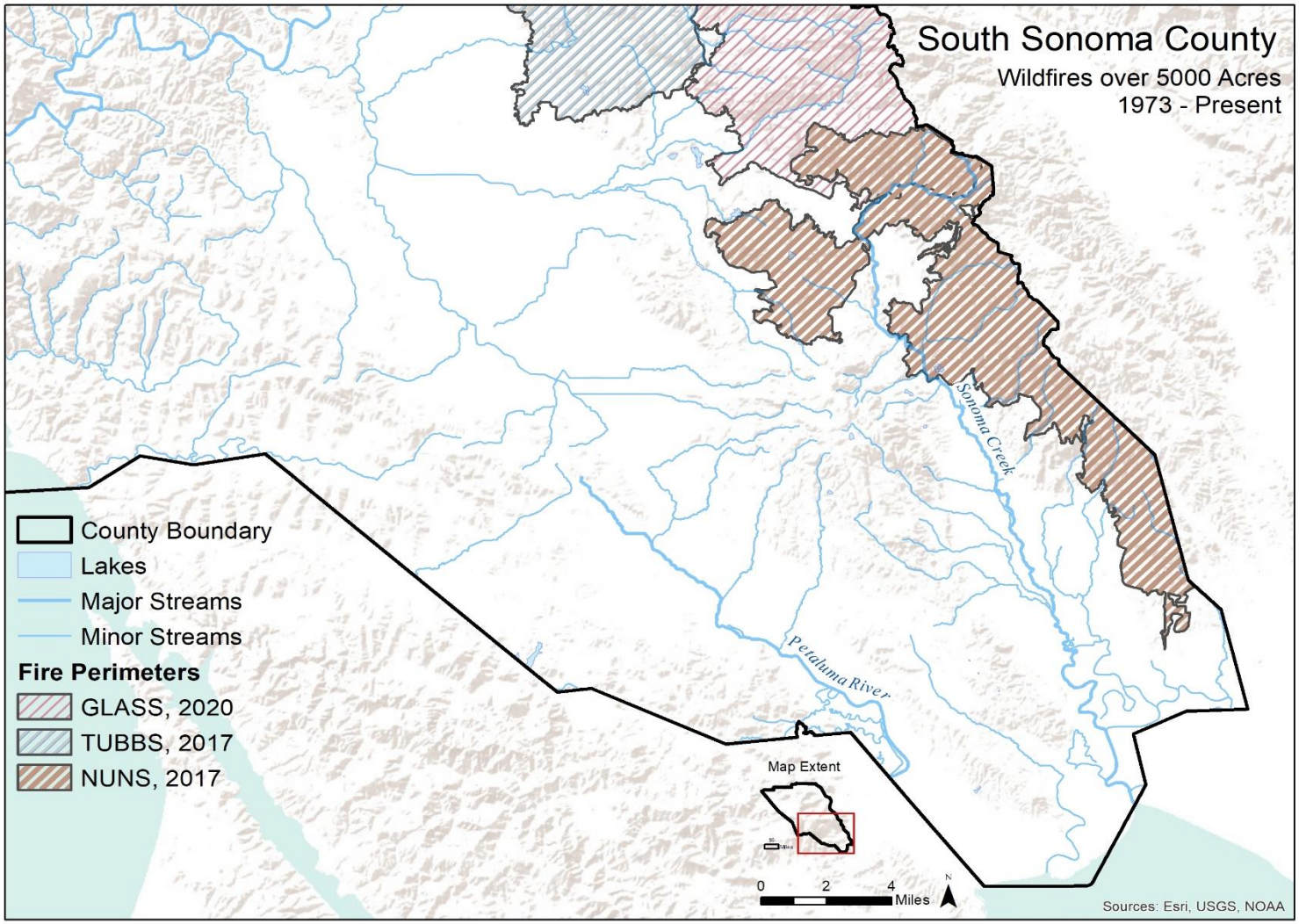


Figure 15. Perimeters for wildfires over 5000 acres since 1973 southern Sonoma County. From CAL FIRE

Table 2. Size of wildfires since 1973

Year	Name	Total Acres	Acres in Sonoma County
2020	WALLBRIDGE	55,208.94	55,208.94
2020	GLASS	67,484.41	26,640.50
2019	KINCADE	77,762.14	77,241.53
2017	NUNS	55,798.19	37,230.84
2017	TUBBS	36,701.98	31,898.22
2017	POCKET	17,359.33	17,359.33
2015	VALLEY	76,084.84	3,699.40
2004	GEYSERS	12,244.40	11,614.34
1991	GEYSERS FIRE	5,770.72	5,770.72
1988	Unnamed	11,380.36	11,380.36
1982	SILVERADO	6,218.79	3,058.54
1978	CREIGHTON RIDGE	10,761.28	10,761.28

From: CAL FIRE

Fire Hazard Severity Zones

Fire hazard severity zones (FHSZ) are based on a model that CAL FIRE developed beginning in 1981 and improved through a 2007 iteration. The model quantifies natural fire hazards near homes and communities. The FHSZ reflect long-term hazards that remain constant for several decades. The zones are not updated following fuel reduction projects or recent fires.

The FHSZ model uses data on vegetation type, topography, climate, crown fire potential, potential ember production and movement, and fire history in wildland areas. The zones delineate patches of land with similar physical features and hazard levels. The model assumes the worst possible fuel load and weather conditions. The probability of fire is based on burn frequency data over the last 30 years and then is interpolated to similar fuel and climate conditions. Potential flame length, another factor in the model, is based on long-term potential fuel loads and fire behavior on land with those fuel loads in hot, dry and windy weather that occurs in a locale. Typically, wildland areas with steep slopes, high fuel loads and hot, dry and windy weather receive the highest hazard ratings.

Figures 16-18 and Table 3 depict the results of the Fire Hazard Severity model for Sonoma County. High fire hazard zones make up 35% of the county for a total of 274,048 acres; very high fire hazard severity zones represent 41% for a total of 320,076 acres and moderate fire hazard severity zones make up 24% for a total of 193,778 acres.

Table 3. Fire hazard severity zones for Sonoma County

Hazard Zone	Acres
Moderate	193,778
High	274,048
Very High	320,076

From CAL FIRE

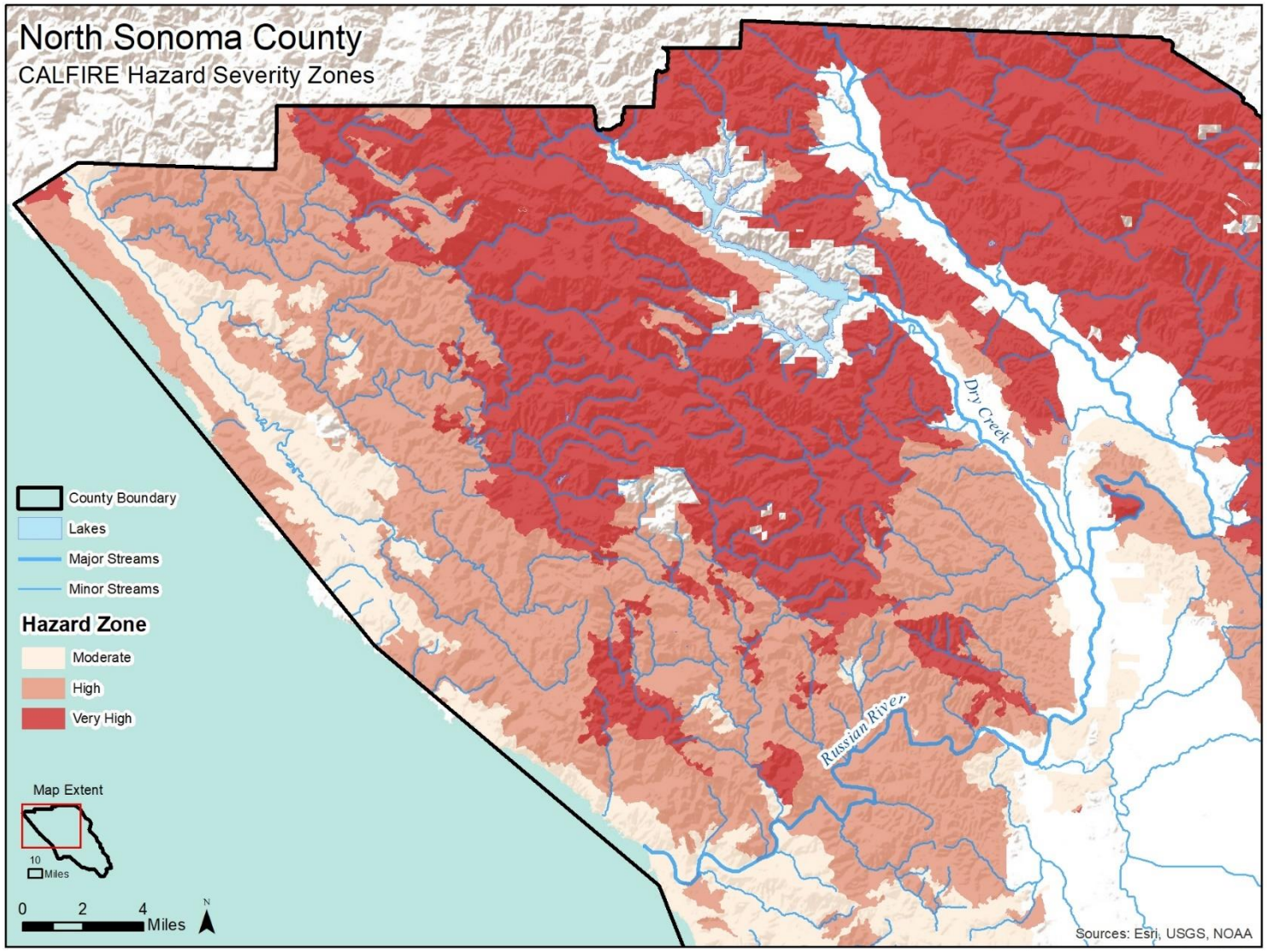


Figure 16. Fire hazard severity zones for northern Sonoma County. From CAL FIRE

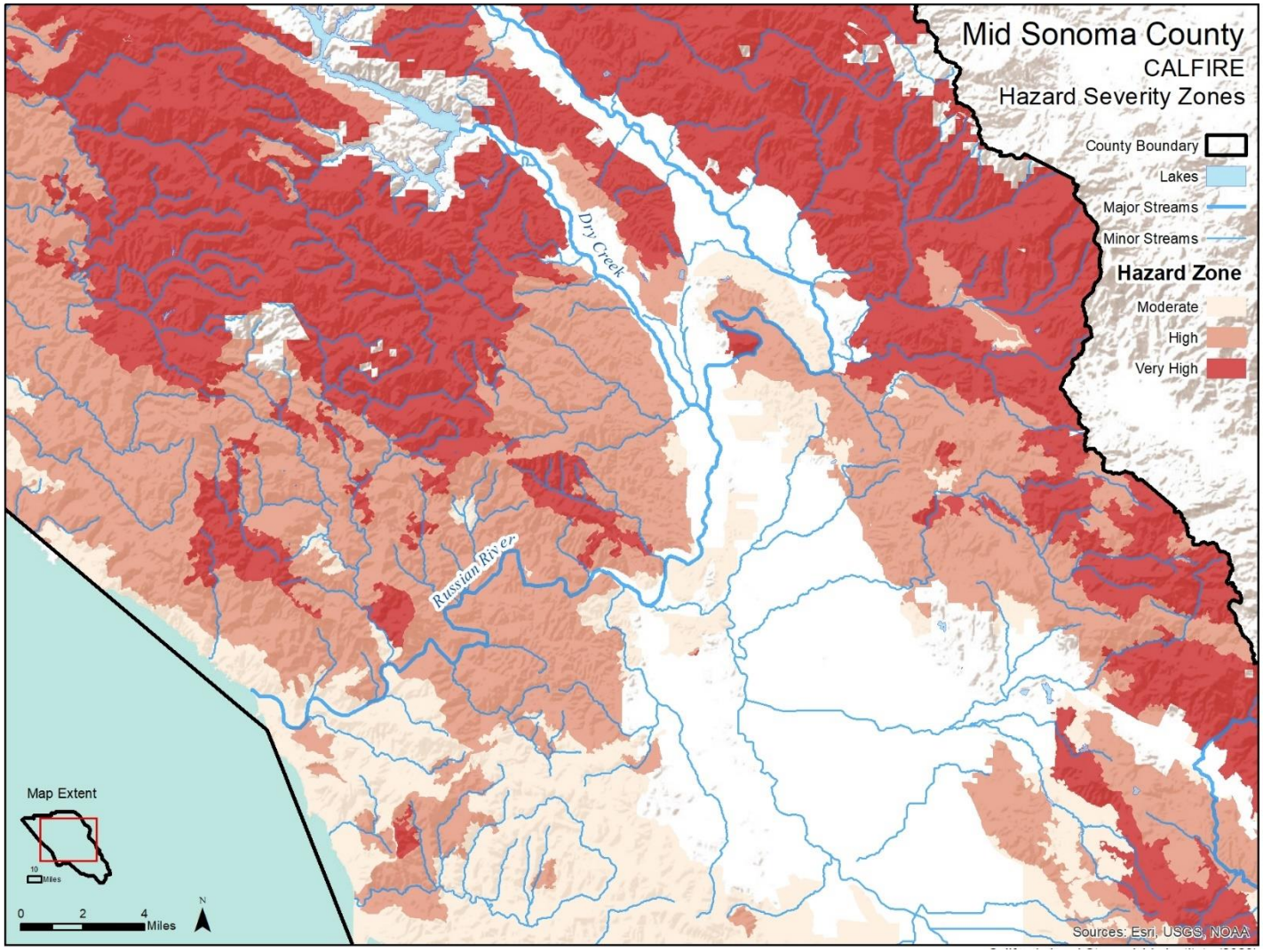


Figure 17. Fire hazard severity zones for middle Sonoma County. From CAL FIRE

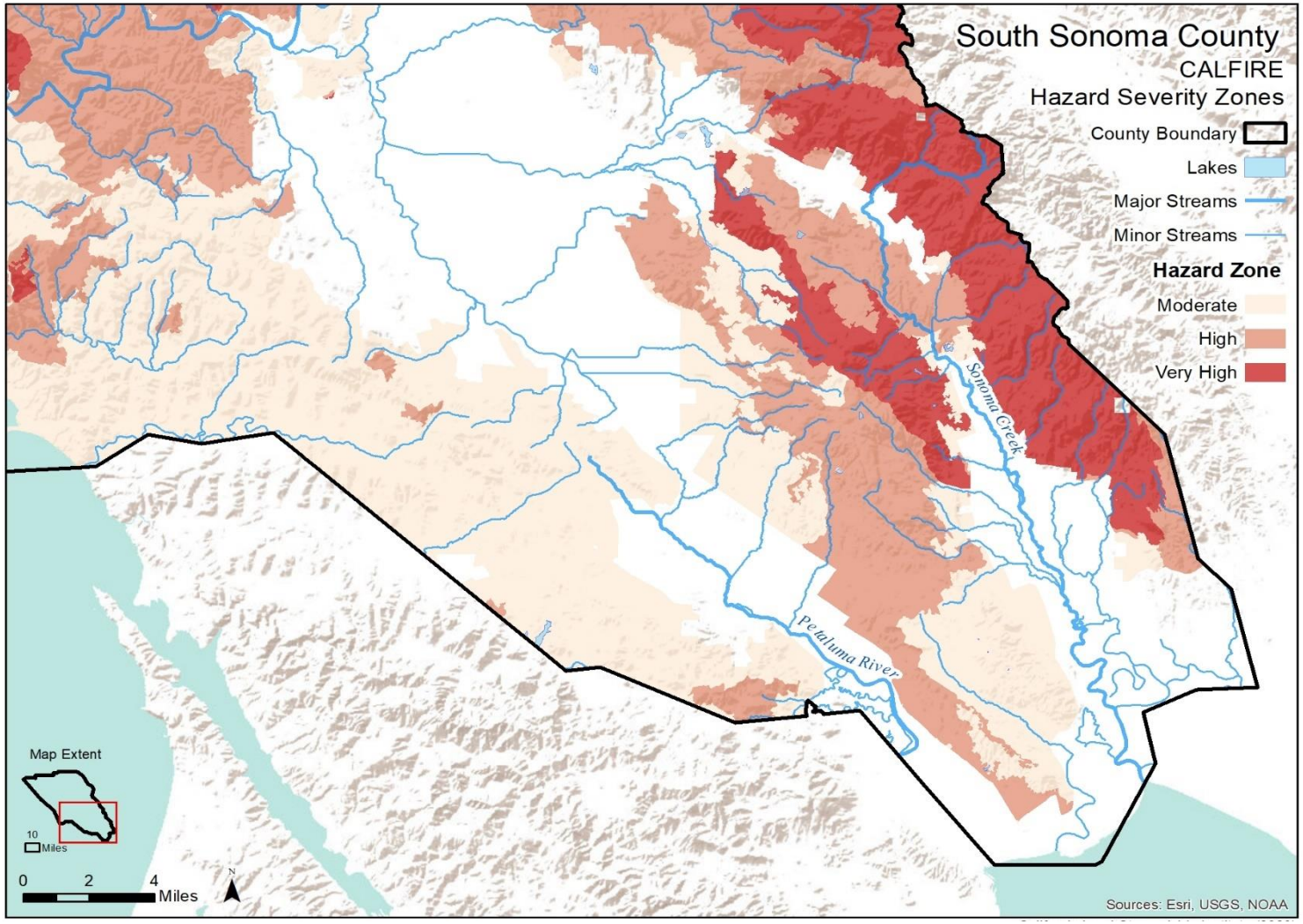


Figure 18. Fire hazard severity zones for southern Sonoma County. From CAL FIRE

Fire Threat

Fire threat rankings from CAL FIRE reflect current fuel conditions and potential fire behavior. The rankings represent the relative likelihood of a damaging or difficult to control fire occurring in a specific location. Figures 19-21 and Table 5 depict the fire threat ranking for areas of Sonoma County. Very high fire threat areas total 19% (160,023 acres) and high fire threat areas total 50% (425,533 acres). High and very high fire threat areas make up nearly 70% of Sonoma County.

Table 5. Level of fire threat for Sonoma County

Threat Class	Acres
Low	75,858
Moderate	185,333
High	425,533
Very High	160,024

From CAL FIRE

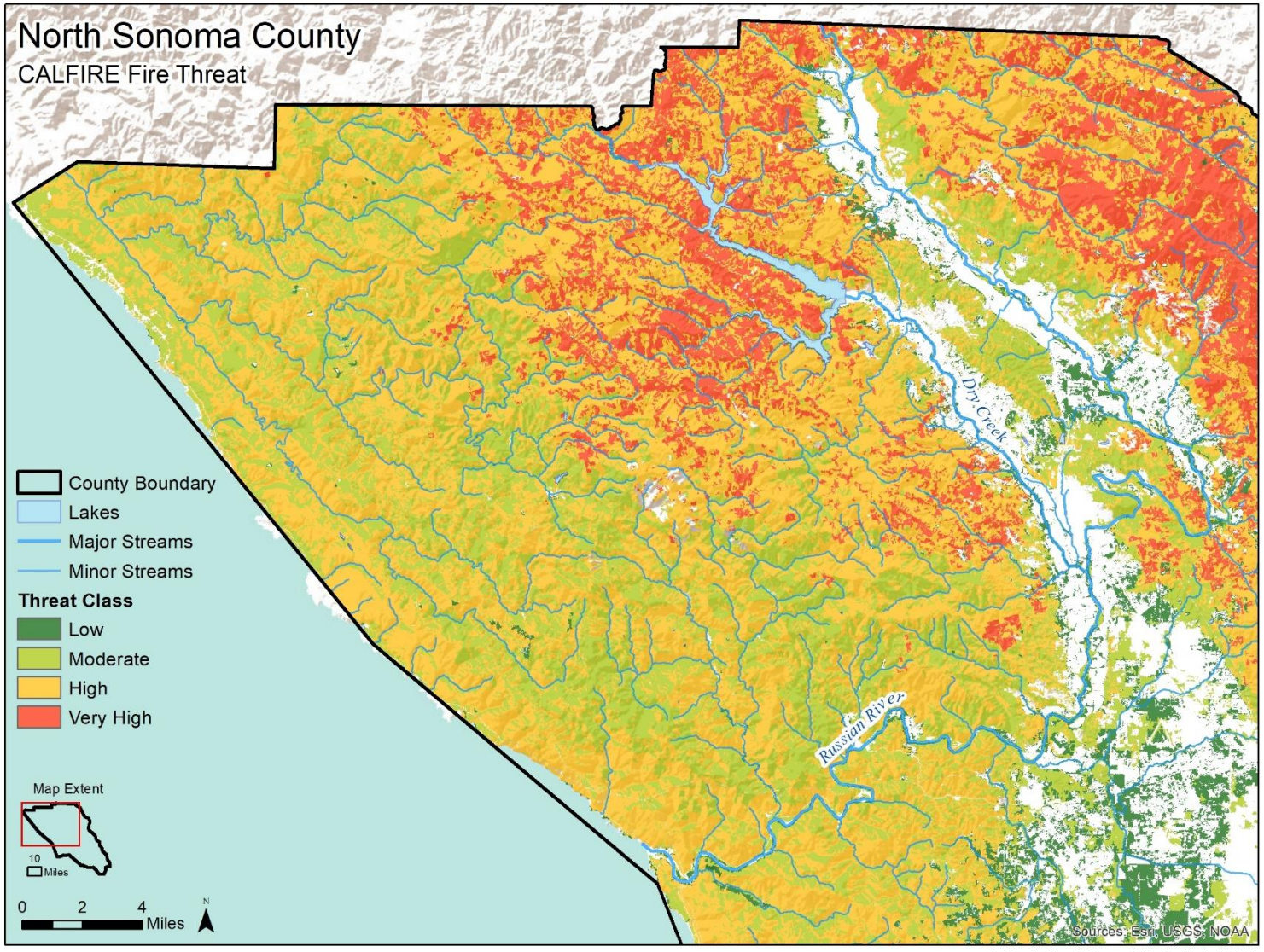


Figure 19. Level of fire threat for northern Sonoma County. From CAL FIRE

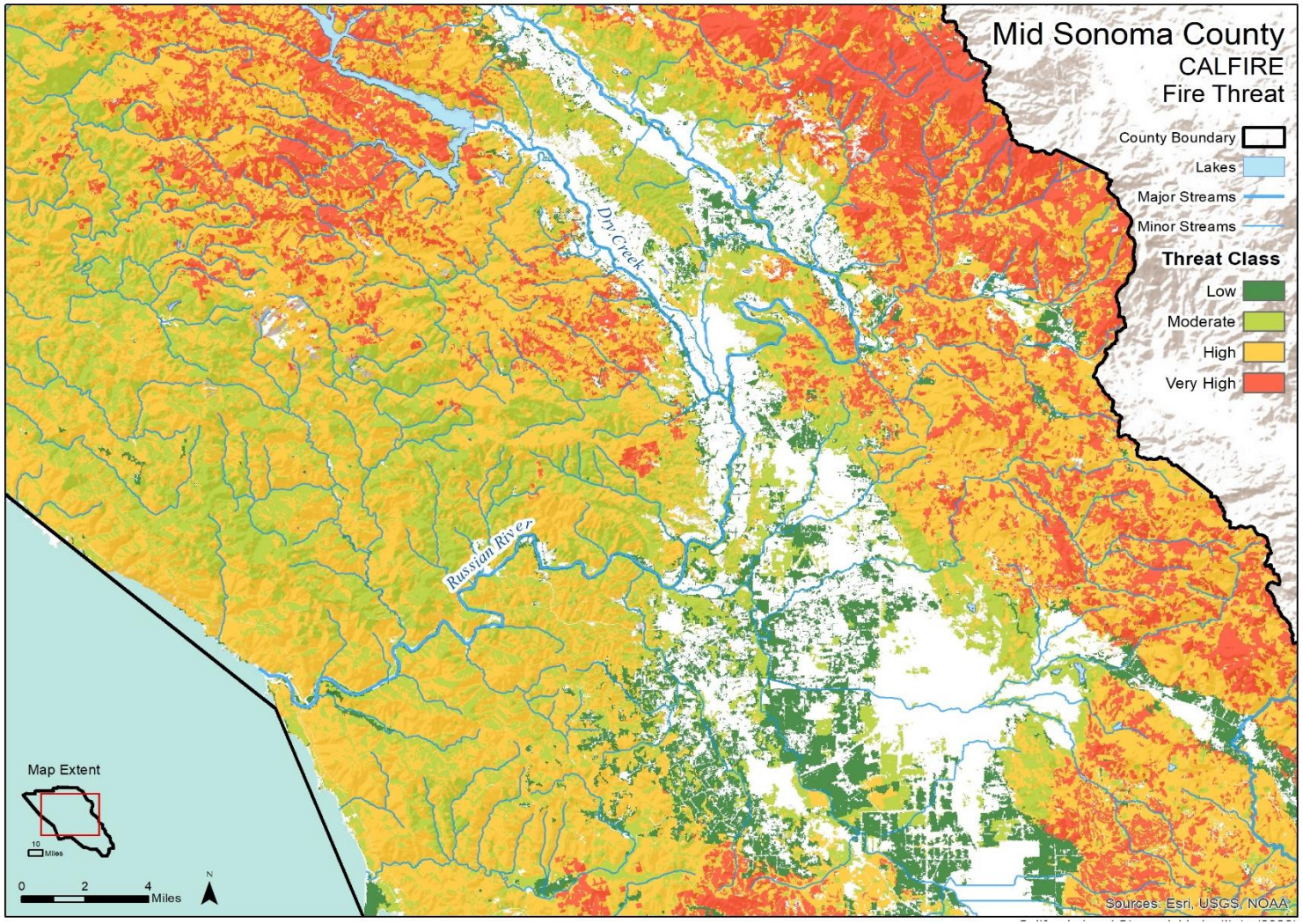


Figure 20. Level of fire threat for middle Sonoma County. From CAL FIRE

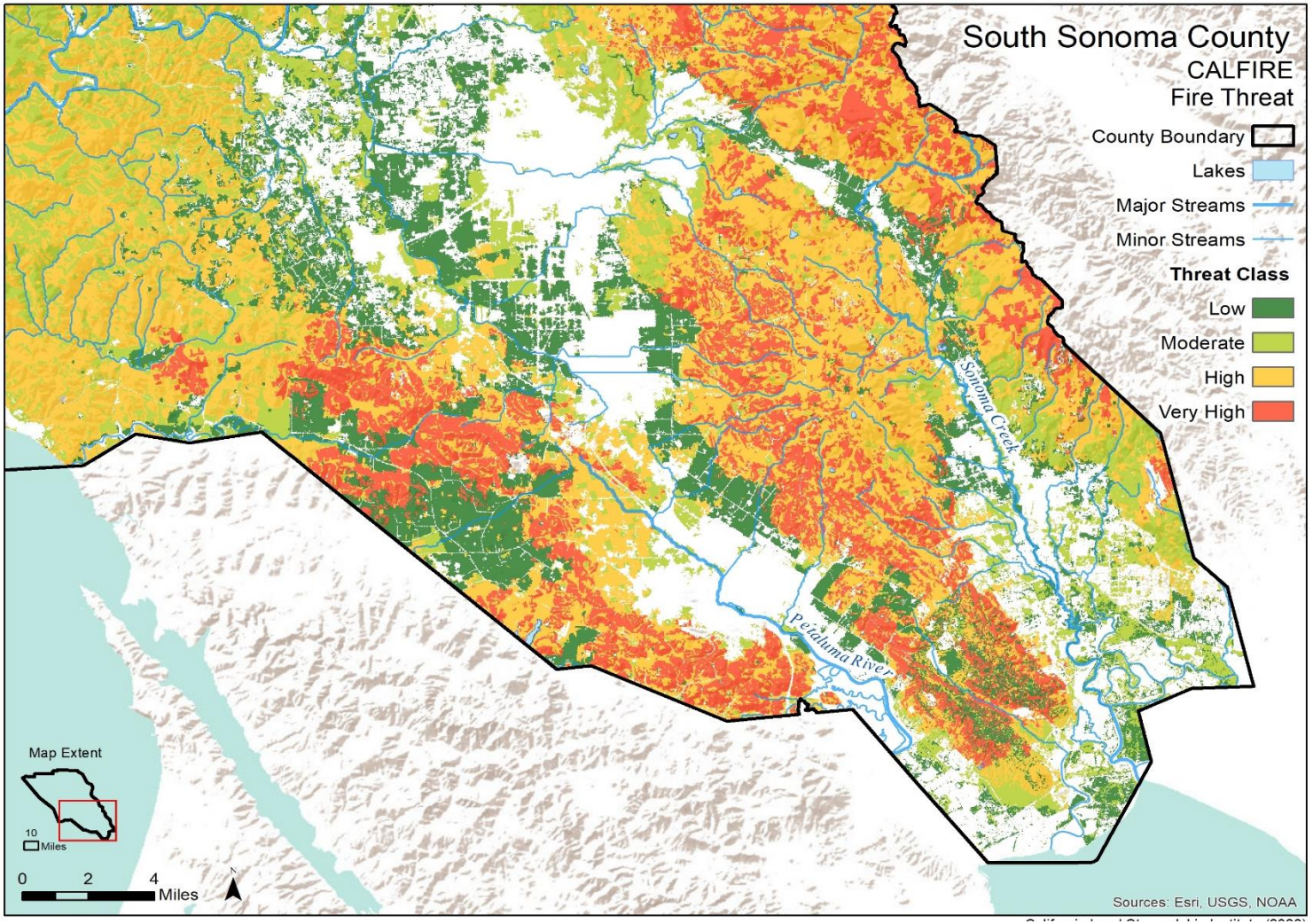


Figure 21. Level of fire threat for southern Sonoma County. From CAL FIRE

SUMMARY

According to CAL FIRE Sonoma County has over 594,100 acres of vegetation that poses a very high and high fire threat. Many vineyards, wineries and agricultural buildings and housing are located in these high and very high fire threat areas.

It is not a matter of whether these lands will burn; it is a matter of when and if the landowner has taken steps to reduce fire damage and spread. The following sections explain a series of Best Management Practices (BMPs) that address:

- Worker safety and evacuation plans
- Hardening and creating defensible spaces around all buildings
- Road, water supply and vineyard drainage infrastructure changes to avoid fire damage
- Managing natural vegetation around the vineyard and on the property to reduce fire risk
- Using prescribed burning to control natural vegetation
- Post fire recovery, clearing and revegetation
- Preventing landslides and debris flows after a fire

These BMPs are the foundation of creating a fire prevention plan for a farm or ranch. We are currently investigating if creating these plans and having them certified by a qualified third party could reduce insurance costs for landowners.

1. DURING A FIRE: FARM WORKER SAFETY

Background: Farm Worker Safety

By the end of the summer and early fall it has been many months since it rained and natural vegetation, soil and creeks reach their driest state. Relative humidity is also typically low. This period of high fire danger overlaps with the harvest season for winegrapes. Should a fire break out during harvest farmworkers can be exposed to hazardous conditions. If the farm is in an evacuation zone all farmworkers should leave. Depending on the location and speed the fire is moving, evacuation may be difficult. Farmworkers may be able to shelter in place if a safety zone can be defined on the vineyard site. The vineyard site must have a site completely cleared of vegetation that is at least 9 time wider than the surrounding vegetation is tall. If a vineyard site is in a forest of 100 ft tall trees the safety zone of cleared land must be 900 ft. wide on all sides. The safety zone must accommodate all personnel and their vehicles. Typically, only large parking lots or possibly reservoirs may qualify as a safety zone on most sites. Evacuation from the site should be done as soon as it is safe

Sometimes the evacuation zones defined by emergency personnel are a much larger area than where the fire is actively moving. Farmworkers that have undergone fire safety training and received an Agricultural Pass from the Agricultural Commissioner can voluntarily return to the farm during daylight hours if emergency personnel allow entry. Workers may return to the farm to evacuate, transport, shelter, feed, water, administer veterinary or other care to livestock; irrigate crops; fuel emergency generators or provide auxiliary support to peace officers and emergency personnel (such as identifying access roads and water). Harvesting or sowing crops, food processing, and facility repairs are not allowed.

Some vineyard management companies have had workers trained and equipped to serve as Firefighters Type 2 and may be able to assist emergency personnel.

Assessment: Farm Worker Safety

- ❑ Are there large enough locations for a safety zone to be established on the property?
- ❑ Do supervisors or managers monitor fire danger conditions regularly? (see Evacuation Plans)
- ❑ Does the vineyard have an established evacuation plan for wildfire response?
- ❑ Have all workers including supervisor and managers completed the fire safety training and have an Agricultural Pass? The pass expires 3.5 years after the training course completion.
- ❑ Are any workers qualified and equipped to fight fires?
- ❑ Does the vineyard have wildfire suppression equipment available if workers are trained to fight fires?
- ❑ Are there residences on the vineyard site?

Applying BMPs – Farm Worker Safety

- ❑ Identify safety zones where workers could shelter if evacuation is not possible.
- ❑ Safety zones should be areas clear of flammable materials for distances that are at least 9 times wider than the height of adjacent vegetation.
- ❑ Water bodies can serve as safety zones.
- ❑ Vehicles can offer a measure of protection.

- ❑ Encourage workers to wear or have available heavy cotton clothes, leather or cotton gloves, and dry cotton bandanas.
- ❑ Make sure all workers, supervisors and managers complete fire safety training and acquire an Agricultural Pass from the Agricultural Commissioner's Office.
- ❑ If there are residences on the property be sure to include all tenants in all actions related to safety zones including meetings and trainings
- ❑ Encourage residents and farm workers to create an emergency go kit to grab when going to safety zones or evacuating. Go Kit should include:
    - Bandana, N95 mask, goggles, leather gloves, long shirt and pants, boots and hat
    - Flashlight and headlamp with spare batteries
    - Extra car keys, credit cards, and cash
    - Prescription medications
    - Extra eyeglasses or contact lenses
    - First aid kit
    - Battery powered radio and extra batteries
    - Cell phones, laptops and other devices
    - Copies of important documents (birth certificates, passports, insurance policies)
    - Water bottles and food
    - Sanitation supplies
    - Change of clothing
    - Spare chargers for cell phones, laptops etc.

Optional

If workers are qualified as Firefighters Type 2:

- ❑ Establish standards for overtime and hazard pay.
- ❑ Obtain insurance to cover employees engaged in firefighting.
- ❑ Maintain current training and certifications for all workers involved including:
    - Annual refresher training
    - Work capacity (pack) test
    - Shelter deployment
- ❑ Annually check all personal protective equipment including:
    - Nomex shirt and pants
    - Hard hats (fire line certified)
    - Fire shelters
    - Eye and ear protection
    - Gloves
    - Boots
- ❑ Annually check firefighting tools and equipment including:
    - Hand tools—check handles are secure in tool heads, handles are not damaged
    - Power saws—check fuel, tools, extra chains, sharpening jigs, all personal protective gear
    - Slip-on pump units—check oil, fuel, spark plug, hoses and connections
    - Hose packs—check hose, nozzles, and hardware including T's, Y's, reducers, increasers, water thieves, shutoffs

2. DURING A FIRE: EVACUATION PLANS

Background: Evacuation Plans

Since 2015 California wildfires have resulted in over 140 deaths of civilians attempting to flee wildfires. Vineyards are often in remote areas with limited road access, presenting challenges for safe evacuation of workers and residents. Evacuation planning can increase the likelihood of all workers and residents staying safe during wildfires. Planning should focus on identifying two ways out of vineyards, buildings, houses and the site. Public agencies and fire safe organizations have developed useful guidance for evacuation of residential areas (see https://www.readyforwildfire.org/campaign-toolkits/go-evacuation-toolkit/)

Assessment: Preparing an Evacuation Plan

- ❑ Is the vineyard property accessible by more than a single road?
- ❑ Could a secondary evacuation route be established through a neighboring property?
- ❑ Are access roads on the farm paved, graded, or graveled?
- ❑ Are access roads of adequate width, a minimum of 12-15 ft.?
- ❑ Has vegetation along evacuation routes been evaluated and cleared to create a shaded fuel break and facilitate safe vehicle passage?
- ❑ Are there any locked gates located along evacuation routes?
- ❑ Are evacuation routes and safety zones clearly identified on maps and with signs?
- ❑ Are maps available to workers and residents?
- ❑ Is reliable cell phone service available at the vineyard site and along the evacuation route, and could cell service be affected by fires?
- ❑ Is all fire safety information available in all languages used by all vineyard workers?
- ❑ Have managers/supervisors all signed up for emergency notices to receive evacuation announcements? (https://public.coderedweb.com/CNE/en-US/BF7053564662)
- ❑ Do managers monitor weather reports for red flag warnings and watches and inform workers that a fire could occur and to review the evacuation plan?
- ❑ Do managers know the evacuation zones the site is located in and the surrounding zone numbers?
- ❑ Do managers/supervisors know how to use the evacuation zone map (socoemergency.org/get-ready/evacuation map) to determine public roads that lead away from the fire front and therefore are safe so workers can use them once off the vineyard site?
- ❑ Are there residences on the site?
- ❑ Are there animals on the site?

Applying BMPs – Evacuation Plans

- ❑ Establish an evacuation plan with text and maps for your vineyard site (Figures 22-23), that includes:
    - primary and alternate evacuation routes – give each a number
    - include the locations of gates, safety zones, and water sources on each evacuation route
    - relevant phone numbers for emergency agencies, managers and all workers
    - daily personnel lists
    - locations to gather either on-site and organize for evacuation and off site so manager can account for everyone.

- ❑ Include a description of the evacuation process identifying: on site gathering location, on-site exit route, who checks with emergency personnel and makes decisions about public road evacuation routes, off-site gathering place, who determines that everyone has evacuated. On-site safety zones should evacuation not be possible and who decides if staying on-site is necessary.
- ❑ Work with neighboring landowners to identify and improve potential alternate evacuation routes in case the primary route is blocked.
- ❑ Maintain evacuation route surfaces to allow a reasonable travel speed.
- ❑ Keep vegetation trimmed along evacuation routes, ensuring a minimum road width of 12 feet, and remove any obstructions less than 14 feet above the road.
    - Remove concentrations of fuel along evacuation routes, focusing on highly flammable plants such as chamise, manzanita, French broom, juniper, rosemary and tree canopy close to the road.
- ❑ Post signs in English, Spanish, and any other languages used by vineyard workers to identify evacuation routes, especially at road junctions. Maintain year round.
- ❑ Keep gates unlocked during fire season. When a red flag warning occurs open all gates.
- ❑ As a backup, equip manager/supervisor and vineyard management vehicles with bolt cutters.
- ❑ Provide maps to workers and managers/supervisors showing evacuation routes.
- ❑ Although most vineyard workers can communicate in English and/or Spanish, some workers may only be fluent in indigenous languages and may need special translations of safety information.
- ❑ Develop a communication plan so that vineyard workers can be contacted and appraised of emergency situations even if cell service is disrupted.
    - Consider flags, horns, and other non-electronic signals for use on site.
- ❑ Review evacuation procedures with all workers and managers/supervisors once a month during summer and fall
- ❑ Practice evacuating after every review of procedures
- ❑ For all buildings and houses: shut all windows and doors, remove shades and curtains from windows, move furniture to the center of the room, leave indoor and outdoor lights on, shut off air conditioning and ceiling fans, turn off gas.
- ❑ If there are large animals arrange for trailers to transport if possible. Open pasture and corral gate when evacuating if animals cannot be transported. Collect up all small animals and have carriers on had to transport.
- ❑ If there are tenants in on site residences include them in all aspects of the planning and practice for evacuations. Inform them of the need to maintain a go bag of all important papers, keys, wallet, cell phone and charger, ID, masks to aid breathing, flashlight and batteries, goggles, gloves and head protection to take with them when evacuating.

Figure 22. Red outline shows the vineyard site in the context of regional roads. The manager/supervisor has to evaluate the major public road that is safest for workers to use. In this case Chalk Hill Road to Highway 128 could take evacuees to the north and west to a large valley or Chalk Hill Road could take evacuees to the south to Highway 101. The safety of each route can be evaluated through local sheriff information. The amount of overhanging vegetation and direction that fires typically come from would be evaluated as part of creating the site evacuation plan.

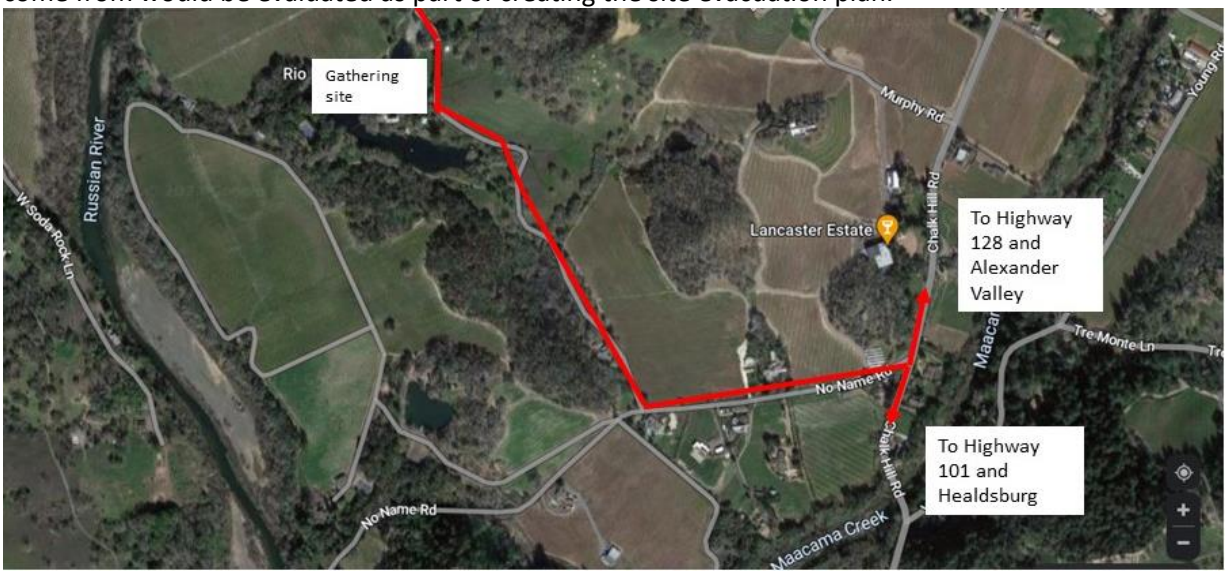


Figure 23. Evacuation plan map. The evacuation plan and map identify the home site as the area to gather and leave from so the manager/supervisor can make sure everyone evacuates. A winery or other commonly known site could be used. The evacuation plan and map will indicate the primary and secondary roads to use to exit the property and then the two routes to exit the area. The manager/supervisor will determine which route is safe by checking current evacuation zones to determine where the fire is active (socoemergency.org/get-ready/evacuationmap) and communicate this to workers and residents as part of the evacuation process. Post evacuation gathering site is in Healdsburg.

Figure 24. Second way out evacuation plan. Landowner works with neighbors to use existing roads to reach Highway 128 and travel to highway 101. Post evacuation gathering site is in Healdsburg.

3. PREPARING FOR FIRE: HARDENING BUILDINGS

Background: Building Hardening

Buildings are high-value assets that require protection from wildfires. Buildings specifically related to the vineyards include: pump and well houses, chemical storage sheds, and shops and barns and wineries, offices and residences. Building hardening techniques developed to protect homes in wildland-urban interfaces (WUIs) can be applied to protect buildings on vineyard sites from wildfires.

Assessment: Building Hardening

- ❑ Are roofs covered with flammable wood shingles, or metal, composite or tile shingles?
- ❑ Are windows single or multi-pane and is the glass tempered?
- ❑ Are vents covered with wire mesh with openings 1/8 inch or less?
- ❑ Is siding flammable wood or flame-resistant stucco, concrete, or metal?
- ❑ Are roof gutters and surfaces maintained free of leaves and debris?
- ❑ Are hydrants, sprinklers, or other water sources available within 50 feet of the building?

Applying BMPs – Building Hardening

- ❑ Hardening buildings from wildfire includes the following actions:
  - Use construction materials that are not flammable. Replace wood siding and shake roofs.
  - Install multi-pane windows. When replacing windows, use double-pane windows with at least one pane made of tempered glass.
  - Cover all vents and other openings in the eaves or walls of the building with a wire mesh with openings of 1/8 inch or less to prevent embers entering attics or crawl spaces.
  - Apply caulk to gaps or holes in siding
  - Clean leaves and debris off roof and out of gutters annually before and during fire season
  - Remove all flammable materials within 30 feet of buildings. This includes agricultural chemicals, gas or diesel tanks, gas cylinders and other materials
- ❑ For new construction or roof replacements, utilize flame-resistant materials:

  Consult the CAL FIRE list of recommended building materials (WUI Listed Products):

Decking	OSFM Category 8110
Exterior windows	OSFM Category 8120
Exterior wall siding and sheathing	OSFM Category 8140
Exterior doors	OSFM Category 8150
Under eave protection	OSFM Category 8160
Vents	OSFM Category 8165
Non-wood roof covering/assemblies	OSFM Category 8180

- ❑ Consider having a separate power source such as a solar powered battery to run water pumps or a self-powered submersible pump in reservoirs or wells if regular power goes out
- ❑ Consider installing a hydrant or hose bib within 50 feet of buildings to provide water for firefighting

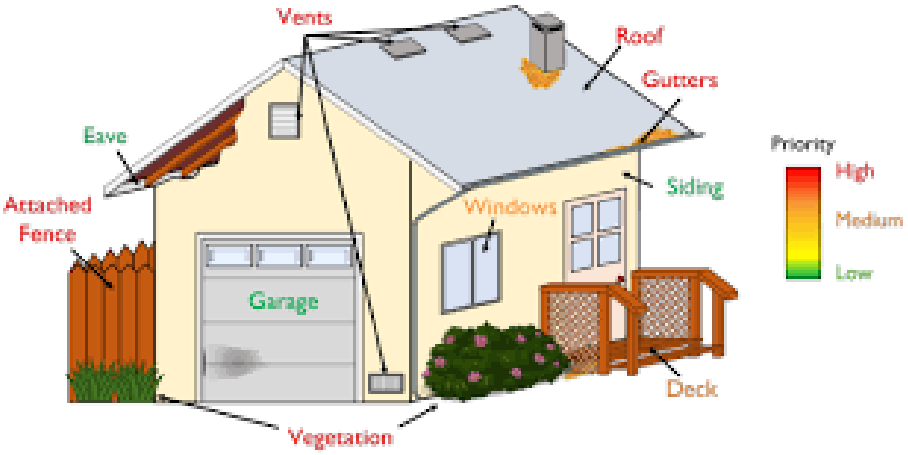


Figure 25. Illustrations of home hardening including roof replacement, removal of leaves and clearing of gutters, improvement of vents, metal fencing, and fire-resistant walls

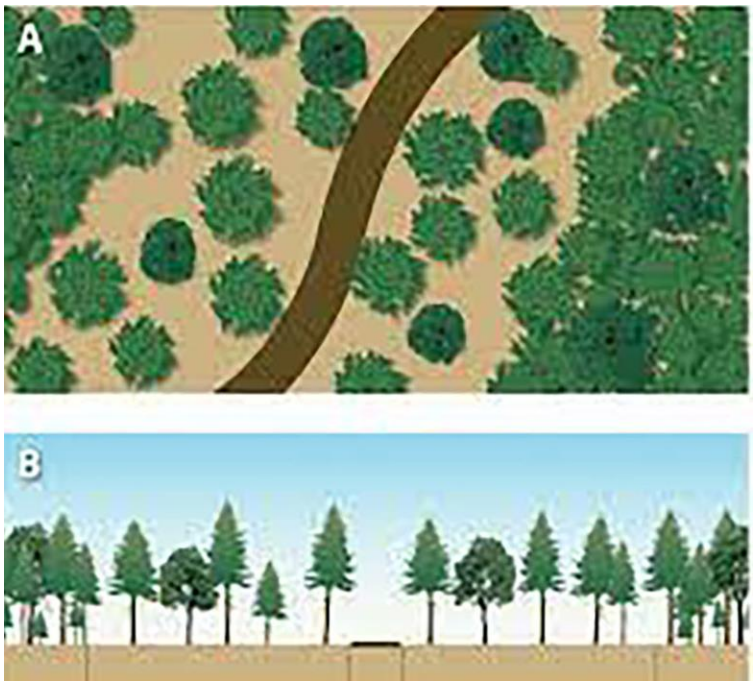


Figure 26. Forest clearing along evacuation route. Ladder fuels, undergrowth and small trees are removed for a wide corridor along the road. Crowns of trees along the road should not touch.

4. PREPARING FOR FIRE: DEFENSIBLE SPACE AROUND BUILDINGS

Background: Defensible Space

Protection of buildings during wildfires depends heavily on limiting vegetation around buildings, a concept known as defensible space. Defensible space has been incorporated into planning for wildfire resilience for homes in wildland-urban interfaces (WUIs) and can be applied to buildings in and around vineyards and wildlands. Defensible space involves concentric zones of vegetation, with flammable vegetation increasingly limited in the zones closest to the building.

Assessment: Defensible Space

- ❑ Walk around the 100 ft of each building and think like a fire. Note all the locations that are flammable and where and what direction fire can spread
- ❑ Are propane tanks and flammable lockers 30 feet or more from buildings in an area free of weeds and other vegetation?
- ❑ Are combustible materials stored within 30 feet of buildings?
- ❑ Do tree branches overhang the building's roof or any chimneys?
- ❑ Is all vegetation, flammable mulch and ground covers, such as bark or wood chips removed from 0 to 5 feet of building (Zone 0), including near stairs and decks?
- ❑ Are "ladder fuels" (bushes, vines, and branches that provide a pathway for fire to move from ground fuels to tree crowns) present within 100 feet of the building (Zones 0-2)?
- ❑ Are bushes and trees far enough apart that fire is unlikely to spread from one to another?

Applying BMPs – Defensible Space

- ❑ Zone 0, 0 to 5 feet from building
  - For buildings on slopes, use fire-resistant building materials on the underside of decks and structures
  - Eliminate all flammable stored materials
  - Eliminate all vegetation in Zone 0
  - Replace organic mulches such as wood chips and bark with non-flammable ground covers such as gravel
  - Relocate propane tanks or flammable lockers to Zone 2
  - Remove leaves from building gutters and roof surface frequently
  - Trim branches overhanging roofs

- ❑ Zone 1, 5 to 30 feet from buildings
  - Remove stored flammable materials such as wood piles (move to Zone 2)
  - Break continuity of fuel so fire cannot spread by leaving open nonflammable space between all trees and limbs
  - Trim "ladder fuels" within 10 feet of the ground
  - Cut grass to a height of 4 inches or less using weed whackers and cut in spring to avoid creating an ignition source when grasses area dry
  - Plant only low growing and irrigated plants
  - Relocate propane tanks or flammable lockers to Zone 2

- ❑ Zone 2, 30 to 100 feet from buildings
  - Maintain vertical and horizontal separation between plants
  - Cut grass to a height of 4 inches or less using weed whackers and cut in spring to avoid creating an ignition source when grasses area dry
  - Remove all dead woody material
  - Maintain 10 feet of vegetation free clearance around propane tanks and flammable lockers
- ❑ Wildland Zone, greater than 100 feet from buildings
  - Eliminate “ladder” fuels
  - Maintain a tree density such that at maturity tree canopies do not touch. The density will vary by tree species and the number of trees per are can be determined by a Registered Professional Forester
  - Maintain horizontal and vertical space between trees and shrubs
  - Remove dead trees, but leave 2 to 4 dead standing trees per acre of wildland for wildlife habitat
  - Lop and scatter dead and down wood into pieces 18” or smaller, leaving 80% of wood in contact with soil to aid decomposition

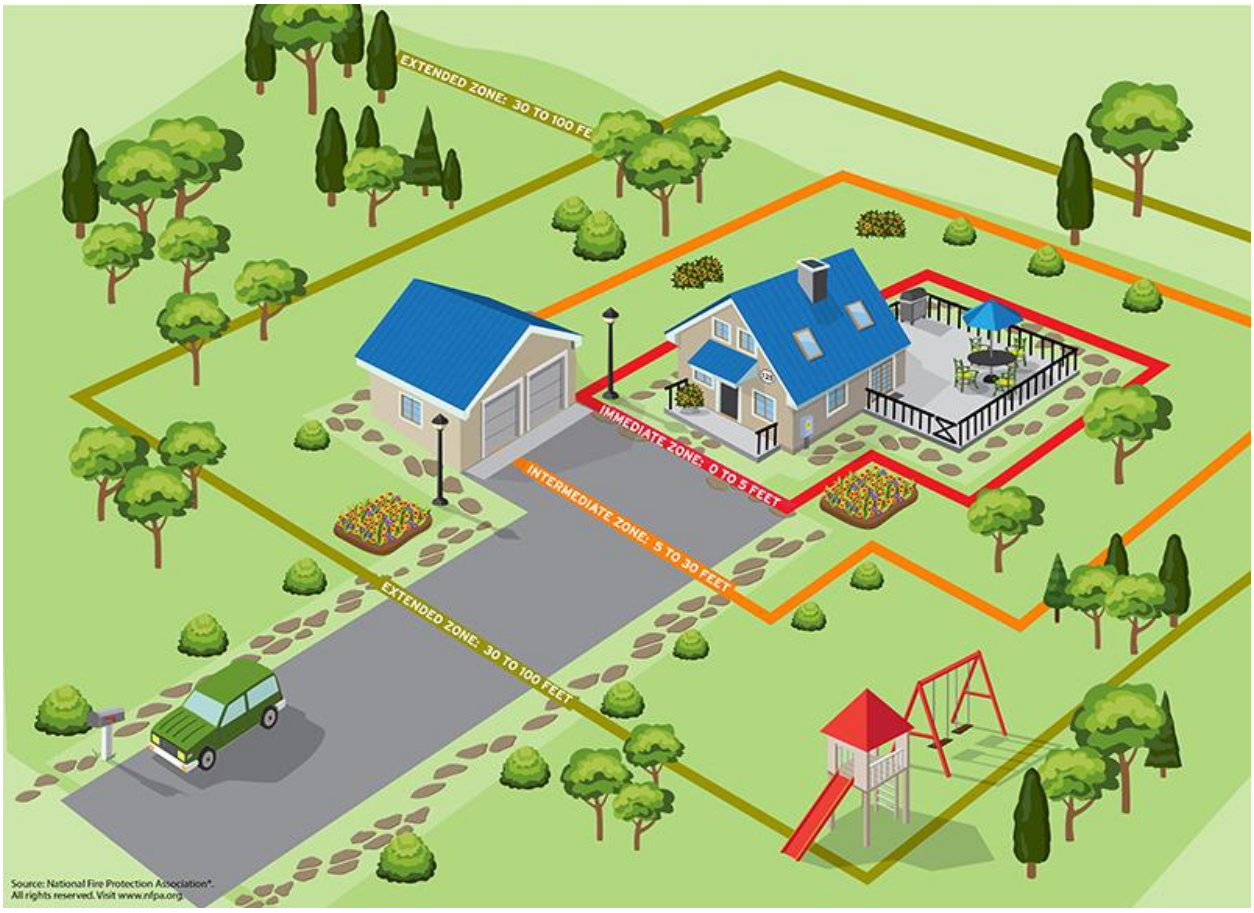


Figure 27. Defensible space zones

Zone 0 0-5 ft from building no vegetation

Zone 1 5 to 30 ft from building
Separated irrigated vegetation

Zone 2 30 to 100 ft from building
Trees don't touch, ladder fuels and understory cleared. Grass removed

Figure 28. Defensible space works to protect buildings

5. PROTECTING SITE INFRASTRUCTURE AND VINEYARDS: WATER SUPPLY

Background: Water Supply

The majority of vineyards in Sonoma County are irrigated and require pipe infrastructure. Water tanks and pipelines are often constructed of plastic in order to reduce costs of purchase and installation. Plastic water pipe infrastructure is vulnerable to damage during wildfires. Burial of pipes to a depth of 6" can reduce damage.

Assessment: Water Supply

- ❑ Are irrigation lines and water tanks made of combustible materials?
- ❑ Determine the depth of your irrigation supply pipes.

Applying BMPs – Water Supply

- ❑ Replace plastic water tanks with metal or concrete tanks.
- ❑ Bury irrigation supply lines to depths of 6 inches or more.
- ❑ Dry farming eliminates the need for irrigation lines but is only recommended for vineyards with slopes less than 5% to limit soil erosion.
- ❑ Dry farming of wine grapes is most likely to be successful (Lambert, 2014) when:
  - Annual rainfall is more than 15 inches
  - Soils are deeper than 3 feet
  - Rootstocks adapted to dry conditions include: St. George, 1103 Paulsen, 110 Richter, and 140 Ruggeri
  - Winegrape varieties adapted to dry conditions include: Cabernet Sauvignon, Sauvignon Blanc, Zinfandel, Petite Sirah, Grenache and southern Italian and Iberian varieties have been successfully grown without irrigation
  - Spacing of rows and vines is 8 feet x 8 ft or greater
  - Vines are head trained
  - Cover crops are cultivated to reduce competition with vines for water
  - Dry farmed vineyards may still have water infrastructure for frost control and should apply water supply BMPs to this infrastructure.

Figure 29. Melted plastic tank

6. PROTECTING SITE INFRASTRUCTURE AND VINEYARDS: ROAD AND VINEYARD DRAINAGE

Background: Road and Vineyard Drainage

Plastic culverts and pipes are often used for road crossings, ditch relief culverts, and vineyard drainage systems owing to the relatively low expense and ease of installation. Plastic is combustible, and plastic pipes and culverts are often destroyed in wildfires. When fires burn pipes and culverts roads are left undrivable and potential sources of soil erosion are created. Metal and concrete culverts can be used in place of plastic in many instances and will not burn.

Assessment: Road and Vineyard Drainage

- ❑ Are road culverts or vineyard drains constructed of plastic pipe?
- ❑ Are stream crossings on perennial or nonperennial streams constructed with plastic pipe?

Applying BMPs—Road and Vineyard Drainage

- ❑ Replace plastic culverts in road crossings with metal or concrete pipes.
    - Size culverts for the 100-year flood, using design and sizing standards from one of the following sources:
        - Federal Highways Administration (2012) https://www.fhwa.dot.gov/engineering/hydraulics/library_arc.cfm?pub_number=7&id=13
        - Designing Watercourse Crossings for Passage of 100-Year Flood Flows, Wood, and Sediment (2017), https://34c031f8-c9fd-4018-8c5a-4159cdff6b0d-cdn-endpoint.azureedge.net/-/media/calfire-website/what-we-do/natural-resource-management/forest-practice/forest-practice-files/100-year-review.pdf?rev=b27322cf1e6a4e66bbb3c0282fd54096&hash=2BDD1257811D2C115B273A7BBE9FB2AE
        - Handbook for Forest, Ranch & Rural Roads (2015) https://www.pacificwatershed.com/roadshandbook
    - When determining the size for a new culvert, allow additional space for transport of the woody debris that often occurs after a fire.
    - Install culverts at the grade of the stream channel.
    - Install trash rack of a single piece of rebar roughly one channel width upstream of the culvert inlet in the center of the stream channel. The rebar can assist in turning tree trunks and branches to flow through the culvert rather than blocking the inlet and causing overtopping and flooding
- ❑ Consider replacing stream culverts with a rock ford for crossings of nonperennial creeks.
- ❑ Consider using bridges built of metal for crossings of perennial creeks.
- ❑ Replace plastic ditch relief culverts along roads with metal pipes and install rock energy dissipators at outlets.
- ❑ Consider replacing sections of vineyard drain lines that are closer than 6 inches to the ground surface with metal pipe.
- ❑ Install metal T-spreaders and rock energy dissipators at drain outlets to reduce erosion.
- ❑ Follow general guidance for road and vineyard drainage from FFF BMPs for vineyard drainage and roads (Elements 3 and 5).

- ❑ Before implementing changes to culverts at stream crossings, obtain appropriate permits for work in stream channels:
  - U.S. Army Corps of Engineers for fill in waters of the United States.
  - 401/WDR Notice of Intent for Regional Water Quality Control Boards.
  - Section 1600 Lake and Streambed Alteration Agreements from California Department of Fish and Wildlife.
  - County grading or riparian corridor permits from Permit Sonoma.

Figure 30. Melted plastic pipes after 2020 Glass Fire

7. PROTECTING SITE INFRASTRUCTURE AND VINEYARDS: VINE PROTECTION

Background: Vine Protection

Although vineyards are often less combustible than surrounding natural vegetation, vines can be directly and indirectly damaged by wildfires. The primary points of ignition in vineyards are cover crops, irrigation tubing, and vine canopies. Direct damage results from burning and scorching of vines. Indirect damage results from destruction of irrigation and drainage infrastructure and smoke taint of unharvested grapes. Irrigation tubes can melt and kill vines during fires even when the vines themselves do not burn.

Assessment: Vine Protection

- ❑ Does the farm have crop insurance that covers wildfire and smoke damage to winegrapes?
- ❑ Are cover crops mowed, tilled, or grazed prior to the onset of fire season?
- ❑ Are sprinklers used for frost control?
- ❑ Is the vineyard perimeter cleared of combustible vegetation?

Applying BMPs – Vine Protection

- ❑ Consider purchasing U. S. Department of Agriculture crop insurance to prevent financial losses when grapes cannot be harvested owing to fire damage or smoke taint.
- ❑ Mow, till or graze cover crops so there will be limited cover by the end of summer.
- ❑ If a sprinkler system is used for frost control, maintain the sprinkler system through the fire season so that sprinklers can be turned on to protect vines during wildfires.
- ❑ Clear a 30-foot perimeter around vineyards to prevent spread of ground fires into vineyard blocks.
    - Cut filter strips with weed whackers to reduce flammable vegetation in the spring. If done later when vegetation is dry cutting can start a fire.
    - Livestock grazing using goats, sheep, or cattle may be effective in controlling understory in dense vegetation adjacent to vineyards.

Figure 31. Vineyard burned in 2020 Glass fire

8. REDUCING FIRE RISK: VEGETATION MANAGEMENT

Background: Vegetation Management

Vegetated wildlands can carry wildfires into vineyards either directly or through ember cast. Fuel loading and rate of wildfire spread have increased over the past several decades. Fire suppression, introduction of invasive nonnative flammable shrubs and trees and climate change induced warmer temperatures and droughts are the primary factors in this increase.

Vegetation of wildlands can be managed to reduce wildfire risks. This section is intended for vegetated wildlands not recently burned; for recently burned areas, see Post-Fire Recovery: Clearing and Revegetation BMP.

Wildland vegetation is managed based on the type of vegetation. Each type of vegetation is managed differently to reduce wildfire risk, but in all cases the fuel load is reduced.

Grasslands can be grazed by cattle, sheep or goats on a seasonal basis to remove grasses and herbs prior to the fire season. Grasslands burn rapidly for a short period of time and can carry fire into adjacent woody habitats.

Chaparral is the most difficult vegetation type to manage. Chaparral is composed of dense hardwood shrubs and naturally only burns once every 75-100 years. Clearing shrubs may not reduce fire hazards and can be expensive. However, removal of invasive nonnative shrubs and grasses can lower fire risks.

Hardwood forest or woodlands are best managed through direct removal of understory shrubs, ladder fuels and small trees. A portion of standing trees can also be removed.

Conifer forests should have understory ladder fuels, small trees, leaf and branch litter and dead trees removed.

Riparian corridors along creeks and rivers have to be carefully managed and are subject to 1600 permits from the Ca. Dept of Fish and Wildlife. Often these corridors have a dense understory of invasive nonnative plants such a Himalayan blackberry, blue periwinkle, grasses, broom, giant reed and others. These invasives should be removed, but most of the native trees – willows, cottonwoods, alders, valley oaks and others should not be cut or pruned.

Assessment: Vegetation Management

- ❑ Is your property eligible for inclusion in a grant funded vegetation management program? Check with your local fire district or Firewise organization.
- ❑ Registered Professional Foresters, certified range managers, restoration ecologists, prescribed burn practitioners and other professionals can assist landowners to prepare vegetation management program for their land
- ❑ Can you work with neighboring landowners to create a larger vegetation management project?

Grasslands

- ❑ Are there fences and water sources that could be used to allow grazing of the grassland.
- ❑ Is there a drivable access road to bring animals in and out?

- ❑ Is the grassland made of grass primarily or, are larger plants such as black mustard, yellow star thistle, purple star thistle and others present?
- ❑ If a fire started in the grassland, what area would it spread to: buildings, vineyards or other vegetation types?
- ❑ Is the grassland at the top or the bottom of a hill? Take photos

Chaparral

- ❑ Are there roads or trails through the chaparral and how large of an area does the chaparral cover?
- ❑ Are there large patches of invasive nonnative grasses and shrubs such as French, Scotch or Spanish broom present?
- ❑ How large are the infested areas and are they accessible from a road or trail?
- ❑ Are there hills in the chaparral area? Take photos.

Hardwood Forest/Oak Woodland/Conifer Forest

- ❑ How large of an area of forest is on the property?
- ❑ Are there roads or trails through the forest?
- ❑ How dense is the forest? Can you easily walk through it or do you have to climb over shrubs and between tree limbs?
- ❑ Are there hills in the forest area?
- ❑ Are invasive flammable species such as Eucalyptus, Acacia, French, Scotch or Spanish broom present and how large are the patches of these species? Take photos.

Riparian Corridors

- ❑ Is the riparian corridor dense with understory shrubs and vines? Take photos

<u>Applying BMPs – Vegetation Management</u>

Grassland

- ❑ Consult a certified range management professional to develop a grazing plan for grasslands and oak woodland understory.
- ❑ For large areas of grassland grazing, cattle are likely to be more cost effective than other types of livestock. Goats may be more appropriate than cows or sheep for concentrations of large plants in grasslands.
- ❑ Adjust stocking rates to achieve desired levels of grazing. Remaining grass cover is called residual dry matter and can be monitored. Grazing should produce low levels of residual dry matter to reduce fire risk while retaining adequate cover to protect soil against erosion.
    - Ensure a water supply of 10 to 20 gallons of water per animal daily, based on season.
    - Use water sources and supplemental feeding to improve distribution of livestock.
    - Protect riparian corridors by monitoring and adjusting stocking rates and seasons of use. Locate alternative water sources outside the creek and consider herding or fencing the area to keep livestock out of creeks. Short-term flash grazing may reduce understory invasive plants.
- ❑ Winter/early spring grazing may provide the best timing for reducing fuels prior to the fire season

Prescribed burns can keep grassland from conducing fire into shrubs or forest

Cattle require on site water in troughs not creeks and fences but owner may receive payment

Goat and sheep grazing usually require payments of $1-2,000/acre/treatment but often use electric fence and potable water systems. Animals need shepherd for protection

Figure 32. Management of Grasslands

Chaparral

- ❑ Focus on removing invasive species such as brooms, grasses and herbs through grazing or hand crew clearing. These invasive species are fire prone and will increase fire risk in the chaparral. If roads and clearings are bulldozed into the chaparral it opens up the cleared areas to invasions of nonnative plants and increases fire risk.

Hardwood Forest/ Oak Woodland/Conifer Forest

- ❑ Consult a registered professional forester to develop a forest management plan for hardwood and conifer forests that includes:
  - Reduce forest density so that the crowns of mature trees do not touch by removing excess small trees.
  - Limb tree branches within 10 feet of the ground surface to eliminate "ladder fuels."
  - Trim or remove shrubs to leave spacing of 10 to 20 feet between mature shrubs.
  - Fall dead trees and remove if possible, leaving 2 to 4 dead trees standing per acre for wildlife habitat.
  - Hand crews or equipment may be used depending on terrain and road access.
  - Depending on how dense the forest is prescribed burning may also be used.
- ❑ Control invasive shrubs and trees that are fire-prone, such as French, Scotch and Spanish broom. Manually pull broom shrubs with roots, or use weed wrenches, work when soil moisture is high and repeat every year. Herbicides can be used to control regrowth. Masticators or other mowers can provide initial treatment for dense thickets without native trees on slopes of 40% or less with road access for equipment to travel. Follow up with manual or herbicide treatments.
- ❑ Dispose of woody material to reduce fuel loading. Lop and scatter dead and down wood into pieces 18" or smaller, leaving 80% of material in contact with mineral soil to expedite decomposition. Alternatively, chip woody debris and haul off site for use in landscaping, biochar, and erosion control; do not spread wood chips on perimeter vineyard or access roads as chips are flammable and can spread fire.
- ❑ Woody material can also be piled and burned. Permits are required from local and/or state fire agencies and from either the Bay Area Air Quality Management District or the Northern Sonoma County Air Pollution Control District, depending on the project location. Burn boxes may also be used if there is adequate space and road access.

Riparian Corridors

- ❑ Riparian corridors should be managed to retain trees and remove invasive tree and understory species to reduce fire risk. Annual manual removal can be done over many years or herbicide application done at the time when the plant will absorb the chemicals and translocate it to the roots (Table 6)
- ❑ Obtain the required permits before removing vegetation in riparian zones. Permits that may be required include:
  - California Department of Fish and Wildlife Lake and Streambed Alteration Agreement (Section 1600 permit).
  - Sonoma County Riparian Corridor Use Permit

Figure 33. Chaparral management

Figure 34. Hand crews and mechanical clearing in forests

Figure 35. After (left) and before (right) forest thinning projects

Figure 36. Before (left) and after (right) forest thinning projects

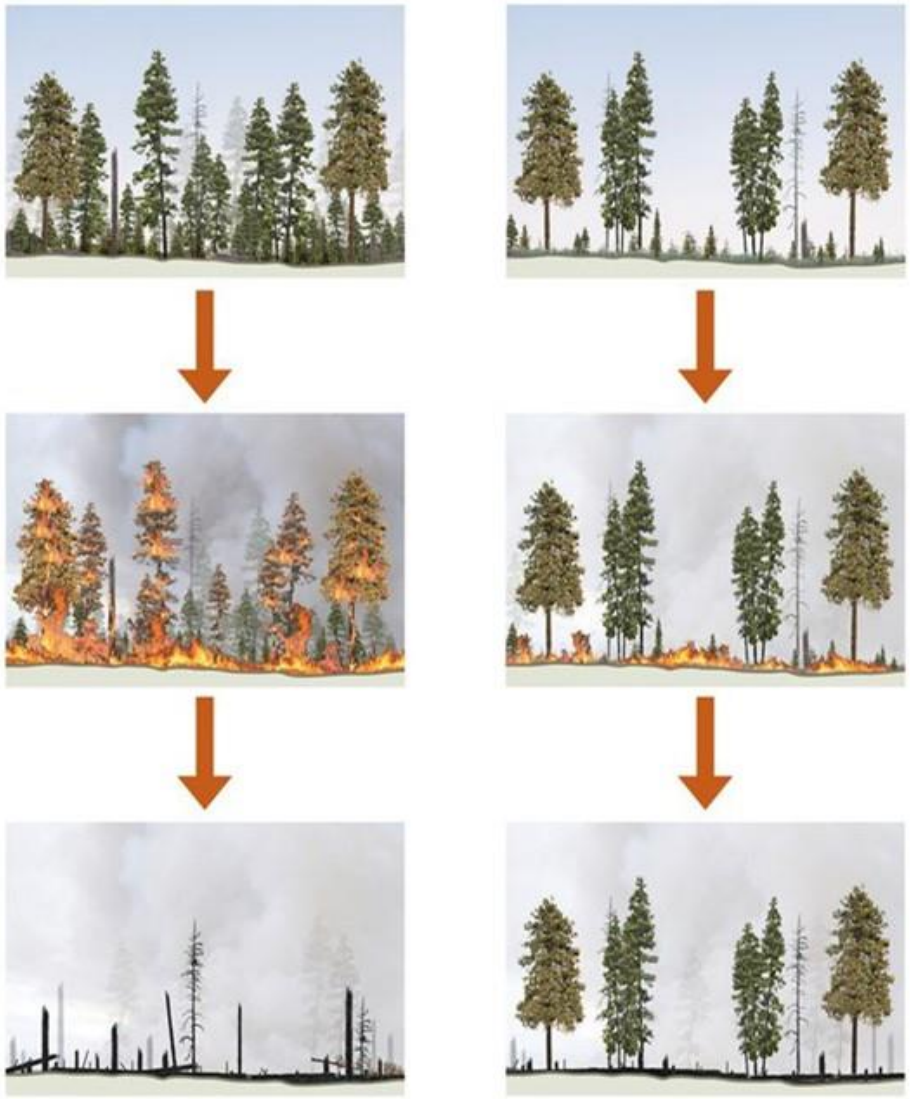


Figure 37. Fire effects with and without forest thinning. Well-spaced healthy forest trees

Figure 38. Invasive nonnative plants found in riparian corridors

Potential Funding Sources

CAL FIRE has a number of programs that can fund vegetation management including prescribed burning on private land. These programs include:

Forest Health Grants (https://www.fire.ca.gov/what-we-do/grants/forest-health) aim to make forests more resilient, reduce fire risk and mitigate climate change. Activities funded include fuel management, prescribed fire, clearing and replanting of burned areas and other practices. Funds must go through local government or fire district or nonprofit organization.

Wildfire Prevention Grants (https://www.fire.ca.gov/what-we-do/grants/wildfire-prevention-grants)fund projects that manage vegetation create fuel breaks ad thin trees near communities or critical infrastructure. Ladder fuel removal, shaded fuel breaks next to roads, chipper and defensible space programs and grazing to reduce fuel loads area all covered by this program. These grants also fund wildfire prevention education and planning. Funds must go through local government or fire district or nonprofit organization.

Wildfire Resilience Program (https://www.fire.ca.gov/what-we-do/natural-resource-management/wildfire-resilience#ResilienceGrantAnchor). These grants focus on non-industrial timber lands and fund easements to protect private forest land, forest stewardship technical and financial assistance and reforestation services.

California Forest Improvement Program (https://www.fire.ca.gov/what-we-do/grants/california-forest-improvement) funds improved management of California forest lands through thinning and fuel reduction and reforestation. This grant does not fund prescribed burning.

The Vegetation Management Program (VMP) (https://www.fire.ca.gov/what-we-do/natural-resource-management/vegetation-management-program) is a cost-sharing program that focuses on the use of prescribed fire, and some mechanical vegetation clearing to address wildland fire fuel hazards and other resource management issues. The VMP allows private landowners to enter into a contract with CAL FIRE to implement projects that are identified through the local unit's Fire Plan. Landowners should contact tier local CALFIRE office to discuss participation in the VMP.

The California Vegetation Treatment Program (Cal VTP) EIR (https://bof.fire.ca.gov/projects-and-programs/calvtp-homepage-and-storymap/) was approved in 2019 by the California Board of Forestry. It can provide for CEQA coverage for a project included in one of the above grants.

Table 6. Treating invasive plants in riparian corridors

Species	Treatment
Giant reed (*Arundo donax*)	This is a very difficult plant to remove once established. Try to confine as soon as any of these are found on your property. There are several approaches to eradication - lasso the Arundo clump and spray the foliage with glyphosate in the fall. Herbicide application must avoid overspray onto native trees. Another method involves cutting the Arundo to remove the biomass in the summer, then spraying the re-growth with glyphosate in the fall. A third method involves a two-person crew: one person cuts the Arundo just above the ground and the other person paints the cut stem with full strength glyphosate within 30 seconds of cutting in the fall. All cut Arundo should be moved to an area outside the floodplain and be burned or chipped as soon as possible.
Blue periwinkle (*Vinca major*)	Spray foliage with glyphosate when plant is green and growing vigorously during any periods in January or February when no rain is forecast for at least a week. Be careful to avoid other plants and any drift. Don't spray when plant is wilted. Re-spray all survivors. This understory plant provides little to no erosion control and soil can be washed out from underneath without notice. This plant is a host species for Pierce's disease that kills winegrapes. This plant will dominate the understory of established riparian areas and reduce or eliminate the germination of native tree seedlings and shrubs. Over time, as the riparian trees age and die, the corridor will have no replacement trees and a monoculture of Vinca is created. Hand removal can be done, but must be repeated several times a year.
Himalayan blackberry (*Rubus discolor*)	This is the blackberry that has big leaves, big thorns and big berries and is found both on streams and roadsides. It is a host species for Pierce's disease and an invasive plant that will take over native areas and provide little erosion protection for banks. Spray foliage with glyphosate in the fall. Cutting and painting stems with glyphosate is also effective. If it is interspersed with natives or if mechanical methods are preferred, cut and pull by hand using really thick gloves and follow up with removal several times a year.
Tamarisk (*Tamarix sp*.)	This is a desert species of tree that is becoming established in California and is tough to get rid of. Cut the tree before it has a chance to flower and paint with triclopyr or glyphosate immediately following cutting. Remove duff with seeds to the greatest extent possible. Pull out all seedlings and retreat any re-sprouting stumps.
Tree of heaven (*Ailanthus altissima*) Acacia (*Acacia sp.)*	These invasive trees should be cut and then painted with glyphosate to kill the root system in the fall. They can also be cut continuously several times a year and all seedlings removed. In fall root sprouts can be sprayed.
Scotch (*Cytisus scoparius*) or French (*Genista monspessulana*) broom	There are a number of invasive brooms that can be cut and painted with glyphosate and seedlings hand pulled. Hand removal requires all parts including roots and the seed bank be removed. There are areas in the riparian corridor that may have broom, although it is more common on hillsides. A weed wrench works well for removal of this species because broom generally does not re-sprout from roots.
Cape (*Delairea odorata*) and English (*Hedera helix*) ivy	These very invasive species spread by runners. Spray with glyphosate and remove and re-spray all survivors until it is gone. Cape ivy will climb trees and smother them resulting in the dead tree falling and often taking the stream bank or slope with it. If it is interspersed with natives, cut and pull by hand.

Table 6. (cont.) Treating invasive plants in riparian corridors
Consult with a Pest Control Advisor on all uses of herbicide for invasive plant control. It is important to note that any use of herbicides should be done in full accordance with label directions and restrictions. In general, if the area to be treated is next to water, the herbicide suggested is a formulation safe for use near to water. Consult with the County Agricultural Commissioner for details on herbicide use. For most projects in the riparian corridor a 1600 Streambed Alternation Permit from the California Department of Fish and Wildlife is required. If a large area of invasive plants is removed, a plan for revegetation of the area should be completed. Native plant sprigs or container stock from local genetic stock should be on order when the eradication is done, as these species are not readily available from nurseries.
Invasive plants typically move from upstream to downstream and should be removed starting from the upper watershed or channel. In almost all trials and studies of invasive plant removal, herbicide has proven more effective than mechanical removal methods. However, hand removal performed several times a year consistently for a decade or more can completely eradicate invasive plants if no re-infestations occur from upstream.
A good reference book on invasive plants is Invasive Plants of California's Wildlands by Brossard, Randall, and Hoshovsky. The California Invasive Plant Council (http://www.cal-ipc.org) has information also.

9. REDUCING FIRE RISKS: PRESCRIBED BURNING

Background: Prescribed burning

For many thousands of years Native Americans in California used cultural burning to remove dense vegetation, improve growing conditions for food plants and animal habitats and enhance the ecosystem. It is estimated that nearly four million acres were burned each year in California. These fires were low intensity staying on the ground and not advancing into the tree tops.

Europeans wrote about California's forests with little understory growth and limited small trees making for easy passage and a tended look. Cultural burning created this park like appearance.

Prescribed burning is similar, but not the same as cultural burning. It can be a cost-effective method of managing vegetation including: reduced fuel loading, elimination of ladder fuels, removal of invasive grasses and forbs, including medusahead grass, broom, yellow star thistle and others. Controlled burns have a number of benefits beyond the reduction of fuel loads and reduction of wildfire risk. Controlled burns do not result in large erosion risks as wildfires do. The burning of understory and small trees provides for the release of nitrogen for use by the larger conifer and hardwood trees.

Prescribed burns produce smoke, but not nearly as much as uncontrolled wildfires. Managing thousands of acres of wildland using a series of smaller fires (1000 acres) does not produce the large blankets of smoke that large wildfires burning under critical conditions can create.

Table 7 lists the natural fire return intervals for various vegetation types as modeled by the LANDFIRE Rapid Assessment Vegetation Model of the U.S. Forest Service. Replacement fire severity is a crown fire that kills 75% of the trees. In the case of chaparral and grassland all fires are replacement fires. Surface or low fire severity affect the understory of the forest and would be the objective for prescribed burns in hardwood, redwood and conifer forests.

In the past few years, prescribed burn associations (PBAs) have been established in California to provide landowners with assistance in conducting prescribed burns. A PBA is a collaborative community-based organization consisting of landowners, land managers, community members, non-profit organizations, and fire professionals. Members of the PBA pool their resources and expertise to assist private landowners apply prescribed fire safely to their land.

Table 7. Fire frequency intervals for various vegetation types

Vegetation type	Fire severity	Fire regime characteristic			
		Percent of fires	**Mean interval in years**	**Minimum interval in years**	**Maximum interval in years**
Annual grassland	replacement	100%	2	1	3
Mixed chaparral	replacement	100%	50	30	125
Oak woodland	replacement mixed surface or low	8% 2% 91%	120 500 10		
Ponderosa pine	replacement mixed surface or low	5% 17% 78%	200 60 13		
Ca mixed evergreen	replacement mixed surface or low	10% 58% 32%	140 25 45	65 10 7	700 33
Coast redwood	replacement Surface or low	2% 98%	>1,000 20		
Mixed conifer north slopes	replacement mixed surface or low	5% 7% 88%	250 200 15	 10	 40
Mixed conifer south slopes	replacement mixed surface or low	4% 16% 80%	200 50 10		

Fire Severities—
Replacement: Any fire that causes greater than 75% top removal of a vegetation-fuel type, resulting in general replacement of existing vegetation; may or may not cause a lethal effect on the plants.
Mixed: Any fire burning more than 5% of an area that does not qualify as a replacement, surface, or low-severity fire; includes mosaic and other fires that are intermediate in effects.
Surface or low: Any fire that causes less than 25% upper layer replacement and/or removal in a vegetation-fuel class but burns 5% or more of the area

From: US Forest Service Fire Effect Information System. 2023 LANDFIRE Rapid Assessment Vegetation Models. Fire regimes of the conterminous United States.
https://www.fs.usda.gov/database/feis/fire_regime_table/fire_regime_table.html#California

Assessment: Prescribed Burning

- ❑ Contact qualified prescribed fire practitioners to plan and implement burns. CAL FIRE can carry out prescribed fire on private land if the burn is considered a prior in a CAL FIRE plan or analysis. When CAL FIRE carries out a burn they take liability responsibility for the project. The Good Fire Alliance is designated as a prescribed burn association for Sonoma County. The nonprofit organization Fire Forward works with the Good Fire Alliance and offers prescribed fire services in Sonoma County. The University of California Cooperative Extension (UCCE) can provide assistance with finding the right resources for prescribed burns on private lands in Sonoma County
- ❑ Are neighboring parcels potentially available for inclusion in a prescribed fire? Prescribed fires area difficult to implement on small areas It is best to include all the parcels in a topographic area such as from a creek to the ridgetop. This area is a natural unit for fire.
- ❑ Are grasslands dominated by invasive grasses and forbs such as yellow star thistle?
- ❑ Are forests dominated by dense thickets of young trees?
- ❑ Are more than 25% of the trees on your property dead, including fallen trees?
- ❑ Create a map of roads and trails in the vegetated area. This information can be used as part of the burn plan

Applying BMPs – Prescribed Burning

- ❑ Contact CAL FIRE, the Good Fire Alliance, Fire Forward, or a private fire management company for assistance
- ❑ Prescribed fires require permits from fire agencies and a permit and smoke management plan approved by the local air quality district. Use the following link to identify the project property on the map viewer. This will help determine which fire agencies and air quality district will need to be contacted for permits.
  https://calfireforestry.maps.arcgis.com/apps/instant/lookup/index.html?appid=123729e886fc4eafbc7f14d7c8c5083e
- ❑ Identify available water sources, road access, and fences
- ❑ Contact neighbors to inform them of planned burns
- ❑ Some vegetation management using power or hand tools may be needed prior to the burn.
- ❑ Invasive shrubs and trees such as French broom and acacia may require cutting or herbicide treatment for effective removal
- ❑ Many native hardwoods may produce excessive basal sprouts after fires and may need to be pruned to remain healthy
- ❑ Prescribed fire involves some risk and must be implemented by qualified personnel under specified conditions
- ❑ Prescribed burning requires a detailed plan for each unit of land that will be burned. Burn plans both for large land units and smaller project burns should always be prepared by personnel with experience directing controlled burns. The unit plan should include the following sections:

  - Objectives of the burn plan

    Objectives for using controlled burns can include reducing fuel and fire hazards, restoring fire to the landscape and ecosystem, preparing the seedbed for forest tree planting, reducing understory

brush and others. For a dense forest the objective may also include mechanical or hand removal of small trees and brush prior to burning.

- Description of the vegetation
  This section describes the types of vegetation, species present, density and size classes for a variety of locations.

- Fuel conditions
  This section describes the understory conditions, kinds of fuels, amount of fuel, size classes and proportion of dead to living plants for each vegetation type. For example, for a conifer or hardwood forest type the number and size class of living trees, depth of litter or duff, and the density of underbrush and small trees and the size class of each would be described. For grassland or chaparral all the plant material is considered fuel and would be described.

- Topography
  This section describes the steepness and direction of slopes as these features determine the rate of spread (ROS) and the direction the fire will burn. A topographic map can be used for this analysis. Surprisingly, flat areas of forest can be the most difficult to manage whereas burning on slopes offer greater control of the fire.

- Wind patterns
  Wind information is needed for all seasons and on a daily basis to understand how the fire will behave. A nearby weather station should have basic information that can be bolstered with local knowledge.

- Size and shape of burn
  This evaluation uses the information from items 1-5 and defines the smaller project areas within the unit that will burn in a reasonable time. Creeks, recent burns and roads may serve as boundaries to burn areas.

- Prescriptions for burning
  The fire needs to effectively implement the project objectives and be managed without an escape. The season for the burn will vary (spring/fall/winter) depending on weather patterns for the site and fuel conditions. For example, deep duff/litter will burn for many months and require monitoring. If burned in the fall winter rains will put the fire out and reduce the time and expense of the fire.

  The size of project burns will depend on the initial fuel load. Large fuel loads may require a more complex initial burn and easier follow-up burns.

  The prescription will not only define the season and size of the project burn but also the weather constraints and fire behavior during which burning will be allowed. All prescriptions should be written and carried out by qualified personnel.

- Burn techniques
  There are different techniques for application of prescribed fires that depend on factors such as weather, topography, fuel type and fuel loading. There are three basic types of fire spread. Backing fires are typically set to burn downslope or on level site and move slowly. Head fires burn upslope or

on level ground with the wind and can move fast. Flanking fires spread at right angles to the slope or wind. These can be used next to a backing fire for increased control. Different firing patterns are used to tailor the prescribed burns to each site.

- Preparations for the burn
  A great deal of public education will be needed so the community understands what will be done, where and for how long. The precautions included in the burn should be emphasized. Education of the public should be done by all the agencies involved and include many different media outlets and in both English and Spanish to reach the entire community.

  Ensure burn permits have to be acquired from the local air quality district and CAL FIRE and local fire district as required.

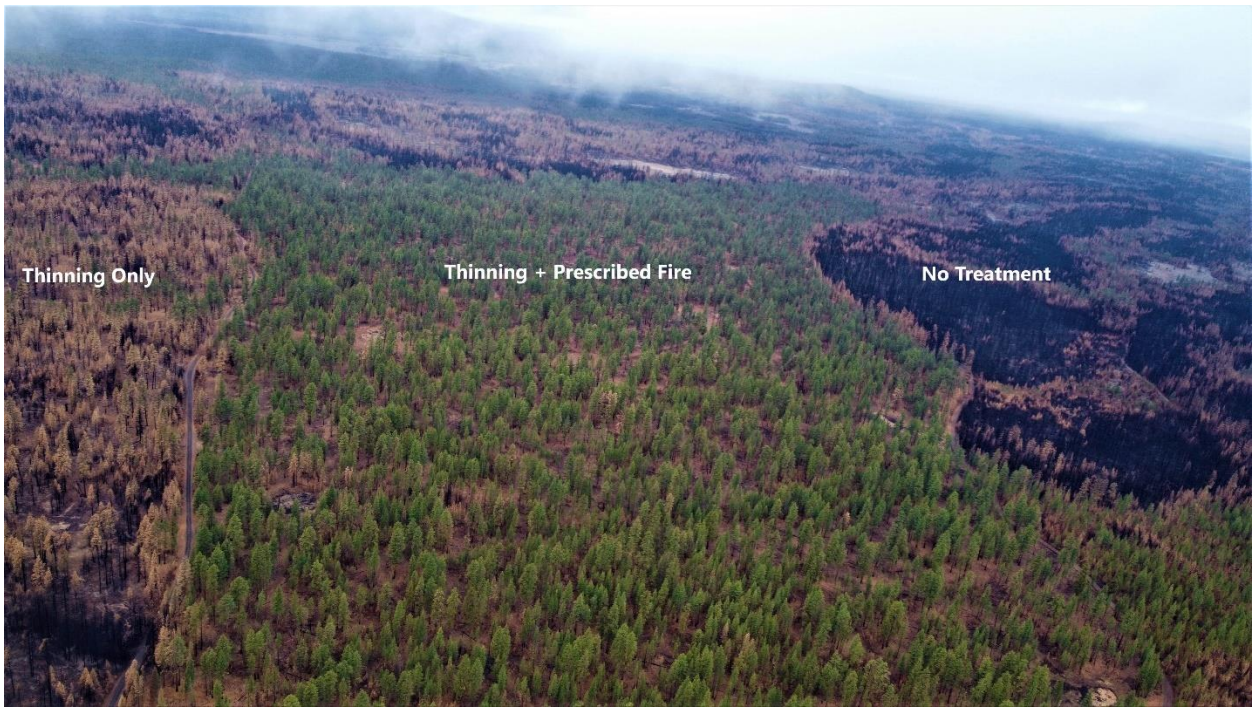
  All equipment should be available and in working order. An experienced burn boss should oversee all aspects of the burn. The number of crew members is determined by the size and complexity of the burn.

- Patrolling the fire
  Careful patrolling of burns is a requirement and may involve overnight patrols.

- Recording burning conditions
  Keeping records of the conditions before and during a burn is required whenever the burn requires a plan to ensure that the burn remains in prescription. If a plan is not required, it can still help to document the process should anything go wrong

- Inspections
  Following a burn, the area should be thoroughly inspected and any unexpected conditions recorded.

- Monitoring
  Following the burn, the site should at least be monitored and conditions noted for several years to 10 years following the burn. Quantitative monitoring may also be designed to answer specific ecological questions.



Cost for prescribed burns vary from $100-1000 per acre depending on project size, need for pretreatment thinning, existing roads and need to create fire breaks ,and vegetation type

Figure 39. Prescribed fire

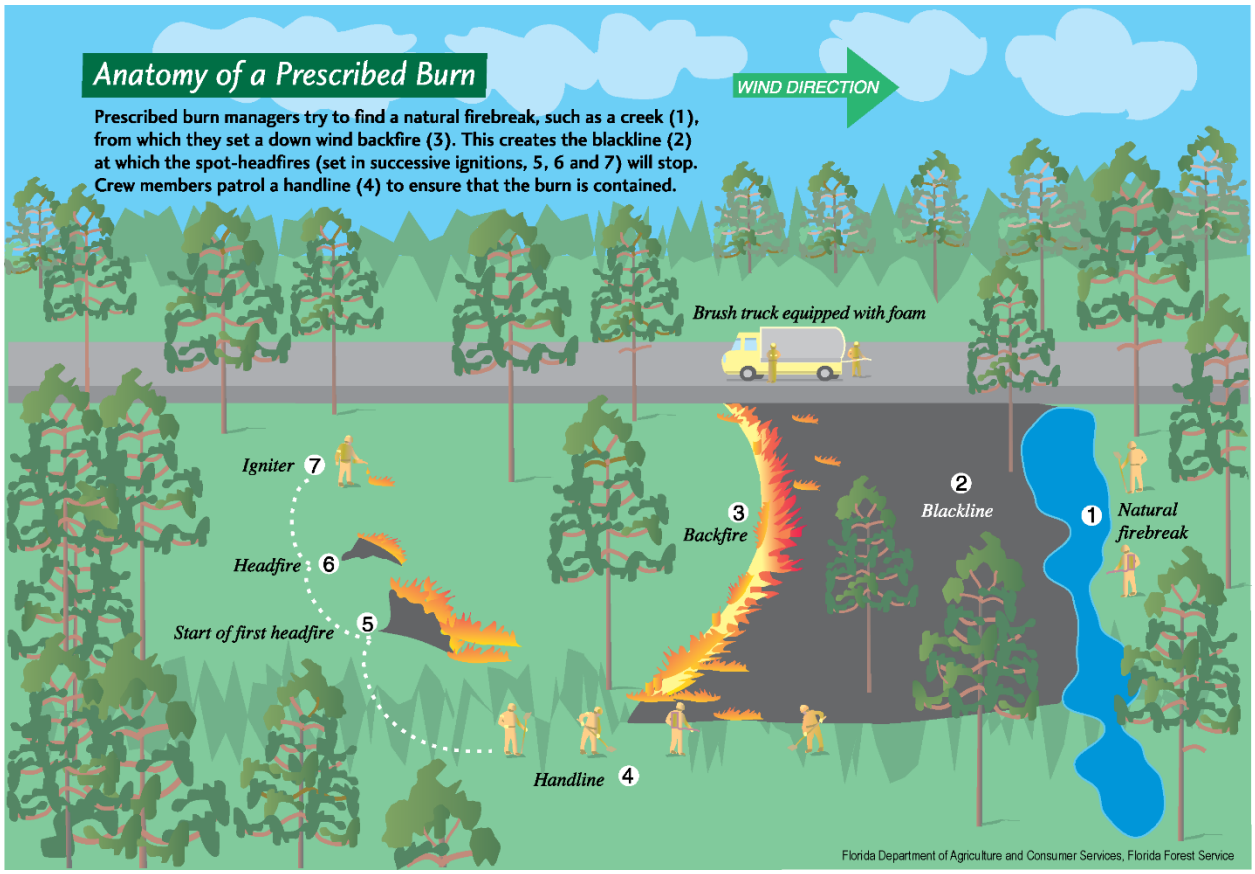


Figure 40. Drawing of prescribed burn and photo of prescribed burn in redwoods

10. POST-FIRE RECOVERY: CLEARING AND REVEGETATION

Background: Post-Fire Recovery: Clearing and Revegetation

Wildfires leave behind a mix of dead, damaged, and live vegetation, as well as woody debris. Many landowners want to "clean up" the burned area to reduce the fuel load of dead vegetation and also replant. Burned areas are vulnerable to rapid spread of invasive plants, such as French, Scotch and Spanish broom and yellow star thistle, that increase risks of future fires, prevent recovery of native plants, reduce wildlife habitat quality, and in some cases, consume more water than native plants. Removing invasives as soon as they show up usually involves pulling seedlings or spraying small areas with herbicides and can stop the spread of these pest species before they get established. Dead trees need to be removed before replanting. Salvage logging can remove fire-killed trees and allow for use of the lumber. Seeding is effective in re-establishing native perennial and annual grasses and forbs. Revegetation with appropriate native plants will speed post-fire recovery, reduce erosion, and limit the spread of invasive flammable shrubs.

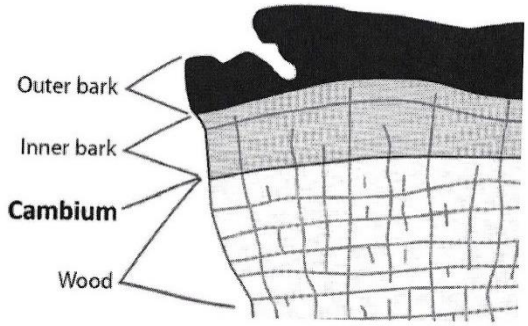
Assessment: Post-Fire Recovery: Clearing and Revegetation

- ❑ Are burned dead trees posing a threat to buildings, roads, or locations in the vineyard where workers could be hurt?
- ❑ Did the fire consume all ground cover, leaving the soil exposed to rainfall?
- ❑ Outline the burned areas of the property on a map. What percentage of trees within the fire perimeter on the site burned?
- ❑ For the conifers (see Tables 8 and 9):
    - Determine the percentage of the crown of each conifer that has burned. If 70% or more of the crown is burned the tree may not recover. Coastal redwoods are the exception as they can withstand fire and resprout.
    - What percentage of the trees on site are redwoods that may resprout and survive? An expert should be consulted to look for indicators of cambium damage.
    - Is the trunk severely burned over more than 50% of the circumference? The tree will likely die unless the species has thick bark.
    - Cut away a small square of bark to reach the cambium (Figure __). Is the cambium green and moist or dark and dry?
    - Do trees have bark beetles?

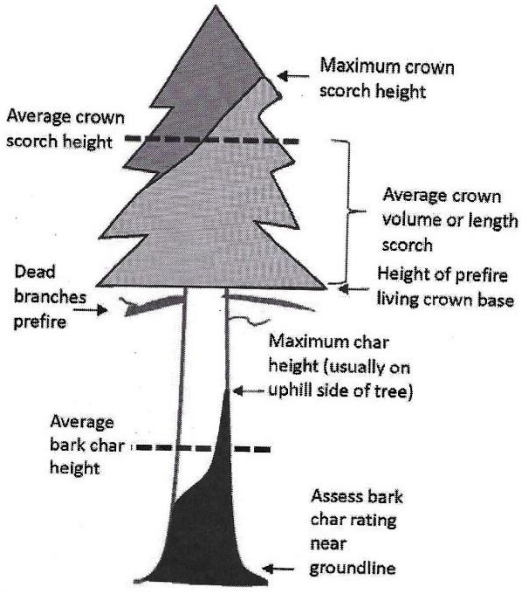
Table 8. Fire Injury Categories

	Heavy-Severe **Trees very likely to die**	**Moderate-Significant** **Trees may die, less predictable, time will tell**	**Light-Minor** **Trees not likely to die**
Crown	Little or no live crown remaining	Varying levels of crown scorch	Most of the crown intact
Bole	Deep char	Varying levels of bole char	Very little bole char
Base, Root crown	Deep basal char; all 4 quarters -total circumference	Varying levels of basal char;2-4 quarters	Very little basal char, 1 quarter or less

From: Ahrens



Tables 8 and 9 outline the effects of bark char and crown scorch on tree viability



Hardwood trees can burn and then resprout

Most conifers often do not survive crown fires. The exception are redwoods that sprout following fire

Figure 41. Fire effects different species of trees in different ways

Table 9. Guide for assessing damage based on bark char

Heavy-Severe	Moderate-Significant	Light-Minor
Bark burned into, not necessarily to the wood, Species bark characteristics are lost, bark smoothed, all ridges are gone Considerable or deep duff and woody debris burning around base Many roots exposed and charred due to combustion of organic matter	Bark is uniformly black except some inner fissures, species bark characteristics still discernable Some organic matter consumed in the burned area Some roots maybe exposed and charred	Bark is not completely blackened; species bark characteristics obvious, edges of bark plates charred. Little duff or organic matter consumed Roots not exposed or charred

From: Ahrens

- ❑ For the hardwoods (See Tables 8 and 9):
  - Check for charred bark, particularly if charring extends around the entire circumference of the trunk
  - Cut small openings in the bark around the base of the tree to check the cambium layer (Figure 41). If cambium layer beneath the bark is green, pink light in color and moist tree may survive. If the cambium layer is dark or yellow, the tree will not likely survive.
  - If large vertical cracks in the bark are present, the tree is unlikely to survive.
  - Trees may survive if only leaves are scorched.
  - If the trunk is blackened but bark thickness has not been reduced, the tree will probably survive.
- ❑ Were invasive shrubs such as French broom growing in or near your property before the fire? Have they started to show up in the burned area as seedlings?
- ❑ Do you want to salvage log the timber, and if so, do you plan to sell the logs?
- ❑ Consider and write down your long-term goals for post-fire restoration for your property.

Applying BMPs – Post-Fire Recovery: Clearing and Revegetation

- ❑ Based on the survey for trees that threaten buildings, roads, and vineyard workers, remove trees.
- ❑ Use mulches and grass seed to control erosion (see Prevention of Landslides and Debris Flows).
- ❑ Consult with a Registered Professional Forester and a Licensed Timber Operator to develop and implement a salvage logging plan; if logs will be sold, obtain a permit from CAL FIRE. An exemption must be filed with CAL FIRE if logs will be traded for the costs of the logging.
- ❑ If over 70%of the crown is burned the tree is at serious risk of dying.
- ❑ If no salvage logging is planned, fall selected dead standing trees to reduce fuel loading and allow for replanting:
  - Dispose of woody materials by burning, chipping, lop and scatter, or box burning for biochar.
  - Leave remaining woody material 80% in contact with mineral soil to speed decomposition.
- ❑ Leave 2 to 4 large dead standing trees per acre for wildlife habitat in locations that will not threaten buildings, roads, or workers.
- ❑ Replant deforested areas using native seedlings grown in or collected from the same watershed as the site (for example, the Russian River or Sonoma Creek watersheds)

- Select a mix of species that occurred on the site previously or are growing in the area of the site and are adapted to local conditions. A restoration ecologist or native plant nursery can provide advice.
- Consider future climate change in selecting plant species
- Droughts will likely be more frequent and longer, so selecting drought-tolerant plants is recommended. Do not plant ornamental species or invasive species (Eucalyptus, Acacia) as many of these can worsen fire conditions.
- Rainstorms, although less frequent, may be more intense, resulting in higher peak flows on creeks; trees well adapted to inundation, such as willows, alders, and cottonwoods, should be planted along channel banks.

❑ Plant all native species in winter or early spring when soil moisture is high; do not plant in summer as most native species will not survive.

❑ Plant trees with a minimum spacing of 20 feet between individual plants. Do not over plant as the forest will be overstocked and too dense with a greater fuel load and fire risk.

❑ Plant pathogens can be introduced through planting. Sudden Oak Death (SOD) caused by Phytophthora ramorum is of particular concern and can cause mortality among tanbark oak, black oak and live oak. Take precautions to avoid spread of pathogens through use of sterilized soil and clean containers when repotting plants, cleaning and sterilization of tires, tools, and boots between work sites, and using plants grown from local acorns. California bay laurel (Umbellularia californica) is a primary vector of SOD spreading the pathogen to oaks but remaining unaffected.

❑ Provide irrigation for the first three summers for newly planted trees and shrubs if possible.

❑ If water is limited, consider increasing the number of trees planted to allow for mortality and/or replant over time.

❑ If needed, use deer exclosures and gopher cages to protect seedlings.

❑ Holes excavated for planting seedlings should be of depths equal to the rootball lengths, and should be twice the diameter of rootballs.

❑ Do not fertilize seedlings.

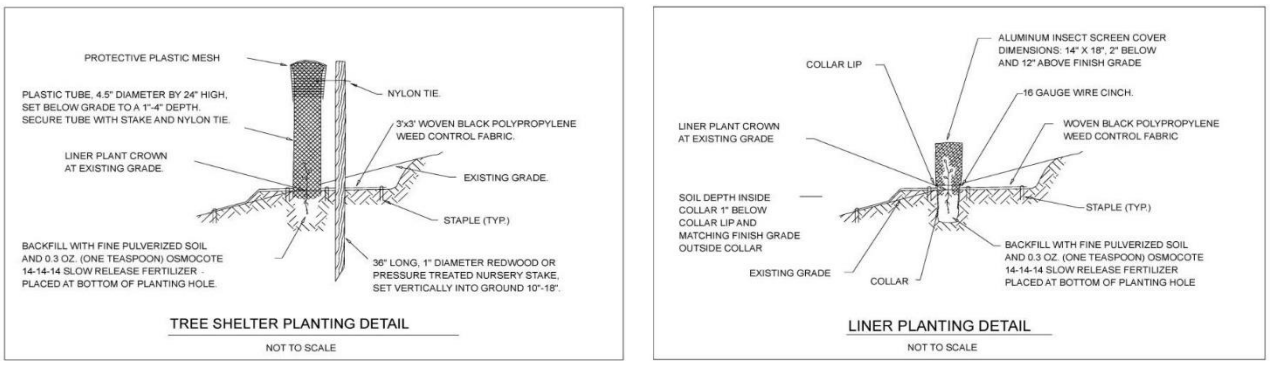


Figure 42. Planting details. Plant conifers approximately 20 feet apart so the forest is not overly dense and fire prone

Figure 43. Fires can create hydrophobic soils and result in both greater runoff and soil erosion. Mulch, hay and hydroseeding can reduce erosion if installed in the first year after the fire

Figure 44. Salvage logging will remove dead conifers so forest will regrow faster or can be replanted

Figure 45. Two to four standing dead trees should be retained per acre to support birds when salvage logging or clearing dead burned conifers

11. POST FIRE RECOVERY: PREVENTING LANDSLIDES AND DEBRIS FLOWS

Background: Preventing Landslides and Debris Flows

Burned landscapes are at an elevated risk for erosion by surface runoff, including "runoff" debris flows, in the first three years following fires. A hydrophobic seal can form on the soil surface in burned areas, reducing infiltration of rainfall and increasing surface runoff and erosion. Hydrophobic soils are particularly likely in burned chaparral areas. Hydrophobic soils can greatly increase the volume of runoff from a rain storm creating a major event, which prior to the fire would have been small. This increase in runoff can lead to mobilization of loose soil, rock, and debris and the initiation of a "runoff" debris flow. Hydrophobic soils tend to break down within 1 to 3 years.

Wildfires also increase risks of landslides. Roots of trees provide tensile strength to soils and help to stabilize hillslopes prone to landsliding. Roots of fire-killed trees decay after 3 or more years, reducing root strength and increasing potential for shallow landslides. If a large storm occurs after the fire has killed the trees and the roots have rotted and before new trees can grow large enough the hillslope is vulnerable to large landslides. New conifer trees may have to grow for 20 years before they provide the same level of stability to hillslopes as existed prior to the fire (Abe and Ziemer 1991)

Loss of tree roots combined with heavy rainfall can also trigger debris flows on oversteepened slopes (hillslopes steeper than the angle of repose for unconsolidated material owing to tectonic or erosional activity), and in accumulations of colluvium (soil and rock transported by the force of gravity rather than by flowing water). These "saturation" debris flows are not the result of hydrophobic soil conditions, but can occur preferentially in burned areas. Road drainage can contribute to hillslope instability by concentrating runoff, saturating soils, and increasing the downslope component of gravitational force.

Assessment: Preventing Landslides and Debris Flows

- ❑ Was burn severity high, medium or low on your property based on criteria described in Table 10?
- ❑ Is there evidence of previous landslide erosion on your property, including:
  - Abrupt elevation changes near tops or bottoms of hillslopes
  - Large boulders deposited in creeks
  - Burial of tree trunks
  - Unvegetated hillslopes (prior to fires)
  - Large cracks in soils
  - Trees, especially conifers, leaning downslope
  - Fallen trees
- ❑ What proportion of trees are living after the fire?
- ❑ Are all roads needed during wet conditions, or can some be closed during winters?

Applying BMPs – Preventing Landslides and Debris Flows

- ❑ Implement erosion control measures to limit surface runoff erosion in areas where slopes experienced high severity fire (Table 10). As much as possible limit driving over steep burned areas and having numerous people walk over the site. These actions compact the ground and can cause storm runoff to channel and erode rills and gullies in the hillsides. Native grass seed can be blown on, dropped by drone or aircraft. Mulch can be blown on but may require spreading.

Table 10. Burn Intensity

Vegetation	Low Severity	Medium Severity	High Severity
Litter, humus	Scorched, charred, blackened, but with identifiable plant parts remaining; 40 to 85% of litter remains	Litter partially consumed, <40% litter remains	No litter remains
Small woody debris (<3")	Surfaces are burned, with some unburned areas	Surfaces are charred; some pieces partially or entirely consumed	Fully consumed
Large woody debris	Surfaces blackened, with some unburned areas	Surfaces are all blackened; char goes into wood	Only large deeply charred logs are left
Stumps	Intact but blackened	Burned deep enough to form charcoal	Stumps are gone, leaving holes where stumps and roots were
Ash, mineral soil	Exposed soils unchanged or blackened, with isolated areas gray to orange where logs burned	Black, gray, and/or orange soil dominates area, with little to no unburned areas; gray ash is present in patches covering <20 percent of area.	Black, gray and orange soil dominates area; gray ash layers may be deep and extensive.

From Barkley 2019

- ❑ Protect burned soils using mulch, coir blankets, and native grass. Mulch can be purchased or made from ground up woody debris, dead trees and shrubs. Apply mulch at rates of 0.5 to 2.0 tons per acre. Mulch more than 2-3 inches deep can restrict regrowth of native plants from the existing seed bank. Slash (twigs and limbs cut with a chainsaw as 18" at largest) is also an effective ground cover for dispersing and slowing overland flow. Recommended coverage, post-fire, is 70%.
- ❑ Plant native grass seed at rates of roughly 50 to 75 pounds per acre; native grasses suitable for seeding include:
  - Purple needlegrass (*Nasella pulchra*)
  - Creeping wildrye (*Elymus triticoides*)
  - California fescue (*Festuca californica*)
  - Deergrass (*Muhlenbergia rigens*)
  - Reedgrass (*Calamagrostis foliosa*)
  - Foothill sedge (*Carex tumulicola*)
  - Common rush (*Juncus patens*)
  - Tufted hairgrass (*Deschampsia cespitosa*)
  - California oatgrass (*Danthonia californica*)
- ❑ Native grass seeds can be purchased in Sonoma County at:
  - LeBallisters Nursery, Santa Rosa
  - Harmony Farm Supply, Penngrove
- ❑ Apply gravel to the surface of roads that will be needed during winter.

- ❑ Construct water bars on roads that will not be used during winter, and cover with mulch or plant with grass seed.
- ❑ Select from the following emergency erosion control measures to slow runoff and to prevent sediment from reaching waterways:

  - **Silt fencing** – A barrier of filter fabric cloth can be purchased and stretched across a slope to further reduce surface soil movement. The posts need to be firmly anchored into the ground at an adequate depth for the soil types and slope. The fabric is stretched tightly and firmly trenched several inches into the slope surface. Posts should be four feet apart or less. Staples attaching the material to the posts should face upslope. Silt fencing is often used in several areas of a long slope as one silt fence at the bottom of a long slope is not likely to be sufficient.
  - **Straw bale check dam** – Bales of clean straw bound with wire or plastic twine can be placed across an area of surface sheet flow, or rilling, and anchored into the soil surface with rebar or stakes. Anchor the bales tightly together to form a barrier across the entire area of surface flow. Don't create a path for the water to go around the outside or under the bales. The stakes, or rebar, should be driven into the ground 1.5 to 2 feet and the bales should be set at least 4 inches into the ground.
  - **Straw wattle water bars** - Straw wattles can be used to create temporary water bars across a road, a temporary sediment barrier to protect a waterway, a silt filter at drop inlets, or contain sediment along a vineyard edge. A series of straw wattle waterbars, may be needed for a long slope. They should cross the entire width of the erosion site and be spaced to allow for sediment accumulation. Straw wattles can be carried to locations. The wattles are staked into a shallow trench and can be stacked 2 wattles high.
  - **Water bars**– Water bars consist of a berm and ditch to collect and direct water off the road surface before concentrated flow can cause erosion. Water bars should be installed on all steep (>10% slope) seasonal vineyard roads as part of the winterization process. Water bars are placed across the road at a 30–40-degree angle, oriented downgrade to the road centerline. The water bars should be oriented to direct the storm water into the vineyard drainage system, or into vegetation with a rock dissipater. If a swale or creek is nearby, a vegetated area, or filter strip, should exist between the road and the creek channel and an energy dissipater of gravel should be placed at the outlet of the water bar. Water bars should be installed at a greater frequency on steeper roads. The water bar should extend from the inboard road cut to the outer edge of the road a distance of 3-6 feet. The water bar consists of a berm and a ditch. The edges of the berm should be 4-6 inches above the roadbed and the ditch should be 4-6 inches deep.
  - **Rolling dips –** If roads that require use are on a hillside slope, rolling dips can be installed. Unlike abrupt waterbars, rolling dips should be able to be driven at prevailing speeds on the road where they are installed. Rolling dips are smooth, angled depressions constructed in the roadbed. They are appropriate for road grades up to 12-14%. In general, broad rolling dips are usually built perpendicular to the road alignment, with a cross slope of 3 to 5 percent greater than the grade of the road. Like waterbars, discharge in proximity to watercourses should be avoided or have a vegetative filter strip between the outlet and the watercourse.
  - **Temporary sediment basin or barrier** – A temporary sediment basin is used to catch and settle out sediment before it can enter a waterway. These are usually placed at the base of a slope, or drainage area. Sediment basins are designed for small watershed areas (no greater than 5 acres) and small storm sizes (10-year recurrence interval). A small basin can be created from compacted soil, rocks or straw bales. The basin embankment should not exceed four feet in height. A drain or outlet is used to restrict flow from the basin to allow for sediment to be trapped. A small berm, or square, of straw bales can be created around the drop inlet of the

vineyard drainage system to reduce siltation. A straw bale sediment barrier can be placed along the burn edge prior to the rainy season to protect water quality. Be sure that the straw bales are securely anchored with stakes or rebar.

- **Plastic-lined ditch -** When a rill begins to form or a slip occurs in a hillslope, plastic can be placed over the eroding site to reduce soil loss temporarily. Strong plastic should be used to avoid puncture by rocks and sticks. The plastic sheets should be anchored so that surface runoff, or wind, cannot move the plastic. Rebar is preferable for staking the plastic. Placing rocks on top of the plastic is not sufficient. Sheets of plastic should be overlapped a minimum of 12 inches and tightly staked at the overlap. The maximum length for use of plastic lining is 400 feet.

❑ Plant native trees and shrubs appropriate for site conditions in potential landslide and debris flow source areas:

- For areas that remain wet into the dry season, use the following plants to encourage transpiration and enhance slope stability:
  - Willows (Salix spp.)
  - Sedges (Carex spp.)
  - Rushes (Juncus spp.)
  - White alder (Alnus rhombifolia)
  - California bigleaf maple (Acer macrophyllum)
  - Valley oak (Quercus lobata)
- For drier forested areas, select species with root networks that will hold soil on steep hillslopes. Be sure to select species that either grew there prior to the fire or grow in the nearby area.
  - Coast live oak (Quercus agrifolia)
  - Madrone (Arbutus menziesii)
  - California bay laurel (Umbellularia californica)
  - Blue oak (Quercus douglasii)
  - Black oak (Quercus kelloggii)
  - Grey pine (Pinus sabiniana)
  - Knobcone pine (Pinus attenuata)
  - In some locations Douglas Fir (Pseudotsuga menziesii), Coastal Redwood (Sequoia sempervirens) and Ponderosa Pine (Pinus ponderosa) may be appropriate
- For dry south facing slopes with chaparral the following species can be used. Be sure to select species that either grew there prior to the fire or grow in the nearby area
  - Manzanita (Arctostaphylos spp.)
  - Chamise (Adenostoma fasciculatum)
  - Toyon (Heteromeles arbutifolia)
  - California lilac (Ceanothus spp)





Figure 46. Fires remove the layer of vegetation protecting soils, can create hydrophobic soils for several years and result in higher runoff and erosion

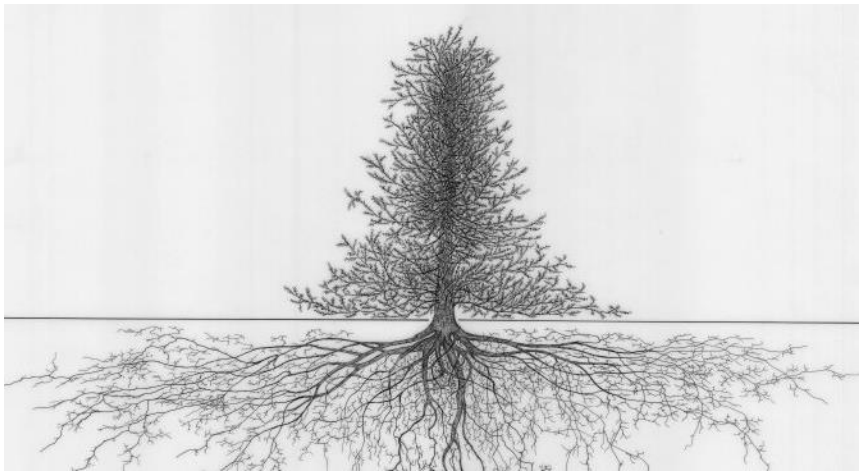


Figure 47. Once the roots of dead burned trees rot saturation debris flows and landslides may occur during large rainstorms until forests regrow

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