4. The Santa Rosa Wildland Urban Interface:

Historical Context and Perspective

Vegetation communities surrounding the city of Santa Rosa have been affected and altered by human activities such as logging, agriculture, grazing and residential development for more than a century. However, most of areas surrounding Santa Rosa retain a large component of natural vegetation community structure and species composition. Historically, the vegetation communities in the Santa Rosa environment were maintained by frequent natural fires caused by lightning or deliberate burning by indigenous people. These fires often covered thousands of acres, burning until weather conditions changed or they were stopped by natural barriers. Natural Fire return intervals are estimated from almost annual occurrence in Oak Savannas (Vogel, 1977) to every 5 to 25 years in montane hardwoods, mixed chaparral, Douglas-fir and redwood forest types (Brown, 1999 and Arno, 2000). Most of these vegetation types have evolved strategies for survival in an environment of frequent fire including thick fire resistant bark (coastal live-oak, valley oak, Douglas-fir and redwoods), root or crown sprouting capabilities (coast live oak, redwoods and chamise), prolific post-fire seed production (Douglas-fir) and fire stimulated seed germination (whiteleaf manzanita). The frequent natural fires were usually low intensity surface fires, which consumed accumulations of dead woody material and reduced the potential for stand replacement fires. These fires also cycled nutrients into the soil and stimulated reproduction of various species of grass, shrubs and trees maintaining a healthy vigorous ecosystem.

With the advent of modern fire suppression capabilities in the mid twentieth century, the role and function of periodic natural fires was eliminated from the natural areas surrounding Santa Rosa. The result of success in fire suppression has been the gradual accumulation of dead woody material in mixed chaparral, montane woodland and coniferous forest vegetation types. In the past, frequent fires created open, park like forest and woodland habitat, with sparse understory vegetation. Ground fuels primarily consisted of surface litter without large accumulations of dead trees and branches. In the absence of natural fire, forest canopies have become much denser, creating conditions that favor shade-tolerant conifers like white fir. Much of the understory of the Redwood -Douglas fir forest association is now dominated by white fir in forested areas surrounding the city of Santa Rosa. White fir is highly susceptible to root and heart rot, which has created significant amounts of dead fuels in these stands. The dense canopies and extreme fuel loading currently found in these stands present a high probability of eventual crown fires and significant threat to adjacent structures. In addition, shrub densities have increased significantly in the sub-canopy layers of oak and montane woodlands that provide" "ladder fuels" which promote crown fire development.

Probabilities of wildfire occurrence in fire dependent ecosystems are largely a function of time and ignition sources. Dead fuel accumulation is largely a function of time since the last fire, and can be accelerated by disease and bug infestations in decadent stands of forest, woodland and brush communities that have not burned for long periods. It has been over forty years since the Hanly fire, which is at least fifteen years past the natural fire return interval and even longer in other areas surrounding the city. Lacking fire occurrence data or anecdotal evidence, some areas in the Santa Rosa interface may have fuel accumulations of up to eighty years or more. It is probable that the next major fire to affect the city of Santa Rosa will be sooner rather than later.

Project Methodology and Analysis

The vegetation and fuel type maps for the city of Santa Rosa were interpreted from high-resolution aerial photos taken of Sonoma County in March of 2003. The digital aerial photo image was provided in GIS data format by Mike Hargreaves, GIS specialist with the City of Santa Rosa Information Services Division. Vegetation was mapped within a 2-mile zone on the North, East and South boundaries of the City of Santa Rosa as well as potentially flammable vegetation within the city limits. The area mapped was based on the assumption that fuel types on the west side of the city of Santa Rosa are predominantly agricultural lands that have fuel types that are considered low risk in relation to supporting fire behavior characteristics that would present a significant urban interface threat, although in the right circumstances they can be problematic. The distance mapped adjacent to and within the city limits is related to the standard of fuel mapping used in CWPP's (one half mile) and recognition that the Santa Rosa Fire Department has cooperative responsibilities for structure protection in the wildland areas well beyond the city limits. This information can also be used to determine the most probable path that wildland fires would follow in an interface fire scenario, assuming that heavy fuel loading plays a significant role determining fire behavior.

Vegetation communities were distinguished and classified from the aerial images by gradations in color, structure, texture and ecological variables related to elevation, slope and aspect. Map polygons were derived by digitizing transitional areas between the various vegetation types (Image 7). Attribute data fields for each polygon include vegetation type and fire behavior fuel models that are discussed in detail in subsequent sections of this document. Acreage for each polygon was automated and calculated from map topology. Additional attributes relating to hazard treatment category and priority were assigned to specific areas based on fuel type and proximity to dense residential development in order to develop strategies for hazard fuel treatments.

The vegetation type classifications within the map data was derived from the "CWHR - California Wildlife Habitat Relationship System" (Mayer and Laudenslayer, 1988). The CWHR vegetation classification system is utilized in the GIS Fuels data developed by the California Department of Forestry's Fire and Resource Assessment Program (FRAP). The CWHR classification system is derived from other standard GIS based vegetation classification systems, including the CALVEG system and the National GAP analysis program. Vegetation community descriptions and attribute data utilized within GIS maps were in some cases adapted, modified or expanded upon to provide a more accurate description of the conditions found within the Santa Rosa Fire Environment.

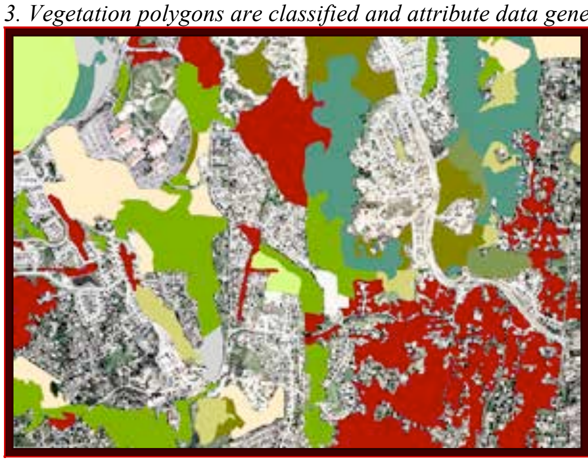
The vegetation communities delineated within the GIS maps were assigned appropriate fuel models within the associated attribute table. Fuel models are used in fire behavior prediction models such as BEHAVE or FARSITE. Fuel models are the result of extensive research conducted by U.S. Forest Service laboratories to describe and predict the characteristics of fire intensity, spread rates, flame length and spotting potential of various grass, brush, woodland and timber fuel types common to North America. Anderson's seminal publication "Aids to Determine Fuel Models for Estimating Fire Behavior" is the standard methodology used by wildland fire agencies for translating vegetation community types into fuel models for fire behavior prediction (Anderson, 1982).

Image 7. GIS mapping: Interpretation and Classification Process

1. Aerial Photo zoomed to High Resolution (Fountain Grove – Montecito area)

2. *Vegetation Communities are distinguished and digitized*.

3. Vegetation polygons are classified and attribute data generated.



The GIS map data was verified by field reconnaissance in early October of 2004. The GIS vegetation map data was taken into the field on a laptop computer linked to a Global Positioning System (GPS) in order to assess map data accuracy in real time. Approximately 100 miles of the road accessible area was traversed with the GIS map displaying the vegetation data and the current GPS position of the field survey team. GPS positional data had an accuracy of approximately 15 feet. The survey team consisted of one GIS / GPS specialist and a Plant Ecologist with local knowledge of plant communities and species composition. Map classification data was verified by correlation of real-time GPS location to the surrounding vegetation in relation to mapped attributes of the area. Brief foot surveys of local vegetation were conducted to assess major species components of the classified areas fuel type characteristics (dominant shrub and tree species). The field survey results were subsequently utilized to refine the accuracy of the vegetation and fuels data within the GIS products.

5. The Santa Rosa Fire Environment: Fuels, Weather and Topography

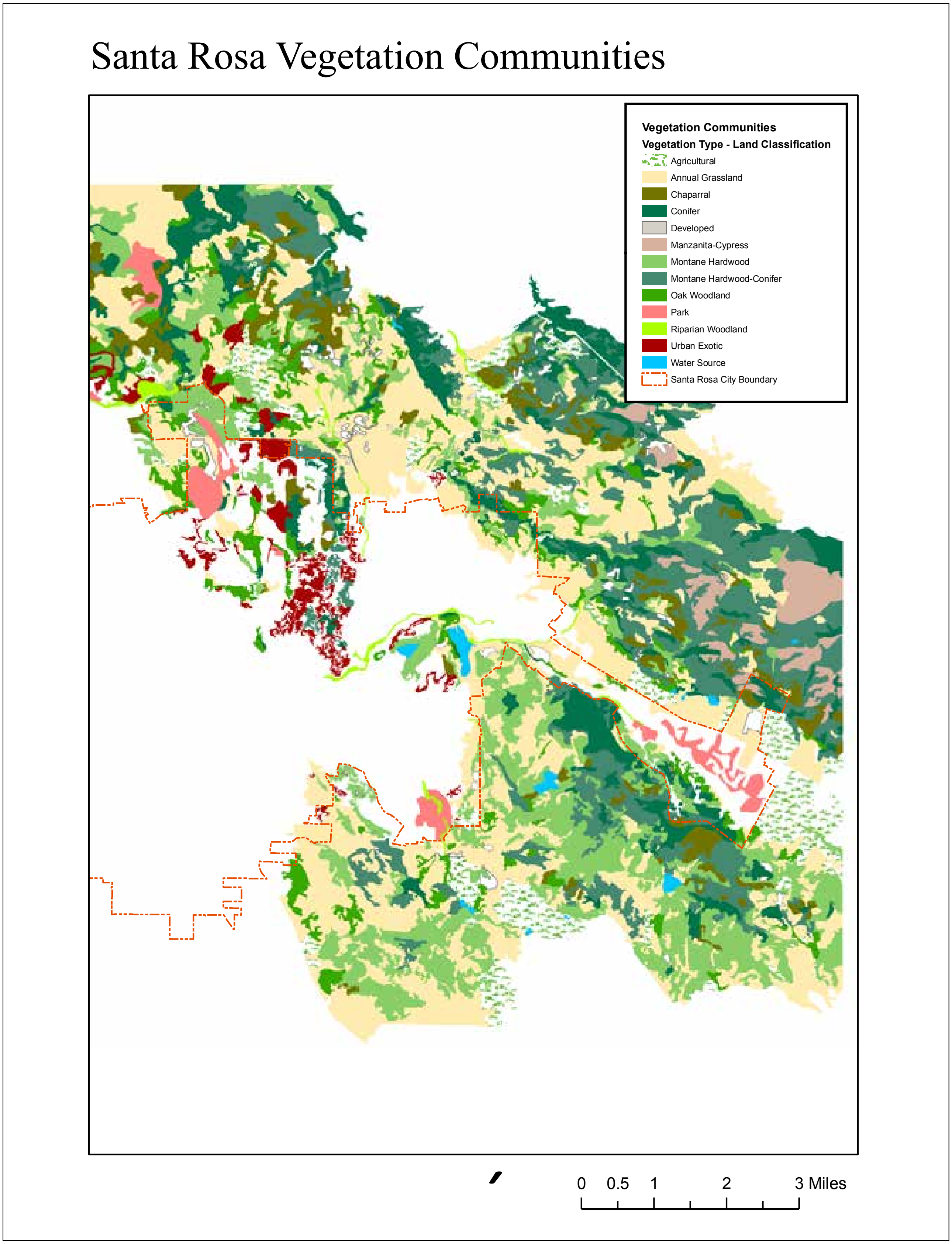
The wildland fire environment is defined by factors that influence the behavior of the fire and often interact with each other in a synergistic manner to magnify the amplitude of the fires rate of spread and intensity. These factors include fuels, weather and topography.

Fuels are defined by the predominant vegetation types found within the fire environment. They are classified by characteristics of physical structure, live and dead biomass (fuel loading). The primary fuel groups are classed as grass, brush, timber or logging slash. These major fuel classes are further sub-classified to represent specific fuel types found within unique geographic areas such as the chaparral fuel model found within California and Arizona or the pinyon-juniper fuel model of the Great Basin region. Fuels are also defined as being either dead fuels or live fuels. Live fuels types such as chaparral or brush fuel types are able to maintain moisture uptake from the physiological processes of translocation and evapotranspiration with living roots and leaves. Dead fuels describe dead tree trunks, branches, forest surface litter and cured grasses. Dead fuel moisture levels are determined by weather factors of precipitation, relative humidity and to some extent wind speed. Fuel moisture levels determine what is termed fuel availability or how receptive the fuel particle is to combustion. This is true for both live and dead fuels. The lower the live and dead fuel moisture is, the more probable the occurrence of wildland fire. Fuel moisture levels are one of the most important variables measured in fire behavior prediction systems. Drought is perhaps the most important predictor of large fire occurrence, since both live and dead fuels become extremely dry and “available” to the combustion process.

Vegetation Community Discussion

The vegetation communities that encompass the wildland urban interface of Santa Rosa are highly variable and include grassland, shrub, woodland and coniferous forest habitat types (Map 9). As can be seen from the vegetation map, most of the wildland urban interface hazards are located on the north, east and southern boundaries of the city. Topographic features of elevation, slope and aspect are influential factors in determining the distribution of vegetation communities. Valleys and rolling hills on the periphery of the city consist primarily of oak savannas and oak woodland. Some significant riparian woodland vegetation types exist within the city limits along the Santa Rosa and Mark West creek areas. These areas were mapped within the project extents, but due to high moisture content of the vegetation in these areas, these fuels usually do not present a fire threat except during extreme drought. As elevation increases, montane woodlands composed of a variety of shrub and hardwood tree species become more dominant on south and west facing aspects. North and east slope aspects have more variable species composition with conifers becoming more prevalent due to higher soil moisture content resulting from less direct sun exposure. Due to this factor, fuel loading tends to be higher on north and east facing aspects with less grass understory and more shrub understory components. These areas are dominated by the montane hardwood conifer type, with conifers comprising a significant percentage of the overstory. West and south facing aspects at higher elevations southeast of Santa Rosa have

Map 9

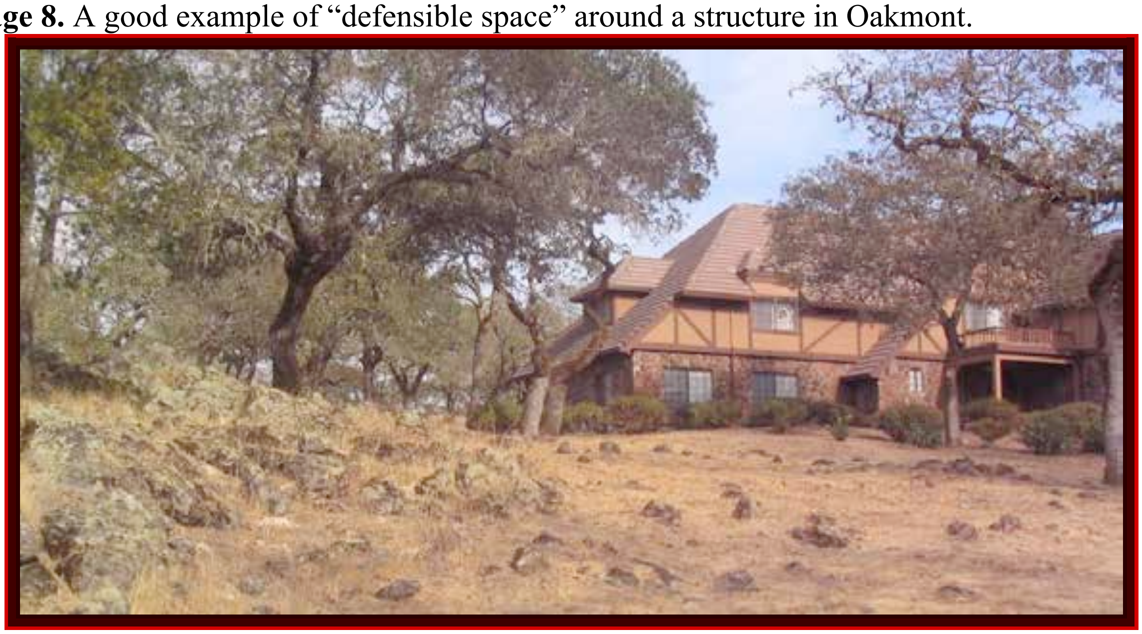

Santa Rosa Vegetation Communities
Vegetation Communities
Vegetation Type - Land Classification
Agricultural
Annual Grassland
Chaparral
Conifer
Developed
Manzanita-Cypress
Montane Hardwood
Montane Hardwood-Conifer
Oak Woodland
Park
Riparian Woodland
Urban Exotic
Water Source
Santa Rosa City Boundary
0
0.5
1
2
3 Miles

significant areas of mixed chaparral and manzanita-cypress brush fuel types. Many of these areas appear to have experienced clear-cut logging in the past and may represent a seral successional stage of degraded site conditions resulting from the logging disturbance. As elevation increases east of Santa Rosa, coniferous forest dominated by Douglas-fir and redwoods become increasingly predominant.

Within the Santa Rosa city limits, some communities have significant relic stands of native brush, hardwoods and coniferous forest intermingled with homes and exotic vegetation. The communities of Fountain Grove, Montecito, Bennett Valley and Oakmont represent the areas at greatest risk from a wildland urban interface fire. This situation has been well documented in previous reports on the threat of wildland urban interface fire to the city of Santa Rosa including; *Fountaingrove II Wildland Urban Interface Threat and Mitigation Recommendations* (Martin, 2004), *District 7 Wildland Urban Interface Threat Assessment* (Ricci, SRFD 2003) and the *City of Santa Rosa: Hazard Analysis Threat Summary* (SRFD, 1999). These areas, while seeming to be a safe distance from surrounding natural vegetation, have significant amounts of flammable vegetation in the form of residual natural vegetation (oak and conifers) and exotic species planted by homeowners for landscaping such as eucalyptus, pine, juniper, redwood and exotic shrubs and grasses (fountain grass, bamboo etc.). These species are extremely flammable due to high amounts of aromatic oils in their leaves and stems. Extensive documentation exists regarding the threat of these species to structural protection in wildland urban interface fires. Field surveys conducted in these areas during this study indicate that some homeowners understand the potential for a wildland urban interface fire in their neighborhood and have undertaken steps to thin and prune the native and exotic vegetation around their homes. However, homes with good clearance of flammable vegetation seem to be the exception rather than the rule in these areas.

Please refer to the appendices of this document for a listing of major species and scientific nomenclature that comprise the various vegetation communities discussed in this document.

Image 8. A good example of “defensible space” around a structure in Oakmont.



Fuel Types and Fire Behavior Characteristics

Fuel Model 1 (Annual Grassland): This fuel type is the most widely distributed fuel type in the Santa Rosa urban interface and is most predominant at lower elevations. Annual grasses are the primary carrier of fire in oak savannas, low-density oak woodlands and other hardwood habitat. At higher elevations, the fuel type is found in open meadows on ridgelines and flat canyon bottoms, often in association with widely dispersed conifers and canyon live oak. Fallow fields, pastures, abandoned vineyards and other agricultural lands, often within the city limits of Santa Rosa are dominated by annual grasses. Fine fuels in the 1-hour fuel class are the primary mode of fire spread. Exotic weeds and grasses now dominate many of these disturbed areas. Fire behavior characterized by rapid surface spread through cured grasses and weeds, accentuated by spotting ahead of the fire front.

Image 9. Typical annual grassland fuel type near Santa Rosa.

Coast-live oak and black oak are the most common tree species on the hilly grasslands surrounding Santa Rosa. Valley oak is common in some of the flatter valley bottoms, however much of the natural valley oak habitat is now developed or converted to agricultural lands in the Santa Rosa area. The oaks within this fuel type do not significantly contribute to fire spread in relation to the predominant grass fuels. Crown scorch is common in oaks during a wildfire, but most species have thick bark that protects the cambium and the ability to resprout new branches and leaves. During the dry season when grasses are cured, this fuel type is highly flammable and easy to ignite with careless fire use. Even small fires, with the influence of slope or wind, can rapidly spread and threaten structures in this fuel type. In a major urban interface fire, the extensive annual grasslands in the Santa Rosa area would provide a receptive fuelbed for spotfires to occur resulting from long range spotting in heavier fuels, rapidly expanding the fire front into more developed areas.

Chaparral (Fuel Model 4): Chaparral is a generic term for brush fuel types that are widely distributed throughout California and Arizona which have a wide variety of species diversity and structural characteristics. Chaparral typically grows as dense, nearly impenetrable thickets, with shrubs comprising 80 % or more of the surface cover. Chaparral is a fire dependent vegetation type with many species dependent on frequent fire for germination of seeds. Other species are highly adapted to fire and are able to resprout from root burls following fire. Canopy height is related to the interval since the last fire, with recently burned stands ranging from one to five feet. Mature stands can reach up to 12 feet depending on species composition, but generally range from five to ten feet in height. One of the characteristics of chaparral that make it a highly flammable fuel type is the considerable amount of dead branches carried in the shrub canopy of mature stands. As chaparral matures, the ratio of dead to live material in the stand increases dramatically which can create extreme fire behavior, rapid crown spread and flame lengths of over 100 feet. In addition, many species of chaparral plants have volatile oils in their leaves and branches that increase fire intensity.

Image 10. Typical stand of chamise chaparral near Mt. Hood State Park.

Chaparral surrounding Santa Rosa is typically found on south or west facing slopes. Common species include chamise, manzanita, scrub oak, ceanothus, sumac and coyote brush. Chaparral stands in many areas surrounding Santa Rosa may be the result of past clear-cut logging practices in coniferous forest with marginal sites characteristics of thin, rocky soils and low moisture retention capabilities.

Closed Cone Pine-Cypress (Fuel Model 4)

Closed cone-cypress communities form a distinctive vegetation type and are predominantly located southwest of Santa Rosa near Sugarloaf Ridge State Park & Hood Mountain Regional Park. Formal classifications of the vegetation type describe associations of pine, cypress and various species of chaparral. The vegetation type is dominated by whiteleaf manzanita averaging four to six feet in height with MacNab and Sargent cypress scatted throughout the stands. The nomenclature for this vegetation type may be deceptive in relation to the type within the Santa Rosa area, since the type more closely resembles a brush vegetation community. This is compensated for by assigning a chaparral fuel model within the map attribute data. Some scrub oak and chamise can be found within the stands, however these species do not comprise a significant component of the type. Like chaparral, the vegetation type primarily occurs on south and west facing slopes and may be an artifact of past clear-cut logging practices. Many old logging roads and landings were observed within these areas. Conifer reproduction was observed in moist canyons below the stands of manzanita, which may indicate the vegetation type represents an early seral stage of succession to a conifer climax forest.

Image 11. Closed Cone-Cypress dominated by manzanita in Mt. Hood State Park

Fire behavior characteristics of this fuel type would be similar to chaparral with rapid rates of spread on steep slopes, extreme intensity and flame lengths. Whiteleaf manzanita is an obligate seeding species and requires fire for reproduction, lacking the ability to resprout following fire.

Montane Hardwood (Fuel Model 8): This fuel model represents a woodland fuel type that is widely distributed within the urban interface of Santa Rosa. Montane hardwood communities form dense canopies comprised of a variety of hardwood species including coast live-oak, black oak, tanoak, California bay and Pacific madrone with scattered occurrence of conifers, mostly Douglas-fir. Most stands have a significant understory of shrubs including manzanita, coyote bush, toyon, mountain mahogany and profuse amounts of poison oak.

Image 12. Typical Montane Hardwood vegetation in the Fountain Grove area.

This fuel type retains high levels of fuel moisture during most of the year, which would prevent significant fire spread except during the dry fall season or during extreme drought conditions. Fine fuels are present in the understory but generally do not have enough fuel loading to contribute significantly to crown fire development except during wind events or on steeper slopes. Stand density and canopy closure are probably much greater than those that occurred under natural fire regimes, making this fuel type a serious urban interface threat based upon its extensive distribution in the Santa Rosa area.

Montane Hardwood Conifer (Fuel Model 8): A woodland / conifer fuel type composed of various species intermingled with mature and immature conifer trees. Many of the same species of hardwoods and shrub species are present within the vegetation type that are found within the Montane Hardwood association. Within the map classification system, Montane Hardwood-Conifer was distinguished from Montane Hardwood based upon having a conifer canopy comprising at least 50% of the stand. The habitat often occurs in a mosaic-like pattern with small pure stands of conifers interspersed with small stands of broad-leaved trees (Sawyer 1980). This diverse habitat consists of a broad spectrum of mixed, vigorously growing conifer and hardwood species. Typically, conifers to 65 m (200 ft) in height form the upper canopy and broad-leaved trees 10 to 30 m (30 to 100 ft) in height comprise the lower canopy (Proctor et al. 1980, Sawyer 1980). Most of the broad-leaved trees are sclerophyllous evergreen, but winter-deciduous species also occur. However, considerable ground and shrub cover can occur in ecotones or following disturbance such as fire or logging (Cheatham and Haller 1975).

Image 13. Typical Montane Hardwood Conifer vegetation west of Santa Rosa.

Montane Hardwood-Conifer is generally found at higher elevations around Santa Rosa and in many cases seem to be areas that were previously logged, since many of the conifers present are not as tall as those described in the previously. Dead woody fuels are more predominant than in Montane Hardwood communities due to prolific self-pruning of sub-canopy branches in the conifers. Fine fuels composed of needles and leaves, form thick layers on the surface and will contribute significantly to surface spread and canopy preheating. Significant ladder fuels are present in the sub-canopy represented by conifer reproduction. As with the Montane Hardwood type, extreme fire behavior and crown fires are restricted to the driest parts of the year (fall), steep slopes, extended droughts and wind events.

Oak Woodland (Fuel Model 8)
Oak woodlands are prolific on the low elevation hillsides adjacent to the urban interface of Santa Rosa. Coast live-ok, California black oak, canyon live-oak and some residual valley oak are the most abundant species in this vegetation type. On moist sites with deeper soils, and canyon bottoms cost live-oak forms dense canopies with little understory vegetation. Dead fuels in larger size classes are sparse with leaves and litter comprising the majority of the fine fuel loading. On drier sites, California black oak is more predominant with other species of oaks comprising a less significant part of the woodland type. Shrubs and grasses are more abundant due to the more open aspect of the woodland tree canopy, particularly in areas where woodlands are adjacent to chaparral and Montane Harwood vegetation types.

Image 14. Typical Oak Woodland habitat south of Santa Rosa.

The natural fire ecology of oak woodlands is one of frequent fire, estimated to range from 2 to 17 years (Brown, et. al., 1999). These natural fires were of low intensity surface fires, with low mortality rates among the oaks. With the advent of modern fire suppression capabilities, fire has been eliminated as an ecosystem maintaining process within oak woodlands, as well as other fire adapted vegetation types. This has allowed surface fuels to accumulate as well as allow other species of shrubs and trees to encroach into the understory of the oak woodlands. Wildfires in the current environment of accumulated dead surface fuels and shrub encroachment cause significant mortality to mature oaks. Most oaks have the ability to crown sprout following a severe fire if the damage to the cambial tissue is not complete (Paysen et. al., 2000). Oak woodlands near the interface would be greatly benefited by understory thinning to prevent severe crown fires that will pose a threat to nearby residences.

Image 15. Coniferous Forest I Annadel State Park.

Coniferous Forest (Fuel Model 10)

The distribution of coniferous forest surrounding Santa Rosa has been altered from historic distribution and stand density primarily due to the effects of logging and fire suppression. Very few relic stands of the old growth redwood – Douglas-fir association were detected or observed in the Santa Rosa interface zone in either the aerial photograph analysis or subsequent field surveys. Most of the coniferous forest in the vicinity of Santa Rosa is represented by early to mid successional stages of second or third growth Douglas-fir, redwood and white fir. Stand density is very high in comparison to historic basal areas distribution primarily due to the elimination of natural fire as a thinning agent. As a result, white fir has become a major component of stand composition in comparison to pre-fire suppression densities. Fuel loading in these overstocked forests is very heavy and is also a result of fire exclusion. White fir in overstocked stands is very susceptible to root and heart rot (*Amilliaria* sp.) and the high mortality rates of this species contribute to extreme levels of dead and down branches and boles on the forest floor. Fuel complexity is further magnified by extensive amounts of shrubs and hardwoods in the subcanopy of some stands which provide ladder fuels which can contribute to crown fires under the right weather and fuel moisture conditions.

Fire behavior in the coniferous forests surrounding Santa Rosa can reach extreme intensity due to the fuel conditions described previously. The combination of steep slopes, heavy dead fuel loading and ladder fuels can easily create crown fire conditions and long range spotting even without the influence of high winds. The potential for smaller fires (100 to 1000 acres) in the proximity of developed areas to create significant threats to adjacent structures increases in probability with the passage of time. It is highly recommended that these areas be thinned with low impact mechanical treatments such as horse logging or feller-bunchers with rubber tires. Residual fuels can be piled for burning or chipping with minimal environmental impact. The process would also have the added benefit of reducing the potential for stand replacement fires and restoring more natural stand basal area and composition.

Urban Exotic (Fuel Model 10)

This fuel type represents areas of dense residential development that have significant amounts of residual native vegetation (primarily oaks and conifers) with the addition of extensive exotic landscaping. This exotic landscaping often includes highly flammable species of trees and shrubs including eucalyptus, pines, redwoods, and junipers along with exotic grasses like bamboo and fountain grass. While this fuel type is not formally a part of any vegetation or fuel type classification system, the extent and distribution of this fuel type situation is significant enough in the Santa Rosa urban interface to warrant its own category within the context of this study. This fuel type represents residential areas at greatest risk from wildland fire within the Santa Rosa interface. A distinctive classification for these areas within the map data in order to identify priority areas for fire prevention, hazard reduction, brush clearance and fire suppression planning activities. Fuel model 10 classification was assigned to these areas because the fire behavior approximates crown fire in heavy, closed canopy timber in interface fire situations.

Image 16. Example of Urban Exotic Fuel Type near Bennett Valley.

This fuel type represents the type of urban interface fuels complex that proved to be deadly and devastating in the Oakland Hills fire in 1991 and the Southern California fires of 2003. Many of the exotic vegetation types are extremely flammable having high concentrations of aromatic oils in their leaves and branches which increase the heat output when the burn. Increased heat levels create intense spotting through convection and fire spread via radiant heat loading. Dense exotic vegetation around a home makes it impossible for firefighters to defend it during an urban interface fire. These types of homes are termed “losers” in the structure triage process undertaken by firefighters during the initial assessment of which homes can be saved and those that can’t be defended without risk to their personal safety. Obviously, it is not possible or desirable to remove all landscape vegetation, but thinning and pruning can significantly reduce risk by creating “defensible space” around homes. Areas identified as being with the Urban Exotic fuel type are areas that need to have focused homeowner education and outreach programs in “Fire Wise” wise landscaping. For more information on these types of programs and strategies employed visit the website of the Firewise organization at (http://www.firewise.org).

Other land classifications within the map data

Agricultural: This land classification is extensive in low elevation areas surrounding Santa Rosa. This classification was assigned to areas that were obviously under cultivation, tree orchards or working vineyards at the time the aerial photographs were taken of the Santa Rosa vicinity. In most situations, these areas would not have sufficient ground fuels to carry fire, although there is anecdotal evidence of vineyards exhibiting extreme fire behavior during dry, windy conditions (Chief C. Hanley, SRFD).

Developed: These areas are represented by large ranches, farms, agricultural operations, large estates or clusters of residential development in the urban interface beyond the city limits of Santa Rosa. The classification includes maintained landscapes that lack natural fuels except for scattered oak or conifers.

Riparian Woodland: Riparian woodlands in the map data are predominantly found within the low valley bottoms of the Santa Rosa urban interface. This vegetation type is not formally classified within fuel classification systems although fuel model 8 (woodland) may be appropriate in some cases. Usually these areas maintain high moisture levels due to their proximity to rivers, washes and streams. Riparian woodlands are depicted in the map data in areas where they are adjacent to wildland fuels that could possibly generate enough radiant heat and spotting to ignite a riparian woodland. Extreme drought conditions would be required for riparian woodlands to contribute to fire spread in the interface. Oaks, sycamores, willow, cottonwood and conifers represent some of the predominant tree species found in riparian woodlands in the Santa Rosa area.

Fire Weather Analysis

Understanding the weather conditions under which wildland fires most frequently occur is a key element in the development of pre-attack strategies and preparedness planning. Wildland fire agencies throughout the world use networks of weather stations to provide statistical analysis of historic weather data and fire occurrence to identify weather conditions under which wildland fires are most likely to occur. This information is used to increase staffing of fire engines, fire prevention patrols, interagency coordination and increase public awareness of fire danger levels. Fire suppression strategic planning requires detailed understanding of the combined factors of current fire weather and fuel conditions. This section will provide a brief analysis of historic fire weather data from the Santa Rosa weather station in order to understand the weather and fuel variables that contribute to wildland fire occurrence. (National Weather Service Station ID : 047965) The Santa Rosa weather station data is part of a nationwide network of weather stations that comprise the National Fire Danger Rating System (NFDRS).

Weather factors influencing the fire environment include temperature, relative humidity, wind speed and precipitation. These weather variables influence the amount of moisture in the ambient environment and determine the fuel moisture component of various fuel types. Temperature functions in drying out fuels making them more available and raises the temperature of the fuel particles closer to the combustion point. Relative humidity changes seasonally and on a diurnal basis depending on weather conditions such as cloud cover, fog or precipitation events. Short term or diurnal changes in relative humidity primarily effect fine fuels such as grass and pine needles on the forest floor. In most fire environments, fuel moisture in live and dead fuels is primarily affected by long term seasonal drying trends.

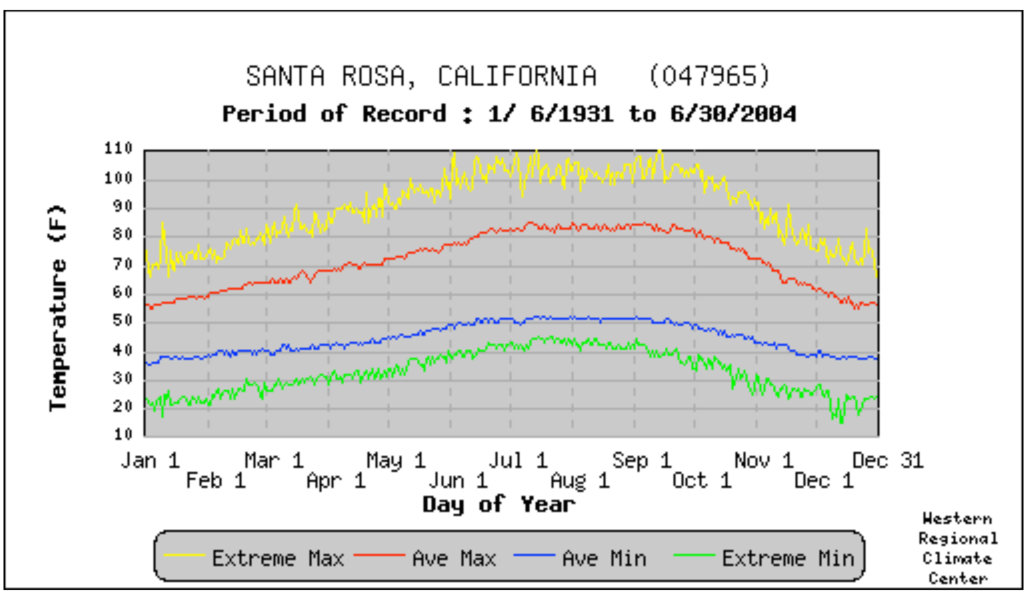
Wind can affect fuel moisture content, primarily in fine dead fuels. Fine fuels have high surface to volume ratios which increase exposure to the drying influence of winds. Larger fuel classes, such as branches and logs have less exposed surface area and consequently have moisture content that is much more affected by seasonal drying trends rather than the short term influence of wind. Wind primarily affects fire behavior by increasing the amount of oxygen available to the combustion process and the rate at which fire spreads through various fuel classes and types.

Santa Rosa Climate Data Summary

Climate conditions in Santa Rosa are characterized by long periods of hot dry weather with very little rainfall and a wet winter season with significant precipitation most years. The average annual temperature of Santa Rosa is 58.1°F. Average summer high temperatures are 71.7 °F, with a maximum high temperature of 110 °F recorded on several occasions in the past 50 years. Winter temperature minimums average 44.4 °F, with a record low of 15°F recorded in 1932 (all weather data in this report is derived from historic records for Santa Rosa stored at the Western Regional Climate Center, NOAA).

Graph 1 depicts the average and extreme temperature variables found within the Santa Rosa weather station period of record, which ranges back to 1931, providing a robust statistical data set. In relation to fire weather conditions, maximum average and extreme temperatures generally occur from June 15th through October 15th. Temperature is an important factor in relation to fuel moisture conditions and fuelbed receptiveness to fire starts, but it should be pointed out that extreme fire behavior can occur in much cooler temperatures under the combined conditions of high wind speed and extreme fuel loading.

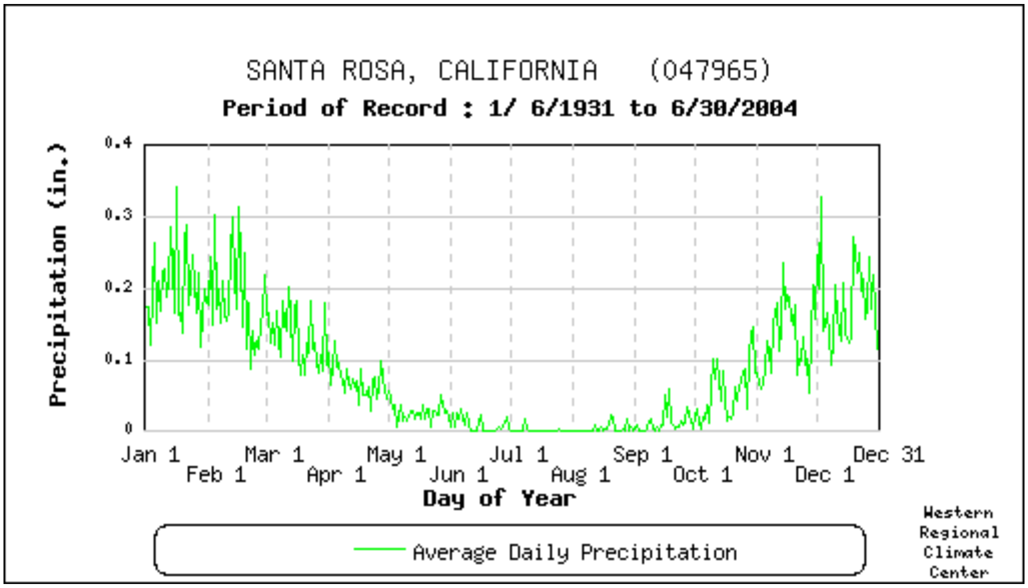
Graph 1. Average and Extreme Temperature Variation for Santa Rosa



Annual precipitation for Santa Rosa averages 30.27 inches. Maximum annual precipitation occurred in

1983 with a total of 63.07 inches. Minimum annual precipitation occurred in 1976 with a total moisture input of 11.38 inches. The maximum one-day total precipitation occurred on December 12th, 1981 with 5.23 inches falling in a 24 hour period.

Graph 2. Average Daily Precipitation Inputs for Santa Rosa



From the graph above, it can be observed that average daily precipitation input closely corresponds to the high average and extreme temperature distribution in the previous temperature graph. The period of June 15th through October 15th is marked by minimal precipitation.

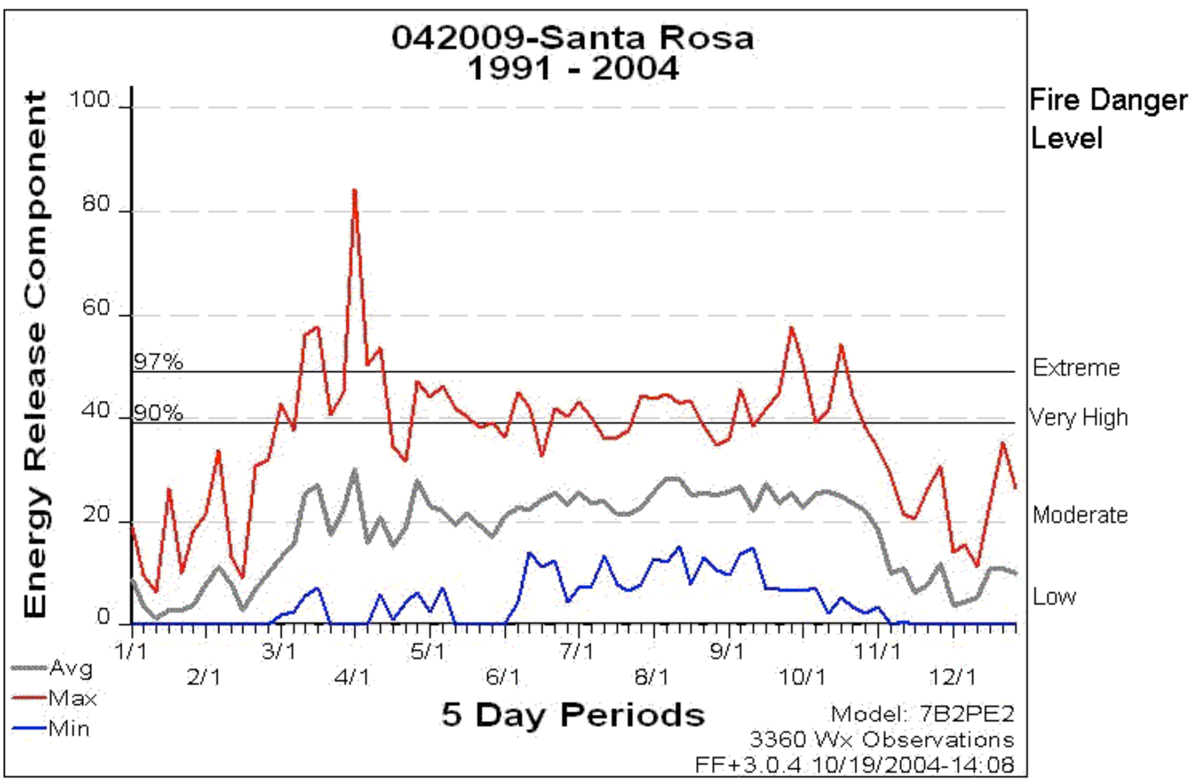
Temperature and precipitation data can be used in statistical fire weather analysis programs to define the most probable periods and environmental conditions under which wildland fires can occur. The most widely used fire weather software analysis program used by wildland fire agencies is called Fire Family Plus. This software uses historic fire weather data to predict annual fire season characteristics and periods of extreme conditions. The software can compare historic fire weather conditions with current weather data to determine fire danger rating levels of various NFDRS indices. The NFDRS indices are used to predict seasonal changes in fire behavior characteristics for purposes of preparedness planning, staffing levels of emergency personnel, fire prevention activities and interagency coordination procedures.

The most common NFDRS indices used by wildland fire agencies to predict fire danger levels are the energy release component (ERC) and the Keetch-Byrum Drought Index (KBDI). ERC is an index that indicates the potential heat output (in BTU's) per unit area (square foot) within the flaming front at the head of a fire. ERC is considered a composite fuel moisture index as it reflects the contribution of all live and dead fuels to potential fire intensity (Anderson, 1988). ERC is a function of the fuel model and live and dead fuel moistures. Fuel loading, woody fuel moistures, and larger fuel moistures all have an influence on the ERC, while the lighter fuels have less influence and wind speed has none. ERC has low variability, and is the best fire danger component for indicating the effects of intermediate to long-term drying on fire behavior

ERC is affected by seasonal temperature and precipitation gradients rather than daily variations in moisture or wind speed inputs.

Graph 3 below depicts historic ERC values for the city of Santa Rosa. The fuel model used in this analysis is Fuel Model B: Chaparral. This model was selected since brush fuels are a significant component of a large percentage of the fuel types found in the Santa Rosa interface, including Montane Hardwood and Montane Hardwood Conifer. Other data runs were completed using other fuel types common in the Santa Rosa area, but were very similar in terms of output. The graph shows that during average fire seasons, extreme fire danger conditions are not attained in the Santa Rosa fire environment. Most years indicate only moderate to high fire danger levels. This data seems to be supported by the recent fire history or lack thereof, in the Santa Rosa Fire Environment. The ERC chart seems to demonstrate that extreme fire weather is somewhat of a rare occurrence, occurring only during exceptionally dry years with drought conditions. It should be noted that the period of record of data in the WIMS / NFMID database only goes back to about 1991, when weather data was first archived in the national computer system, so that it is possible that more extreme fire seasons occurred prior to 1991. In general, the ERC and KDBI indices have proven to be reliable indicators of extreme fire weather conditions throughout the west since they were first introduced despite the limited temporal range of the data sets.

Graph 3. Historic Energy Release Component Index for Santa Rosa (data source: NFMID)

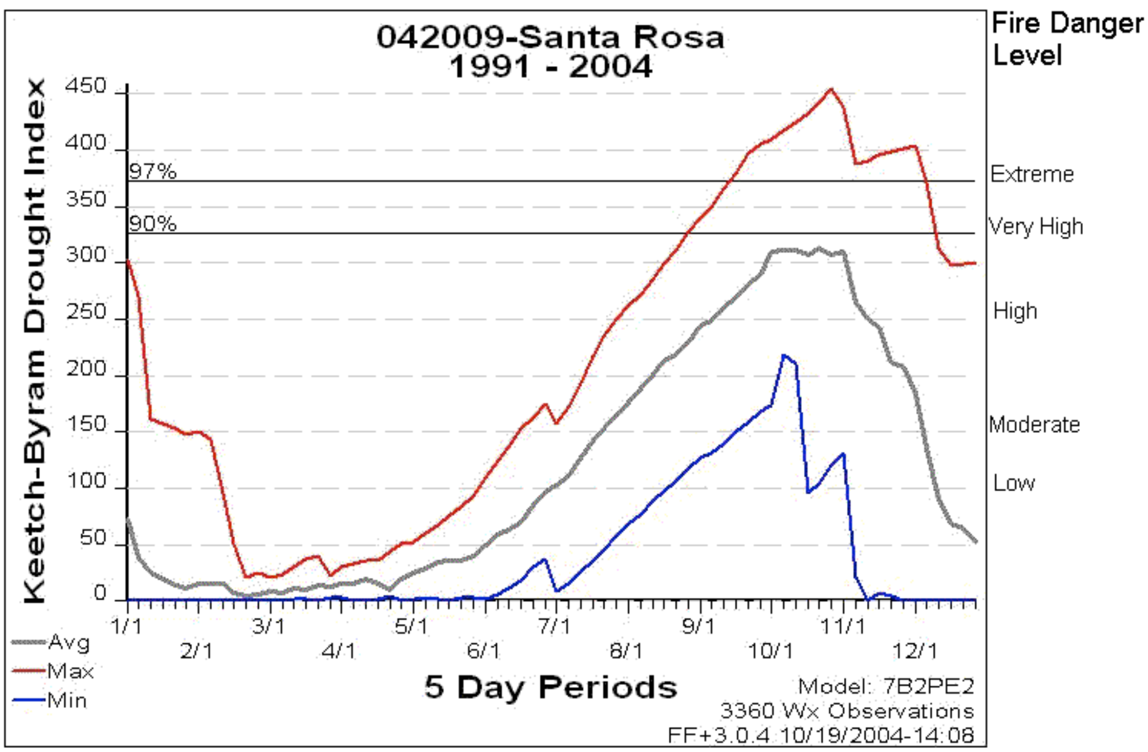


It is interesting to note that the ERC data indicates that extreme ERC levels can be attained early in the annual fire season before greenup in natural vegetation occurs. While early season fires are possible, it could be expected that these fires would be restricted to fine fuels in grassland habitats, with little chance of significant spread.

Another fire behavior variable that is perhaps more indicative of actual fire season conditions within the Santa Rosa fire environment would be the Keetch-Byrum Drought Index (KDBI). KBDI was specifically developed to equate the effects of drought with potential fire activities, is the most widely used drought prediction system use by wildland fire agencies. This mathematical system for relating current and recent weather conditions to potential or expected fire behavior results in a drought index number ranging from 0 to 800. This number accurately describes the amount of moisture that is missing; a rating of 0 defines a point of no moisture deficiency and 800 defines the maximum drought possible.

Prolonged droughts (high KBDI) influence fire intensity since more fuel is available for combustion (i.e. fuels have a lower moisture content). In addition, dry organic material in the soil can lead to increased difficulty in fire suppression. High values of the KBDI are an indication that conditions are favorable for the occurrence and spread of wildfires, but drought is not by itself a prerequisite for wildfires. Other weather factors, such as wind, temperature, relative humidity and atmospheric stability, play a major role in determining the actual fire danger.

Graph 4. Historic Keetch-Byrum Drought Index for Santa Rosa (source NFMID)



The KDBI chart for Santa Rosa (Graph 4) indicates that during average years the drought index barely reaches the very high level. This same pattern was observed previously in the ERC chart. Considering that Santa Rosa receives over 30 inches of precipitation on an average annual basis and is located close to the Pacific Ocean where morning fog often moderates fire danger, these types of outputs could be expected. On average, drought and extreme fire danger levels are not attained in Santa Rosa during most years, but these factors do not entirely preclude the potential for a serious interface fire during any fire season. The Hanly Fire occurred in 1964, when over 26 inches of precipitation were received during the winter and spring preceding the fire, suggesting a wind driven fire supported by heavy fuel accumulations (fire spread was from the northeast and progressed in a southwesterly direction into Santa Rosa).

These charts and associated data must be viewed and understood from the standpoint that the analysis is based on the very limited weather data set that is available in the National Fire Management Information Database (1991-2004). However, some conclusions can be assumed from the data:

1. Extreme fire weather conditions do not develop during most fire seasons.
2. ERC and KDBI charts should be utilized to track the occurrence of extreme drought and fire weather conditions for preparedness planning.
3. Extreme wind events in combination with heavy fuel loading could possibly create conditions for a large interface fire without high fire danger levels or drought conditions.
4. “Red-Flag” fire weather events, especially during the fall, when east winds occur, are the most probable scenario for a large interface fire in Santa Rosa.

Topography and Fire Behavior

Terrain features of slope, elevation and aspect are very influential in the affecting fire spread and intensity. Elevation and aspect affect the type of vegetation and fuels present on any given site. Higher elevations receive more precipitation and have vegetation types that are more commonly associated with moist environments such as woodlands and coniferous forest types. Aspect refers to the direction of exposure of a slope to the drying influence of the sun. South and west facing slopes receive most direct solar exposure and tend to be much drier than east and north facing slopes. South and west aspects being much drier support more sparse, drought tolerant species such and annual grasses and brush fuel types.

Slopes affect fire behavior by conducting radiant heat upslope of the fire, pre-heating the fuels. Pre-heating dries out the upslope fuels, raising the fuel temperature to combustible levels, often releasing flammable chemicals as hot gases, which can create rapid, uphill spread of the fire through the canopy of the fuels. These upslope crown fires are extremely fast moving, and are virtually impossible to stop from a suppression standpoint. Many firefighters have been fatally injured by fast spreading, upslope crown fires.

Fortunately, most of the urban interface of Santa Rosa is down slope of the steep topography that surrounds the city (Map 10). However, it should be recognized that extensive numbers of homes, ranches, farms and estates are located in the steep topography surrounding the city of Santa Rosa. Many of these developments and access roads are located on mid-slope terrain that would be subject to extreme fire behavior during an interface fire. Evacuation and structural protection would be very dangerous and difficult in these areas for the fire agencies and emergency services. Any evacuation plan for these areas should consider the potential for evacuees to become trapped on the winding roads that lead down to safe areas. Shelter in place strategies and safety zones should be identified and communicated to residents of these areas as part of a pre-incident planning process.

It would seem that being down slope of heavy fuel accumulations would provide some margin of safety from interface fires for the city of Santa Rosa. However, the down slope location of the city of Santa Rosa is remarkably similar to the topographic configuration of areas that have experienced historic urban interface fires over the past several decades. Areas with similar topography have familiar names in the annals of historic California wildland urban interface fires: Oakland Hills, San Diego, Malibu and Santa Barbara to name a few. Topography has significant influence on the fire behavior of wind driven fires. Canyons and slopes increase fire spread rate and intensity by funneling winds much like water in a stream.

Despite the down slope configuration in interface topography, wind driven fires will spot far ahead of the fire front. Wind driven embers, often falling a mile or more ahead of the fire front, start spot fires in steep canyons with heavy fuels. As the spot fires grow in size, they coalesce into large, rapidly spreading uphill runs. Combined with slope pre-heating of heavy fuels, these fires create extreme fire intensity with intense convection columns of smoke and flames that can carry embers and firebrands well beyond the interface into the densely developed areas.

Potential Urban Interface Fire Scenarios:

It should be noted that while standard fuel models were utilized within the map attribute data to describe fuel conditions in the interface of Santa Rosa, the actual fire behavior encountered in an interface fire situation may be much more extreme than predicted by the mathematical models. Standard fuel models (Fire Behavior Prediction System or Behave) only model fire spread through surface fuels. Most interface fires occur during extreme wind events accentuated by crown fires in heavy fuels. There are crown fire prediction models such as *Nexus* (USFS), but these programs require extensive fuel load and canopy sampling techniques that are labor intensive to provide data for the model (Reinhardt and Scott, 2001). For purposes of this analysis it may be most important to understand that an extreme urban interface fire in Santa Rosa will be characterized by rapid spread rates, crown fires, long range spotting, extreme radiant heat and flame lengths exceeding 100 feet. In these types of fires, fire suppression capabilities to suppress the fire are limited at best. It is important to recognize the conditions which precede these types of fires (wind events or extreme drought) and employ structural defense tactics and evacuation procedures early in the incident planning process.

With the heavy fuel loading and steep slopes found in the interface of Santa Rosa it should be recognized that the potential exists for smaller fires under less than extreme weather conditions to create a significant interface fire within localized areas. In these situations, small fires making uphill runs in grass, brush or timber can threaten dozens of structures. While maintaining a vigilant and capable suppression capability is a critical component of emergency response, the best defensive tactic that can be employed is to reduce hazard fuel accumulations and create defensible space around structures by mechanically thinning and disposing slash. Hazard fuel reduction and creating defensible space around structures has been identified on numerous occasions as the primary factor in structure survival during interface fires. An excellent example of this type of fuels reduction in the Santa Rosa area is the Fountain Grove Master Ranch Association project. Photographs of the project can be found on the Sonoma County Firewise website (http://www.firesafesonoma.org). Excellent information and links for homeowner information regarding the creation of defensible space can be found on this website.

Map 10.


Santa Rosa Slope and Topography
Legend
Slope Percent
<VALUE>
0 - 10
10 - 20
20 - 30
30 - 40
40 - 100 >
Santa Rosa City Boundary
0
0.5
1
2
3 Miles

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Appendix B. Vegetation Communities and Major Species Components

Annual Grassland

Coast Live Oak	*Quercus agrifolia*
Black Oak	*Quercus kelloggii*
California Bay Laurel	*Umbellularia californica*
Pacific Madrone	*Arbutus menziesii*
Canyon Oak	*Quercus chrysolepis*
Valley Oak	*Quercus lobata*
Blue Oak	*Quercus douglasii*
Tan Oak	*Lithocarpus densiflorus*
Big Leaf Maple	*Acer macrophyllum*
Coyote Brush	*Baccharis pilularis*
Scotch Broom	*Cytisus scoparius*
Chamise	*Adenostoma fasciculatum*
Scrub Oak	*Quercus dumosa*
Poison Oak	*Toxicodendron diversilobum*
Coffeeberry	*Rhamnus californica*

Brush / Chaparral

Scrub Oak	*Quercus dumosa*
Coyote Brush	*Baccharis pilularis*
Chamise	*Adenostoma fasciculatum*
Manzanita	*Arctostaphylos manzanita*
Mountain Mahogany	*Cercocarpus betuloides*
Coffeeberry	*Rhamnus californica*
Scotch Broom	*Cytisus scoparius*
Pinon Pine	*Pinus sp.*
Gowen Cypress	*Cupressus goveniana*
Canyon Oak	*Quercus chrysolepis*
Juniper	*Juniperus californica.*
Toyon	*Heteromeles arbutifolia*

Manzanita Cypress

Manzanita	*Arctostaphylos manzanita*
Scrub Oak	*Quercus dumosa*
Juniper	*Juniperus californica*
Chamise	*Adenostoma fasciculatum*
Toyon	*Heteromeles arbutifolia*
MacNab Cypress	
Sargent Cypress	

Oak Woodland

Coast Live Oak	*Quercus agrifolia*
Black Oak	*Quercus kelloggii*
Canyon Oak	*Quercus chrysolepis*
Valley Oak	*Quercus lobata*
Blue Oak	*Quercus douglasii*
Tan Oak	*Lithocarpus densiflorus*
California Bay Laurel	*Umbellularia californica*
Douglas Fir	*Pseudotsuga menziesii*
Pacific Madrone	*Arbutus menziesii*
Big Leaf Maple	*Acer macrophyllum*
Poison Oak	*Toxicodendron diversilobum*
Toyon	*Heteromeles arbutifolia*

Montane Hardwood

Coast Live Oak	*Quercus agrifolia*
Black Oak	*Quercus kelloggii*
Canyon Oak	*Quercus chrysolepis*
Tan Oak	*Lithocarpus densiflorus*
California Bay Laurel	*Umbellularia californica*
Douglas Fir	*Pseudotsuga menziesii*
Pacific Madrone	*Arbutus menziesii*
Big Leaf Maple	*Acer macrophyllum*
California Buckeye	*Aesculus californica*
Incense Cedar	*Calocedrus decurrens*
Gowen Cypress	*Cupressus goveniana*
Redwood	*Sequoia sempervirens*
White Fir	*Abies concolor*
Juniper	*Juniperus californica*
Manzanita	*Arctostaphylos manzanita*
Valley Oak	*Quercus lobata*
Blue Oak	*Quercus douglasii*
Red Alder	*Alnus rubra*

Box Elder	*Acer negundo*
Oregon Ash	*Fraxinus latifolia*
Cottonwood	*Populus fremontii*
Willow	*Salix sp.*
California Black Walnut	*Juglans californica*
Pine	*Pinus sp.*
Spruce	*Picea sp.*
Blue Gum Eucalyptus	*Eucalyptus globules*
Sycamore	*Platanus racemosa*
Western Redbud	*Cercis occidentalis*
Coyote Brush	*Baccharis pilularis*
Scotch Broom	*Cytisus scoparius*
Silk Tassle	*Garrya elliptica*
Toyon	*Heteromeles arbutifolia*
Hazelnut	*Corylus cornuta*
Poison Oak	*Toxicodendron diversilobum*
Oleander	*Nerium oleander*
Pepper Tree	*Schinus sp.*
Mountain Mahogany	*Cercocarpus betuloides*
Salmonberry	*Rubus spectabilis*
Blackberry	*Rubus ursinus*
Buck Brush	*Ceanothus cuneatus*

Montane Hardwood-Conifer

Douglas Fir	*Pseudotsuga menziesii*
Coast Live Oak	*Quercus agrifolia*
Black Oak	*Quercus kelloggii*
California Bay Laurel	*Umbellularia californica*
Pacific Madrone	*Arbutus menziesii*
Big Leaf Maple	*Acer macrophyllum*
California Black Walnut	*Juglans californica*
California Buckeye	*Aesculus californica*
Canyon Oak	*Quercus chrysolepis*
Valley Oak	*Quercus lobata*
Blue Oak	*Quercus douglasii*
Tan Oak	*Lithocarpus densiflorus*
Incense Cedar	*Calocedrus decurrens*
Redwood	*Sequoia sempervirens*
White Fir	*Abies concolor*
Juniper	*Juniperus californica*
Manzanita	*Arctostaphylos manzanita*
Red Alder	*Alnus rubra*
Box Elder	*Acer negundo*
Oregon Ash	*Fraxinus latifolia*
Cottonwood	*Populus fremontii*

Willow	*Salix sp.*
Pine	*Pinus sp.*
Spruce	*Picea sp.*
Blue Gum Eucalyptus	*Eucalyptus globules*
Sycamore	*Platanus racemosa*
Western Redbud	*Cercis occidentalis*
Coyote Brush	*Baccharis pilularis*
Scotch Broom	*Cytisus scoparius*
Silk Tassle	*Garrya elliptica*
Toyon	*Heteromeles arbutifolia*
Hazelnut	*Corylus cornuta*
Poison Oak	*Toxicodendron diversilobum*
Oleander	*Nerium oleander*
Pepper Tree	*Schinus sp.*
Mountain Mahogany	*Cercocarpus betuloides*
Salmonberry	*Rubus spectabilis*
Blackberry	*Rubus ursinus*
Buck Brush	*Ceanothus cuneatus*

Coniferous Forest

Douglas Fir	*Pseudotsuga menziesii*
Tan Oak	*Lithocarpus densiflorus*
California Bay Laurel	*Umbellularia californica*
Black Oak	*Quercus kelloggii*
Coast Live Oak	*Quercus agrifolia*
Redwood	*Sequoia sempervirens*
California Black Walnut	*Juglans californica*
California Buckeye	*Aesculus californica*
Incense Cedar	*Calocedrus decurrens*
Pacific Madrone	*Arbutus menziesii*
Big Leaf Maple	*Acer macrophyllum*
White Fir	*Abies concolor*
Pine	*Pinus sp.*
Spruce	*Picea sp.*
Western Redbud	*Cercis occidentalis*
Braken Fern	*Pteridium aquilinum*
Sword Fern	*Polystichum californicum*
Buck Brush	*Ceanothus cuneatus*
Salmonberry	*Rubus spectabilis*
Blackberry	*Rubus ursinus*
Poison Oak	*Toxicodendron diversilobum*
Silk Tassle	*Garrya elliptica*
Toyon	*Heteromeles arbutifolia*
Hazelnut	*Corylus cornuta*

Riparian Woodland

California Bay Laurel	*Umbellularia californica*
Red Alder	*Alnus rubra*
Pacific Madrone	*Arbutus menziesii*
Big Leaf Maple	*Acer macrophyllum*
Box Elder	*Acer negundo*
Oregon Ash	*Fraxinus latifolia*
Cottonwood	*Populus fremontii*
Willow	*Salix sp.*
Salmonberry	*Rubus spectabilis*
Blackberry	*Rubus ursinus*
California Black Walnut	*Juglans californica*
California Buckeye	*Aesculus californica*
Blue Gum Eucalyptus	*Eucalyptus globules*
Sycamore	*Platanus racemosa*