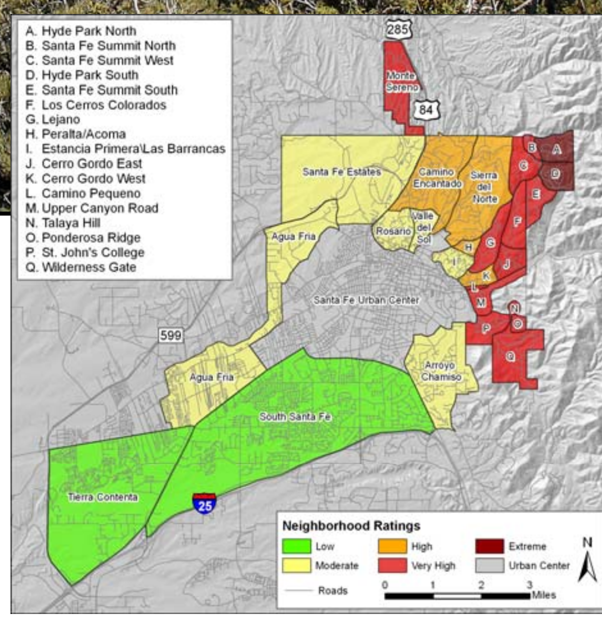
City of Santa Fe

Wildland Urban Interface
Wildland Fire Hazard and Risk Analysis



Prepared for:

Santa Fe Fire Department

Santa Fe, New Mexico

Submitted By:

Anchor Point
Boulder, Colorado

September 2006

FIRE MANAGEMENT

TABLE OF CONTENTS

LIST OF FIGURES

SUMMARY OF THIS DOCUMENT

This document incorporates new and existing information relating to wildfire that will be valuable to citizens, policy makers, and public agencies in the City of Santa Fe, NM. Wildfire hazard data is derived both from the community Wildfire Hazard Rating system (WHR), and from the analysis of Fire Behavior Potential, which is extensive and/or technical in nature. These detailed findings and methodologies are included in their entirety in appendices rather than the main report text. This approach is designed to make the actual plan more readable, while establishing a reference source for those interested in the technical elements of the Santa Fe wildfire hazard and risk assessment.

PURPOSE

The purpose of this document is to provide a comprehensive, scientifically based assessment of the wildfire hazards and risks within the Santa Fe study area.

The assessment estimates the hazards and risks associated with wildland fire in proximity to neighborhoods. This information, in conjunction with Values at Risk, defines "areas of concern" for the City of Santa Fe and allows for prioritization of mitigation efforts. From the analysis of this data, solutions and mitigation recommendations are offered that will aid homeowners, land managers and other interested parties in developing short-term and long-term fuels and fire management plans.

For the purposes of this report the following definitions apply:

> **Risk** is considered to be the likelihood of an ignition occurrence. This is primarily determined by the fire history of the area.
>
> **Hazard** is the combination of the WHR ratings of the Wildland-Urban Interface (WUI) neighborhoods and the analysis of Fire Behavior Potential, as modeled from the fuels, weather, and topography of the study area. Hazard attempts to quantify the severity of undesirable fire outcomes to the Values at Risk.
>
> **Values at Risk** are the intrinsic values identified by the citizens as being important to the way of life in the study area (e.g., life safety, property conservation, access to recreation, and wildlife habitat).

Goals and Objectives

Goals for this project include the following:

1. Enhance Life Safety for Residents and Responders.
2. Mitigate Undesirable Fire Outcomes to Property and Infrastructure.
3. Mitigate Undesirable Fire Outcomes to the Environment, Watershed, and Quality of Life.

In order to accomplish these goals, the following objectives have been identified:

1. Establish an approximate level of risk (the likelihood of a significant wildfire event in the study area).
2. Provide a scientific analysis of the fire behavior potential of the study area.
3. Group Values at Risk into "neighborhoods" that represent relatively similar hazard factors.
4. Identify and quantify factors that limit (mitigate) undesirable fire effects to the Values at Risk (hazard levels).
5. Recommend specific actions that will reduce hazards to the Values at Risk.

Other Desired Outcomes

1. To promote community awareness:

   Quantifying the community's hazards and risk from wildfire will facilitate public awareness and assist in creating public action to mitigate the defined hazards.
2. To improve wildfire prevention through education:

   Community awareness, combined with education, will help to reduce the risk of unplanned human ignitions.
3. To facilitate and prioritize appropriate hazardous fuel reductions:

   Organizing and prioritizing hazard mitigation actions into Fire Management Units (FMUs) will provide stakeholders with social and fire-management perspectives, allowing them to make better decisions about their future efforts.
4. To promote improved levels of response:

   The identification of areas of concern will improve the accuracy of pre-planning, and facilitate the implementation of cross-boundary, multi-jurisdictional projects.

COMMUNITY OVERVIEW

The City of Santa Fe Fire Department response area is located in Santa Fe County, New Mexico. The Santa Fe County Fire Department is the adjacent responding fire authority on most sides of the city. The USDA Forest Service responds to any fires on the adjacent National Forest Service land to the east of the city. In New Mexico, the State Forestry Division has the ultimate jurisdiction for wildland fire suppression on all non-municipal, non-federal lands. The study area for this project covers 29,694 acres (46.4 square miles), and has approximately 66,476 residents (2000 census data). The primary access to the study area is via US Highway 285 and Interstate 25.

The majority of Santa Fe is considered to be in the Sonoran and Transition life zones.[1] Elevations in the study area range from 5,935 feet to approximately 9,422 feet. The most common native vegetation community is piñon/juniper (*Pinus delis* and *Juniperus monosperma* dominant).

Figure 1. Typical Landscape

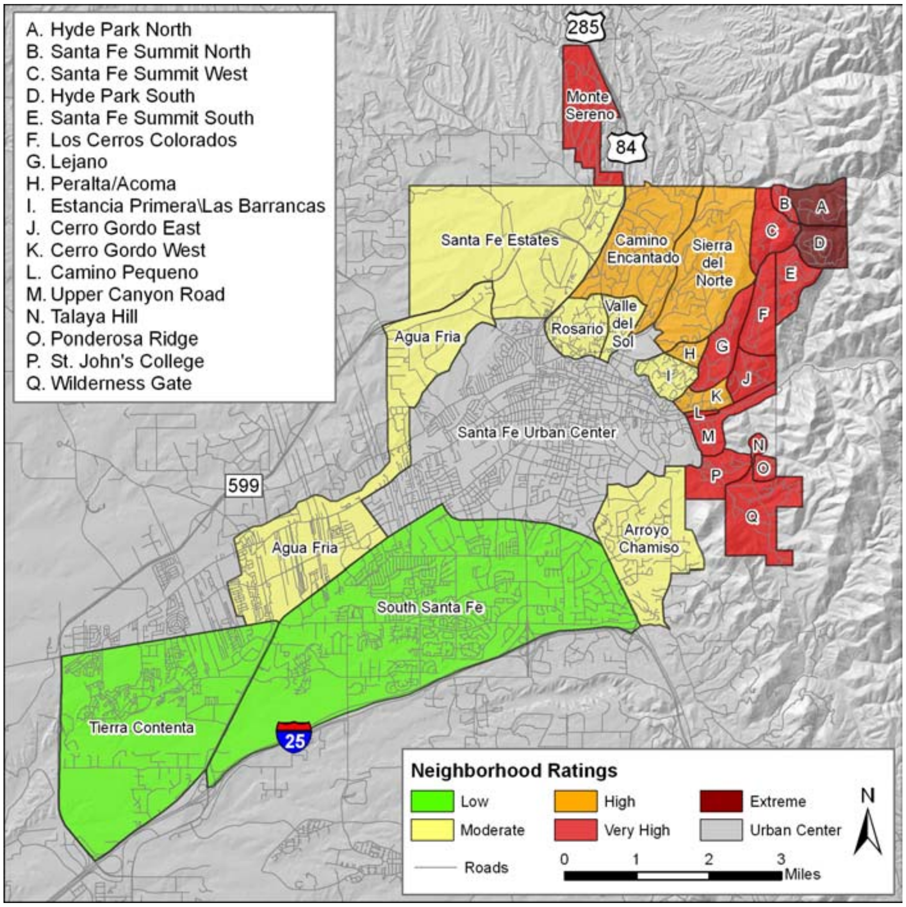
Other significant plant communities include grasslands, ponderosa pine (*Pinus ponderosa*)/Gambel oak (*Quercus gambelii*) forests, and riparian vegetation. The grasslands occur primarily in the western portion of the study area at the lower elevations. Blue grama (*Bouteloua gracilis)* is dominant, sometimes with abundant chamisa (*Chrysothammus nauseosus*, also known as rabbitbrush), with a variety of perennial grasses as co-dominants. The ponderosa/Gambel oak community occurs on slopes and in canyons of the foothills and is often surrounded by and/or mixed with piñon/juniper stands. This plant community is found exclusively on the eastern side of the study area at the higher elevations. The riparian plant community is located throughout the urban and semi-urban portions of the study area in association with streams, arroyos and seeps or springs. This plant community is composed of a mix of native and introduced species including cottonwood (*Populus fremontii)*, chamisa, cattails (*Typha laifolia*), coyote willow (*Salix exigua*), Siberian elm (*Ulmus pumila*), and others. Coverage within the study area ranges from open grassland and savannah to dense canopies of mixed conifer.

Figure 2 shows the neighborhoods that define the Wildland-Urban Interface (WUI) study area. As a part of this project, the most populated areas in the WUI were divided into 27 neighborhoods. Each neighborhood represents certain dominant hazards from a wildfire perspective. Fuels, topography, structural flammability, availability of water for fire suppression, egress and navigational difficulties, as well as other natural and manmade hazards, are considered in the overall hazard ranking of these neighborhoods. The methodology for this

[1] Life zone information taken from the Randall Davey Audubon Center and The Nature Conservancy Santa Fe Canyon Preserve website: http://nm.audubon.org/iba/ibawriteups/rdactnc.html 2006

assessment uses the WHR community hazard rating system that was developed specifically to evaluate neighborhoods within the WUI for their relative wildfire hazard.[2] The WHR model combines physical infrastructure (structure density, roads, etc.) and Fire Behavior Components (fuels, topography, etc.) with the field experience and knowledge of wildland fire experts. For more information on the WHR methodology please see **Appendix B**.

Figure 2. Santa Fe Neighborhood Hazard Rating Map



1. Hyde Park North	10. Los Cerros Colorados	19. Sierra del Norte
2. Hyde Park South	11. Lejano	20. Arroyo Chamiso
3. Santa Fe Summit North	12. Santa Fe Summit South	21. Rosario
4. Santa Fe Summit West	13. Monte Sereno	22. Santa Fe Estates
5. Wilderness Gate	14. Upper Canyon Road	23. Estancia Primera/Las Barrancas
6. Talaya Hill	15. St. John's College	24. Agua Fria
7. Ponderosa Ridge	16. Camino Encantado	25. Valle del Sol
8. Cerro Gordo East	17. Peralta/Acoma	26. South Santa Fe
9. Camino Pequeno	18. Cerro Gordo West	27. Tierra Contenta

[2] White, C. "Community Wildfire Hazard Rating Form." *Wildfire Hazard Mitigation and Response Plan*. Colorado State Forest Service. Ft. Collins, CO. 1986.

Figure 3 and **Figure 4** show the general topography of the area. These graphic representations of the landforms of the study area (elevation and slope) will be helpful in interpreting other maps in this report. Please refer to these figures as necessary while reading this document.

Figure 3. Percent Slope

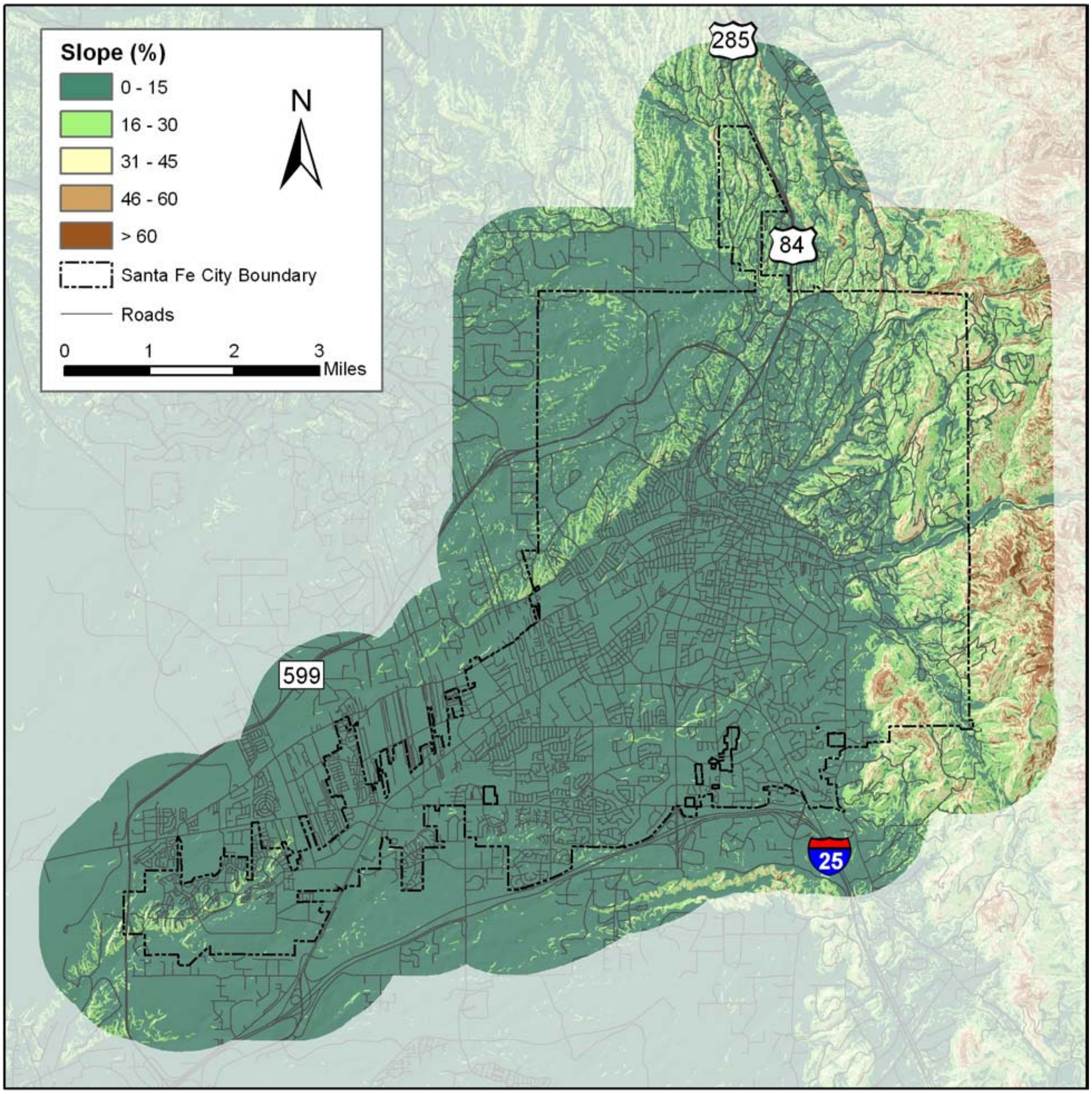
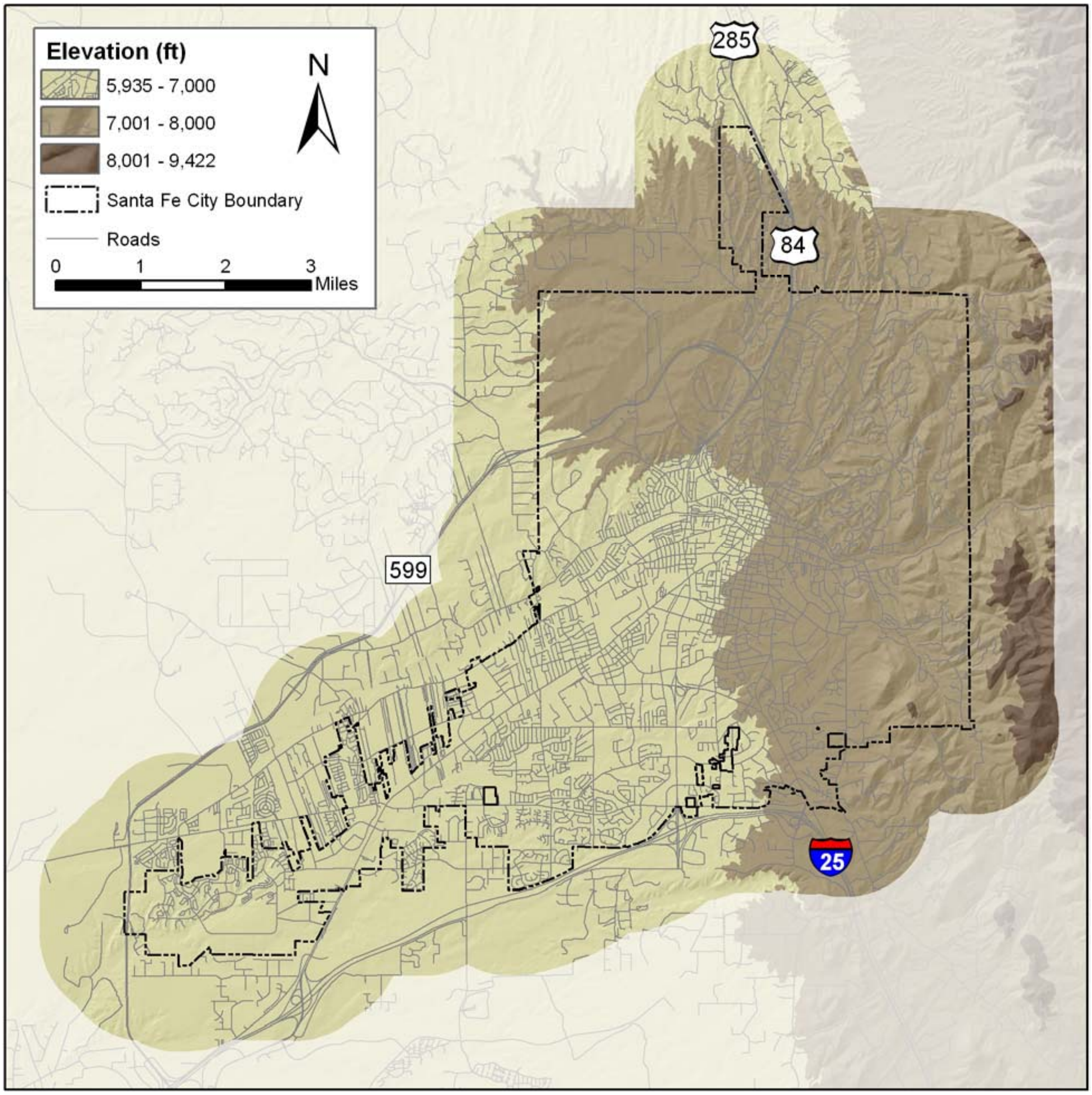


Figure 4. Elevation



CURRENT RISK SITUATION

For the purposes of this report the following definitions apply:

Risk is considered to be the likelihood of an ignition occurrence. This is primarily determined by the fire history of the area.

Hazard is determined by combining the WHR ratings of the WUI neighborhoods with Fire Behavior Potential, as modeled from the fuels, weather, and topography of the study area.

The northern and eastern portions of the district are at a high risk for WUI fires. The western portion of the district is at a moderate risk for WUI fires. This assessment is based on an analysis of the following factors.

- The Santa Fe watershed, located in the eastern portion of the study area, and the surrounding lands, is listed in the Federal Register as an area at high risk from wildfire (http://www.fireplan.gov/reports/351-358-en.pdf).
- The City of Santa Fe and Hyde Park Estates are listed in the 2005 New Mexico Communities at Risk Assessment Plan as areas at high risk from wildfire (http://164.64.103.42/EMNRD/Forestry/FireMgt/docs05/2005NM_CAR.pdf)
- Fire history data gathered from the New Mexico State Forestry Division for Santa Fe County shows 470 fires from 1987-2006.[3] This data is displayed in **Figure 5**. There is an annual average of 25 fires per year, county-wide. This represents an active, but not extreme, fire history. It is worth noting that this data set shows more actual ignitions in the western portion of the district. However, most of these are likely to be grass fires, considering the available fuels in this area. The data does show a recent history (within the last 20 years) of significant fires in the study area. This data, combined with the Fire Regime and Condition Class assessment (FRCC) data, available fuels, and expected fire movements (based on prevailing winds and the Fire Behavior Analysis) suggest that at least the northern and eastern portions of the study area are at high risk for a significant wildfire occurrence.
- The Fire Regime and Condition Class (FRCC)[4] assessment of the study area and the surrounding lands reveals an extreme departure from reference condition vegetation (historic norms), and relatively short return intervals (less than 35 years) in the eastern side of the study area. Departure from reference conditions is less severe in the western portion of the district, though the return intervals are still short (less than 35 years). In the northern portion of the district, departure from reference condition vegetation is extreme, but return intervals are longer (35 to 100 years). This information is displayed graphically in **Figure 6** on page 14.

---

[3] http://www.emnrd.state.nm.us/emnrd/forestry/FireMgt/StateForestryandGIS.htm

[4] FRCC is an interagency, standardized tool for determining the degree of departure from reference condition vegetation, fuels, and disturbance regimes. For more information on FRCC please see http://www.frcc.gov/.

Figure 5. Santa Fe County Fire History (from NM State Forestry Division Data)

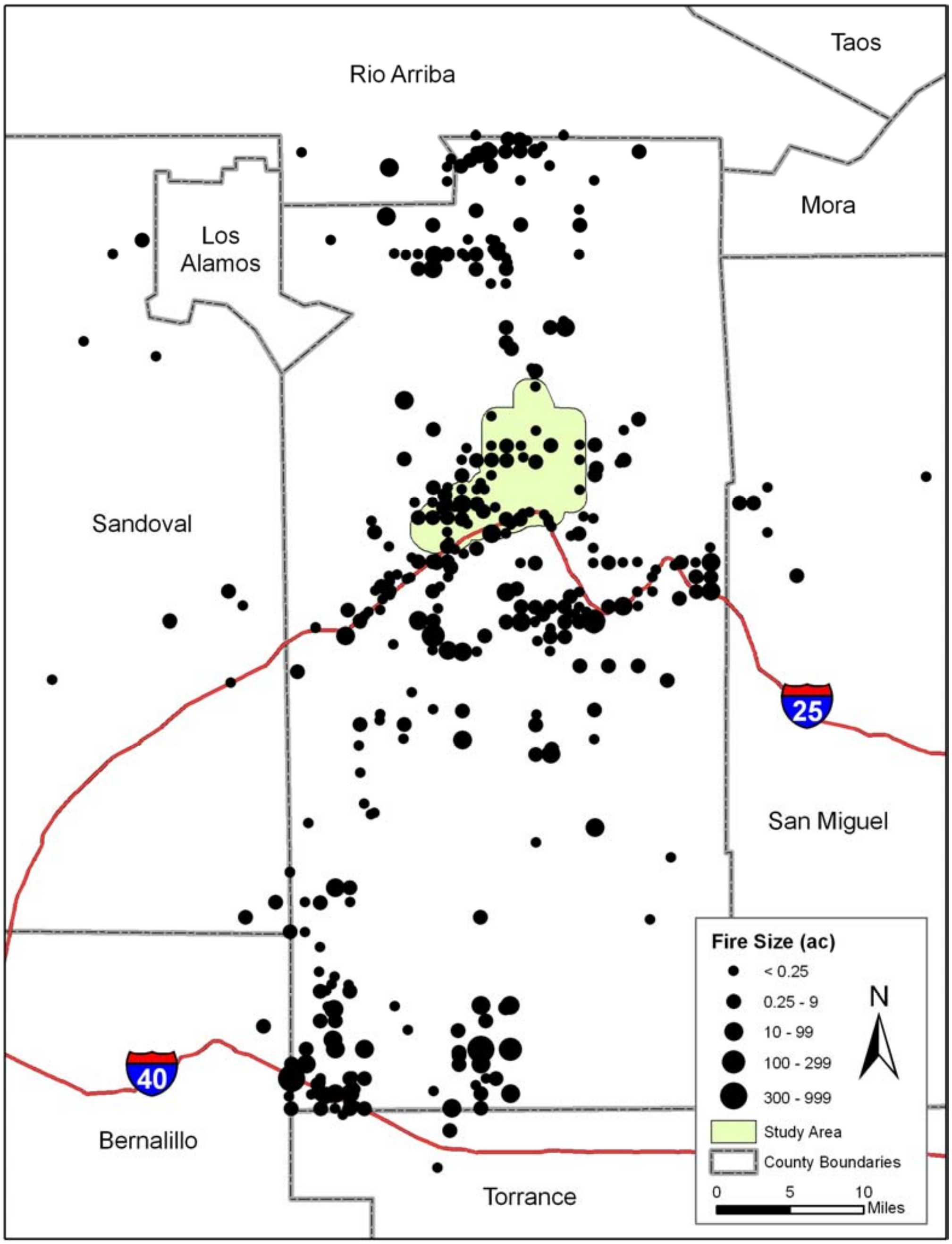
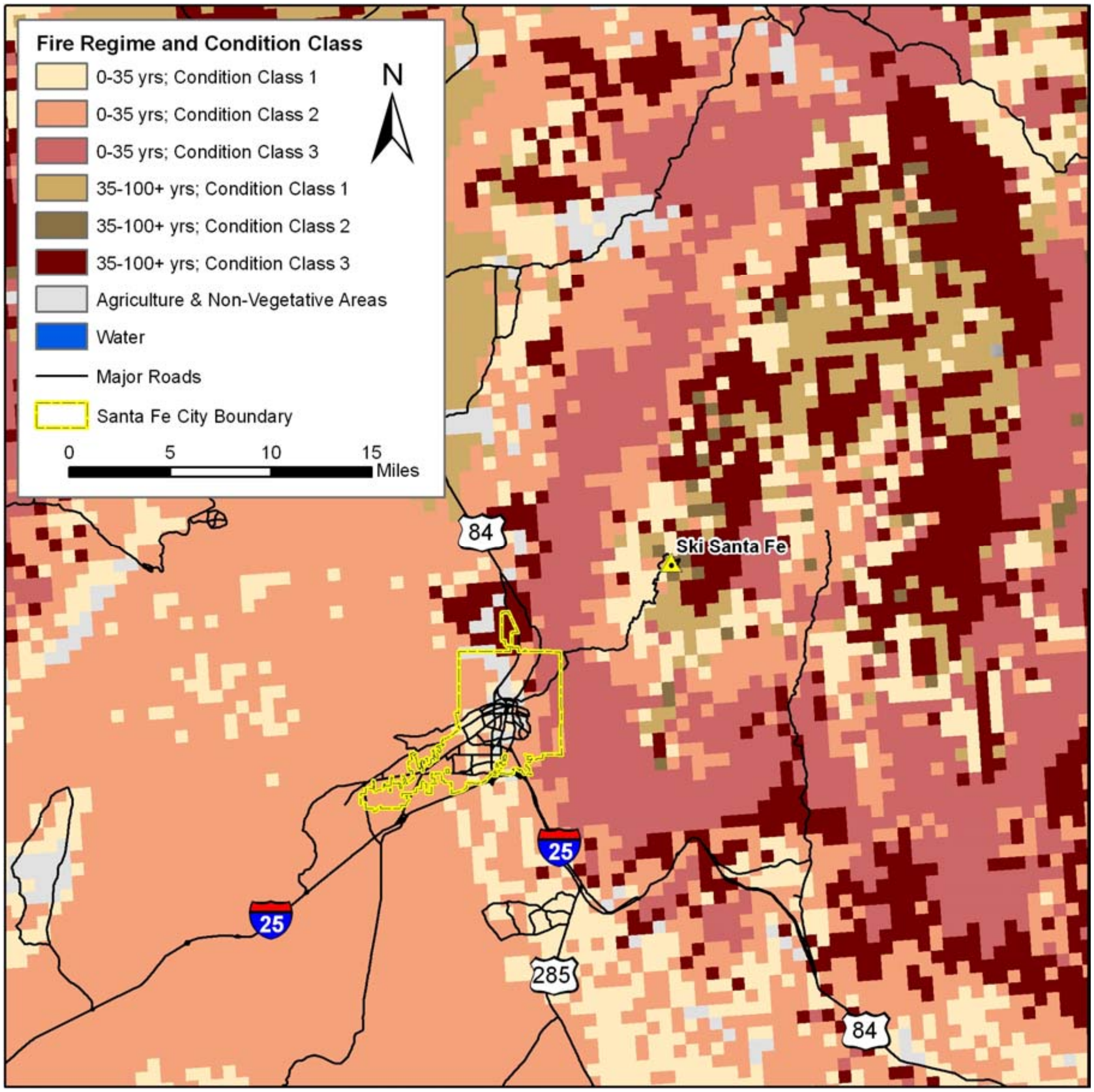
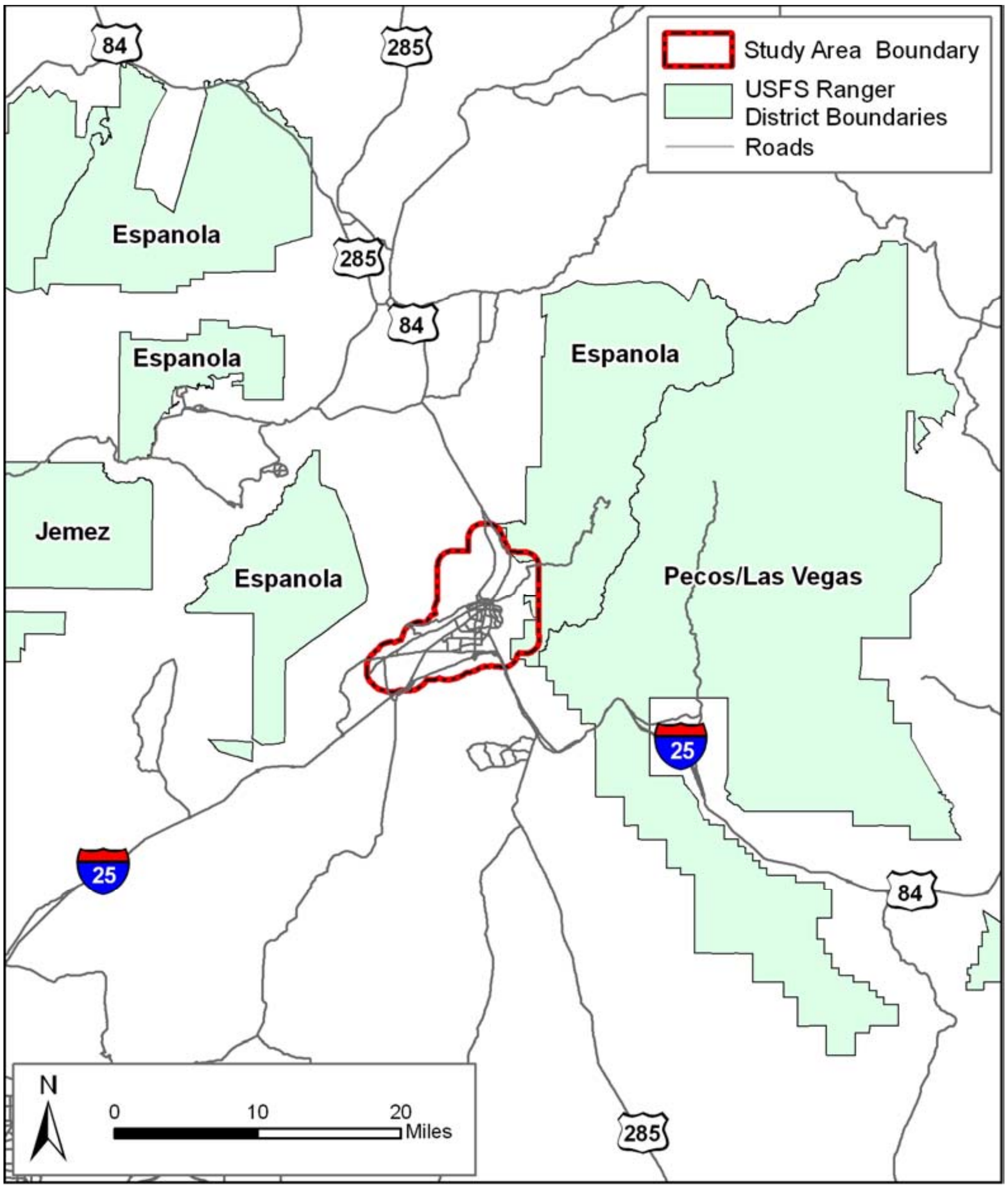


Figure 6. Fire Regime and Condition Class



- The surrounding federally managed lands report an active fire history. Fire occurrences for the Las Vegas and Espanola Ranger Districts (USFS) were extracted from Personal Computer Historical Analysis (PCHA) data for the 35-year period from 1970-2005. These areas represent all USFS managed lands in and near the study area, but do not include any data from areas that are exclusively the responsibility of city or county fire departments. **Figure 7** shows the data extent for this analysis. The results are graphed and summarized below.

Figure 7. Data Extent for Santa Fe Fire History



- **Figure 8** shows the number of fires in the Las Vegas and Espanola Ranger Districts of the U.S. Forest Service between 1970 and 2005. The number of annual fires ranges from approximately three to over 40 per year, with significant variation from year to year. Similarly, there is a large degree of variability in the annual number of acres burned, ranging from too few to appear on the graph to more than 40,000 acres burned per year. The size class distribution of fires is shown in **Figure 9**. Of the 678 fires recorded between 1970 and 2005, 16 were major fires (fires of 100 acres or more). The vast majority of fires were extinguished before reaching 100 acres in size. This could reflect the type of fuels and weather conditions encountered by suppression resources in the Santa Fe vicinity. It could also be an indicator of the effectiveness of suppression capabilities in the area. It is likely that a combination of the two has dictated this size classification. **Figure 10** shows the number of fires occurring by each cause class. As shown in the graph, the overwhelming majority (514 of 678) of fires in the area were caused by lightning, followed by campfires (66 fires), and arson (37 fires). The prominence of naturally-occurring (lightning-ignited) fires in the area could be an indicator that fire return intervals are still primarily controlled by natural processes. As large areas of wildland fuels come under pressure through increasing development and recreational use, the causes of wildfires could shift toward human-caused events.

Figure 8. Number of Fires by Year (1970-2005)

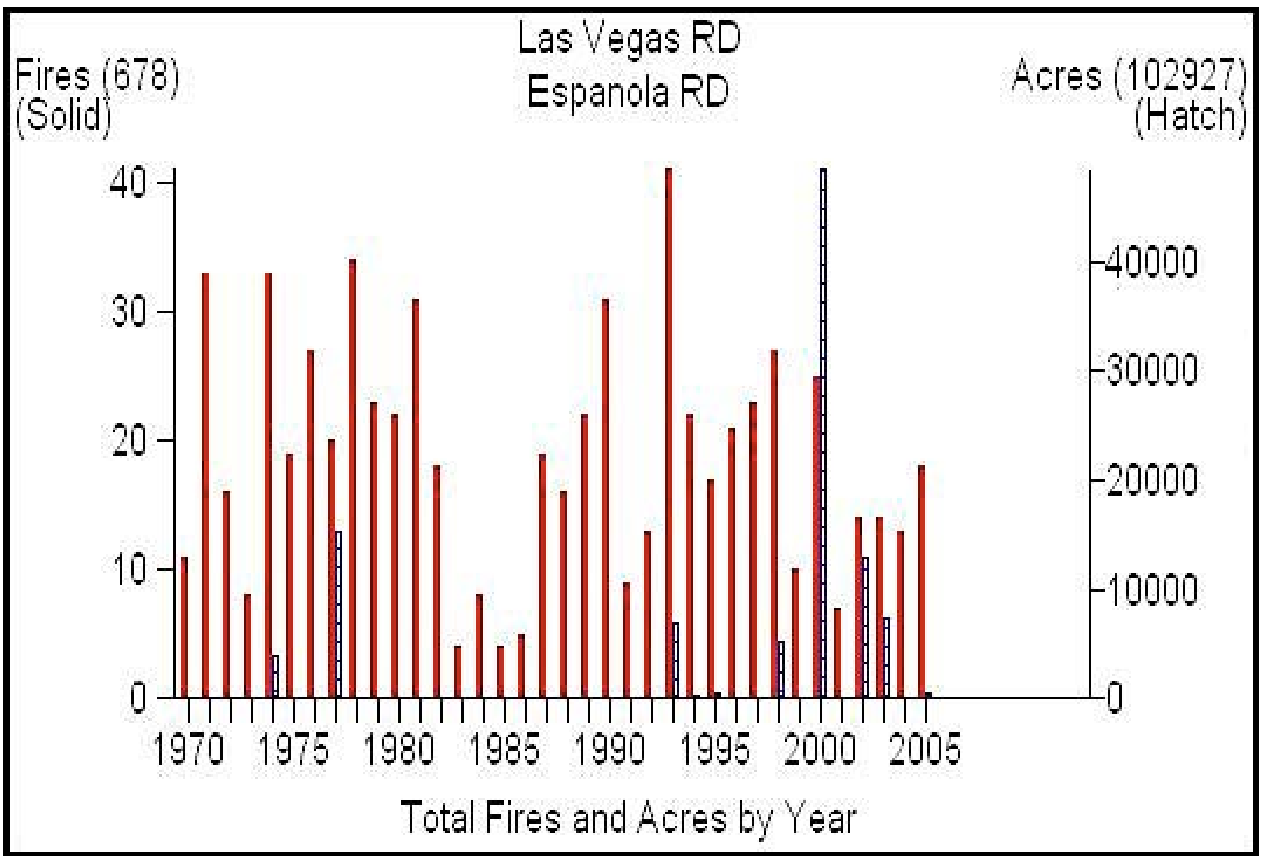


Figure 9. Number of Fires by Size Class (Acres)

Size Class	Acres
A	< ¼
B	¼ - 9
C	10 – 99
D	100 – 299
E	300 – 999
F	1000 – 4999
G	5000 +

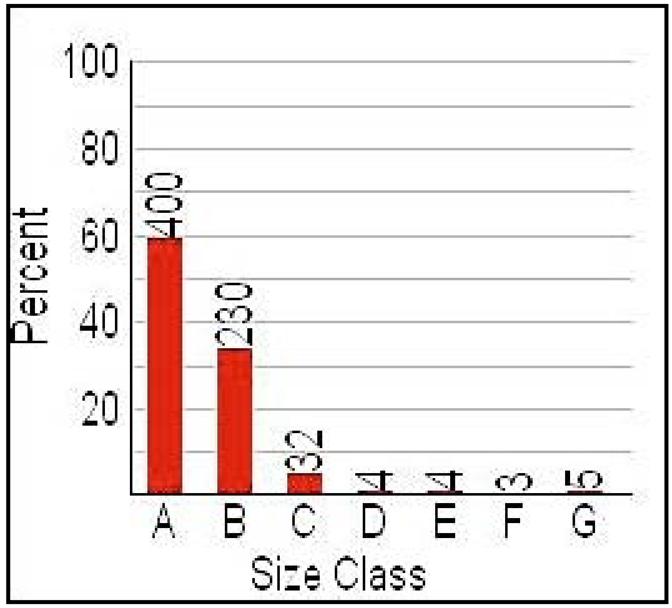
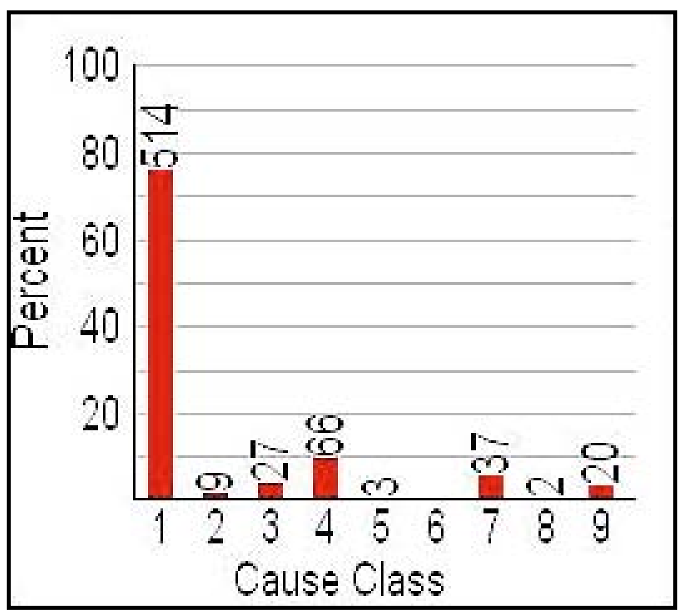


Figure 10. Number of Fires by Cause

Cause Class	Cause
1	Lightning
2	Equipment
3	Smoking
4	Campfire
5	Debris Burning
6	Railroad
7	Arson
8	Children
9	Misc.



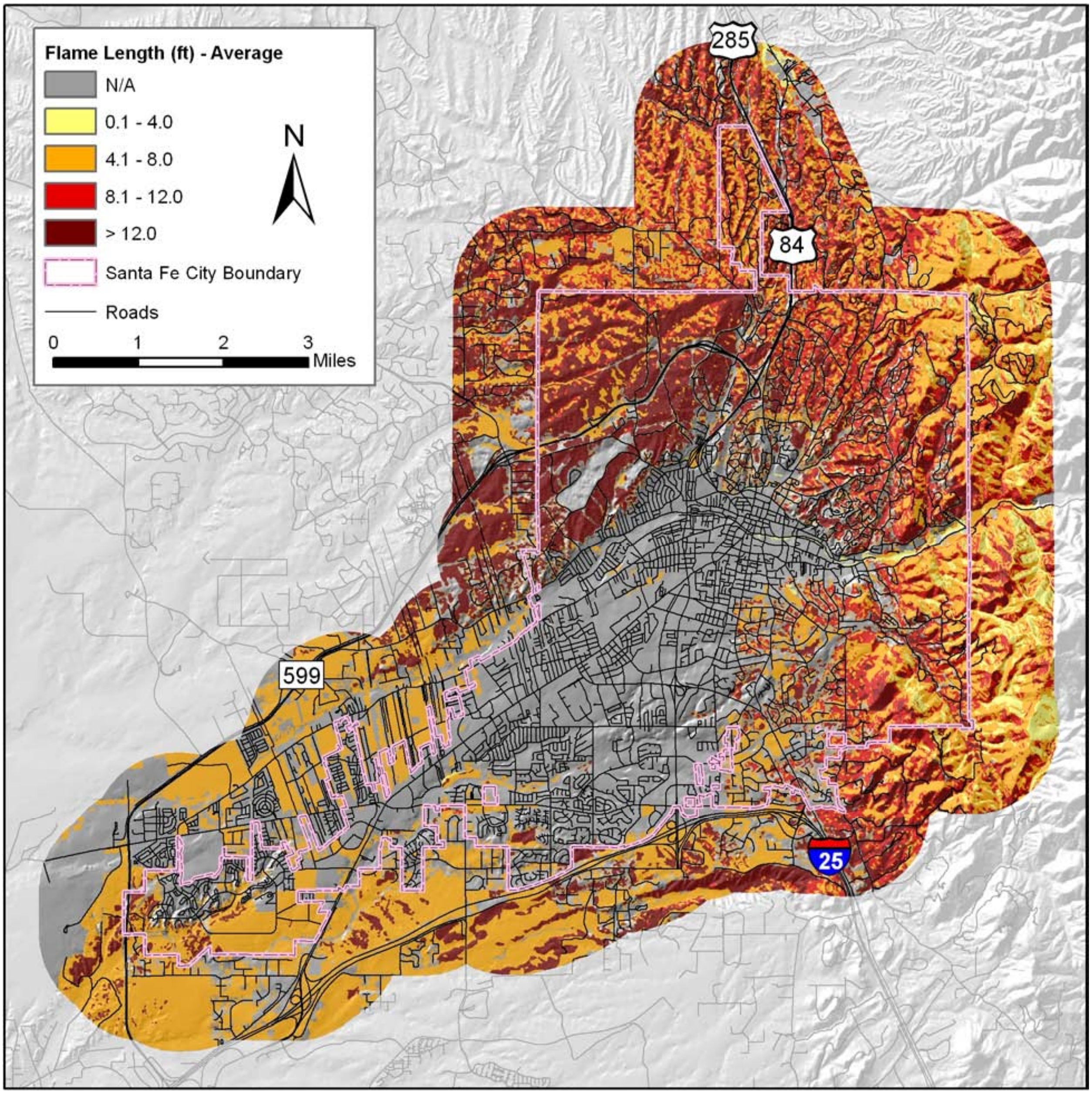
FIRE BEHAVIOR POTENTIAL

Figures 11-13 are Fire Behavior Potential maps for average conditions. They graphically display potential crown fire activity, flame length, and rate of spread generated. These maps have been made with FlamMap 2.0 fire behavior modeling software (see **Glossary**). Weather observations from the nearby Pecos Remote Automated Weather Station (RAWS) site were averaged for an eleven-year period (1994-2005) to derive relevant fuel variables for inclusion in FlamMap. The average conditions class (16^{th} to 89^{th} percentile) was calculated for each variable (1 hour, 10 hour, and 100 hour fuel moisture, woody fuel moisture, herbaceous fuel moisture, and wind speed) using the Fire Family Plus (see **Glossary**) computer software package. This weather condition class most closely represents an average fire season day.

The extreme conditions maps, **Figures 14-16**, were calculated using ninety-seventh percentile weather data. This means that the weather conditions of the four most severe fire weather days (sorted by Spread Component) in each season for the eleven-year period were averaged together. It is reasonable to assume that similar conditions may exist for at least four days of the fire season during an average year. In fact, during extreme years such conditions may exist for significantly longer periods. Even these calculations may be conservative compared to observed fire behavior.

Weather conditions are extremely variable and not all combinations are accounted for. These outputs are best used for pre-planning and not as a stand-alone product for tactical planning. This model can be combined with the WHR and Values at Risk information to generate current and future "areas of concern," which are useful for prioritizing mitigation actions. This is sometimes referred to as a "values layer." When this information is used for tactical planning, it is recommended that fire behavior calculations be done with actual weather observations during the fire event. For greatest accuracy, the most current Energy Release Component (ERC) values should be calculated and distributed during the fire season, for use as a guideline for Fire Behavior Potential. For a more complete discussion of the Fire Behavior Potential methodology, please see **Appendix A**.

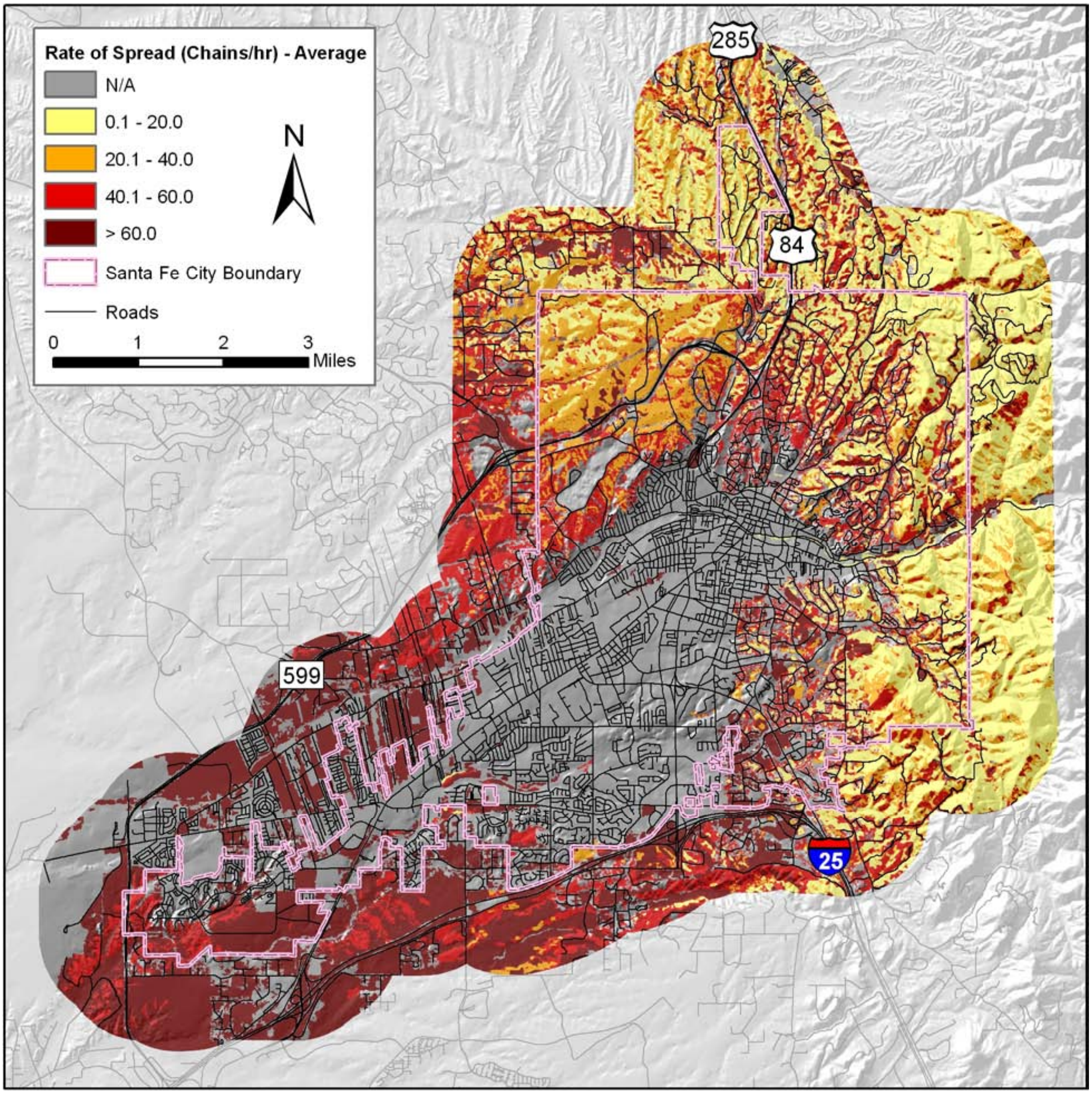
Figure 11. Flame Length Predictions (Average Weather Conditions)



N/A = Not Applicable

Flame Length: The distance between the flame tip and the midpoint of the flame depth at the base of the flame (generally the ground surface). Flame Length is an indicator of fire intensity.

Figure 12. Rate of Spread Predictions (Average Weather Conditions)

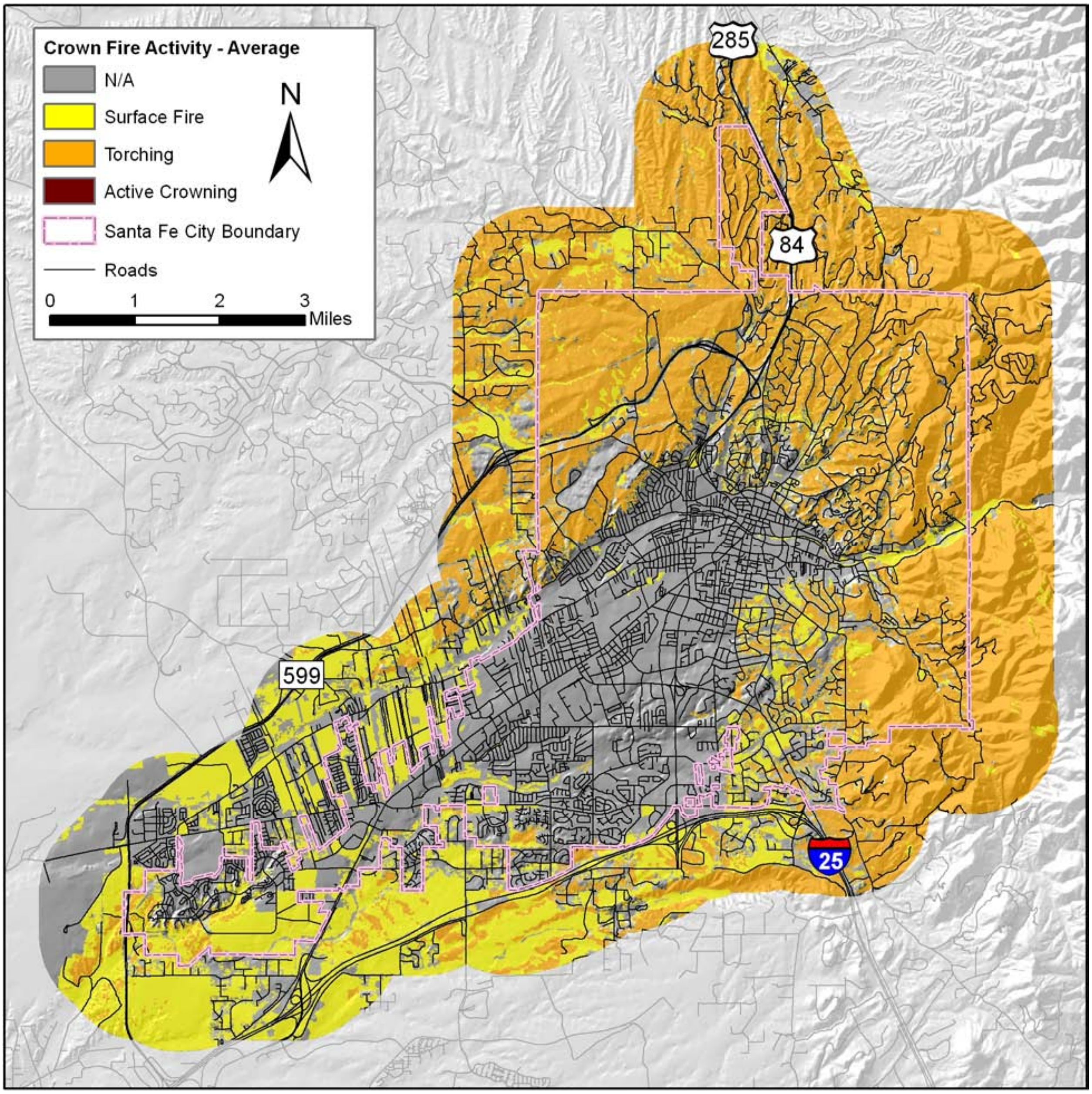


N/A = Not Applicable

A *chain* is a logging and fire line measurement. 1 chain = 66 feet. 80 chains/hour = 1 MPH

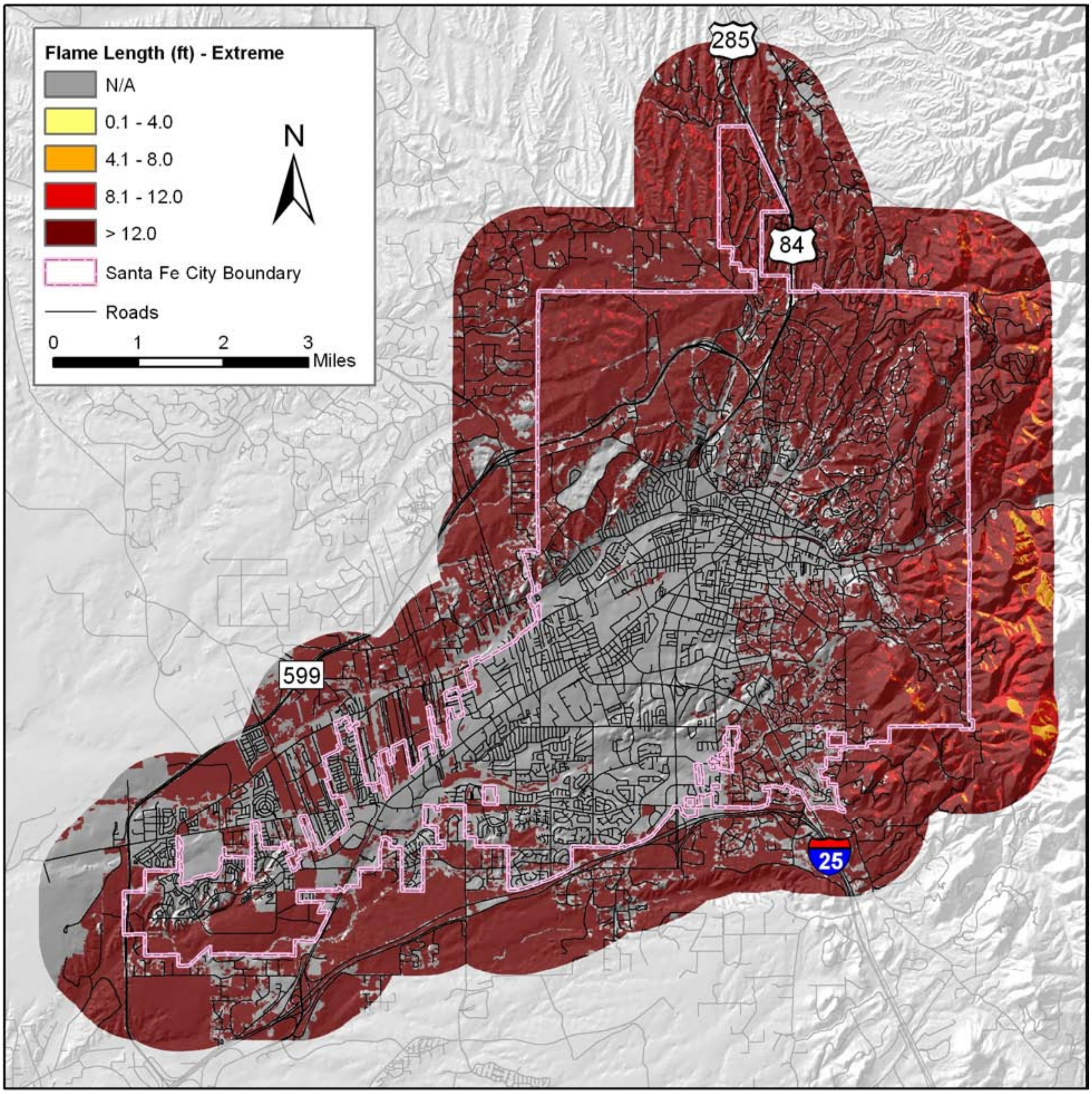
It is important to note that "spotting" or burning embers landing ahead of the fire front can effectively increase the rate at which the fire moves across the landscape.

Figure 13. Crown Fire Potential (Average Weather Conditions)



N/A = Not Applicable

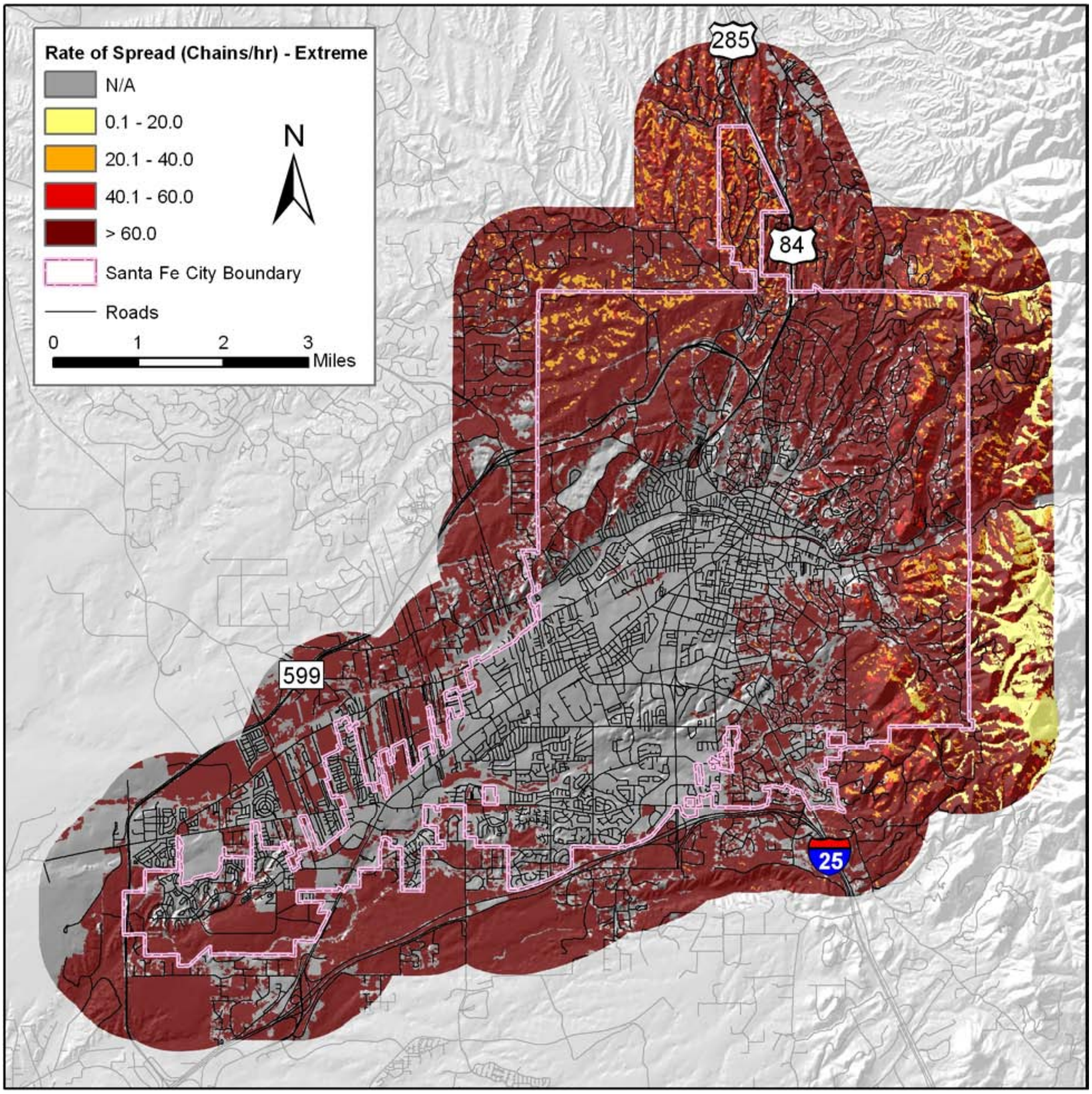
Figure 14. Flame Length Predictions (Extreme Weather Conditions)



N/A = Not Applicable

Flame Length: The distance between the flame tip and the midpoint of the flame depth at the base of the flame (generally the ground surface). Flame Length is an indicator of fire intensity.

Figure 15. Rate of Spread Predictions (Extreme Weather Conditions)

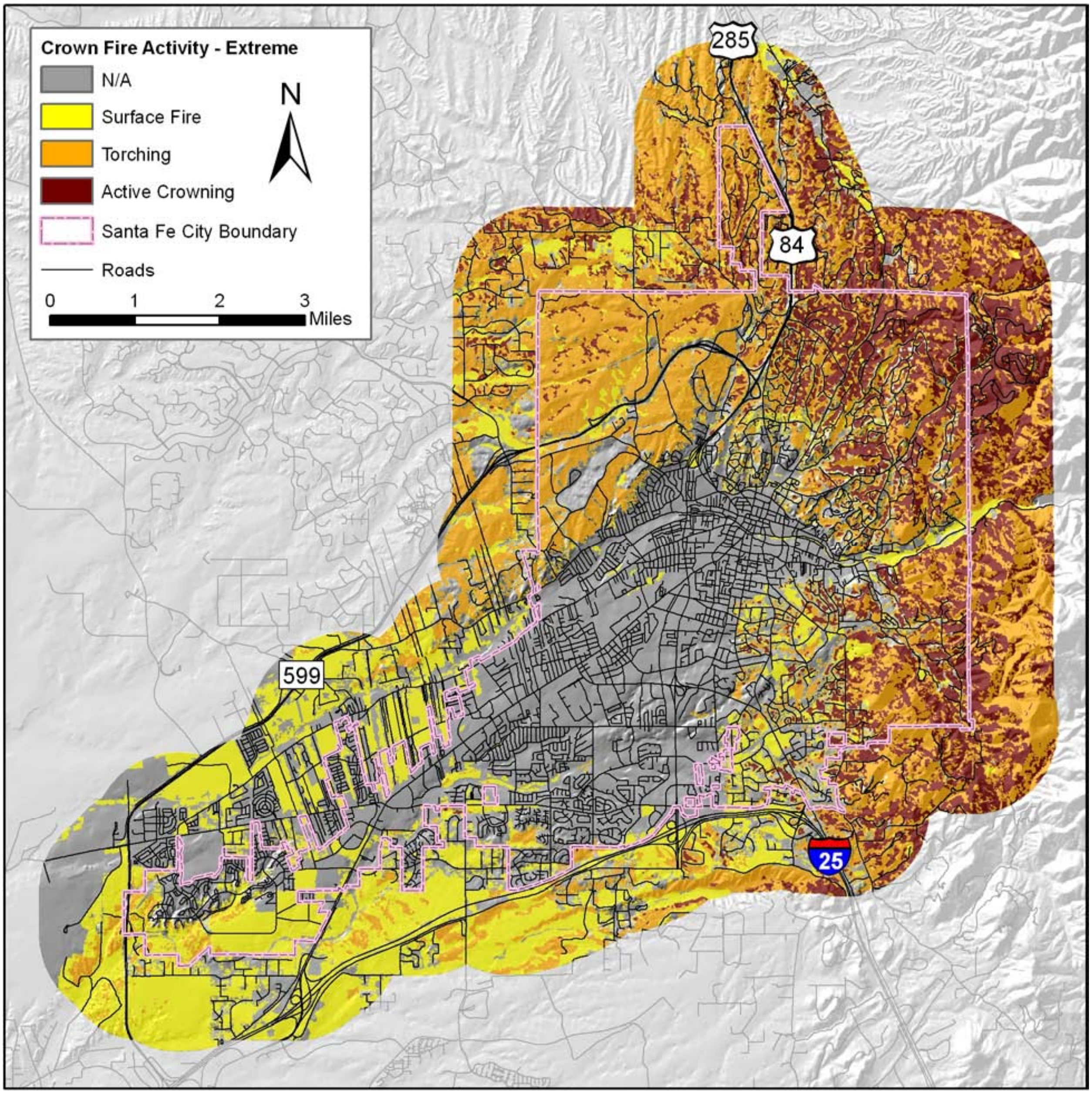


N/A = Not Applicable

A *chain* is a logging and fire line measurement. 1 chain = 66 feet. 80 chains/hour = 1 MPH

It is important to note that “spotting” or burning embers landing ahead of the fire front can effectively increase the rate at which the fire moves across the landscape.

Figure 16. Crown Fire Potential (Extreme Weather Conditions)



N/A = Not Applicable

SOLUTIONS AND MITIGATION

Establishing and Prioritizing Fire Management Units (FMUs)

An efficient method of prioritizing work efforts is to create FMUs. Each unit reflects a particular function, such as the development of an effective public outreach program, or a geographic treatment area with related fuels reduction projects. FMUs are created prior to initiating management projects and mitigation activities. Unique activities and objectives are recommended for each unit. Local land and fire management agencies, with the input of a citizen's advisory council or FireWise council, must determine priority actions.

The following FMUs have been identified for the Santa Fe Fire Department response area. Recommendations are provided for each. FMUs are NOT ranked by priority, although priority recommendations have been provided for specific tactical mitigation actions where appropriate within the FMUs.

- Addressing, Access, Evacuation, and Shelter-in-Place FMU
- Public Education FMU
- Home Mitigation FMU
- Fuels Modification Projects FMU
- Water Supply FMU

Addressing, Evacuation, and Shelter-In-Place FMU

Addressing

In most neighborhoods within the study area, missing or inadequate street signage and addressing is an issue. This problem is also noted in the individual neighborhood descriptions in **Appendix B**. Markers of all types, some homemade, are used throughout the study area with no particular order or system. There are many homes that have no address markers on the house or at the intersection of the driveway and the street (see **Figure 17**). The most common address marker is at the mailbox. Address numbers on the box itself, or on the post, are frequently the only indication of the address. In some cases the mailbox pole is wood (see **Figure 18**). There are several driveways in the study area where multiple homes are accessed from a single driveway off the public road. Some of these are gated and unmarked (see **Figure 19**), and some have flagged addressing. Flagged addressing is a term used to describe the placement of multiple addresses on a single sign that serves multiple structures located on a common access. Where flagged addressing exists, marker placements are inconsistent and in some cases confusing (see **Figure 20**). While some residents may consider reflective address signage to be unattractive, it is essential to ensure quick and effective response. The time saved, especially at night and in difficult smoke conditions, cannot be underestimated. Knowing at a glance the difference between a road and a driveway (and which houses are on the driveway) cuts down on errors and time wasted interpreting maps. This is especially true for outside resources, which do not have the opportunity to train on access issues. Recommendations for address markers can be found in **Appendix D**.

Figure 17. No Address Markers

Figure 18. Typical Address Marker
(non-reflective on a wooden pole)

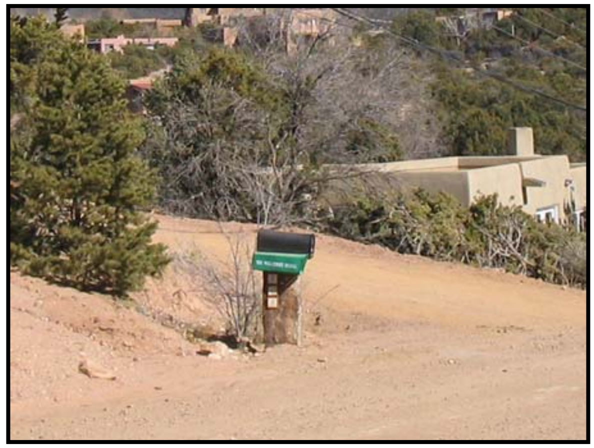


Figure 19. Gated and Unmarked Driveway

Figure 20. Confusing Markers
(boxes between two driveways)

Recommendations

- A program to replace worn or difficult to read street signs should be undertaken. Every intersection and street name change should have large, reflective signage.
- Flagged addressing on common driveways should be replaced with reflective markers that indicate the proper road fork, where applicable, for each address. This system should be repeated at every point where the driveway divides and an individual driveway leaves the common driveway.
- Reflective markers should be placed for each home where the driveway leaves an access road and on the house itself. These may be in addition to, or in place of, existing decorative address markers. Consistency in height and placement should be stressed.
- Lot markers should be replaced with address markers as soon as a home has a certificate of occupancy.
- Where dead-end and private road markers occur, the addresses of homes beyond the marker should be clearly posted. This can be done with a group address marker. For example "14391-14393 Highway 84."

Evacuation Routes

Neighborhoods rated from Extreme to High Hazard were evaluated for the possibility of developing alternate evacuation routes. In all of the neighborhoods studied, it was determined that the existing primary access roads are the best option for access and egress. Where alternate trails/private roads were available, several problems were noted. Most of these have impassible dead ends, run through heavy fuels, have very poor driving surfaces, lead directly towards expected fire movement based on prevailing winds and slope conditions, and/or do not lead evacuees to a substantially better position. One potential evacuation route that has been proposed is worthy of mention. Use of an existing jeep trail for evacuation from the Wilderness Gate neighborhood to the south would require removal of an existing barrier, high clearance 4WD vehicles and would require evacuees to travel through areas where heavy, continuous fuel beds encroach on the route. Use of this route would place evacuees in more danger and possibly result in the need for difficult and hazardous rescue efforts. For these reasons, the use of this route is strongly discouraged.

Other evacuation recommendations

- Mark all fire evacuation routes clearly with non-combustible markers and poles. Where intersections exist, be sure the correct direction is clearly marked.
- In order to reduce conflicts between evacuating citizens and incoming responders, it is desirable to have nearby evacuation centers for citizens and staging areas for fire resources. Evacuation centers should include heated and cooled buildings with facilities large enough to handle the population. Schools and churches are usually ideal for this purpose. Fire staging areas should contain large safety zones, a good view in the direction of the fire, easy access and turnarounds for large apparatus, a significant fuel break between the fire and the escape route, topography conducive to radio communications, and access to water. Local responders are encouraged to preplan the use of potential staging areas with property owners.

- Identify and pre-plan citizen evacuation centers and staging areas.
- Perform response drills to determine the timing and effectiveness of fire resource staging areas.
- Educate citizens on the proper escape routes and the location of evacuation centers to use in the event of an evacuation.
- Use the existing Dialogic system (also referred to as a "reverse 911 system") or call lists to warn residents when an evacuation may be necessary. The Dialogic system may not be 100% effective in reaching residents. Therefore, notification should also be carried out by local television and radio stations. It is important to note that Voice Over Internet Protocol or Voice Over IP negates the reverse 911 system for its users. A solution may be forthcoming but is not currently available.

Shelter-in-Place

Fire is a normal part of Santa Fe's environment. This is evident from the record of fire occurrence—470 fires from 1987-2006—as described in the risk section above. Wildland fires are a serious threat to life and property. Not all wildland fires are big, but many have the potential to grow and become destructive. Empirically, local residents know that wildland fires are a common occurrence during drier periods of the year. Wildland fires that occur on hot, dry, windy days frequently cause significant damage to built assets and occasionally cause loss of life. Potential fire conditions were modeled using extreme weather conditions inputs. The outputs of this analysis are displayed graphically in **Figures 14-16** on pages 17-19.

Loss can be reduced or avoided in some cases, but cannot be entirely prevented. It is theoretically possible to prevent all loss by wildland fire through the total removal of all vegetation across the landscape. Such a measure is not possible in practical terms and is unacceptable to the community. A balance must be struck between measures taken to reduce or avoid loss due to wildland fire and the preservation and protection of other values.

This compromise involves acceptance of the inevitability of some loss. The Santa Fe Fire Department can assist neighborhoods in determining what level of risk they are prepared to accept. Losses can be reduced if buildings are designed, constructed, and maintained to resist wildland fire. Buildings designed to be fully resistant to wildland fire could be built, but at significant expense. Other measures, such as appropriate building site selection and the management of ornamental and natural fuels, can actually provide very high levels of protection to less fire-resistant structures, at a much lower cost.

There are several ways to protect the public from an advancing wildfire. One of these methods is evacuation, which involves relocating the threatened population to a safer area. Another method is to instruct people to remain inside their homes or public buildings until the danger passes. This concept, known as shelter-in-place, is relatively new to wildfire in the United States, but not to hazardous materials incident management (such as a toxic gas leak), where time, hazards, and sheer logistics often make evacuation impossible. This concept is also the dominant method for public protection from wildfires in Australia, where fast moving fires in light fuels make evacuation impractical.

In many of the neighborhoods in Santa Fe, a significant wildfire could make going outdoors dangerous. Leaving the area might take too long and/or put residents in harm's way. In such a case it may be safer to stay indoors than to go outside. Shelter-in-place tactics are designed to make the building as safe as possible for residents until help arrives. Residents should not try to shelter in a vehicle unless they have no other choice. Vehicles are not airtight. They do not provide enough protection from radiant heat, nor do they provide protection from smoke and gasses.

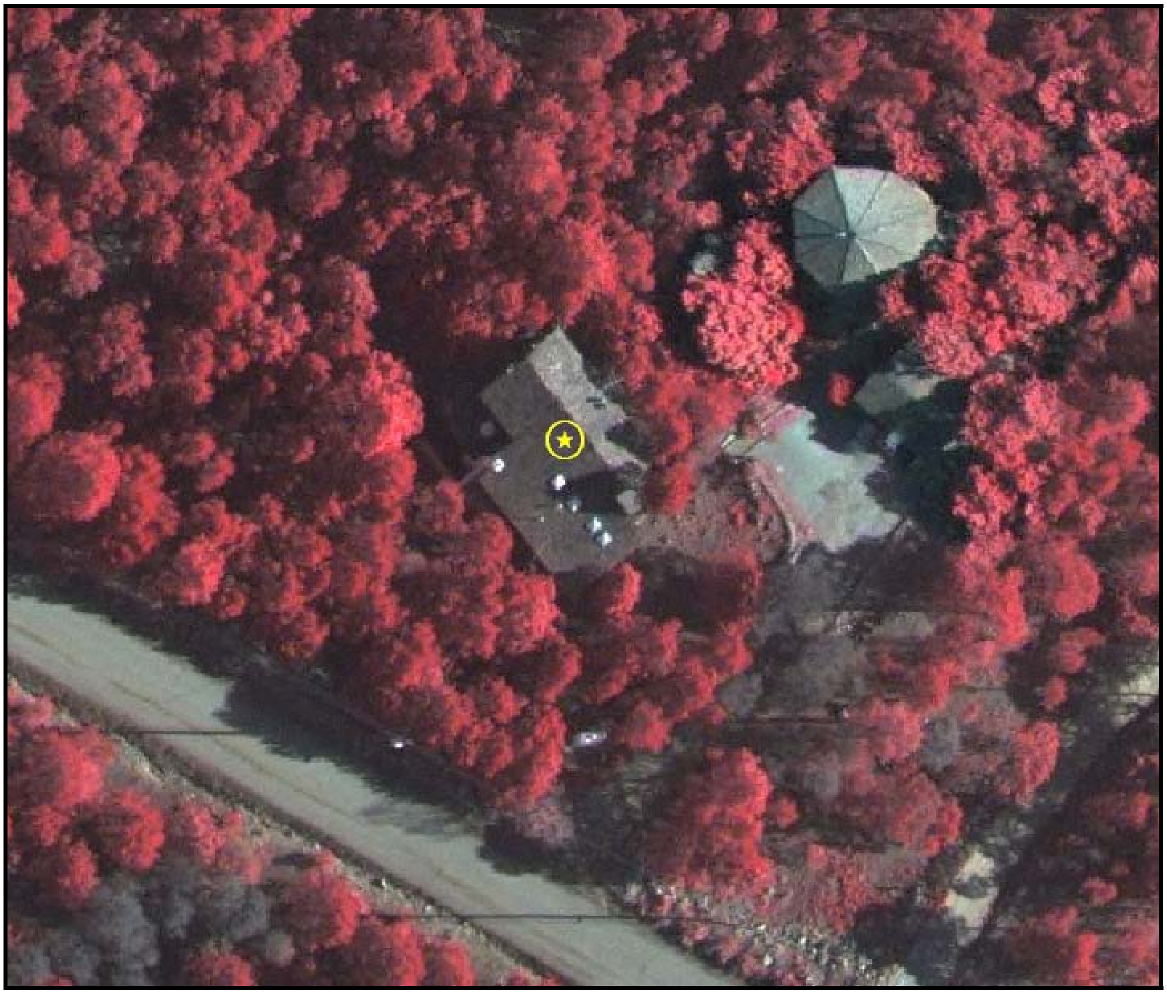
Appropriately prepared and constructed buildings, as described below, offer protection to people during wildland fires, reducing the likelihood of wildland fire-related injury and fatality. Many homes in the hazardous eastern portion of the study area could be cut off by fires below the structures and/or near critical access roads. In addition to improved access/egress, consideration should be given to developing shelter-in-place structures that are designed as alternatives to evacuation through hazardous areas. Shelter-in-place recommendations are noted in the **Appendix B** neighborhood sheet for each neighborhood where field evaluators deemed this tactic may be appropriate.

The success of shelter-in-place tactics depends on a detailed preplan that takes into account several factors. The construction type and materials of the designated building, depth and type of the fuel profile, and topography are all important, as is current and expected weather and fire behavior. An individual home assessment should be conducted in each case, to decide whether a given structure is appropriate for use as shelter-in-place.

Shelter-in-place should only be considered when the structure is determined to be "stand-alone," that is, survivable without firefighter intervention. In order to be stand-alone, homes or buildings need to have defensible space and must meet certain standards for ignition-resistant construction. Depending on the fuel type and fuel bed depth, it may be necessary to continue treatment beyond the minimum recommended defensible space boundaries in order to make the home stand-alone. For a list of defensible space recommendations please see the "General Recommendations" section of **Appendix B**.

Ignition-resistant construction is essential to the success of shelter-in-place tactics. Wooden roofs and old structures with untreated wooden siding are particularly hazardous and should not be considered. It is crucial to have metal, asphalt, tile, built roof, or some other ignition-resistant roofing material. Ignition resistant siding materials such as stucco or concrete—especially close to the ground—are also important. Eaves should be enclosed. Any holes in the foundation, siding, or eaves should be covered to prevent embers from entering. From high resolution aerial imagery supplied by the City of Santa Fe, a roof type analysis for all neighborhoods of the study area rated from High to Extreme Hazard by the Wildfire Hazard Rating index was conducted. From this analysis, two flammable roofs were detected in the study area (see **Figure 21**). It was determined with a high degree of certainty that there are no other flammable roofs within the High to Extreme Hazard areas. The combination of this analysis and field data gathered by Anchor Point leads us to conclude that the vast majority of roofs (typically the most fire-susceptible portion of a structure) in the study area are built of low or non-combustible materials. These materials include tile, metal, and composition roofs with a gravel top layer.

Figure 21. Flammable Roof in the Hyde Park Neighborhood



The majority of the homes in the Santa Fe study area, with the exception of the Hyde Park area, are constructed in the traditional southwest "Pueblo" architectural style, which features flat roofs with parapet walls, irregular/rounded edges to walls, stucco surfaces, and, often, *vigas* (round roof beams) extending through walls to the exterior.

Figure 22. Pueblo Architectural Style

The American Society for Testing and Materials (ASTM) E119, "Standard Test Methods for Fire Tests of Building Construction and Materials," describes test procedures for determining fire endurance of building materials. In fire endurance tests, concrete stucco generally fails by heat transmission long before structural failure, whereas other construction materials fail by heat transmission when collapse is imminent. A two-hour fire endurance rating for a concrete stucco wall means that the wall will experience an average temperature rise of 250°F for all points, or 325°F at any one point. The fire endurance of concrete can be determined by its thickness and type of aggregate used.

Stucco has also performed well during WUI fires. Data collected after several fires shows a correlation between fire damage and the exterior surfaces of buildings, including the following:

- Concrete or clay tile roofs performed much better than wood shake or shingle roofs.
- Buildings having non-combustible exterior wall surfaces, such as masonry or stucco, achieved a higher level of survival.
- Double-pane and tempered glass windows are needed to minimize heat transfer to the building interior.
- Minimal roof projections (or the use of non-combustible materials to protect combustible eaves and projections), plus the elimination of soffit vents, will also increase a structure's chances of surviving a wildland fire.

Figure 23. Stucco Home Survives Wildfire

Stucco is fire-resistant, which is one of the main reasons this home was the only house left standing on this California hillside after the wild fire. (PCA No. 13560)

Fortunately for the majority of the structures in the study area, local architectural controls and the generally accepted Pueblo architectural style provide a home which is inherently resistant to wildfire.

The To Bui home, (pictured above – **Figure 23)**, often referred to as the "miracle home," was intentionally built to withstand a significant wildfire event. For example, exterior walls are 2"x

6” wood-frame construction, with R-19 foil-faced insulation to increase the structure’s resistance to radiant heat. The exterior wall stucco is up to an inch thick with a nominal thickness of 3/4” (on most homes the nominal thickness of stucco is 5/8”). Where 1/2” wallboard is the minimal requirement on interior walls and ceilings, 5/8” wallboard and one-hour-rated exterior doors and jambs were used for this home.

Single-pane windows are generally acceptable in most climates. However, double-pane windows that contain an insulating air gap will provide greater protection against radiant heat from a wildfire. At 400°F, curtains, wallpaper, and bedding ignite. Wood studs spontaneously combust at about 450°F (steel studs melt and deform at approximately 1,000°F). At temperatures over 400°F, single-pane windows blow out from heat. Flame and heat rush in to meet interior combustion, thoroughly consuming structures. The entire structure can reach temperatures hot enough to weaken and spall a concrete foundation. Extreme heat has ignited combustible materials inside by entering houses through vents, poorly sealed doors or windows, and cracks in walls, sub-floors, or attics. This can happen even in the absence of direct flame impingement on the structure itself. Windows are the “Achilles heel” of most structures. This is why it is so important for homes in the Santa Fe study area to protect window openings from direct flame contact and extreme heat. This safety measure can be accomplished in several ways. The first and most effective treatment is to remove all flammable vegetation adjacent to windows for a minimum distance of three times the expected flame length as predicted by the Extreme Flame Length Fire Behavior Model shown on **page 17**. For the majority of the eastern area, this would mean at least a 36-foot non-combustible zone adjacent to windows. This by no means implies an area without vegetation, but does describe an area with fire resistant vegetation. Additionally, sturdy shutters can be employed to increase a window’s resistance to heat. As described above, double-pane and even tempered double-pane windows will help reduce the likelihood of fire penetrating window openings. Additionally, light window curtains should be replaced with blinds to help deflect radiant heat.

Figure 24. Double Fascia Covered by Stucco

Figure 25. Sample Roof Vents

Minimal gable-end vents (left) and dormer-type roof vents (right) are adequate for ventilation. Soffit vents are eliminated altogether. Behind the vents, 1/4-in. wire mesh should be installed to reduce the risk of drawing embers into the attic space.

Ventilation, ordinarily found in soffits, on the ridges of roofs, and in crawlspaces, can be placed at the mid-peak points of gabled end walls. Roof vents placed on a class-A cement-tile roof at every peak will allow the quick and efficient release of attic heat. This is critical because attic insulation ignites at about 450°F.

Wooden decks can be another source for structure ignition. Many options exist to retrofit or build with more fire-resistant materials. Wood-deck surfaces can be treated with successive layers of fire-resistant polyurethane and a sand-coating product manufactured by Pacific Polymers Inc. (www.pacpoly.com (714) 898-0025). This is a three-part, trowel-applied material that cures to about a 50-mil thickness and carries a Los Angeles Fire Department class-A fire rating. Other options include light-poured concrete decking or other assemblies which meet local code for "class A" ignition-resistant construction.

Figure 26. Wood Deck Fire Resistant Surface Treatments

Wood-deck surfaces are troweled over with several layers of fire-resistant coating. Undersides of all decking are stuccoed over with a 1-inch layer of cement. The glassed-in deck rails offer further protection against fire.

The owner of this house stuccoed the undersides of all wooden deck surfaces to a maximum thickness of about 1 in., virtually eliminating any exposed wood.

GENERAL RECOMMENDATIONS FOR FIRE-RESISTANT STRUCTURES INCLUDE:

- Venting should *not* be located in roof eaves or cornices, or on the underside or exposed edges of decks. Required individual venting at gable ends and on roofs should not exceed 144 square inches and should be covered with ¼" wire mesh screen. The Uniform Building Code normally calls for total square footage of venting to be 1/150th of the total attic area, but the code allows for modifications by local building officials when they determine it to be necessary, as in cases of milder or drier climates, or where fire-safety requirements warrant it.
- Exterior-wall surfaces should be concrete block or brick, cement plaster, or stucco (3/4" minimum thickness). If wood, vinyl, or fiber exterior siding is used, it should be applied directly over standard 5/8" type-X gypsum wallboard, a gypsum-core panel laced with chemical additives and glass fibers that are commonly used in one-hour fire-rated walls that are between attached garages and living areas.
- All projections, such as roof overhangs, balconies, decks, exterior stairs, carports, or patio covers should be protected on their undersides and on exposed edges with cement plaster. Alternatively, these architectural projections can be protected by a continuous wall around the perimeter of the projection or "boxing in" the projection from the facia down to the existing grade. These walls can be built from cinder block, stucco, or with UBC-approved fire-retardant wood specially treated with fire-retardant chemicals such as Dricon by the Hickson Corporation (www.dricon.com (404) 801-6600).
- Wood deck and trellis members should be at least 2"x 4". Wood beams, floor joists and stair stringers should be at least 4"x 6". Posts should be at least 6"x 6". All such wood should be UBC-approved fire-retardant material or cement plastered.
- Glass in exterior openings should be dual-glazed / tempered and resistant to transmission of radiant heat from direct flame. Though there is no industry-approved uniform fire rating for dual-glazed windows, windows with an insulating-air-gap feature have proven to be safer under actual fire conditions. We also recommend the use of newly developed heat-reflective single-pane windows, which reflect heat back to the source while at the same time keeping the inside cool. These windows can be found at O'Keefe, Inc., 75 Williams Ave., San Francisco, Calif. 94124-0443 (800) 227-3305. The windows are made of a calcium silica-based float glass with a lab-tested 60-minute fire-resistance rating. It is also stronger than normal glass.
- Class-A fiberglass or cement-tile roof coverings should be used on all new construction, additions, or repairs in designated high-hazard areas. Eave-end gaps in tile roofs should be fire-stopped with cement mortar or ¼-inch metal mesh, available at most roofing supply stores.

Threats to residents who remain in structures during a fire include heat, smoke, and ignition of the structure itself. Several steps can be taken by residents to mitigate the effects of heat exposure. The following list highlights some of the most important.

- Close all doors and windows, and shut down all ventilation systems such as air conditioning, heating, and attic fans.

- If there is adequate time and water, consider plugging downspouts and filling any gutters with water.
- If a sprinkler that will reach the roof is available, it should be set up so that it covers as much of the roof as possible, paying particular attention to the direction from which the fire is approaching.
- Fill all of the tubs and sinks with water, as well as any buckets that are easily handled.
- Remove any lightweight or highly-flammable window coverings. Heavy drapes or blinds should be closed in case the windows break.
- Move furniture away from windows. Remove flammables, such as gasoline and propane, to a safe distance away from the structure. Propane and other volatile compressed gas tanks may rocket as far as one-half mile, so they are best removed to an area cleared of fuels, but not near the access road or driveway.
- Wear clothes of fire resistant natural fibers such as wool or cotton. Be sure to cover as much exposed skin as possible, and keep water with you. Do not wear polyester or other synthetics that may melt to your skin when exposed to high temperatures.
- When the fire arrives retreat to the room in the house farthest away from the flaming front.
- Take drinking water with you and drink often to avoid dehydration.
- Even if it becomes uncomfortably hot and smoky do not run outside while the fire is passing.

Fires consume oxygen and produce toxic gasses and smoke. A great deal of research has been done in the hazardous materials field on the effects of the infiltration of toxic gasses into structures. Average homes under average weather conditions may experience indoor concentrations of smoke and contaminants of 45% to 65% of the outdoor concentrations in 30 minutes. In two hours, the concentrations can reach 60% to 65% of the outdoor levels.[5] These numbers are for homes with all doors and windows closed and ventilation systems turned off. Buildings with open windows, doors, or operating ventilation systems will experience contamination levels close to the outdoor levels in minutes. Residents can further slow contamination by blocking gaps around doors and windows with wet towels. The amount of time in which a fire is likely to impact a home can be estimated by referring to the Rate of Spread models on pages 15 (**Figure 12**) and page 18 (**Figure 15**). Rate of Spread indicates how fast a fire could move, given the established weather conditions used in the calculations. The impact of smoke on a structure is harder to estimate, because smoke can reach the home well in advance of the fire. Estimated Rate of Spread for the study area ranges from less than ¼ MPH to over 1 MPH. For a 100x100 foot home, it is reasonable to assume that the “flaming front” of the fire would approach, overrun, and move beyond this home in one to four minutes. If the above home mitigation steps have been verified and refined, it is likely that the smoke concentrations in the home would not approach outdoor levels.

---

[5] "Handbook of Chemical Hazard Analysis Procedures" (Washington, D.C.: FEMA, 1990).

After the fire has passed, the main danger to residents is ignition from embers and sparks that entered the home during the flame front passage. Once the flame front passes, it is crucial to systematically patrol inside and outside, looking for embers and spot fires. Be sure to include attics and other roof spaces. Houses may catch fire several hours after the fire has passed if embers are not found and extinguished. For more information on structural triage and preparation, please see **Appendix C**.

Public buildings or even large residences may make good evacuation centers for nearby residents, assuming that fuels such as vegetation are removed to a sufficient distance to prevent radiant heat from overwhelming occupants. Schools are often useful in incident response as evacuation centers, Incident Command Posts (ICPs), and resource staging. For example, the Manderfield School could be an excellent staging area or evacuation center for incidents involving the Camino Pequeno and Cerro Gordo West neighborhoods. Incident managers should investigate the suitability of these sites for specific tactical applications before making use assignments.

The development of additional sites is generally encouraged, and in neighborhoods where the need is especially great, a recommendation to develop shelter-in-place sites has been added to the neighborhood recommendations in **Appendix B**. Shelter-in-place tactics are recommended for evaluation in all or part of the following neighborhoods:

- Hyde Park North
- Hyde Park South
- Santa Fe Summit North
- Santa Fe Summit West
- Santa Fe Summit South
- Los Cerros Colorados
- Sierra Del Norte
- Camino Encantado
- Lejano
- Peralta/Acoma
- Cerro Gordo East
- Upper Canyon Road
- Talaya Hill
- Ponderosa Ridge
- Wilderness Gate
- St. John's College

Public Education Efforts FMU

The study area is experiencing continuing development. Increasing property values have resulted in neighborhoods with a mix of some or all of the following: high-value residences, older residences, commercial properties, and out-buildings in various states of decay. Residences vary from very fine custom homes to older mobile homes. There is likely to be a varied understanding among property owners regarding the intrinsic hazards associated with building in WUI areas. In addition to community and emergency services efforts to reduce risks associated with wildfire, the City of Santa Fe should use an approach to wildfire education that emphasizes safety and hazard mitigation on an individual property level. Combining community values such as quality of life, property values, and ecosystem sensitivity will increase public receptivity to the wildfire prevention and mitigation message.

It is crucial that the notion of shared responsibility be promoted. Homeowners must be made aware that fire suppression resources cannot be the only line of defense against wildland fires. Landowners and homeowners must take responsibility as key players in mitigation efforts. *Landscape-scale fuels modifications alone will not be effective in preventing the loss of structures in the fuels and conditions that exist in the study area.* Defensible space planning, maintenance, ignition-resistant construction, and fire-resistant or "FireWise" landscaping techniques are critical to the mitigation of the loss of life and property during wildfire events. Property owner education should be conducted through personal contact whenever possible. Homeowner education and participation is key to the successful preservation of life and property during wildfire events, especially in light of the difficulties evacuation poses for residents, and the importance of shelter-in-place tactics in Santa Fe.

Of the 678 fires reported in **Figure 18**, 76% were caused by lightning. The remaining 24% are human caused. Escaped campfires represent 40% of these man-made ignitions.

Recommendations

- Post campfire safety information at all designated or social trailheads, and at day-use areas. Include campfire safety messages in chamber of commerce literature and throughout all fire department public education literature.
- Public and homeowner education materials can be found at the following Web sites:
  - http://www.nwcg.gov/pms/pubs/pubs.htm
  - http://www.firewise.org
  - http://www.santafenm.gov/fire/WildfireSafety.asp (Santa Fe Fire Department wildfire safety page)
  - http://164.64.103.42/EMNRD/Forestry/FireMgt/FireProtectionHome.htm (New Mexico State Forestry Division Web site)
- Provide citizens with the findings of this study, especially:
  - Levels of risk and hazard
  - Value of fuels-reduction programs
  - Consequences and results of inaction regarding wildfire mitigation in the community

- Handouts on evacuation and shelter-in-place guidelines

- Post and maintain the appropriate hazard rating for wildfire danger on a daily basis throughout Santa Fe.
  - Include a phone number for more information on all fire danger rating signage.
  - Update fire danger ratings daily on all applicable Web sites.
  - Post fire danger rating signs on all fire duty vehicles. (There could be a permanent sign stating "Today's fire danger rating is ____" and a magnetic sign with the appropriate rating that could be switched on a daily basis.)
  - Use mobile signs to notify the public of meetings, events, and extreme wildfire hazard conditions.
- Utilize regional/local media to promote wildfire public education messages in the area.
- Develop a wildfire education mobile trailer that can be used to explain the concepts of defensible space and wildfire hazard mitigation. Anchor Point recommends that the information in this report be incorporated into this resource for the education of homeowners district-wide. This could be done through informational gatherings sponsored by the SFFD during local festivals, school events, or at times of extreme fire danger or other times of heightened awareness concerning wildfire. It is far easier to bring information to citizens than to bring citizens to the information, making this an especially powerful resource.

Home Mitigation FMU (Structural Ignitability Reduction)

Personal responsibility for self-protection from wildfire is essential. Educating homeowners is the first step in promoting shared responsibility. Part of the educational process is defining the hazards both at the neighborhood and parcel level.

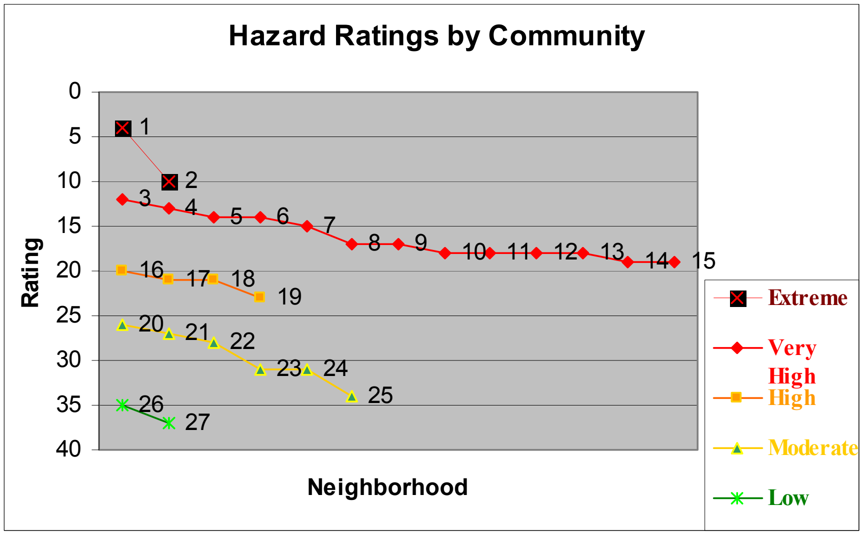
The community assessment has identified 15 extreme or very high hazard neighborhoods among the 27 neighborhoods in the study area. Construction type, condition, age, position, and the fuel loading of the structure/contents are contributing factors in making homes more susceptible to ignition under even moderate burning conditions. Under extreme burning conditions, there is a likelihood of rapid fire growth and spread in these areas, due to steep topography, flammable construction types, natural or manmade hazards, fast burning or flashy fuel components and topographic features that contribute to channeling winds and the promotion of extreme fire behavior. These areas may also represent a high threat to life safety due to poor egress, the likelihood of heavy smoke and heat, long response times, and/or inadequate response levels.

Figure 27 illustrates the relative hazard rankings for neighborhoods in the study area.

- A rating of 10 or less indicates an area of extreme hazard.
- A rating of 11 to 20 indicates a very high hazard.
- A rating of 21 to 25 indicates high hazard.
- A rating of 26 to 34 indicates moderate hazard.
- A rating of 35 or greater indicates a low hazard.

The neighborhoods with extreme to high hazard ratings should be considered for individual home or parcel level analysis. This should be implemented as soon as possible. Please see **Appendix B** for more detailed information on neighborhood rankings and parcel level analysis recommendations.

Figure 27. Relative Hazard Ranking for Neighborhoods



ExtremeVery High High ModerateLow

1. Hyde Park North	15. St. John's College
2. Hyde Park South	16. Camino Encantado
3. Santa Fe Summit North	17. Peralta/Acoma
4. Santa Fe Summit West	18. Cerro Gordo West
5. Wilderness Gate	19. Sierra del Norte
6. Talaya Hill	20. Arroyo Chamiso
7. Ponderosa Ridge	21. Rosario
8. Cerro Gordo East	22. Santa Fe Estates
9. Camino Pequeno	23. Estancia Primera/Las Barrancas
10. Los Cerros Colorados	24. Agua Fria
11. Lejano	25. Valle del Sol
12. Santa Fe Summit South	26. South Santa Fe
13. Monte Sereno	27. Tierra Contenta
14. Upper Canyon Road	

As in any fire district, firefighters' response time to emergency calls varies throughout the jurisdiction. In Santa Fe, the most important variable in response time is the home's distance from the nearest fire station. **Figure 28** shows the existing distance from the nearest fire station to the neighborhoods of the study area. **Figure 29** shows the changes in distance to the nearest fire station for the neighborhoods of the study area once the proposed station has been completed in the North West quadrant. Distances were calculated in ArcGIS and take into account the road distance to a given area rather than merely the "flight distance." Some neighborhoods in the most hazardous portion of the study area, the east side, have a significant number of homes greater than five miles from a fire station. For the purposes of this report, this is not an Insurance Services Office (ISO) issue but one of defining response distance, and therefore time, to fire ignitions. This distance analysis calculates *drivable distance, not drive time,* although distance was utilized as a factor in rating neighborhood hazards. Response times may vary greatly over the same distance due to road conditions, steepness, curvature of roads, and evacuation traffic. However, poor road conditions and steep terrain were found to be most common in neighborhoods located furthest from the nearest fire station.

Most fire service leaders agree that response time is composed of three distinct elements.

1. **Call processing time**: the time it takes for dispatchers to ascertain the location and nature of the emergency and initiate the appropriate response.
2. **Turnout or staffing time**: the time it takes for personnel to respond to the dispatch, board apparatus, and begin traveling to the scene.
3. **Travel time**: the actual time it takes to travel from the station to the scene.

Further, the National Fire Protection Agency (NFPA) has established the following time objectives for fire response:

NFPA 1710 requires:

1. Turnout time of one minute.
2. Four minutes or less for the arrival of the first arriving engine company at a fire suppression incident and/or eight minutes or less for the deployment of a full first alarm assignment at a fire suppression incident.[6]

If turnout time of one minute is met, and average driving speed is estimated at 30 MPH, then the engine company could drive two miles in the four minutes established by NFPA 1710. Therefore, neighborhoods with mean distances greater than two miles from a fire station fall outside the NFPA established time objectives and are more hazardous (more likely to experience significant damage from a moderately advancing wildfire) than those located less than two miles from the nearest station. A significant portion of the most hazardous neighborhoods in the study area have mean distances further than two miles from the nearest fire station. A thorough understanding of wildfire hazards is crucial to the safety of residents in these areas. Proper defensible space and hazard mitigation is the single most important factor in limiting fire damage in areas where response by fire suppression forces is inevitably delayed.

---

[6] http://www.iaff.org/academy/content/online/modules/1710/summary.htm

Figure 28. Map – Existing Neighborhood Distances to Nearest Fire Stations

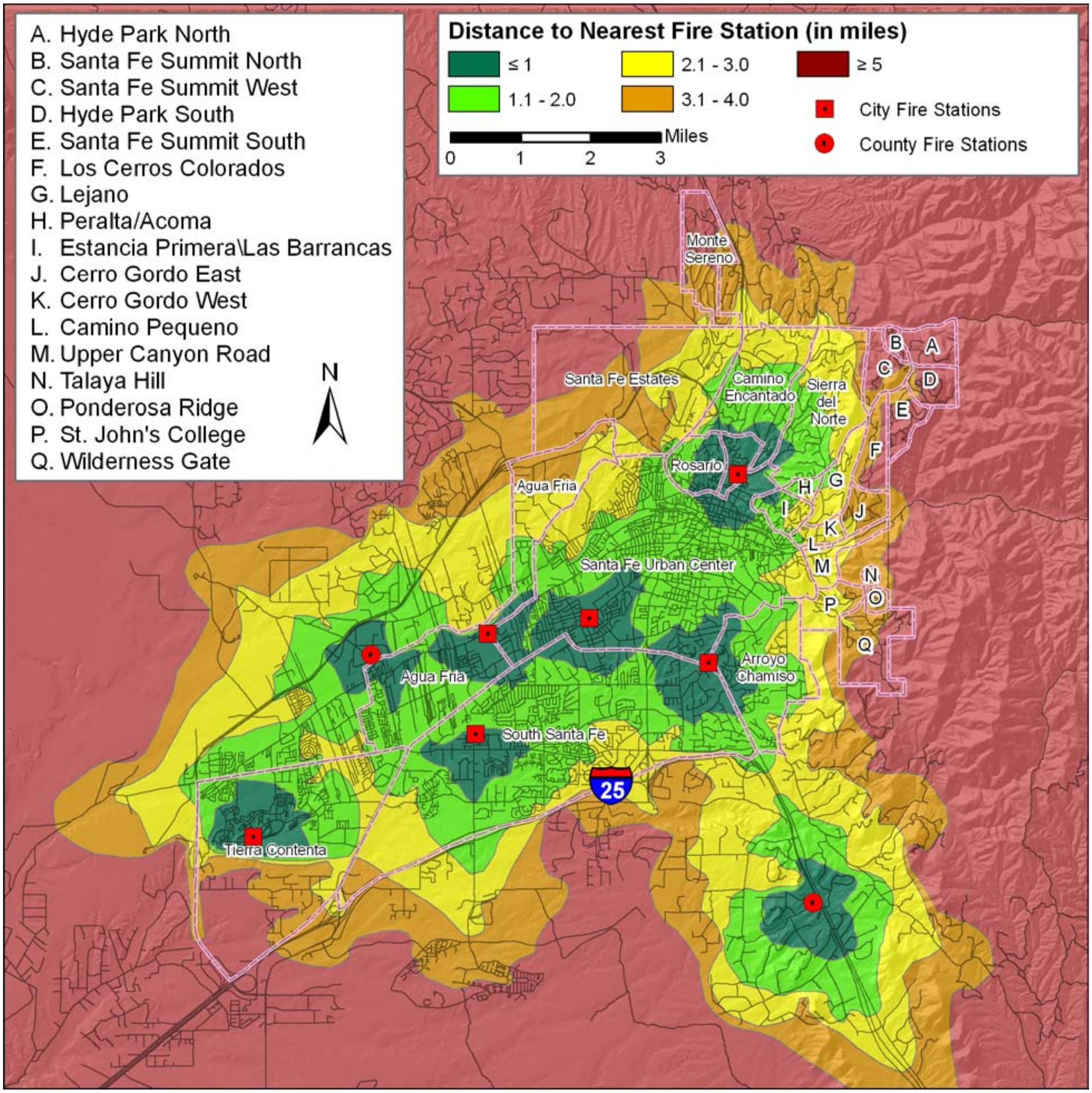
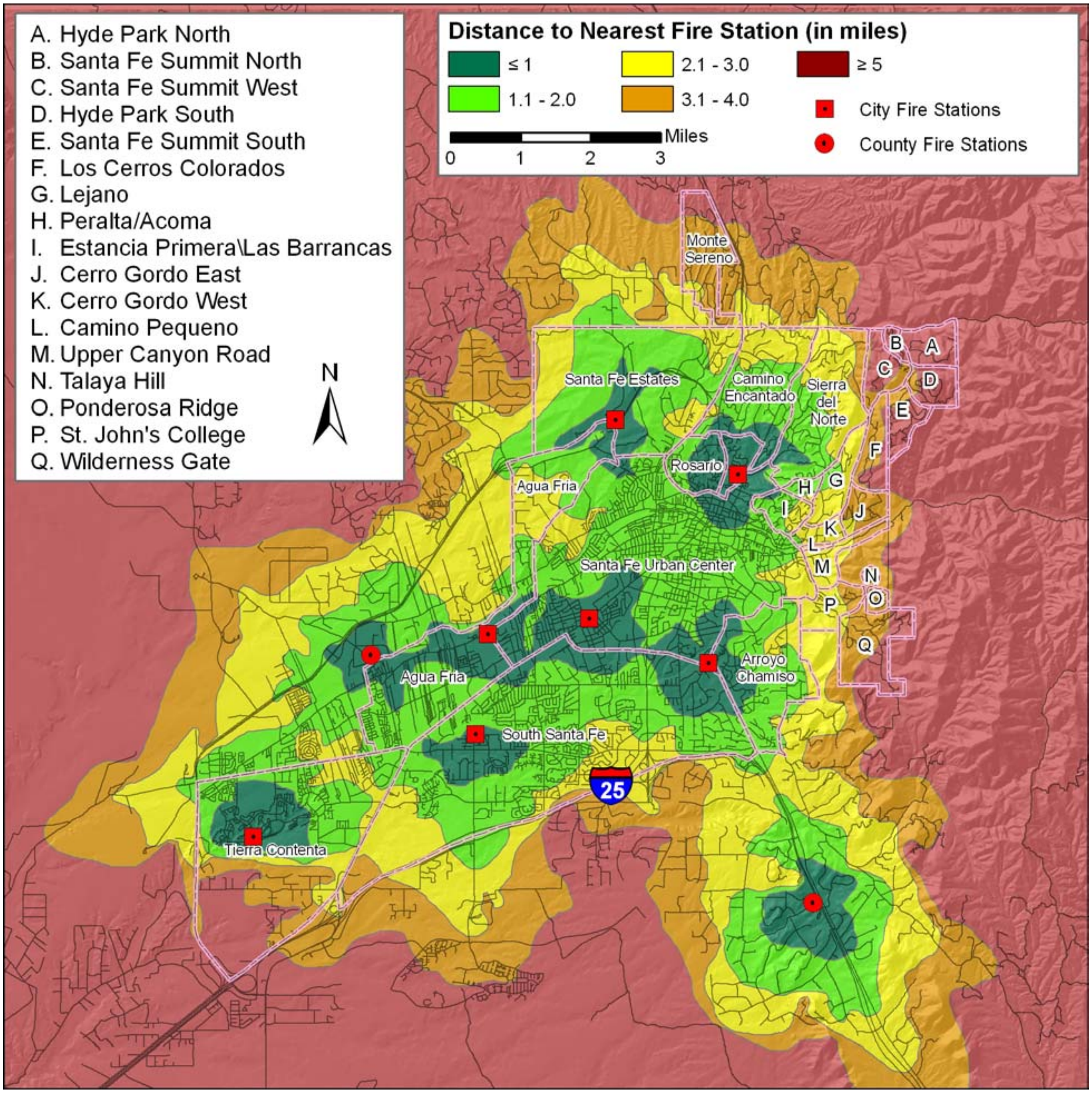
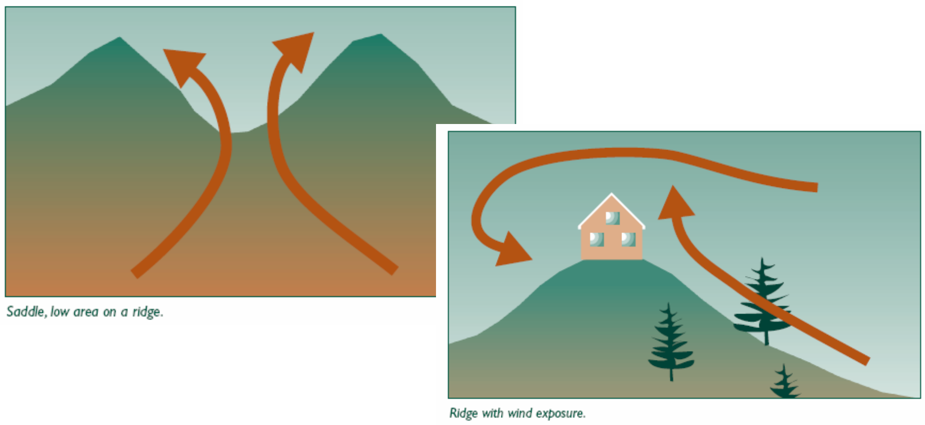


Figure 29. Map – Future Neighborhood Distances to Nearest Fire Stations



The most important element for the improvement of life safety and property preservation is compliance with defensible space recommendations at every home in the study area. This is especially important for homes with wood roofs, and for homes located on steep slopes, in chimneys or saddles, or on, in, or near any other topographic feature that can contribute to fire intensity.

Figure 30. Saddle & Ridge Top Development



[7]

AN AGGRESSIVE PROGRAM OF EVALUATING AND IMPLEMENTING DEFENSIBLE SPACE FOR HOMES WILL DO MORE TO LIMIT FIRE-RELATED PROPERTY DAMAGE THAN ANY OTHER SINGLE RECOMMENDATION IN THIS REPORT.

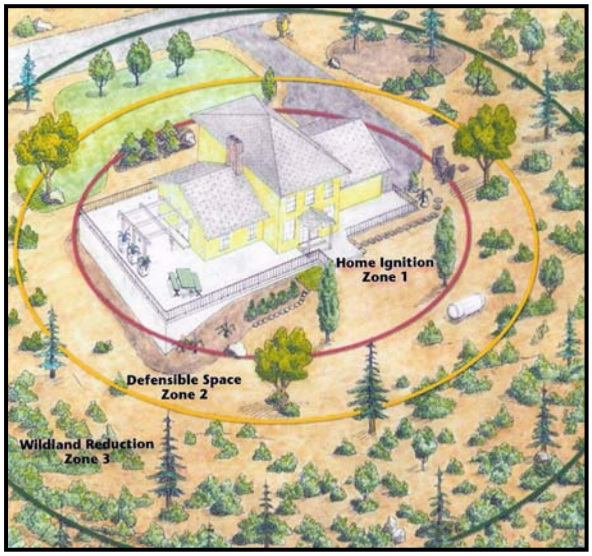
There is no question that piñon/juniper stands or any other type of dense, flammable vegetation should be removed from around a home in order to reduce the risk of structural ignition during a wildfire. The question is how much to remove. The basic rule is to eliminate ALL flammable materials (fire-prone vegetation, wood stacks, wood decking, patio furniture, umbrellas, etc.) from within 30 feet (**referred to as Zone 1 in this report**) of the home. For structures near wildland open space, an additional 70 feet (**referred to as Zone 2 in this report**) should be modified by removing all dead wood from shrubbery, thinning and trimming trees and shrubs into “umbrella” like forms (lower limbs removed), and preventing the growth of weedy grasses. The Zone 2 prescription also applies to “lot thinning” projects where no structure is present. Steep slopes and/or the presence of dangerous topographic features as described above may require the Zone 1 & 2 distances to be increased by as much as an additional 100 feet.

---

[7] *FireWise Construction*, Peter Slack, Boulder Colorado

Figure 31. Defensible Space Zones

8



Although some people believe all vegetation must be removed down to bare soil, the New Mexico State Forestry Division says the following regarding Zones 1 & 2: "To a distance of 100 feet (200 feet on steep lots), remove some trees and shrubs to create 10 feet of space between adjoining tree's outermost branches. Prune lower branches of remaining trees up to 10 feet off the ground."[9] Removal of all vegetation to bare soil increases erosion, and will lead to the growth of weeds in the now disturbed soil. These weeds are considered to be "flashy fuels" which actually increase fire risk because they ignite so easily.

Defensible space must be ecologically sound, aesthetically pleasing, and relatively easy to maintain. Only then will the non-prescriptive (voluntary) use of fuels reduction around homes become commonplace.

RECOMMENDATIONS

- Conduct a parcel level wildfire hazard analysis for the homes in the study area. By starting with homes in neighborhoods rated as extreme, very high, and high, the city will ensure that the most critical homes are evaluated first. Completing this process will facilitate the following important fire management practices:
    - Establish a baseline hazard assessment for homes in these neighborhoods
    - Educate the community through the presentation of the parcel-level hazard-risk analysis at neighborhood public meetings
    - Identify defensible space needs and other effective mitigation techniques
    - Inspect homes for likely areas of ember intrusion and collection
    - Identify and facilitate "cross-boundary" and "cross-lot" projects

---

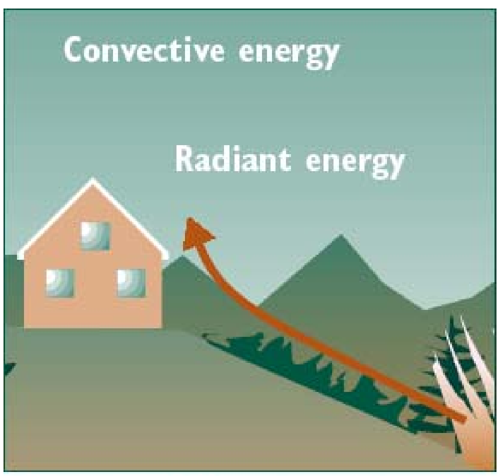
[8] *A Homeowner's Guide to Fire Safe Landscaping*(2005) www.FireSafeCouncil.org

[9] http://164.64.103.42/EMNRD/Forestry/FireMgt/FireProtectionHome.htm

- Improve access roads and turnarounds on driveways to create safer access for firefighting resources. See Santa Fe Hazard Assessment Emergency Access and Water Supply (**Appendix D**).
- Discourage the use of any flammable building materials.
- Add reflective address signs at each driveway entrance to all homes (**See Appendix D** for recommendations).
- Encourage and/or mandate the use of ignition resistant construction for all remodeled and new construction.

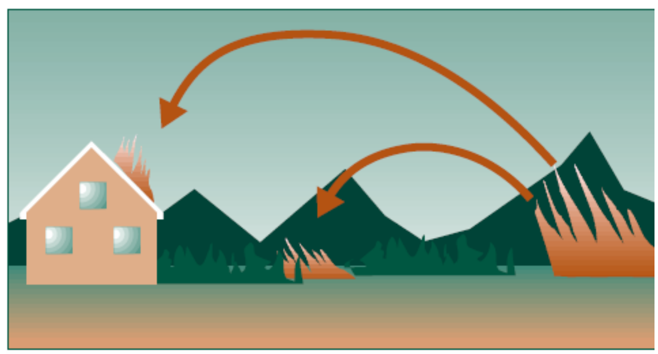
As stated above, the most effective wildfire mitigation technique for property conservation will be the widespread utilization of defensible space in combination with ignition resistant construction. Until appropriate construction can be retrofitted on existing homes, defensible space will at least reduce radiant heat energy (see **Figure 32**), and therefore structure ignition, from direct flame contact or radiant heat. Firebrand generation (see **Figure 33**) will need to be mitigated by a very refined inspection of each structure for any openings or areas of likely ember collection. These areas should be identified and mitigated as part of every defensible space inspection.[10]

Figure 32. Convective & Radiant Energy



Convective and radiant energy from a fire.

Figure 33. Firebrands



Firebrands, transported by convective lifting, create spot fires.

[10] *FireWise Construction*, Peter Slack, Boulder Colorado

Fuels Modifications Projects FMU

Introduction

One of the most effective forms of landscape-scale fuels modification is the fuelbreak (sometimes referred to as "shaded fuelbreak"). A fuelbreak is an easily accessible strip of land of varying width, depending on fuel and terrain, in which fuel density is reduced, thus improving fire control opportunities. Vegetation is thinned, removing diseased, fire-weakened and most standing dead trees. Where possible, thinning should select for the more fire resistant species. Ladder fuels, such as low limbs and heavy regeneration, are removed from the remaining stand. Brush, dead and down materials, logging slash, and other heavy ground fuels are removed to create an open park-like appearance. The use of fuelbreaks under normal burning conditions can limit uncontrolled spread of fires and aid firefighters in slowing the spread rate. Under extreme burning conditions where spotting occurs for miles ahead of the main fire, and the probability of ignition is high, even the best fuelbreaks are not effective. However, fuelbreaks have proven to be effective in limiting the spread of crown fires in timbered fuel models.[11]

In the study area, piñon pine/juniper stands are the most common fuel model. These stands usually have light surface litter and little or no understory plants. Fires propagate primarily through the crowns and usually require high wind speeds to make significant runs. At the higher elevations, piñon/juniper becomes mixed with ponderosa pine, offering more of an opportunity for fires to spread in the surface litter layer. However, even in these areas there are few continuous surface fuel beds of significant size. Increasing the spacing between tree crowns is an especially effective tactic in limiting fire spread in the most common fuels in the study area. Factors to be considered when determining the need for fuelbreaks in WUI subdivisions include:

- The presence and density of hazardous fuels
- Slope
- Hazardous topographic features
- Crowning potential
- Ignition sources
- Operability

Increasing slope causes fires to move more easily from the surface fuels to crowns, due to preheating. A slope of 30% causes the fire spread rate to double, compared with the same fuels and conditions on flat ground. Chimneys, saddles, and deep ravines are all known to accelerate fire spread and influence intensity. Neighborhoods with homes located on or above such features, as well as homes located on summits and ridge tops, are good candidates for fuel breaks. Neighborhoods having an average slope of 30% or greater were closely evaluated for potential fuelbreaks. Where known likely ignition sources (such as railroads or recreation areas that allow campfires) were present in areas where fire could be channeled into neighborhoods, fuelbreaks were considered.

Fuelbreaks should always be connected to a good anchor point, like a rock outcropping, river, lake, or road. The classic location for fuelbreaks is along the tops of ridges, where they can stop

[11] Dennis, Frank C. "Fuelbreak Guidelines for Forested Subdivisions." Colorado State Forest Service. Colorado State University [CSFS #102-1083]. 1983.

fires from backing down the other side or spotting into the next drainage. This is not always practical from a WUI standpoint because the structures firefighters are trying to protect are usually located at the tops of ridges or mid-slope. Mid-slope positioning is considered the least desirable for fuelbreaks, although in some cases it is the easiest to achieve, as an extension of defensible space work or extension of existing roads and escape routes. One possible tactic is to create fuelbreaks on slopes below homes located mid-slope or on ridge tops, so that the area of continuous fuels between the defensible space around homes and the fuelbreak is less than ten acres. We have recommended this approach for some neighborhoods. Please see the **Landscape Scale Fuels Recommendations** section below for details.

Since fuelbreaks can have an undesirable effect on the aesthetics of the area, crown separation should be emphasized over stand density levels. In other words, isolating groupings rather than cutting for precise stem spacing will help to mitigate the visual impact of the fuelbreak. Irregular cutting patterns (mosaic cuts) that reduce canopy and leave behind islands with wide openings are effective in shrub models.

Another issue in mechanical thinning is the removal of cut materials. One consequence of failing to remove slash is to add to the surface fuel loading, perhaps making the area more hazardous than before treatment. It is imperative that all cut materials be disposed of by piling and burning, chipping, physical removal from the area, or lopping and scattering. Of all of these methods lopping and scattering is the cheapest, but also the least effective since it adds to the surface fuel loading.

It is also important to note that fuelbreaks must be maintained to be effective. Thinning usually accelerates the process of regenerative growth. The effectiveness of the fuelbreak may be lost in as little as three to four years if ladder fuels and regeneration are not controlled.

Current Projects

Approximately 3 million acres from Santa Fe north to the Colorado border are under study by the ForestERA. ForestERA is a collaborative process that studies forest ecosystems to discover better ways to restore their health and protect communities from wildfire. Stakeholders representing diverse backgrounds, priorities, needs, and points of view work together in small groups to develop recommendations. ForestERA products are not fuels management plans in and of themselves, however. They are recommendations and assessments that can be used by stakeholders to develop plans. At some point, specific fuels-management plans will probably be developed based on ForestERA recommendations that may have an impact on the study area.[12]

The USDA Forest Service has been implementing a major vegetation treatment in the Upper Municipal Watershed for the past several years. For a complete discussion of the scope of this project, please see *Santa Fe Municipal Watershed Fuels Reduction Project Briefing Paper* in Appendix F. This document has been included as an attachment to this report.

Some smaller scale fuels reduction projects involving the Audubon Society and Nature Conservancy properties located to the east of certain “very high hazard” neighborhoods are either ongoing or in planning. Although project specifics were not available for this report, we

[12] http://www.forestera.nau.edu/

highly recommend that these projects be evaluated by local Santa Fe Fire Department experts forpossible cross-boundary linkage with the projects proposed in this report.

ACCESS ROUTE FUELS MODIFICATION RECOMMENDATIONS

Fuels modification projects for primary access corridors and critical escape routes should be implemented. Breaking up canopy fuels along primary escape routes reduces smoke and heat for evacuees and firefighters. Clumps of trees and shrubs should be broken up and trimmed back away from the road. Generally, crown spacing of 10-30 feet is desirable. The minimum recommended fuelbreak width is usually 200 feet. As spread rate and intensity increases with slope angle, the size of the fuel break should also be increased, with an emphasis on the downhill side of the roadbed or centerline employed. The formulas for slope angles of 30% and greater are as follows: below road distance = 100' + (1.5 x slope %); above road distance = 100' – slope %. Fuelbreaks that pass through hazardous topographic features should have these distances increased by 50%.[13] On steeper slopes, more should be cut on the downhill side. Exact amounts and distances should be assessed on a case-by-case basis by a certified forester familiar with local vegetation and fire behavior.

Most of the neighborhoods in the study area would benefit from fuels reduction along their principal access routes. However, first priority should be given to the highest-hazard neighborhoods and neighborhoods where the primary access requires relatively long drives through heavy fuels, since these routes could become impassable due to heat and smoke. High population density areas that could become bottlenecks due to heat and smoke from heavy fuels are also a high priority.

The neighborhoods that should be considered highest priority for fuels reduction along access corridors are listed below in no particular order:

Hyde Park North	Camino Pequeno
Hyde Park South	Talaya Hill
Santa Fe Summit North	Ponderosa Ridge
Santa Fe Summit West	St. John's College
Santa Fe Summit South	Wilderness Gate
Cerro Gordo East	Monte Sereno
Upper Canyon Road	Lejano

Individual prescriptions and marking will need to be done with local experts on a case-by-case basis to guarantee the most effective results. The primary goal in piñon/juniper stands is to interrupt the crown continuity of fuels. Interruption of crown continuity describes the need to separate individual trees or shrubs to help prevent tree-to-tree or shrub-to-shrub fire spread. In areas where significant amounts of ponderosa pine and other conifers are mixed with piñon/juniper, and in some of the riparian neighborhoods, reduction of ladder fuels through

---

[13] Dennis, Frank C. "Fuelbreak Guidelines for Forested Subdivisions." Colorado State Forest Service. Colorado State University [CSFS #102-1083]. 1983.

limbing should also be emphasized. Ladder fuels are small-diameter, low branches that can transport or "ladder" fire from grasses to the top of the tree or shrub.

The cooperation of adjacent, contiguous landowners must be secured because the city's easements are quite narrow. Landowner participation also allows the project to be more flexible in selecting trees and shrubs for removal. It allows greater consideration for the elements of visual screening and aesthetics. Enlarging the project dimensions allows more options for vegetative selection while still protecting the access/egress corridor.

LANDSCAPE SCALE FUELS MODIFICATION RECOMMENDATIONS

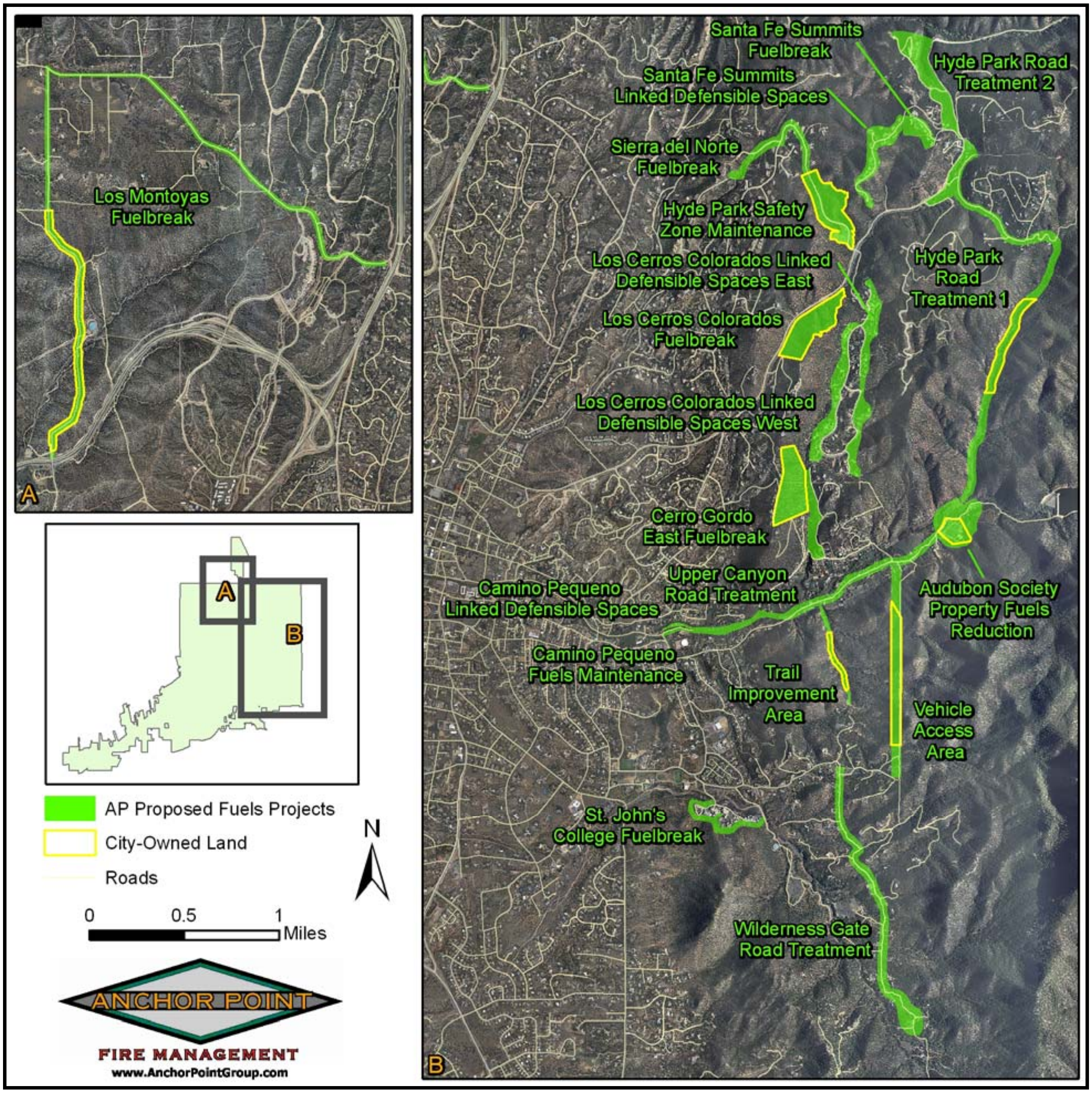
The following recommendations are in addition to, not in place of, the fuels reductions mentioned in the **Access Route Fuels Modification Recommendations** section of this report. Historically, most fires have moved with the prevailing wind patterns in this area (southwest to northeast). The landscape scale fuelbreak recommendations made in this report have been designed to take advantage of this general pattern and cannot account for all weather conditions and circumstances.

Recommendations are listed by priority level. However, recommendations within each priority level are of relatively equal importance, and no further sorting is necessary. The prioritization of recommendations was driven principally by life safety concerns. Conservation of property and operability were considered as secondary factors. Only treatments inside the boundaries of the SFFD response area have been included. However, since fire does not respect administrative boundaries, cooperative efforts with adjoining fire agencies are highly recommended.

All of these recommendations will require the cooperation of private landowners, and in some cases land managers from public agencies. Negotiations and public education efforts should begin as soon as possible to secure a consensus for future fuels reduction projects on the landscape scale.

These recommendations are not a replacement for defensible space or other recommendations in this report. It is important to understand that defensible space for all homes is a critical element in reducing hazards to life and property. These recommendations will only achieve maximum effectiveness in conjunction with defensible space treatments. In addition to the defensible space treatments and access route fuels reduction projects previously mentioned in this document, the following landscape scale fuels treatments are recommended:

Figure 34. Recommended Fuels Modification Projects



A. **Hyde Park Road Treatment 1 (Approximately 77 Acres).** **Priority level - High.** **(see Figures 35 and 40)** This project involves thinning along Hyde Park Road, La Entrata and Paseo Primera in the area west and south of the Hyde Park South neighborhood. This project ties in with Hyde Park Road Treatment #2 at a clearing just to the east of Ten Thousand Waves Spa. In addition to the larger treatment area shown along Hyde Park Road, we recommend that thinning to conform to the shaded fuelbreak guidelines (described in the **Access Route Fuels Modification Recommendations** section) be continued along La Entrada and Paseo Primero to their intersection and through the prominent drainage running south into the city and Nature Conservancy land. Thinning should be continued along the drainage to tie in with fuels reduction work on the Audubon Society property (see **project I**). This project incorporates an area of existing thinning on city owned land (outlined in yellow in the figures). This project will protect access and create a fuelbreak to help protect homes in Hyde Park from ignitions along Hyde Park Road and the trails immediately south of this neighborhood. This project will also help protect the watershed from an ignition along or west of Hyde Park Road.

B. **Hyde Park Road Treatment 2 (Approximately 35 Acres). Priority level - High. (see Figure 35)** The selected treatment area concentrates on limbing, thinning, and surface fuel removal in the heavy ponderosa pine and piñon/juniper mixed stands to the west of Hyde Park Road below the Santa Fe Summit North neighborhood. This project is high priority because of the threat posed to the only access into the Santa Fe Summit North neighborhood, and the potential for existing heavy fuels to greatly increase fire intensity below the homes in this neighborhood.

C. **Wilderness Gate Road Treatment (Approximately 55 Acres). Priority level – High. (see Figure 38)** This project focuses on limbing and thinning along Wilderness Gate Road, from the entrance to the Wilderness Gate neighborhood south to an existing clearing at the intersection of Wilderness Gate Road and two east-west running spurs. This intersection could be improved to provide a safety/deployment zone for suppression resources. Thinning along Wilderness Gate Road should be conducted to conform to the shaded fuelbreak guidelines described in the **Access Route Fuels Modification Recommendations** section. If combined with defensible spaces for all homes along Wilderness Gate Road, this project would create a barrier to ignitions moving east out of the heavy fuels in the St. John's saddle area. This project will also help protect a critical access route and create a potential safety/deployment zone for firefighters.

D. **Upper Canyon Road Treatment (Approximately 38 Acres). Priority level – High. (see Figure 42)** This project ties in the Camino Pequeno fuels maintenance project (**project N**) with the Audubon Society property fuels reduction (**project I**) including an area of existing thinning (outlined in yellow in the figures). Limbing and thinning should be continued from the Camino Pequeno project across the drainage and along Upper Canyon Road to connect with the Audubon Society property project. Thinning should be conducted to conform to the shaded fuelbreak guidelines described in the **Access Route Fuels Modification Recommendations** section. If combined with defensible spaces for all homes along Upper Canyon Road, this project will help protect a critical access route, as well as reduce the potential that a structure fire along Upper Canyon Road will spread to the watershed.

E. **Santa Fe Summits Fuelbreak (Approximately 11 Acres). Priority level - High. (see Figure 35)** When combined with the Santa Fe Summits linked defensible spaces project, this project will provide a significant fuelbreak for homes in Hyde Park North, Hyde Park South and Santa Fe Summits West neighborhoods. Thinning to conform to the shaded fuelbreak guidelines described in the **Access Route Fuels Modification Recommendations** section of this report should be conducted along Summit Ridge, North Summit Drive, North Point and the unnamed dirt road linking North Summit Drive to Spanish Hill.

F. **Santa Fe Summits Linked Defensible Spaces and Lot Thinning (Approximately 24 Acres). Priority level - High. (see Figure 35)** This project is critical to complete the fuelbreak treatment in **Project E** (Santa Fe Summits Fuelbreak). Evaluate and mark (as allowed by property owners) defensible space around homes located on Summit Ridge, North Summit Drive, North Point, and Spanish Hill. If there are any lots without existing structures, thinning and limbing should be conducted as described for Zone 2 in the **Home Mitigation FMU** section of this report. The goal of this project is create defensible spaces that will continue seamlessly from property to property in order to provide the maximum effectiveness for the fuelbreak.

G. **Los Cerros Colorados Linked Defensible Spaces and Lot Thinning, West Side (Approximately 27 Acres). Priority level - High. (See Figure 36)** Evaluate and mark (as allowed by property owners) defensible space around homes located on Cerros Colorados above Hyde Park Road. If there are any lots without existing properties, thinning and limbing should be conducted as described for Zone 2 in the **Home Mitigation FMU** section of this report. The goal of this project is to create defensible spaces that will continue seamlessly from property to property in order to create a ridge-top fuelbreak for homes in the Los Cerros Colorados neighborhood that would be effective against ignitions occurring along Hyde Park Road or in the drainages between Hyde Park Road and Cerros Colorados.

H. **Cerro Gordo East Fuelbreak (Approximately 43 Acres). Priority level – High. (see Figure 37)** This project involves mosaic cut thinning of piñon/juniper stands between Paseo de Andres, Paseo de Don Carlos, Paseo de Florencio, and the dirt trails to the west. This project should continue from the north end of Paseo de Andres to Cerro Gordo Road. The goal of this project is to provide a fuelbreak and safer access for homes in the Cerro Gordo East neighborhood, which are difficult to evacuate.

I. **Audubon Society Property Fuels Reduction. (Approximately 32 Acres) Priority level – High. (See Figure 40)** Limb, thin and mosaic cutting of piñon/juniper fuels should be conducted, as described for Zone 2 in the **Home Mitigation FMU** section of this report, for approximately 200 feet from the buildings and parking lots of the Audubon Society property. Clean up weeds, vines and other vegetation to create conforming defensible space for the Audubon Society buildings. Clean up weeds and vines in the field to the north of the Audubon Society Buildings to create a staging area/safety zone for fire resources. This project is high priority because it provides an anchor for the north/south fuelbreak recommended in **Project A**, which is designed to protect the watershed.

J. **Cerros Colorados West Fuelbreak (Approximately 31 Acres). Priority level – High. (see Figure 36)** This project involves mosaic cut thinning of piñon/juniper stands between Canada Ancha, Los Cerros Colorados and east of Hyde Park Road. This project should continue from the north end of Canada Ancha to the entrance of Los Cerros Colorados. The goal of this project is to reduce the intensity and limit the spread of potential ignitions occurring along Hyde Park Road below the Los Cerros Colorados neighborhood.

K. **Sierra Del Norte Fuelbreak. (Approximately 30 Acres) Priority level –Moderate. (See Figure 35)** Beginning at the Hyde Park Safety Zone described in **Project Q,** thinning should be continued north along Sierra Del Norte Road as far as the end of Calle Conejo. Thinning should conform to the shaded fuelbreak guidelines described in the **Access Route Fuels Modification Recommendations** section. From the end of Calle Conejo thinning should continue into the east/west running drainage in order to connect Calle Conejo to Barranca Road. This project provides an additional fuelbreak for homes in Santa Fe Summit North, Santa Fe Summit West, and the northern portion of the Sierra Del Norte neighborhood, thus protecting against ignitions occurring in the heavy fuels between Hyde Park Road and this area.

L. **Los Cerros Colorados Linked Defensible Spaces and Lot Thinning, East Side (Approximately 34 Acres). Priority level - Moderate. (see Figure 36)** This project continues defensible space treatments and lot thinning from **Project G** (Los Cerros Colorados Linked Defensible Spaces and Lot Thinning, West Side). Evaluate and mark (as allowed by property owners) defensible space around homes located on Senda de Eleutherio, Cerros Colorados, Senda de Andres, and Senda de Daniel. If there are any lots without existing properties, thinning and limbing should be conducted as described for Zone 2 in the **Home Mitigation FMU** section of this report. Although this project may provide a fuelbreak to homes in Los Cerros Colorados from ignitions occurring along the popular Dale Ball trail system, it is of lower priority since these ignitions are against the prevailing wind direction. The importance of wind in the spread of piñon/juniper fires is discussed in the introduction to this section.

M. **St. John's College Fuelbreak (Approximately 13 Acres). Priority level - Moderate. (see Figure 38)** Clearing and thinning are recommended for approximately 200 feet from the buildings and parking lots of St. John's College to the south. This project helps prevent an ignition on the heavily used St. John's College campus from spreading to the heavy fuels in the Saint John's saddle area and Wilderness Gate neighborhood to the south and east. There is heavy trail use in this area as well as a significant number of non-resident students who may be unfamiliar with local fire hazards. This project also enhances the usefulness of the college campus as a potential evacuation center for residents of the Wilderness Gate, Talaya Hill, St. John's College, and Ponderosa Ridge neighborhoods. Additional work along trails and power line cuts was considered in the St. John's saddle area and in the Talaya Hill, Wilderness Gate, and Ponderosa Ridge neighborhoods, but no other effective and/or reasonable fuels modification projects were identified, beyond extended defensible spaces and access road treatments.

N. **Camino Pequeno Fuels Maintenance (Approximately 1.8 Acres). Priority level - Moderate. (see Figure 39)** Clean up riparian vegetation, grasses, and dead and down fuels along the access road, the bosque, and the coyote fencing that separates Camino Pequino from Upper Canyon Road. Investigate the possibility of engaging the party responsible for ditch maintenance along this portion of the bosque in vegetation cleanup and maintenance. It may also be possible to tie in limbing and thinning work with planned or existing mitigation work done on the Audubon Society property to the east of this area. As a part of this project, homeowners should be educated to prevent the dumping of debris and slash along the bosque.

O. **Camino Pequeno Linked Defensible Spaces (Approximately 1.6 Acres). Priority level - Moderate. (see Figure 39)** This project is designed to complete the fuels reduction treatment in **Project N** (Camino Pequeno Fuels Maintenance). Evaluate and mark (as allowed by property owners) defensible space around homes located on Camino Pequeno. If there are any lots without existing structures, thinning and limbing should be conducted as described for Zone 2 in the **Home Mitigation FMU** section of this report. The goal of this project is to create defensible spaces that will continue seamlessly from property to property.

P. **Los Montoyas Fuelbreak. (Approximately 82 Acres) Priority level – Low. (See Figure 41)** Thinning to conform to the shaded fuelbreak guidelines described in the **Access Route Fuels Modification Recommendations** should be conducted along Camino De Los Montoyas from the intersection with Highway 599 north to Tano Road and then east along Tano Road to the intersection with US 285/84. This project includes thinning on city owned land (outlined in yellow in the figures). This project provides a control line and vital access link (potential escape/access route) for fires occurring in the adjacent fuels which could, under some conditions, threaten homes in the Santa Fe Estates and Monte Sereno neighborhoods as well as homes in Santa Fe County. Although this project could be operationally important under certain conditions, it is rated as low priority because of the relatively low density of properties that would be immediately threatened by fires occurring along Camino De Los Montoyas.

Q. **Vehicle Access (Approximately 37 Acres) and Trail Improvement Areas (Approximately 8 Acres) Priority level – Low. (see Figure 42)** An existing power line cut along the eastern boundary of city lands could be improved for suppression apparatus access from Upper Canyon Road to East Ridge Road. Fuels should be removed for a distance of 300 feet along the centerline of the existing power line cut, and the surface should be improved to be compatible with Type 3X engine access. An existing trail to the west of the power line cut running south from Upper Canyon Road could also be improved to be compatible with Type 6X engine access. Although these projects do not directly protect life safety or property, they would create potentially important control lines for suppression forces working fires in the otherwise continuous fuels between Talaya Hill and Upper Canyon Road. The high potential for human caused starts in the Talaya Hill area is an additional reason to consider installing and maintaining additional fire crew and apparatus access.

R. **Hyde Park Safety Zone Maintenance (Approximately 6 Acres). Priority level - Low. (see Figure 35)** Keep the dirt and gravel area at the corner of Hyde Park Road and Sierra Del Norte free of vegetation and include it in initial attack pre-plans as a permanent safety zone. This project has been rated as low priority, because no fuels work is needed at this time. Although minimal future maintenance is likely to be required to maintain this area as a viable safety zone, its position relative to extreme and very high hazard neighborhoods makes it worthy of consideration as an ongoing project.

Forest Health Recommendations

There are some neighborhoods in the study area that have a high number of standing dead trees. As part of the remote sensing work done for this project, near infra-red (NIR) was used in conjunction with field location to generate a mask showing which fuels polygons had a majority of dead and dying trees. NIR can be a good indicator of relative tree health. A high response indicates active photosynthesis, which indicates healthy trees. A tree that is stressed will have foliage with a lower response. For a remote sensing study of this kind, field data would typically be collected as close to the time of imagery collection as possible so that subtle changes in the NIR could be detected. This field collection was made approximately a year after the image collection. To compensate for this discrepancy, our goal in the field was to find trees that were dead or dying but still showed a healthier NIR spectral response in the imagery. From this we could determine what the sickly trees looked like in the imagery. We did not find any instances where the ground situation differed from the imagery. Therefore, there was no training data available to run a spectral analysis to find current dying trees. A good percentage of the ground was compared to the imagery. From this we were able to infer that the outbreak was in submission for the previous year. The file sf_dead_and_dying.img accompanying this report in the GIS data set is a mask showing which polygons had a majority of dead and dying trees. We recommend that an annual insect and disease inventory of stands in these areas be conducted between October and May.

Figure 35. Fuels Projects – Hyde Park Road & Santa Fe Summits

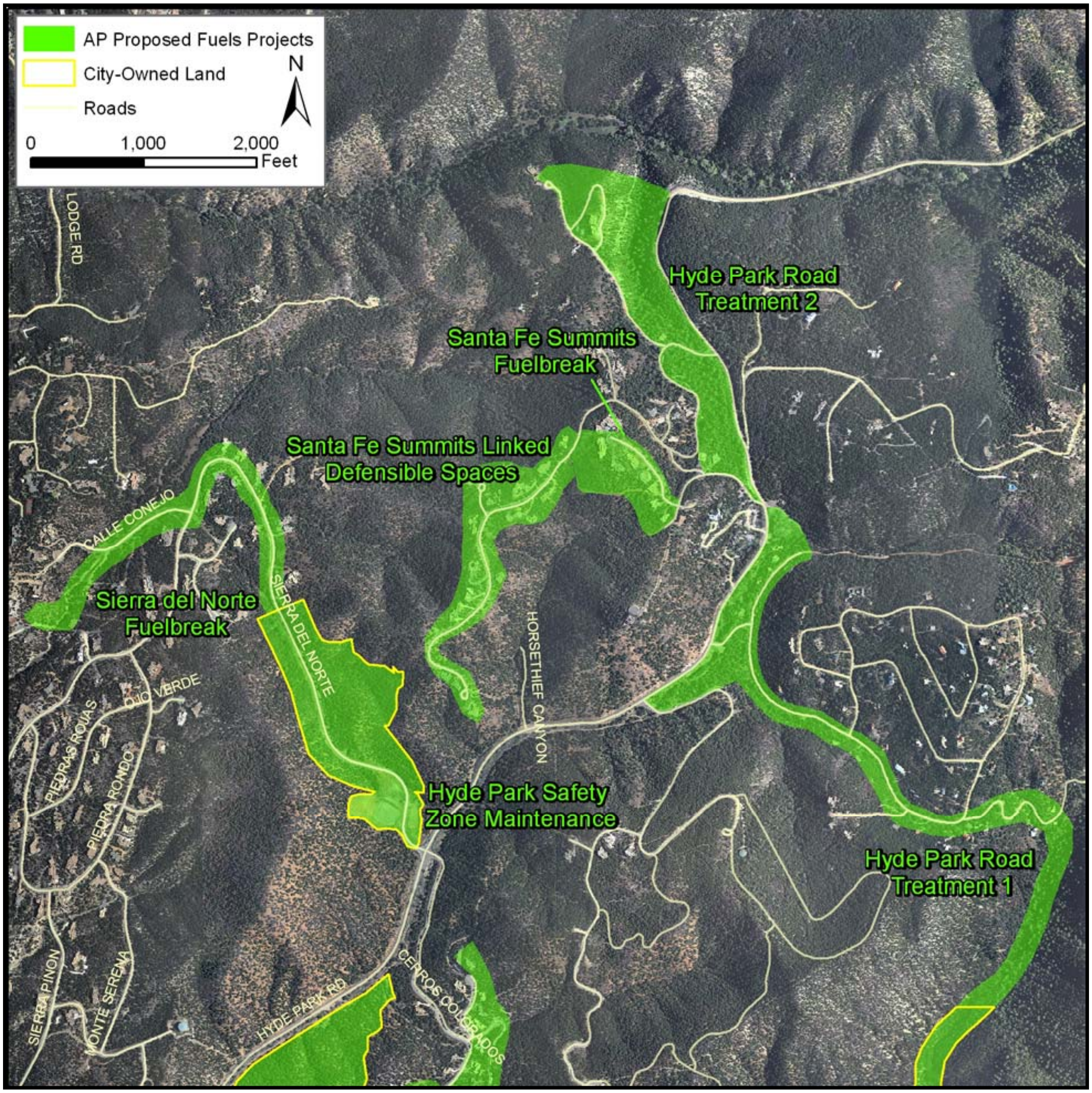


Figure 36. Fuels Projects – Los Cerros Colorados

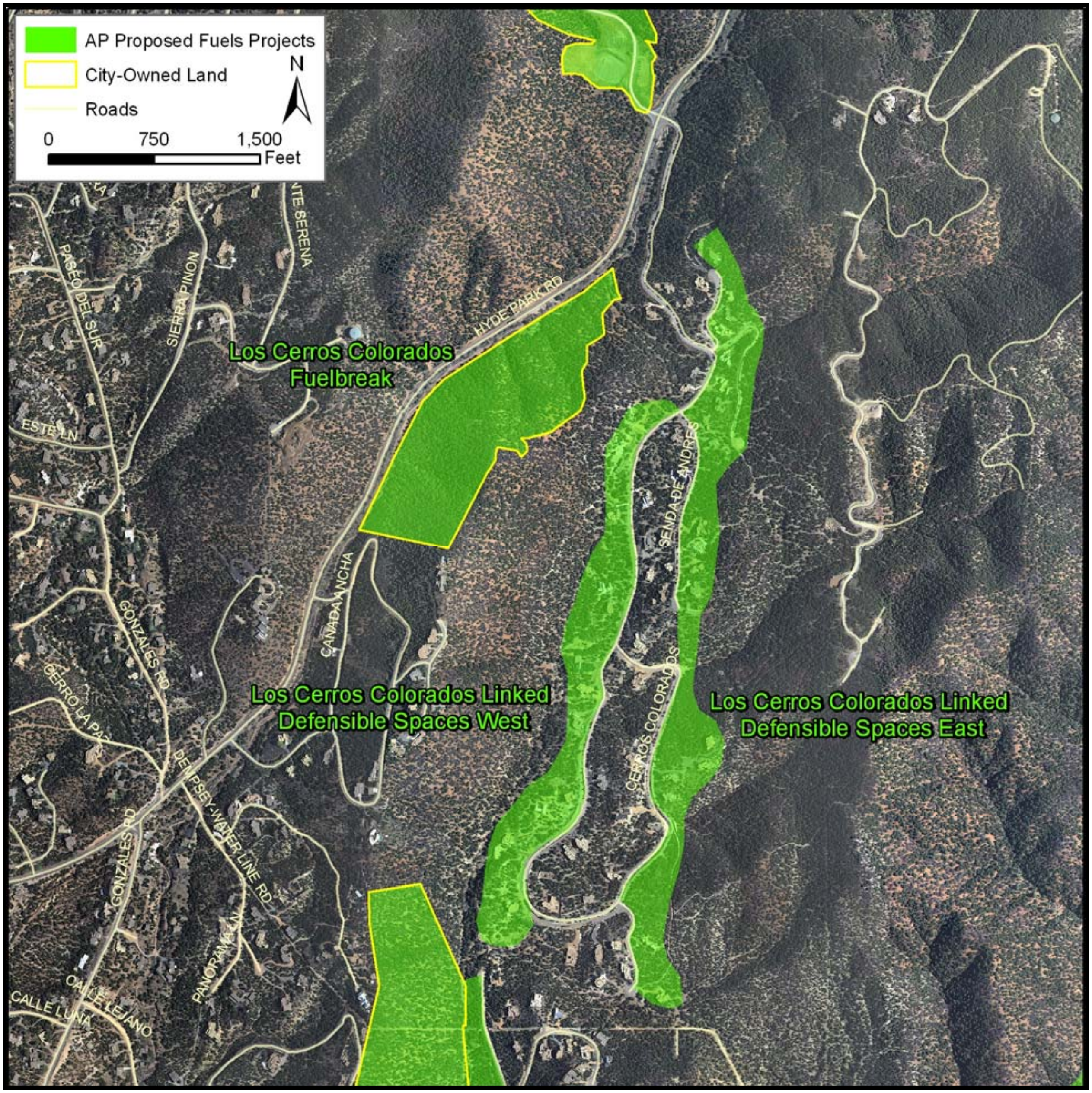


Figure 37. Fuels Projects – Cerro Gordo

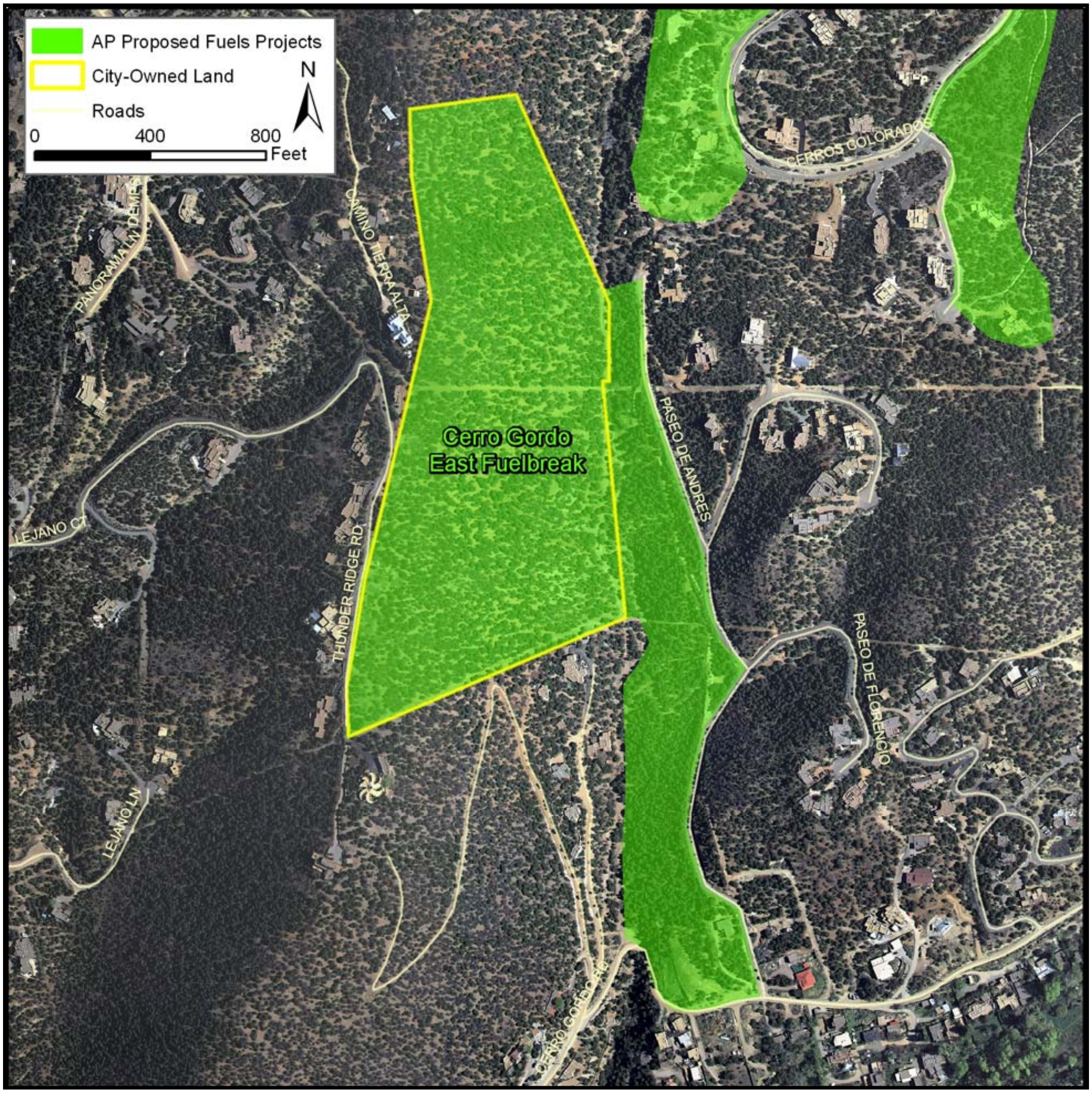


Figure 38. Fuels Projects – St. John's College and Wilderness Gate

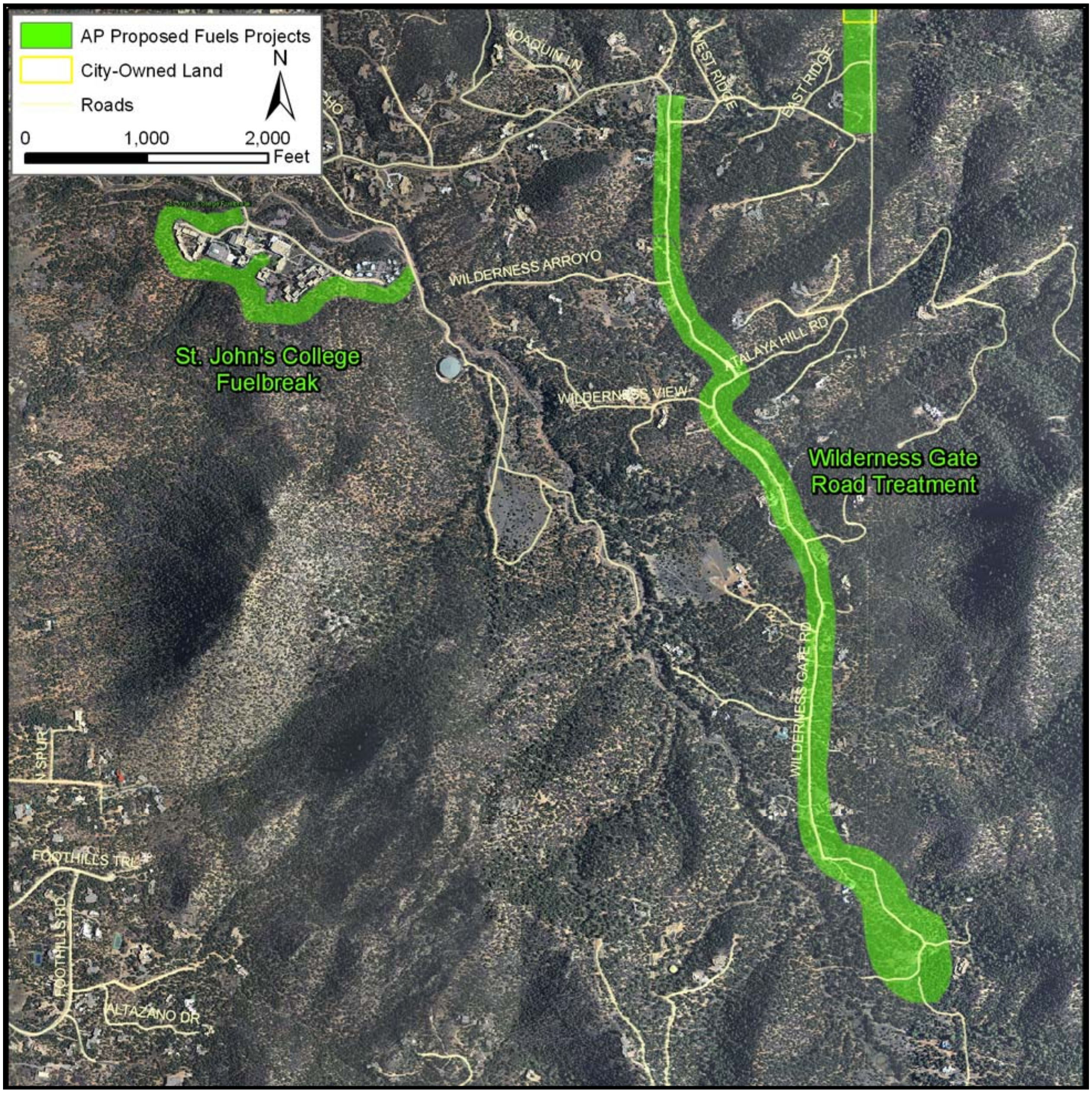


Figure 39. Fuels Projects – Camino Pequeno

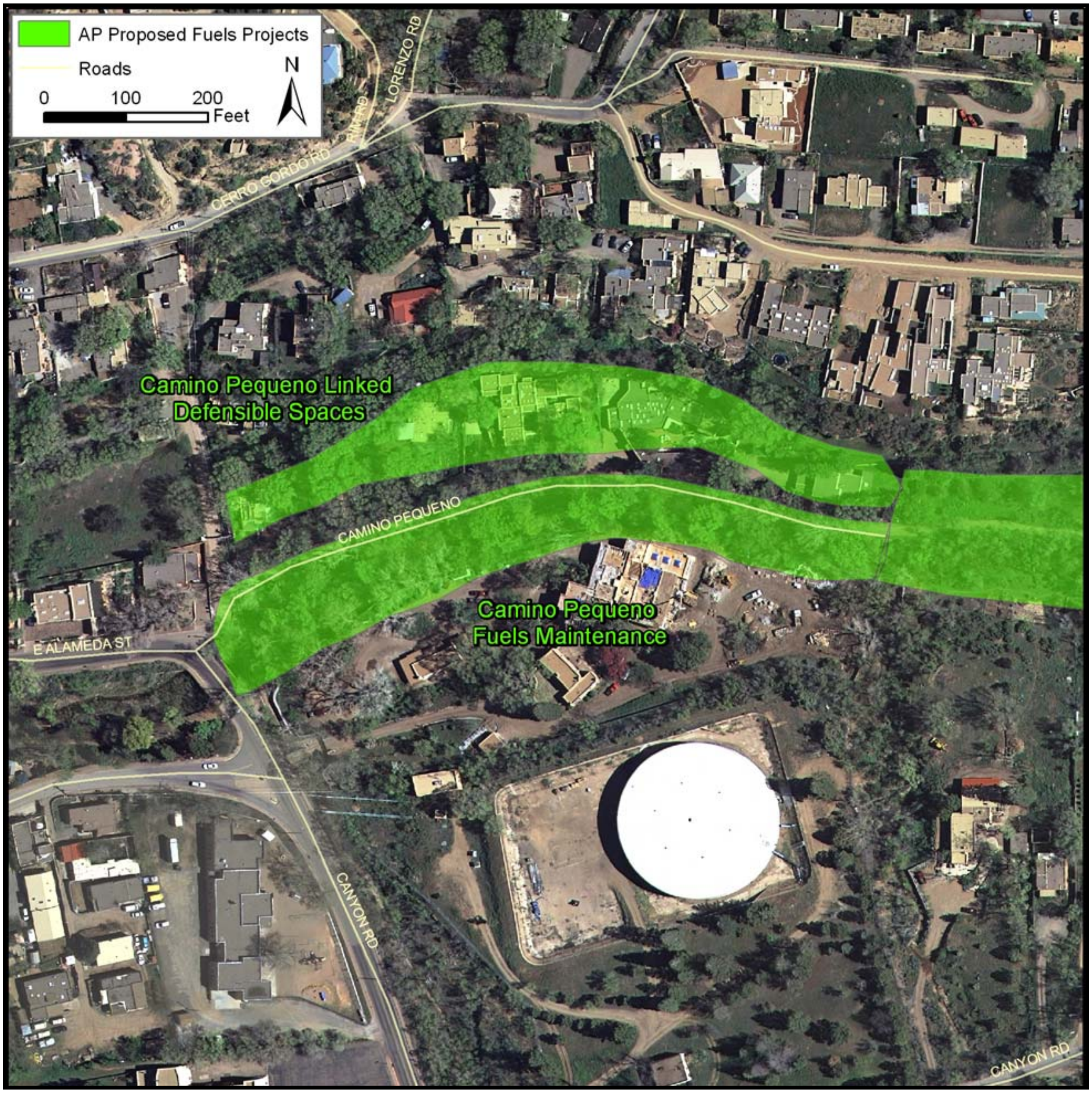


Figure 40. Fuels Projects – Audubon Society Property

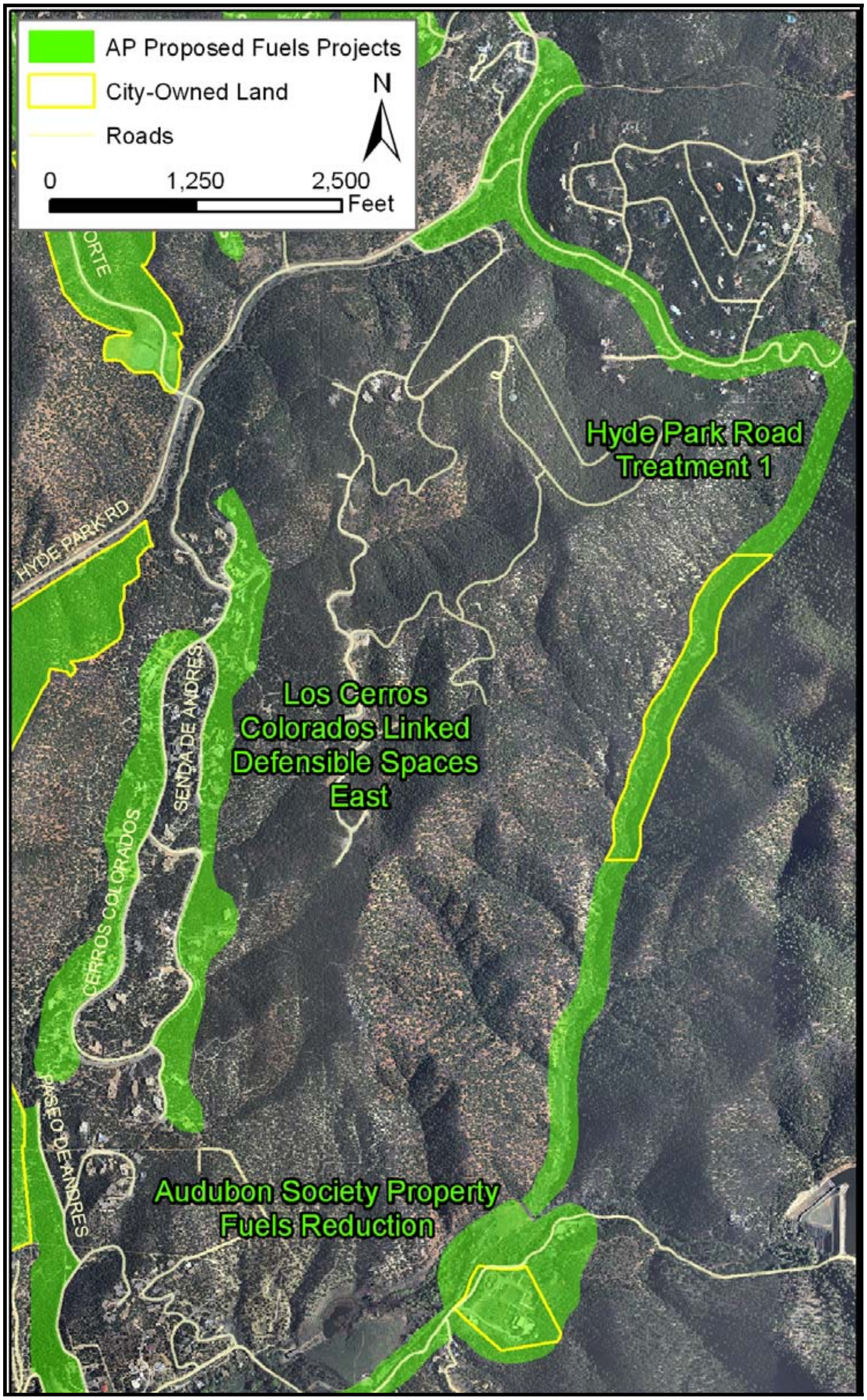


Figure 41. Fuels Projects – Camino Los Montoyas Fuelbreak

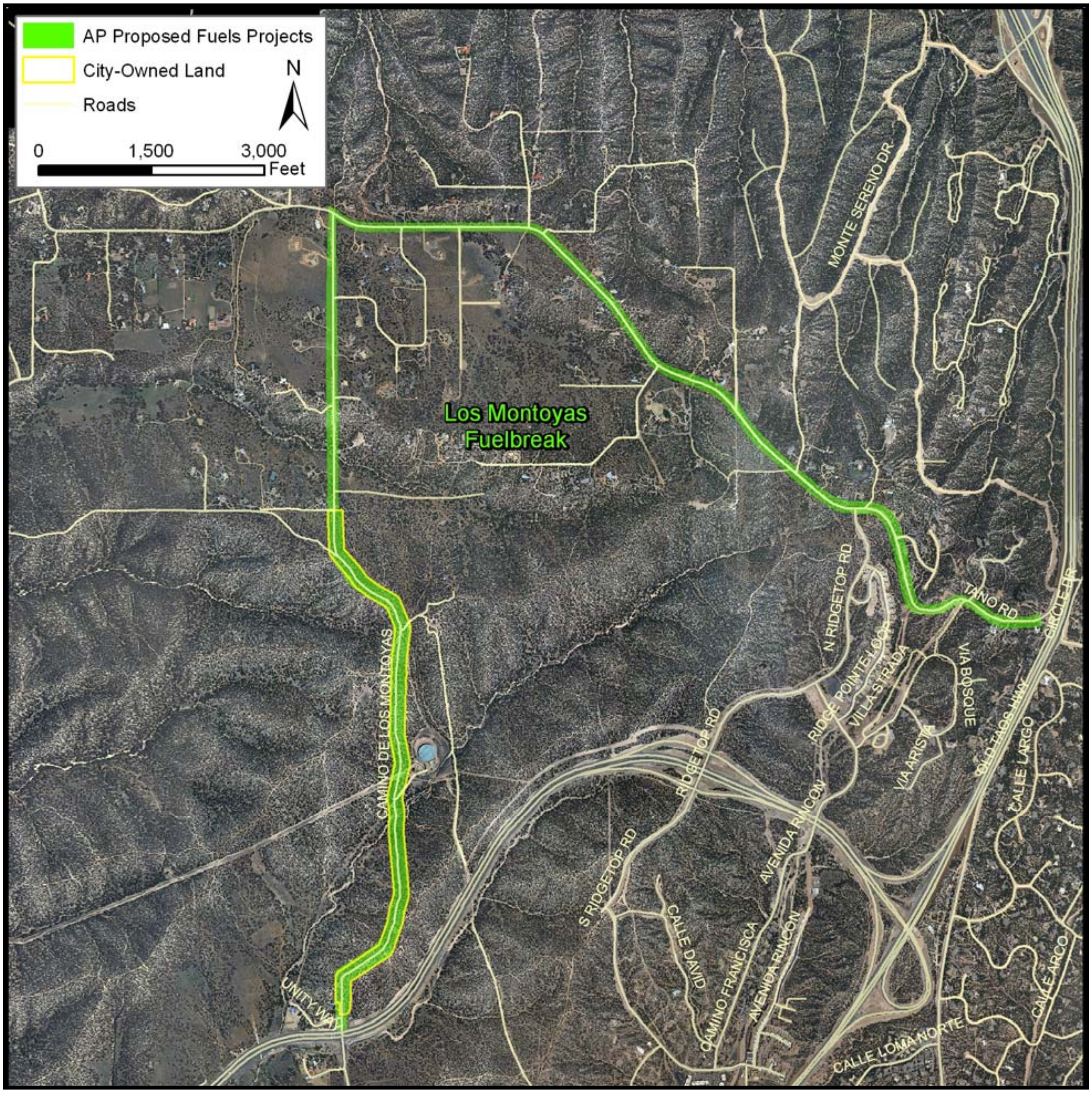
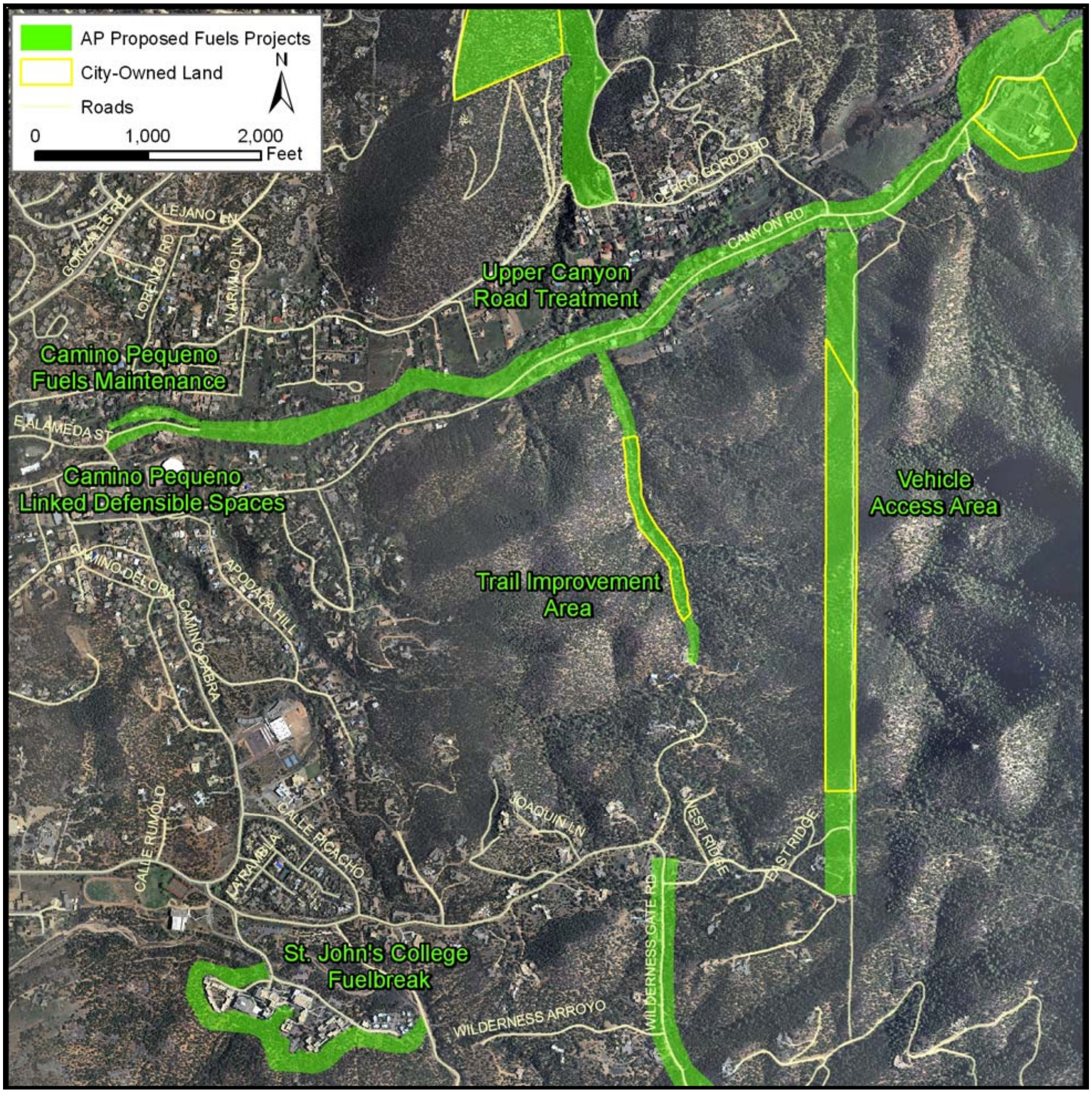


Figure 42. Fuels Projects – Upper Canyon Road Treatment



Water Supply FMU

Most people think of using water to extinguish fires. But just as water may not be the right thing for all fires inside a house (e.g., a grease fire), it may not provide the best solution for all wildland fires. Unless the water is dropped by helicopters and/or mixed with fire retardant and dropped by fixed-wing planes, it is not very useful when fighting major crown fires.

Water is most useful in fighting wildland fires:

1. If the fire is still small and can be extinguished quickly with water and/or hand tools.
2. If the water is mixed with foam and/or gel to protect structures from an advancing fire.
3. If the major threat to the wildland is from a burning structure (and water can be used to extinguish the structure fire).
4. AFTER the fire, during "mop-up," when firefighters can patrol the area and put out burning debris or "hot spots."

Unlike many Wildland-Urban Interface areas in the western United States, Santa Fe has an excellent network of pressurized hydrants. There are, however, some neighborhoods in the study area that do not have hydrants or adequate water supplies for fire suppression. This includes the neighborhoods of Hyde Park North, Hyde Park South, Wilderness Gate, Talaya Hill, and Ponderosa Ridge.

In rural areas, fire cisterns (tanks which collect rainwater or are filled manually) are typically used to augment an existing water supply or the water shuttle established by the fire department.

The potential benefits of cisterns include:

1. Providing a water source near the fire, thus eliminating the time spent driving to hydrants.
2. Providing enough water that, when mixed with foam, can be invaluable in protecting a structure or vegetation from an advancing fire.

The potential weaknesses/shortcomings of cisterns include:

1. They are not typically large enough to meet fire flow requirements for structure fires.
2. They are not reliable in terms of the amount of water being held on any given day (this depends on rainfall, other uses of the water, general maintenance, etc.).
3. Smaller cisterns may hold only enough water to fill a small engine (or water tender) once or twice, which may make the effort of hooking up less efficient than driving to a nearby hydrant.
4. They may be placed improperly or at a distance that renders them useless.
5. Improper designs, materials, or fire department connections may prevent local firefighters from using the water supply.

The following recommendations are meant to enhance the existing hydrant network. They should be implemented by homeowners only on a case-by-case basis with the full participation of the City of Santa Fe Fire Marshal.

RECOMMENDATIONS

- Discuss with interested citizens the possibility of adding cisterns at homes designated as last resort shelter-in-place areas in the Hyde Park North and Hyde Park South neighborhoods.
- Consider recommending to homeowners the addition of small individual cisterns (1,000 to 2,000 gallons) or larger group cisterns (20,000 to 30,000) along key roads in the Wilderness Gate neighborhood.
- Consider recommending to homeowners the addition of small individual cisterns (1,000 to 2,000 gallons) to all properties further than 1000 feet (measured along the center line of the road or driveway) from the single hydrant at the entrance in the Talaya Hill neighborhood.
- Encourage the homeowners in the Ponderosa Ridge neighborhood to complete their hydrant system.
- Consider requiring an individual cistern for residences with private driveways longer than 1000 feet (measured along the center line of the road or driveway) from the nearest public hydrant.
- Ensure that all interface engines and tenders are equipped with port-a-tanks or pumpkins during the wildland fire season.
- Inspect all hydrants at least once every two years to ensure that they are still viable and have adequate flow and pressure.

GLOSSARY

The following definitions apply to terms used in the **City of Santa Fe Hazard and Risk Analysis.**

1 hour Timelag fuels: Grasses, litter and duff; <¼ inch in diameter.

10 hour Timelag fuels: Twigs and small stems; ¼ inch to 1 inch in diameter.

100 hour Timelag fuels: Branches; 1 to 3 inches in diameter.

1000 hour Timelag fuels: Large stems and branches; >3 inches in diameter.

Active Crown Fire: a crown fire in which the entire fuel complex—all fuel strata—become involved, but the crowning phase remains dependent on heat released from the surface fuel strata for continued spread (also known as a running crown fire or continuous crown fire).

ArcGIS 9.x: Geographic Information System (GIS) software designed to present mapping data so that it can be analyzed, queried and displayed. ArcGIS is in its ninth major revision and is published by the Environmental Systems Research Institute (ESRI).

Crown Fire (Crowning): The movement of fire through the crowns of trees or shrubs. A crown fire may or may not be independent of the surface fire.

Defensible Space: An area around a structure where fuels and vegetation are modified, cleared, or reduced to slow the spread of wildfire toward or from the structure. The design and distance of defensible space is based on fuels, topography, and the design/materials used in the construction of the structure.

Energy Release Component: An index of how hot a fire could burn. ERC is directly related to the 24-hour, potential worst case, total available energy within the flaming front at the head of a fire.

Extended Defensible Space (also known as Zone 3): A defensible space area where treatment is continued beyond the minimum boundary. This zone focuses on forest management. Here, fuels reduction is a secondary consideration.

Fine Fuels: Fuels that are less than ¼ inch in diameter, such as grass, leaves, draped pine needles, fern, tree moss, and some kinds of slash which, when dry, ignite readily and are consumed rapidly.

Fire Behavior Potential: The expected severity of a wildland fire expressed as the rate of spread, the level of crown fire activity, and flame length. Derived from fire behavior modeling programs which analyze the following inputs: fuels, canopy cover, historical weather averages, elevation, slope, and aspect.

Fire Danger: Not used as a technical term in this document due to various and nebulous meanings that have been historically applied.

Fire Hazard: Given an ignition, the likelihood and severity of Fire Outcomes (Fire Effects) that result in damage to people property and/or the environment. Derived from the Community Assessment and the Fire Behavior Potential.

Fire Mitigation: Any action designed to decrease the likelihood of an ignition, reduce Fire Behavior Potential, or to protect property from the impact of undesirable Fire Outcomes.

Fire Outcomes (aka Fire Effects): A description of the expected effects of a wildfire on people, property, and/or the environment, based on the Fire Behavior Potential and physical presence of Values at Risk. Outcomes can be desirable as well as undesirable.

Fire Risk: The probability that an ignition will occur in an area with potential for damaging effects to people, property, and/or the environment. Risk is based primarily on historical ignitions data.

Flagged Addressing: A term describing the placement of multiple addresses on a single sign which serves multiple structures located on a common access.

FlamMap: A software package created by the Joint Fire Sciences Program at the Rocky Mountain Research Station. The software uses mapped environmental data such as elevation, aspect, slope, and fuel model, along with fuel moisture and wind information, to generate predicted fire behavior characteristics such as Flame Length, Crown Fire Activity, and Spread Rate.

Flame Length: The distance between the flame tip and the midpoint of the flame depth at the base of the flame (generally the ground surface). Flame length is an indicator of fire intensity.

FMU (Fire Management Unit): A method of prioritizing fire mitigation work efforts. Units can be defined as functional (e.g., public education efforts) or geographic (e.g., fuel reduction projects in a given area).

Fuelbreak: A natural or constructed discontinuity in a fuel profile used to isolate, stop, or reduce the spread of fire. Fuel breaks may also make retardant lines more effective and serve as control lines for fire suppression actions. Fuel breaks in the WUI are designed to limit the spread and intensity of crown fire activity.

ICP (Incident Command Post): The base camp and command center from which fire suppression operations are directed.

ISO (Insurance Standards Office): A leading source of risk information to insurance companies. ISO provides fire risk information in the form of ratings used by insurance companies to price fire insurance products to property owners.

Jackpot Fuels: A large concentration of fuels in a given area such as a slash pile.

Passive Crown Fire: A crown fire in which individual or small groups of trees torch out (candle), but solid flaming in the canopy fuels cannot be maintained except for short periods.

Shelter-in-Place Areas: A method of protecting the public from an advancing wildfire that involves instructing people to remain inside their homes or public buildings until the danger passes. This concept is new to wildfire in the United States, but not to hazardous materials incident response where time, hazards, and sheer logistics often make evacuation impossible. This concept is the dominant modality for public protection from wildfires in Australia where fast moving, short duration fires in light fuels make evacuation impractical. The success of this tactic depends on a detailed preplan that takes into account the construction type and materials of the building used, topography, depth and type of the fuel profile, as well as current and expected weather and fire behavior. For a more complete discussion of the application and limitations of Shelter-in-place concepts see the **Addressing, Evacuation, and Shelter-In-Place FMU** section in the main report.

Slash: Debris left after logging, pruning, thinning, or brush cutting. Slash includes logs, chips, bark, branches, stumps, and broken understory trees or brush.

Spotting: A type of fire behavior producing sparks or embers that are carried by the wind and then start new fires beyond the zone of direct ignition by the main fire.

Structural triage: The process of identifying, sorting, and committing resources to a specific structure.

Surface fire: A fire that burns through the surface litter, debris, and small vegetation on the ground.

Timelag: Time needed under specified conditions for a fuel particle to lose about 63 percent of the difference between its initial moisture content and its equilibrium moisture content.

Values at Risk: People, property, ecological elements, and other intrinsic values within the project area that are identified by citizens as being important to the way of life in the study area and which are susceptible to damage from undesirable fire outcomes.

WHR (Community Wildfire Hazard Rating, aka Community Assessment): A fifty-point scale analysis designed to identify factors that increase the potential and/or severity of undesirable fire outcomes in WUI neighborhoods.

WUI (Wildland Urban Interface): The line, area, or zone where structures and other human development meet or intermingle with undeveloped wildland or vegetative fuels. Sometimes referred to as Urban-Wildland Interface, or UWI.

RECOMMENDED REFERENCES

Anderson, Hal E. *Aids to Determining Fuel Models for Estimating Fire Behavior*. National Wildfire Coordinating Group. NFES 1574. April 1982.

At Home in the Woods – Lessons Learned in the Wildland/Urban Interface. FEMA. 2004.

Bachmann, Andreas and Allgower, Britta. *A Consistent Wildland Fire Risk Terminology is Needed!* Fire Management Today (61,4). USDA Forest Service. Washington, DC. Fall 2001.

Dennis, Frank, C. *Fuelbreak Guidelines for Forested Subdivisions.* Colorado State Forest Service. Colorado State University. 1983.

Developing a Cooperative Approach to Wildfire Protection. National Wildland-Urban Interface Fire Protection Program.

Development Strategies in the Wildland/Urban Interface. International Association of Fire Chiefs and Western Fire Chiefs Association. Billings, Montana. July 1991.

Firefighter Safety in the Wildland/Urban Interface – A Video Series (VHS Video - 60 Mins.). National Wildland/Urban Interface Fire Program. 2003.

Fires that Changed the Fire Service – Wildlands (VHS Video – 84 Mins.). American Heat. March 2000.

FireSmart – Protecting Your Community from Wildfire. Partners in Protection. Edmonton, Alberta, CANADA. May 1999.

Hirsch, K.G., M.M. Pinedo, and J.M. Greelee. *An International Collection of Wildland-Urban Interface Resource Materials*. Information Report NOR-X-344. Canadian Forest Service – Northwest Region – Northern Forestry Centre. 1996.

Home Improvement: A Firewise Approach (VHS Video – 15 Mins.). 2003.

Introducing Firewise Communities Workshops (VHS Video– 6 Mins.). Firewise Communities. Quincy, MA.

Mangan, Richard J. *Improving Firefighter Safety in the Wildland-Urban Intermix*. FE02P16 – USDA Forest Service Technology and Development Program. Missoula, Montana. February 2000.

National Wildland/Urban Interface Fire Protection Program Building a Fire wise Home (VHS Video – 20 Mins.). Hearst-Argyle Television Productions. Needham, MA. November 1997.

Langowski, P. *Fire and Fuels Analysis to Support Project Planning*. November 2003.

Preparing a Community Wildfire Protection Plan – a Handbook for Wildland-Urban Interface Communities, Sponsored by: Communities Committee, National Association of Counties, National Association of State Foresters, Society of American Foresters, Western Governors' Association. March 2004.

Queen, Phillip L. *Fighting Fire in the Wildland/Urban Interface*. Fire Publications, Inc. Bellflower, California. 1993.

Slaughter, Rodney (ed.), *California's I-ZONE – Urban/Wildland Fire Prevention & Mitigation*. Sacramento, California. January 1996.

Standard for Protection of Life and Property from Wildfire. NFPA 299. National Fire Protection Association. Quincy, MA. 1997.

Standard for Protection of Life and Property from Wildfire. NFPA 1144(02) (Formerly *NFPA 299*) National Fire Protection Association. Quincy, MA. 2002.

Urban-Wildland Interface Code™. International Fire Code Institute. Whittier, California. January 2000.

White, Christopher. *Dry Hydrant Manual – A Guide for Developing Alternative Water Sources for Rural Fire Protection.* Developed for Summit County, Colorado.

Wildfire! Preventing Home Ignitions! (VHS Video – 19 Mins.). Firewise Communities. Quincy, MA.

Wildland/Urban Interface Fire Hazard Assessment Methodology. Developed by National Wildland/Urban Interface Fire Protection Program.

Wildland/Urban Interface Fire Policy Action Report. Western Governor's Association. February 1996.

INTERNET RESOURCES

FireWise. http://firewise.org/ January 2005.

Fire Regime Condition Class. http://www.frcc.gov/ July 2005.

FRAMES -- Fire Research and Management Exchange System. **http://www.frames.gov/tools/** January 2005.

Interagency Wildland Fire Communications Group – Rocky Mountain Area. http://www.rockymountainwildlandfire.info/grants.htm January 2005.

NFPA 1710 summary. http://www.iaff.org/academy/content/online/modules/1710/summary.htm

National Database of State and Local Wildfire Hazard Mitigation Programs. http://www.wildfireprograms.com January 2005.

RAMS - (Risk Assessment and Mitigation Strategies). U.S. Department of Interior, Bureau of Land Management, National Interagency Fire Center, Wildland Fire Management Information. http://www.nifc.blm.gov/nsdu/fire_planning/rams January 2005.

Standard for Protection of Life and Property from Wildfire. NFPA 1144. http://www.normas.com/NFPA/PAGES/NFPA-1144(02).html January 2005.

Standard for Protection of Life and Property from Wildfire. NFPA 299. http://webstore.ansi.org/ansidocstore/product.asp?sku=29997PDF January 2005.