Appendix C

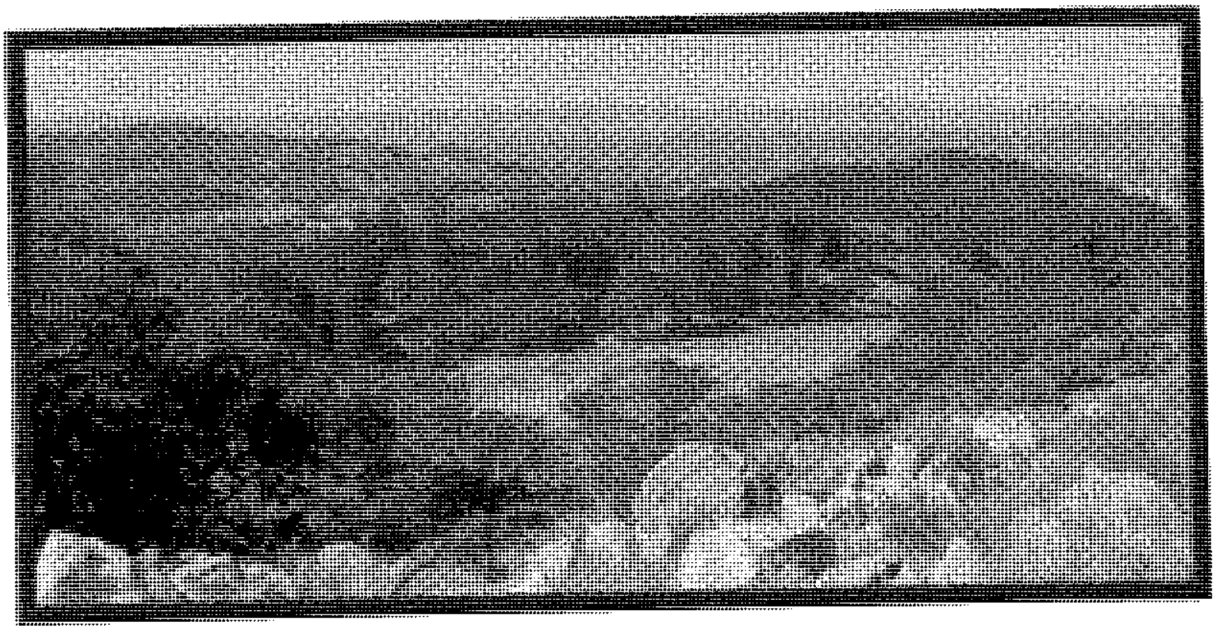
Santa Rosa Wildland Urban Interface

Hazard Fuel Risk Assessment

City of Santa Rosa, California

February, 2016: Santa Rosa Fire Marshal Scott Moon notes that, though the information in this Assessment is dated, it is still valid.

Wildland Urban Interface Hazard Fuel Risk Assessment: City of Santa Rosa, California



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October, 2004

List of Maps, Figures, Graphs and Tables

Santa Rosa Wildland Urban Interface Fire Risk Assessment

1. Executive Summary – Project Objectives

The primary objective of the risk assessment was to develop a highly detailed Geographic Information System (GIS) mapping analysis of the spatial distribution and composition of vegetation communities and fuel types that comprise the "Wildland Urban Interface" of the city of Santa Rosa. The wildland urban interface (WUI) is defined as an area where flammable brush or forest are located adjacent to or are intermingled with homes, businesses and other infrastructure development. The GIS map data presented in this analysis is summarized within this report to assist in the development of strategies and initiatives for hazard fuel reduction, homeowner education programs and fire suppression strategies within and surrounding the city of Santa Rosa.

Over the last decade, numerous communities throughout the west have been devastated by extreme wildland fires that have destroyed thousands of homes, damaged public infrastructure, disrupting private business, costing hundreds of millions of dollars in property damage, suppression and rehabilitation costs. Unfortunately, the human cost has been a high price to pay as well, with thousands of injuries and scores of fatalities among firefighters trying to save homes and citizens trapped by these infernos.

The city of Santa Rosa is located within the same fire environment that witnessed one of the most disastrous interface fires in history, the Oakland Hills fire of 1991. Thousands of homes and over 25 lives were lost in a single day. The vegetation communities that surround Santa Rosa to the north, east and south are similar in fuel type classification to those that burned in the Oakland Hills. In addition, many areas surrounding Santa Rosa have fuel types and dead fuel loading that are even more hazardous than those present during the Oakland Hills Fire. These areas contain coniferous forest, woodland and chaparral fuel types, which have not burned in over sixty years, creating excessive levels of dead fuel loading (dead logs, branches and forest debris). Excessive accumulations of dead fuels is one of the primary factors that contribute to the development of the extreme fire behavior, crown fire and long range spotting, which often characterize wildland fire in the urban interface.

Decades of research, analysis and experience has demonstrated that there are actions that communities can take to mitigate and prepare for the inevitability of an urban interface fire. One aspect of preparing for an interface fire involves the development of a pre-incident plan. The pre-incident planning process incorporates the shared input of local fire and police agencies, emergency coordination centers, community service organizations (Red Cross, humane society etc.) and public utility providers to facilitate communication and coordination during an interface fire. Critical elements of the pre-incident plan include the development of evacuation procedures and responsibilities, structural protection strategies, fire suppression operations and restoration of public services. An essential component of pre-incident plans is the development of information which analyzes the magnitude of fire potential (hazard fuel distribution), where it poses the greatest threat (interface risk prioritization) and the circumstances under which that risk occurs (fire weather analysis). These intelligence inputs can be utilized to increase force preparedness levels in city emergency services when the situation warrants, based upon knowledge of environmental factors related to the probabilities of extreme fire behavior.

The pre-incident planning process, along with hazard reduction strategies and homeowner outreach programs to promote fire prevention and "Firesafe" communities, are the core elements of a comprehensive Community Wildfire Protection Plan (CWPP). The development of a CWPP is prerequisite for local fire agencies to qualify for assistance in the implementation of strategies defined in the planning process under the provisions of the California State Fire Plan (California Department of Forestry, 2003) and the National Fire Plan (National Interagency Fire Center, 2000).

This report and associated GIS fuels mapping data provide an important first step in the development of a CWPP by identifying specific areas at risk to wildland fire within and adjacent to the city of Santa Rosa. In addition, the data in this report comprise a significant component of the requirement for municipalities to identify natural hazards under the provisions of the Disaster Mitigation Act of 2000 (DMA 2000). The development of a CWPP is a collaborative process involving public, governmental and private partnerships that include local, state and federal cooperators, emergency service agencies, community organizations, homeowner groups, private and public utilities and individual citizens.

Following the historic fire season of 2000, federal wildland fire agencies implemented the National Fire Plan. The National Fire Plan outlined a comprehensive strategy with a commitment to funding "Hazardous Fuel Reduction" programs and "Community Assistance/Community Protection Initiatives." As part of the implementation of the National Fire Plan, each state was required to identify specific "communities at risk" from wildland fire. This assessment was a collaboration of wildland fire specialists from federal, state and local agencies. The assessment analyzed specific local environmental factors that contribute to interface risk including fuel types, fire weather, and topography, structures at risk and fire history. The National Fire Plan analysis identified the communities of Santa Rosa, Bennett Valley and Oakmont as being in the highest risk category (Level 3) which is the highest level of hazard ranking for a community at risk (http://www.cafirealliance.org/communities_at_risk_a-d.php).

2. Lessons Learned from the Southern California Fires of 2003

In relation to the content and objectives of this report, it would be useful to examine some of the findings and recommendations of the post-fire reviews conducted following the southern California fires of 2003. During late October and early November of 2003, 14 major fires burned over 750,000 acres with the loss of 24 lives and the destruction of over 3,710 homes. These fires were not the typical fall "Santa Ana" wind driven fires. Although shifting winds were a factor, most fire commanders noted that the fires ferocity was due to excessive fuel loading that created extreme thermal updrafts and fire whirls with long-range spotting as far as a mile ahead of the fires.

Extensive interviews with fire commanders and firefighters who were on scene during the firestorms are contained in a report titled "Southern California Firestorm 2003" which was developed by the National Advanced Resource and Technology Center in Tucson, Arizona (http://www.wildfirelessons.net/ICTs/LLCICT_SoCa_Final_Report_121903.pdf). The objective of this report was to gather as much information as possible as to what actions and strategies worked during the fire siege and what things went wrong, in order to provide insight to fire agencies and communities on how to prepare for such an event in the future. Below are some of the more pertinent statements and findings of the report that relate to the urban interface risk situation in Santa Rosa.

Lessons Learned: Interface Fire Behavior

- Extreme fire behavior resulted from a convergence of extended drought, fuel conditions, hot and dry weather, and wind.

- After extending into the urban environment, fires often split into multiple heads and spread along paths defined by the available fuel sources. Fires spread over and around barrier after barrier.

- Fires burned beyond the wildland-urban interface into urban environs with little or no wildland fuels.

- Fires spread from structure to structure—an urban conflagration.

- Ornamental vegetation, such as palms, juniper, eucalyptus and pine ignited producing intense ember showers and more spotting.

Lessons Learned: Pre-Incident Planning

- Most of the critical data to support strategic and tactical decision-making existed in pre attack planning documents.

- Many leaders rated the integration of pre-incident planning information as an area for needing improvement using or developing a GIS-map based system.

- Where pre-incident planning information was available it was rated it as invaluable.
Pre-attack planning documents include maps of fuel types, fire history, structure location and triage information regarding defensibility, evacuation routes and sites, staging areas, helispots, and water sources.

- Pre-incident planning was essential to effective evacuation compared to those areas that did not conduct extensive pre-incident planning

- Use the pre-incident planning process to select locations throughout operational jurisdiction for ICP's, Staging Areas, Helispots and Evacuation Centers.

Lessons Learned: Evacuation

- Route control planning was an important part of evacuation. Poor planning resulted in clogged ingress/egress routes and lesser priority evacuations blocking the routes of high priority evacuations.

- In planned evacuations, evacuations were based on pre-established trigger points. Law enforcement moved to known choke points and controlled routes with one-way traffic restrictions and keeping certain streets clear for firefighting equipment.

- Incorporating agencies that manage evacuees into the interagency planning process was effective in ensuring a smooth handoff from firefighters and law enforcement to supporting agencies like the Red Cross.

Lessons Learued: Defensible Space and Hazard Fuel Treatments

- Communities with defensible space and hazard fuel treatments suffered much less structural loss than those without any type of hazard reduction program.

- Newer houses constructed of stucco and sealed eaves with reduced ladder fuels and cleared defensible space survived better than new homes in areas with less restrictive building codes. In one area, over 90% of the homes lost (over 700) had wood shingle roofs.

- Older houses in urban neighborhoods with dense ornamental vegetation and palm trees were also at risk.

- In wildland areas, it proved critical for natural resource agencies to focus their limited resources on priority projects. As one respondent put it, "Six or eight projects, 10 to 100 acres in size made a difference on this fire because they were in key areas. We need to focus on treating fuels around the structures".

- In wildland areas, the quality and placement of fuel treatments—not gross acres treated—mattered most. In some cases, five acres treated in the right spot saved a community.

3. Findings and Recommendations:

This report and associated GIS vegetation and fuels data is detailed with extensive supporting documentation related to the analysis of hazard fuels in the Santa Rosa Wildland Urban Interface and site-specific recommendations for mitigation of that risk. The site-specific recommendations are based upon the synthesis of environmental factors in the Santa Rosa interface that generate conditions of extreme risk related to wildland fire. These environmental factors include hazard fuels (natural and ornamental vegetation), weather conditions, topography, fire history and proximity of structures to hazardous fuels. Subsequent sections of this document provide analysis of these factors as they relate to the specific situation in the Santa Rosa interface and the methodology by which they were derived. The findings and maps presented in this section identify communities within the Santa Rosa interface at greatest risk to wildland fire and site-specific recommendations for hazard fuel treatments and defensible space programs.

The scope of GIS mapping for this project covered over 45,000 acres of wildland hazard fuels within an area defined by a 2 mile buffer zone around the city of Santa Rosa. Within the GIS data sets for this project there are over 1500 vegetation polygons that were interpreted from high-resolution aerial photography and classified based upon the characteristics of various vegetation communities, fuel types and hazard risk factors in the Santa Rosa urban interface. Detailed information regarding the specific methodology of how the GIS mapping data was derived, interpreted and verified is contained in Section 4 of this document.

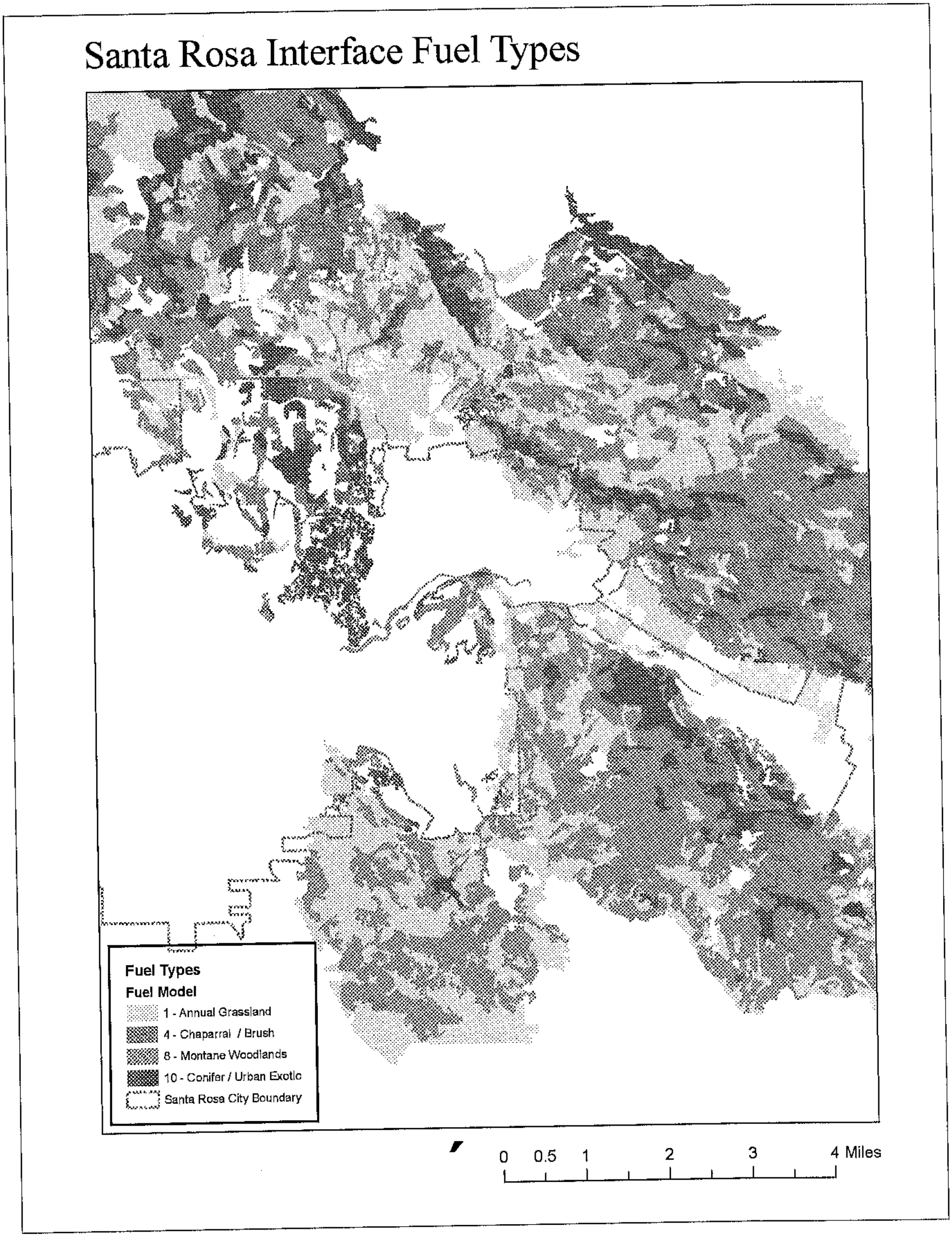
Within this section the GIS map data has been refined to depict areas that have the most serious wildland fire risk in the Santa Rosa interface. These areas were determined to be at most risk based on analysis of past fire history, hazard fuel distribution, fire weather data, topographic factors and the proximity of high-density residential development to hazardous fuels.

To preface the interface discussion, please refer to Map 1. Santa Rosa Interface Fuel Types. This map depicts the spatial extent and distribution of various fuel types in the Santa Rosa interface based upon classification of grass, brush, woodland and coniferous forest vegetation communities. Fuel types are based on fuel models which are used in fire behavior prediction software 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 rate, flame length and spotting potential within various grass, brush, woodland and timber fuel types. For more detailed information on fuel types and fuel model selection please refer to Section 5 of this document.

The hazard fuel reduction treatment techniques referred to in this report and GIS data are limited to "mechanical treatments". Mechanical treatments involve the use of various types of mechanical equipment that can thin brush, woodland and timber fuels. These include chainsaws operated by loggers or fire crews, mechanical tree harvesters, log skidders and wood chippers. The strategy involves reducing both the horizontal and vertical continuity of vegetation in order to decrease the potential of crown fires and keep fire within surface fuels where it is less of a threat to nearby structures and more easily controlled by fire suppression forces. The technique can be applied in an aesthetic manner, retaining the natural qualities of the vegetation community by selectively removing shrubs and trees, leaving behind the most healthy and vigorous specimens. The reduction in stand density is beneficial in terms of reducing competition between individual shrubs or trees, creating healthy stands that are more resistant to insect and disease infestations. Wildlife species benefit from the openings created within the stands, promoting herbaceous understory growth which provides nutritious browse and seed sources. Soil disturbance is a short term impact that can be minimized through the utilization of rubber tired mechanical harvest equipment and areas of disturbance can be rehabilitated after the thinning operation. Slash and harvest residue can be chipped on site or removed for mulching operations. In areas of extensive treatment residue, pile burning can be safely conducted during winter rains. The use of prescribed fire in the Santa Rosa interface is otherwise not recommended due to potential problems associated with escaped fires close to residential development and smoke impacts on local air quality.

Site-specific recommendations for hazard fuel reduction are made solely based upon consideration of the potential threats to adjacent structures. It is recognized that various land ownership and land management constraints exist based upon various jurisdictions and boundaries. Development of a cohesive management strategy as described in the State and National Fire Plan requires the collaboration and cooperation of landowners, local government and land management agencies.

Map 1.


Santa Rosa Interface Fuel Types
Fuel Types
Fuel Model
1 - Annual Grassland
4 - Chaparral / Brush
8 - Montane Woodlands
10 - Conifer / Urban Exotic
Santa Rosa City Boundary
0 0.5 1 2 3 4 Miles

Santa Rosa Interface Hazard Reduction Priorities

Identification of hazard reduction priorities within the Santa Rosa interface was derived from the fuel type map and is classified by two categories within the map attribute data that relate to treatment strategies.

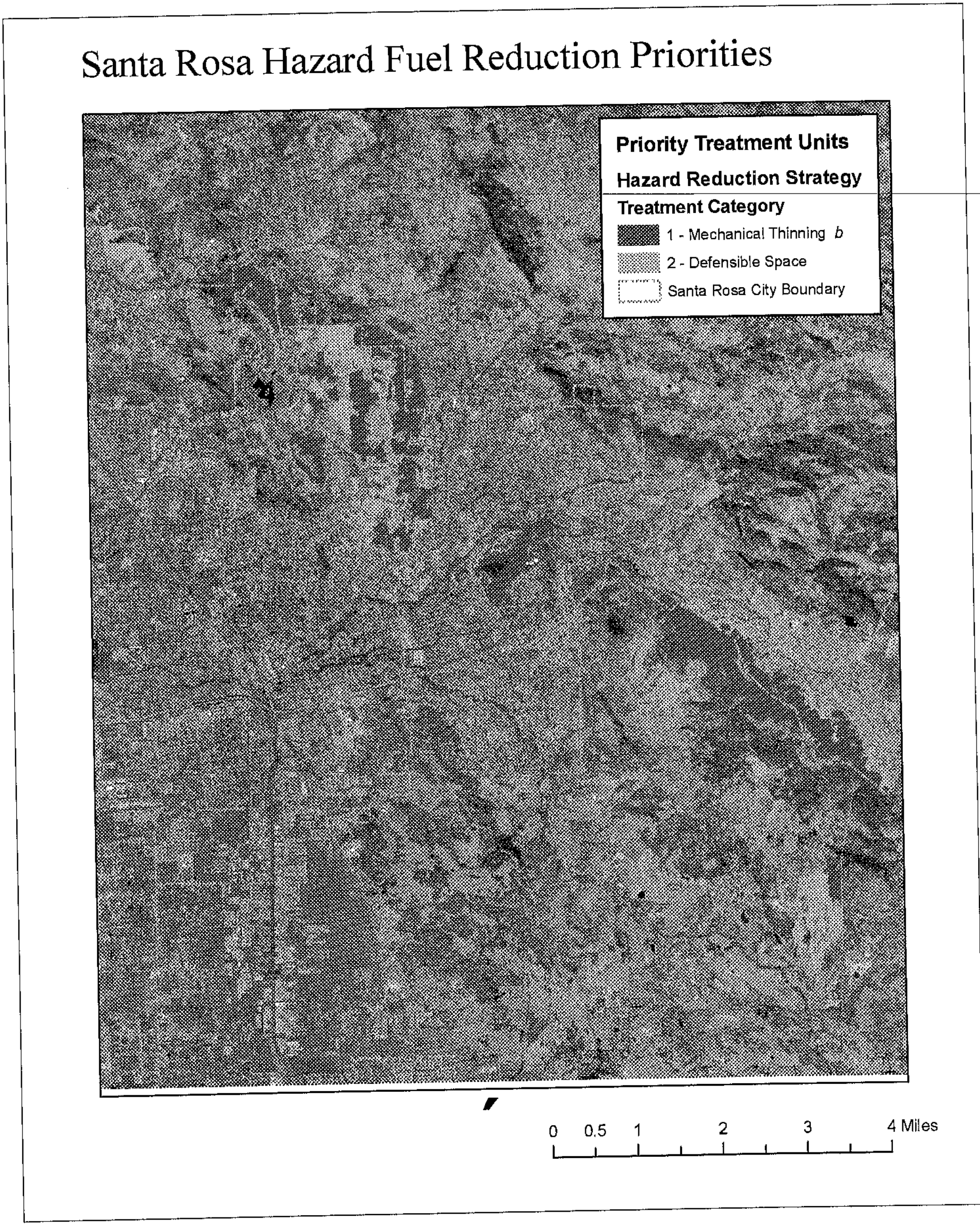
Category 1 (Mechanical Thinning): Natural and contiguous stands of brush, woodland or conifer forest adjacent or proximal to high- density residential development. These areas are the highest priority for fuels reduction projects within the Santa Rosa interface.

Category 2 (Defensible Space): Areas of residential development that have dense accumulations of natural and exotic vegetation intermingled with structures. These areas are designated as "Urban Exotic" within the vegetation community map (Map 9.) and are designated as Fuel Model 10 on the fuels map. These areas represent high priorities for homeowner education and outreach programs regarding the creation of defensible space around homes, which is a critical component of reducing the risk of wildland fire within the Santa Rosa interface. These areas should be intensively surveyed by structural protection specialists in order to develop recommendations for individual homeowners in creating defensible space. In some instances, more extensive, contiguous stands of fuels within the residential areas may be identified and treated with mechanical thinning operations.

Map 2. Santa Rosa Hazard Fuel Reduction Priorities provides an overview of the most critical areas at risk in relation to wildland fire in the interface. Red shaded areas are stands of "Category 1" fuels where mechanical treatment strategies should be implemented to reduce hazard fuels. Orange shaded areas represent areas of high density residential development with significant levels of natural and exotic fuels to warrant implementation of "Defensible Space" strategies. These areas may require more selective fuel reduction techniques of using hand labor to thin and prune trees around structures.

The category 1 and 2 areas depicted in Map 2 were derived from careful consideration of all factors that constitute fuel risk in the interface including fuel types, fire weather conditions, topography and proximity to residences. Most of the areas not shaded on the aerial image within the interface are buffered from heavy fuels by annual grassland. While annual grasslands do present significant risk to structures in interface fires, treatment techniques are more simplified and generally involve mowing or creating fuelbreaks in strategic locations.

Map 2.


Santa Rosa Hazard Fuel Reduction Priorities
Priority Treatment Units
Hazard Reduction Strategy
Treatment Category
1 - Mechanical Thinning b
2 - Defensible Space
Santa Rosa City Boundary
0 0.5 1 2 3 4 Miles

Critical Area Discussion:

This section will examine the three most critical areas for hazard fuel reduction within the Santa Rosa interface. These areas are Fountain Grove – Montecito, Oakmont and Bennett Valley. Discussion will include detailed map analysis of each area, identification of the most important units to be treated by polygon ID number, fuel type and acres to be treated.

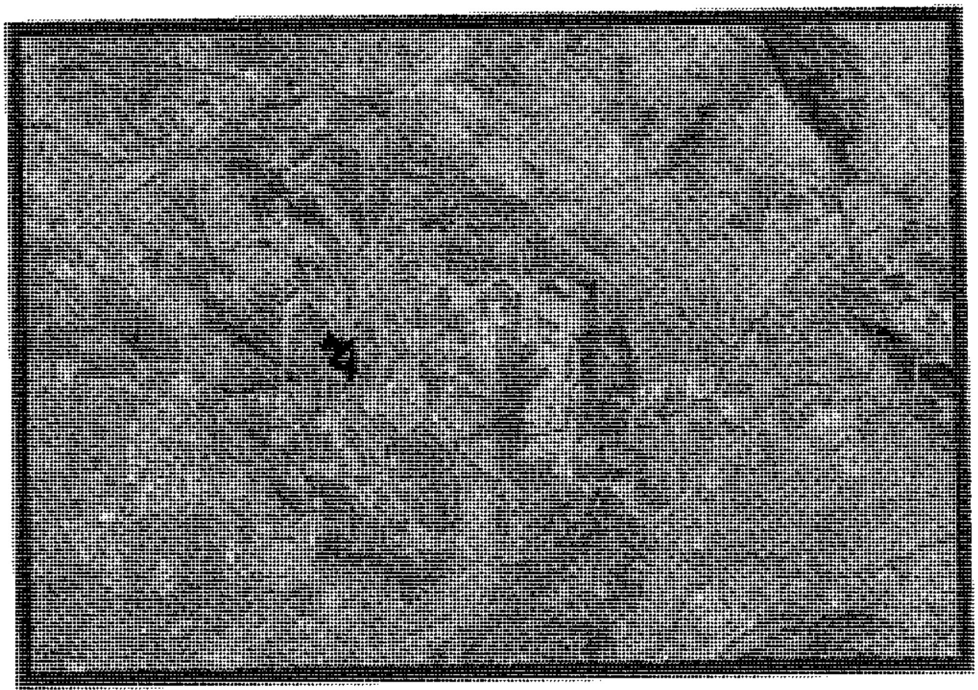
Fountain Grove – Montecito

Without question, the most critical areas at risk in terms of potential interface fire severity are the Fountain Grove – Montecito communities. The Fountain Grove community lies at the top of a ridge which extends from the northern city limits and extends southward for about two miles through the Montecito area (Image 1). Fountain Grove is surrounded by steep slopes with extensive natural fuels, primarily conifer forest and montane hardwood types. Some slopes on the west side of Fountain Grove have well developed brush fuel types. The combination of steep slopes with heavy fuels adjacent to dense residential development creates an interface situation of very high risk.

Image 1. View of the east side of Fountain Grove from above the Rincon Valley.

The last major fire occurring in the Santa Rosa area was the Hanly Fire, which occurred on September 9th, 1964. The Hanly fire covered an estimated 55,000 acres and burned well within the current boundaries of the city, including areas of Fountain Grove (Image 2). The pattern of the Hanly fire perimeter suggests that the fire was driven by "katabatic" or downhill winds. These types of east winds are typical of fire weather conditions throughout coastal California and often described as Chinook, Diablo or Santa Ana winds. These wind patterns develop when cool, low pressure systems move cold air masses across coastal mountain ranges, and increase in wind speed as they flow into low valleys vacated by rapidly rising warm air in coastal areas. The east winds are further accelerated by topographic factors of steep slopes and canyons which channel the cool air much like water accelerates in tight river channels. These winds often reach speeds of 40 to 60 miles per hour and account for the atypical pattern of rapid downhill fire spread that characterizes fall fires in California.

Image 2. Hanly Fire in relation to the current boundary of north Santa Rosa. (Source data: CDF and City of Santa Rosa Information Services. Red – Hanly Fire Perimeter / Green – Santa Rosa Boundary.)

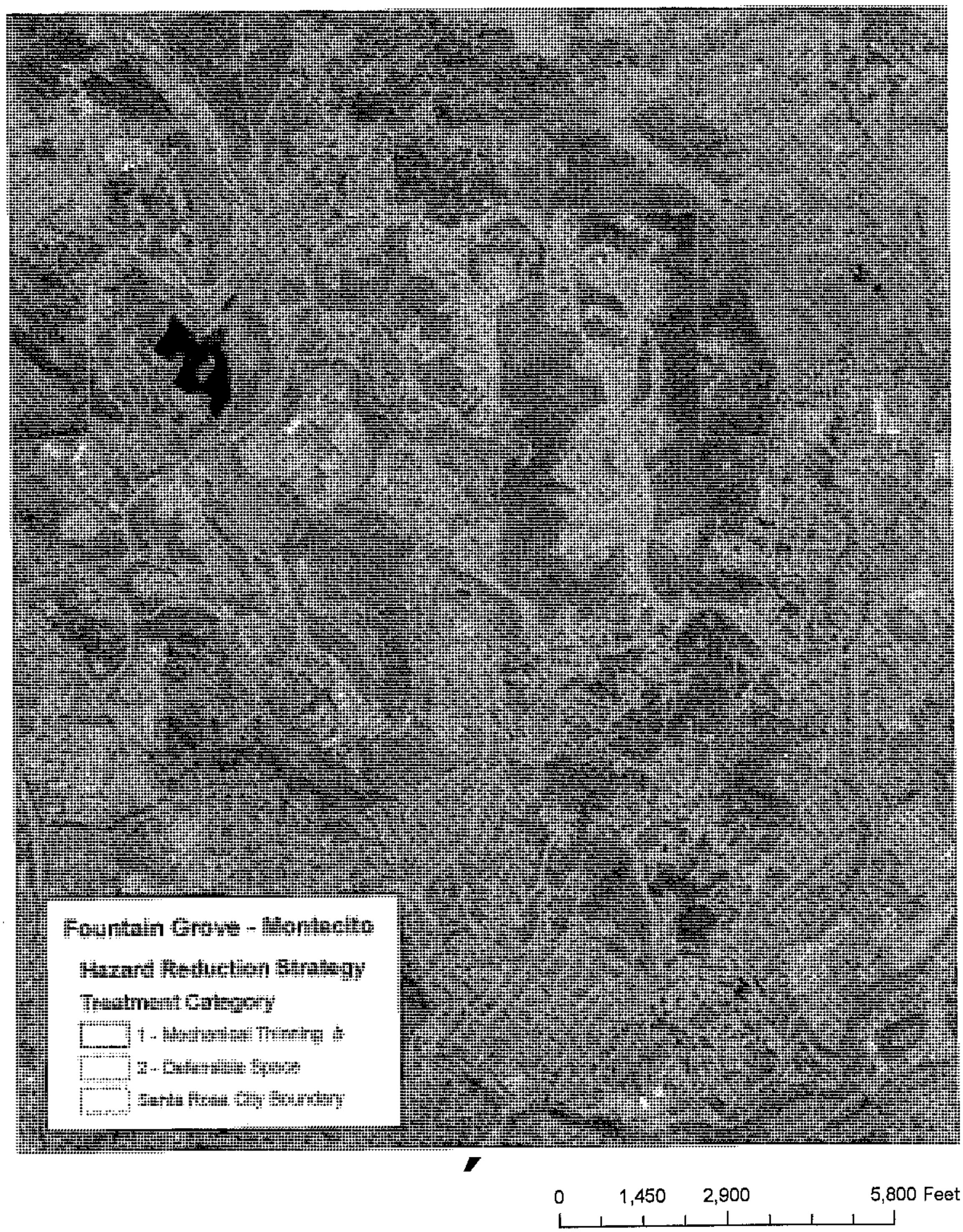


The combination of steep slopes, heavy fuels and east wind fire weather conditions are the factors that create extreme interface risk for Fountain Grove and Montecito and rank it as the top priority for hazard fuel reduction in the city of Santa Rosa (Map 5). Fountain Grove does have some advantages in that the residential development is fairly recent with homes that have non-flammable roof types and relatively sparse exotic landscaping. However, the proximity of heavy fuels on the steep slopes below the development raise the specter of structural loss due to radiant heat, direct flame impingement or embers finding receptive ignition sites under eves, through vents or flammable material on the exterior of the structures.

The community of Montecito is an older community with many homes that have wood shake roofs, extensive exotic landscaping and residual native fuels consisting of grass, brush, oaks and conifers. While Montecito is well within the city limits, downwind fuels in the Fountain Grove area under east wind conditions could easily carry enough airborne embers into the Montecito area to create a serious situation called "mass ignition". Mass ignition occurs, as the name implies, when embers carried by the wind are spread over a large area creating numerous spotfires that rapidly coalesce into a large conflagration. These types of situations are often impossible for structural fire protection agencies to suppress or protect structures. Firefighter and public safety can be compromised to the extreme and evacuation routes can be cut off without warning. These situations need to be anticipated early on in the incident planning process and evacuation procedures need significant pre-planning and public notification.

Map 3.

Fountain Grove - Montecito Hazard Reduction Strategies



Map 3 depicts areas in the Fountain Grove and Montecito that are recommended for various hazard fuel treatments. The vegetation surrounded by red polygons contain stands of natural fuels, either brush, montane hardwoods or coniferous forest that are recommended for mechanical thinning operations through the entire stand. Areas depicted by orange polygons represent areas dominated by the "urban exotic" fuel type. These areas have significant residential development within them which may preclude the opportunity to use heavy equipment in hazard reduction activities. However, the fuels loading in these areas can not be ignored and must be thinned and pruned to provide defensible space around the structure as well as provide firefighters the safety zone required to carry out structural protection operations. Many wildland firefighting crews are familiar with these types of hazard fuel reduction operations and can be contracted to do this work during the winter months. There may be some opportunity for feller-bunchers to operate in some larger stands within this hazard category, but this must be determined by on-site analysis of the particular needs of each unit. Mechanical fuelbreaks are not recommended in these types of fuel situations as they are ineffective in stopping large fires and erosion can be significant.

Maps 4 and 5 are high resolution maps of priority treatment units within Fountain Grove and Montecito displayed on the air photo base image. These areas represent stands of natural fuels that require mechanical treatment within the communities of Fountain Grove and Montecito respectively. The polygon ID numbers from the map attribute tables are displayed on the maps for purposes of identifying the highest priority treatment areas that will be most effective in reducing direct threats to structures. These polygons are listed in the tables below for reference, along with vegetation type, fuel model and the number of acres within the unit.

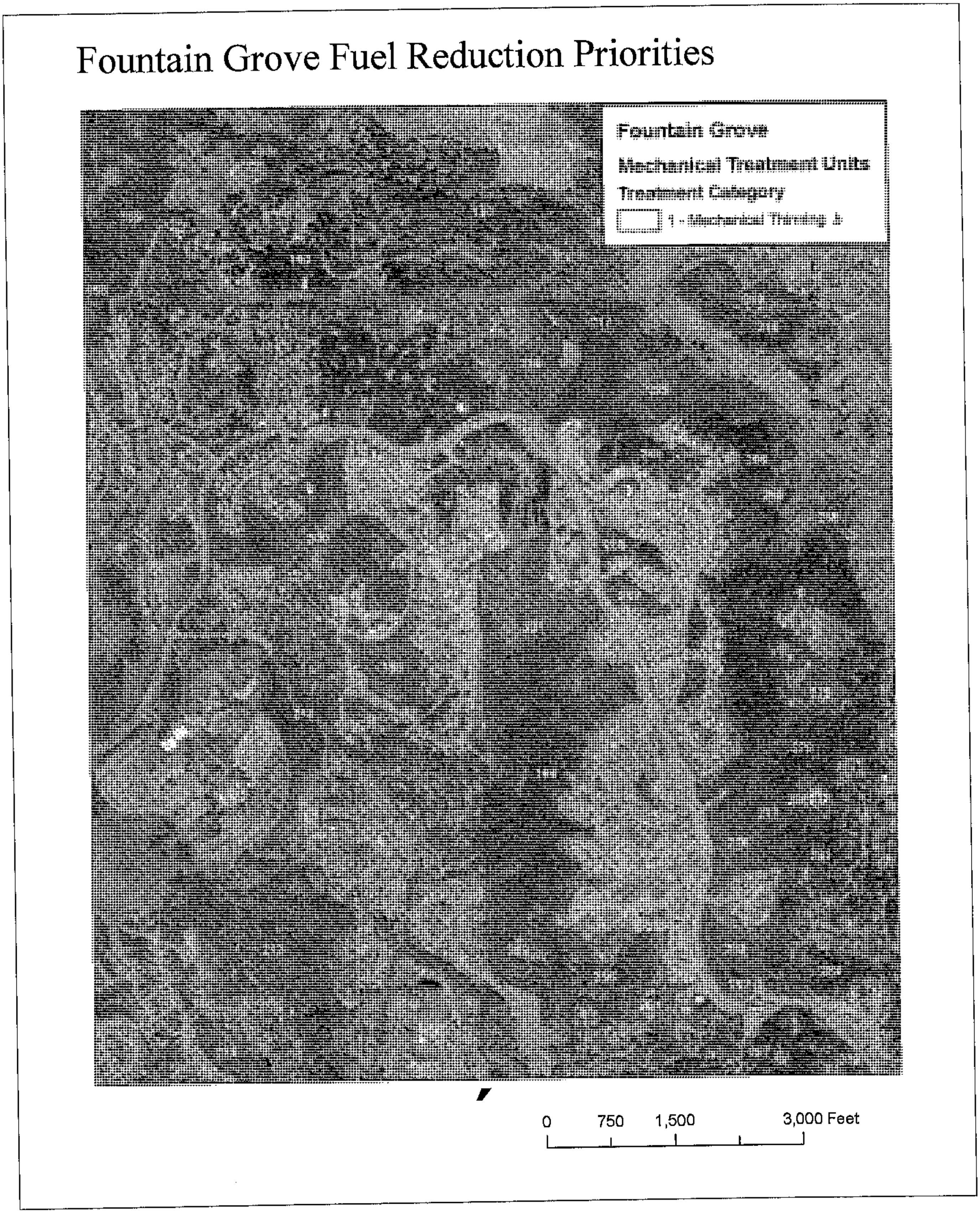
Table 1. Fountain Grove Priority Treatment Units

Priority	FID #	Vegetation Type	Fuel Model	Acres
1	279	Conifer	10	80
2	266	Conifer	10	18
3	220	MHC	8	39
4	199	Conifer	10	56
5	216	MHC	8	19
6	277	MHC	8	11.5
7	201	Chaparral	4	42
8	202	Oak Woodland	8	24
9	200	MHW	8	47
10	213	Oak Woodland	8	60
11	159	MHW	8	69

Total Acres: 465.5

MHC = Montane Hardwood – Conifer
MHW = Montane Hardwood

Map 4.


Fountain Grove Fuel Reduction Priorities
Fountain Grove
Mechanical Treatment Units
Treatment Category
0
750
1,500
3,000 Feet

Montecito

Most of the Montecito area is densely developed, although several conterminous areas do stand out as being potentially compatible for mechanical treatment with heavy equipment such as feller bunchers or log skidders, however slope limitations may limit the use of heavy equipment in both Fountain Grove and Montecito. The density of residential development in the Montecito area may require that hazard reduction efforts in the community focus on the creation of defensible space around individual structures rather than the large scale treatments used in stands of natural fuels. There may be opportunities for groups of landowners within specific neighborhoods to create both defensible space and larger scale treatments where conterminous stands of natural fuels overlap individual property boundaries. These situations will have to be determined through the use of ground surveys of individual neighborhoods to determine where opportunities for larger scale treatments exist, and enlisting the cooperation of affected property owners.

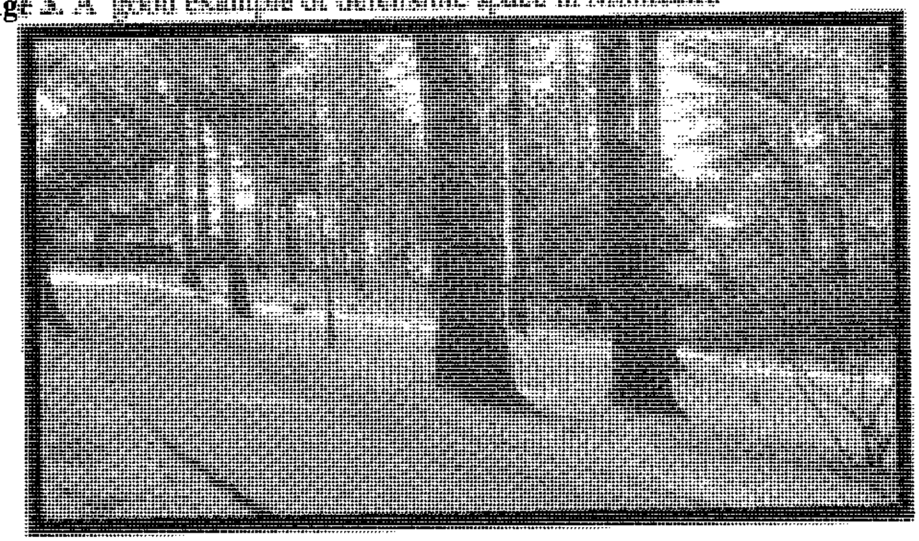
Table 2. Montecito Priority Treatment Units (refer to Map 5.)

Priority	FID #	Vegetation Type	Fuel Model	Acres
1	1532	MHC	8	25
2	287	MHC	8	32
3	298	Conifer	10	23
4	302	MHC	8	30.5
5	284	MHC	8	13
6	283	Chaparral	4	14
7	256	Conifer	10	14

MHC = Montane Hardwood Conifer

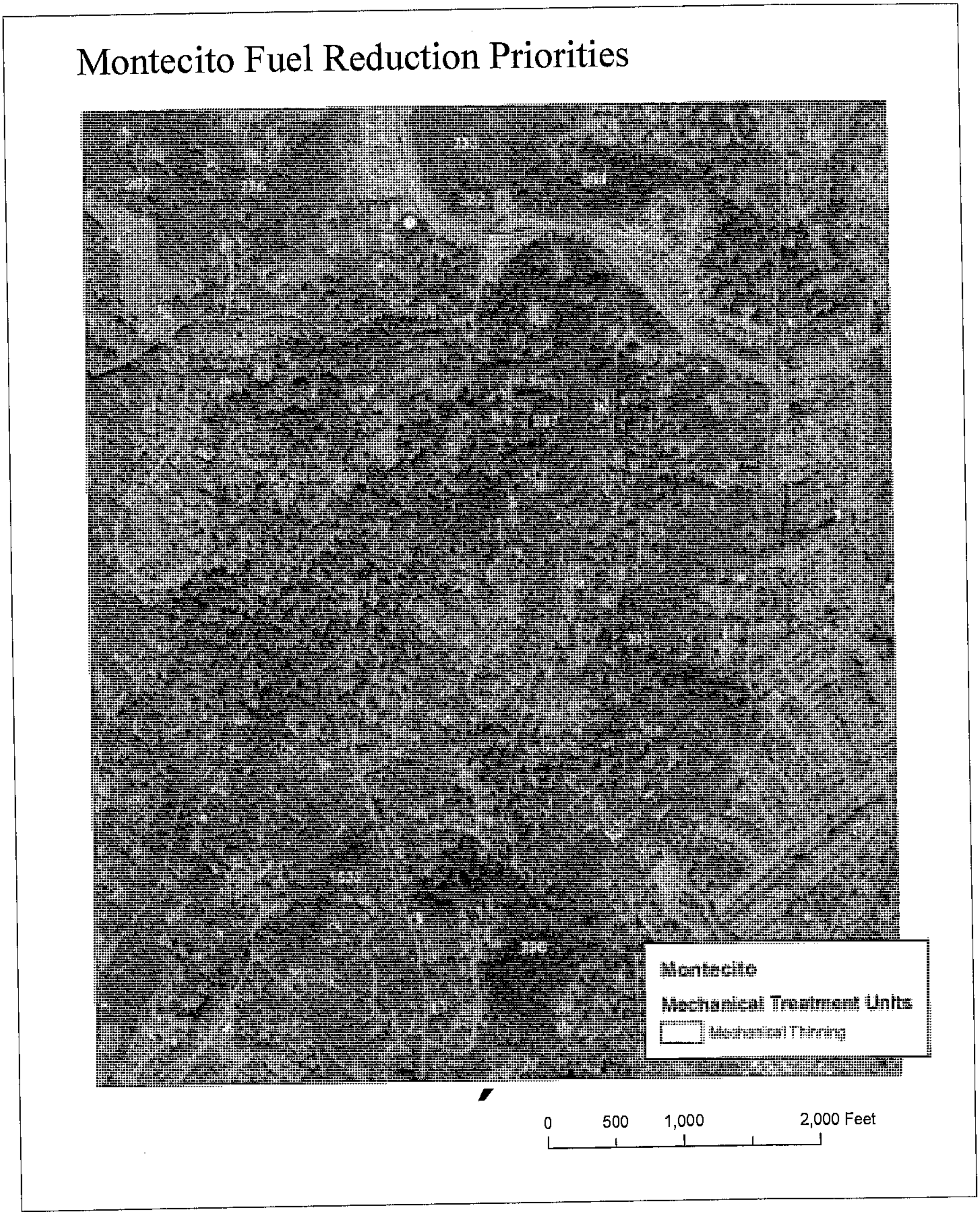
Total Acres = 151.5 acres

Image 3. A good example of defensible space in Montecito



The total priority treatment area for hazard fuel reduction within the Fountain Grove and Montecito communities totals 616 acres. This amount of acreage could rapidly be treated by mechanical equipment with concerted effort. No doubt, this type of program will require significant public and homeowner outreach programs to develop the permissions, cooperation, contracts and coordination required in areas where multiple land ownerships exist within units requiring treatment. However, as the "Lessons Learned" report states "Six or eight projects, 10 to 100 acres in size made a difference on this fire because they were in key areas."

Map 5.


Montecito Fuel Reduction Priorities
Montecito
Mechanical Treatment Units
Mechanical Thinning
0
500
1,000
2,000 Feet

Oakmont

The hazard fuel risk within the community of Oakmont is well documented in several previous reports, most notably the "District 7 Wildland Urban Interface Threat Assessment" prepared by Captain Don Ricci of the Santa Rosa Fire Department. This report identified over six hundred homes within the community as being at risk to wildland fire. The community of Oakmont is located in the Los Guilicos Valley southeast of downtown Santa Rosa. The community is bordered by steep northeast slopes with heavy fuels, primarily coniferous forest and montane hardwood – conifer fuel types. Much of this area lies within the 5000 acre Annadel State Park.

The fuels situation adjacent and within the community of Oakmont presents a couple of different scenarios for a serious interface fire. One potential scenario involves a fire starting in the low elevation grasslands on the west side of Annadel State Park in the Bennett Valley, which spreads upslope across Bennett Ridge into the heavy fuels above Oakmont. The heavy fuels in Annadel State Pak above Oakmont would present a serious threat from numerous spotfires falling throughout residential development potentially creating a mass ignition situation. This scenario could be precipitated by a hot summer day with moderate west winds (15 – 20 mph).

Another possible scenario involves a fire driven by east winds on the ridges above the Los Guilicos Valley. The area east of the valley is dominated by heavy fuels consisting of coniferous forest, montane hardwood and chaparral fuel types. Extreme east winds could potentially start numerous spotfires throughout the Los Guilicos Valley and carry through low elevation grasslands into the community of Oakmont where significant amounts of natural fuels are interspersed with exotic vegetation. Many of the high value homes within the community of Oakmont have wood shake roofs, further complicating the structural protection difficulties for fire agencies.

Hazard fuel treatment priorities within the community of Oakmont were initially selected based upon stands of natural fuels which are located outside of Annadel State Park and within city boundaries (Map 6). Obviously, significant hazard fuels exist within Annadel State Park, but thinning operations conducted on State Park lands must be initiated by State land management agencies and would require extensive environmental documentation and planning. The areas adjacent to the state park would provide an initial buffer to heavy fuels within the park, but it is highly recommended that discussion of hazard fuel reduction within the park be considered. Thinning operations would also provide for the restoration of more natural ecological conditions within the Park by reducing stand density to natural stocking levels.

Table 3. Oakmont Priority Treatment Units (refer to Map 6).

Priority	FID #	Vegetation Type	Fuel Model	Acres
1	1187	MHC	8	18
2	1115	MHW	8	34
3	1116	Conifer	10	22
4	1168	MHW	8	20
5	1164	Conifer	10	9
6	1166	MHC	8	9
7	1167	Conifer	10	5
8	1523	Oak Woodland	8	37
9	1526	Conifer	10	139
10	1184	Conifer	10	2

Total Acres = 295

Map 6.

Oakmont Hazard Fuel Reduction Priorities

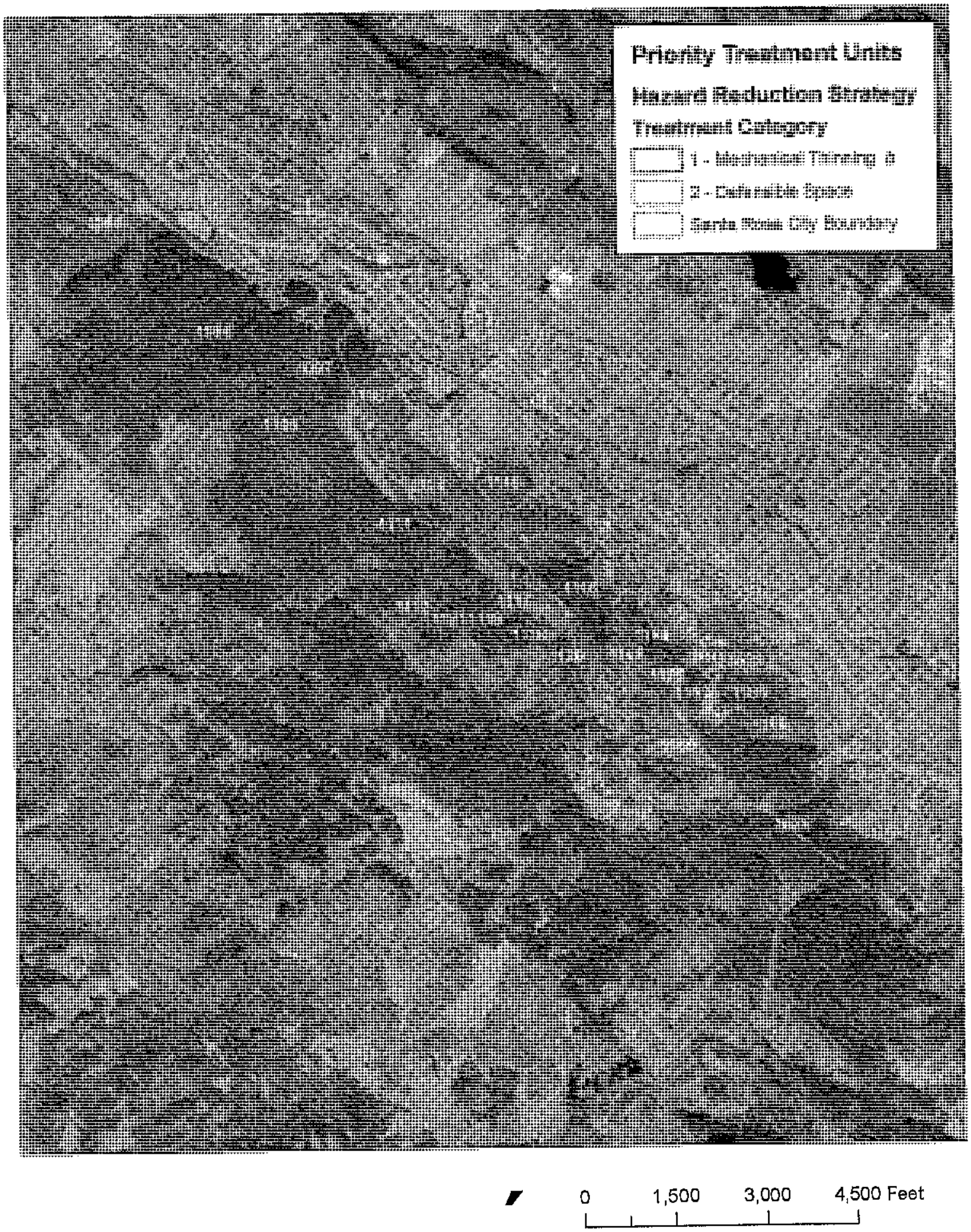
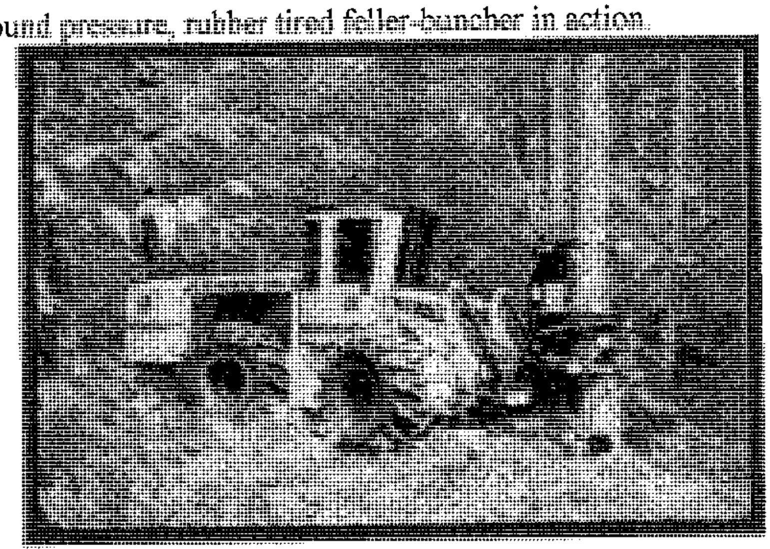


Image 4. View of Oakmont and adjacent fuels from above the Los Guilicos Valley

Howarth Park

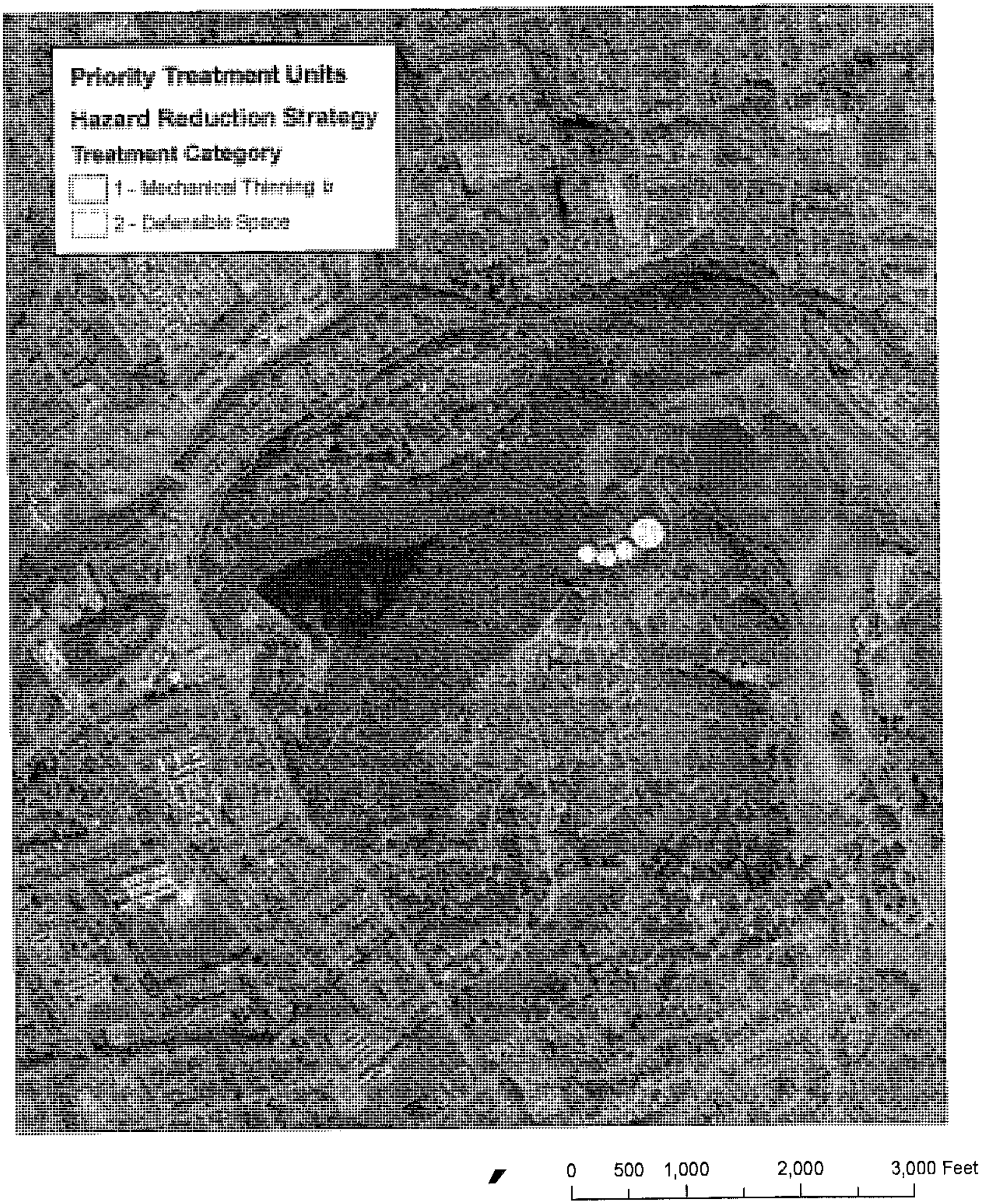
The fuels in Howarth Park are primarily represented by montane hardwood vegetation types. The vegetation in Howarth Park is problematical from the standpoint that the park is virtually surrounded by high density residential development. These fuels represent a threat to structures in the vicinity both from the standpoint of a large conflagration or a smaller fire that increases in intensity due to steep slopes and heavy fuels. Recommended treatment for Howarth Park is to mechanically thin the 151 acres of fuels within the red polygons as depicted in Map 7. This is not a large amount of acreage in terms of hazard fuel treatment and could be accomplished within several months with handcrews and chainsaws or within several weeks by heavy equipment such as a feller-buncher. Residual fuels could be chipped and used on trails and pathways within the park. Initial treatment efforts should focus on areas that are proximal to residential development, particularly on the north side of the park where numerous structures are adjacent to the park just southeast of Montgomery Street. Within this subdivision there is a significant amount of both natural and exotic vegetation which should be evaluated for implementation of defensible space projects.

Image 5. Low ground pressure, rubber tired feller-buncher in action.



Map 7.

Howarth Park Hazard Fuel Reduciton Priorities



Bennett Valley

While Bennett Valley was identified as a "community at risk" in the National Fire Plan, it does not have the significant areas of heavy fuel classes that are represented by other areas identified within this study. Much of the hazard fuel distribution in Bennett Valley is scattered in isolated patches surrounded by annual grasslands. Most of the densely developed areas in Bennett Valley are buffered from heavier fuel accumulations by swaths of annual grassland, particularly in areas within the city limits of Santa Rosa. The most substantial hazard fuels in Bennett Valley are in the vicinity of Mt. Taylor and west of Bennett Valley Road. As with the Howarth Park area, the potential for a small fire under dry, windy conditions is considerable. Fine fuels on the west side of Mt. Taylor create the potential for a rapidly spreading grass fire to get into the heavier fuels on the east side of Mt. Taylor, which consist primarily of montane hardwoods with scattered stands of conifer and create a serious interface fire situation.

Image 6. Typical fuels and slope configuration on the west side of Mt. Taylor.

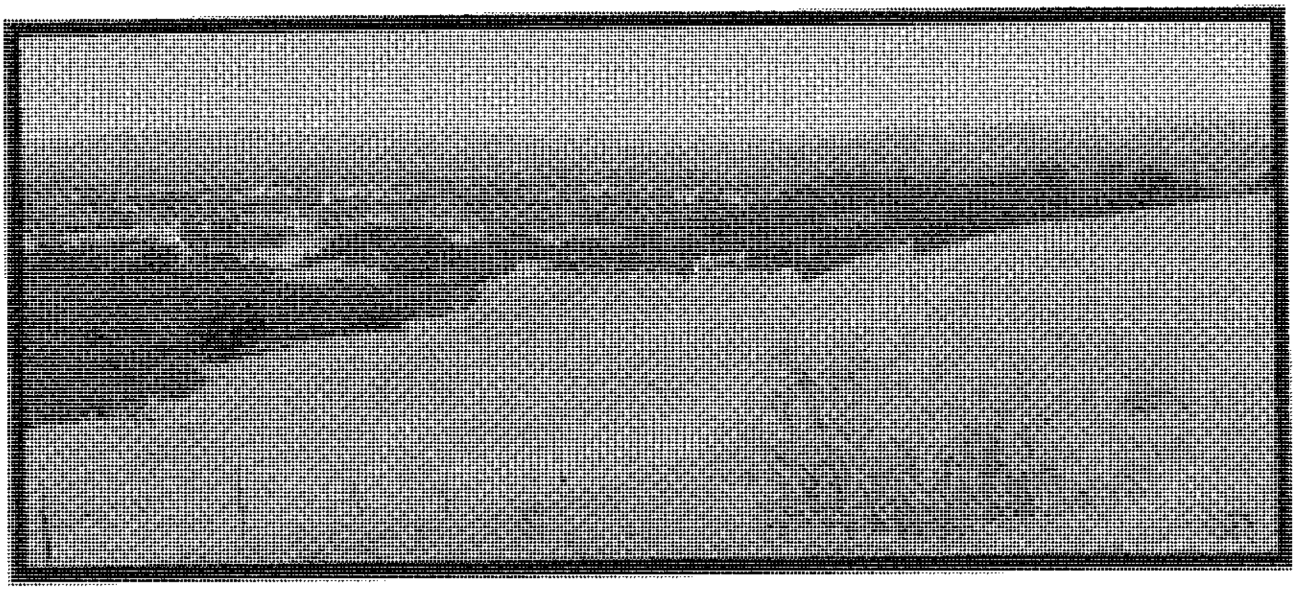


Table 4. Bennett Valley Priority Treatment Units (refer to Map 8)

Priority	FID #	Vegetation Type	Fuel Model	Acres
1	1305	MHW	8	41
2	1308	MHW	8	17
3	1295	MHW	8	8
4	1304	MHW	8	29
5	1067	MHW	8	11
6	1064	MHW	8	6

MHW = Montane Hardwood   Total Acres = 112

Map 8.

Bennett Valley Fuel Reduction Prioities

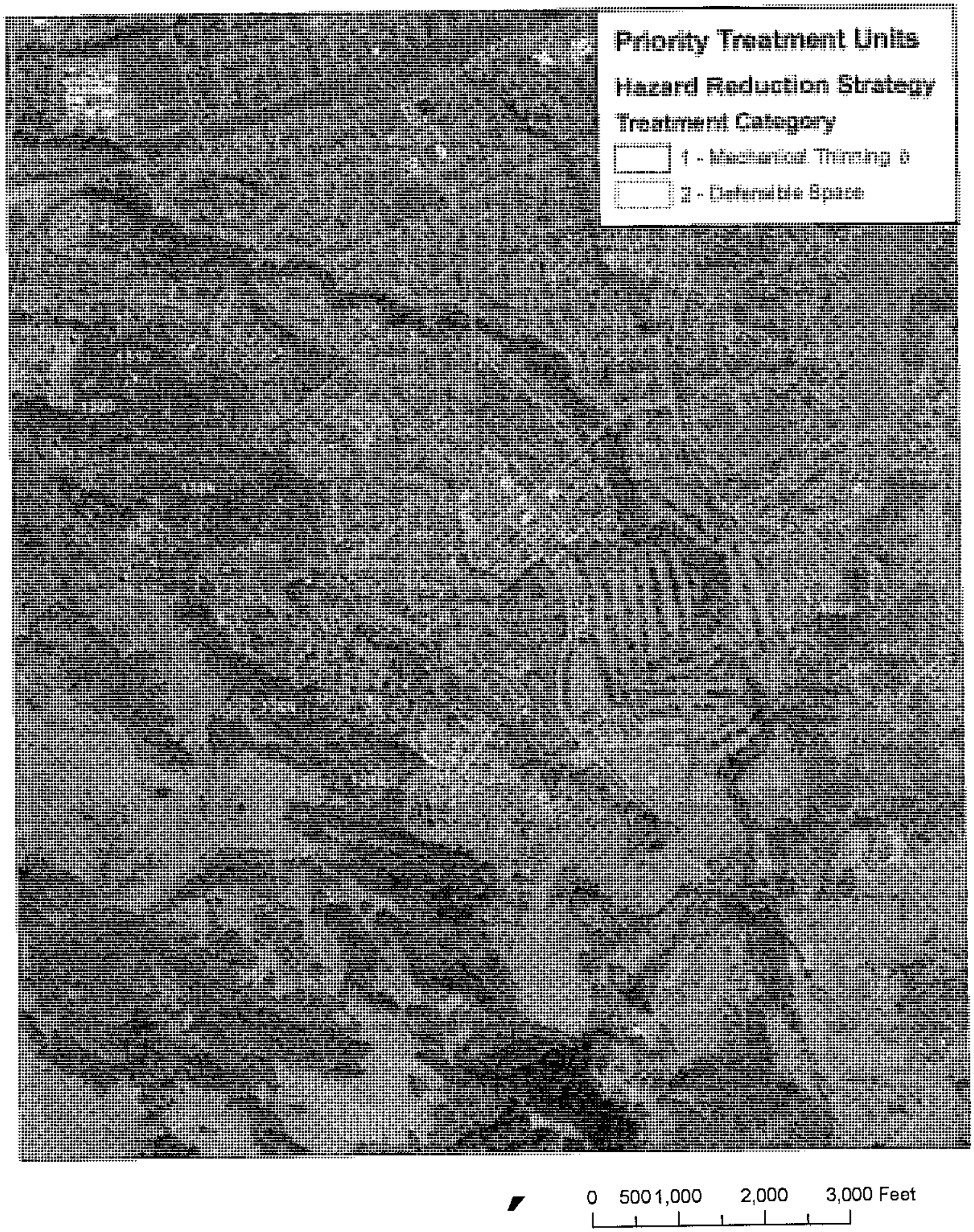


Table 5. Mechanical Thinning Unit Treatment Summary

Community	Acres
Fountain Grove	465.5
Montecito	151.5
Oakmont	295
Howarth Park	151
Bennett Valley	112

Total Treatment Acres = 1175

The areas identified as priorities for hazard fuel treatment within this report are based upon the combined variables of fuel type, proximity to residential development, fire history, topography, fire weather analysis and potential fire behavior. The units identified for mechanical thinning would provide a significant reduction in interface risk in the most critical areas of Santa Rosa. Upon further analysis of this data other areas may be determined to be included as treatment priorities. Local knowledge of fire department personnel and subsequent ground surveys can be used to further refine these initial recommendations. It should be recognized that this analysis is focused on identifying areas of heavy fuel types that can be treated with various mechanical thinning techniques. There are other areas within the Santa Rosa interface that face serious interface threats due to the proximity of wildland fuels. Most of the areas not identified in this analysis still retain significant amount of risk from annual grasslands which are the predominant fuel classification within the Santa Rosa Interface. Homeowners in these areas must be informed of that risk and assisted in identifying actions that they can take to reduce their exposure to interface fire hazards. This study focused primarily on risks within and immediately adjacent to the city of Santa Rosa. There exists a significant amount of structural exposure in the scattered, low density developments that are found throughout the hillsides and mountains surrounding Santa Rosa. Some of these more prominent exposures are identified on the Priority Treatment Units map (Figure 2) and are identified as areas where defensible space is needed. The community of Bennett Ridge is a prominent example of these types of area. These areas may require more substantial hazard reduction treatments based upon the review and recommendations of the local fire agency of jurisdiction.

The 1,175 acres identified in this study represent the most critical areas for hazard fuel reduction and defensible space creation that lie within the jurisdiction of the Santa Rosa Fire Department. This amount of acreage is not extraordinary in terms of being a realistic goal for hazard fuel reduction and would provide a significant first step in reducing the risk of the inevitable interface fire. Risk analysis is a dynamic process that must be continually re-evaluated in terms of changes in development patterns or annexation of new areas into the city. Hazard fuel reduction and the creation of defensible space around homes is not a "one time" treatment application. Vegetation and fuel loading will increase with time both within the wildland surrounding Santa Rosa as well as the open spaces and yards of communities. Treated areas should be re-evaluated for follow up treatments at least every decade. Subsequent treatments should be much less of a work load once initial treatments are accomplished.

Recommended Course of Action

The Santa Rosa Fire Department should immediately begin developing strategies for contacting homeowners within the priority areas to make them aware of the findings of this study. Public meetings with local homeowner groups and concerned citizens should be held to provide information, present alternatives and recommendations for creating defensible space around structures in the critical areas.

Lists of homeowners and landowners of parcels of land within the areas identified as priority hazard fuel reduction units should be compiled. The owners of these parcels should be contacted to determine it they are amenable to hazard fuel reduction projects being carried out on their property. It would be very difficult and unproductive to carry out hazard reduction activities on these units if certain portions were excluded due to landowner reluctance to agree to the projects implementation on their land. On units where merchantable timber is available, the removal of portions of the unit may provide cost offsets for contractors expenses in exchange for treatment of non-merchantable slash and logging residue. As a general rule, objectives for thinning in stands of timber seek to remove at least 60% of the existing basal area to provide enough canopy opening to prevent crown fire. Thinning by crews with chainsaws in non-merchantable vegetation generally costs about $200-300 per acre range, with slash disposal requiring additional cost depending on the disposal technique selected. Based upon the amount of acreage needing treatment an initial project funding target of $300,000 should provide a good start in treating the most critical areas. This amount may seem like a lot of money, but it is certainly less than 20 houses burning down in an interface fire.

The city of Santa Rosa should consider the development of a comprehensive Community Wildland Fire Protection Plan. This plan would include pre-incident plans which would include evacuation procedures and strategies, fire suppression options, identify priority areas for structural protection, fire support facilities such as evacuation areas, staging areas, ICP locations, helispots and water sources. Other elements of the plan would include fire prevention programs that include high profile homeowner outreach programs to provide information related to specific neighborhood evacuation procedure, routes and evacuation center locations. This program may want to consider conducting individual homeowner evaluations of structural risk and site-specific recommendations for mitigation of that risk. This information could also be incorporated into pre-incident plans for the purpose of structural triage in planning structure protection operations during an interface fire.

The final part of the CWPP plan and perhaps most important in relation to protection of structures is the hazard fuel reduction component. The development and implementation of hazard reduction programs will require significant effort and detailed attention. Once programs are implemented on the ground, thinning operations must be monitored to ensure compliance with contract specifications, coordination with private landowners and documentation of project progress. It is recommended that the city of Santa Rosa consider creation of a dedicated staff position within the Fire Department to serve as a Fuels Management Program Coordinator to oversee program implementation.
Specific details, contents and recommended outlines of Community Wildfire Protection Plans can be found on the web at the following location:

CWPP development **http://www.cafirealliance.org/downloads/March2004NFPC.pdf**

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.

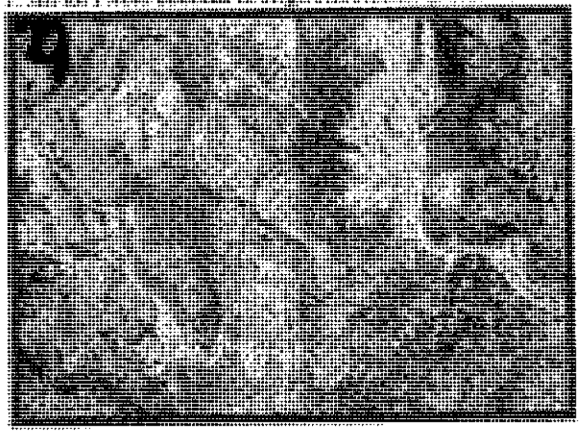
Vegetation communities were distinguished and classified from the aerial images by gradations in color, structure, texture and ecological variables related to elevation, slope and aspect. Map polygons were derived by digitizing transitional areas between the various vegetation types (Image 7). Attribute 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.

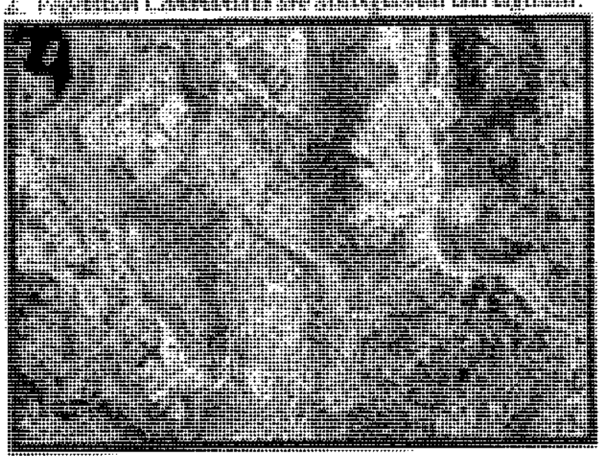
The vegetation communities delineated within the GIS maps were assigned appropriate fuel models within the associated attribute table. Fuel models are used in fire behavior prediction models such as BEHAVE or FARSITE. Fuel models are the result of extensive research conducted by U.S. Forest Service laboratories 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

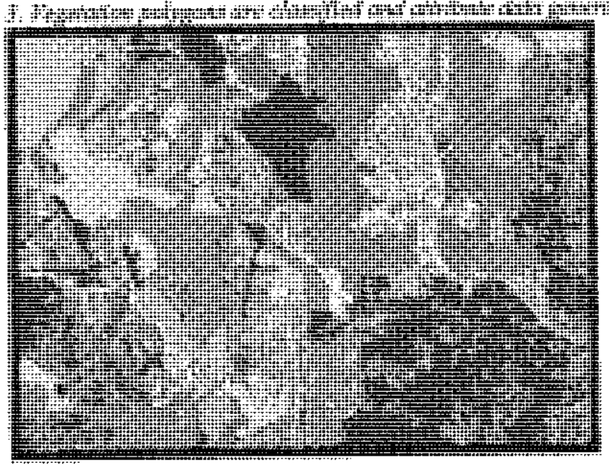
1. Aerial Photo scanned to High Resolution (Fountain Grove – Montecito area)



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.

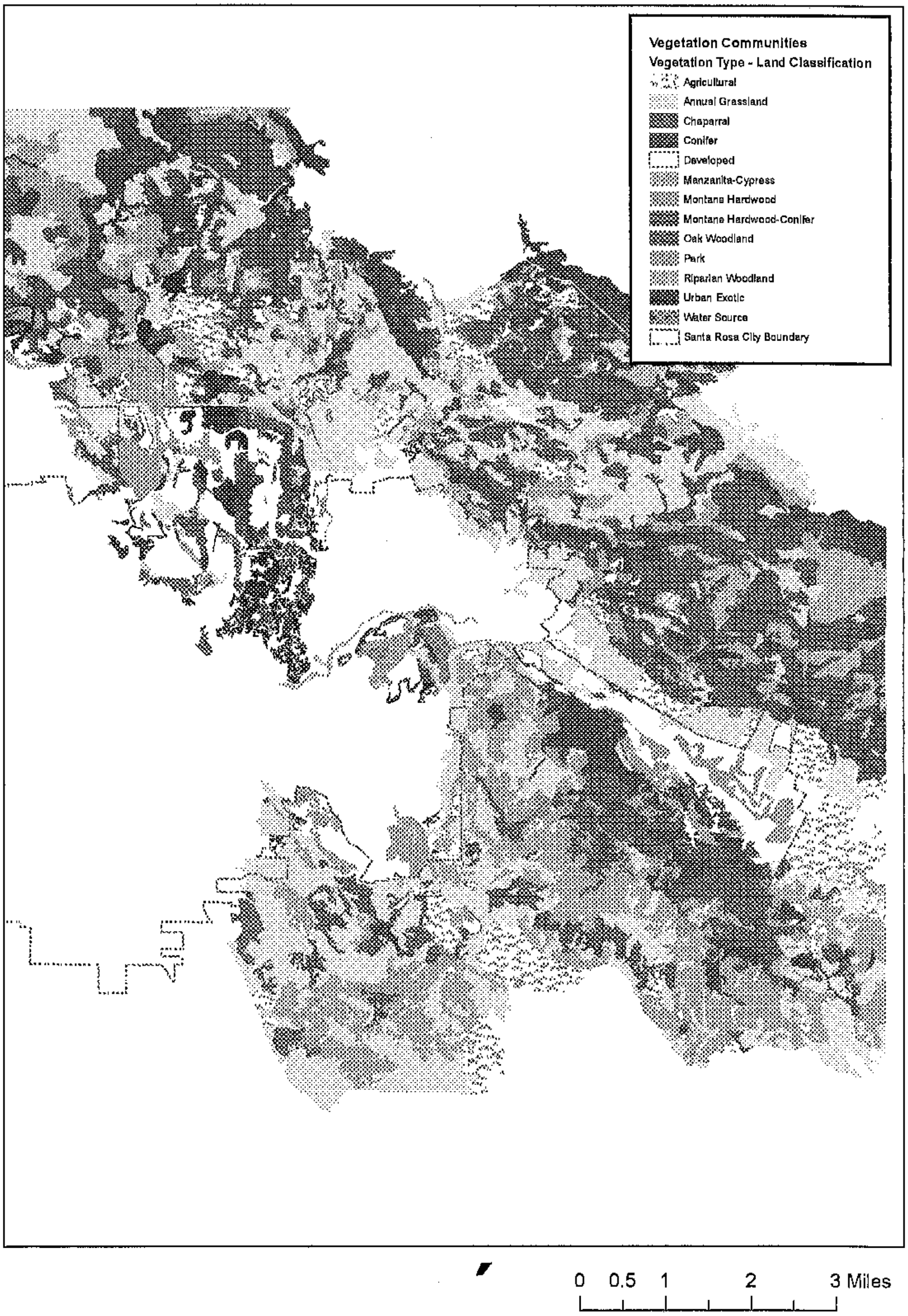
Fuels are defined by the predominant vegetation types found within the fire environment. They are classified by characteristics of physical structure, live and dead biomass (fuel loading). The primary fuel groups are classed as grass, brush, timber or logging slash. These major fuel classes are further 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

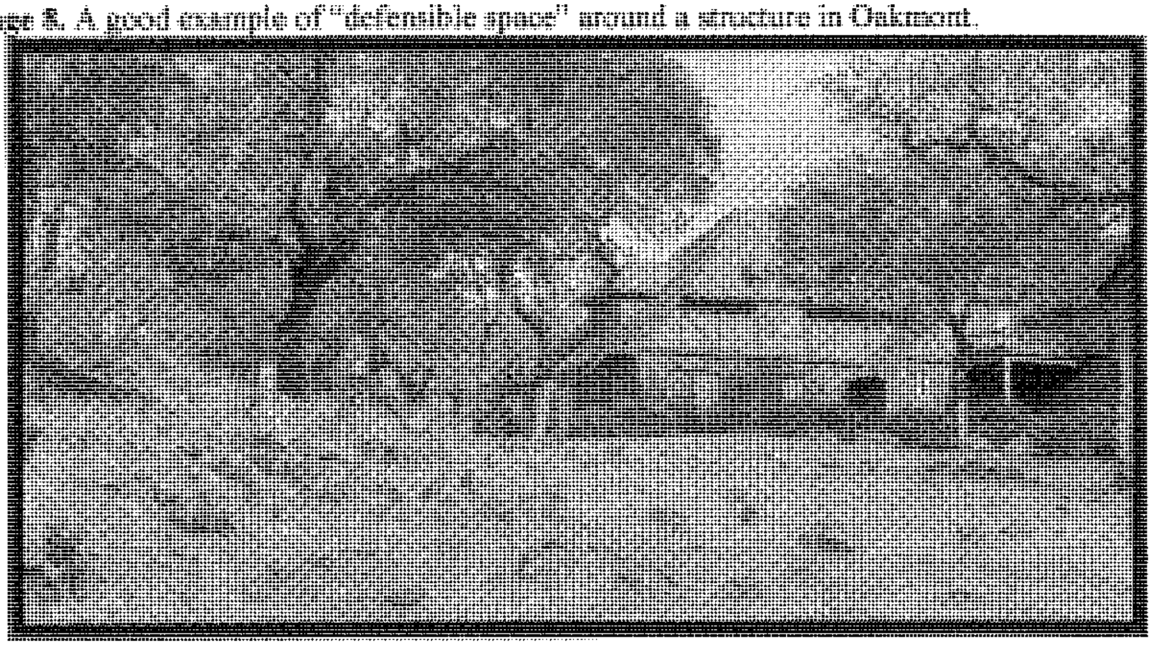


significant areas of mixed chaparral and manzanita-cypress brush fuel types. Many of these areas appear to have experienced clear-cut logging in the past and may represent a seral successional stage of degraded site conditions resulting from the logging disturbance. As elevation increases east of Santa 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

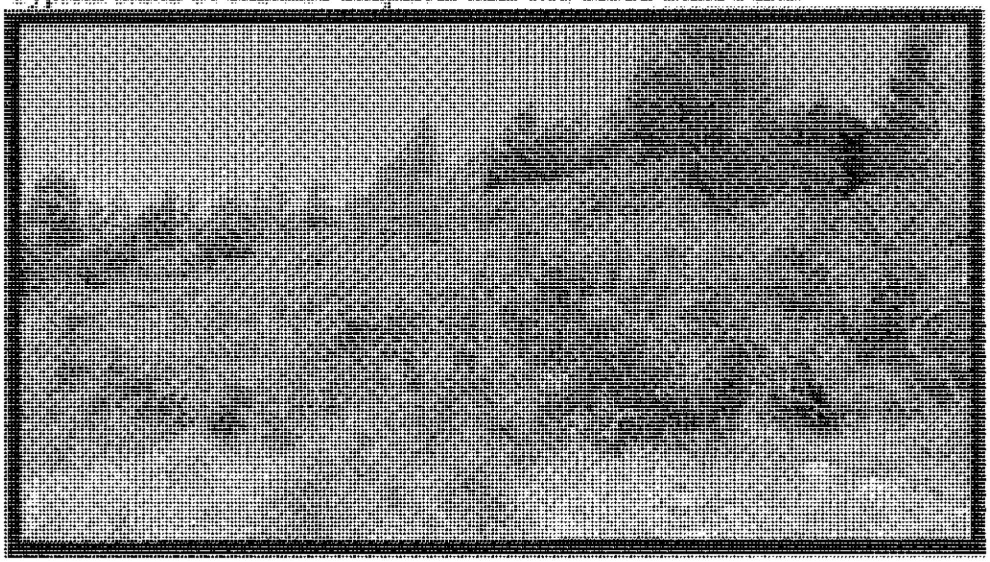
Fuel Model 1 (Annual Grassland): This fuel type is the most widely distributed fuel type in the Santa Rosa urban interface and is most predominant at lower elevations. Annual grasses are the primary carrier of fire in oak savannas, low-density oak woodlands and other hardwood habitat. At higher elevations, 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

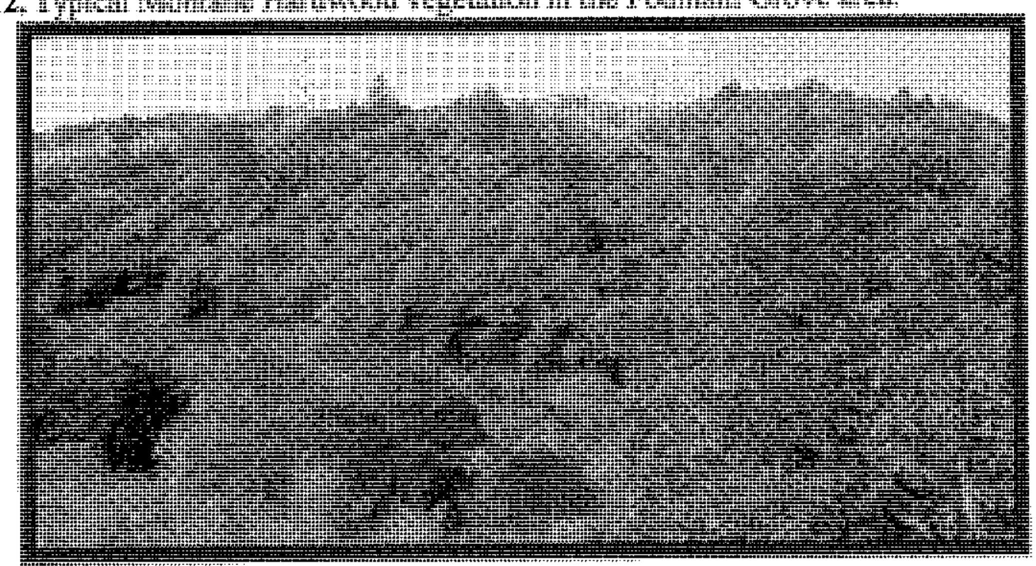
logging roads and landings were observed within these areas. Conifer reproduction was observed in moist canyons below the stands of manzanita, which may indicate the vegetation type represents an early seral stage of succession to a conifer climax forest.

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.

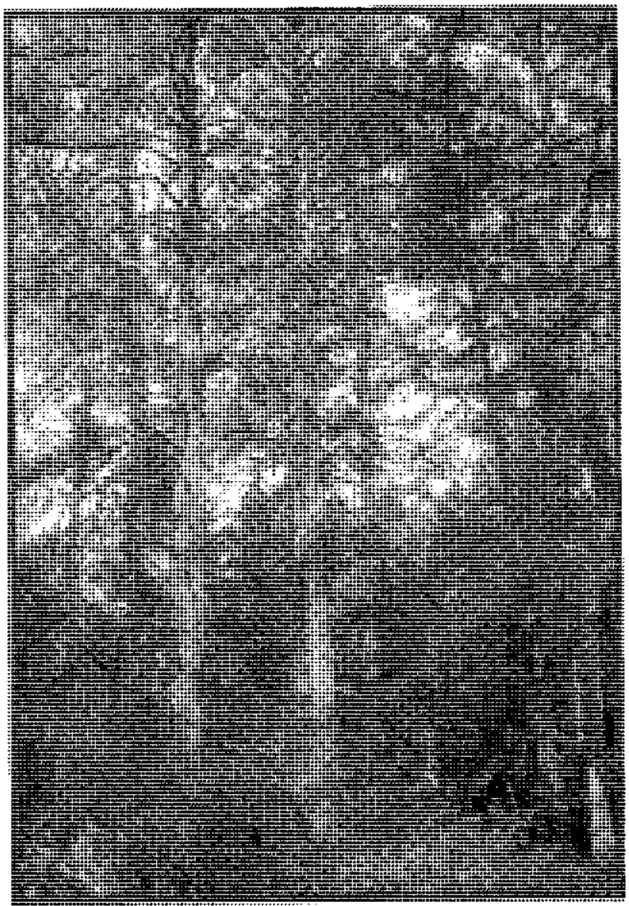


Image 15. Coniferous Forest I Annadel State Park.

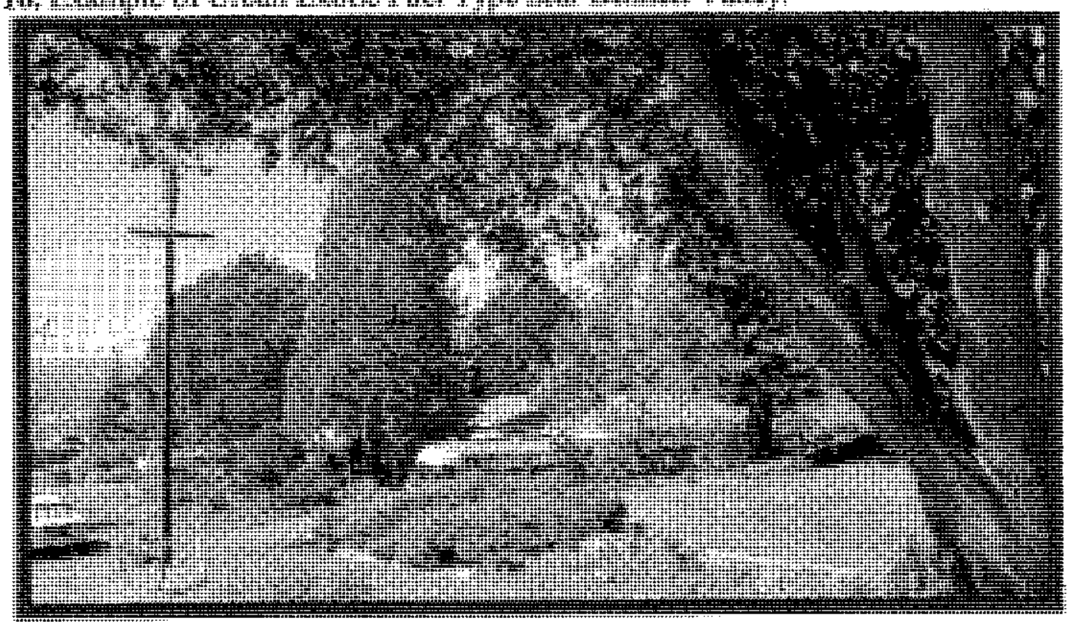
Coniferous Forest (Fuel Model 10)
The distribution of coniferous forest surrounding Santa Rosa has been altered from historic distribution and stand density primarily due to the effects of logging and fire suppression. Very few relic stands of the old growth redwood – Douglas-fir association were detected 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.

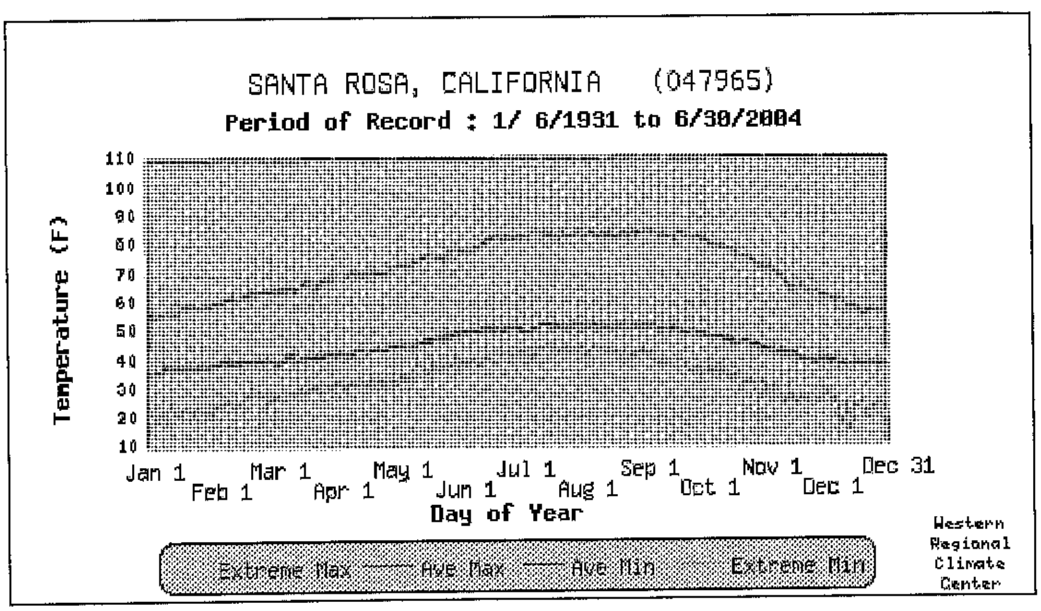
Wind can affect fuel moisture content, primarily in fine dead fuels. Fine fuels have high surface to volume ratios which increase exposure to the drying influence of winds. Larger fuel classes, such as branches and logs have less exposed surface area and consequently have moisture content that is much 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).

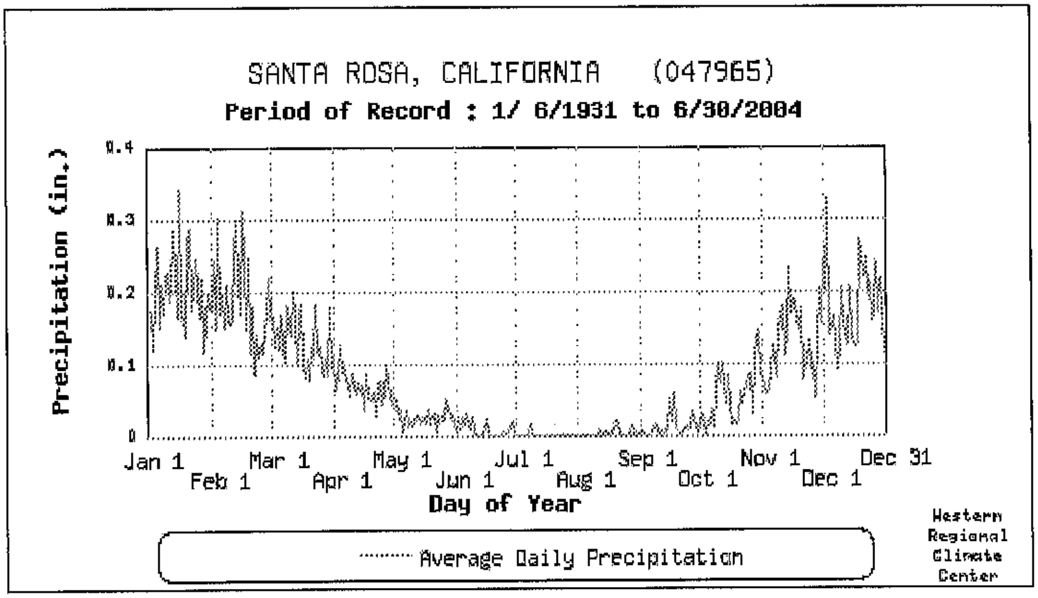
Graph 1 depicts the average and extreme temperature variables found within the Santa Rosa weather station period of record, which ranges back to 1931, providing a robust statistical data set. In relation to fire weather conditions, maximum average and extreme temperatures generally occur from June 15th 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



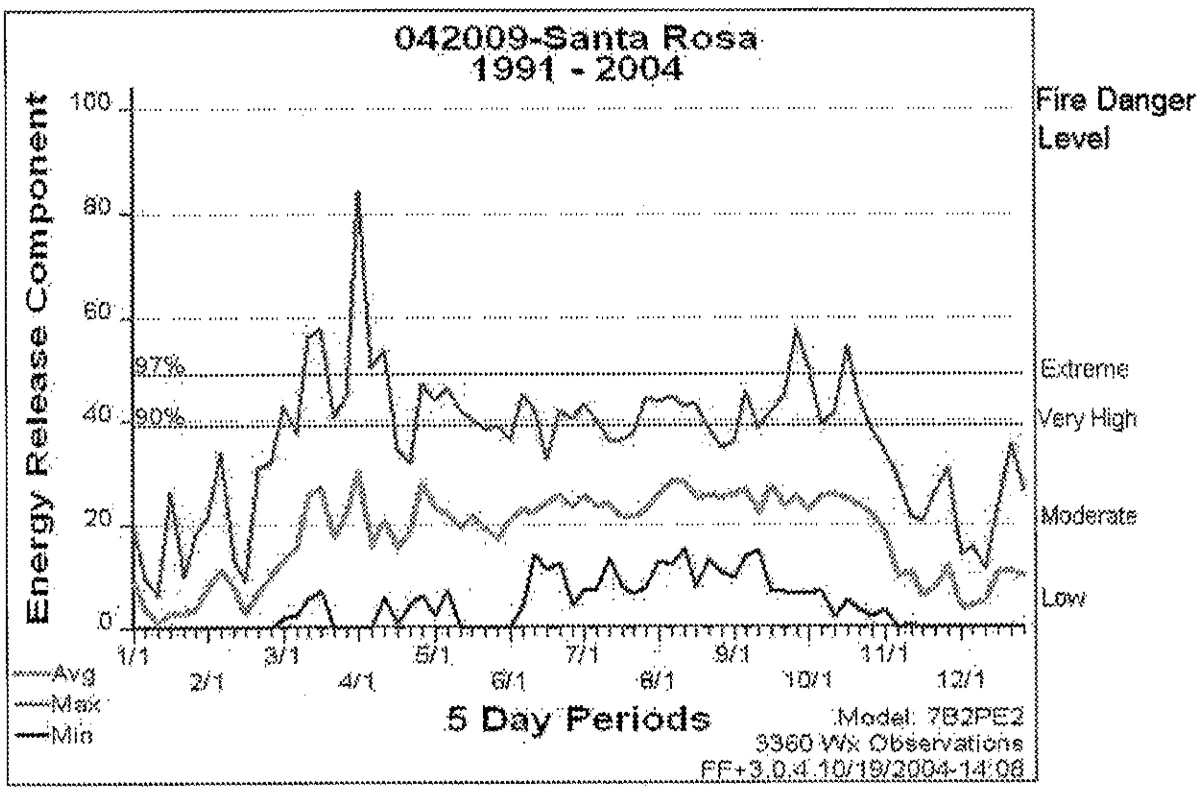
From the graph above, it can be observed that average daily precipitation input closely corresponds to the high average and extreme temperature distribution in the previous temperature graph. The period of June 15th through October 15th is marked by minimal precipitation.

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)

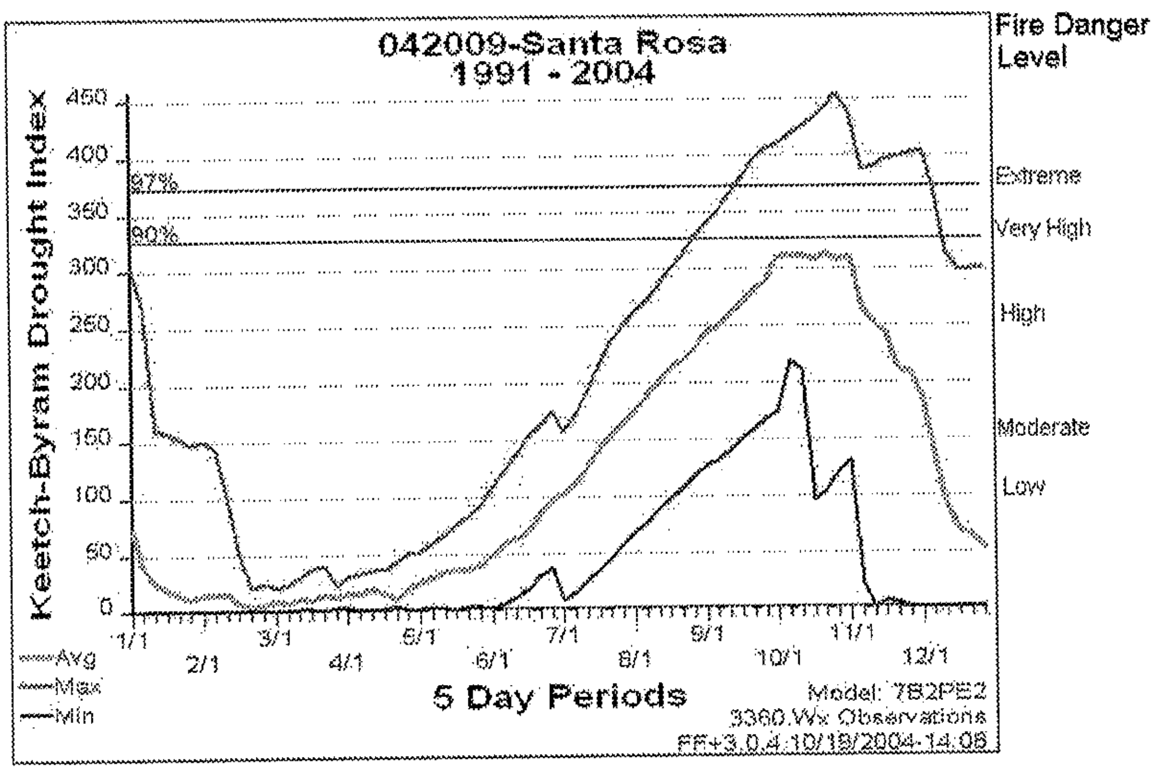


It is interesting to note that the ERC data indicates that extreme ERC levels can be attained early in the annual fire season before greenup in natural vegetation occurs. While early season fires are possible, it could be expected that these fires would be restricted to fine fuels in grassland habitats,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

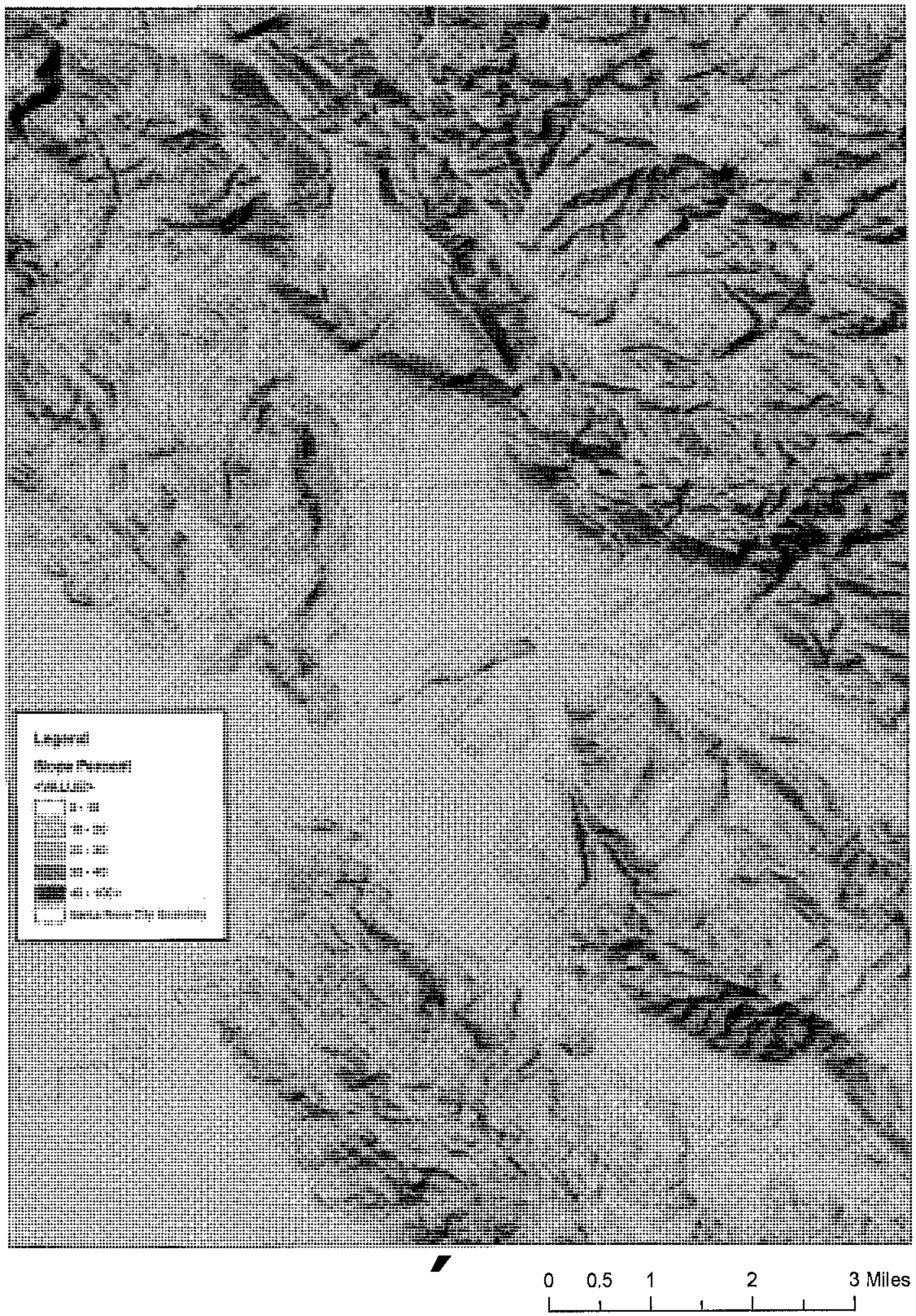
Potential Urban Interface Fire Scenarios:

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



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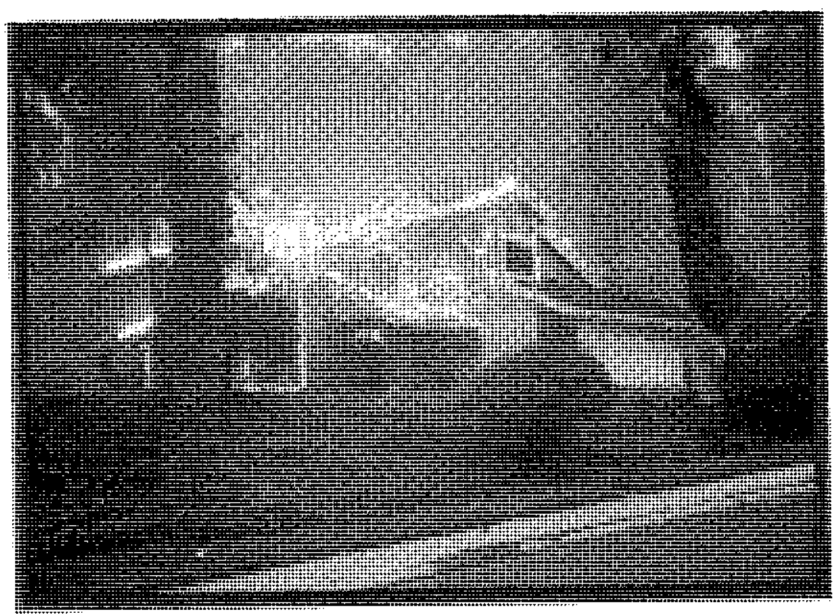

Appendix B. Vegetation Communities and Major Species Components

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*