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5.2 WILDFIRE ENVIRONMENT

5.2.1 INTRODUCTION: WHY IS WILDFIRE AN ISSUE IN HUMBOLDT COUNTY?

Understanding wildfire's causes and behaviors, as well as its role in the ecosystem, can help residents to better prepare for and survive its inevitability. Wildfire is a natural ecological feature throughout Northern California. At the same time, it can threaten human safety and property, especially in the *wildland-urban interface* (WUI). Finally, wildfire suppression; land uses such as development, timber management, and grazing; and climate change, together are fundamentally altering wildfire behavior, often devastating ecosystem health and human communities.[1]

Wildland-Urban Interface (WUI): The zone where structures and other human developments meet, or intermingle with, undeveloped wildlands.

Wildlands: Areas in which development is essentially nonexistent, except for occasional roads, railroads, power lines, and similar transportation facilities. Structures, if any, are widely scattered. Can include large cattle ranches and forests managed for timber production.

This chapter provides an introduction to Humboldt County fire history and the fire science used as a basis for planning, preparing for, and predicting fire effects on both human and non-human natural communities. It describes wildfire in Humboldt County, and the statewide context.

The landscapes of Humboldt County have adapted to and evolved with fire; fire will continue to shape them. It is not a question of *if* a wildfire will occur here, but rather *when*.

> Fire is an integral part of most California landscapes. Many of our native plants, including trees, are adapted to burn periodically; they need fire to be healthy, reproduce, and survive. Fire suppression activities over the last 100–150 years have largely taken fire out of the system, causing far-reaching changes in habitats and forest health.[2]

Compared to fire patterns before European settlement, it is generally accepted that fires in California today are more severe and more difficult to control. More catastrophic wildfire can impact ecosystem services such as wildlife habitat, carbon sequestration, and water and air quality.[3] Wildfire is among Humboldt County's most dangerous natural disasters, with wide-ranging potential for destruction.

5.2.2 GENERAL WILDFIRE ENVIRONMENT DESCRIPTIONS

Human activities and natural factors combine to affect *fire behavior* and its consequences throughout the county.

Human factors include:

- Home design and landscaping,
- Community hazardous fuel reduction and wildfire preparedness,
- Land-use planning, and
- Fire ignition management.

Natural features include:

- Topography,
- Weather, and
- Condition and type of vegetation and other fuels.

[1] State Board of Forestry and Fire Protection & California Department of Forestry and Fire Protection (2018). 2018 Strategic Fire Plan for California. (p. 6). Retrieved from http://cdfdata.fire.ca.gov/fire_er/fpp_planning_cafireplan

[2] California Forestland Stewardship Program. (2010). What can you do to protect your property from wildfire? Retrieved from http://calfire.ca.gov/foreststeward/fire_and_fuels

[3] Wimberly, M.C. & Liu, Z. (2014). Interactions of climate, fire, and management in future forests of the Pacific Northwest. *Forest Ecology and Management* 327: 270-279 (p. 277).

This section focuses on these natural features and other aspects of fire behavior, in order for Humboldt County residents to understand and reduce the negative impacts of wildfire and gain the *resiliency* to rebound when fires do occur.

Knowing the attributes of fire behavior is important when describing the threats from a fire and also in order to carry out effective fire control and mitigation. *Flame length, fire intensity, heat output*, *rate of spread*, *residence time*, and whether a fire burns on the surface (forest floor) or crown (tops of trees) are all ways to describe fire behavior. These factors can influence resulting damage as well as potentially positive impacts of fire. *See Appendix E,* ***Background for Wildfire Environment.***

Ecosystem functions: The processes and interactions that occur between organisms and the physical environment.
Fire behavior: The manner in which a fire reacts to the influences of fuel, weather, and topography. Common terms used to describe behavior include smoldering, creeping, running, spotting, torching, and crowning**.**

Fire-dependent: Plants, vegetation communities, and specific habitat types that have evolved to rely on fire in order to exist and/or thrive.
Fuel(s): Combustible structures and vegetative materials. Includes dead plants, parts of living plants, duff, and other accumulations of flammable vegetation, such as grass, leaves, ground litter, shrubs, and trees that feed a fire.
Resilient/Resiliency: The ability of an ecosystem or a community to return to its functionally balanced state after a disturbance.

Fire Behavior Characteristics:

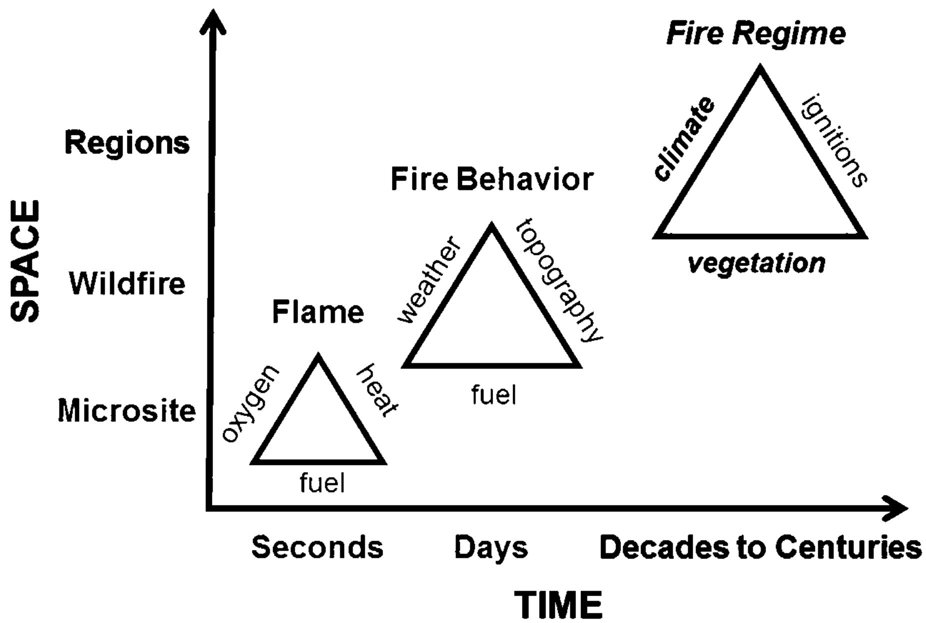
- **Flame length:** The distance between the flame tip and the midpoint of the flame depth at the base of the flame (generally the ground surface); an indicator of fire intensity.
- **Fire intensity:** The amount of heat released by a fire in an area in any given time period. Fire intensity is usually related to flame length.
- **Heat output:** The total amount of heat a fire releases in a specific area during the passing of the flaming front.
- **Rate of spread:** The speed of an advancing fire. May be measured by the growth in area or by the speed of the leading edge of the fire.
- **Residence time:** Time, in seconds, required for the flaming front of a fire to pass a stationary point at the surface of the fuel. The total length of time that one flaming front of the fire occupies one point.

Humboldt County is composed of several different ecosystem types, most of which have evolved with fire. **This is a *fire-dependent* environment. As this chapter will show, fire has played a prominent role in shaping the natural environment here. Wildfire will happen. Exclusion of wildfire is not an option.**

As stated above, topography, weather, and vegetation contribute to the type and intensity of wildfire, or fire behavior. Together they are known as the "fuel triangle." The graphic on the following page shows the difference between the fire triangle (flame), the fuel triangle (fire behavior), and finally a fire-regime triangle, which incorporates climate change. These concepts are all explained in this chapter. The following graphic helps to put them in a spatial and temporal context. *See Appendix E,* ***Background for Wildfire Environment*** *for a description of these concepts.*

Figure 5.2.1 Fire Triangles

"Conceptual model describing the controls of fire across spatial and temporal scales, adapted from Moritz et al. Much of fire science focuses on understanding fire behaviour, which is sensitive to weather, fuels, and topography. Fire regimes describe the characteristic patterns of wildfires over large spatial and temporal scales, and they are sensitive to changes in climate, vegetation, and ignitions."[4]



Topography

Humboldt County has a mixture of rugged mountains, rolling hills, and broad valleys. Elevations range from the coastal sand-swept streets of Manila, just 13 ft. above sea level, to Salmon Mountain, the county's highest peak at 6,962 ft. (in the Trinity Alps Wilderness of Six Rivers National Forest). The drier, more fire-prone areas of the county are also the steepest and most rugged. These steep drainages can act as chimneys, which can move wind and fire very quickly up a slope. Due to the remoteness and steepness of slopes within the county, fire equipment and personnel can be limited in their access to wildfires. This adds significant fire risk to Humboldt County communities.

For more information on local geologic features, and aspect and slope maps, see Appendix E, ***Background for Wildfire Environment.***

Weather

Humboldt County has moderate temperatures and considerable precipitation. The Pacific Ocean creates a cool, stable temperature regime along coastal areas. Further inland the marine influence is lessened and there is a wider variation of temperatures with lower humidity. Temperatures along the coast vary only 10 degrees from summer to winter. Freezing temperatures are experienced nearly every winter throughout the county, with colder temperatures prevailing in the interior. Maximum annual temperatures rarely exceed 80°F on the coast, while triple-digit days are common in the mountain valleys.

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[4] Higuera, P.E. (2015). Taking time to consider the causes and consequences of large wildfires. Proceedings of the National Academy of Science, October 27, 2015. 112 (43) 13137-13138, Figure 1. Retrieved from https://doi.org/10.1073/pnas.1518170112

Historically, rainfall occurs during every month, although amounts are negligible from June through August. Seasonal totals average between 30 – 40 inches in the driest area along Humboldt Bay and exceed 90 inches in the wettest, in the Kings Range and along the ridges in the northeastern portion of the county. Because of the moisture and moderate temperature, the average relative humidity is high.

*See Map E.3, **Precipitation** in Appendix E for more information on local weather conditions, and section 5.2.6, **Climate Change and Wildfire in Humboldt County** below for more information on changing weather patterns.*

Inland, thunderstorm activity typically begins in June with wet storms. These storms often turn dry and are accompanied by lightning as the season progresses into July and August. The combination of these dry thunderstorms and the lack of marine influence increases the potential for summer fires in the eastern portion of the county.

Prevailing winds during Humboldt County's *fire season* (generally June through October) are out of the northwest. In July and August, local winds (slope winds and sea breezes) predominate, with the Pacific jet stream weak and well to the north. By September, weak to moderate north-to-northeast winds can become more prevalent. These winds are more critical for bringing in moist ocean air than in the late spring. The more easterly flows in particular are problematic, being significantly drier.

Fires during *foehn events*—or subsiding winds—usually result in extreme fire behavior as the winds are particularly strong and dry, reducing *fuel moistures*. This leads to easier ignitions and increased fire intensity and rate of spread. Foehn winds can also cause extreme fire behavior at night when fires normally die down.

Fire season: 1) Period(s) of the year during which wildland fires are likely to occur, spread, and affect resource values sufficient to warrant organized fire management activities. 2) A legally enacted time during which burning activities are regulated by state or local authority.

Foehn winds: A wind that blows warm, dry, and generally strong, creating extremely dry fuel and dangerous fire potential.

Fuel moisture content: The amount of water in a material divided by its oven-dry mass, expressed as a percentage. Moisture content is a key factor in determining how a fuel will burn, along with such factors as density and surface-to-volume ratio.

Honeydew Fire burning down to the ocean in 2003.

An important local phenomenon is that which occurred with the 2003 Honeydew Fire in the King Range National Conservation Area. Instead of the usual and expected gradual cooling and humidity accumulation throughout the night, around midnight temperatures increased and relative humidity dropped for several hours, resulting in a more active nocturnal burning period. This increased nocturnal burning effect is well-known here. There are generally two burn periods: late afternoon and early morning.

The National Weather Service provides daily fire weather forecasting for Humboldt County from its Eureka office. All fire weather forecasts are available at the Eureka office main webpage: *https://www.weather.gov/eka*.

Vegetation and Fuels

Vegetation usually provides most of the fuel to feed wildfire, combined with other flammable materials such as buildings. However, in WUI fires, it is often the homes and other *urban fuels* that provide the most fuel for a fire.

Fuel includes anything that can burn: grass, shrubs, and trees, along with urban fuels such as fences, decks, furniture, cars, and houses. These can be described using *fuel models* *(see Appendix E),* or in terms of their size, volume, and arrangement:

- Light fuels (e.g. grass, foliage, kindling-size twigs, or baskets and brooms),
- Medium fuels (e.g. shrubs, branches, and fences), or
- Heavy fuels (e.g. logs, tree trunks, and houses).

Light, medium, and heavy fuel loadings describe fuel volume. Fuel arrangement is commonly discussed in terms of continuity—both horizontal and vertical. **Fuel continuity is an important concept for homeowner and community wildfire preparedness.** It is discussed in *Chapter 3.2,* the ***Wildfire Preparedness*** countywide action plan and *Appendix H,* ***Living with Wildfire*****.**

Nearly every major *fuel type* in California exists within Humboldt County, including grasslands, oak woodlands, brushlands*,* hardwood forests, mixed conifer forests, and conifer forests including the iconic redwood groves. Because of this ecosystem diversity, Humboldt County can experience virtually any type of wildfire that can occur in California, from fast-spreading grass fires to long-duration forest fires. *For more information, see Map 5.2.1* ***Surface Fuels,*** *and* ***Fuel Models*** *in Appendix E.*

The virtual exclusion of widespread low- to moderate-severity fire *(see* ***Fire History*** *section below)* has affected the structure and composition of *vegetation types*. Conifer stands are generally denser, mainly in small- and medium-*size classes* of *shade-tolerant* and *fire-sensitive* tree species like Douglas fir and tanoak. Fuels have become more vertically continuous, contributing to more spatially homogeneous forests. Selective cutting of large overstory trees, intense fire suppression, and the relatively warm, moist climate during much of the twentieth century likely enhanced conifer seedling establishment and hardwood sprouting.

Urban Fuels: Any flammable materials within a landscape as a result of urban development. Examples include urban structures, landscaping, and urban debris such as wood piles, trash dumps along roadsides, and die-back from weedy invaders

Fuel Model: A standardized description of fuels available to a fire, based on the amount, distribution, and continuity of vegetation and wood.

Fuel type: An identifiable association of fuel elements of a distinctive plant species, form, size, arrangement; or other characteristics that will cause a predictable rate of fire spread or difficulty of control under specified weather conditions**.**

Vegetation Type: A standardized description of vegetation. The type is based on the dominant plant species and the age of the forest or ecosystem. It also indicates how moist a site may be and how much fuel is likely to be present.

Size Class: The division of trees in a forest by the size of their diameter, sometimes split into three categories—seedlings, pole, and saw timber—or by diameter in inches.

Shade-tolerant: Attribute of a species that is able to grow and mature normally in and/or prefers shaded areas.

Fire-sensitive: A species of tree or other plants that are more susceptible to fire damage. Sensitivity may be due to thin bark or easily ignitable foliage.

As described in *section 5.1.3,* the use of the “hack and squirt” or “frilling” forest practice is also increasing standing dead forest fuels, contributing to increased wildfire hazards in those areas. This practice leaves conditions similar to those seen by sudden oak death, as described in the following section.

Sudden Oak Death

A significant increase in hazardous fuels in the last two decades resulted from the introduction of *sudden oak death* (SOD). SOD is a plant disease caused by *Phytophthora ramorum,* an invasive forest pathogen introduced to California in the mid-1990s through the horticultural plant trade (especially through rhododendron, camellia, and viburnum species). It was first identified in Humboldt County in 2002 in the Redway area of Southern Humboldt. It has since spread throughout Southern Humboldt and the South Fork Eel River watershed to just north of Weott, and to the southeast of Blocksburg just into Trinity County. There is also a significant infestation around the community of Redwood Creek (assumed to be introduced through nursery species) that has spread downstream into Redwood National Park, as well as a small infestation upstream (further south) in that drainage. SOD has been spreading at an average rate of approximately 1,500 acres/year here since 2004. Detections of the pathogen have recently been found in the water, as well as in a limited number of trees in the Mad River and Mattole watersheds. A new and potentially more virulent strain from Europe was recently detected in a stream in McKinleyville.[5]

> ***Snags:*** Snags are standing dead trees, which can be very flammable. They are often teeming with life such as insects and woodpeckers, and hence an important part of local forest biodiversity.

This pathogen has caused widespread dieback of tanoak *(Notholithocarpus densiflorus)* and several true oak species throughout coastal California counties. Bay laurel *(Umbellularia californica)* is a common host, infecting nearby oak stands. **Depending on the time since infection, and the specific rate of tree mortality, affected areas can have a significantly higher fire hazard due to higher proportions of dead fuels of all sizes, and a prevalence of *snags*.** This disease spreads easily by wind-driven rain events and the locally affected area is anticipated to grow substantially. Research over the past two decades has helped to characterize the nature of the risk and will help to guide firefighter response.[6]

Several factors make the spread of SOD a particular concern in Humboldt County: [7, 8]

- The pathogen continues to spread here. The small infestation detected in Redway in 2002 has since grown to include patches scattered over several dozens of square miles, directly impacting approximately 30,000 acres. It could continue to spread and eventually affect tanoak throughout much of the North Coast.
- Ecologists expect sudden oak death's impacts to local forest ecosystems (e.g. timber, tribal, wildlife, fire hazard, aesthetics, etc.) to be significant.
- Early response and pathogen control is limited to a narrow window from the point of detection.
- New species have recently been discovered to be affected by the disease, including chinquapin and several manzanita species.
- The European strain of the pathogen recently detected in Oregon and in a stream in McKinleyville may have the potential to affect conifers more severely than the North American strain present on the West Coast up to now.[9]

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[5] Valachovic, Y. (2018). "Managing Uncertainty: Sudden Oak Death and Other Pests, Fire, and Drought." Workshop, March 22, 2018, University of California Cooperative Extension (UCCE), Eureka, CA. USA.

[6] Valachovic, Y., Lee, C., Scanlon, H., Varner, J.M., Glebocki, R., Graham, B.D., & Rizzo, D.M. (2011). Sudden oak death-caused changes to surface fuel loading and potential fire behavior in Douglas-fir-tanoak forests. *Forest Ecology and Management* 261, 1973-1986. [PDF]. Retrieved from http://www.suddenoakdeath.org/?bibliography=sudden-oak-death-caused-changes-to-surface-fuel-loading-and-potential-fire-behavior-in-douglas-fir-tanoak-forests

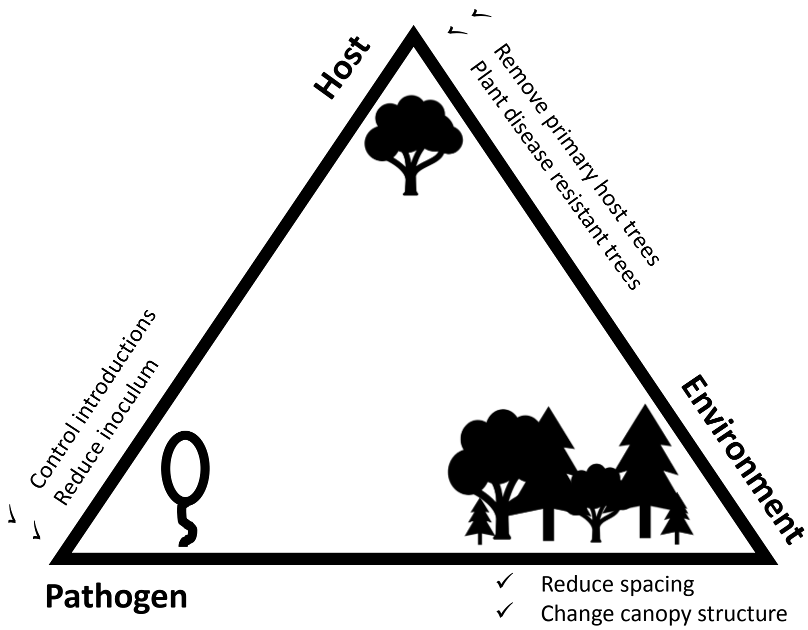
[7] Valachovic, Y., personal communications, August 31, 2012; August 2017; April 2018, and "Managing Uncertainty: Sudden Oak Death and Other Pests, Fire, and Drought." Workshop, March 22, 2018, UCCE, Eureka, CA. USA.

[8] For more see: UCCE: Humboldt – Del Norte Counties. (2012). Disease Locations and Pathogen Monitoring. Retrieved from http://cehumboldt.ucanr.edu/Programs/Forestry/Sudden_Oak_Death/Disease_Locations_and_Pathogen_Monitoring

Given these findings, the effect of sudden oak death on the wildfire environment in Humboldt County is significant. The disease and its ramifications in local ecosystems must be considered in fuel-reduction and other ground-disturbing activities in the county to minimize its negative effects.

The following graphic from the University of California Cooperative Extension (UCCE) shows the three sides of management actions required to control sudden oak death.

Figure 5.2.2 Sudden Oak Death Disease Triangle[10]



General land-management practices that are beneficial for fuel-hazard reduction are consistent with practices that <u>may</u> help reduce the infestation and spread of sudden oak death. These include, but are not limited to:

- Thinning the understory of forests, especially suppressed tanoaks,
- Removing dead and dying trees,
- Reducing ladder fuels,
- Reintroducing fire through prescribed burning, and
- Facilitating more air flow through forest stands to reduce their humidity has proven effective in anecdotal cases.

For more information on Sudden Oak Death:

- **Sudden Oak Death:** ***http://cehumboldt.ucdavis.edu/Sudden_Oak_Death*** University of California Cooperative Extension (UCCE): Humboldt – Del Norte Counties.
- **California Oak Mortality Task Force:** ***http://www.suddenoakdeath.org***
- **Best Management Practices:** ***http://www.suddenoakdeath.org/diagnosis-and-management/best-management-practices***
- **UCIPM, How to Manage Pests, Sudden Oak Death:** ***http://ipm.ucanr.edu/PMG/PESTNOTES/pn74151.html***

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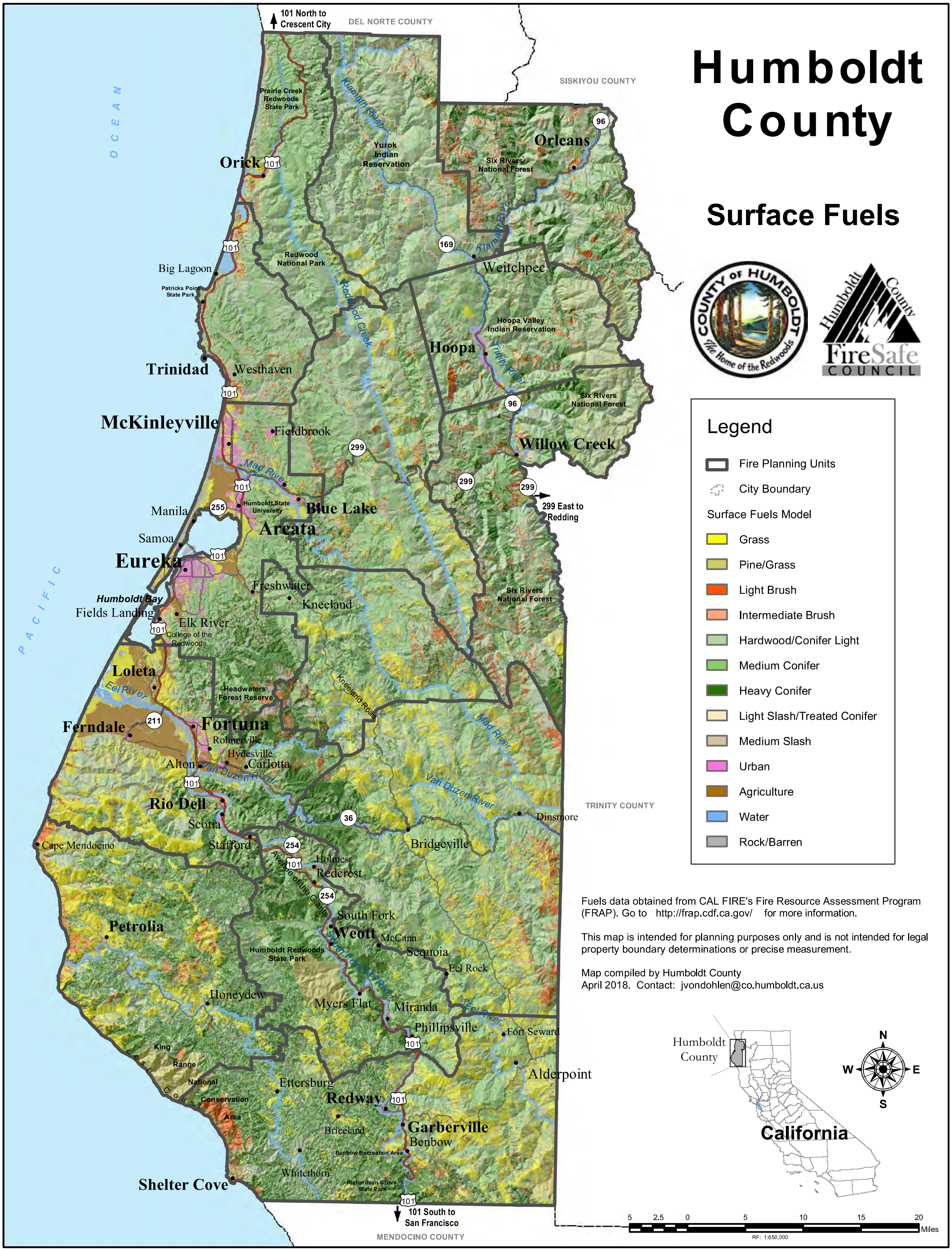
[9] LeBoldus, J.M., Sondreli, K.L., Sutton, W., Reeser, P., Navarro, S., Kanaskie, A., & Grunwald, N.J. (2018). First report of *Phytophthora ramorum* lineage EU1 infecting Douglas fir and grand fir in Oregon. *Phytopathology* 102 (2), (p. 455).
[10] Valachovic, Y. (2018). Workshop, March 22, 2018, UCCE, Eureka, CA.

Map 5.2.1 Surface Fuels



5.2.3 WILDFIRE HAZARD

The term "hazard" is used in relation to topography, introduced in the previous section, and *fuel complex. Fire hazard* is a description of the fuels available to burn in a given area and how they could burn. It can be influenced by past *disturbances* or management activities that alter the hazard for better or worse, including changing the site moisture. It is also affected by the volume and spatial arrangement of fuels. Fire hazard is distinct from *fire risk;* the latter incorporates the probability of wildfire occurrence, or ignitions.

Fuel complex: The volume, type, condition, arrangement, and location of fuels.

Fire hazard: A fuel complex that determines the degree of ease of ignition and of resistance to control.

Fire risk: The combination of vegetation, topography, weather, ignition sources, and fire history that leads to fire and/or ignition potential and danger in a given area.

Stand-replacing fire: A fire that kills most or all of the trees in a section of forest

Disturbances: Various activities that disrupt the normal state of the soil, such as digging, erosion, compaction by heavy equipment, etc.

Fire Hazard Severity Zones

A site's fire hazard ranking shows the expected behavior of fire in severe weather (when wind speed, humidity, and temperature make conditions favorable for a *stand-replacing fire*). *Fire Hazard Severity Zones* (FHSZs) are how the state of California currently assesses and defines fuel hazards.[11] FHSZs range from Moderate to High to Very High.[12]

Humboldt County exhibits the complete range of severity classification from Moderate to Very High; *(see **Fire Hazard Severity Zone** map in Part 2).* In *State Responsibility Area* (SRA)[13] lands, **the map generally reflects a High rating in the western portions of Humboldt County,** where the fuel potential is high but the climate is damp. **Humboldt's Very High ratings are generally in the drier, eastern portions of the county, or in very steep terrain,** such as found along the Lost Coast. **Moderate ratings are in valley bottom areas,** which are generally urban or agricultural. Those areas with lower fire risk are concentrated in coastal and estuary lands. There are no Very High classifications in the *Local Responsibility Area* (LRA) in Humboldt County.

Fire Hazard Severity **as Determined by CAL FIRE**
❖ The classification of a zone as Moderate, High, or Very High fire hazard is based on a combination of how a fire will behave and the probability of flames and embers threatening buildings.
❖ Zone boundaries and hazard levels are determined based on vegetation. For wildland areas, the current FHSZ model uses burn probability and expected fire behavior based on weather, fuel, and terrain conditions. For urban areas, zone boundaries and hazard levels are based on vegetation density, adjacent wildland FHSZ scores, and distance from wildlands.
❖ Each area of the map gets a score for flame length, embers, and the likelihood of the area burning. Scores are then averaged over the zone areas.

State Responsibility Area (SRA): The area in the state where the State of California has the primary financial responsibility for the prevention and suppression of wildland fires.
Local Responsibility Area (LRA): The area in the state where the financial responsibility of preventing and suppressing fires primarily rests on the local jurisdiction.

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[11] FHSZ methodology is currently being updated by CAL FIRE. Ratings for Humboldt County are not expected to change significantly. *David Sapsis, personal communication, May 7, 2018.*

[12] *See Appendix E, **Background for Wildfire Environment** for a description of the attributes included in the California Department of Forestry and Fire Protection's (CAL FIRE's) Fire Hazard Severity analysis.*

[13] For more information on SRA vs. LRA, please see *Fire Protection Responsibility Areas in Chapter 5.3, **Wildfire-Protection Capabilities***.

Forty-five percent of Humboldt County is classified as Very High, 48% as High, and only 4% Moderate, the remainder being unclassified as unzoned or water, etc. The table below and the map on the following page illustrate the distribution of FHSZs in acres by planning unit and geographically throughout the county. *For a detailed map of FHSZ ranking for each Planning Unit, see Part 4, **Planning Unit Action Plans**.*

FIGURE 5.2.3 FIRE HAZARD SEVERITY BY PLANNING UNIT (ACRES AND PERCENTAGE)

PLANNING UNIT	*Very High*	%	*High*	%	*Moderate*	%	*Other*	%
Orick–Redwood Park (PU 1)	15,228	15	72,174	72	12,132	12	876	1
Upper Yurok Reservation (PU 2)	132,016	88	16,237	11	1,857	1	1,063	1
Mid Klamath (PU 3)	134,324	99	78	0	37	0	1,897	1
Hoopa (PU 4)	107,620	94	4,768	4	544	0	2,303	2
Trinidad (PU 5)	6	0	45,980	68	21,336	32	59	0
Redwood Creek (PU 6)	117,895	62	71,983	38	103	0	0	0
Willow Creek Area (PU 7)	163,937	97	3,921	2	114	0	376	0
Humboldt Bay Region (PU 8)	1,017	1	97,029	61	25,118	16	41,089	36
Kneeland–Maple Creek (PU 9)	79,578	65	43,553	35		0	0	0
Eel (PU 10)	2	0	133,267	70	24,138	13	65,653	35
Mad–Van Duzen (PU 11)	189,558	62	113,881	37	1,596	1	0	0
Mattole–Lost Coast (PU 12)	13,821	7	180,174	90	6,077	3	716	0
Southern Humboldt (PU 13)	58,028	23	194,740	76	1,964	1	402	0
Avenue of the Giants (PU 14)	19,508	13	120,897	82	6,780	5	0	0
Total	**1,032,538**	45%	**1,098,682**	48%	**101,793**	4%	**114,434**	0

**Other = Non-Wildland/Non-Urban or Urban Unzoned*

Fire Regime and Condition Class

Fire-return interval: Number of years between two successive fire events for a given area. Also referred to as fire interval or fire-free interval.

Fire regime is a description of fire's historic natural occurrence, variability, and influence on vegetation dynamics in the landscape. The five historical fire regimes are classified based on the average number of years between fires (fire frequency) combined with the fire severity (amount of consumption of the dominant overstory vegetation). The difference in fire regime between pre- and post-European settlement is described by the *condition class,* or the degree of departure from the historical natural fire regime.

According to CAL FIRE, **Humboldt County primarily has Fire Regime I, which means a natural *fire-return interval* between 0–35 years of low severity fire. There are also scattered areas of Fire Regime III, with a 35–100+ year frequency of mixed severity fire, generally found on ridgetops, and more often in the eastern parts of the county.**

All three condition classes (1, 2, and 3) exist in Humboldt County. Condition class is generally within or near fires' historical range for the western and lower elevation/riparian areas of the county. As elevation increases, condition class changes from moderately altered to severely altered from historical range.

*See Appendix E, **Background for Wildfire Environment**, for a more detailed description and maps of both fire regime and condition class in Humboldt County.*

5.2.4 WILDFIRE RISK AND IGNITION SOURCES

As described in the previous section, fire risk differs from hazard in that in incorporates ignitions and fire history**. In California and elsewhere, people are responsible for starting most wildfires.** Major human-related causes include arson, recreational fires that get out of control, smokers' carelessness, debris burning, children playing with fire, and more recently industrial marijuana production.

*Map E.6, **Potential Incendiary Wildfire Ignition Sources**, in Appendix E* shows areas where fires are expected to start in Humboldt County. These potential ignition areas are generally around residential areas, commercial or industrial lands, power lines, and railroad lines. *Map E.6* shows that many of these potential ignition sources are located in the more populated, western areas of the county. However, that map does not include lightning occurrence areas, which is significant in the eastern areas of the county, (as is shown on the following map below). Future versions of this map should include the locations of industrial operations that pose a particular wildfire risk; these might include marijuana production and extraction sites, which are not currently included in this data set.

Alternatively, *Map 5.2.2, **Wildfire Starts*** below, shows that most actual wildfire ignitions (whether human- or lightning-caused) have been heaviest in the less populated, eastern areas of the county. Of all the fires that have occurred from 1974 to 2017 with known ignition sources, 60% were started by people including 35% as arson, and 12% by lightning. The remaining 28% were of unknown origin.[14] Interestingly, different fire-ignition causes have changed over the decades in Humboldt County. In the 1970s smoking lead to more fires than in later decades, arson fires peaked in the 1990s, and more recently vehicles, equipment, and powerline fires are on the rise.[15]

CAL FIRE data show that human activities directly cause most wildfires in Humboldt County.[16] The table following the map *(Figure 5.2.4 Humboldt County, Arson Ignitions by Month)* shows arson ignitions by month. **Arson, as defined by CAL FIRE, is the leading cause of ignitions in Humboldt County from June through October.[17]** There is an especially high number of incidents classified as arson on tribal land, as indicated on the map.

Marijuana

Wildfire ignition risk—the probability for a fire to start—can be great in the marijuana industry. Fire service personnel report that this risk has risen over the past decade with the increased number of people associated with marijuana "grow scenes" scattered in very remote places around the county, often in High and Very High Fire Hazard Severity Zones.[18] More people in remote areas during fire season, with the addition of spark-generating equipment such as vehicles and generators, means the probability of fire starts is greater. The number of fires started by marijuana operations is not tracked, so it is difficult to document the extent of this impact. It is also unclear how the legalization and regulation of this industry will impact associated wildfire risks.

[14] CAL FIRE. (2018). Humboldt Del-Norte Unit Pre-Fire Planning Battalion (ignition data from National Fire and Aviation Management [FAMWEB] fire and weather data or FAMWEB).

[15] CAL FIRE. (2018).

[16] CAL FIRE. (2018).

[17] CAL FIRE. (2018).

[18] *See section 5.2.3 for more information on Fire Hazard Severity Zones.*

Map 5.2.2 Wildfire Starts

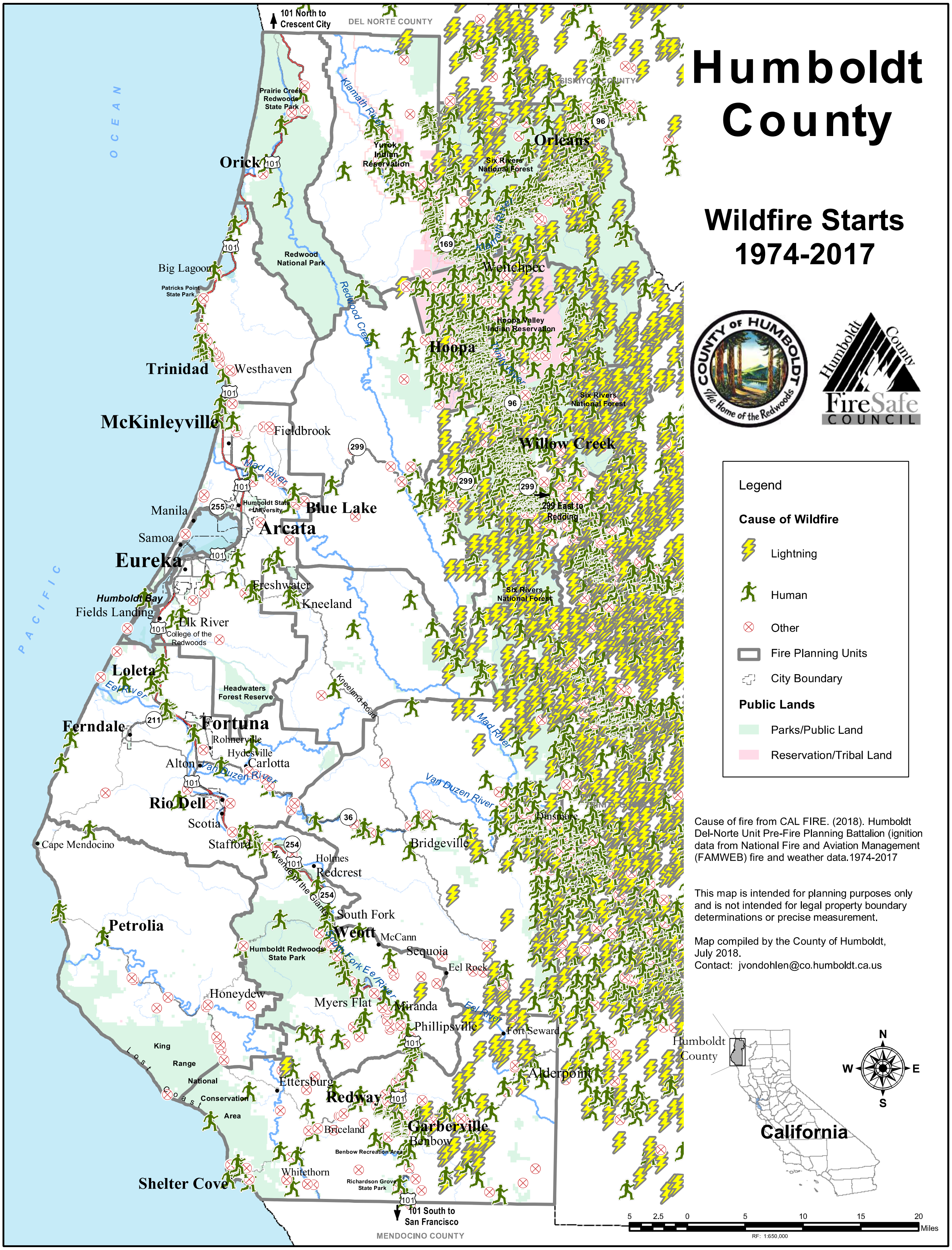
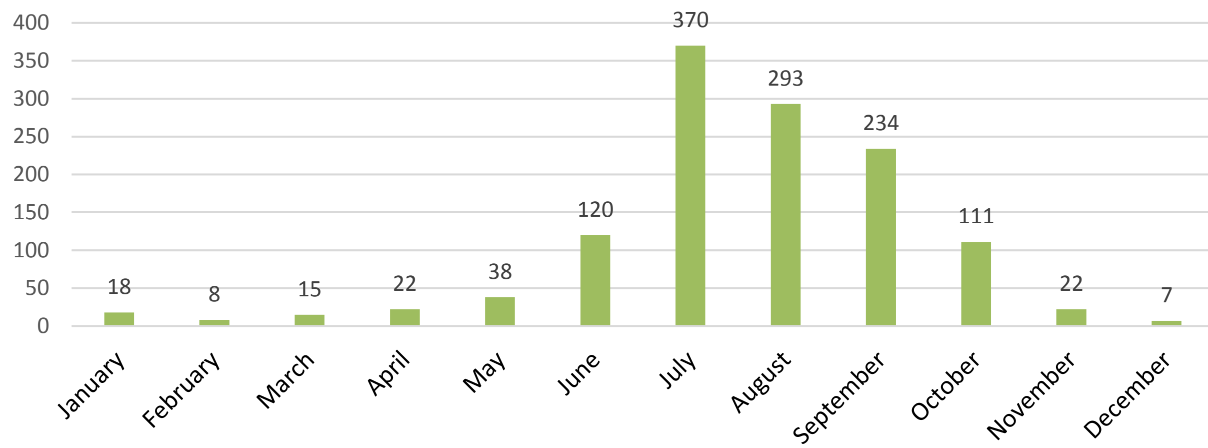


Figure 5.2.4 Humboldt County, Arson Ignitions by Month, 1974–2017[19]



Wildfire in the redwood forests, Canoe Fire 2003, photo: S. Underwood.

The wildfire season in Humboldt County historically began in June and ended in mid-October; however, today's fire season is expected to be longer. In most parts of the state, the fire season is now considered to be year-round. Drought, light snow pack, and local weather conditions can expand or shorten the length of fire season. As described below in *section 5.2.6* changing climatic conditions are beginning to change the local fire season, especially in terms of earlier snowmelt and increased night-time temperatures.

The following *Figure 5.2.5* shows the number of fire ignitions by month in Humboldt County, for the years 1974-2017. The greatest potential for ignitions occurs annually between June and October with the greatest number of ignitions occurring in July. *Figure 5.2.6* shows the average number of acres burned by month for the same years. The greatest potential for fires to grow to a large size happens in September. This is likely due to weather and fuel conditions, and the possibility that fire suppression resources could be stretched throughout the state in the fall.

[19] CAL FIRE. (2018). Humboldt Del-Norte Unit Pre-Fire Planning Battalion.

Figure 5.2.5 Humboldt County, Average Number of Ignitions by Month, 1974-2017[20]

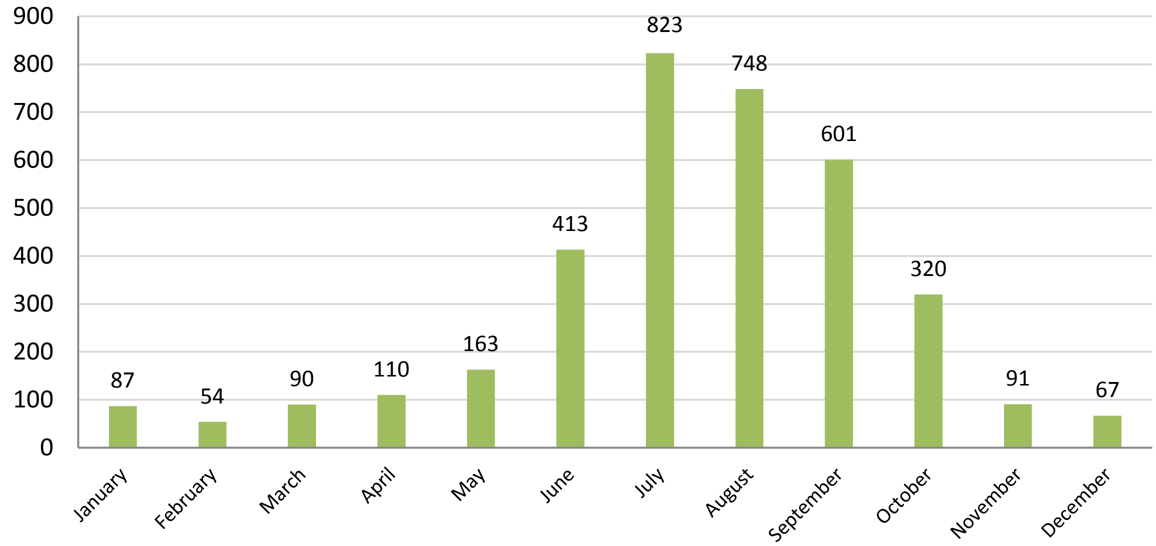
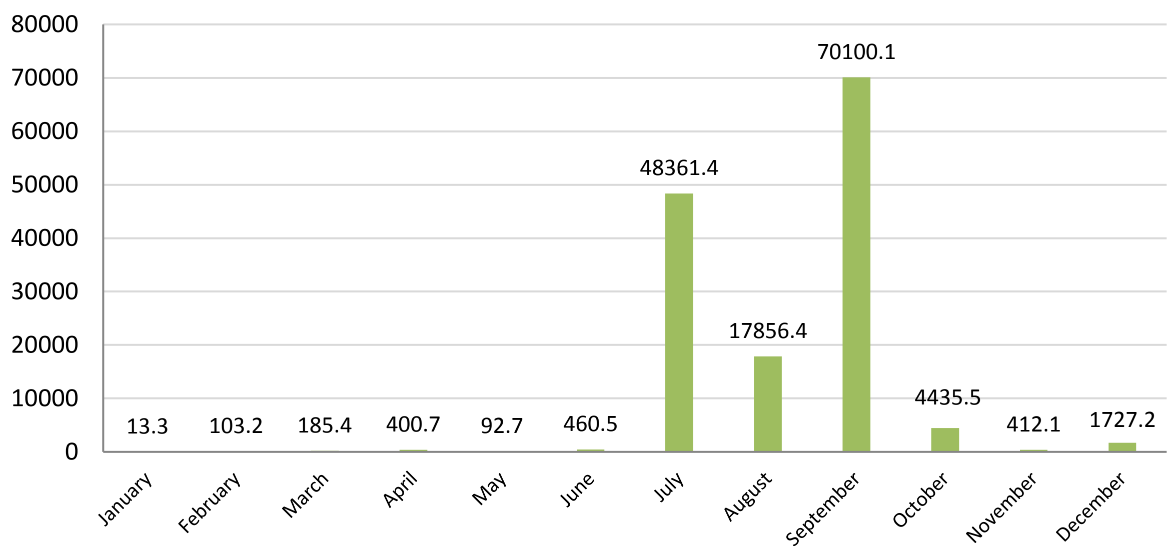


Figure 5.2.6 Humboldt County, Average Number of Acres Burned by Month, 1974-2017[21]



Coastal, or western, Humboldt County's wildfire season is typically shorter than that of the eastern half for a number of reasons:

- The western half of the county receives more rainfall;
- The western half has spring seasons that are wetter and cooler than the eastern;
- Temperatures in the eastern portion of the county are much higher in the summer months; and
- Much of the precipitation received in the east falls as snow during the winter, which under normal conditions, melts to provide water flow later into the year. *See section 5.2.6 for more information on changing snowmelt.*

[20] CAL FIRE. (2018). Humboldt Del-Norte Unit Pre-Fire Planning Battalion.

[21] CAL FIRE. (2018).

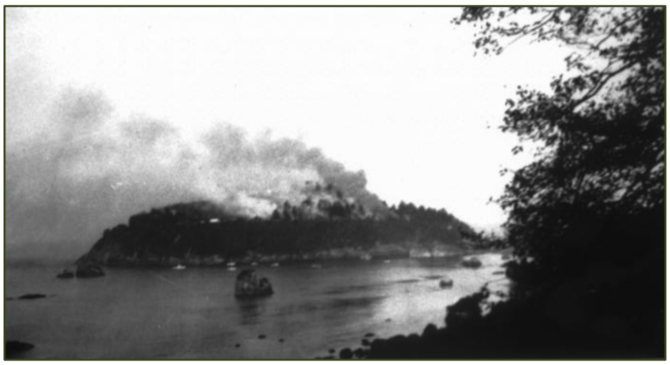
5.2.5 FIRE HISTORY

It is essential to understand the fire history of an area to comprehend its potential for future fires. Under most conditions, it can be assumed that if there is a history of frequent fire in a particular location, fire will likely return there again.

Fire history discerned through fire scars on tree rings—under low or moderate severity fire regimes[22]—may indicate the way fires have changed over time, both in frequency and intensity. This can guide goals for future fuel conditions, and their potential for management or restoration to historic conditions.

Fire has been a significant factor throughout the region's history, even in redwood forests where fire scars date back over one-thousand years. Despite the generally damp climate in redwood forests, studies have suggested a historical fire-return interval of 12 to 50 years.[23]

Current fire history data are maintained by CAL FIRE's Fire and Resource Assessment Program (FRAP). The county's fire history map, *in Part 2 of this CWPP,* is based on FRAP data and includes the occurrence of several large fires along the coast from as early as 1908. **Although it is a common belief in the Humboldt Bay area that fires don't happen along our coast, several large, destructive fires occurred on the coast around the Trinidad area over the last century.** These include the 7,432-acre Luffenholtz fire of 1908, the 17,527-acre A-Line fire of 1936, and a 15,000-acre unnamed fire near Patrick's Point in 1945.



Trinidad Head fire, 1943.

*Map 2.3.2, **Humboldt County Fire History** (in Part 2)* shows these fires and others between 1908 and 2017. As described throughout this chapter, the highest occurrence of wildfire in the county is in the northeast and southwest areas, although several significant fires historically occurred along the northern coastal areas of the county.

According to current CAL FIRE data, 554 wildfires burned in Humboldt County between 1908 and 2017. As shown in the *Figure 5.2.7,* the decade with the highest number of large fires was the 1950s, followed by the decades at the beginning of the 20th century. Although this data is generated by CAL FIRE, it is "a multi-agency…map of fire history. For CAL FIRE, timber fires 10 acres or greater, brush fires 30 acres and greater, and grass fires 300 acres or greater are included. For the USFS, there is a 10-acre minimum for fires since 1950."[24]

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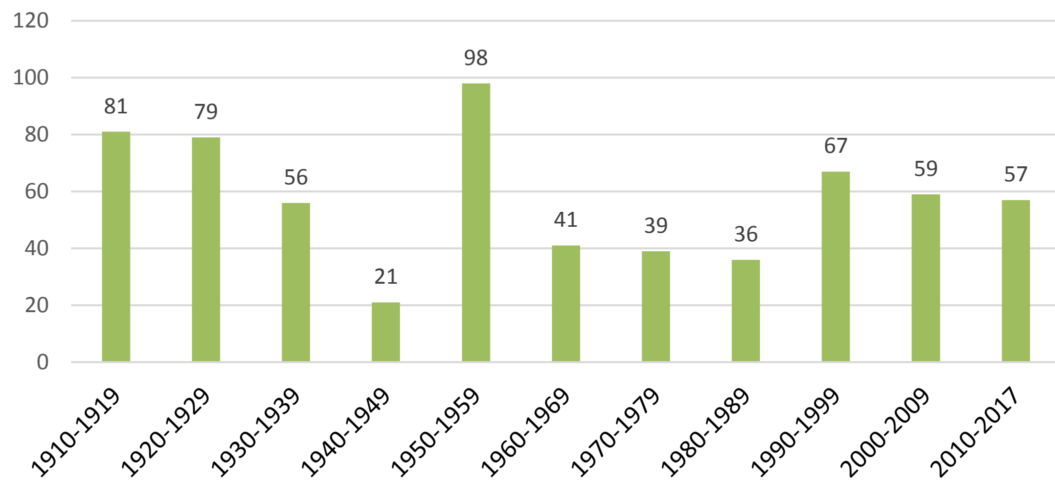
[22] More severe fires usually leave few trees where rings can be analyzed. See the previous section or *Appendix E* for more information on fire regimes.

[23] CAL FIRE: Humboldt – Del Norte Unit (HUU). (2017). Strategic Fire Plan Humboldt – Del Norte Unit 2017. (p. 9). Retrieved from http://cdfdata.fire.ca.gov/fire_er/fpp_planning_plans_details?plan_id=270

[24] CAL FIRE. (2017). Fire Resources Assessment Program (FRAP). State Fire Perimeters 1908-2017. Retrieved from http://www.fire.ca.gov/fire_prevention/fire_prevention_wildland_zones_maps

Figure 5.2.7 Humboldt County, Large Fires by Decade, 1908–2017[25, 26]

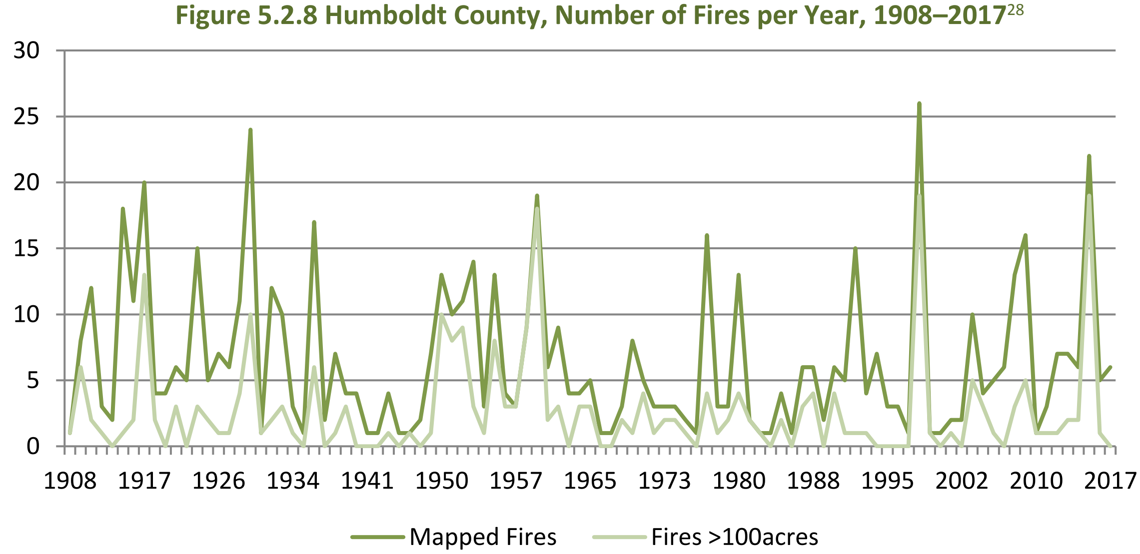


Recent decades do not show as many large fire occurrences as earlier in the last century. *Figure 5.2.8* below shows high fire occurrence in recent years. In terms of the numbers of fires, 1998 matched 1929, in that both saw 24 fires in Humboldt County, the most in any one year in recorded history. The 2015 fire season neared that record with 22 fires.[27] Of note is that lightning was primarily the cause of the 1998 and 2015 spikes.

Although there were only five wildfires in Humboldt County in 2016 and six in 2017, several large lightning fires burned just across the county line in 2017. These lightning fires are important to keep in mind, in terms of the potential for more lightning ignitions with climate change. Lightning can be particularly problematic if multiple ignitions occur around the same time. *See section 5.2.6,* ***Climate Change and Wildfire in Humboldt County*** *for more information.*

The following *Figure 5.2.8* shows all fires mapped by CAL FIRE since 1908, versus those of 100 acres or more. It is interesting to see that many of the years with the most fires over 100 acres, such as 1998 and 2015, were often the years with the highest number of fires.

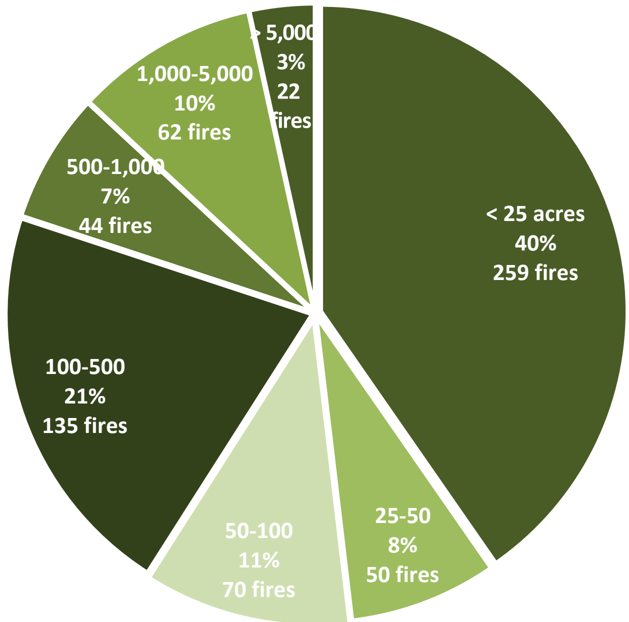
Figure 5.2.8 Humboldt County, Number of Fires per Year, 1908–2017[28]



[25] CAL FIRE. FRAP. (2018). State Fire Perimeters 1908-2017.
[26] Note that the last period, 2010-2017 was only 8 years, not 10.
[27] CAL FIRE. FRAP. (2018). State Fire Perimeters 1908-2017.
[28] CAL FIRE. FRAP. (2018). State Fire Perimeters 1908-2017.

The following chart, *Figure 5.2.9* shows the total number of fires by size, between 1908 and 2017. As expected, most fires (259 or 40%) are small, in this case less than 25 acres. Beyond these small fires, the largest number of fires (135 fires or 21% of all fires in Humboldt County between 1908 and 2017) were between 100 and 500 acres. The data indicate that there have been only 22 fires over 5,000 acres since 1908, or only 3% of wildfires in Humboldt County in recorded history. Of those 22 large fires, however, seven occurred since 1999.

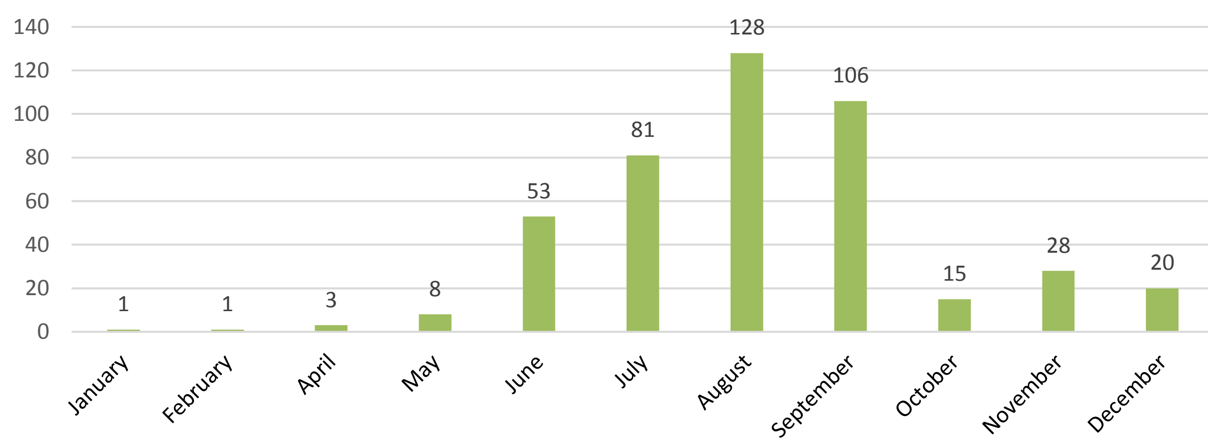
Figure 5.2.9 Humboldt County, Total Number of Fires by Acreage Range, 1908–2017[29]



Fire Caused by Natural Lightning

While lightning-caused fires are a significant factor in eastern Humboldt, they are generally much less prevalent in coastal Humboldt County. They do occur however. This was seen in recent decades in dozens of "lightning complex" fires from single storms in 2003, 2008, and 2015. *Figure 5.2.10* below shows that most lightning fire ignitions occur in late summer and early fall.

Figure 5.2.10 Humboldt County, Total Number of Lighting Ignitions by Month, 1974–2017[30]



[29] CAL FIRE. FRAP. (2018). State Fire Perimeters 1908-2017.

[30] CAL FIRE. (2018). Humboldt Del-Norte Unit Pre-Fire Planning Battalion.

The northeastern area of the county has the highest prevalence of lightning, which can be seen in *Map 5.2.2, Wildfire Starts.* Lightning fire ignitions are particularly problematic from a suppression standpoint, due to the likelihood of multiple ignitions within a few hours, and the increased likelihood of those starts (ignitions) occurring in more remote areas. Since 2015, most lightning-ignited larger fires have burned just beyond the county line.

In *Fire in California's Ecosystems*, Stephens, Kane, and Stuart write about the history and ecology of fire in the North Coast Bioregion:

> "Whereas lightning does occur along the North Coast bioregion during the summer fire season, it is much less prevalent than on the higher ridges and mountains to the east (Keeley 1981). van Wagtendonk and Cayan (2008) found that lightning strike density ranged from 0.9 to 9.3 yr^{-1} 100^{-1} km^{-2}, with density increasing with distance from the Pacific Ocean and increasing elevation for the period between 1985 and 2000. Notwithstanding the lightning fire potential in northwestern California, ignitions by Native Americans likely accounted for most fires (Fritz 1931, Lewis 1993, Stephens and Fry 2005). [31]"

Native American Fire History

It is generally accepted that the original inhabitants of North Coastal California actively stewarded and extensively managed their lands, including an active and deliberate use of cultural burning. The resultant frequent, low-intensity burns helped to keep pest populations down, improved the health of the acorn crop and other desirable forest products, and improved hunting grounds. It is assumed that Native American burning occurred here for many thousands of years prior to European colonization.

> "The Native people of Hoopa Valley understood and used the natural cycle of burning. Cultural burning for clearing areas for crops, basketry material (Hazel and Beargrass), and hunting has been done for thousands of years in the region. According to tribal elders, traditional and naturally occurring fires were used to "cleanse" the land and were allowed to burn naturally without suppression. This resulted in fuel load reduction and decreases in fire severity and intensity.[32]"

The acreage burned by California's earliest inhabitants was significant. Fire scientists Robert Martin and David Sapsis estimated that 5.6 to 13 million acres of California burned annually under both lightning and indigenous peoples' fire regimes.[33] However, fire scientists Scott Stephens, Sapsis, and others have since estimated lower numbers. Stephens et al. estimate that around 4.5 million acres were burned annually in California prior to 1800, excluding the southwestern deserts.[34] This estimate of prehistoric California annual area burned is close to (88% of) the total annual "extreme" wildfire area burned in the entire United States in the decade from 1994 to 2004.[35]

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[31] Stephens, S.L., Kane, J.M., and Stuart, J.D. (2018). North Coast Bioregion. In: van Wagtendonk, J.W., Sugihara, N.G., Stephens, S.L., Thode, A.E., Shaffer, K.E., Fites-Kaufman, J.A., & Agee, J.K. (Eds.). *Fire in California's Ecosystems, Second Edition* (p. 149). Berkeley: University of California Press.

[32] Hoopa Valley Tribe. (2016). Hoopa Valley Indian Reservation Community Wildfire Protection Plan. (p. 8).

[33] Martin, R. & Sapsis, D.B. (1992). Fires as agents of biodiversity: pyrodiversity promotes biodiversity. In *Proceedings of the conference on biodiversity of northwest California ecosystems. Cooperative Extension, University of California, Berkeley*, pp. 150-157.

[34] Stephens, S.L., Martin, R.E., & Clinton, N.E. (2007). Prehistoric Fire Area and Emissions from California's Forests, Woodlands, Shrublands, and Grasslands. *Forest Ecology and Management* 251: 205-216.

[35] Stephens, S.L., et al. (2007).

In contrast, from 1955 to 2017, the average annual area burned by wildfire in all vegetation types in California was approximately 383,341 acres per year, or only approximately 8.5% of what traditionally burned annually in pre-settlement times.[36] **Regardless of errors in either estimation, prior to modern fire suppression, very large amounts of land burned in California.[37] Skies may have been smoky much of the summer and fall during this period.**

Stephens et al. in 2018 surmise that Native American burning contributed extensively to local fire history:

> Fire history studies from the last 1,000 years reveal a variable pattern of fire frequencies throughout northwestern California. The most frequently burned landscapes were ignited on a near annual basis by Native Americans (Lewis 1993) and were generally in close proximity to villages or in areas cultured for food and basketry materials such as in grasslands and oak woodlands. Vegetation adjacent to Native American use areas experienced more frequent fire than would be found in the same vegetation type further away (Whitlock and Knox 2002). [38]

Native populations made use of fire and natural resources in many ways, including the active stewardship of prairies, oak woodlands, and forests. These burns improved wildlife habitat and enhanced the health and growth of tanoak for acorns, and plants used for basket making, such as bear grass.

> There is a long tradition of fire management by the Yurok for the purposes of increasing acorn-producing hardwood areas, basket material gathering sites, maintaining fuel breaks around villages and houses, and maintaining open prairies for insect population management, and agricultural areas. Federal authorities in the early 1900s forced the end of these practices, and the forest has, for the most part, invaded most open areas. Not only has this reduced the availability of basketry materials and food sources, but has increased the risks of both structural and timber losses to wildfires. Given this exclusion of fire, it is likely that some hardwood stands may be now slowly converting to conifer cover types.[39]

Local tribes are now leading efforts locally and nationally to return fire to the landscape as an effective and sophisticated management tool.

Understory burning on Yurok Tribal land in 2018. Photos: Cultural Fire Management Council.

[36] CAL FIRE. (2017). FRAP. State Fire Perimeters 1908-2017.
[37] Stephens, S.L. et al. (2007).
[38] Stephens, S.L. et al. (2018). (p. 153).
[39] Yurok Tribe. (2012). Yurok Indian Sustained Yield Lands Forest Management Plan. (p. 24). [PDF]. Retrieved from http://www.yuroktribe.org/departments/forestry/Documents/FMP2012DraftRev3.14.pdf

> The Karuk use of fire as a land management tool was complex and multi-faceted. As with other ceremonial and religious aspects of Karuk culture, the role of fire was one to be contemplated and learned from at the deepest levels.[40]
>
> …
>
> The Karuk People see the role of fire touching upon many aspects of their life. Fire caused by natural and human ignitions affects the distribution, abundance, composition, structure and morphology of trees, shrubs, forbs, and grasses (Skinner et al. 2006) which in turn can be beneficial or detrimental depending on habitat or resource needs and condition prior to disturbance.[41]

Fire scientists, ecologists, and others now recognize the importance of Native American burning practices and are exploring ways to reincorporate them into current land management practices. The forefront of this work is happening on the Humboldt – Siskiyou county border with the *Somes Bar Integrated Fire Management Project*[42] of the Western Klamath Restoration Partnership. *For more information on the use of fire as a tool, and tribal leadership with prescribed fire, see the Countywide Action Plan Chapter 3.5,* ***Restoration of Beneficial Fire****.*

European Settlement Fire History

European settlement and colonization in the area began with Spanish and Russian explorers in the late 1700s and early 1800s. The discovery of gold in the Klamath and Trinity mountains brought miners, traders, and explorers, and forever changed the region. The gold rush brought settlement, and mining was quickly replaced by timber as the dominant industry. Logging of the largest, oldest trees was common, with subsequent changes in forest structure and fuel volumes. By 1854, there were nine lumber mills around the county involved in exporting lumber worldwide. Dairy and cattle operations also became a large sector of the county's economy. Many forms of land management during this era (such as logging, grazing, development, and fire suppression) significantly influenced local fire history.

The town of Luffenholtz in 1907, along the original wagon trail to Trinity County gold area, now Westhaven road. Note the burned trees in the background. This area suffered a devastating fire in 1908, the following year. Photo courtesy of Trinidad Historical Society.

The arrival of European-descent settlers brought radical changes and destruction to the indigenous populations, as well as to the "natural" landscape here. In part because of the conflicts between colonists and indigenous land management, violence erupted in many areas, such as in the Mattole Valley in the southwestern corner of the county. To address the resulting crisis,

[40] Karuk Tribe Department of Natural Resources. (2010). Draft Eco-Cultural Resources Management Plan. (p. 3). Karuk Ethnographic Report 12-14, quoting from Salter 1981. Retrieved from http://www.karuk.us/index.php/departments/natural-resources

[41] Karuk Tribe Department of Natural Resources. (2010). Draft Eco-Cultural Resources Management Plan. (p. 4).

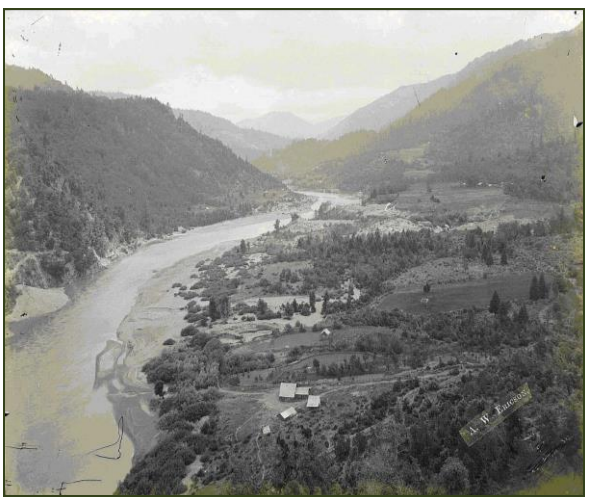
[42] Six Rivers National Forest. (2018). Somes Bar Integrated Fire Management Project, Final Environmental Assessment. [PDF]. Retrieved from https://www.fs.usda.gov/nfs/11558/www/nepa/106291_FSPLT3_4291171.pdf

Mattole colonizers decreed a resolution that was published in the September 18, 1858, *Humboldt Times,*[43] "that the Indians must not set fire to the grass on the hills..."[44] Therefore, burning in the Mattole Valley and other areas of the county was virtually stopped for a short time, until the late 1800s/early 1900s, when ranchers then reinstated it to improve grasslands. The following quote summarizes fire-management practices throughout Humboldt County at that time.

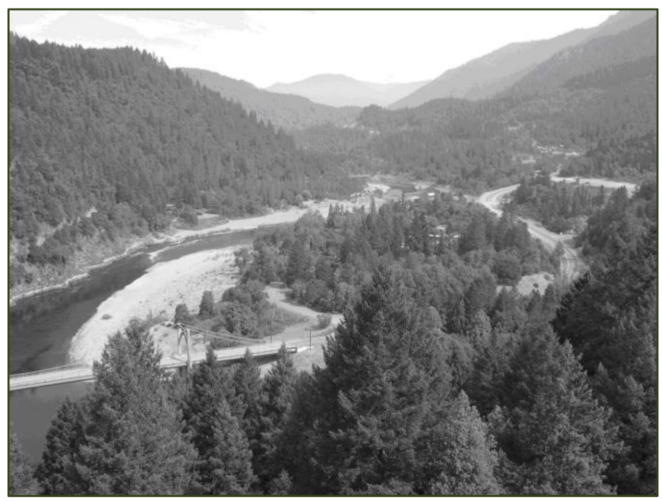
> During the settlement period (1875-1897) European settlers used fire for maintenance and enlarging the pasturelands and as a land clearing method. Major land activities during the post settlement period (1898-1940) were livestock grazing, farming, debarking of the tanoak for tannin production and logging of Douglas fir and coast redwood. Logging was clearly a dominant activity during this time period… In this time of unrefined mechanized equipment, the logging operations were simplified as much as possible. Logged areas were burned to assist with the removal of the logs and reduce the logging debris left behind. These fires were left to burn with no real control efforts. The same can be said for the area ranchers who commonly set fire to their land in order to maintain the grazing.[45]

The pattern of historic native and early colonial burning helps explain the presence of dense old-growth forests in the drainages and open meadows along the ridges throughout the county. This pattern can be seen in the earliest available aerial photographs from 1941.

The following pictures from local fire scientist Frank Lake, show the dramatic changes to the Orleans area along the Klamath River, presumably due principally to the absence of indigenous burning.[46]



Looking north, up-river from Big Rock, Orleans, CA. Circa 1894. Photograph by A.W. Ericson. "View from Rattlesnake Rock, Orleans" No. 62 (Lake 2007).



Looking north up-river from Big Rock, Orleans, CA in September 2006. Photograph by F. K. Lake (Lake 2007).

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[43] CalIndianHistory.org. (2010). September 18, 1958: "Mass Meeting in Mattole Valley". *Weekly Humboldt Times*. Retrieved from http://calindianhistory.org/1858-2

[44] Roscoe, J. (1985). An Ethnohistory of the Mattole, Humboldt County, California. (p. 33). Part of the Archaeology Field Survey Reports Contributed by BLM, Arcata Field Office. DOI: 10.6067/XCV8T72FX0.

[45] CAL FIRE: HUU. (2011). (pp. 5-6).

[46] Lake, F.K. (2007). Traditional ecological knowledge to develop and maintain fire regimes in northwestern California, Klamath-Siskiyou bioregion: management and restoration of culturally significant habitats, Doctoral Dissertation. Oregon State University, Environmental Sciences. Retrieved from https://ir.library.oregonstate.edu/concern/graduate_thesis_or_dissertations/1z40kw515?locale=en

Some of these early prescribed fire practices are being reinstated in the grasslands of Humboldt County. *See the **Prescribed Fire** section below for more information*.

CAL FIRE summarizes the fire history during this period as follows:

> Reviews of area newspapers and various studies at Humboldt State University indicate that there was indeed a significant fire history from the late 1800s through early 1950s. Notable are 24 "fire seasons" between 1880 and 1952. During this time period the fire interval was 3.3 years. Some of these fires included entire towns being burned, such as the 1908 fire that destroyed the community of Luffenholtz. People were left homeless, local mills and railroad tracks all perished from these large severe fires.[47]

The Era of Intensive Fire Suppression

In response to several large destructive fires in the West and Midwest in the early part of the 1900s, fire was viewed as a major threat to lives, property, and natural resources, resulting in the "10 a.m. policy" adopted by the US Forest Service (USFS) in 1935. This policy sought to aggressively suppress fires and have them extinguished by 10 a.m. the morning following a fire being discovered.

> Civilian Conservation Corps began work in the Humboldt–Del Norte area in the mid 1930s, developing an improved local firefighting infrastructure. After 1945, the severity and number of fires began to decline significantly… World War II had taken the work force overseas; with the return of the soldiers came an active fire suppression program.[48]

Emanuel Fritz[49] summarized this time period well in 1951:

> In the early days of forestry we were altogether too dogmatic about fire and never inquired into the influence of fire on shaping the kind of forests we inherited.[50]

These policies and practices set the stage for the intensive fire suppression paradigm that is now beginning to change.

Recent Fire History

Intensive fire suppression since WWII, combined with other factors (e.g. increased development, lack of homeowner defensible space, logging of the largest trees), has led to an increase in the amount of flammable materials now accumulated throughout Humboldt County. It is widely accepted that fires burn longer and hotter than before European settlement.

> More area is burning at high intensity, and this is related, in part, to higher quantities and more homogeneous fuels caused by accumulation during the fire-suppression period.[51]

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[47] CAL FIRE: HUU. (2017). (p. 9).

[48] CAL FIRE: HUU. (2017). (p. 9).

[49] Professor Emeritus of Forestry at University of California Berkeley and Founding Director of the Regional Parks Association.

[50] Stuart, J.D. & Stephens, S.L. (2006). North Coast Bioregion. In: Sugihara, N.G., van Wagtendonk, J., Shaffer, K.E., Fites-Kaufman, J., & Thode, A.E. (Eds.). *Fire in California's Ecosystems* (p. 147). Berkeley: University of California Press.

[51] Skinner, C.N., Taylor, A.H., & Agee, J.K. (2006). Klamath Mountain Bioregion. In: Sugihara, N.G., van Wagtendonk, J., Shaffer, K.E., Fites-Kaufman, J., & Thode, A.E. (Eds.). *Fire in California's Ecosystems* (p. 179). Berkeley: University of California Press.

It is generally accepted that wildfire now only escapes suppression efforts less than 2% of the time[52]—but those few escaped fires find a choked, fuel-heavy landscape and result in the vast majority of damage caused by fire.

> More than 85 percent of Forest Service lands in NW California are burning either less frequently or much less frequently currently than under the pre-Euro-American settlement fire regime, as compared with 67 percent of Forest Service and National Park Service lands in the Sierra Nevada and 19 percent in southern California (Safford and Van de Water 2014).[53]

The following table, *Figure 5.2.11* lists all fires greater than 200 acres in Humboldt County over the last twenty years. Most, but not all, of these fires are part of that small percentage that have escaped suppression efforts.

FIGURE 5.2.11 WILDFIRES OVER 200 ACRES IN THE LAST 20 YEARS (1997-2017)[54]

Fire name	*Location*	*Year*	*Acres*	
			Humboldt	*Total*
Megram	West of Willow Creek and Hoopa	1999	59,272	125,073
1998[55] (no name)	Orleans	1998	19,880	20,282
Honeydew	King Range, Honeydew Creek	2003	11,770	11,794
Corral	Six Rivers National Forest (SRNF), northwest of Willow Creek	2013	11,719	12,541
Blake	SRNF	2015	11,425	11,439
Canoe	Humboldt Redwoods State Park, Canoe Creek	2003	11,044	11,044
Half	Sims Mountain, SRNF	2008	9,078	15,130
Lassics	SRNF, northeast of Blocksburg	2015	7,469	18,192
Somes	SNRF, west of Orleans	2006	6,544	15,506
Johnson	Trinity National Forest, north of Dinsmore	2015	5,139	17,821
Groves	Lone Pine Ridge (SRNF), east of Willow Creek	2015	4,023	6,803
Mill Creek 4	SNRF/Hoopa, east of Weitchpec	2009	2,831	2,831
Sims	Sims Mountain, SRNF	2004	2,021	4,036
LT-17 (Backbone)	Lone Pine Ridge (SRNF), east of Willow Creek	2009	1,779	5,194
Pine 1-44	Pine Mountain, SRNF	2015	1,660	1,773
East	SRNF, northwest of Willow Creek	2015	1,531	1,531

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[52] Stephens, S.L., Collins, B.M., Biber, E. & Fulé, P.Z. (2016). US federal fire and forest policy: emphasizing resilience in dry forests. Ecosphere, 7(11): 1-19. Also see Husari, S.J. & McKelvey, K.S. (1996). Fire-management policies and programs. *In: Sierra Nevada Ecosystem Project, Final Report to Congress, Vol. II, Assessments and Scientific Basis for Management Options. Davis, CA: University of California, Centers for Water and Wildland Resources. Report No. 37.* (pp. 1101-1118).

[53] Butz, R.J., Sawyer, S., & Safford, H. (2015). A summary of current trends and probable future trends in climate and climate-driven processes for the Six Rivers National Forest and surrounding areas. US Forest Service. (p. 13).

[54] CAL FIRE. FRAP. (2018). State Fire Perimeters 1908-2017.

[55] This table entry represents a conglomeration of fires ranging from hundreds to thousands of acres that burned all across the Yurok and mid-Klamath region in October 1998.

FIGURE 5.2.11 WILDFIRES OVER 200 ACRES IN THE LAST 20 YEARS (1997-2017)[54]

Fire name	*Location*	*Year*	*Acres*	
			Humboldt	*Total*
Steelhead 1-54	Eel River, Alderpoint	2015	1,403	1,403
Buck	SRNF, southeast of Dinsmore	2015	1,274	1,420
Nickowitz	SRNF, Del Norte County line	2015	1,263	7,576
Paradise	Southwest of Ettersburg	2008	1,072	1,072
Dobbyn 1-57	Fort Seward	2015	787	787
Tulley	Tulley Creek, Hwy 169	2016	607	607
Dance	Orleans	2013	577	577
Happy	NE (SRNF) and SE of Willow Creek	2015	547	68,095
Spanish	Spanish Flat, King Range National Conservation Area	2011	512	524
Friday	Above Sandy Bar	2003	389	389
Red	East of Maple Creek	2014	332	332
Flat	Spanish Flat, King Range National Conservation Area	2001	289	317
Pilot	North of Dinsmore	2004	287	287
Blocksburg 1-58	South of Blocksburg	2015	284	284
Wildcat 1-51	Wildcat Butte, west of Fort Seward	2015	283	283
Tuk	West of Elk Camp	2003	279	279
Tierney	Buck Mountain, SRNF	2015	248	248
10	King's Peak, King Range National Conservation Area	2003	213	213
Bald Hill 3	Hoopa Reservation, Hog Ranch Prairie	2014	210	210
Buckeye	Buckeye Mountain	2010	202	202

As shown in *Figure 5.2.8* earlier in this chapter, 1998 and 2015 were peak years for wildfire occurrence in Humboldt County. This could be an indication that Humboldt County is following the statewide trend of increased number, size, and severity of wildfires over recent decades. According to the 2010 Strategic Fire Plan for California, "Data suggests a trend toward increasing acres burned statewide, with particular increases in conifer vegetation types."[56]

Effective fire suppression in Humboldt County is one of the factors contributing to a buildup of hazardous wildfire fuels in both the wildlands and WUI areas. Factor in the projected impacts of climate change and sudden oak death to this equation, and Humboldt County could likely face larger and more destructive wildfires in the future—a threat to both natural and community resources.

[56] State Board of Forestry and Fire Protection & CAL FIRE. (2010, Revised 2016). Strategic Fire Plan for California.

Prescribed Fire

No discussion of fire history in Humboldt County would be complete without addressing the resurgence in *prescribed fire (controlled burning)* use. This practice has been utilized historically and more recently by tribes, federal and state agencies, local ranchers, logging companies, and to an increasing extent, homeowners, for fuel reduction and other landscape benefits.

Due to concerted and participatory fire-safety efforts led by local Fire Safe Councils (FSCs) *(see Chapter 5.4, **Community Preparedness**)*, as well as more regional progress and outreach by the Northern California Prescribed Fire Council, public acceptance of prescribed fire has increased in Humboldt communities. In the town of Orleans, for example, the Orleans/Somes Bar FSC has maintained over 1,400 acres of *shaded fuelbreaks* using prescribed fire in the last decade, with funding from the USFS, CAL FIRE, and others.

***Prescribed fire/burn**:* A fire that burns within a range of predetermined conditions (such as fuel moisture content, weather conditions, etc.) that will keep it controllable, at low intensity, and able to achieve its stated objectives. A written, approved prescribed fire plan must exist, and environmental requirements (where applicable) must be met, prior to ignition.

***Shaded fuelbreaks**:* A fuelbreak built in a timbered area where the trees on the break are thinned and pruned to reduce the fire potential yet retain enough crown canopy to make a less favorable microclimate for surface fires.

Broadcast burn: A controlled burn, where the fire is intentionally ignited and allowed to proceed over a designated area within well-defined boundaries for the reduction of fuel hazard, as a resource management treatment, or both

Prescribed fire projects in the county range from small-scale, landowner-conducted individual burns to larger, more complex burns conducted by the county's federal and state agencies. Timberland managers also use fire throughout the county to burn piles or *broadcast burn* larger areas. In early 2018, local residents formed California's first prescribed burn association—the Humboldt County Prescribed Burn Association (HCPBA)—a cooperative group of landowners, non-governmental organizations, and other community members who work together to implement prescribed burns. *For more information on the HCPBA, see Chapter 5.4, **Community Preparedness**.*

State and federal agencies—including CAL FIRE, State Parks, Redwood National Park, the Bureau of Land Management (BLM), and the USFS—all use prescribed fire where appropriate and when possible to achieve a variety of land-management objectives. CAL FIRE is an active cooperator with other public agencies such as State and National Parks, providing equipment, crews, and other resources to assist with their burns. CAL FIRE often achieves these activities via their Vegetation Management Program, or VMP.[57] There are several prescribed-fire programs conducted on federal public lands. Redwood National Park has an active program that uses CAL FIRE resources, and BLM burns are usually coordinated with CAL FIRE.

Prescribed burn on grassland conducted by the HCPBA. Photo: HCPBA.

At the state level, there has been significant movement to scale up the use of prescribed fire on both public and private lands. The *Fire Memorandum of*

[57] CAL FIRE. (n.d.). Vegetation Management Program [Web]. Retrieved from http://calfire.ca.gov/resource_mgt/resource_mgt_vegetation

Understanding demonstrated a shared commitment to the use of fire as a tool, and included a long list of signatories, including the USFS, CAL FIRE, Sierra Forest Legacy, the Northern California Prescribed Fire Council, and many other federal agencies and non-governmental organizations. In 2018, the California Forest Management Task Force was created with a Prescribed Fire Work Group to address this issue statewide. Likewise, there have been several legislative actions to better support prescribed fire and there are more on the horizon. *For more information on countywide actions related to prescribed fire, see Chapter 3.5,* ***Restoration of Beneficial Fire.***

Understanding the local wildfire environment helps residents and decision makers to understand when to be on extra alert in terms of ignitions. As stated in this chapter, the highest number of ignitions in Humboldt County occur in July, with the largest wildfires occurring in September.

Considering the probability of significant increased wildfire threats, it is important that Humboldt County residents are increasingly vigilant regarding reducing wildfire risks and hazards in their homes and communities to improve their fire safety *(see Appendix H,* ***Living with Wildfire,*** *for an in-depth discussion on this topic).* Taking the steps recommended in this CWPP will decrease the vulnerability of communities to damage from wildfire. Fire-hardened homes and communities will provide an opportunity for more active use of prescribed fire as fuel-reduction tool, especially during the early and late fire season when conditions are good for low-intensity burning. This will also facilitate low-intensity wildfires to take their natural course without jeopardizing community and natural resources. Maintaining high-capacity fire services will continue to be important to manage all wildfires threatening communities. Actively prioritizing minimizing wildfire impacts in Humboldt County will likely make a significant difference in its effects here.

5.2.6 CLIMATE CHANGE AND WILDFIRE IN HUMBOLDT COUNTY

> Anyone who says they have a grasp on how climate change will impact future fire regimes possesses an impressive level of optimism.[58]

Predictions vary regarding how changing climate will affect northern California, and specifically Humboldt County, and what those changes might mean in terms of wildfire frequency and severity. This section summarizes current climate change literature as it relates to wildfire in Humboldt County. It quotes passages to which readers may want to refer for more information. A summary of that research can be found in *Appendix F,* ***Climate Research*****.**

Generally, it is expected that weather patterns will continue to get more extreme, especially in inland areas with less of a tempering marine influence. **Regardless of the model, it is largely agreed that "with projected climate change, we expect to face much more forest fire in the coming decades**."[59] The challenge for Humboldt County is how to proactively prepare for and adapt to these likely changes. As one group of researchers note, this region is unique in several ways:

> Northwestern California is a biogeographic and climatic transition zone, and very strong environmental gradients further complicate the picture. It is, therefore, unclear to what extent the region may mimic patterns in other parts of the West, or even other parts of the world with similar climates.[60]

58 Keeley, J.E. & Syphard, A.D. (2016). Climate change and future fire regimes: Examples from California. *Geosciences* 6(3). (p. 10).

59 Stephens, S.L., Agee, J.K., Fulé, P.Z., North, M.P., Romme, W.H., Swetnam, T.W., & Turner, M.G. (2013). Managing forests and fire in changing climates. *Science* 342(6154). (p. 41).

60 Miller, J.D., Skinner, C.N., Safford, H.D., Knapp, E.E., & Ramirez, C.M. (2012). Trends and causes of severity, size, and number of fires in northwestern California, USA. *Ecological Applications* 22(1): 184-203, quote on p. 185.

A 2018 study for the North Coast Resource Partnership (NCRP)[61] predicts "an approximately 40% increase in probability of fire across the [7-county] region by end-century…"[62] Another NCRP report summarized local climate-change predictions regarding wildfire as follows:

> Although there are several factors that affect the size and frequency of wildfires, **the progressively warmer temperatures and associated drought stress projected for the region are expected to contribute to an increase in wildfire size and frequency that climate models predict will worsen over time** (Krawchuck and Moritz, 2012; Yoon et al., 2015)… Given that 13 of California's 20 largest wildfires over an 85-year period have occurred since 2000 (CAL FIRE, 2017), **it's not surprising that some scientists believe that the combined effects of increased heat and drought are already contributing to larger and more frequent wildfires in California** (Krawchuck and Moritz, 2012; Yoon et al., 2015). Interestingly, however, a 2012 study of the Klamath, Mendocino, Shasta-Trinity, and Six Rivers National Forests found that **although wildfire size and frequency have been trending upward, the severity of wildfires has not been** (Miller et al., 2012). This led the study's authors to conclude that**, under appropriate conditions, fire could be more extensively used in the region to achieve management objectives.**[63] [emphasis added]

Although temperatures and drought conditions are expected to increase, fire severity may not. The increased use of fire as a management tool in the face of climate change is consistent with the actions proposed in this CWPP. However, any fuel-reduction activities implemented based on this CWPP should strive for a net-carbon gain, using methods that minimize carbon emissions and maintain and/or restore ecosystem functions, processes, and health. *See the Countywide Action Plan, Chapter 3.5, **Restoration of Beneficial Fire** for more information.*

As many have observed, it is difficult to tease out the human influence as distinct from climatic influences in terms of increased fire frequency and severity, especially given the history and success of fire suppression:

> The success of fire suppression has, ironically, fostered changes in the composition and structure of many ecosystems that are among factors believed to contribute to the current increases in burned area (Biswell 1989, Agee and Skinner 2005, Arno and Fiedler 2005, Husari et al. 2006). At the same time, changing climates are also understood to play a major part in increased fire activity and area burned (Miller 2003, McKenzie et al. 2004, Westerling et al. 2006, Miller et al. 2009b). Indeed, **multiple lines of historical and contemporary evidence tell us that over the long term, changes in fire activity can primarily be explained by broadscale changes in climate, moderated by local changes in vegetation, fuel conditions, and human activities** (Power et al. 2008, Whitlock et al. 2008, Bowman et al. 2009, Marlon et al. 2009).[64] [emphasis added]

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[61] The North Coast Resource Partnership (NCRP) is a stakeholder-driven collaboration among local government, Tribes, watershed groups, and interested partners in the North Coast region of California, comprising seven counties, Tribal lands, major watersheds, and a planning area of 19,390 square miles representing 12% of California's landscape.

[62] Micheli, E., Dodge, C., Comendant, T. & Flint, L. (2018). Climate and Natural Resources Analysis and Planning for the North Coast Resource Partnership: A Technical Memorandum Summarizing Data Products. Final Technical Report. USGS. (p. 26).

[63] Reza, K. & Tinsman, R. (2018). North Coast Regional Climate Adaptation Strategies. North Coast Resource Partnership. (p. 7). Retrieved from *https://northcoastresourcepartnership.org/resources*

[64] Miller, J.D. et al. (2012). (p. 184).

Looking further into the human vs. climatic influences on fire behavior and activity, a 2017 study analyzing fire activity in 37 regions across the continental US summarized:

> Climatic variation played a significant role in explaining annual fire activity in some regions, but the relative importance of seasonal temperature or precipitation, in addition to **the overall importance of climate, varied substantially depending on geographical context. Human presence was the primary reason that climate explained less fire activity in some regions than in others**.[65] [emphasis added]

This influence of human presence on fire frequency is not so clear for Humboldt County, however. As shown in *Map 5.2.2, Wildfire Starts* above, most fires ignite here along the eastern border, both by humans and climate (lightning). However, the *Fire History Map* in *Part 2,* shows more scattered fire activity throughout the county. That said, local experts expect more dramatic changes in climate and resultant fire behavior for the less-populated inland areas of Humboldt County, as compared to the coastal area, which is where the majority of the population resides.

Regional Climatic Data

In 2010 and again in 2015, regional Forest Service ecologists Butz, Sawyer, and Safford summarized current research regarding climate change and its impact to the Six Rivers National Forest and surrounding areas, placing emphasis on higher nighttime temperatures:[66, 67]

> Only two weather stations on the Six Rivers National Forest have adequate long-term temperature data available for analysis. While the average annual temperature at the Willow Creek station has remained relatively constant, average temperatures at the Orleans station have increased approximately 2° F (1.1° C) in the period 1931-2014. **This trend is driven by a highly significant increase in mean minimum (i.e., nighttime) temperatures, which have risen by almost 4° F (2.2° C) over the same period...** The increase in minimum mean (nighttime) temperature when compared to mean and maximum mean (daytime) temperatures [is] consistent with findings across California (Cordero et al. 2011, LaDochy et al. 2007).[68]
>
> …
>
> While most of the weather stations do not receive substantial amounts of snow, **all stations show declining trends in annual snowfall**, one of which is statistically significant (Willow Creek).[69] [emphasis added]

[65] Syphard, A.D., Keeley, J.E., Pfaff, A.H., & Ferschweiler, K. (2017). Human presence diminishes the importance of climate in driving fire activity across the United States. *Proceedings of the National Academy of Sciences* 114 (52): p. 13750.

[66] Butz, R.J. & Safford, H. (2010). A summary of current trends and probable future trends in climate and climate-driven processes for the Six Rivers National Forest and surrounding areas. US Forest Service. (p. 2010).

[67] Butz, R.J., Sawyer, S., & Safford, H. (2015). A summary of current trends and probable future trends in climate and climate-driven processes for the Six Rivers National Forest and surrounding lands. USDA Forest Service Pacific Southwest Region. (p. 3). [PDF]. Retrieved from https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd490216.pdf

[68] Butz, R.J. et al. (2015). (p. 3).

[69] Butz, R.J. et al. (2015). (p. 7).

This change in snowpack may be the most critical influence for wildfire activity in Humboldt County:

> Analyses of hydrometeorological data from the lower Klamath Basin show a **decrease in the percentage of precipitation falling as snow and accelerated snowpack melt, resulting in earlier peak runoff and lower base flows** (Hamlet et al. 2005; Mote et al. 2005; Regonda et al. 2005; Stewart et al. 2005; Mote 2006; Van Kirk and Naman 2008).[70] [emphasis added]

Lack of sufficient snowpack to provide adequate water flows in summer and into fall—during the same time as most local wildfire ignitions *(see **Wildfire Risk and Ignition Sources** section above)*—can substantially increase both local fire hazard (drier fuels) and fire risk (more ignitions, including lightning) for Humboldt County. The Six Rivers study further notes:

> **Although climate models diverge with respect to future trends in precipitation over NW California, there is widespread agreement that the trend toward lower *snow water equivalent* and earlier snowmelt will continue** (Leung and Wigmosta 1999; McCabe and Wolock 1999; Miller et al. 2003; Snyder et al. 2004; Barnett et al. 2005; Zhu et al. 2005; Vicuna et al. 2007; Van Kirk and Naman 2008).[71] [emphasis added]

Climate and Fire

In a 2012 analysis titled *Trends and Causes of Severity, Size, and Number of Fires in Northwestern California,* Miller et al. noted that the above-mentioned changing summer water flows and precipitation patterns are a driving force in increased fire activity in the region.

> Another intriguing trend in northwestern California is a strong temporal increase in the importance of lightning fires in the region. In the early part of the 20th century, lightning accounted for 42% of area burned in all recorded fires, but by the end of the century, 87% of area burned was caused by lightning…. **We suggest the increasing importance of summer precipitation later in the study period may be related to the increasing dominance of lightning caused fires**…. our analysis suggests that **amount of precipitation at the time of ignition has become more important in recent decades than seasonal drought in driving fire activity and fire area. Ironically, dry years in which large areas burn due to lightning-ignited fires are often years of relatively little lightning activity.**[72] [emphasis added]

As shown in the previous sections, fire frequency, size, and total area burned are increasing. This is likely due to a combination of climate change, past land management, and fire suppression. As Miller et al. continue, more and larger fires are expected in the region:

> [O]ur data suggest that fire frequency, size, and total burned area have strongly increased over the last 20 years, and that climate is associated with a growing proportion of the variance in these variables. We believe that this pattern is the product of a changing climate plus increasing and more fire-prone fuels in some forest types, the latter driven by a combination of human- (e.g., fire suppression, land management practices) and climate-

[70] Butz, R.J. et al. (2015). (p. 12).

[71] Butz, R.J. et al. (2015). (p. 16).

[72] Miller, J.D. et al. (2012). (pp. 194-195).

> related (e.g., warming temperature, drier fire seasons) factors. **Regardless, forested systems in northwestern California will burn under favorable weather conditions, and it is logical to expect more and larger fires under future climate change scenarios** (Lenihan et al. 2008, State of California 2009, Gedalof 2011).[73] [emphasis added] ”

Forest Service scientists concur with Miller et al.—based on the research of Westerling et al. (2006) and others—that increased fire activity is at least partially due to changing climate conditions:

> “ Data on forest fire frequency, size, and total area burned all show strong increases in California over the last two to three decades. Westerling et al. (2006) showed that increasing frequencies of large fires (>1,000 acres) across the western United States since the 1980s were strongly linked to increasing temperatures and earlier spring snowmelt. **Northern California forests have had substantially increased wildfire activity, with most wildfires occurring in years with early springs** (Westerling et al. 2006). This increase is likely attributable to both climate and land-use effects. Large percentage changes in moisture deficits in Northern California forests, according to Westerling et al. (2006), were strongly associated with advances in the timing of spring, but this area also includes substantial forested area where forest densification after fire exclusion, timber harvesting, and mining activities have led to increased forest densities and fire risks (McKelvey et al. 1996, Gruell 2001).[74] [emphasis added] ”

Although climate change is expected to bring more fire to the region, including Humboldt County, Miller et al. (2012) found that fire severity[75]—the effects of the fire on the ground, especially to the vegetation and soils—has only increased in younger forest stands in this area.

> “ Our study assessed trends and patterns in fire size and frequency from 1910 to 2008 (all fire 40 ha), and the percentage of high-severity in fire from 1987 to 2008 (all fire 400 ha) on the four national forests of northwestern California. **During 1910–2008, mean and maximum fire size and total annual area burned increased, but we found no temporal trend in the percentage of high-severity fire during 1987–2008.**
>
> **The percentage of high-severity fire in conifer-dominated forests was generally higher in areas dominated by smaller-diameter trees than in areas with larger-diameter trees.** For Douglas-fir forests, the percentage of high-severity fire did not differ significantly between areas that re-burned and areas that only burned once (10% vs. 9%) when re-burned within 30 years.[76] [emphasis added] ”

[73] Miller, J.D. et al. (2012). (p. 201).

[74] Butz, R.J. et al. (2015). (p. 13).

[75] Fire severity is a measure of the physical change in an area caused by burning (Sousa 1984). Whereas “fire intensity” is the heat output of the flaming front of the fire.

[76] Miller, J.D. et al. (2012). (pp. 184).

The California Fire Science Consortium summarized Miller's research with an emphasis on the importance of the relationships between climate, humans, and fire:

> [H]owever, fire severity results are somewhat surprising, suggesting no clear trends in fire severity over time and highlighting new understandings of the relationships between climate, humans, and fire.
>
> …
>
> Intriguingly, the study also showed that fire severity was greater in human-ignited fires than lightning-ignited fires. This is probably because human-ignited fires are isolated incidents that escape under more severe conditions and occur close to population centers, allowing swift and effective suppression and precluding the long, drawn-out, lower-severity events that are more typical of lightning-ignited wildfires. [77]

However, Van Mantgem et al. in their 2013 study of western US forests, showed that climatic stress could predict forest fire severity:

> Our findings show post-fire tree mortality of coniferous trees was influenced by climate across the western US, describing what appears to be a general, but overlooked, climate–fire relationship. This relationship appeared to be consistent across broad geographical regions, major genera and tree sizes. **Climate was predictive of tree mortality after accounting for fire damage and defenses,** supporting conceptual models of tree mortality that account for combined effects of multiple long- and short-term stressors (Franklin *et al.* 1987; Manion 1991). In our case, longer term climatic stress (5 years prior to fire) predisposed trees to be killed from short-term fire damage. **Pervasive warming can be expected to increase the incidence of high severity fire by creating conditions where lower fuel moisture results in fires of higher intensity. An important implication of our results is that chronic stresses on western forests, including continued warming, may also lead to *de facto* increases in fire severity independent of changes in fire intensity.** [78] [emphasis added]

This increasing climatic stress and potential increase in fire severity is negatively affecting post-fire regeneration in forests in the Klamath bioregion, especially after repeated burning of the same area. In 2017, Tepley et al. found in their study of post-fire recovery in the Klamath Mountains:

> An interaction between seed-source availability and climatic aridity drove substantial variation in the density of regenerating conifers. With increasing climatic water deficit, higher propagule pressure (i.e., smaller patch sizes for high-severity fire) was needed to support a given conifer seedling density, which implies that **projected future increases in aridity could limit postfire regeneration across a growing portion of the landscape. Under a more severe prospective warming scenario, by the end of the century more than half of the area currently capable of supporting montane conifer forest**

[77] California Fire Science Consortium. Research Brief for Resource Managers. Based on Miller, J.D. et al. (2012). Trends and causes of severity, size, and number of fires in northwestern California, USA. Ecological Applications, 22: 184-203. Retrieved from http://www.cafiresci.org/research-publications-source/category/wildfire-trends-in-northwestern-california-forests-1

[78] van Mantgem P.J., Nesmith, J.C.B., Keifer, M.B., Knapp, E.E., Flint, A., & Flint, L. (2013). Climatic stress increases forest fire severity across the western United States. *Ecology Letters,* 16: 1151-1156. (quote p. 1154).

> **could become subject to minimal conifer regeneration in even moderate-sized (10s of ha) high-severity patches**....[79]
>
> **Failure to achieve abundant conifer recruitment within the first few years could almost inevitably lead to protracted recovery taking several decades to more than a century to re-establish forest cover** (Lauvaux et al., 2016; Russell et al., 1998; Wilken, 1967).... [T]oward the more severe end of potential warming scenarios (RCP 8.5), more than half of the area currently capable of supporting mixed-conifer/mixed-evergreen forest could soon be at risk of poor initial postfire conifer recruitment (Figure 6). In these areas, **forest loss to high-severity fire could be nearly irreversible if fire activity increases to the point where these areas are prone to reburn severely before a new conifer canopy develops** (Odion et al., 2010; Thompson & Spies, 2010).[80] [emphasis added]

Such a change in post-fire regeneration could significantly alter Klamath forests. This would create profound effects on ecosystem processes including fire, as well as the resultant reverberations to nearby human and wildlife communities. **Local practitioners in the Klamath Mountains have been seeing this change for decades and are actively promoting low-intensity prescribed fire following wildfires to help reduce later fire severity and hence support native conifer regeneration.**[81]

Finally, a potentially positive effect of climate change in the Klamath Mountains is an interesting phenomenon where increased fire frequency creates an inversion layer that cools temperatures and increases humidity, which both aid fire-suppression efforts. This is also a bonus for salmonid populations dependent on cool water. Miller et al. (2012) summarize the effects of such a temperature inversion:

> “In northwest California, fire intensity historically was lowest on lower slopes and north- and east-facing aspects, and greater on mid- and upper-slope positions, especially on south- and west-facing aspects, where higher temperatures and afternoon winds promote drier conditions (Weatherspoon and Skinner 1995, Taylor and Skinner 1998, Alexander et al. 2006). **Long-term temperature inversions under stable air masses that are common within the region during the summer can trap smoke in valleys, leading to cooler temperature and higher humidity, and resulting in less severe fire effects at lower slope positions** (Robock 1988, 1991). Reduced fire intensity, less crowning, and more surface fire are more common under temperature inversions.[82]”

As described in this section, current data and future predictions show that temperatures, precipitation, fire frequency, and possibly severity are changing in Humboldt County, although perhaps not as much, or as quickly, as in the rest of California. This all adds up to less predictable fire behavior here and statewide. In Humboldt County, there may be more frequent and more erratic fires inland, perhaps with a decrease of wildfire along the coastal areas of the county. Such changes and uncertainty make community-based fire-safety efforts all the more important and timely. Continued research and modeling are necessary to better understand the impacts of climate change on the fire environment throughout Humboldt County and to inform adaptation strategies.

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[79] Tepley, A.J., Thompson, J.R., Epstein, H.E., & Anderson-Teixeira, K.J. (2017). Vulnerability to forest loss through altered postfire recovery dynamics in a warming climate in the Klamath Mountains. *Global Change Biology* 23(10), 4117-4132. (p. 1).

[80] Tepley, A.J. et al. (2017). (p. 14).

[81] Will Harling, Mid-Klamath Watershed Council, personal communication, July 16, 2018.

[82] Miller, J.D. et al. (2012). (p. 198).

For a list of relevant research on the relationship between fire and climate change for Humboldt County and north coastal California, see Appendix F, ***Climate Research.***

5.2.7 THE NEED FOR COORDINATED APPROACHES TO WILDFIRE PREPAREDNESS IN THE FACE OF CLIMATE CHANGE

Leading scientists around the state and nation have done the research and arrived at similar conclusions. While guaranteed predictions are impossible, there are trends that must be addressed to coexist with wildfire. Focusing mitigation efforts in the wildland-urban interface is key among the findings.

> Wildfires across western North America have increased in number and size over the past three decades, and this trend will continue in response to further warming. **As a consequence, the wildland–urban interface is projected to experience substantially higher risk of climate-driven fires in the coming decades**….[83] [emphasis added]
>
> Together, these gradually changing variables—climate change, fuels build-up, and residential development—interact with rapid combustion to increase wildfire risks and costs to society and some ecosystems substantially.[84]

The question is whether and to what level mitigation and management actions can alter the trend of increasing fire frequency and severity in the country as well as more locally.

> A major question is whether we can influence the intensity at which future forest fires will burn, and thereby minimize the negative ecosystem effects of fire while maximizing the positive effects.[85]

Management Recommendations

These questions have prompted the evaluation of the effectiveness of landscape-scale fuel-reduction efforts while wildfire damage continues to increase. The results of these studies question the effectiveness of targeting fuel reduction efforts at the landscape scale, versus closer to communities.

> Managing forest fuels is often invoked in policy discussions as a means of minimizing the growing threat of wildfire to ecosystems and WUI communities across the West. However, the effectiveness of this approach at broad scales is limited. Mechanical fuels treatments on US federal lands over the last 15 years (2001–2015) totaled almost 7 million ha [hectares] (*Forests and Rangelands, https://www.forestsandrangelands.gov*), but the annual area burned has continued to set records. Regionally, **the area treated has little relationship to trends in the area burned, which is influenced primarily by patterns of drought and warming** [86] (Westerling et al. (2006); Dennison et al. (2014); and Abatzoglou & Williams (2016)). [emphasis added]

[83] Schoennagel, T., Balch, J.K., Brenkert-Smith, H., Dennison, P.E., Harvey, B.J., Krawchuk, M.A., Mietkiewicz, N., Morgan, P., Moritz, M.A., Rasker, R., & Turner, M.G. (2017). Adapt to more wildfire in western North American forests as climate changes. *Proceedings of the National Academy of Sciences* 114(18). (p. 4582).

[84] Schoennagel, T. et al. (2017). (p. 4583).

[85] Miller, J.D. et al. (2012). (p. 201).

[86] Schoennagel, T. et al. (2017). (p. 4586).

This means treatment areas need to be strategically focused on a network of landscape-scale fuel breaks for managing wildfire, and around communities for direct fire protection. In terms of forest management—a critical issue for Humboldt County—the 2018 North Coast Resource Partnership report recommends:

> According to researchers at the USFS Pacific Northwest Research Station, **"planning needs to embrace managing forests for adaptation to new conditions by promoting the resistance of a forest to change, resilience of a forest in the face of change, and response options that facilitate the transition of forests to new conditions"** (Anderson and Palik, 2011). In other words, forest managers need to consider potential climate effects, spatial scale of response, timing, and prioritization of adaptation efforts. As with conservation lands management, prioritization and planning are key to identifying vulnerabilities and developing a suite of potential actions to address those vulnerabilities.[87] [emphasis added]

Hessburg et al. (2015) emphasizes the need to ensure ecosystem and landscape resiliency, a goal that is explored in this CWPP's *Countywide Action Plan, Chapter 3.5, **Restoration of Beneficial Fire.***

> Wildfires and insect outbreaks are an inevitable part of future landscapes. **Future management should aim to restore more resilient vegetation patterns that can help to realign the severity and patch sizes of these disturbances, promote natural post-disturbance recovery, reduce the need for expensive active management, and drastically reduce the role and need of fire suppression.**[88] [emphasis added]

Finally, in a 2018 issue of *Forestland Steward,* Moritz urged implementing changes now:

> We need the foresight to help guide these ecosystems in a healthy direction now so they can adjust in pace with our changing climate … That means embracing some changes while we have a window to do so.[89]

One of the most important changes being embraced in California towards this end is the active use of fire as a land management tool. It is at the forefront of current management discussions locally, nationally, and internationally:

> Increasing the use of prescribed fires and managing rather than aggressively suppressing wildland fires can promote adaptive resilience as the climate continues to warm.[90]

[87] Reza, K. & Tinsman, R. (2018). North Coast Regional Climate Adaptation Strategies. North Coast Resource Partnership. (p. 27).

[88] Hessburg, P.F., Churchill, D.J., Larson, A.J., Haugo, R.D., Miller, C., Spies, T.A., North, M.P., Povak, N.A., Belote, R.T., Singleton, P.H., & Gaines, W.L. (2015). Restoring fire-prone Inland Pacific landscapes: Seven core principles. *Landscape Ecology 30*(10), pp. 1805-1835. (quote p. 1829).

[89] Changing wildfire patterns require a new mindset for living in the West. *Forestland Steward*, Winter 2018. (p. 5). [PDF]. Retrieved from http://calfire.ca.gov/foreststeward/pdf/Foreststeward%20Winter%202018%20Master.pdf

[90] Schoennagel, T. et al. (2017). (p. 4586).

How to manage wildland fires to meet long-term fuel reduction goals is one of the paramount challenges facing public land managers and fire protection agencies. Fire scientists Miller et al. concluded:

> Overall, the evidence suggests that, **under the right meteorological, ecological, and political circumstances, wildland fires might be more extensively used in northwestern California to achieve management objectives such as reducing landscape-scale fire hazard, and restoring the ecological role of fire by increasing forest heterogeneity and sustaining biodiversity in fire-adapted forests. We recommend that managers consider these conclusions in developing fire management plans.**[91] [emphasis added]

Local and regional fire scientists concur that actively using prescribed fire must be a key element in reducing fuels to reduce fire severity:

> Climate change may also impose greater constraints on the use of prescribed fire, including both planned ignitions and managed wildfires (Wimberly and Liu 2014). **Prescribed burning is a critical component of fuel treatments in drier forests of the Klamath Mountain region and has proven more effective than thinning alone at reducing the severity of large fires** (Agee and Skinner 2005, Raymond and Peterson 2005, Wimberly et al. 2009, Prichard et al. 2010, Prichard and Kennedy 2012).[92] [emphasis added]

To facilitate reducing these fuels and potential fire severity, political support and resources must be dedicated to prescribed fire.

> Increasing both funding and public support for prescribed burning will be critical for sustaining critical ecosystems processes and reducing fire risk in the dry forests of the Pacific Northwest (Ryan et al., 2013).[93]

This Humboldt County CWPP embraces the challenges of applying prescribed fire and managed wildfire to local landscapes. Strategic action steps are outlined in the *Countywide Action Plan, Chapter 3.5 Restoration of Beneficial Fire. Chapter 3.6, Integrated Planning* identifies policy actions to support this and other priorities to better prepare Humboldt County to live with fire. The following findings are consistent with the proposed actions in this CWPP's *Countywide Action Plan*:

> Our key message is that **wildfire policy and management require a new paradigm that hinges on the critical need to adapt to inevitably more fire in the West in the coming decades….** We suggest an approach based on the concept of *adaptive resilience,* or adjusting to changing fire regimes (e.g., shifts in prevailing fire frequency, severity, and size) to reduce vulnerability and build resilience into SESs (social-ecological systems). **Adaptive resilience to wildfire means recognizing the limited impact of past fuels management,**

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[91] Miller, J.D. et al. (2012). (p. 201).

[92] Butz, R.J., Sawyer, S., & Safford, H. (2015). A summary of current trends and probable future trends in climate and climate-driven processes for the Six Rivers National Forest and surrounding lands. USDA Forest Service Pacific Southwest Region*.* (p. 19).[PDF]. Retrieved from https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd490216.pdf

[93] Wimberly, M.C. & Liu, Z. (2014). Interactions of climate, fire, and management in future forests of the Pacific Northwest*. Forest Ecology and Management* 327: 270-279. (p. 277).

acknowledging the important role of wildfire in maintaining many ecosystems and ecosystem services, and embracing new strategies to help human communities live with fire…[94]

Overall, a shift in resources from the defense of the WUI from wildfire to the mitigation of wildfire hazards and risks in advance of events will build a safe operating space for fire-prone communities that increases adaptive resilience to wildfire. **Encouraging development away from fire-prone areas, reducing fuels on private lands in and near communities, and retrofitting and building homes to withstand ignition will increase the adaptive capacity for managing more wildfire** (Calkin et al. 2014), similar to adaptive approaches for other natural hazards such as flooding and earthquakes (Moritz et al. 2014) …. **We also can change how we build, live, and work in fire-prone landscapes to keep our communities safe, healthy, and vibrant.** [95] [emphasis added] ,

Knowledge enables appropriate action. There are still many unknowns to living with wildfire within a changing climate. It is clear that preparing communities to coexist with fire, both planned and unplanned, must be at the center of any effective strategy. The *Countywide Action Plan* in *Part 3* of this CWPP, addresses this challenge from a variety of approaches. In addition, as this CWPP is implemented it will be important to track evolving climate science and make every effort to plan action that supports effective climate change adaptation and wildfire resilience. Careful consideration of greenhouse gas emissions and impacts on carbon sequestration associated with wildfire hazard mitigation will also be important to ensure that they are minimal or outweighed by the benefits.

[94] Schoennagel, T. et al. (2017). (p. 4583).

[95] Schoennagel, T. et al. (2017). (p. 4588).