POUDRE FIRE AUTHORITY

COMMUNITY WILDFIRE PROTECTION PLAN

September, 2011

In the Dead of the Night, depicting the 2011 Crystal Fire
by Lori Forest www.forestimages.com

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2011

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List of Abbreviations

CSFS	Colorado State Forest Service
CWPP	Community Wildfire Protection Plan
GR	Grass Fuel Model
GS	Grass-Shrub Fuel Model
HFRA	Healthy Forest Restoration Act
NB	Non-burnable Fuel Model
PFA	Poudre Fire Authority
MPB	Mountain Pine Beetle
RAWS	Remote Automated Weather Station
SH	Shrub Fuel Model
TL	Timber Litter Fuel Model
TU	Timber Understory Fuel Model
USFS	United States Forest Service
WOPI	WUI Outreach and Planning Initiative
WUI	Wildland Urban Interface

Process for Revision and Updates

The first Poudre Fire Authority (PFA) Community Wildfire Protection Plan (CWPP) was completed in 2006 with a specific timeline for Action Items through 2009. This 2011 CWPP update is the first formal review and revision of the original 2006 CWPP.

Formal Revisions and Updates
We recommend that the CWPP continue to be formally reviewed and revised on approximately a five year cycle. These formal updates should include a review by PFA WUI Program, Operations Division, Fire Prevention Bureau, Larimer County Emergency Services, the PFA Board of Directors, and the Colorado State Forest Service and approval by the Chief of the Poudre Fire Authority, and the Colorado State Forest Service.

Continuous Review and Adaptation
This CWPP is a living document that should allow for the dynamic nature of the fire environment (including changes in fuels and community development) as well as Action Item projects (which are impact by variable funding cycles and shifting capabilities). The PFA WUI Program should review the CWPP annually to ensure the validity of planning assumptions and the progress of Action Items. Adjustments and revisions should be subsequently noted in an electronic version of this document. This will assist in maintaining action-strategy alignment and facilitate the formal quinquennial updates.

Acknowledgements

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Mr. Boyd Lebeda	Colorado State Forest Service
Mr. Mike Gress	Operations Chief, Poudre Fire Authority
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Mr. Tim England	Captain, Poudre Fire Authority
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Mr. Scott Taylor	Firefighter, Poudre Fire Authority
Mr. Pete Barry	Colorado State University
Mr. Rocky Coleman	Colorado State University

Executive Summary

This Community Wildfire Protection Plan (CWPP) was developed by the Poudre Fire Authority (PFA) with guidance and support from Larimer County, the Colorado State Forest Service (CSFS), and the United States Forest Service (USFS). Pursuant to the goal of developing a more wildland fire adapted community and fire department, the objectives of this report are to:

- Reexamine and describe PFA's areas of WUI
- Update community hazards and risks associated with the WUI
- Engage WUI communities and residents in fire mitigation planning, mitigation, and preparedness activities
- Provide updated prioritized recommendations for WUI mitigation, preparedness, response, and recovery
- Provide an Action Plan for implementing recommendations
- Reinforce strategic guidance to the PFA WUI Programs and the City of Fort Collins Natural Areas Program

While many CWPPs concentrate on fuels management activities, much of this CWPP focuses on preparedness and prevention activities that are within the purview of PFA. Fuels management projects are addressed as action items to be implemented by other agencies and homeowners within PFA's jurisdiction. PFA may assist with these projects when appropriate.

Within Poudre Fire Authority's jurisdiction there are a substantial number of structures intermixed with fire adapted vegetation. Intense fires in these ecosystems can be natural or the result of fire exclusion and often exceed the suppression capabilities of handcrews. PFA's vital role in local wildland fire suppression has continued to grow with increased development in the wildland-urban interface.

Studying fire occurrence in terms of geographic location, climatic indices, and values at risk affords a situational understanding upon which pre-fire planning and mitigation efforts can be based. Several points are critical to an understanding of the interface situation in PFA's jurisdiction:

1.) Local wildland fuels can support extreme fire behavior under historic climatic conditions which may be exacerbated by the effects of fire exclusion.

2.) Fire occurrence is grouped into two distinct seasons peaking in March and July.

3.) Geographically, fire occurrence is heaviest in the eastern grasslands and agricultural areas, but the potential for large fire growth and pronounced property loss focuses attention to the west side of the district.

4.) Modeled and observed fire behavior illustrates the need for rapidly deployable engines, indirect line construction, and air resources during times of severe fire weather.

PFA has been actively engaged in executing the action items from the 2006 CWPP. Many of the action items in this CWPP are continuations of those successful efforts. Action items were developed within the context of the four phases of emergency management: mitigation, preparedness, response, and recovery.

Table 1. WUI Action Items

MITIGATION		
Year	**Action**	**Lead**
2011	Conduct QA of the WOPI assessments.	PFA
	Finalize WOPI assessments in the south Horsetooth area.	PFA
	Horsetooth Mountain Park Rx burn	Larimer County
	City of Fort Collins NA burns at Bobcat and Soapstone Natural Areas.	City of Fort Collins Natural Areas Program
	Natural Areas Fire Management Plan.	City of Fort Collins Natural Areas Program
2012	Conduct WOPI assessments in the north Horsetooth area.	PFA
	Explore potential for chipping program in WUI neighborhoods to support defensible space efforts.	PFA with Larimer County and citizens
	Coordinate future planning between water departments and land management agencies. Initiate through the PFA Critical Infrastructure Assessment Project.	PFA, hand-off to relevant land management and water agencies
	Examine need for improved mitigation around critical infrastructure (primarily power lines and above ground natural gas fixtures). Initiate through the PFA Critical Infrastructure Assessment Project.	PFA, hand-off to relevant utilities
	Horsetooth Mountain Park fuels treatment	Larimer County
Ongoing	Continued implementation of prescribed fire on City of Fort Collins Natural Areas.	City of Fort Collins Natural Areas Program
	Fort Collins NA WUI mowing program	City of Fort Collins Natural Areas Program
	Continued fuels treatments on Larimer County lands.	Larimer County
	Continued fuels treatments on Colorado State lands.	Colorado State Forest Service
	Monitor the impacts of the mountain pine beetle epidemic and adjust actions accordingly.	Colorado State Forest Service

Year	Action	Lead
PREPAREDNESS AND RESPONSE		
2011	Pre-incident planning for hosting/supporting large incidents.	PFA, CSU, Larimer County
	Update and distribute tactical WUI maps.	PFA
	Develop WUI pre-incident planning template for specific WUI areas, especially in occluded and eastern WUI.	PFA
	Pursue establishment of cistern or other water supply improvement in Redstone Canyon.	Station 11 (PFA)
2012	Investigate the development of CERT or other citizen organizations in WUI communities.	PFA
	Critical infrastructure assessment, addressing, and mapping as a separate planning initiative that will have overlap with the CWPP.	PFA
Ongoing	Continuation of WOPI program.	
	Continued annual wildland refresher training. Additional equipment purchases and upgrade to Type 6 engine.	City of Fort Collins Natural Areas Program
	Continued participation in interagency WUI exercises.	Larimer County
RECOVERY		
2011	Pre-incident coordination between BAER Teams and water districts.	Fort Collins Water
2012	Fort Collins Recovery Plan.	Fort Collins OEM
	Fort Collins Debris Management Plan.	Fort Collins OEM

1. Introduction

This Community Wildfire Protection Plan (CWPP) was developed by the Poudre Fire Authority (PFA) with guidance and support from Larimer County, the Colorado State Forest Service (CSFS), and the United States Forest Service (USFS). This is an update of the original 2006 CWPP.

The goals of the CWPP updating process are to enhance the protection of lives and property in the wildland-urban interface (WUI) and promote firefighter safety and effectiveness through fostering wildland fire adapted communities and emergency response. The objectives of this report are to:

- Reexamine and describe PFA's areas of WUI
- Update community hazards and risks associated with the WUI
- Engage WUI communities and residents in fire mitigation planning, mitigation, and preparedness activities
- Provide updated prioritized recommendations for WUI mitigation, preparedness, response, and recovery
- Provide an Action Plan for implementing recommendations
- Reinforce strategic guidance to the PFA WUI Programs and the City of Fort Collins Natural Areas Program

PFA recognizes a variety of wildland and WUI threats throughout its district. This plan continues to focus on the more vulnerable western areas of PFA, but seeks to more thoroughly address the entire fire district. While the steep topography and continuous wildland fuels in the western portion of the jurisdiction offer the highest potential for large fires, there are neighborhoods throughout PFA that are exposed to potential wildfire from adjacent undeveloped lands.

1.1 Legislative Authority and Guidance

The CWPP is essentially a strategic plan that identifies wildland fire issues facing the community and outlines prioritized mitigation and preparedness actions required for effective response and recovery per the Healthy Forests Restoration Act (HFRA) of 2003. The first purpose of the HFRA is "to reduce wildfire risk to communities, municipal water supplies, and other at-risk Federal land through a collaborative process of planning, prioritizing, and implementing hazardous fuel reduction projects" (Healthy Forest Restoration Act 2003). Additionally, the HFRA seeks to improved collaboration between federal, state, and local governments in reducing fire hazards in the WUI.

CWPP's have become increasingly important in obtaining grant funds for projects in the WUI. A minimum of 50% of HFRA funded projects must be in WUI communities as defined in a CWPP. A current CWPP has increasingly become a prerequisite for a

variety of other federal and state funding opportunities in the WUI. Per the HFRA, required elements of a CWPP are:

- Collaboration between the local fire department, local government, the state government in consultation with relevant federal agencies
- Prioritized hazardous fuel reduction projects
- Recommendations to reduce structural ignitability

The Colorado State Forest Service provides further guidance for CWPPs through the Minimum Standards for Developing Community Wildfire Protection Plans (2009) pursuant to Colorado Senate Bill 09-001. In addition to the afore mentioned HFRA requirements, the State of Colorado requires:

- A CWPP core group inclusive of the CSFS, local government, local fire authority, local community members, and other relevant federal agencies and stakeholders
- Identification and mapping of the WUI, including adjacent landowners
- A community risk analysis
- A discussion of community response preparedness
- A prioritized implementation plan that includes the identification and mapping of fuels treatment projects

2. PFA Area Profile

2.1 Summary

The Poudre Fire Authority was created in 1981 when the City of Fort Collins and Poudre Valley Fire Departments merged. PFA's jurisdiction spans 235 square miles and encompasses the City of Fort Collins and the towns of Bellvue, Timnath, and LaPorte for a total population of approximately 189,000. The City of Fort Collins comprises 20% of PFA's jurisdiction by area and approximately 73% by population. These population centers are adjacent to a variety of vegetation communities and ownerships, including approximately 25,000 acres of federal, state, county, and city open spaces and conservation easements.

Three general WUI categories have been defined for PFA's jurisdiction: eastern agricultural/grassland areas, occluded pockets of wildland fuels within the urban area, and most substantially the brush and forest dominated western portion of this district.

As the elevation rises from 5000 feet to 7500 feet, three major vegetation zones are encountered: plains grassland, Lower Ecotone, and Lower Montane (Kaufmann et al. 2006). Invasive species, fire exclusion, and other factors have exacerbated potential fire behavior in these zones to varying degrees. The impact is most acute in the mountain mahogany shrublands and ponderosa pine of the Lower Ecotone, where WUI housing patterns are of a high concern.

2.2 Climate

The local climate is semi-arid with the majority of precipitation occurring with spring rains and summer monsoons (table 2). The low precipitation months are typically December, January, and February. The area receives approximately 300 days of sunshine per year and receives an average of 16.1 inches of annual precipitation. Winter high temperatures are typically in the lower to mid-forties, and average summer highs tend reach into the mid-eighties.

Table 2. Fort Collins Climate Data

Climate Attribute	Years	Month												
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Maximum Temperature (F^o)	1971-2000	42.0	46.5	53.7	61.3	70.2	80.5	85.5	83.4	75.4	64.2	50.0	42.9	63.0 avg
	1981-2010	44.2	46.5	54.7	62.2	71.1	80.4	86.6	84.0	75.9	63.9	51.4	42.8	63.6 avg
Average Minimum Temperature (F^o)	1971-2000	15.3	19.8	26.6	34.0	43.3	51.6	56.9	55.2	46.2	35.3	24.1	16.7	35.4 avg
	1981-2010	17.9	20.9	28.2	35.4	44.5	52.6	58.5	56.7	47.5	36.4	25.9	17.7	36.9 avg
Average Total Precipitation (inches)	1971-2000	0.42	0.38	1.42	2.09	2.60	1.99	1.87	1.40	1.38	0.98	0.82	0.49	15.84 total
	1981-2010	0.40	0.40	1.59	2.06	2.43	2.17	1.71	1.60	1.33	1.15	0.76	0.50	16.10 total
Average Snowfall (inches)	1971-2000	8.5	6.3	12.1	6.9	1.5	Trace	0	0	1.4	3.7	9.9	8.3	58.6 total
	1981-2010	7.9	6.9	12.6	6.2	0.7	Trace	0	0	0.9	3.6	8.6	8.4	55.8 total

(National Oceanic and Atmospheric Administration, www7.ncdc.noaa.gov/CDO/cdo)

Average and severe case weather and fuel moisture conditions were determined using records from the local remote automated weather station (RAWS) which collects weather and fuel moisture data specifically for fire danger and fire behavior predictions. Located at 6160 feet in the foothills of PFA's jurisdiction, the Redstone Canyon RAWS is well located for PFA's purposes. The two sets of fuel moisture and weather conditions were developed for the purpose of fire behavior modeling based on data from 1995 through 2010. Fiftieth percentile conditions represent average case, and 90th percentile conditions represent severe case conditions (table 3).

Table 3. Average & Severe Case Fire Weather & Fuel Moisture Conditions, 1995-2010

Months Assessed	Percentile Conditions	Minimum Relative Humidity	1 hr Fuel Moisture	10hr Fuel Moisture	100hr Fuel Moisture	Herbaceous Live Fuel Moisture*	Woody Live Fuel Moisture
April-Oct	50th	21%	6%	7%	11%	30%	97%
	90th	10%	3%	4%	7%	30%	65%

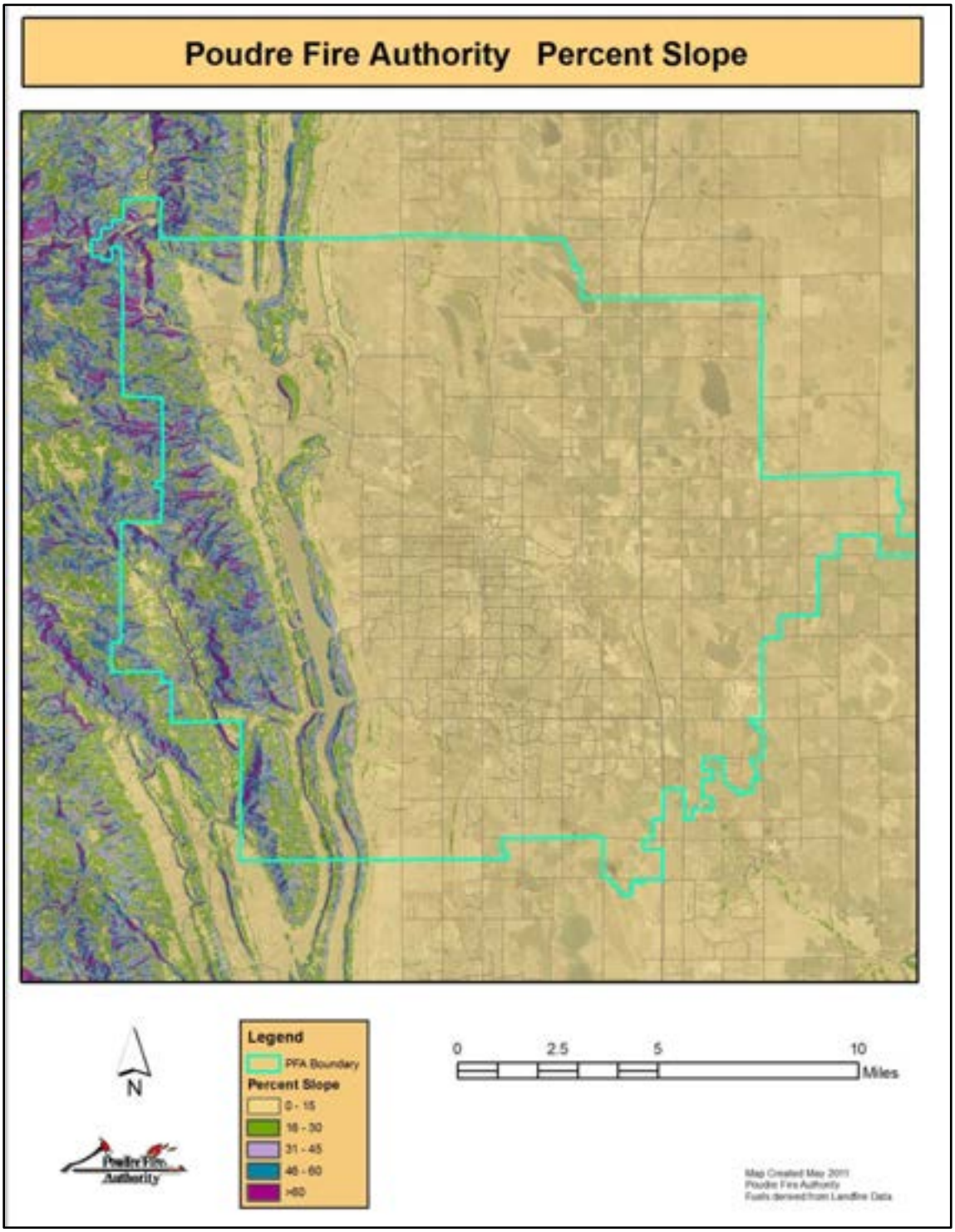
2.3 Terrain

Elevation rises from 4800 feet in the southeastern corner of PFA's jurisdiction to approximately 7500 feet in the foothills to the west. The Poudre River bisects the district, running from the northwest the southeast corner. The eastern two-thirds of PFA's jurisdiction is relatively flat, though short steep slopes are common near some of the streams that run through the area. The area west of Taft Hill Road and Overland Trail abruptly steepens as the foothills rise from 5200 feet to over 7000 feet in elevation.

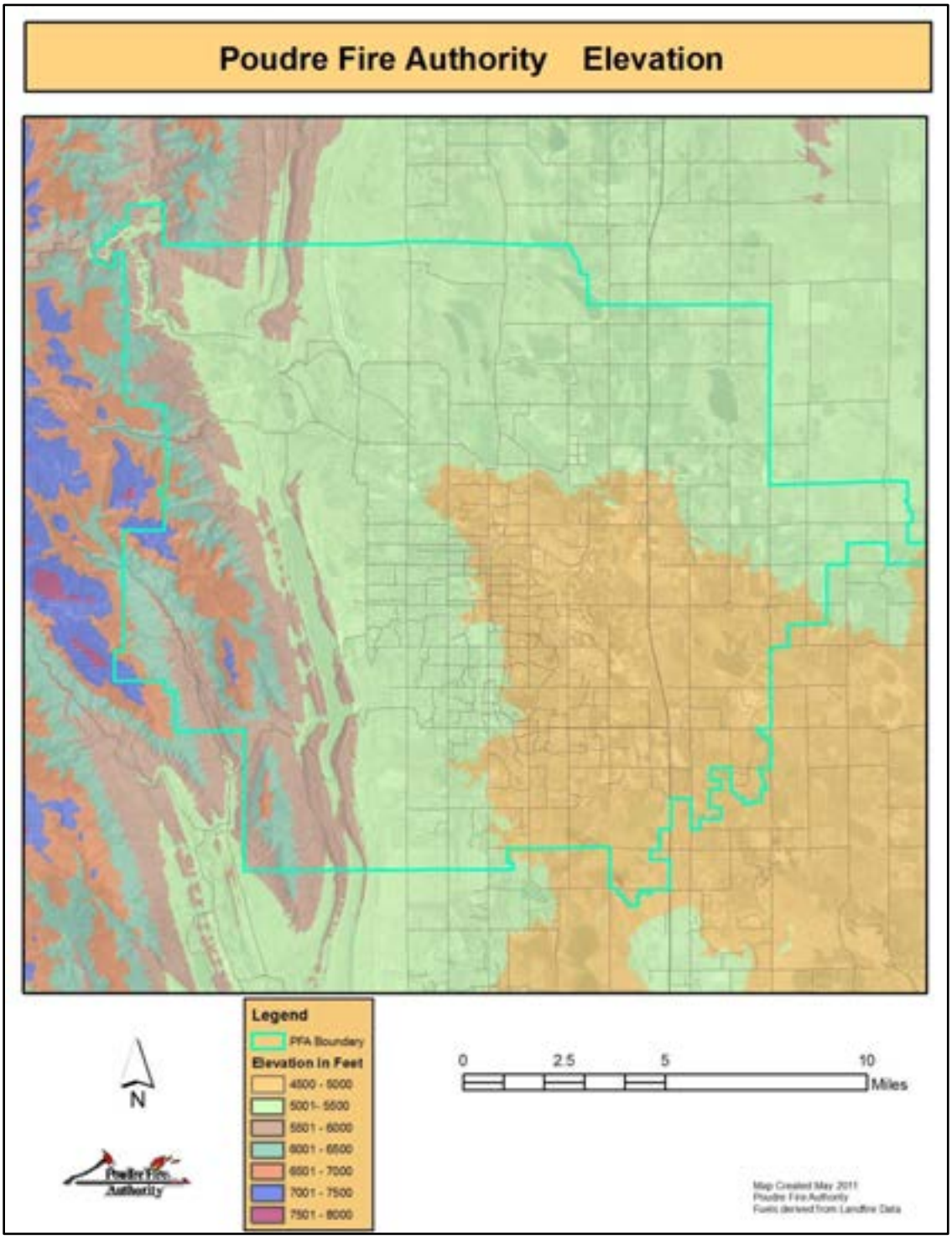
While slope angle can directly influence fire behavior, the effects are often overshadowed by the impact of wind in this area (map 1). Slope, aspect, and elevation combine to play a significant role in determining the fuel type found in an area (map 2). As elevation increases, the fuels generally transition from grass to brush, and finally to timber. Wooded areas on south facing slopes are often characterized by open stands of ponderosa pine mixed with grass and brush, while north facing slopes are favorable to a dense mixture of ponderosa pine and Douglas-fir.

The tactical implications of steep slopes are often most apparent in terms of access and building sites. Steep winding roads and steep home sites are a common concern throughout the western portion of the jurisdiction.

Map 1. Percent Slope



Map 2. Elevation



2.4 WUI General Description

PFA's 235 square miles comprise over 11% of Larimer County as a whole, and over 20% of non-federal lands in the county (Farmer 1997). Of 63 counties in Colorado, the CSFS ranks Larimer County fourth in area of interface with 148,030 acres of WUI. Fifty-eight percent of the county's subdivisions assessed by the CSFS are rated as extreme, severe, or high wildfire hazard (Farmer 1995). Other studies conducted by CSFS foresters have ranked Larimer County as either the first (Summerfelt 1993) or second (Jones 1992) most hazardous county in Colorado with respect to wildfire. While these studies are over a decade old, the factors upon which they are based remain largely in place as substantiated in a 2008 CSFS wildfire risk assessment.

PFA's WUI can be divided into three categories, agricultural/grassland intermix east of the foothills, occluded interface in the City of Fort Collins, and classic wildland-urban intermix in the western part of the jurisdiction (map 4). At least 50 square miles of the western portion of PFA's jurisdiction (22 percent of the district) can be classified as classic wildland-urban intermix.

Table 4. PFA WUI Statistics

PFA WUI Statistics in Summary	
Area of PFA's jurisdiction	235 square miles
Area of PFA's western WUI	50 square miles
Portion of Larimer County WUI rated as high hazard or above	58 percent
Larimer County WUI Hazard Rating	1st or 2nd of 63 counties

2.4.1 Agricultural and Grassland Intermix

The areas to the north, south, and east of the City of Fort Collins are characterized by small neighborhoods interspersed with agricultural lands and larger subdivisions adjacent to large areas of preserved grasslands (map 4). Fires are typically fast moving surface fire of varying intensity. Fuels on agricultural land are frequently altered by irrigation and other agricultural activities making them difficult to characterize. Fuels in designated natural areas may be a direct result of past agricultural activities but are now generally not irrigated or cultivated. As a result, fire behavior in natural areas can be more easily anticipated and modeled, while fire behavior on agricultural land is subject to the cultivation practices at that time.

The hazards in this type of WUI are easy to underestimate due to light fuels and relative ease of emergency access. High population density and agricultural activity create numerous ignition sources, predominantly agriculture burns and misuse of fire by youths. These areas can prove a tactical challenge to PFA at any time of the year. From 2009 through 2011 Oklahoma, Texas, and the Colorado Front Range have all experienced serious, sometimes devastating, fires in this type of WUI.

Figure 1. Grasslands Intermixed with high density residential development is a common WUI situation in the eastern areas of PFA's jurisdiction.

2.4.2 Occluded Interface

Within the City of Fort Collins there are numerous pockets natural areas and undeveloped private lands surrounded by densely populated areas. While fires in natural fuels are common in PFA's occluded interface, they usually remain small due to the discontinuity of fuels, ease of access for fire apparatus, and availability of water. However, these fires can rapidly threaten multiple structures due to the proximity of structures and the flashy nature of the fuels.

Figure 2. Occluded interface can include vacant lots or formerly rural areas surrounded by subdivisions.

2.4.3 Classic Interface or Wildland-Urban Intermix

The western portion of PFA is interwoven with grass, brush, and forested lands managed by the City of Fort Collins Natural Areas Program, Larimer County Natural Resources, and Colorado State Parks. PFA's western boundary is also in close proximity to large areas of United States Forest Service (USFS) land. In general, this area west of Overland Trail is the jurisdiction's most complex area in terms of diversity of fuel types, steep and broken terrain, difficulties of access and water supply, fragmented land management jurisdictions, and heavy fuel loads. Historically, this western portion of the jurisdiction has proven most susceptible to large fire growth (map 13), and devastating fires like the Four Mile Fire of 2010 (Boulder County, CO) illustrate the potential for large scale structure loss in the foothills (table 7).

Figure 3. Classic interface areas west of Fort Collins host subdivision built adjacent to large areas vulnerable to wildland fire.

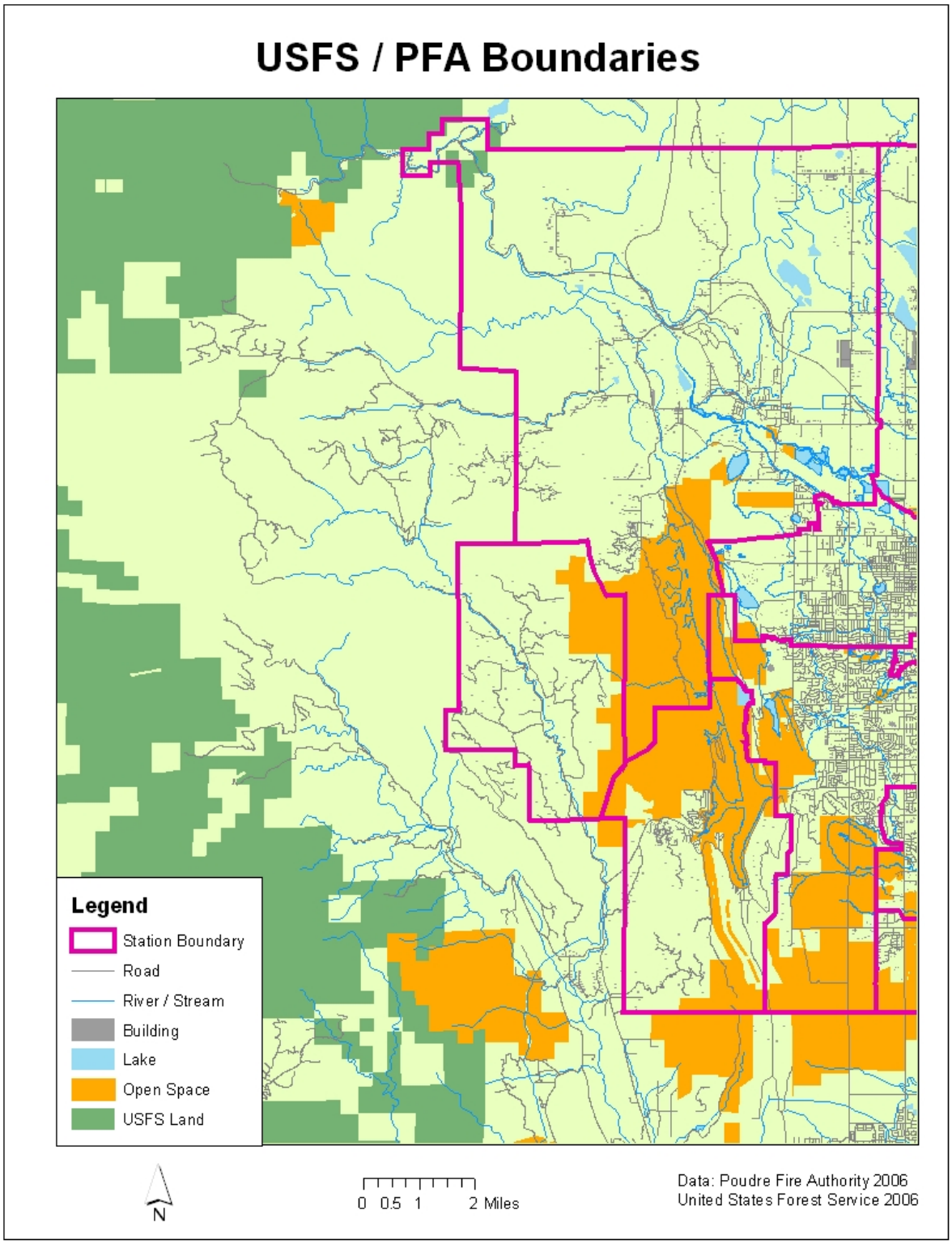
2.4.4 Public Lands

As mentioned, there are approximately 25,000 acres of state and locally managed open lands throughout and adjacent to PFA's jurisdiction, approximately 15,000 acres of which are managed by the City of Fort Collins Natural Areas Program. Larimer County and the City of Loveland administer approximately 7,300 acres to the southwest of Fort Collins, 1,900 acres of which are owned by the U.S. Bureau of Reclamation. Lory State Park is approximately 2,500 acres in size and is part of over 12,000 acres of contiguous non-federal wildlands on the western edge of Fort Collins.

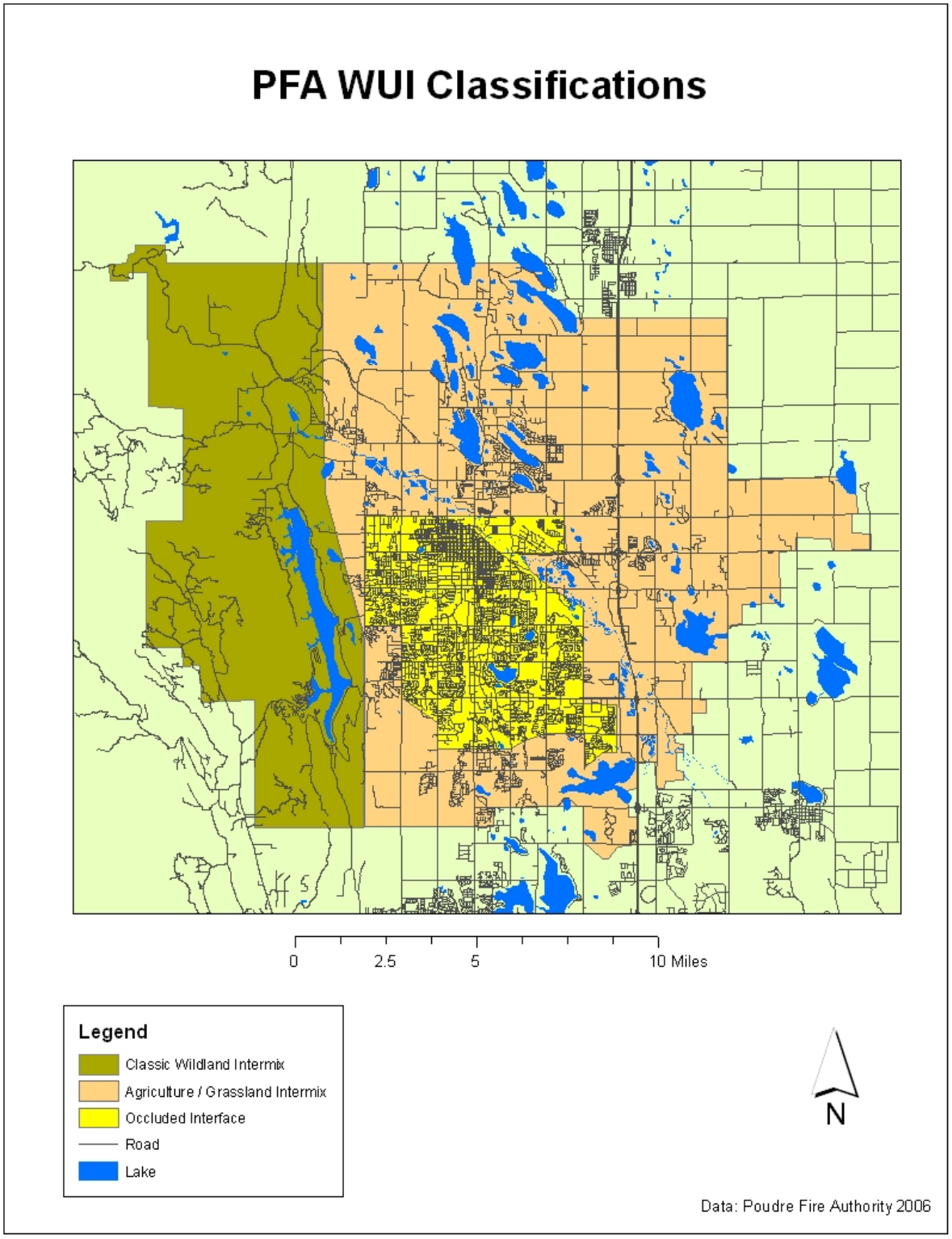
The northwest corner of PFA's jurisdiction is adjacent to the Canyon Lakes District of the 1.5 million acre Arapaho and Roosevelt National Forests. The remainder of PFA's western border is two to ten miles from USFS land (map 3). Though PFA does not share a very extensive common boundary with USFS lands, the proximity has proven significant during several major incidents. The Bobcat Gulch Fire threatened to burn into PFA's jurisdiction in 2000. Conversely, the Picnic Rock Fire of 2004 burned from PFA's jurisdiction onto USFS lands. In 2011 the Crystal Fire spotted over a mile and burned into Redstone Canyon.

Figure 4. Parks and Open Space comprise approximately 25,000 acres within PFA's jurisdiction.

Map 3. U.S. Forest Service and PFA Boundaries



Map 4. PFA WUI Classifications



2.5 Local Fire Environment

An understanding of local historic fire regimes is essential for developing sound fire and natural resource management strategies. The western portion of PFA's fire district consists of timber, brush, and grasslands. The grasslands extend eastward as the dominant vegetation in undeveloped and non-agricultural lands. The occluded interface of Fort Collins is predominantly grass with riparian corridors along the Cache La Poudre River and Spring Creek.

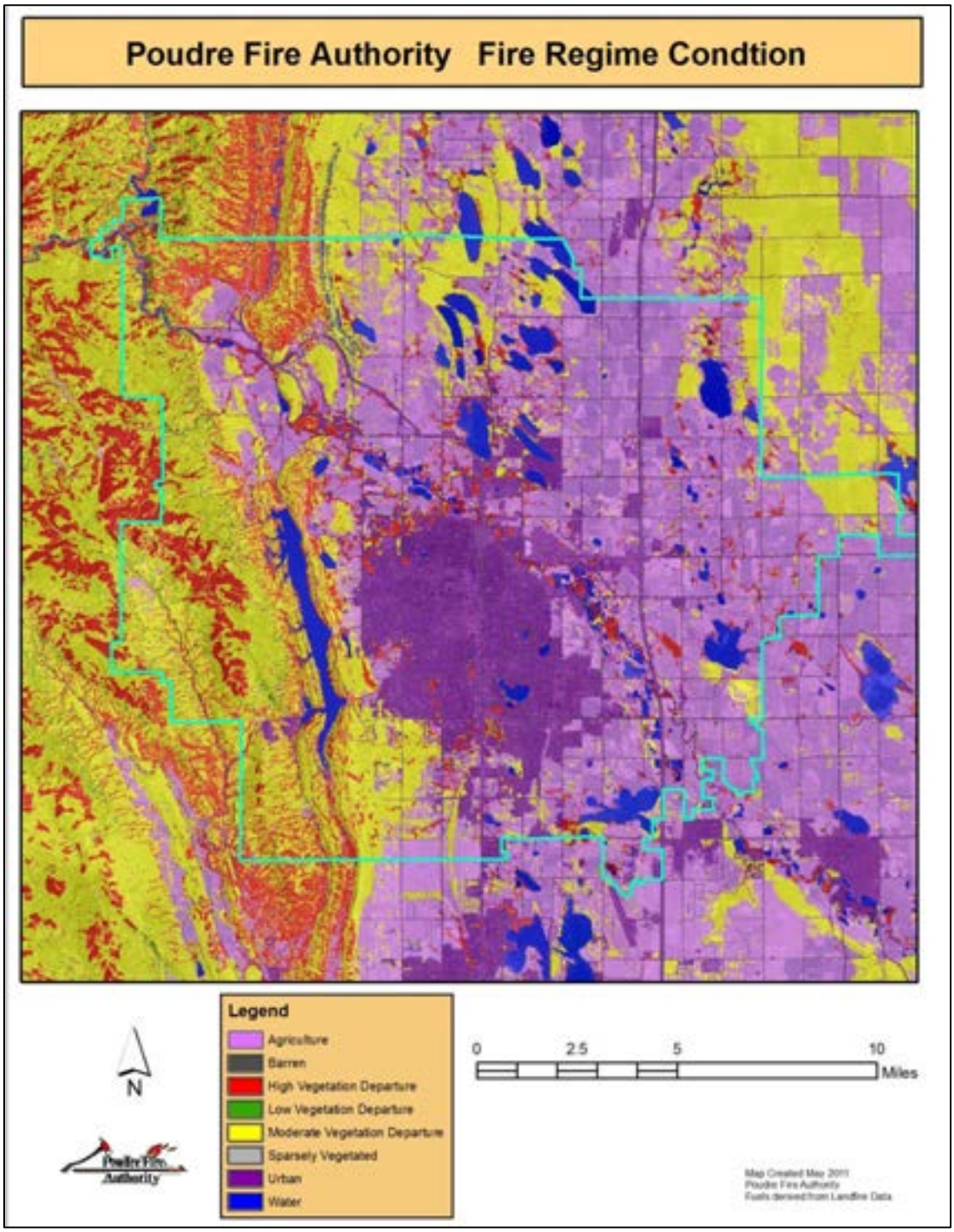
Figure 5. Foothills Ecotones. West of Fort Collins the ecotones transition from grasslands, to shrublands, to timber.

Of primary interest for this fire regime discussion are ponderosa pine and ponderosa pine / Douglas-fir forest, mountain mahogany shrublands, and to a lesser extent grasslands (figure 5). Understanding the range of historic fire intensity and frequency will help fire managers evaluate the extent of problems associated with fire exclusion and anticipate possible future fire behavior.

Fire regime condition classes define the vegetation communities' departure from historic conditions. The determining characteristics can include vegetation density, species composition, stand structure, and ecosystem health. As fire is excluded from an area through suppression, changing land management practices, and regional climate change, vegetation communities can stray from historic conditions.

LANDFIRE (U.S. Geologic Survey 2010) data classifies most of PFA's jurisdiction as agricultural or urban. While the majority of the remaining area is classified as moderately departed from historic conditions, substantial areas are classified as high departure (map 5). These tend to be vegetation communities with substantial brush or grass components, or those areas that experienced relatively frequent fire occurrence through history. By identifying fire regime condition, fire and land managers are better able to prioritize prescriptive fire and fuels management projects. It can also help managers anticipate the degree of potential ecosystem health issues and uncharacteristically severe wildfire potential.

Map 5. PFA Fire Regime Condition Classes



2.5.1 Ponderosa Pine and Ponderosa Pine / Douglas-Fir Communities

Ponderosa pine *(Pinus ponderosa)* is the dominant tree throughout the Larimer County foothills with Douglas-fir *(Pseudotsuga menziesii)* exhibiting co-dominant or dominant canopy position along north facing slopes in the western section of PFA's jurisdiction. Other common tree species include Rocky Mountain juniper *(Juniperus scopulorum)* and aspen *(Populus tremuloides)*. Understory may include litter, grasses, or shrubs such as mountain mahogany and common juniper *(Juniperus communis* ssp. *alpina)* (Peet 1981; Hendon 1984; Botto and Thomas 1989). Fire return intervals for ponderosa pine in Colorado range widely from 8 to over 60 years depending on location, elevation, and historical time period (Brown et al. 1999 and Veblen et al. 2000).

Studies along the Front Range by Brown et al. (1999), Veblen et al. (2000), and Kaufmann et al. (2006) support several general conclusions:

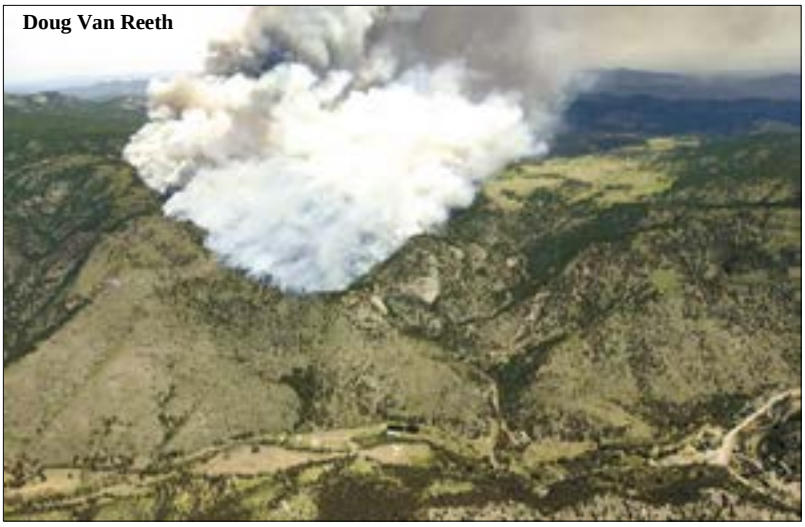
1) Fire frequency and behavior in the ponderosa pine ecosystem are more variable and complex than has often been portrayed.

2) Front Range ponderosa pine at lower elevations (~5500-7000 feet) was historically characterized by relatively high fire frequency and open stand structure similar to ponderosa pine forests of the Southwest.

3) At slightly higher elevations along the Front Range (~6000-9000 feet) ponderosa pine stands are denser and include Douglas-fir. These forests historically experienced a mixture of low, moderate, and high intensity fire behavior at less frequent intervals than the lower elevation ponderosa pine stands.

4) Ponderosa pine forests on the Colorado Front Range seem to be outside of their historic range of variability, most notably in the lower elevations. The resulting increase in stand density and potential for disease and insect infestation has implications for increased fire behavior and fire management requirements.

Figure 6. The Bobcat Fire. Extreme fire behavior is a characteristic of the local ponderosa pine mixed severity fire regime.



2.5.2 Impacts of the Mountain Pine Beetle

The mountain pine beetle (MPB) (*Dendroctonus ponderosae*) is native to western pine forests including lodgepole, ponderosa, and limber pine. It often exists at endemic levels that produce isolated tree mortality, generally in weak or damaged trees. The insect has a one year life cycle that may extend to two years at high elevations. Female beetles initiate attacks on the potential host tree and emit pheromones that attract male beetles into a mass attack. If the adults successfully bore into the tree, they create egg galleries. The beetles' feeding and the introduction of blue stain fungi effectively girdle and kill the host tree (Costello and Howell 2007).

Colorado is currently in the midst of a MPB epidemic that has spread throughout the western forests of Canada and the United States over the past fifteen years. Lodgepole pine forests were the first and hardest hit, but MPB activity in the ponderosa pine of northern Colorado and southern Wyoming has increased steadily since 2008. Almost three-million acres of forest have been impacted by this epidemic in Colorado alone. In 2009 Larimer County experienced the largest impacts of MPB in the state as the affected area nearly doubled from 280,000 acres to 500,000 acres (USDA 2011).

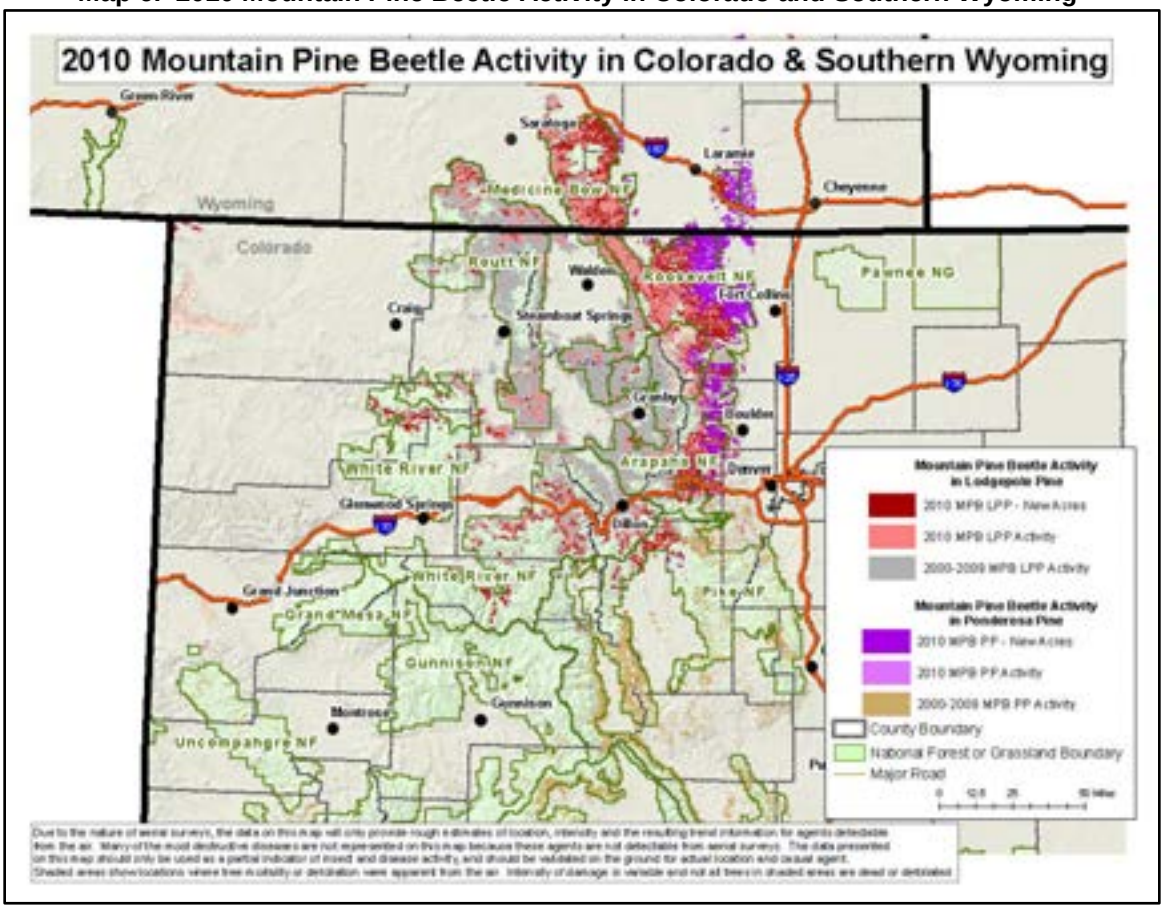
During the first year of a MPB attack, pine needles remain green. In year two, the needles turn yellow or red, eventually dropping off entirely in year three or four. Beginning about seven years post mortem in ponderosa pine, the dead stems become increasingly susceptible to rot and blow-down. The post epidemic fuel profile will depend on a number of variables including the number of years post mortem, the composition of the forest understory, and subsequent disturbances.

While Colorado's lodgepole pine forests have sustained as much as 90% mortality in some areas, it is unknown if the impact in ponderosa pine will be as severe. In contrast to lodge pole pine forests where an entire stand is killed in the space of one or two years, current patterns of mortality in ponderosa pine show a patchy pattern, where several trees to an area of approximately two acres are impacted. Studies suggest that lower density, more diverse stands are less susceptible to MPB outbreaks. This is encouraging for open ponderosa stands or where Douglas-fir is co-dominant. Unfortunately the severity of the current MPB epidemic makes it difficult to predict the end result for the ponderosa pine forests of the northern Front Range (Fettig et al. 2007).

The effects of MPB on fire behavior are nuanced. In brief, the dead crowns are initially more susceptible to fire until the needles begin to drop in year three. As mortality thins the forest canopy, crown fire becomes less of a hazard but surface fuels begin to increase. Anecdotal information from Canadian fire managers indicates that one of the largest fire behavior concerns is long-range spotting potential. Decomposing bark on standing dead stems serves as both an ember source and receptor to a degree far surpassing what is typical in forests not impacted by MPB.

Figure 7. Mountain Pine Beetle has begun to take a toll on the ponderosa pine forests within PFA's jurisdiction. Currently, mortality is limited to small portions of stands.

Map 6. 2010 Mountain Pine Beetle Activity in Colorado and Southern Wyoming



(USDA Forest Service, http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5253129.pdf)

2.5.3 Mountain Mahogany Shrubland Community

The mountain shrub community is found throughout the western area of PFA's district. True mountain mahogany *(Cercocarpus montanus)* is the dominant shrub. Other common shrubs include chokecherry *(Prunus virginiana)*, skunk brush *(Rhus trilobata)*, common rabbitbrush *(Chrysothamnus nauseosus)*, common snow berry *(Symphoricarpos albus)*, bitterbrush *(Purshia tridentata)*, and common juniper *(Juniperus communis)* (Botto and Thomas 1984; Hendon 1984; Balok 1997). These may be found as predominantly shrub communities or as an understory in open ponderosa pine or ponderosa pine / Douglas-fir. Little has been written about the fire regime for mountain mahogany shrublands, and what is available is often not specific to this region. Fire return intervals for mountain mahogany is typically defined by the associated vegetation community and varies widely from less than 35 years in grass communities to 40 to 100 years in Douglas-fir stands (USDA Forest Service 2011).

In general, mountain mahogany burns less readily than some other types of shrubs (Pase and Lindenmuth 1971), but it does have the potential to present a significant wildfire threat as stands become decadent or when live fuel moisture is low (Botto and Thomas1989; Bradley et al. 1991). A recent study of mountain mahogany in Colorado characterizes it as relatively well adapted to fire (Liang 2005). Fire severity, season, and site characteristics all affect the vigor with which it resprouts. Several fires in PFA's jurisdiction have significantly reduced the density or eliminated mountain mahogany from the site in the short term.

Mountain mahogany grows on droughty soils and rocky sites typified by a lack of fuel continuity. In the absence of high winds these conditions will favor small, low severity fires. The resulting fire exclusion can allow a build-up of surface litter and dead branches as well as conifer encroachment, leading to a substantial hazardous fuel profile (Bradley 1991; Cook et al. 1994). Where mountain mahogany has moved into more productive soils, the understory is typically composed of grass and litter. This provides a contiguous fuel bed for fire spread where historically the brush crowns alone may not have been dense enough to carry the fire (Ryan 1976).

2.5.4 Grassland Communities

As the elevation rises from less than 4800 feet to over 7200 feet, a variety of grass types are found in the short grass and mixed grass ecosystems. The lower elevations are dominated by short grass prairie species, including buffalo grass *(Buchloe dactyloides)*, and blue grama *(Bouteloua gracilis)*. Mid-grass types, mostly bunchgrasses, are also found throughout the foothills: western wheatgrass *(Pascopyrum smithii)*, sideoats grama *(Bouteloua curtipendula)*, needle-and-thread *(Stipa comata)*, little bluestem *(Schizachyrium scoparium)*, and Indian ricegrass *(Oryzopsis hymenoides)*(Balok 1997; Lory State Park 1997; CSFS 1998).

Fire exclusion can result in the encroachment of brush and conifers into grasslands. Another major issue on the prairie is the invasion of non-native species. Each of these issues can result in increased fire intensity.

A non-native graminoid that may be found throughout the foothills in the fire district is cheatgrass (*Bromus tectorum*). This species is notorious for its explosive fire behavior and pyrophilia. This invasive annual will often out-compete native vegetation, forming dense fine-stalked monocultures, ripe for rapid fire spread. Additionally, cheatgrass cures four to six weeks earlier than most native perennials, making it highly volatile during the height of the fire season (USDA Forest Service 2011). While not yet a dominant species across this area, the presence of this invader and other brome species is a complicating factor to be considered in the management of both wildfire and prescribed fire.

3. Hazard / Risk Assessment

Hazard and risk are terms that have distinct meanings in the vernacular of emergency management. A hazard is a natural or man-made agent of harm. In the specific context of wildland fire, hazard is often described in terms of fire behavior as dictated by the characteristics of fuels, weather, and topography. Risk is a measure of potential damage or loss contingent upon the probability of a harmful event (Texas Engineering Extension Service 2009).

This section illustrates hazard through a description of wildland fuels and potential fire behavior. Ignitions are analyzed in terms of seasonal occurrence, geographic location, and cause. The risk analysis is based on community assessments that study the local hazards (potential fire behavior as an agent of harm) and vulnerability of assets (subdivision attributes and general characteristics of the homes as indicators of consequences).

3.1 Modeling Assumptions and Parameters

The resolution and precision of fire behavior modeling in this study can be useful for strategic planning but should not be relied upon to provide accurate detailed predictions. The limitations of the input data as well as the fire behavior models themselves should be considered when applying the outputs of this study. This is an issue common to all CWPPs and similar studies but rarely articulated.

LANDFIRE Data- The geographic data are derived from LANDFIRE 1.0.2 (U.S. Geologic Survey) completed in 2010. This data is in 30 meter resolution from imagery obtained from 1999 through 2003. Comparisons between LANDFIRE fuel models and photo points taken in 2011 indicate that while the data represent the general characteristics of the jurisdiction's fuels at the strategic level, the accuracy is variable at the tactical or neighborhood level.

Fuel Models- The 2005 standard fire behavior fuel models (Scott and Burgan 2005) were used for fire behavior modeling. Agricultural lands were changed from a non-combustible fuel model to low load very coarse humid climate grass (grass model 6). While the variability of fuel conditions on agricultural lands make it very difficult to model, converting it to a combustible fuel model at least represents its potential to burn.

Fuel Moisture Data- Historic fuel moistures were taken from the Redstone Canyon remote automated weather station. The 1-hour, 100-hour, 1000-hour, woody and herbaceous live fuel moistures are all derived from algorithms based on 13:00 daily weather observations. An additional limitation is that for many of the years data was only archived for the perceived "fire season" (usually April through October), resulting in an absence of weather data for numerous "off season" fires.

Modeling Tools- Potential fire behavior was modeled graphically using the Nexus 2.0 spread sheet tool (Scott 2004). Geographic fire behavior modeling was performed using FlamMap 3.0 (Finney et al. 2004).

Fire Occurrence Data- PFA has used a number of incident record data bases over the past ten years, and the quality of data is variable. While we were able to analyze fire occurrence data for the past ten years, reliable latitude/longitude locations were available for only 47 % of the fires from the past 53 months. Fire occurrence statistics in this study include all fires categorized as forest, brush, or grass fires.

3.2 Summary

Within Poudre Fire Authority's jurisdiction there are a substantial number of structures intermixed with fire adapted vegetation. Intense fires in these ecosystems can be natural or the result of fire exclusion and often exceed the suppression capabilities. PFA has a vital role in local wildland fire suppression, which has grown with increased development in the wildland-urban interface and increasing fuel loads.

Examining the WUI issue in terms of hazards and risk affords a situational awareness upon which pre-fire planning and mitigation efforts are based. This hazard/risk assessment identifies several significant points:

1.) Local wildland fuels can produce extreme fire behavior under historical conditions. This can be exacerbated by the impacts of fire exclusion, climatic variability, or mountain pine beetle infestation.

2.) Wildland fires occur throughout the year, but are concentrated in two distinct seasons peaking in March and July.

3.) Fire occurrence is statistically correlated to 10 hour fuel moisture, while fire growth is most closely associated with 1000 hour fuel moisture.

4.) Geographically, fire occurrence is most frequent in the occluded interface of PFA's developed areas, but the potential for large fire growth and pronounced property loss focuses attention to the west side of the district.

5.) Modeled and observed fire behavior illustrate the need for rapidly deployable engines, indirect line construction, and air resources during times of severe fire weather.

6.) Given these factors, a range of wildfire mitigation efforts must be considered in the WUI.

3.3 Hazard Profile

Wildfire hazard is identified in terms of potential fire behavior. This section will examine the characteristics of vegetation, climate, and terrain as discussed in the earlier District Profile section. These elements are utilized as inputs for fire behavior modeling in terms of fuel, weather, and topography. Potential fire behavior is modeled using 50th and 90th percentile fuel moisture and weather conditions to represent average and severe case scenarios. Predicted flame length and crown fire potential as determined using the FlamMap Program are then used to identify hazard.

3.3.1 Fuels

Fuels are described using Scott and Burgan's (2005) Standard Fire Behavior Fuel Models. Geographic fuel models were obtained from the LANDFIRE data base (U.S. Geologic Survey 2010). Field visits using photo series were conducted to determine the quality of the data. The LANDFIRE data provide a sound basis for generalized hazard evaluation at the strategic level as required for this report. It lacks the precision desirable for more detailed analysis, such as fire behavior modeling for specific incidents.

Table 5. Wildland Fire Fuel Models

FBFM	Description	Vegetation Communities	Percent of Cover in PFA
NB1	**Non-burnable, Urban Areas**	Developed Lands	19%
NB2	**Non-burnable, Water**	Water	6%
GR2	**Low Load, Dry Climate Grass:** One foot high low density grass. Low flame length and rate of spread. Moderate flame lengths and moderate to high rates of spread.	Native Grasslands	11%
GR3	**Low Load, Very Coarse, Humid Climate Grass:** Continuous coarse grass approximately 2 feet high. Used in this study to depicted agricultural lands.	Agricultural Lands	35%
GS1	**Low Load, Dry Climate Grass-Shrub:** Low density grass and shrub approximately 1 foot high. Moderate spread rate and low flame length.	Light Grass-Shrub Lands	1%
GS2	**Moderate Load, Dry Climate Grass-Shrub:** Shrubs are 1 to 3 feet high, grass load is moderate. Spread rate is high; flame length moderate.	Typical Mountain Mahogany	14%
SH2	**Moderate Load, Dry Climate Shrub:** Shrub fuels approximately 1 foot high. Spread rate and flame length are low.	Brush	2%
SH7	**Very High Load, Dry Climate Shrub:** Heavy shrub and litter loads with fuel bed 4 to 6 feet high. High spread rate and very high flame lengths.	Dense Brush	1%

FBFM	Description	Vegetation Communities	Percent of Cover in PFA
TU1	**Low Load, Dry Climate Timber-Grass-Shrub:** Light loads of grass, shrubs, and litter less than 1 foot high. Spread rate is low; flame length low.	Riparian Understory and Open Ponderosa Pine	5%
TU5	**Very High Load, Dry Climate Timber-Shrub:** Heavy forest litter with a shrub or small tree understory. Spread rate and flame length are moderate.	Dense Ponderosa Pine and Ponderosa Pine/Douglas-fir	2%
TL8	**Long-Needle Litter:** Long pine needles, litter, and light herbaceous load. Spread rate is moderate; flame length is low.	Ponderosa Pine	4%

Grass

GR2: Low Load, Dry Climate Grass:
Native grass fuels are found on the hogbacks and in undeveloped lands east of the foothills, and are best represented by GR2. Fire behavior is characterized by high rates of spread and moderate flame lengths.

GR3: Low Load, Very Course, Humid Climate Grass:
The LANDFIRE data base identifies most of the area east of the foothills as non-combustible agricultural lands. In fact, many of these agricultural lands will burn under the right circumstances. Fallow lands, pasture, and post-harvest stalks can each present a fire hazard, but the variety of irrigation and other cultivation practices make predicting fire behavior impracticable across this large area. The fuel model for agricultural lands was changed to the GR3. While this is an imperfect match for the area as a whole, it reflects the high flame lengths and rates of spread possible in dry contiguous agricultural fields.

Brush

GS2: Moderate Load, Dry Climate Grass-Shrub:
The predominant brush fuel model in the jurisdiction is GS2, found along the hogbacks and on south facing slopes throughout the foothills. The dominant shrub is one to three feet high true mountain mahogany which is mixed with grass. Fire behavior is characterized by high spread rates and moderate flame lengths.

Fires in this fuel type are most active in the early spring prior to green-up, in the fall when the brush enters dormancy and the grass has cured, and during periods of drought. Fire exclusion contributes to an increased density of mountain mahogany and higher dead fuel loads as brush stands become decadent. The fuels management strategy for this vegetation type in the Fort Collins area is very limited.

Figure 8. Moderate Load, Dry Climate Grass-Shrub is the dominant shrub fuel model in PFA's WUI.

Timber

TU1: Low Load, Dry Climate Timber-Grass-Shrub:
Most of the cottonwood stands in riparian zones and some of the open ponderosa pine stands are represented by the TU1 fuel model. The relatively light grass and shrub loads support low rates of spread and flame lengths.

TU5: Very High Load, Dry Climate Timber-Shrub:
The north facing slopes above 5800 feet support relatively dense stands of ponderosa pine and Douglas-fir with an understory of shrubs, small trees, and deadfall represented as TU5. Surface fire is carried by heavy forest litter with a shrub or small tree understory. Fire behavior is characterized by moderate spread rates and flame lengths.

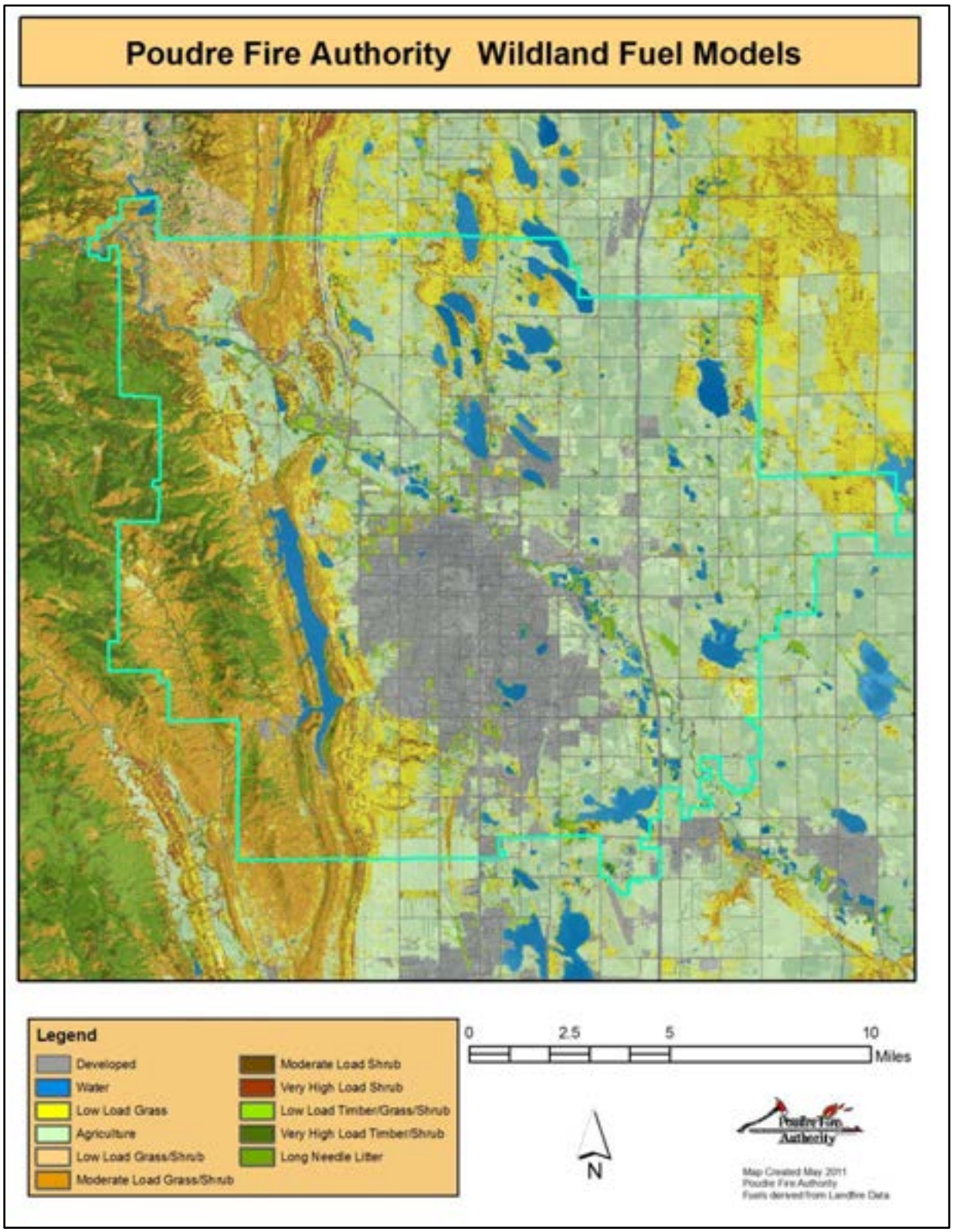
Figure 9. Very High Load, Dry Climate Timber-Shrub in Horsetooth Mountain Park.

TL8: Long Needle Litter:
Forested areas on south facing slopes and lower elevation are comprised of ponderosa pine. Denser ponderosa stands are modeled as TL8 where fire behavior is characterized by relatively moderate spread rates and flame lengths in this fuel bed comprised of needle cast and sparse grass. While there is considerably more variety in the ponderosa pine understory than depicted in the LANDFIRE derived fuel map, TL8 serves as a good median representation of understory conditions. Open ponderosa pine stands and the margins of denser stands are a grass/shrub surface fuel (GS2).

Mortality resulting from the MPB epidemic will result in more open ponderosa pine stands, creating an evolving fuel profile. This will initially create higher loads of fine dead surface fuels as needles are lost in the two to three years following mortality. Inversely, this will reduce crown fire behavior as the continuity of the forest canopy is disrupted over time. The following decade will see increases in heavy surface fuels as larger limbs and tree boles fall. Grass, brush, and young trees will eventually move into the new openings. The extent of these transitions will depend on the severity of the MPB epidemic.

Figure 10. Long Needle Litter is the surface fuel model in denser stands of ponderosa pine.

Map 7. PFA Wildland Fuel Models



3.3.2 Potential Fire Behavior

As described in the climate section of this report, two sets of fuel moisture data were developed for the purpose of fire behavior modeling based on historic observations. Fiftieth percentile conditions represent average case, and 90th percentile conditions represent severe case conditions. These conditions were modeled under a variety of 20 foot wind speeds.

Table 6. Average and Severe Case Fire Behavior Modeling Parameters

Percentile Conditions	1 hr Fuel Moisture	10hr Fuel Moisture	100hr Fuel Moisture	Herbaceous Live Fuel Moisture*	Woody Live Fuel Moisture
50th	6%	7%	11%	30%	97%
90th	3%	4%	7%	30%	60%

Potential surface fire behavior was modeled for predominant fuel models using the Nexus program (Scott 2004). A series of four charts (figures 11-14) compares predicted flame length and rate of spread for each of the four predominate natural fuel models in PFA's jurisdiction under the two weather scenarios. These conditions were modeled on a 30% slope which is common in the foothills west of Fort Collins.

Wind speed affects the open fuel beds of grass and grass/shrubs dramatically while the more sheltered and more densely packed forest understory is less impacted by the wind. Spread rates for all fuel models increase by approximately 50% under severe fuel moisture conditions in comparison with average conditions.

The impact of wind on flame length is more linear in nature. The difference in flame lengths between average and severe conditions is also less dramatic, showing increases of 15% to 50% depending on the fuel model.

The tactical implication for the modeled results suggest that surface fire flame length in closed ponderosa pine stands (TL8) is typically under four feet which can be suppressed by hand crews under all but the most severe winds. Flame lengths in high load timber understory (TU5) exceed 4 feet with a minimal amount of wind in both average and severe fuel moisture scenarios, though rates of spread remain low under both scenarios.

For grass (GR2) and grass/shrub (GS2) rates of spread and flame lengths exceed hand crew capabilities in both average and severe conditions as 20 foot winds move beyond 5 miles per hour. This suggests that engine operations or indirect tactics should be considered in all but the calmest conditions.

Figure 11. Modeled Surface Fire Behavior, Rate of Spread, 50th Percentile Climatic Conditions

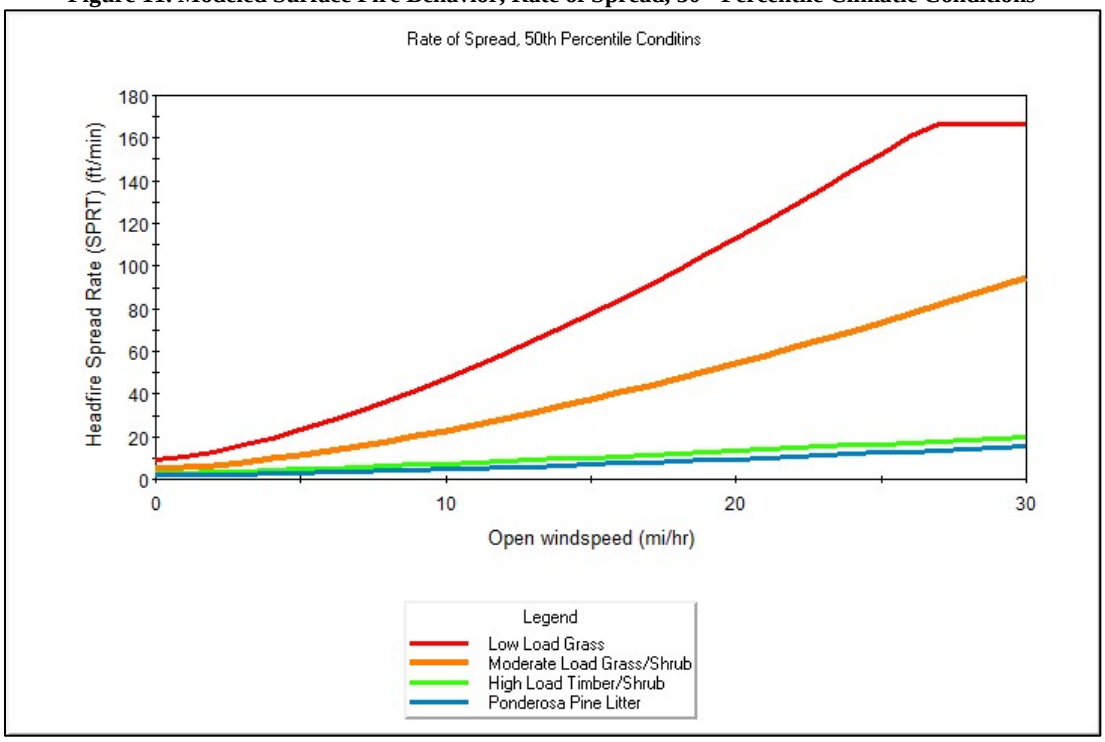


Figure 12. Modeled Surface Fire Behavior, Rate of Spread, 90th Percentile Climatic Conditions

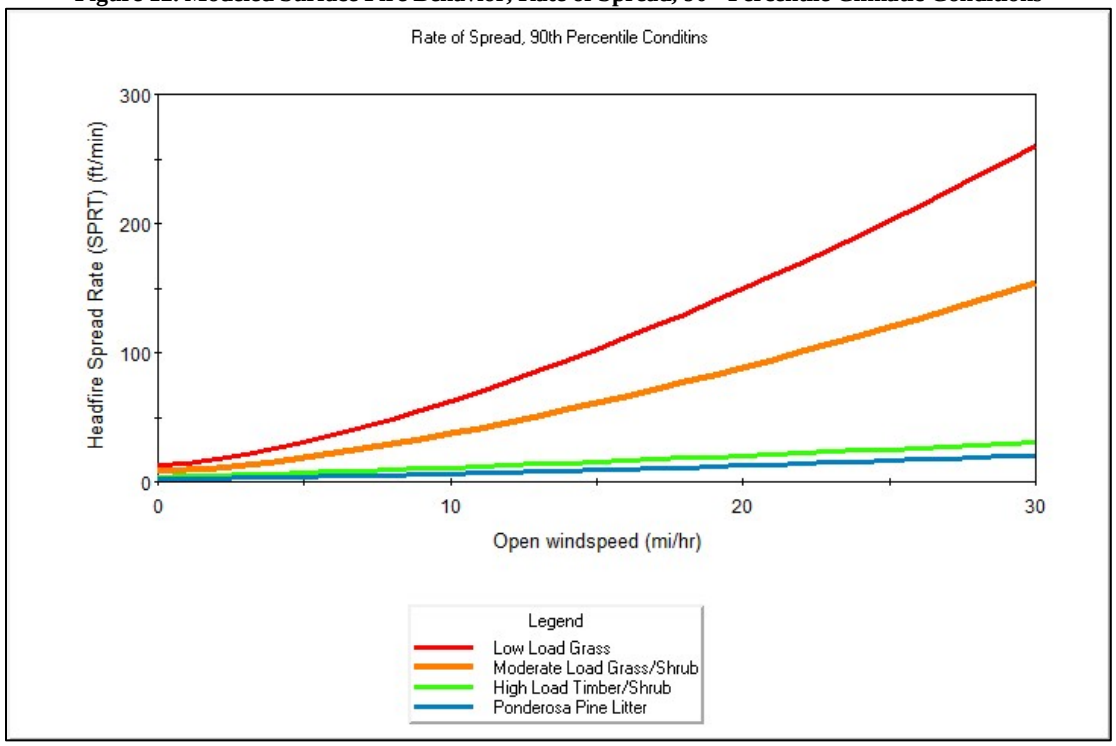


Figure 13. Modeled Surface Fire Behavior, Flame Length, 50th Percentile Climatic Conditions

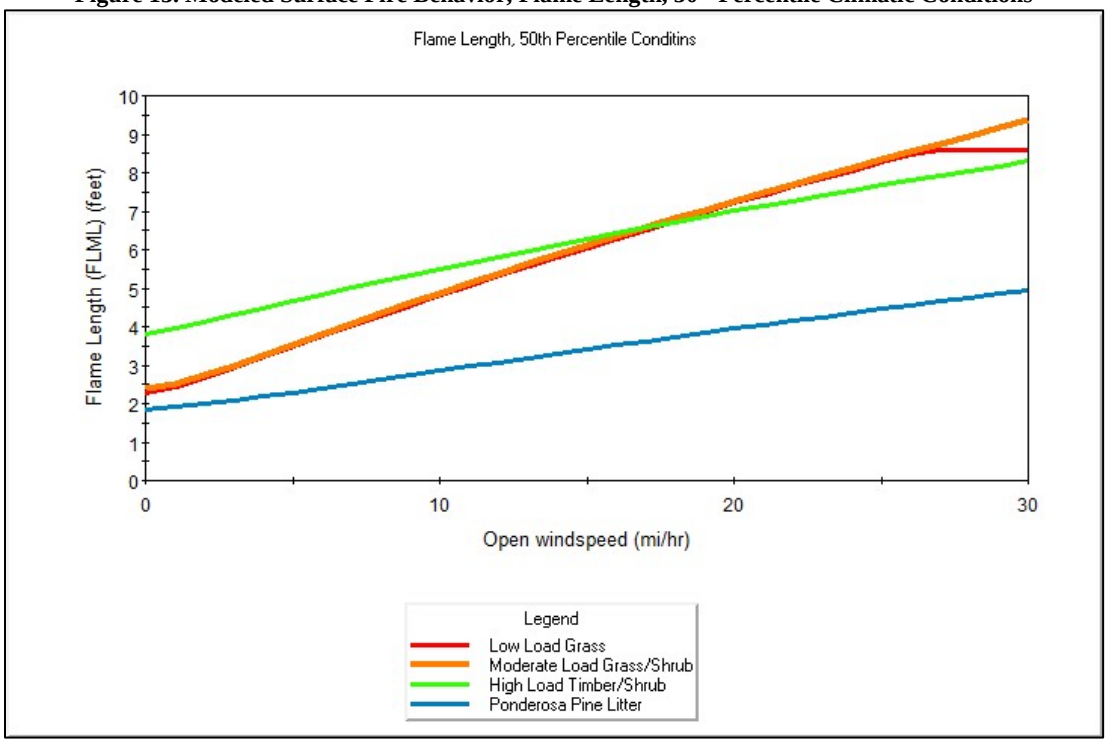
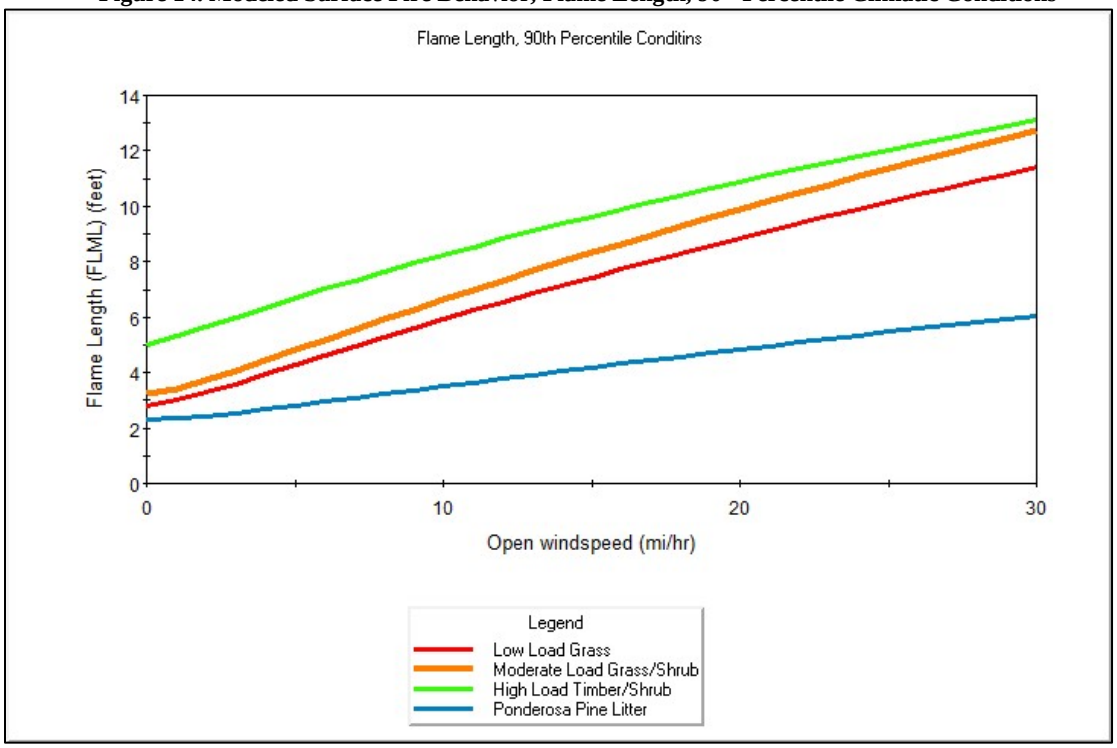


Figure 14. Modeled Surface Fire Behavior, Flame Length, 90th Percentile Climatic Conditions



Potential fire behavior was also modeled geographically utilizing the FlamMap program (Finney et al. 2004). Crown fire potential was modeled using the Scott algorithm option. FlamMap was used to illustrate flame lengths and crown fire behavior based on fuels (map 7) and slope (map 1) for three climatic scenarios:

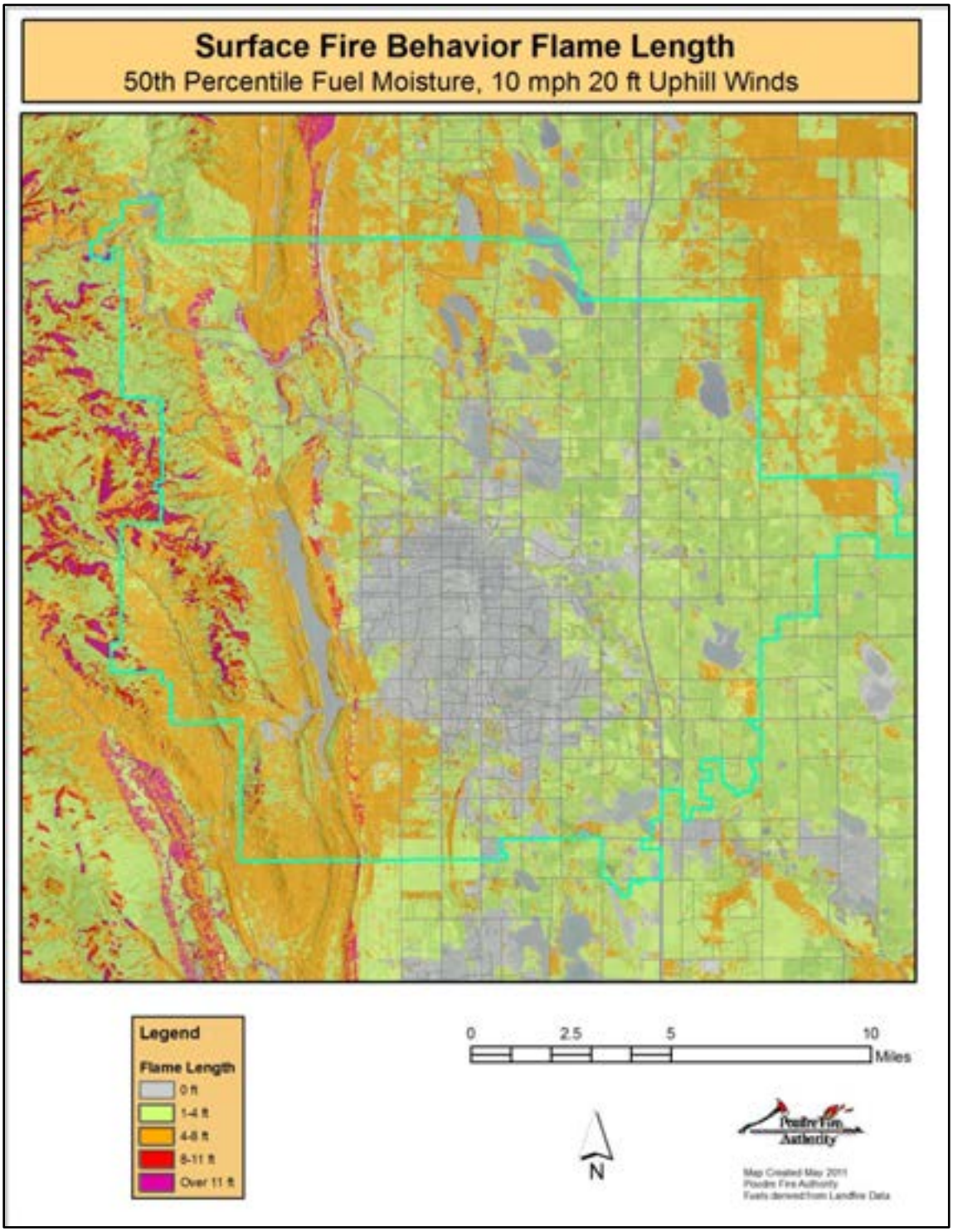
1. Moderate fuel moistures (50th percentile) with 10 mph 20 foot winds
2. Severe fuel moistures (90th percentile) with 10 mph 20 foot winds
3. Severe fuel moistures (90th percentile) with 20 mph 20 foot winds (shown only for flame lengths because crown fire results were indistinguishable from 90th percentile with 10 mph winds)

Notable results from FlamMap include:

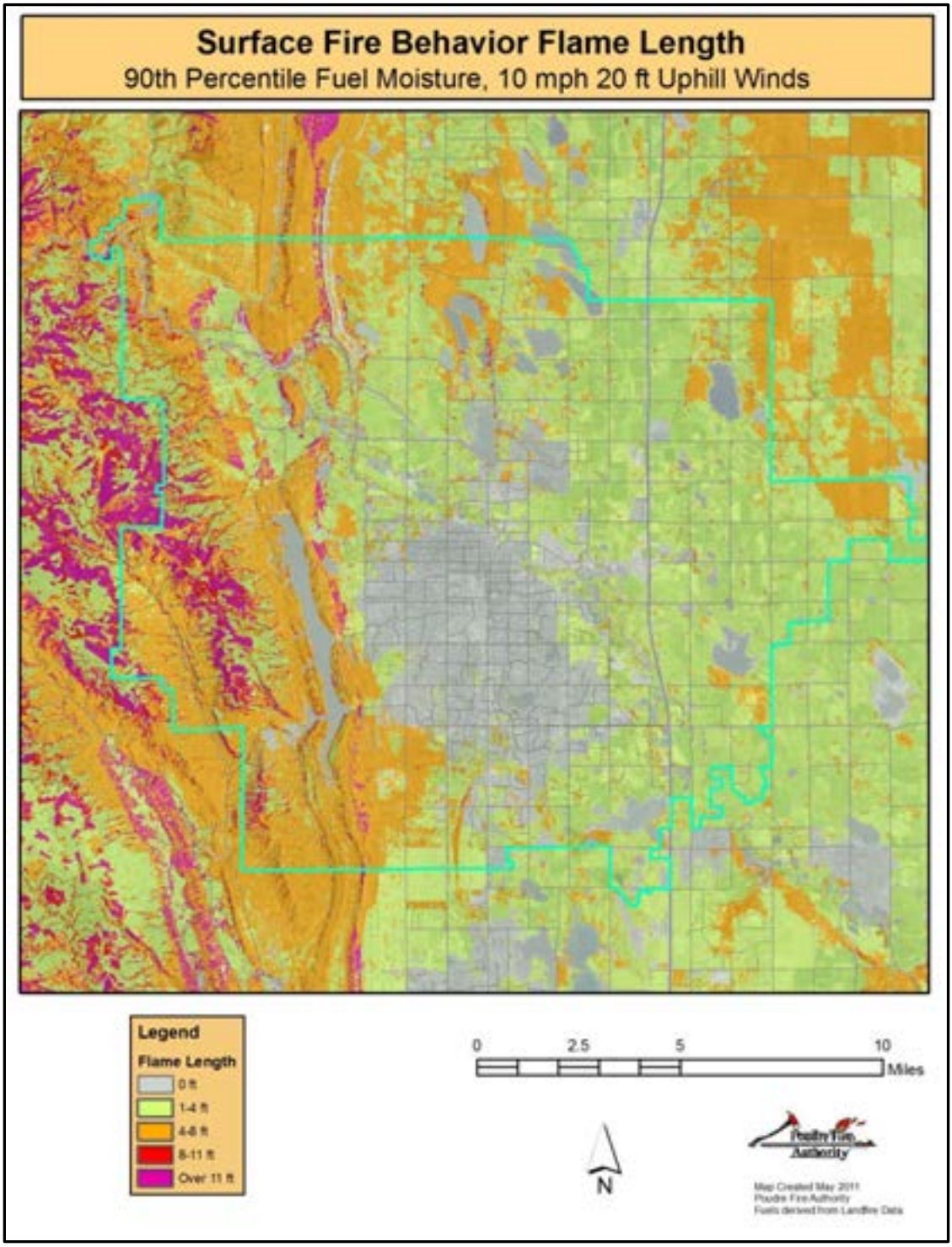
- A move from average to severe fuel moisture most notably increases predicted flame lengths in very high load timber understory and moderate load brush with a less pronounced effect in ponderosa pine litter understory (maps 8 and 9). Under average condtions, crown fire potential in forested areas is a mix of surface fire and passive crown fire with some pockets of active crown fire (map 11). As fuel moisture condtions become severe, large areas of forest become suceptible to active crown fire (map 12).

- An increase of 20 foot winds from 10 to 20 miles per hour under severe fuel moisture conditions shows a marked increase of fire intensity in grass and shrub fuel models with flame lengths predicted to exceed 8 feet (maps 9 and 10). An increase in winds for 90th percentile conditions showed no change in crown fire potential which is why only the 10 mile per hour crown fire map is presented (map 12).

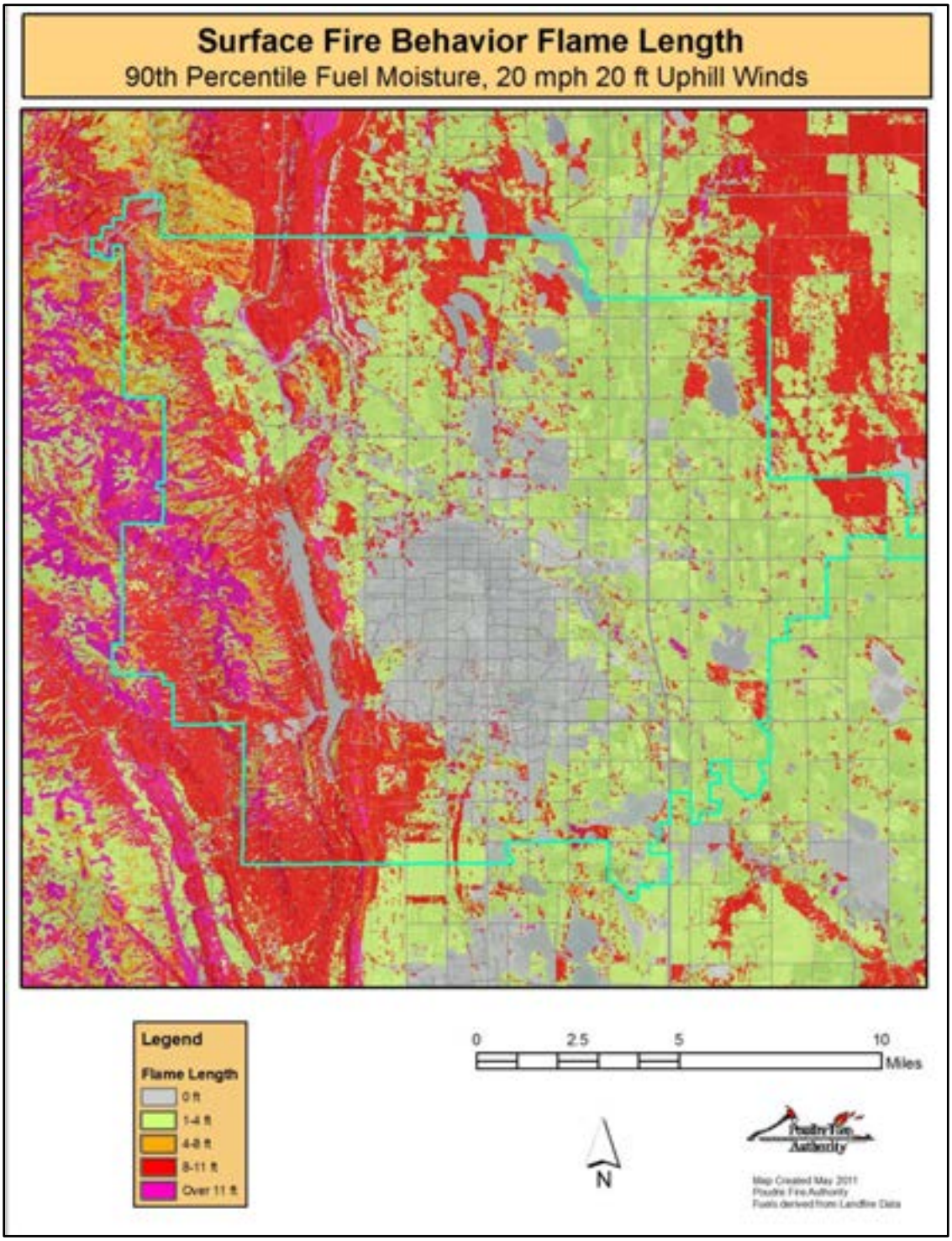
Map 8. Surface Fire Behavior Flame Length, Average Case Scenario



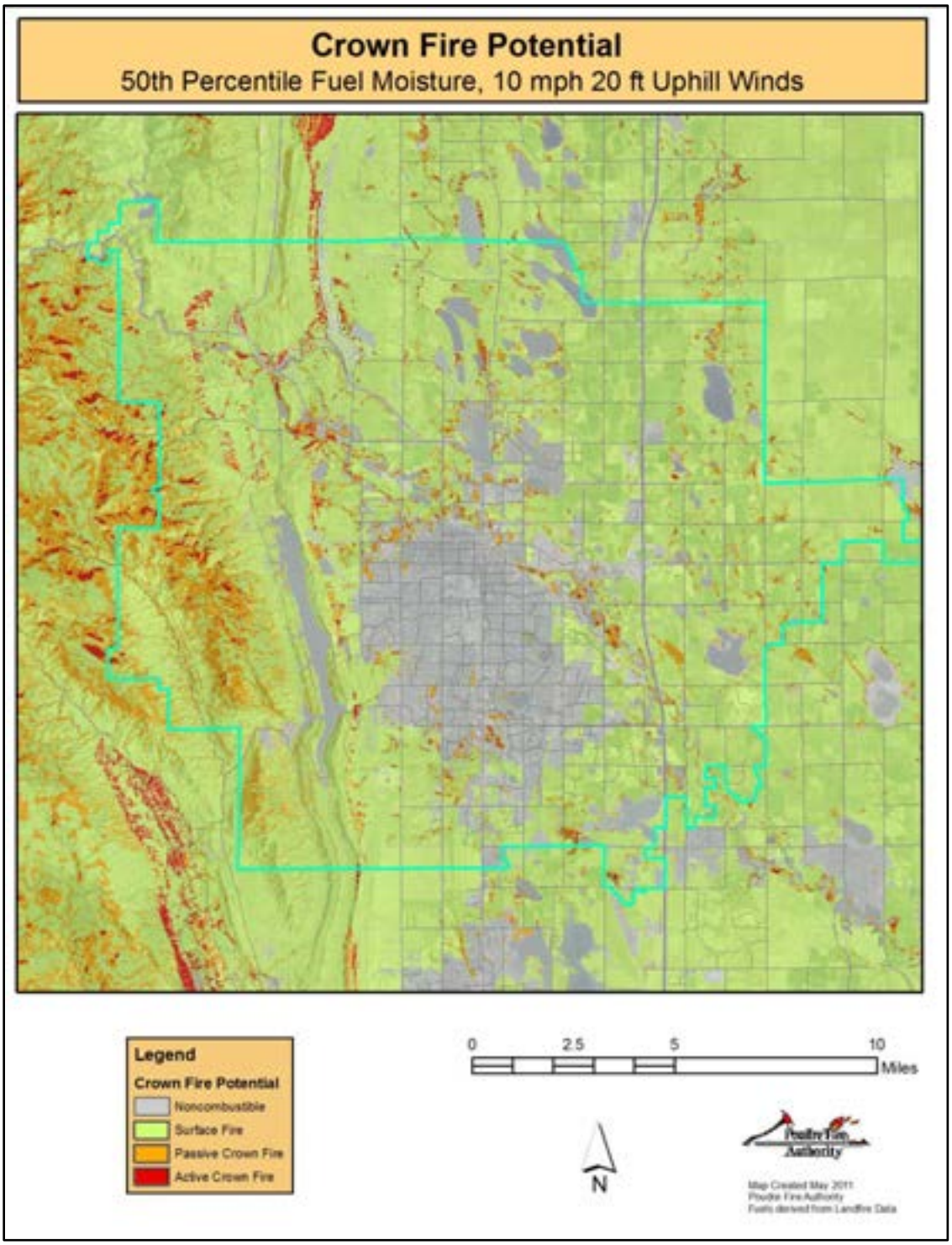
Map 9. Surface Fire Behavior Flame Length, Severe Case Scenario - Moderate Wind



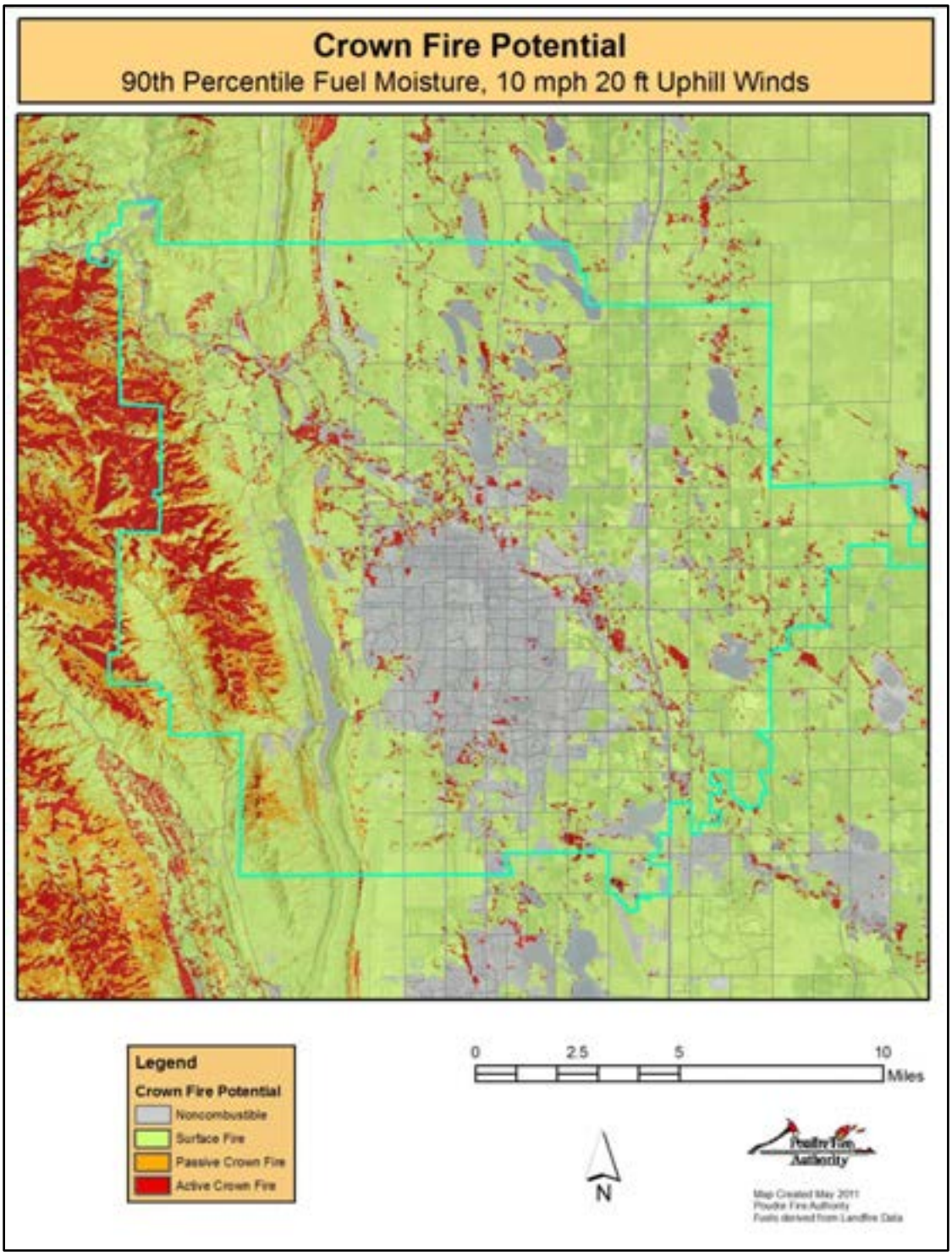
Map 10. Surface Fire Behavior Flame Length, Severe Case Scenario - High Wind



Map 11. Crown Fire Potential, Average Case Scenario - Moderate Wind



Map 12. Crown Fire Potential, Severe Case Scenario - Moderate Wind



3.4 Ignitions Profile

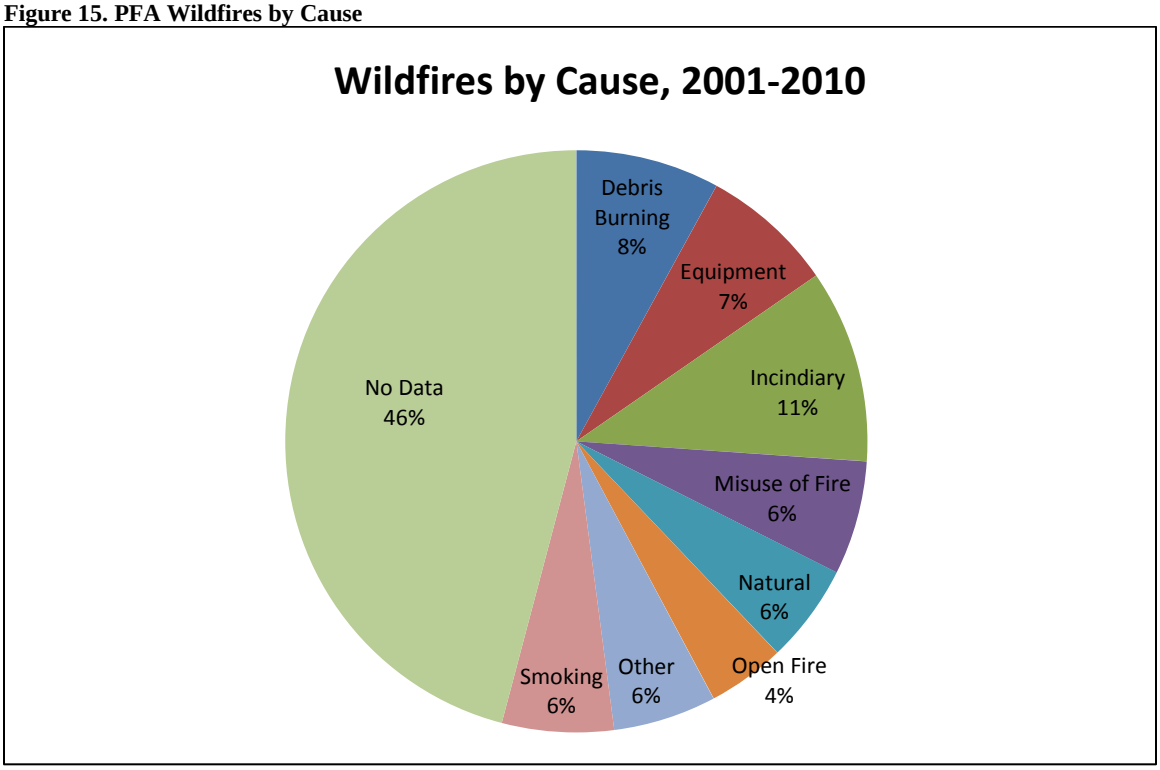
3.4.1 Cause of Ignitions

Nationally the vast majority of wildfire ignitions are lightning caused. By contrast, on the Arapaho and Roosevelt National Forests over 50% of fires are human caused. With only 6% of ignitions over the past ten years attributable to lighting, the vast majority of PFA wildfires are human caused. Most major fires along the northern Front Range over the past decade have all been caused by humans, including the Bobcat Fire, Big Elk Fire, Picnic Rock Fire, Four Mile Fire, Reservoir Road Fire, and the Crystal Fire. While the majority of ignitions occur in the occluded interface or agricultural areas east of town, the greatest potential for fire growth is in the western portion of the jurisdiction, as substantiated by numerous examples over the past twelve years (map 13).

Table 7. Significant Fires of Larimer and Boulder Counties

Fire Name	Date of Ignition	Acres	Losses
Bobcat	6/12/2000	10,599	18 homes
Big Elk	7/17/2002	4,400	3 deaths, 1 cabin
Picnic Rock	3/30/2004	8,900	2 structures
Four Mile	9/6/2010	6,181	169 homes
Reservoir Road	912/2010	750	2 homes
Crystal	4/1/2011	2,940	13 homes

Figure 15. PFA Wildfires by Cause



3.4.2 Temporal Distribution

During the past decade, PFA has averaged 111 wildfire responses per annum (including grass, brush, and forest fires), down slightly from an average of 133 wildfires per annum in the previous decade. Seventy eight percent (87 per annum average) of these were fires requiring suppression action, excluding incidents resulting in investigation only or a cancelled response. While annual wildfire occurrence in PFA's district have declined slightly during the past decade (figure 16), statewide data show a marked increase in acres burned over the past five decades (figure 17).

Figure 16. PFA Wildfires, 2001 through 2010

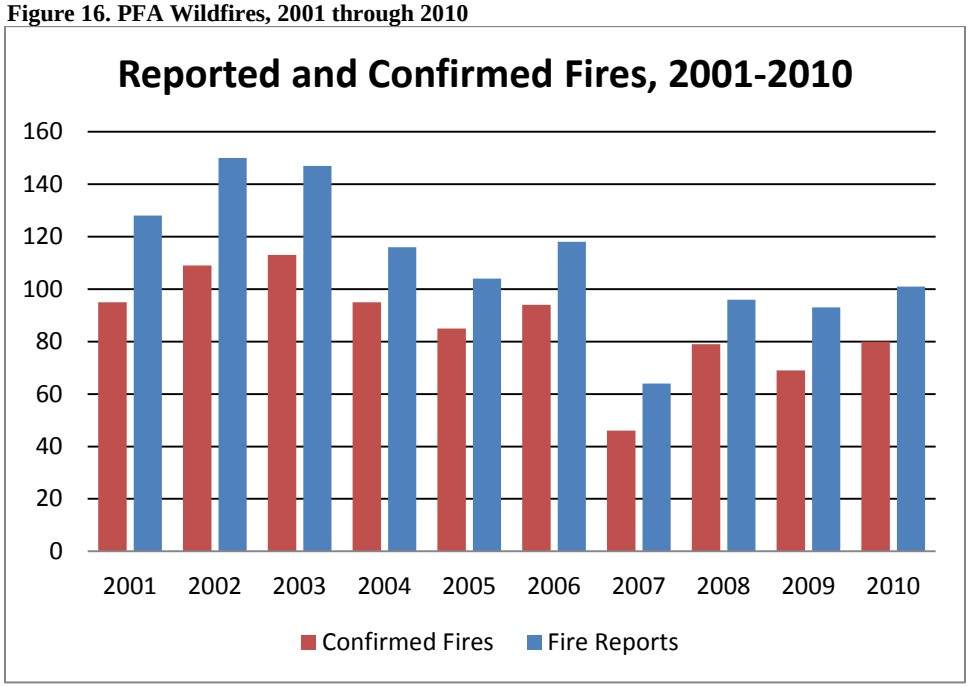
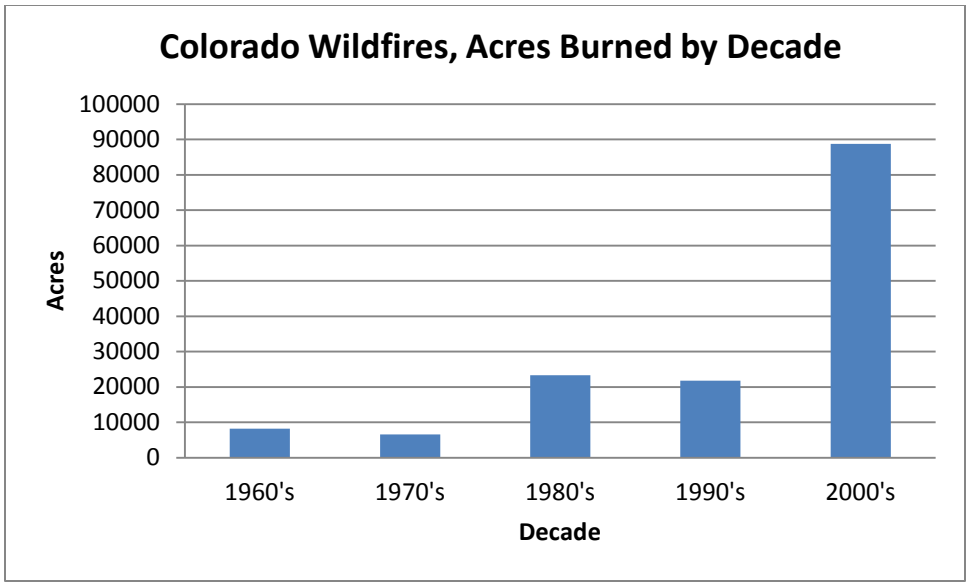


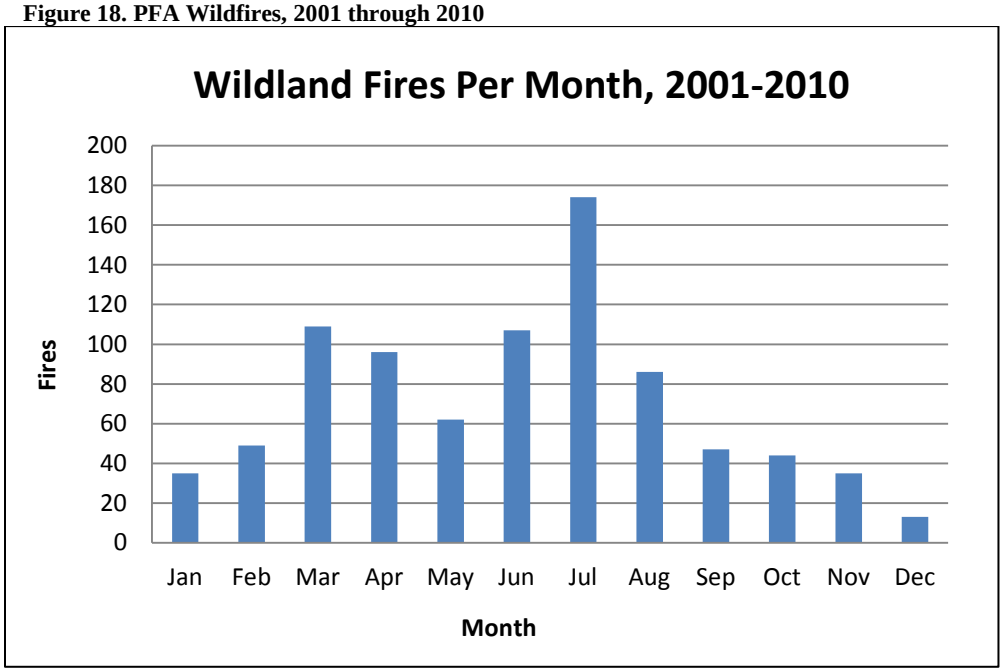
Figure 17. Acres Burned in Colorado Wildfires, 1960 through 2010



(CSFS: http://csfs.colostate.edu/pages/documents/COLORADOWILDFIRES_reprt_table_cb_000.pdf)

Data from 2001 through 2010 illustrate a bimodal distribution of wildfires throughout the year with a spring season peaking in March and a summer season peaking in July (figure 18). Consistent with the previous decade, July is the busiest month with an average of 17 vegetation fires followed by March with a mean fire occurrence of 11.

Figure 18. PFA Wildfires, 2001 through 2010



While several large historic fires along the Front Range have occurred in the fall, it is not typically a busy season in terms of number of fires. Frequent agricultural burns combined with high winds and dry fuels during the spring, lead to a large number of escaped burns in March and April prior to green-up. Seasonally dry conditions and illegal use of fireworks are factors contributing to July's fires.

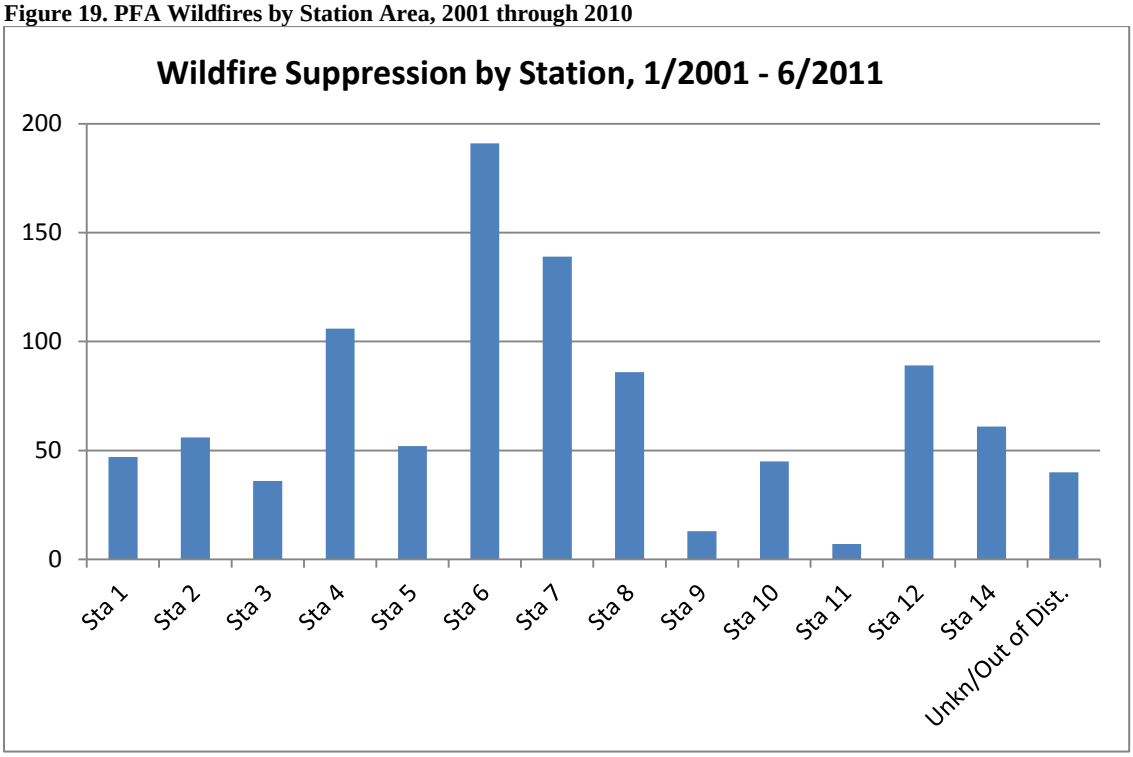
3.4.3 Geographic Distribution

Wildfires requiring suppression action within PFA's jurisdiction were enumerated by fire station response area for 2001 through June of 2011. To generalize by station areas, the largest concentration of fires at 46% was in the eastern grasslands and agricultural lands of stations 6, 8, 12, and 14. The western area of the jurisdiction, including stations 4, 7, 9, and 11, saw 29% of wildfires. Urban areas of stations 1, 2, 3, 5, and 10 saw the remaining 25% of fires. PFA recorded 40 responses to fires out of its jurisdiction or without a valid location during this time.

Table 8. Proportion of PFA Wildfires by WUI Type and Station Area, 2001-2010

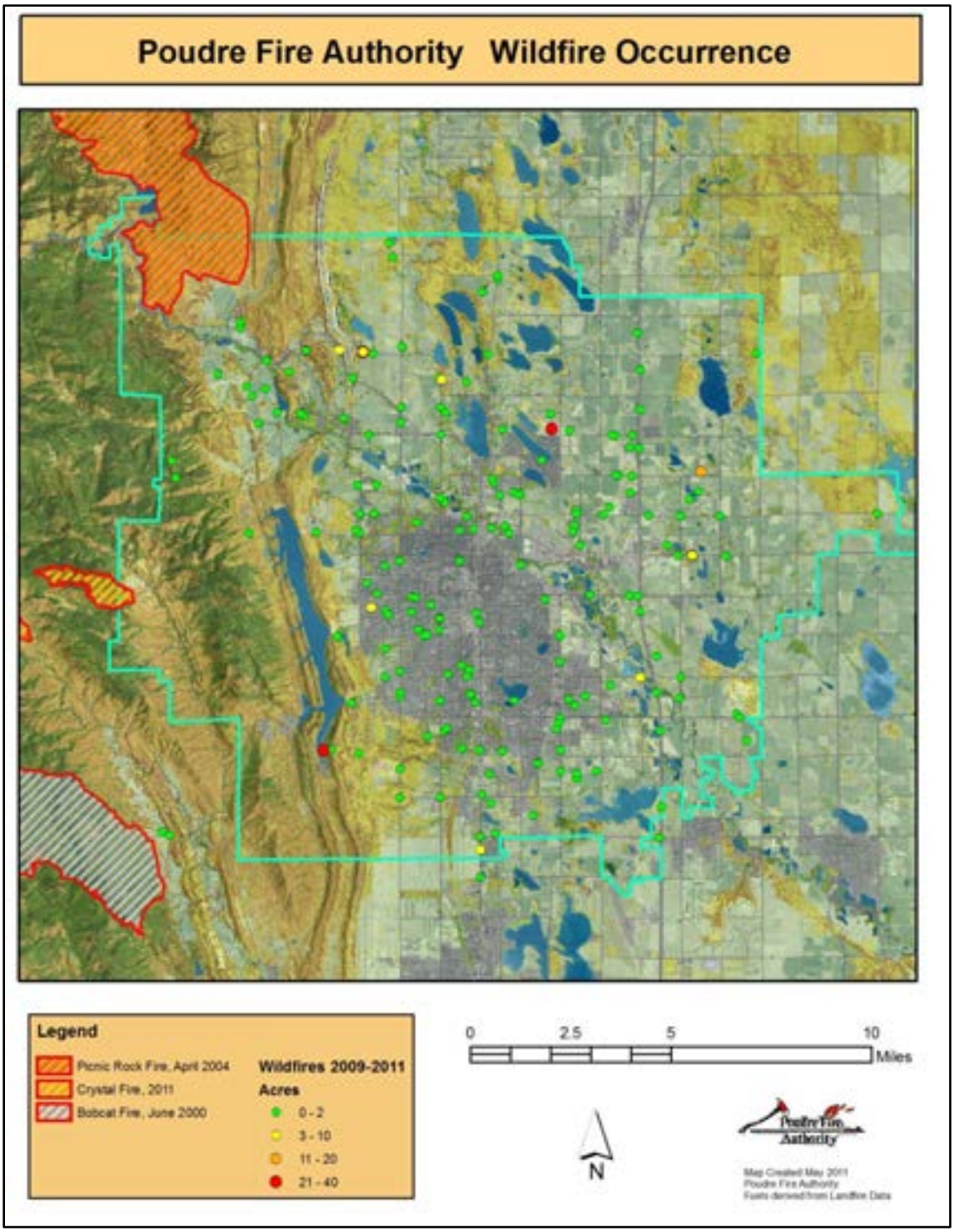
General Area	Station Areas	Proportion of Fires
Eastern grass/agricultural lands	6, 8, 12, 14	46%
Western foothills	4, 7, 9, 11	29%
Urban areas	1, 2, 3, 5, 10	25%

Figure 19. PFA Wildfires by Station Area, 2001 through 2010



Valid latitude/longitude locations were available for 71 fires (40% of recorded fires) from January 2009 through June 2011. Despite this inherent limitation, a geographic display of this fire history illustrates the general distribution of wildfires throughout the jurisdiction (map 13). While fewer fires occur in the western portion of the jurisdiction, the prevalence of large fires in the foothills (map 13) indicates that this area is more vulnerable to the impacts of wildfire.

Map 13. PFA Wildfire Occurrence



3.5 Risk Assessment

This CWPP update includes a hazard and risk analysis for the eastern portion of PFA's jurisdiction that was largely absent in the earlier plan. This analysis confirms that the WUI risk is most pronounced in the western portion of the jurisdiction.

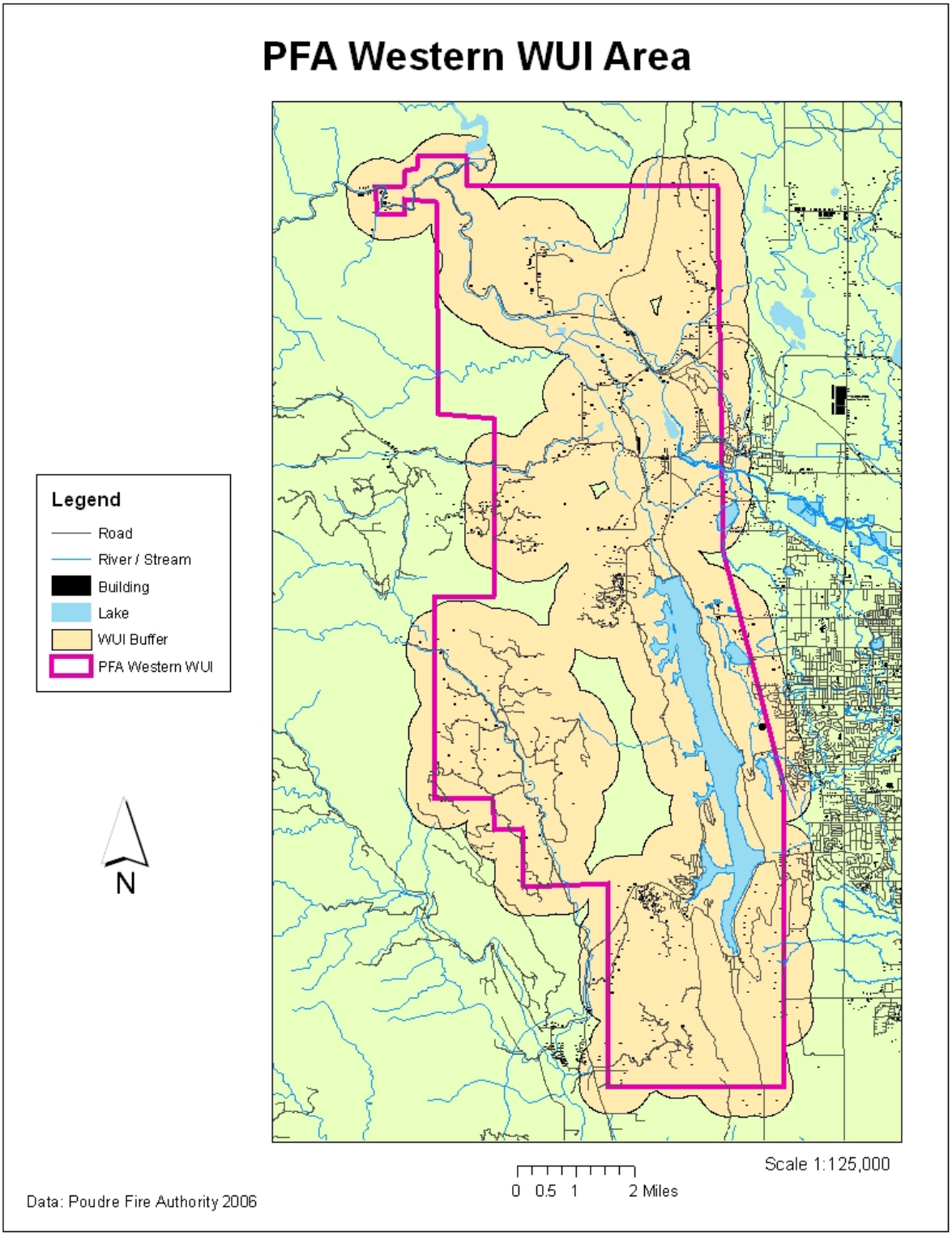
A PFA risk assessment was performed for WUI neighborhoods in the western portion of the jurisdiction and for eastern subdivisions that are adjacent to large areas of undeveloped land or protected natural areas. The risk analysis for each subdivision included and evaluation of hazard (fuels and topography), vulnerability (characteristics of individual structures), and community infrastructure (roads, water supply).

Community risk ratings for the majority of the western area were based on compilations of individual home assessments performed through the WOPI program. For the eastern area of the jurisdiction and western subdivisions that have not yet had individual home assessments, the same criteria were applied to the general characteristics of the subdivision and a sampling of individual homes.

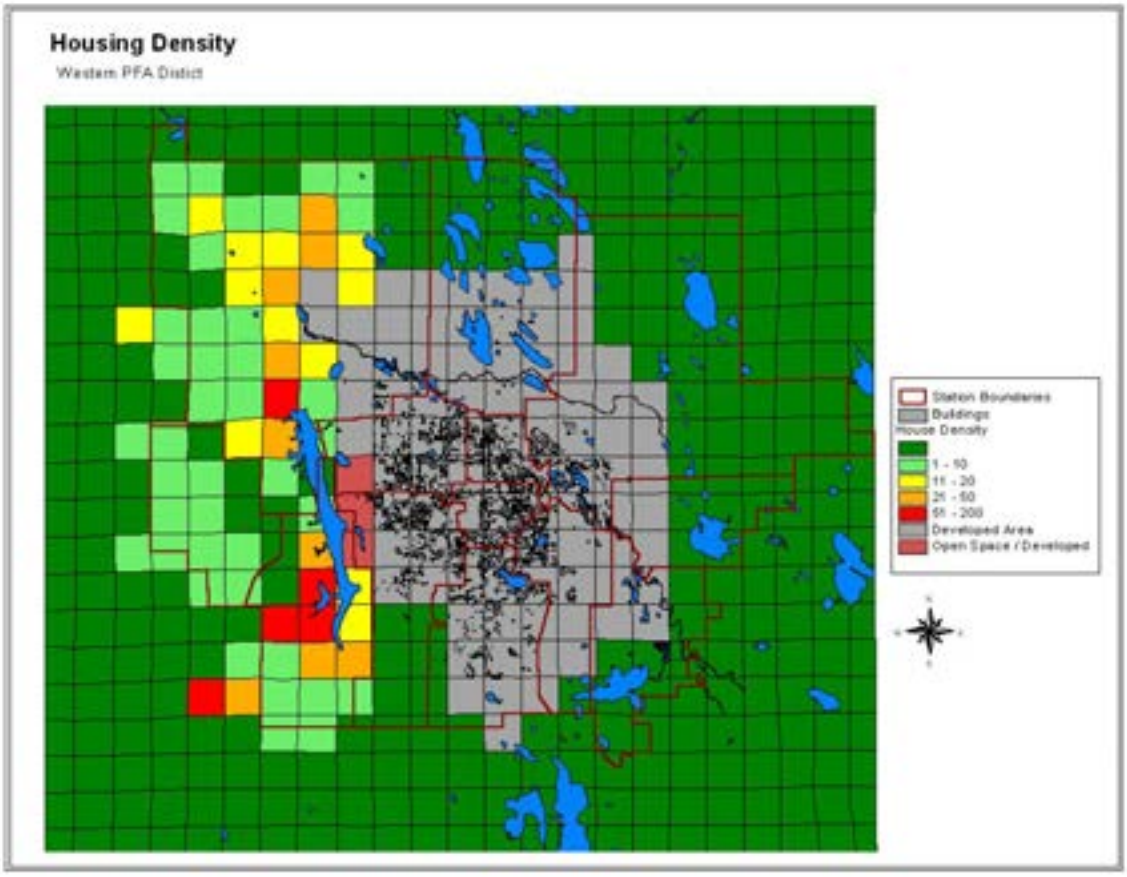
3.5.1 Western Area - Classic WUI and Intermix

This western WUI zone is approximately 50 square miles or 32,000 acres in size, comprising 22% of PFA's district. PFA's western WUI is generally defined by Overland Trail on the east and PFA's jurisdictional boundaries to the north, south, and west (map 14) and includes approximately 1080 residences intermixed with public and private wildlands (map 18). This area holds the largest designated open spaces within PFA's jurisdiction and the most complex fuels, topography, access, and water supply issues within the jurisdiction. This is also a complex area in terms of ownership and jurisdiction, sharing boundaries with Larimer County, the U.S. Forest Service, the Bureau of Reclamation, the State of Colorado, Loveland Fire, the City of Fort Collins, and Rist Canyon VFD.

Map 14. PFA Western WUI, based on ½ mile buffer around roads within jurisdiction.



Map 15. Housing Density, houses per square mile in western WUI. Data: PFA, 1999

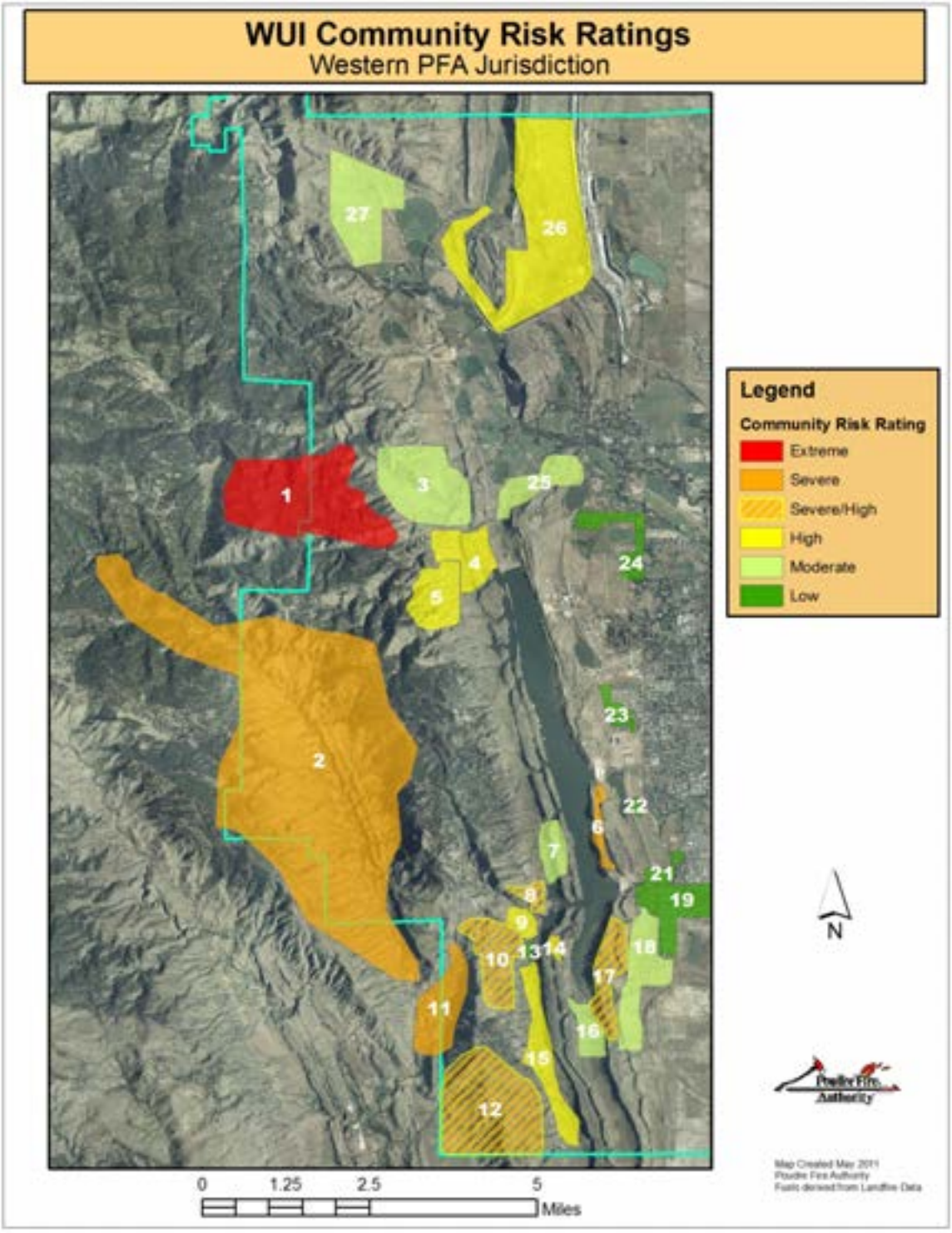


Within the PFA western WUI, four areas of special concern have been identified: Whale Rock, Redstone Canyon, North Horsetooth Area, South Horsetooth Area. PFA has assigned risk ratings to 18 subdivisions in its western area (map 16). These ratings are compared with 11 subdivisions rated in a 1997 CSFS study (Farmer) which were based on a combination of weighted factors, including fire hazard (comprised of emergency access, fuels, topography, construction characteristics, and water access), number of fires, and average fire size. Larimer County evaluated 14 subdivisions in the same area based on factors such as access, defensible space, home construction, surrounding fuels, and fire protection.

Table 9. PFA Western WUI Hazard and Risk Ratings

Area of Special Concern	Map ID	Subdivision	CSFS Hazard Rating	Larimer County Hazard Rating	PFA Risk Rating	Number of Addresses
Whale Rock	1	Whale Rock/Saddle Ridge	Extreme	Severe/Extreme	Extreme	26
Redstone Canyon	2	Redstone Canyon	Severe	Severe	Severe	78
North Horsetooth Area	3	CR 25G (Lakeview Cottages)	High	Severe	High	8
	4	Soldier Canyon	High	High	High	28
	5	CR 50 (Mill Canyon/Red Rock Estates)	--	Moderate	Moderate	142
	26	Totanka	--	--	High	92
	27	McMurry Ranch	Moderate	--	Moderate	36
South Horsetooth Area	6	Centennial (Morill)	--	Severe	Severe	24
	7	Continental North (Garcia Ranch)	--	Moderate	Moderate	80
	8	Cushman's Lakeview	--	High	Severe/High	62
	9	Spring Canyon Heights	--	Moderate	High	86
	10	Horsetooth Lake Estates	--	High	Severe/High	225
	11	Milner Mountain	--	--	Severe	13
	12	Stag Hollow	--	--	Severe/High	19
	13	Inlet Knoll	--	Low	Low	37
	14	Continental West	--	Severe	High	33
	15	Rimrock Ranch	Moderate	Moderate	High	6
	16	South Bay (Kintzelys)	--	High	Moderate	49
	17	Bighorn Crossing	--	--	Severe/High	18
	18	Hidden Springs	--	--	Moderate	18

Map 16. Western WUI Community Risk Ratings



3.5.2 Eastern Area - Agriculture/Grass Lands and Occluded Interface

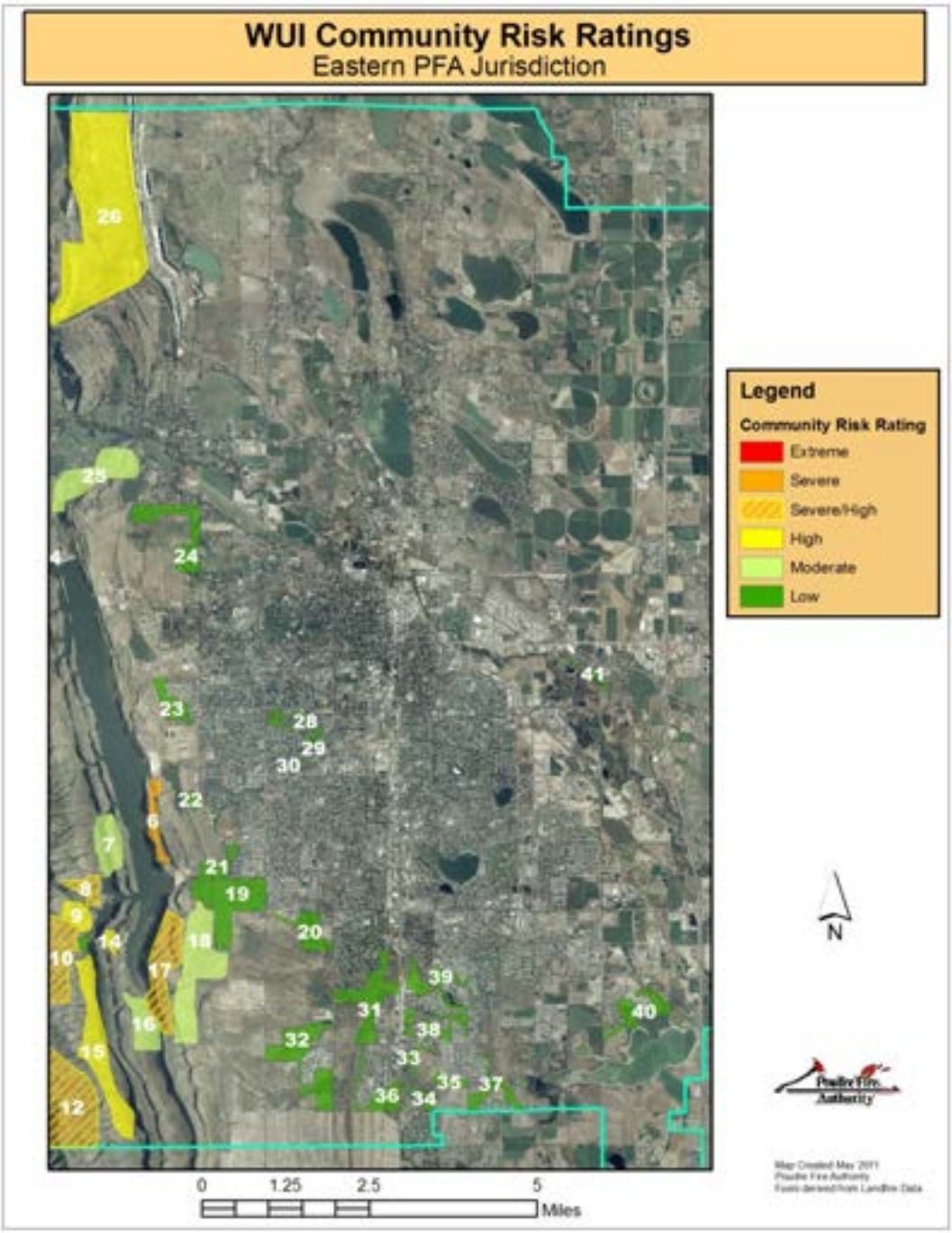
While the eastern portion of PFA's jurisdiction arguably may not have the same potential for large destructive fires more common to the foothills, the grasslands and occluded interface are where 71% of PFA's wildfires have occurred in the past decade. Fortunately, the nature of fuels, topography, defensible space, and infrastructure keep most of the eastern WUI subdivisions to a rating of low risk. However, fast moving and intense grass fires can prove destructive and deadly as dramatically illustrated by fires in Oklahoma in 2009 and Texas in 2011.

Table 10. PFA Eastern WUI Risk Ratings
(*WUI Area naming convention is based on the adjacent natural area name)

Area of Special Concern	Map ID	WUI Area*	PFA Risk Rating	Number of Addresses
Eastern Areas	19	Cathy Fromme West	Low	421
	20	Cathy Fromme East	Low	173
	21	Pineridge	Low	49
	22	Skimmerhorn	Low	39
	23	Maxwell	Low	185
	24	Reservoir Ridge	Low	26
	25	Bingham Hill	Moderate	23
	28	Redfox Meadows	Low	296
	29	Fischer	Low	38
	30	Ross	Low	21
	31	Hazaleus/Redtail	Low	148
	32	Coyote Ridge	Low	179
	33	Pelican Marsh North	Low	15
	34	Pelican Marsh South	Low	27
	35	Pelican Marsh East	Low	121
	36	Colina/Long View	Low	191
	37	Fossil Cr Wetlands	Low	95
	38	Prairie Dog	Low	112
	39	Two Creeks	Low	437
	40	Swift Farm	Low	178
	41	River Bend Ponds	Low	68

The identified eastern WUI subdivisions (table 10) are not an exhaustive inventory of areas at risk to wildfire. The extent and inconstant nature of privately owned agricultural and undeveloped lands make it impractical to assess all areas at potential risk to grass fire. The identified WUI subdivisions are adjacent to publicly owned designated natural areas. These are areas where the wildfire hazard will remain relatively constant over time, and where management actions will be relatively easy to plan and implement due to the strong relationship between PFA and the City of Fort Collins Natural Areas Program.

Map 17. Eastern WUI Community Risk Ratings



3.5.3 Other Values at Risk

In additions to structures, there are many other values at risk in PFA's WUI. These include critical infrastructure and natural resources. The most vulnerable values in PFA's jurisdiction are electrical utilities, water utilities, and natural areas. Each is touched upon briefly in this section with independent planning initiatives in process or pending. The City of Fort Collins Natural Areas Program has developed a series of fire management plans for its properties, while Horsetooth Mountain Park and Lory State Park each has active forest management programs. PFA currently has a grant under consideration for critical infrastructure assessment and planning which will allow specific concerns to be addressed in a more secure document.

Critical Facilities

There are several physical plants where vulnerability to wildfire is of particular concern. The Colorado State University facilities at the west campus and several other government facilities are positioned against the grass and brush fuels of the foothills and house a variety of potentially sensitive activities. These facilities generally have adequate defensible space for the surrounding fuel hazard. Horsetooth Reservoir, smaller lakes, irrigation canals, roads, and parking lots all serve to break-up the continuity of fuels in this area. Efforts should be undertaken to ensure evacuation plans and heating-ventilation-air conditioning (HVAC) are adequate to address the potential wildfire threat.

Electrical Infrastructure

The electrical infrastructure includes distribution lines, transmission lines, and substations. Utility companies are aware that it is impractical to mitigate the wildfire threat to vast system of distribution lines in the WUI, but knowledge of the location of main distribution feeds may be helpful in reducing damage when planning burnouts or other tactical operations on incidents. Mountain pine beetle induced mortality will increase the hazard along distribution right-of-ways in terms of standing dead fuels as well as potential deadfall that can ignite wildfires.

Transmission lines are a crucial component of the national power grid and concern over their vulnerability is on the rise, especially in the wake of the mountain pine beetle infestation. However, within PFA's jurisdiction transmission lines are generally located in non-forested areas. Substations are typically provided with substantial defensible space, which is the case for the several substations located in PFA's WUI.

The overall wildfire risk for electrical infrastructure in the jurisdiction is relatively low. While electrical lines and substations are typically on a 1 to 3 year vegetation maintenance cycle, utility companies should increase their vigilance along right-of-ways where mountain pine beetle mortality is an emerging issue. Maps of main distribution feeds as well as transmission lines could be very helpful to incident management teams and should be made available for use on incidents.

Natural Gas Infrastructure

Natural gas infrastructure can be categorized as part of a distribution system or transmission system. Distribution systems supply gas to residences and business and are buried underground, largely protecting them from wildfires. While many of the WUI structures have propane tanks rather than natural gas lines, the primary point of vulnerability to wildfire is at the structure itself. If a neighborhood with natural gas is threatened by wildfire, the typical procedure followed by the gas company is to clamp and cap the distribution supply to the area and work with the local fire department or incident management team to determine if the residual downstream gas should be vented or left in the lines. The key elements to this procedure are early involvement of the gas company and coordination with the incident command structure.

There are several high pressure gas transmission lines that run through PFA's jurisdiction. These steel pipelines are typically buried and run through the city and some areas with light grass fuels. As such, their vulnerability to wildfire is extremely low. Above ground transfer stations and valve sets are more vulnerable, and efforts should be made to map their locations for use by incident management teams.

Water Infrastructure

Crucial water department facilities are addressed and will be subject to point protection as practicable during a wildfire. The primary threat to water infrastructure is sedimentation resulting from post-fire runoff and erosion. Severe erosion following the 1996 Buffalo Creek and 2002 Hayman fires have caused the equivalent of decades of sedimentation to accumulate in the Stontia Springs and Cheeseman Reservoirs respectively. Watershed recovery efforts, dredging, and filtration plant repairs from these fires had cost the Denver Water Board $8,000,000 by 2004, and the recovery efforts continue today (Barry 2004). These costs are separate from the $16,500,000 spent for post-fire rehabilitation on U.S. Forest Service lands following the Hayman Fire.

The water infrastructure in PFA's jurisdiction is generally less vulnerable than those of the Denver Water Board. There are two primary water sources that concern communities in PFA's jurisdiction, the Colorado-Big Thompson Project and the Cache la Poudre Watershed. The Colorado-Big Thompson Project, which includes Carter Lake, Pinewood Reservoir, Flatiron Reservoir, and Horsetooth Reservoir, has a smaller watershed and smaller natural channel feeds than the Cheeseman or Strontias Spring Reservoirs that are located on the South Platte River. Its reservoirs are largely fed by canals and pipelines that can be shut off, thereby limiting sediment intake. Sediment threat to these canals can be dealt with on a post-fire case by case basis, as was done to protect the Hansen feeder canal after the Bobcat Fire. The Horsetooth Reservoir in particular has had a number of fuels projects implemented in its watershed that are discussed in the following section (map 19).

The Poudre River watershed is more comprehensively addressed in the Cache la Poudre Wildfire/Watershed Assessment (Piehl 2010). The twenty-one sub-watersheds were given composite hazard ratings based on wildfire, debris flow, and soil erosion hazard. The two sub-watersheds in PFA's jurisdiction (lower Cache la Poudre and Horsetooth Reservoir) are rated as relatively low risk. The main mitigation recommendation in this report is for increased fuels management planning among stakeholders. In PFA's jurisdiction this should involve City of Fort Collins Water, City of Greely Water, the U.S. Forest Service, Larimer County, and the Colorado State Forest Service. Pre-incident planning between water departments and Burned Area Emergency Rehabilitation (BAER) teams may also enhance post-fire mitigation efforts.

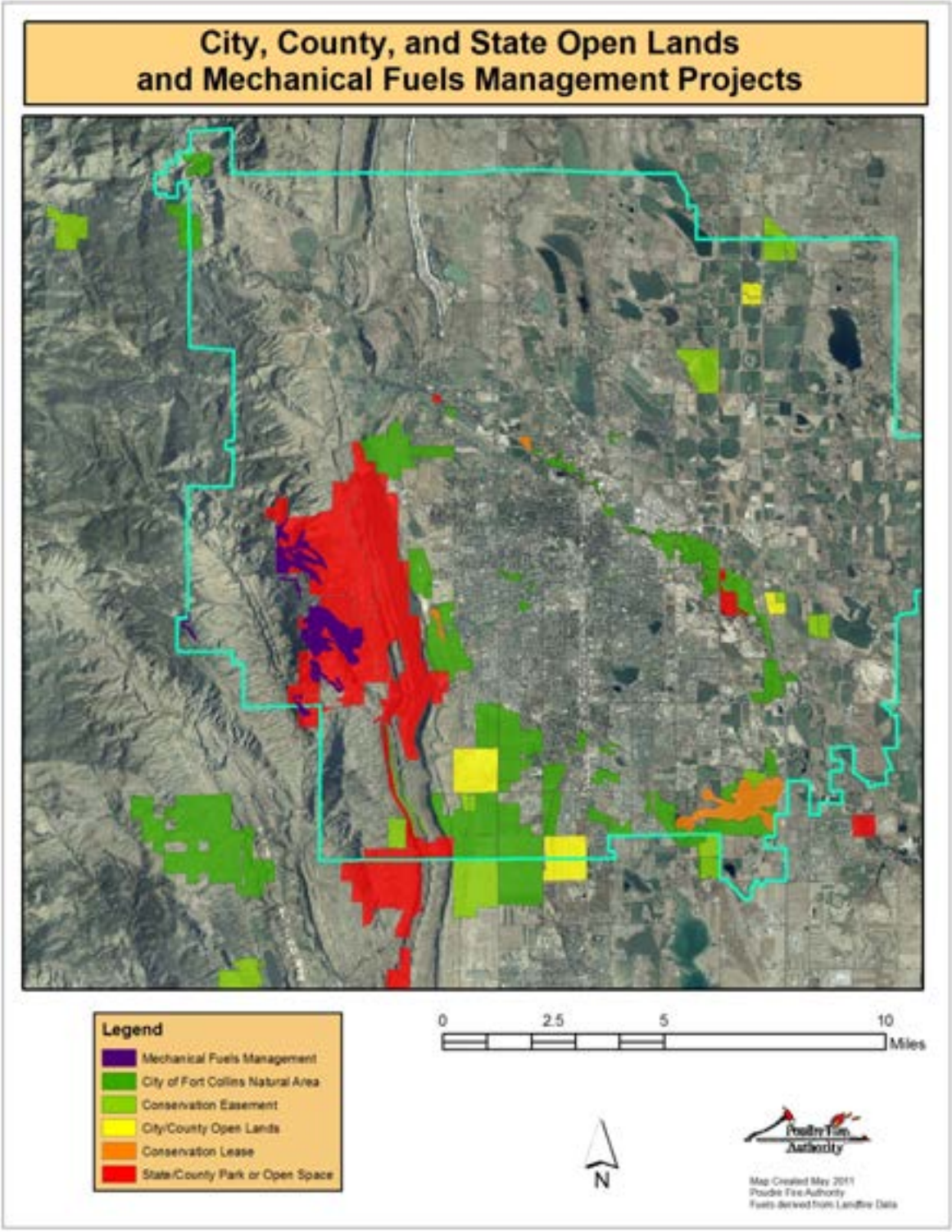
Natural Areas and Open Space

State and local agencies manage approximately 25,000 acres of natural areas within PFA's jurisdiction that have value in terms of watershed, wildlife habitat, recreation, and view sheds. While fire is an integral process to all natural areas within the jurisdiction, uncontrolled wildland fires can cause undesirable effects that are inconsistent with land management objectives.

The agencies in charge of natural areas management within PFA's jurisdiction (Colorado State Parks, Larimer County Parks and Open Lands, and the City of Fort Collins Natural Areas Program) have all implemented fuels management programs. Larimer County Parks and Open Lands has engaged in mechanical thinning in Horsetooth Mountain Park and prescribed fire in its open space areas. Lory State Park has performed mechanical thinning (map 19). The Fort Collins Natural Areas Program has a mowing project where grasslands are adjacent to high density housing and manages a prescribed fire program in concert with the Nature Conservancy.

There are also substantial fuels management efforts ongoing in several communities that are adjacent to public lands. The community of Redstone Canyon, that is adjacent to Horsetooth Mountain Park, has implemented several mechanical thinning projects. The two larger projects are included on the subsequent map. Several residents in the Whale Rock community near public lands have engaged undertaken substantial fuels reduction projects.

Map 18. Open Lands and Fuels Management



4. Hazard/Risk Reduction Strategies, Priorities, and Actions

The scale of the WUI issue in PFA's jurisdiction requires a strategic approach involving all phases of emergency management: mitigation, preparedness, response, and recovery. Action items will require a coordinated effort among multiple stakeholders.

4.1 Mitigation

There are two main strategies towards WUI hazard mitigation in PFA's WUI that are pursued in coordination with one another: public engagement and fuels management.

4.1.1 Public Engagement

Public engagement encourages individual and community actions on the part of residents in the WUI through continued outreach and support from public agencies. Since 2007 PFA has accomplished this through its Wildland-Urban Interface Outreach and Planning Initiative (WOPI). The WOPI involves several steps:

1. An initial orientation meeting is conducted with a WUI community about the initiative.
2. A public mailing notifies the community that we will have assessors in their neighborhood.
3. Teams of PFA firefighters perform WUI risk assessments on individual homes and perform individual homeowner education.
4. Residents are notified by mail when their risk assessment has been completed and are invited to view their assessment at an individualized secure web address. This site provides details as of each home's vulnerabilities and educational materials on how to reduce risk.
5. Data gathered during the home assessments is formatted into tactical scale maps for use by emergency responders.

The data gathered is designed for use by individual homeowners and emergency responders and is neither designed nor available for other uses. To date, the WOPI program has assessed over 700 homes in PFA's WUI. Tactical WUI maps were employed on the Crystal Fire in April of 2011. This ongoing program's success has been contingent upon grant funding through the CSFS and Colorado Department of Emergency Management.

Community feedback has been provided on how to better engage citizens in conducting improvements in defensible space and structure characteristics to reduce the risk of structure ignition. Further feedback has been received on the need for better quality assurance of the WOPI data being gathered. Both issues will be addressed during the fall of 2011.

4.1.2 Fuels Management Methods

Defensible Space

The most effective fuels management method for protecting structures in the WUI is the creation of defensible space around structures. By managing the fuels and reducing the potential fire intensity immediately adjacent to the structure, firefighters may more safely defend the home. Defensible space may even increase the probability of the structure withstanding a fire in the absence of firefighters.

Defensible space consists of pruning trees, applying low flammability landscaping, and cleaning up surface fuels and other fire hazards near the home. These efforts are typically concentrated within 30 to 75 feet of the home (see Appendix D).

Fuel Breaks and Area Fuels Treatments

By breaking-up vertical and horizontal fuel continuity in a strategic manner, fire suppression resources are afforded better opportunities to contain wildfires and community assets will have an increased probability of survival. In addition to the creation of defensible space, fuel breaks may be utilized to this end. These are strategically located areas where fuels have been reduced in a prescribed manner, often along roads. These fuel breaks may be associated with or tapered into larger area treatments. When defensible space, fuel breaks, and area treatments are coordinated, a community and the adjacent natural resources are afforded an enhanced level of protection from wildfire (see Appendix E).

The objectives of a specific fuels treatment may include reducing surface fire intensity, reducing the likelihood of crown fire initiation, reducing the likelihood of crown fire propagation, and improving forest health. These objectives may be accomplished by reducing surface fuels, limbing branches to raise canopy base height, thinning trees to decrease crown density, and/or retaining larger fire resistant trees. Fuel reduction projects should also be consistent with other community values such as wildlife habitat and esthetics.

Improperly implemented fuels treatments can have negative impacts in terms of forest health and fire behavior. Thinning forest stands in wind prone areas too rapidly can result in subsequent wind damage to the stand. Thinning can also increase the amount of sun and wind exposure on the forest floor, which can increase surface fire intensity if post treatment debris disposal and monitoring are not properly conducted. The overall benefits of properly conducted mitigations treatments are, however, well established.

Prescribed Fire

Prescribed fire may be used as a resource management tool under carefully controlled conditions. Prescribed fire can be an effective tool to improve wildlife habitat, abate

invasive vegetation, reduce excess fuel loads, and lower the risk of future wildfires in the treatment area.

Prescribed fire may be conducted either in a defined area, as a broadcast burn, or in localized burn piles. Broadcast burns are used to mimic naturally occurring wildfire but only under specific weather conditions, fuel loads, and expert supervision. Burn piles are utilized to dispose of excess woody material after thinning if other means of disposal are not available or cost-prohibitive. It should be noted that pile and debris burning have started numerous catastrophic wildfires along the Front Range. The use of prescribed fire in the WUI must be carefully planned, enacted only under favorable weather conditions, comply with local laws and regulations, and must meet air quality requirements of the Colorado Department of Public Health and Environment (CDPHE) Air Pollution Control Division.

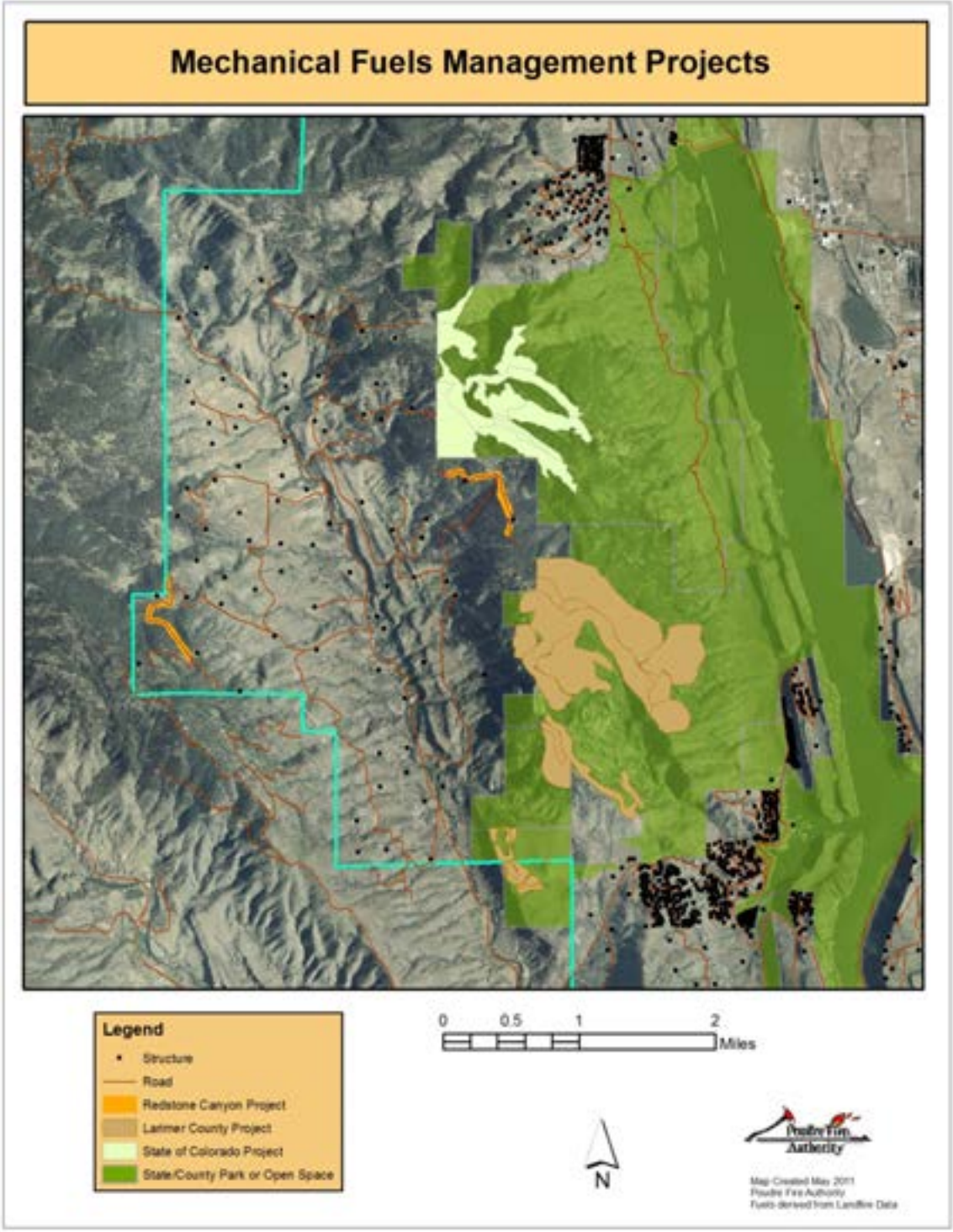
4.1.3 Current Fuels Management Projects

Fuels management projects include hazardous fuels mitigation planning and reduction projects, largely on the part of public agencies. The agencies engaged in fuels management within PFA's jurisdiction are the State of Colorado, Larimer County, and the City of Fort Collins. Mechanical treatments on public lands have been concentrated in the forested areas of Lory State Park and Horsetooth Mountain Park with approximately 400 and 800 treated acres respectively (map 19).

One promising development in mitigation efforts, are the large scale fuels treatments on private lands. These treatments are larger than single home defensible space that are being organized and, to a large degree, implemented by private citizens in their own communities. Significant efforts have been undertaken by individuals in the Whale Rock area and a community group in Redstone Canyon. While grant supported, these efforts have succeeded due to the substantial physical efforts of community members.

Local building codes and outreach programs conducted by Larimer County, PFA, and the CSFS have sought to encourage individual homeowners to create of defensible space. PFA plans to continue its efforts through continued home site visits and exploring other incentives for the creation of defensible space.

Map 19. Fuels Management Projects



4.1.4 Mitigation Action Items

There are several mitigation action items that should be continued or initiated in PFA's jurisdiction. Most of the items and the associated timeline are greatly dependent on grants and other variable funding streams.

Table 11. PFA WUI Mitigation Action Items

Year	Action	Lead
2011	Conduct QA of the WOPI assessments.	PFA
	Finalize WOPI assessments in the south Horsetooth area.	PFA
	Horsetooth Mountain Park Rx burn	Larimer County
	City of Fort Collins NA burns at Bobcat and Soapstone Natural Areas.	City of Fort Collins Natural Areas Program
	Natural Areas Fire Management Plan.	City of Fort Collins Natural Areas Program
2012	Conduct WOPI assessments in the north Horsetooth area.	PFA
	Explore potential for chipping program in WUI neighborhoods to support defensible space efforts.	PFA with Larimer County and citizens
	Coordinate future planning between water departments and land management agencies. Initiate during through the PFA Critical Infrastructure Assessment Project.	PFA, hand-off to relevant land management and water agencies
	Examine need for improved mitigation around critical infrastructure (primarily power lines and above ground natural gas fixtures). Initiate during through the PFA Critical Infrastructure Assessment Project.	PFA, hand-off to relevant utilities
	Horsetooth Mountain Park fuels treatment	Larimer County
Ongoing	Continued implementation of prescribed fire on City of Fort Collins Natural Areas.	City of Fort Collins Natural Areas Program
	Fort Collins NA WUI mowing program	City of Fort Collins Natural Areas Program
	Continued fuels treatments on Larimer County lands.	Larimer County
	Continued fuels treatments on Colorado State lands.	Colorado State Forest Service
	Monitor the impacts of the mountain pine beetle epidemic and adjust actions accordingly.	Colorado State Forest Service

4.2 Preparedness/Response

Response to wildfires within PFA's jurisdiction is the purview of PFA with support from its cooperators. Preparedness is an integral component of effective response, and these are the primary roles of PFA in the WUI.

4.2.1 PFA Wildfire Capabilities and Response

PFA's 150 career firefighters are cross-trained and red carded as wildland firefighters, with a number of firefighters holding qualifications as engine boss, strike team leader, division supervisor, and several other positions. In addition the majority of PFA's 40 or so volunteer firefighters are red carded. PFA also supports a WUI program that coordinates wildland training, preparedness, equipment, apparatus, and out-of district deployments.

PFA is a close cooperator with Larimer County Emergency Service and the surrounding fire protection districts. These relationships are governed by a variety of formal and informal interagency agreements and MOU's.

PFA operates a fleet of firefighting apparatus and in 2011 took delivery of a new Type-3 wildland engine. Excluding reserve apparatus, this includes:

(awd = all-wheel drive)

6	Type-6 4x4 engines	8	Type-1 engines
1	Type-3 awd engines	1	awd tactical water tender
1	Type-4 awd engine	2	water tenders
3	Type-1 awd engines	2	aerial ladder trucks

A 2002 study (Butler) concluded that the strongest climatic predictors for fire occurrence in PFA's jurisdiction are 10-hour fuel moisture for fire occurrence and 1000-hour fuel moisture for fire growth. A reexamination of updated data indicates that the correlation between fire occurrence and 10-hour fuel moisture remains statistically strong. The relationship between large fire growth and 1000-hour fuel moistures could not be accurately reassessed due to the incomplete fire size data set.

Wildfire response is determined based on fuel moisture and fire location. Fuel moisture readings from the Redstone Canyon remote automated weather station are assessed on a daily basis, and the response level is set based on the following criteria:

Table 12. PFA WUI response levels

Fire Danger	Fuel Moisture	Urban Core	Eastern Plains	Western Foothills
Low/Moderate	10-hr > 6% 1000-hr > 11%	1 Engine	1 Engine	1 Engine
High	10-hr ≤ 6% 1000-hr ≤ 11%	1 Engine	1 Engine 1 Brush	1 Engine 1 Brush 1 Tender 1 Battalion Chief
Extreme	10-hr ≤ 4% 1000-hr ≤ 8%	1 Engine 1 Brush 1 Battalion Chief	1 Engine 1 Brush 1 Tender 1 Battalion Chief	1 Engine 2 Brush 1 Tender 1 Battalion Chief

4.2.2 Preparedness

Effective response is dependent upon proper preparedness. PFA addresses preparedness through training and pre-incident planning. The primary training initiatives have been the annual wildfire refresher training and participation in an annual inter-agency WUI exercise. In 2010 PFA and the residents of Redstone Canyon hosted a full scale WUI exercise.

Pre-fire planning is typically conducted at the company level, but has been greatly facilitated by tactical scale maps developed through the WOPI program. While the WOPI program has focused on the western WUI neighborhoods at greatest risk, there is a need for enhanced pre-incident planning in the occluded interface and eastern WUI. The development of a WUI pre-plan template to accompany maps may be a useful tool for assisting companies in conducting these plans.

One issue that emerged during the Crystal Fire in April of 2011 was the need to improve the ability to host a large incident management team and large incident preparedness in general. Coordination with Larimer County, Colorado State University, and local venders may allow for more efficient large scale operations in the future. Colorado State University has already begun improving their ability to coordinate facilities for hosting future incidents.

Input from community members has indicated a need and an interest to develop community teams comprised of local citizens to assist neighbors and responding agencies during an incident. The development of Community Emergency Response Teams (CERT) or similar training may be an appropriate means of meeting this need.

4.2.3 Response and Preparedness Action Items

Response and preparedness action items are largely a continuation of existing programs. There are several new initiatives that will dependent on grants and other variable funding streams.

Table 13. PFA WUI Response and Preparedness Action Items

Year	Action	Lead
2011	Pre-incident planning for hosting/supporting large incidents.	PFA, CSU, Larimer County
	Critical infrastructure assessment , addressing, and mapping- a separate planning initiative that will have overlap with the CWPP.	PFA
	Update and distribute tactical WUI maps.	PFA
	Develop WUI pre-incident planning template for specific WUI areas, especially in occluded and eastern WUI.	PFA
	Pursue establishment of cistern or other water supply improvement in Redstone Canyon.	Station 11 (PFA)
2012	Investigate the development of CERT or other citizen organizations.	PFA
Ongoing	Continued annual wildland refresher training.	City of Fort Collins Natural Areas Program
	Continued participation in interagency WUI exercises. Include Natural Areas Program.	Larimer County

4.3 Recovery

Recovery from a significant WUI incident can require a massive interdisciplinary effort at multiple scales. PFA will most likely be involved in short term recovery efforts, but must be prepared to support long term efforts as well. In order to be better equipped for short term recovery efforts, PFA firefighters who responded to the Four Mile Fire have been discussing lessons learned. One effort being considered is to cross-train credentialed field observes in multi-hazard preliminary damage assessment. PFA is in the process of compiling additional recovery lessons learned from recent significant WUI fires.

Long term recovery efforts tend to reside outside of the purview of the fire department, requiring the planning efforts of the local emergency managers. Currently the City of Fort Collins Office of Emergency Management is working towards the development of a Recovery Plan and a Debris Management Plan. Because this office is restricted to working on issues specific to the those areas of PFA's jurisdiction within the City of Fort Collins, coordination will be required to ensure that WUI recovery in unincorporated areas is adequately addressed in separate plans or as a separately funded addendum to these plans.

The potential severity of post-fire damage to watersheds and water supply infrastructures has been illustrated in earlier sections. It is highly recommended that the water departments address recovery through continued planning. Consultation between the City of Fort Collins Water Utility and representatives of a Burned Area Emergency Rehabilitation (BAER) Team are currently being pursued.

Table 14. PFA WUI Recovery Action Items

Year	Action	Lead
2011	Pre-incident coordination between BAER Teams and water districts.	Fort Collins Water
2012	Fort Collins Recovery Plan.	Fort Collins OEM
	Fort Collins Debris Management Plan.	Fort Collins OEM

5. Conclusion

Recent WUI fires along the northern Front Range have highlighted the potential for devastation and the need to address the wildfire hazard at each of the phases of emergency management: mitigation, preparedness, response, and recovery.

PFA has substantial exposure to the hazards of wildfires. Of PFA's three major WUI classifications, the most significant in terms of extent, complexity, and degree of risk is the wildland-urban intermix in the western 25% of the district. Efforts to define the risks in detail and engage in mitigation strategies for the PFA's WUI communities are ongoing. The WUI Outreach and Planning Initiative has been a central vehicle in this effort.

Preparedness and response actions will be centered on the continuation and enhancement of existing programs at PFA. Several new initiatives, such as the development of community support teams, are being examined. While responsibility for recovery efforts typically resides with agencies other than PFA, the agency should be prepared to engage cooperatively in short term recovery efforts and support long term recovery as practicable.

Communication and coordination are the critical foci in successfully addressing the WUI issues within PFA's jurisdiction. Only through continued collaboration with citizens, cooperators, and other stakeholders will the needs of our community be met. As with all effective endeavors at PFA, the continued success of the WUI Program remains contingent upon a continuity of commitment and leadership throughout all ranks of the organization.

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Appendix A. List of Fire Management Terms

Canopy Bulk Density (CBD)	The mass to volume ratio of forests in the forest canopy.
Chain	A unit of linear measurement equal to 66 feet.
Chimney	A steep gully or canyon conducive to channeling strong convective currents, potentially resulting in dangerous increases in rates of fire spread and fireline intensity.
Crown Fire	The movement of fire through the crowns of trees or shrubs relatively independent of the surface fire.
Dead Fuels	Fuels with no living tissue in which moisture content is governed almost entirely by atmospheric moisture (relative humidity and precipitation), dry-bulb temperature, and solar radiation.
Defensible Space	An area, either natural or manmade, where material capable of causing a fire to spread has been treated, cleared, reduced, or changed to act as a barrier between an advancing wildland fire and values at-risk, including human welfare.
Dominant	Trees with crowns extending above the general level of crown cover. Larger than average tree with a well-developed crown.
Fire Behavior	The manner in which a fire reacts to the influences of fuel, weather, and topography.
Fire Danger	The broad-scale condition of fuels as influenced by environmental factors.
Fire Hazard	The presence of ignitable fuel coupled with the influences of terrain and weather.
Fire Intensity	A general term relating to the heat energy released by a fire.
Fireline Intensity	The level of heat radiated from the active flaming front of a fire, measured in British thermal units (BTUs) per foot.
Fire Regime	The characterization of fire's role in a particular ecosystem, usually characteristic of particular vegetation and climatic regime, and typically a combination of fire return interval and fire intensity.
Flame Length	The distance from the base to the tip of the flaming front. Flame length is directly correlated with fire intensity.

Flaming Front	The zone of a moving fire where combustion is primarily flaming. Light fuels typically have a shallow flaming front, whereas heavy fuels have a deeper front.
Fuel	Combustible material that includes vegetation such as grass, surface litter, plants, shrubs, and trees that feed a fire. Not all vegetation is necessarily considered fuel. Deciduous vegetation such as aspen actually serve more as a barrier to fire spread and many shrubs are only available as fuels when they are drought-stressed.
Fuelbreak	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.
Fuel Loading	The amount of fuel present expressed in terms of weight of fuel per unit area.
Fuel Model	Simulated fuel complex (or combination of vegetation types) for which all fuel descriptors required for the solution of a mathematical rate of spread model have been specified.
Ground Fire	Fire that consumes the organic material beneath the surface litter ground, such as a peat fire.
Ground Fuel	Combustible materials below the surface litter, including duff, tree or shrub roots, decomposing wood, and peat that normally support glowing combustion without flame.
Ladder Fuels	Fuels that provide vertical continuity between strata, allowing fire to carry from surface fuels into the crowns of trees or shrubs with relative ease. Ladder fuels help initiate and ensure the continuation of crowning.
Overstory	The forest canopy.
Regeneration	The new growth within a forest.
Risk	A measure of potential damage or loss contingent upon the probability of a harmful event.
Stand Replacement	An event that kills the majority of the mature trees in a forest stand such as a crown fire or clear cut.
Surface Fire	Fire that burns loose debris on the surface, which includes dead branches, leaves, and low vegetation.

Surface Fuels	Surface litter normally consisting of fallen leaves, needles, cones, and small branches. It also includes grasses, forbs, shrubs, tree seedlings, heavier branchwood, downed logs, and stumps interspersed with or partially replacing the litter.
Torching	The burning of the foliage of a single tree or a small group of trees, from the bottom up. Passive crown fire.
Understory	Vegetation growing on the forest floor, under the canopy.
Wildfire	An unplanned and unwanted wildland fire that is not meeting management objectives and thus requires a suppression response.
Wildland Fire	Any fire burning in wildland fuels, including prescribed fire, fire use, and wildfire.
Wildland Fire Use	The management of naturally ignited wildland fires to accomplish specific pre-stated resource management objectives in pre-defined geographic areas outlined in fire management plans.

Appendix B. Wildland Fire Primer

A basic understanding of wildland fire is essential for understanding the analysis and conclusions of this report. This section provides an introduction to wildland fire behavior, ecology, and the WUI as pertinent to this document.

Wildland fire is defined as any fire burning in wildland fuels and includes wildfire, prescribed fire, and wildland fire use (WFU). Wildfires are unwanted and unplanned fires that result from natural ignition or human-caused fire. Prescribed fires are planned human-ignited fires for specific natural resource management objectives. Natural ignitions that are allowed to burn for natural resource benefits under specific conditions are termed WFU.

While wildland fire bears many benefits, this plan is largely concerned with mitigating its negative impacts on human society. The threat of wildland fire can be described in a variety of ways. Fire risk is the probability that wildfire will start from natural or human-caused ignitions. Fire hazard is the presence of ignitable fuel coupled with the influences of topography and weather, and is directly related to fire behavior. Fire severity, on the other hand, refers to the effects a fire has on vegetation and soils. Fire intensity generally refers to the amount of energy released by the flaming front. Rate of spread and flame length are often used as key measures of fire behavior.

Wildland Fire Behavior

Fire behavior is the manner in which a fire reacts to the influences of fuel, weather, and topography. Vegetative fuels are characterized by size, shape, and quantity and are classified in terms of fire behavior fuel models (FBFM). These fuel characteristics determine responsiveness to weather conditions and ignition. Important weather elements include temperature, relative humidity, and wind. Temperature and relative humidity help determine how easily fuels will ignite and burn, while wind is the dominant force in determining a fire's rate and direction of spread. Topography also influences spread rate and direction, and also influences wind and the reception of sunlight.

Wildland fires may be classified as ground, surface, or crown fires. Ground fire involves smoldering materials such as duff and roots. Surface fire includes the burning of forest litter, down woody materials, grass, low shrubs and small trees. Crown fire moves through the canopy of trees or shrubs and can be further classified as active or passive. In passive crown fire, often called "torching", individual or small groups of trees are ignited by surface fire on an isolated basis. Fuels that support fire spread from the surface to the canopy, such as low branches or tall shrubs, are called ladder fuels. Active crown fire spreads through the forest canopy as a flaming front. High intensity surface fires and crown fires pose the greatest challenge to suppression resources and the greatest threat to community values.

Fuels, weather, and topography are used as inputs for modeling potential fire behavior. Fire behavior is typically modeled at the flaming front of the fire and described most

simply in terms of fireline intensity (flame length), the rate of forward spread, and the potential for developing into a passive or active crown fire. Passive crown fire is largely determined by flame height relative to crown base height, essentially how close the fire comes to the tree crowns. Active crown fire is a modeled as a function of canopy bulk density, or how much fuel is in a given volume of forest canopy. This sort of modeling can help guide fire preparedness, suppression planning, and mitigation activities.

Fire Ecology

Fire is an essential component of most vegetated ecosystems in the western United States. Some vegetative communities, such as Southwest ponderosa pine woodlands, experience relatively frequent fire, burning every ten to thirty years. Other forest types, like the local spruce-fir forests, may go for hundreds of years without burning. The frequency of burning is determined by the continuity of vegetation, dryness of fuels, and prevalence of ignition sources as well as other factors.

Wildland fire also varies in terms of its severity. In very general terms, where fire is more frequent it tends to burn with less severity. Frequent burning inhibits the build-up of large amounts of fuel. Areas that burn less frequently often have heavy concentrations of surface fuels and/or dense canopies that can sustain more severe burning. There are also vegetative communities that fall into intermediate or mixed fire frequency and severity categories. The characteristic fire behavior and frequency is referred to as the fire regime. Agriculture, human development, and fire suppression have effectively reduced fire frequency across much of the American landscape. In areas with high frequency – low severity fire regimes, these activities have led to fuel build-ups outside of the historic norm, resulting in abnormally severe fires. For low frequency fire regimes, there has been little or no impact. The spruce-fir and lodgepole pine forests of the Upper Blue River Basin are classified as a low frequency - high severity fire regime, essentially meaning that severe crown fires can be expected to burn large portions of the forest on order of every 100 to 300 years (U.S. Geologic Survey 2010). In other words, stand replacing fires that consume large portions of the forest canopy are quite natural in this area, though infrequent.

Wildland Urban Interface (WUI)

The highest potential for negative and even deadly impacts of wildland fire is where communities abut or mix with forests and open spaces. This zone is most commonly known as the wildland – urban interface (WUI) and is the central focus of this report. Every fire season catastrophic losses from wildfire plague the WUI. Homes are lost, businesses are destroyed, community infrastructure is damaged, and, most tragically, lives are lost. Precautionary action taken before a wildfire strikes often makes the difference between saving and losing a home. Creating a defensible space around a home is an important component in wildfire hazard reduction. This involves reducing combustible vegetation around the structure.

The attributes of the structure itself are also essential to determining survivability during a wildfire. Experiments indicate that even the intense radiant heat of a crown fire is unlikely to ignite a structure that is more than 30 feet away as long as there is no direct flame impingement (Cohen and Saveland 1997). Post fire home survivability studies determined that homes with noncombustible roofs and a minimum of 30 feet of defensible space had an 85% survival rate. Conversely, homes with wood shake roofs and less than 30 feet of defensible space had a 15% survival rate (Foote and Gilles 1996).

Hazardous Fuels Mitigation

Wildfire behavior and severity are dictated by fuel type, weather conditions, and topography. Because fuel is the only variable of these three that can be practically managed, it is the focus of many mitigation efforts. The objectives of fuels management may include reducing surface fire intensity, reducing the likelihood of crown fire initiation, reducing the likelihood of crown fire propagation, and improving forest health. These objectives may be accomplished by reducing surface fuels, limbing branches to raise canopy base height, thinning trees to decrease crown density, and/or retaining larger fire-resistant trees.

By breaking up vertical and horizontal fuel continuity in a strategic manner, fire suppression resources are afforded better opportunities to control fire rate of spread and contain wildfires before they become catastrophic. In addition to the creation of defensible space, fuelbreaks may be utilized to this end. These are strategically located areas where fuels have been reduced in a prescribed manner, often along roads. Fuelbreaks may be strategically placed with other fuelbreaks or with larger-area treatments. When defensible space, fuelbreaks, and area treatments are coordinated, a community and the adjacent natural resources are afforded an enhanced level of protection from wildfire.

Improperly implemented fuel treatments can have negative impacts in terms of forest health and fire behavior. Aggressively thinning forest stands in wind-prone areas may result in subsequent wind damage to the remaining trees. Thinning can also increase the amount of surface fuels and sun and wind exposure on the forest floor. This may increase surface fire intensity if post-treatment debris disposal and monitoring are not properly conducted. The overall benefits of properly constructed fuelbreaks are, however, well documented.

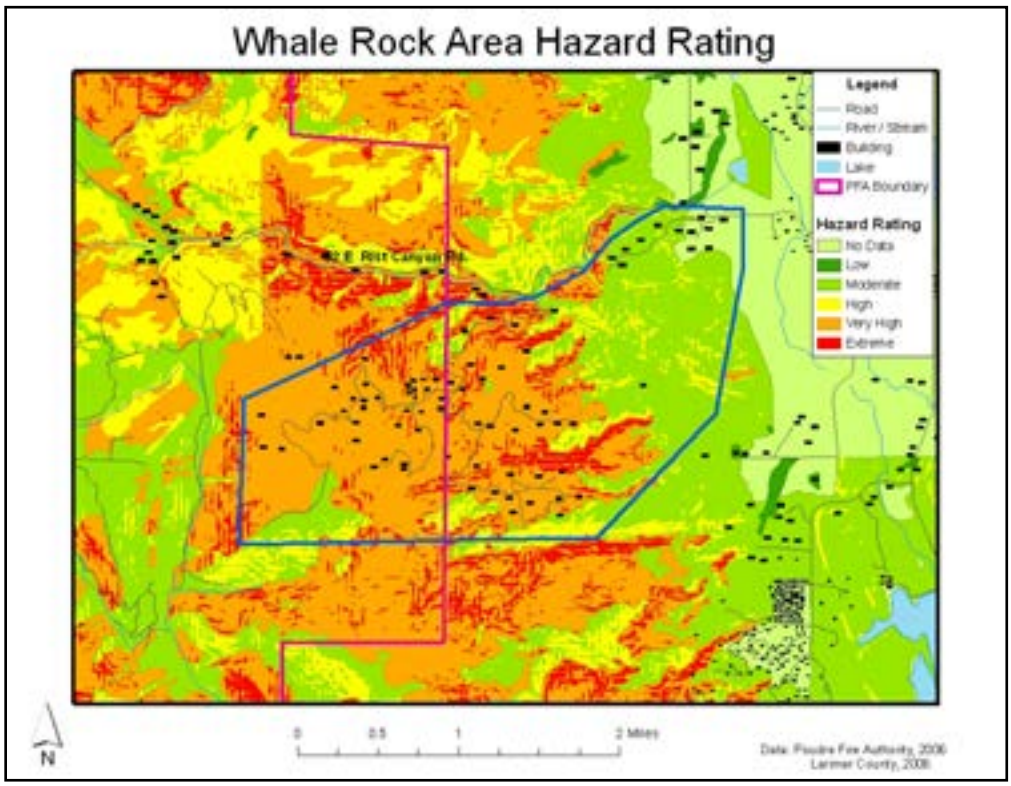
Appendix C. Areas of Special Concern

This section is a partial reprint of the 2006 Areas of Special Concern and represents conditions observed at that time. As of fall 2011, these areas are undergoing a reevaluation and will be inventoried in a separate addendum.

Whale Rock – Saddle Ridge Area

The Saddle Ridge and Whale Rock subdivisions are organized under the Mountain Estates and Saddle Ridge Road Association. These subdivisions include residences on both sides of the section line that divides the Rist Canyon Volunteer Fire Department (RCVFD) and PFA jurisdictions, making close coordination between the two departments recommended for fire management efforts in this area. RCVFD station 4 is located in the center of Whale Rock. PFA station 7 is the closest paid station, approximately 5.5 miles away. This station houses a Type 1 and a Type 3 engine and serves as the department's wildland specialty station with a crew of four firefighters.

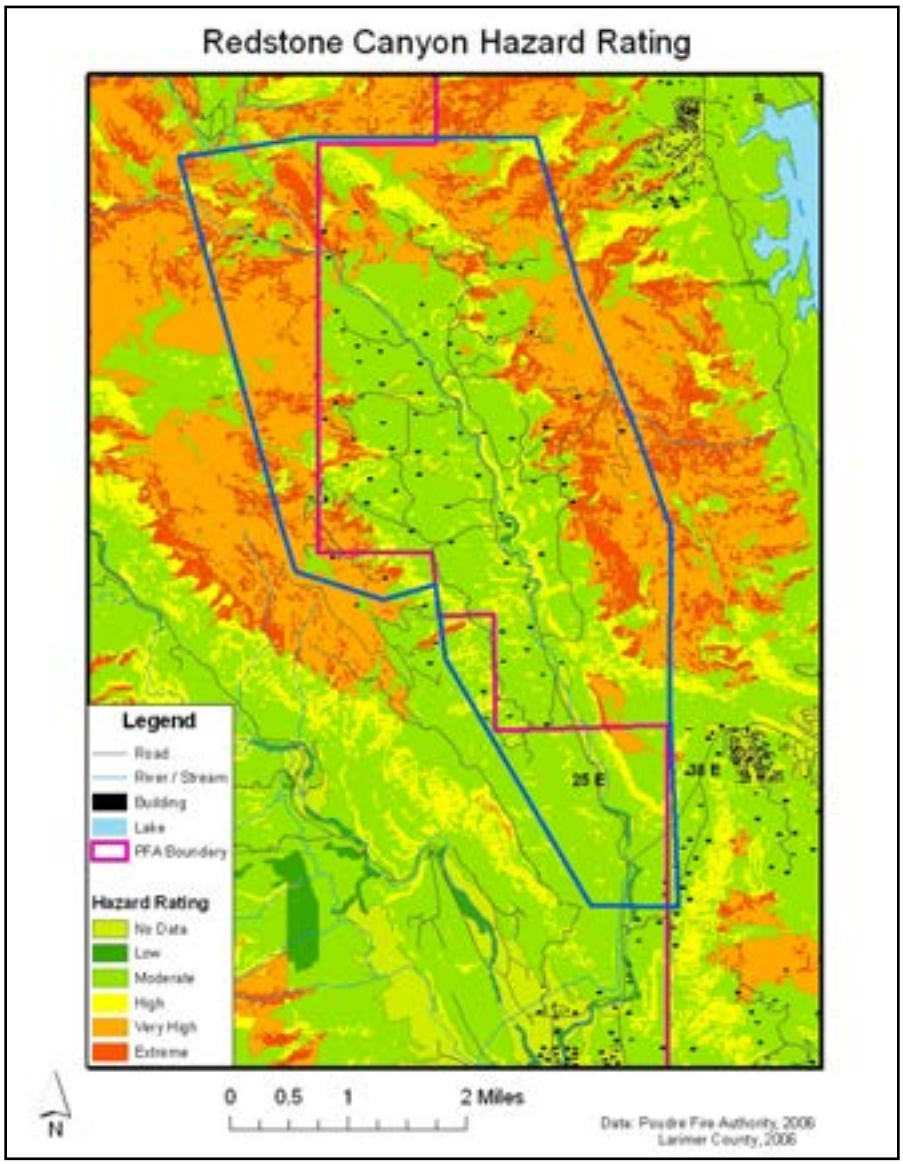
Saddle Ridge and Whale Rock have been rated extreme and severe respectively by Larimer County in terms of fire hazard. The CSFS rated both subdivisions as extreme. Access is characterized by steep narrow roads. Thick timber is the predominant fuel in this area. A few land owners have created adequate defensible space, with some undertaking extensive forest management efforts. However, less than 30% of the homes have adequate defensible space.



Redstone Canyon Area

Eighty percent of the homes in Redstone Canyon are members of the Redstone Canyon Association (RCA). PFA station 11 is midway up the canyon and is staffed by community volunteers. PFA Station 9 is also a volunteer station and is approximately 2.5 miles from the entrance to Redstone Canyon. Station 4 is the closest paid station, approximately 9 miles from the canyon entrance. Loveland Fire Rescue and Larimer County Emergency Services also respond to wildfires in this area.

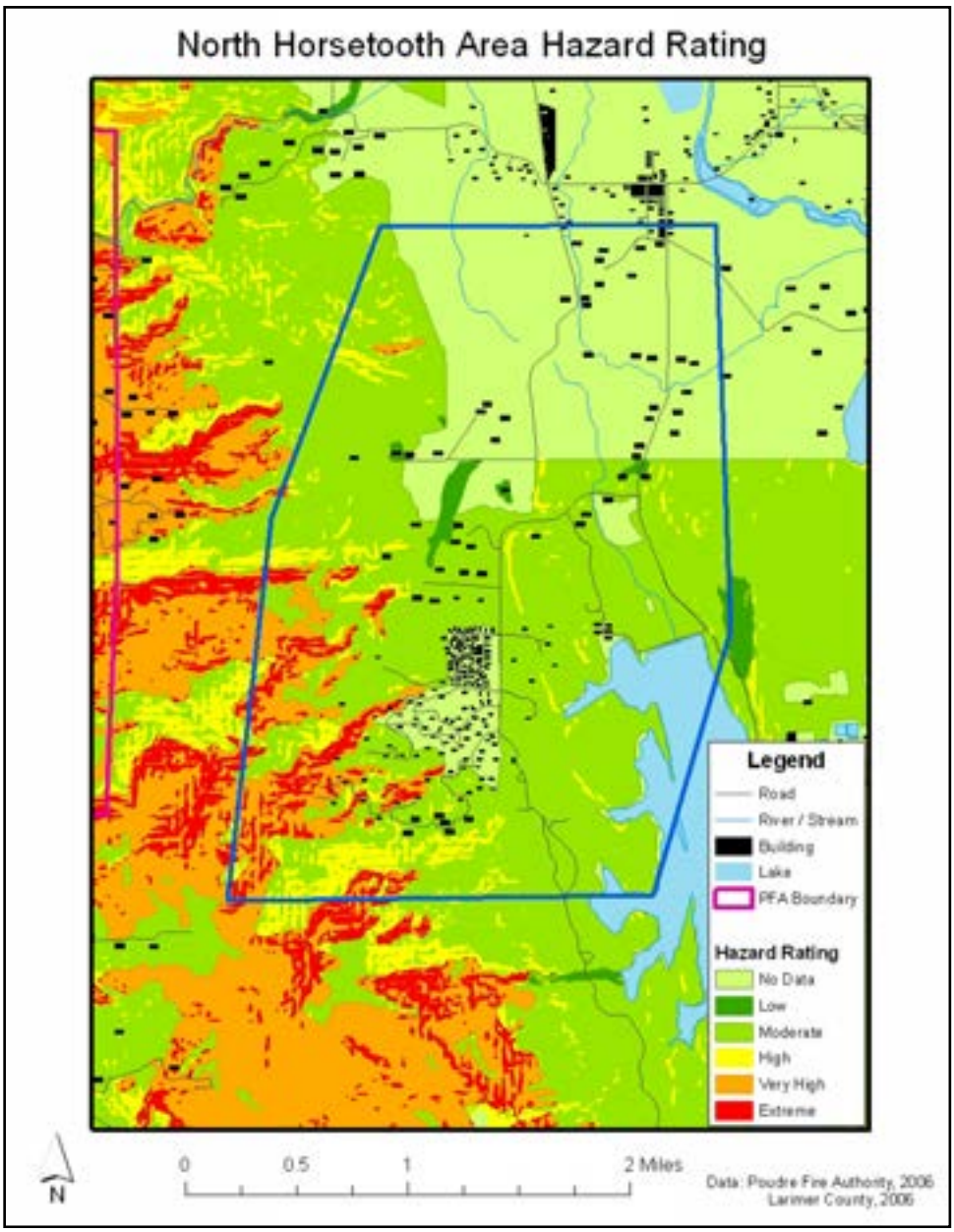
This community borders Lory State Park and Horsetooth Mountain Park to the East. Surface fuels are predominantly grass or grass with timber overstory. There are areas of mountain mahogany brush throughout the canyon and timber on the upper slopes of the canyon. Most of the homes in this canyon are located in grass fuels.



North Horsetooth Area

This area lies immediately north of Lory State Park at the northwest end of Horsetooth Reservoir. Four subdivisions are included and range in their hazard rating from moderate to severe. Grass and brush fuels are predominant throughout most of the area, though timber is present along the western and southern edges of the area.

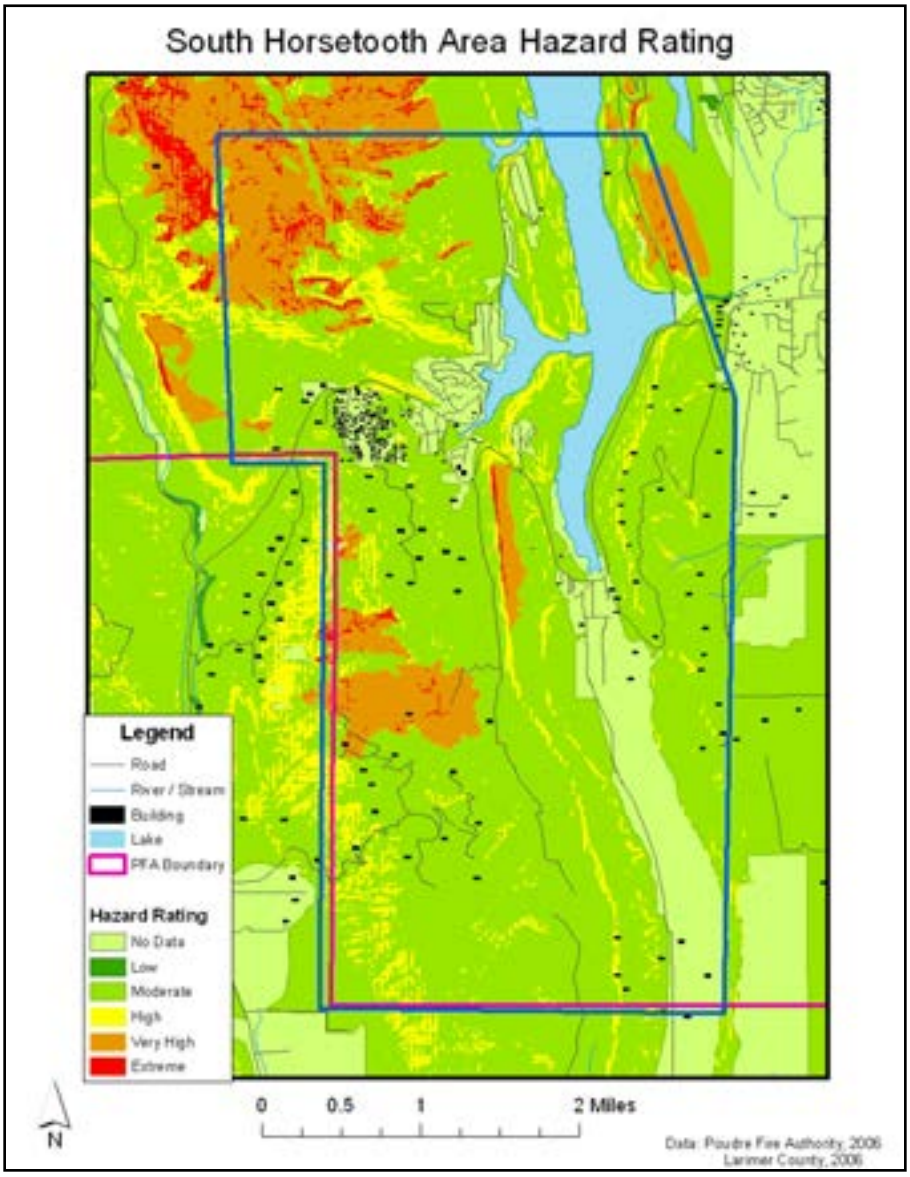
Wildfire response in this area comes from PFA station 7 and Larimer County Emergency Services. Station 7 is 3.5 to 5.5 miles from the homes in this area and houses a Type 1 and Type 3 engine. This station serves as the department's wildland specialty station and is staffed by a crew of four.



South Horsetooth Area

The South Horsetooth Area is comprised of eleven subdivisions ranging in hazard rating from low to severe. Most of the homes lie on steep brush covered slopes. Egress and fire department access are an issue on many of the steep and narrow roads in this area. The subdivisions of this area bounded on all sides by open space and preserved lands that for the most part have seen only very limited hazard fuel mitigation.

Wildfire response in this area is provided by PFA volunteer station 9, PFA station 4, and Larimer County Emergency Services. Station 9 houses a Type 1 and Type 6 engine, but response is dependent upon the availability of volunteers who generally do not reside in the area. Station 4 is the closest fully staffed company and houses a Type 1 and Type 6 engine. This station is approximately five to ten miles from most of the homes in the area.



Appendix D. Creating Wildfire Defensible Space

NATURAL RESOURCES SERIES

FORESTRY

Creating Wildfire-Defensible Zones no. 6.302

by F.C. Dennis [1]

Quick Facts...

Wildfire will find the weakest links in the defense measures you have taken on your property.

The primary determinants of a home's ability to survive wildfire are its roofing material and the quality of the "defensible space" surrounding it.

Even small steps to protect your home and property will make them more able to withstand fire.

Consider these measures for all areas of your property, not just the immediate vicinity of the house.

Fire is capricious. It can find the weak link in your home's fire protection scheme and gain the upper hand because of a small, overlooked or seemingly inconsequential factor. While you may not be able to accomplish all measures below (and there are no guarantees), each will increase your home's, and possibly your family's, safety and survival during a wildfire.

Start with the easiest and least expensive actions. Begin your work closest to your house and move outward. Keep working on the more difficult items until you have completed your entire project.

Defensible Space

Two factors have emerged as the primary determinants of a home's ability to survive wildfire. These are the home's roofing material and the quality of the "defensible space" surrounding it.

Use fire-resistive materials (Class C or better rating), not wood or shake shingles, to roof homes in or near forests and grasslands. When your roof needs significant repairs or replacement, do so with a fire-resistant roofing material. Check with your county building department. Some counties now restrict wood roofs or require specific classifications of roofing material.

Defensible space is an area around a structure where fuels and vegetation are treated, cleared or reduced to slow the spread of wildfire towards the structure. It also reduces the chance of a structure fire moving from the building to the surrounding forest. Defensible space provides *room for firefighters to do their jobs.* Your house is more likely to withstand a wildfire if grasses, brush, trees and other common forest fuels are managed to reduce a fire's intensity.

The measure of fuel hazard refers to its continuity, both horizontal (across the ground) and vertical (from the ground up into the vegetation crown). Fuels with a high degree of both vertical and horizontal continuity are the most hazardous, particularly when they occur on slopes. Heavier fuels (brush and trees) are more hazardous (i.e. produce a more intense fire) than light fuels such as grass.

Mitigation of wildfire hazards focuses on breaking up the continuity of horizontal and vertical fuels. Additional distance between fuels is required on slopes.

Creating an effective defensible space involves developing a series of management zones in which different treatment techniques are used. See Figure 1 for a general view of the relationships among these management zones. Develop defensible space around each building on your property. Include detached garages, storage buildings, barns and other structures in your plan.

The actual design and development of your defensible space depends on several factors: size and shape of buildings, materials used in their construction, the slope of the ground on which the structures are built, surrounding topography,

Colorado State University Cooperative Extension

Putting Knowledge to Work

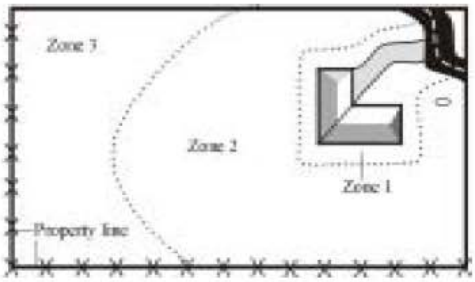


Figure 1: Forested property showing the three fire-defensible zones around a home or other structure.

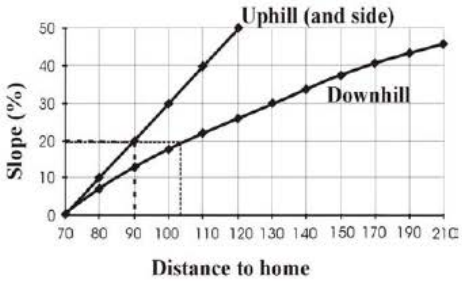


Figure 2: This chart indicates the *minimum recommended* dimensions for defensible space from the home to the outer edge of Zone 2. For example, if your home is situated on a 20 percent slope, the minimum defensible space dimensions would be 90 feet uphill and to the sides of the home and 104 feet downhill from the home.

and sizes and types of vegetation on your property. These factors all affect your design. You may want to request additional guidance from your local Colorado State Forest Service (CSFS) forester or fire department. (See the Special Recommendations section of this fact sheet for shrubs, lodgepole pine, Engelmann spruce, and aspen.)

Defensible Space Management Zones

Zone 1 is the area of maximum modification and treatment. It consists of an area of 15 feet around the structure in which all flammable vegetation is removed. This 15 feet is measured from the outside edge of the home's eaves and any attached structures, such as decks.

Zone 2 is an area of fuel reduction. It is a transitional area between Zones 1 and 3. The size of Zone 2 depends on the slope of the ground where the structure is built. Typically, the defensible space should extend *at least* 75 to 125 feet from the structure. See Figure 2 for the appropriate distance for your home's defensible space. Within this zone, the continuity and arrangement of vegetation is modified. Remove stressed, diseased, dead or dying trees and shrubs. Thin and prune the remaining larger trees and shrubs. Be sure to extend thinning along either side of your driveway all the way to your main access road. These actions help eliminate the continuous fuel surrounding a structure while enhancing homesite safety and the aesthetics of the property.

Zone 3 is an area of traditional forest management and is of no particular size. It extends from the edge of your defensible space to your property boundaries.

Prescriptions

Zone 1

The size of Zone 1 is 15 feet, measured from the edges of the structure. Within this zone, several specific treatments are recommended.

Plant nothing within 3 to 5 feet of the structure, particularly if the building is sided with wood, logs or other flammable materials. Decorative rock, for example, creates an attractive, easily maintained, nonflammable ground cover.

If the house has noncombustible siding, widely spaced foundation plantings of low growing shrubs or other "fire wise" plants are acceptable. Do not plant directly beneath windows or next to foundation vents. Be sure there are no areas of continuous grass adjacent to plantings in this area.

Frequently prune and maintain plants in this zone to ensure vigorous growth and a low growth habit. Remove dead branches, stems and leaves.

Do not store firewood or other combustible materials in this area. Enclose or screen decks with metal screening. Extend the gravel coverage under the decks. Do not use areas under decks for storage.

Ideally, remove all trees from Zone 1 to reduce fire hazards. If you do keep a tree, consider it part of the structure and extend the distance of the entire defensible space accordingly. Isolate the tree from any other surrounding trees. Prune it to at least 10 feet above the ground. Remove any branches that interfere with the roof or are within 10 feet of the chimney. Remove all "ladder fuels" from beneath the tree. Ladder fuels are vegetation with vertical continuity that allows fire to burn from ground level up into the branches and crowns of trees. Ladder fuels are potentially very hazardous but are easy to mitigate. No ladder fuels can be allowed under tree canopies. In all other areas, prune all branches of shrubs or trees up to a height of 10 feet above ground (or 1/2 the height, whichever is the least).

Zone 2

Zone 2 is an area of fuel reduction designed to reduce the intensity of any fire approaching your home. Follow these recommended management steps.

Thin trees and large shrubs so there is at least 10 feet between crowns. Crown separation is measured from the furthest branch of one tree to the nearest branch on the next tree (Figure 3). On steep slopes, allow more space between tree crowns. (See Figure 4 for *minimum recommended* spacing for trees on steep slopes.) Remove all ladder fuels from under these remaining trees. Carefully prune trees to a height of at least 10 feet.

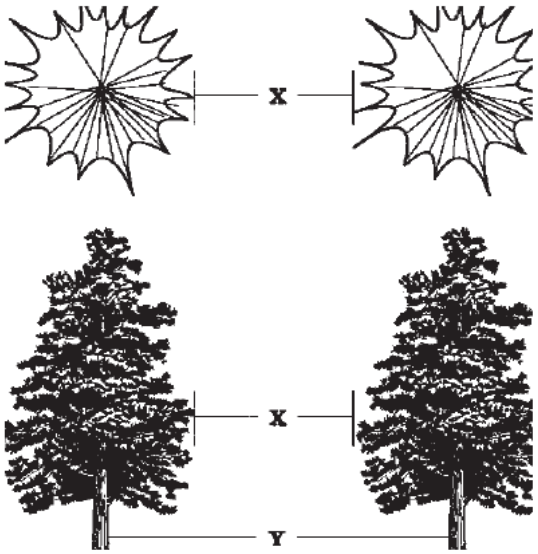


Figure 3: X = crown spacing; Y = stem spacing. Do not measure between stems for crown — measure between the edges of tree crowns.

Small clumps of 2 to 3 trees may be occasionally left in Zone 2. Leave more space between the crowns of these clumps and surrounding trees.

Because Zone 2 forms an aesthetic buffer and provides a transition between zones, it is necessary to blend the requirements for Zones 1 and 3. Thin the portions of Zone 3 adjacent to Zone 2 more heavily than the outer portions.

Isolated shrubs may remain, provided they are not under tree crowns. Prune and maintain these plants periodically to maintain vigorous growth. Remove dead stems from trees and shrubs annually. Where shrubs are the primary fuel in Zone 2, refer to the Special Recommendations section of this fact sheet.

Limit the number of dead trees (snags) retained in this area. Wildlife needs only one or two snags per acre. Be sure any snags left for wildlife cannot fall onto the house or block access roads or driveways.

Mow grasses (or remove them with a weed trimmer) as needed through the growing season to keep them low, a maximum of 6 to 8 inches. This is extremely critical in the fall when grasses dry out and cure or in the spring after the snow is gone but before the plants green up.

Stack firewood and woodpiles uphill or on the same elevation as the structure but at least 30 feet away. Clear and keep away flammable vegetation within 10 feet of these woodpiles. Do not stack wood against your house or on or under your deck, even in winter. Many homes have burned from a woodpile that ignited as the fire passed. Wildfires can burn at almost any time in Colorado.

Locate propane tanks at least 30 feet from any structures, preferably on the same elevation as the house. You don't want the LP container below your house — if it ignites, the fire would tend to burn uphill. On the other hand, if the tank is above your house and it develops a leak, LP gas will flow downhill into your home. Clear and keep away flammable vegetation within 10 feet of these tanks. Do not screen propane tanks with shrubs or vegetation.

Dispose of slash (limbs, branches and other woody debris) from your trees and shrubs through chipping or by piling and burning. Contact your local CSFS office or county sheriff's office for information about burning slash piles. If neither of these alternatives is possible, lop and scatter slash by cutting it into very small pieces and distributing it over the ground. Avoid heavy accumulations

% slope	Tree Crown Spacing	Brush and Shrub Clump Spacing
0 -10 %	10´	2 1/2 x shrub height
11 - 20%	15´	3 x shrub height
21 - 40%	20´	4 x shrub height
> 40%	30´	6 x shrub height

Figure 4: Minimum tree crown and shrub clump spacing.

Grasses

Keep dead, dry or curing grasses mowed to less than 6 inches. Defensible space size where grass is the predominant fuel can be reduced (Figure 5) when applying this practice.

Windthrow

In Colorado, certain locations and tree species, including lodgepole pine and Engelmann spruce, are especially susceptible to damage and uprooting by high winds (windthrow). If you see evidence of this problem in or near your forest, or have these tree species, consider the following adjustments to the defensible space guidelines. It is highly recommended that you contact a professional forester to help design your defensible space.

Adjustments: If your trees or homesite are susceptible to windthrow and the trees have never been thinned, use a stem spacing of diameter plus five instead of the guides listed in the Zone 3 section. Over time (every 3 to 5 years) *gradually* remove additional trees. The time between cutting cycles allows trees to "firm up" by expanding their root systems. Continue this periodic thinning until the desired spacing is reached.

Also consider leaving small clumps of trees and creating small openings on their lee side (opposite of the predominant wind direction). Again, a professional forester can help you design the best situation for your specific homesite and tree species. Remember, with species such as lodgepole pine and Engelmann spruce, the likelihood of a wildfire running through the tree tops or crowns (crowning) is closely related to the overabundance of fuels on the forest floor. Be sure to remove downed logs, branches and *excess* brush and needle buildup.

Maintaining Your Defensible Space

Your home is located in a forest that is dynamic, always changing. Trees and shrubs continue to grow, plants die or are damaged, new plants begin to grow, and plants drop their leaves and needles. Like other parts of your home, defensible space requires maintenance. Use the following checklist each year to determine if additional work or maintenance is necessary.

% slope	D-space size (uphill, downhill, sidehill)
0 - 20 %	30'
21 - 40%	50'
> 40%	70'

Figure 6: Minimum defensible space size for grass fuels.

Defensible Space and FireWise Annual Checklist

- ☐ Trees and shrubs are properly thinned and pruned within the defensible space. Slash from the thinning is disposed of.
- ☐ Roof and gutters are clear of debris.
- ☐ Branches overhanging the roof and chimney are removed.
- ☐ Chimney screens are in place and in good condition.
- ☐ Grass and weeds are mowed to a low height.
- ☐ An outdoor water supply is available, complete with a hose and nozzle that can reach all parts of the house.
- ☐ Fire extinguishers are checked and in working condition.
- ☐ The driveway is wide enough. The clearance of trees and branches is adequate for fire and emergency equipment. (Check with your local fire department.)
- ☐ Road signs and your name and house number are posted and easily visible.
- ☐ There is an easily accessible tool storage area with rakes, hoes, axes and shovels for use in case of fire.
- ☐ You have practiced family fire drills and your fire evacuation plan.
- ☐ Your escape routes, meeting points and other details are known and understood by all family members.
- ☐ Attic, roof, eaves and foundation vents are screened and in good condition.

Appendix E. Fuelbreak Guidelines for Subdivisions

Fuelbreak Guidelines for Forested Subdivisions & Communities

By

Frank C. Dennis

Colorado State Forest Service

Knowledge to Go Places

This publication was developed for use by foresters, planners, developers, homeowners' associations and others. Implementation of these measures cannot *guarantee* safety from all wildfires, but will greatly increase the probability of containing them at more manageable levels.

Inadequate fire planning can result in loss of life or property and costly suppression activities.

Colorado's forested lands are experiencing severe impacts from continuing population increases and peoples' desire to escape urban pressures. Subdivisions and developments are opening new areas for homesite construction at an alarming rate, especially along the Front Range and around recreational areas such as Dillon, Vail, and Steamboat Springs.

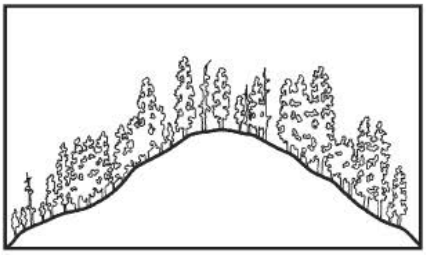
But with development inevitably comes a higher risk of wildfire as well as an ever-increasing potential for loss of life and property. Methods of fire suppression, pre-suppression needs, and homeowner and fire crew safety must all be considered in the planning and review of new developments as well as for the "retrofitting" of existing, older subdivisions.

Fuelbreaks should be considered in fire management planning for subdivisions and developments; however, the following are guidelines **only**. They should be customized to local areas by professional foresters experienced in Rocky Mountain wildfire behavior and suppression tactics.

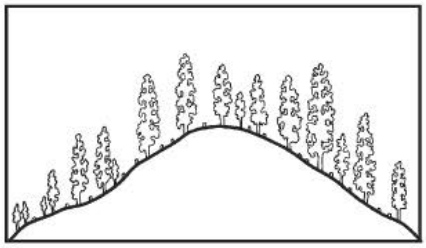
Fuelbreak vs Firebreak

Although the term fuelbreak is widely used in Colorado, it is often confused with firebreak. The two are entirely separate, and aesthetically different, forms of forest fuel modification and treatment.

• A firebreak is strip of land, 20 to 30 feet wide (or more), in which all vegetation is removed down to bare, mineral soil each year prior to fire season.



Above, cross section of mixed conifer stand before fuelbreak modification. Below, after modification.



• A fuelbreak (or shaded 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. The stand is thinned, and remaining trees are pruned to remove ladder fuels. Brush, heavy ground fuels, snags, and dead trees are disposed of and an open, park-like appearance is established.

The following is a discussion of the uses, limitations, and specifications of fuelbreaks in wildfire control and fuels management.

Fuelbreak Limitations

Fuelbreaks provide quick access for wildfire suppression. Control activities can be conducted more safely due to low fuel volumes. Strategically located, they break up large, continuous tracts of dense timber, thus limiting uncontrolled spread of wildfire.

Fuelbreaks can aid firefighters greatly by slowing fire spread under normal burning conditions. However, under extreme conditions, even the best fuelbreaks stand little chance of arresting a large

Before and after photos of a forest stand thinned to reduce fuel loads.

fire, regardless of firefighting efforts. Such fires, in a phenomenon called "spotting," can drop firebrands 1/8-mile or more ahead of the main fire, causing very rapid fire spread. These types of large fires may continue until there is a major change in weather conditions, topography, or fuel type.

It is critical to understand: A fuelbreak is the line of defense. The area (including any homes and developments) between it and the fire may remain vulnerable.

In spite of these somewhat gloomy limitations, fuelbreaks have proven themselves effective in Colorado. During the 1980 Crystal Lakes Subdivision Fire near Fort Collins, crown fires were stopped in areas with fuelbreak thinnings, while other areas of dense lodgepole pine burned completely. A fire at O'Fallon Park in Jefferson County was successfully stopped and controlled at a fuelbreak. The Buffalo Creek Fire in Jefferson County (1996) and the High Meadow Fire in Park and Jefferson Counties (2000) slowed dramatically wherever intense forest thinnings had been completed. During the 2002 Hayman Fire, Denver Water's entire complex of offices, shops and caretakers' homes at Cheesman Reservoir were saved by a fuelbreak with no firefighting intervention by a fuelbreak.

Burned area near Cheesman Reservoir as a result of the Hayman Fire. Note the unburned green trees in the middle right of the photo, a treated fuelbreak.

The Need For A Fuelbreak

Several factors determine the need for fuelbreaks in forested subdivisions, including: (1) potential problem indicators; (2) wildfire hazard areas; (3) slope; (4) topography; (5) crowning potential; and (6) ignition sources.

Potential Problem Indicator

The table below explains potential problem indicators for various hazards and characteristics common to Colorado's forest types. All major forest types, except aspen, indicate a high potential for wildfire hazard.

Fuel Type	Characteristics			Hazards			
	Aesthetics	Wildlife	Soil	**Wildfire**	Avalanche	Flood	Climate
Aspen	2	3	3	**2**	4	3	2
Douglas-fir	2	2	3	**5**	2	2	3
Greasewood-Saltbrush	4	2	2	**2**	1	3	3
Limber-Bristlecone Pine	3	2	4	**3**	4	2	5
Lodgepole Pine	2	2	3	**5**	4	2	4
Meadow	5	4	4	**2**	3	4	3
Mixed Conifer	2	1	1	**5**	3	1	3
Mountain Grassland	5	3	4	**3**	3	2	4
Mountain Shrub	3	5	4	**4**	2	2	3
Piñon-Juniper	2	3	4	**4**	2	3	2
Ponderosa Pine	2	3	1	**5**	2	2	3
Sagebrush	4	4	3	**3**	3	2	3
Spruce-Fir	2	3	3	**4**	5	**3**	4

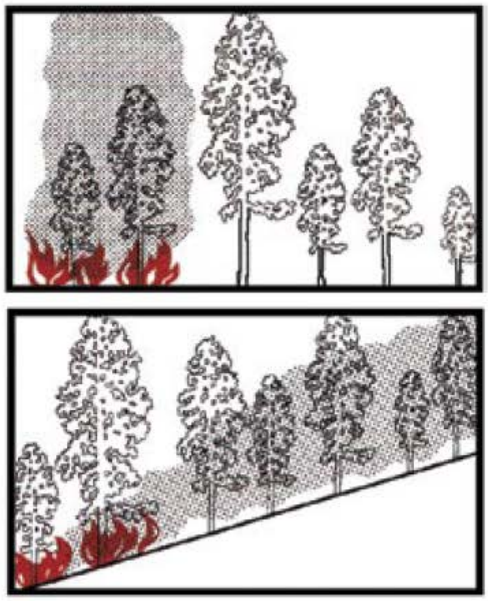
Legend: 5 – Problem may be crucial; 4 – Problem very likely;
3 – Exercise caution; 2 – Problem usually limited;
1 – No rating possible

Wildfire Hazard Maps

The Colorado State Forest Service (CSFS), numerous counties and some National Forests have completed wildfire hazard mapping for many areas within Colorado, particularly along the Front Range. These maps typically consider areas with 30 percent or greater slope; hazardous fuel types; and hazardous topographic features such as fire chimneys. Wildfire Hazard Ratings may be depicted in several ways. Whatever system is used, areas rated moderate or higher should be considered for fuel modification work.

Slope

Rate of fire spread increases as the slope of the land increases. Fuels are preheated by the rising smoke column or they may even come into contact with the flames themselves.



Fire effects, flat vs steep terrain. Note preheating of fuels on steep ground from passage of smoke column.

At 30 percent slope, rate of fire spread doubles compared to rates at level ground, drastically reducing firefighting effectiveness. **Areas near 30 percent or greater slopes are critical and must be reviewed carefully.**

Topography

Certain topographic features influence fire spread and should be evaluated. Included are fire chimneys, saddles, and V-shaped canyons. They are usually recognized by reviewing standard U.S.G.S. quad maps.

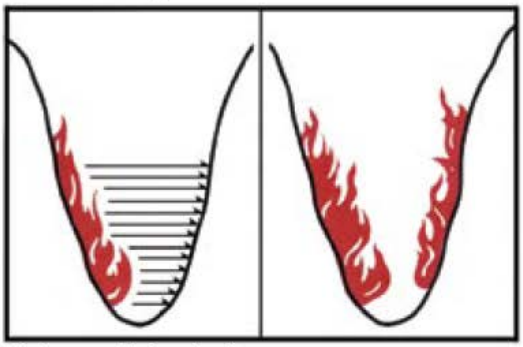
• Chimneys are densely vegetated drainages on slopes greater than 30 percent. Wind, as well as air pre-heated by a fire, tends to funnel up these drainages, rapidly spreading fire upslope.

• Saddles are low points along a main ridge or between two high points. Like chimneys, they also funnel winds to create a natural fire path during a fire's uphill run. Saddles act as corridors to spread fire into adjacent valleys or drainages.

Chimney.

Saddle.

• Narrow, V-shaped valleys or canyons can ignite easily due to heat radiating from one side to the other. For example, a fire burning on one side of a narrow valley dries and preheats fuels on the opposite side until the fire "flashes over." The natural effect of slope on fire then takes over and fire spreads rapidly up drainage and uphill along both sides of the valley.



Flashover in V-shaped valley.

Crowning Potential

An on-site visit is required to accurately assess crowning potential. A key, below, helps determine this rating. Fuel modification is usually unnecessary if an area has a rating of 3 or less.

Crowning Potential Key

	Rating
A. Foliage present, trees living or dead — B	
B. Foliage living — C	
C. Leaves deciduous or, if evergreen, usually soft, pliant, and moist; never oily, waxy, or resinous.	0
CC. Leaves evergreen, not as above — D	
D. Foliage resinous, waxy, or oily — E	
E. Foliage dense — F	
F. Ladder fuels plentiful — G	
G. Crown closure > 75 percent	9
GG. Crown closure < 75 percent	7
FF. Ladder fuels sparse or absent — H	
H. Crown closure > 75 percent	7
HH. Crown closure < 75 percent	5
EE. Foliage open — I	
I. Ladder fuel plentiful	4
II. Ladder fuel sparse or absent	2
DD. Foliage not resinous, waxy, or oily — J	
J. Foliage dense — K	
K. Ladder fuels plentiful — L	
L. Crown closure > 75 percent	7
LL. Crown closure < 75 percent	4
KK. Ladder fuels sparse or absent — M	
M. Crown closure > 75 percent	5
MM. Crown closure < 75 percent	3
JJ. Foliage open — N	
N. Ladder fuels plentiful	3
NN. Ladder fuels sparse or absent	1
BB. Foliage dead	0

The majority of dead trees within the fuelbreak should be removed. Occasionally, large, dead trees (14 inches or larger in diameter at 4 1/2 feet above ground level) may be retained as wildlife trees. If retained, all ladder fuels must be cleared from around the tree's trunk.

Ignition Sources

Possible ignition sources, which may threaten planned or existing developments, must be investigated thoroughly. Included are other developments and homes, major roads, recreation sites, railroads, and other possible sources. These might be distant from the proposed development, yet still able to channel fire into the area due to slope, continuous fuels, or other topographic features.

Fuelbreak Locations

In fire suppression, an effective fire line is connected, or "anchored," to natural or artificial fire barriers. Such anchor points might be rivers, creeks, large rock outcrops, wet meadows, or a less flammable timber type such as aspen. Similarly, properly designed and constructed fuelbreaks take advantage of these same barriers to eliminate "fuel bridges." (Fire often escapes control because of fuel bridges that carry the fire across control lines.)

Since fuelbreaks should normally provide quick, safer access to defensive positions, they are necessarily linked with road systems. Connected with county-specified roads within subdivisions, they provide good access and defensive positions for firefighting equipment and support vehicles. Cut-and fill slopes of roads are an integral part of a fuelbreak as they add to the effective width of modified fuels.

Fuelbreaks without an associated road system, such as those located along strategic ridge lines, are still useful in fire suppression. Here, they are often strengthened and held using aerial retardant drops until fire crews can walk in or be ferried in by helicopter.

Preferably, fuelbreaks are located along ridge tops to help arrest fires at the end of their runs. However, due to homesite locations and resource values, they can also be effective when established at the base of slopes. Mid-slope fuelbreaks are least desirable, but under certain circumstances and with modifications, these too, may be valuable.

Fuelbreaks are located so that the area under management is broken into small, manageable units. Thus, when a wildfire reaches modified fuels, defensive action is more easily taken, helping to keep the fire small. For example, a plan for a subdivision might recommend that fuelbreaks break up continuous forest fuels into units of 10 acres or less. This is an excellent plan, especially if defensible space thinnings are completed around homes and structures, and thinning for forest management and forest health are combined with the fuelbreak.

When located along ridge tops, continuous length as well as width are critical elements. Extensive long-range planning is essential in positioning these types of fuelbreaks.

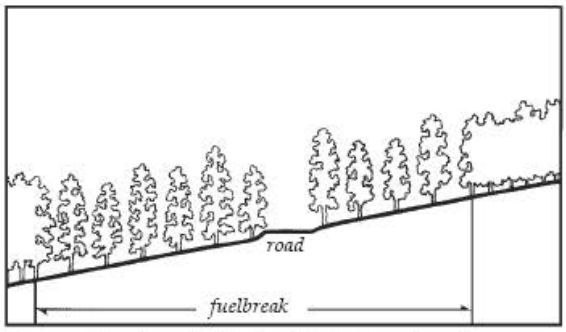
Aesthetics

Improperly planned fuelbreaks can adversely impact an area's aesthetic qualities. Careful construction is necessary when combining mid-slope fuelbreaks with roads involving excessive cut-and-fill.

These photos, far- and near- views of the same site, illustrate that forest can be thinned without impacting aesthetics.

Care must also be taken in areas that are not thinned throughout for fuel hazard reduction. In such cases the fuelbreak visually sticks out like a "sore thumb" due to contrasting thinned and unthinned portions of the forest. (Especially noticeable are those portions of the fuelbreak above road cuts).

These guidelines are designed to minimize aesthetic impacts. However, some situations may require extensive thinning and, thus, result in a major visual change to an area. Additional thinning beyond the fuelbreak may be necessary to create an irregular edge and to "feather," or blend, the fuelbreak thinning into the unthinned portions of the forest. Any thinning beyond the fuelbreak improves its effectiveness and is highly recommended.



Cross-section of a typical fuelbreak built in conjunction with a road.

Constructing the Fuelbreak

Fuelbreak Width and Slope Adjustments

Note: Since road systems are so important to fuelbreak construction, the following measurements are from the toe of the fill for downslope distances, and above the edge of the cut for uphill distances.

The minimum recommended fuelbreak width is approximately 300 feet for level ground. Since fire activity intensifies as slope increases, the overall fuelbreak width must also increase. However, to minimize aesthetic impacts and to maximize fire crew safety, the majority of the increases should be made at the bottom of the fuelbreak, below the road cut.

Widths are also increased when severe topographic conditions are encountered. Guidelines for fuelbreak widths on slopes are given below:

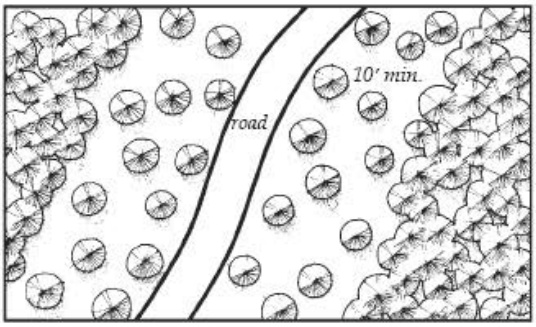
Fuelbreak Width/Slope

Percent Slope (%)	Minimum Uphill Distance (ft)	Minimum Downhill Distance (ft)	Total Width of Modified fuels (ft)*
0	150	150	300
10	140	165	303
20	130	180	310
30	120	195	315
40	110	210	320
50	100	225	325
60	100	240	340

*As slope increases, total distance for cut-and-fill for road construction rapidly increases, improving fuelbreak effective width.

Stand Densities

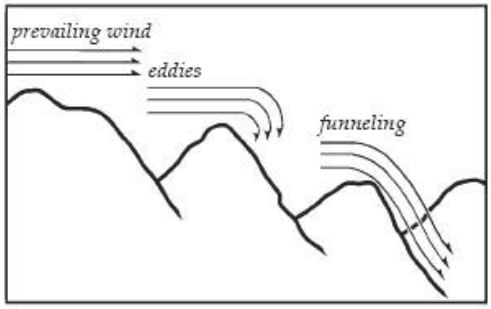
Crown separation is a more critical factor for fuelbreaks than a fixed tree density level. A *minimum* 10-foot spacing between the edges of tree crowns is recommended on level ground. As slope increases, crown spacing should also increase. However, small, isolated groups of trees may be retained for visual diversity. Increase crown spacing around any groups of trees left for aesthetic reasons and to reduce fire intensities and torching potential.



Plan view of fuelbreak showing minimum distance between tree crowns.

In technical terms, a fuelbreak thinning is classified as a heavy "sanitation and improvement cut, from below." Within fuelbreaks, trees that are suppressed, diseased, deformed, damaged, or of low vigor are removed along with all ladder fuels. Remaining trees are the largest, healthiest, most wind-firm trees from the dominant and co-dominant species of the stand.

Because such a thinning is quite heavy for an initial entry into a stand, prevailing winds, eddy effects, and wind funneling must be carefully evaluated to minimize the possibility of windthrow. It may be necessary to develop the fuelbreak over several years to allow the timber stand to "firm-up" — this especially applies to lodgepole pine and Engelmann spruce stands.



Topography affects wind behavior – an important consideration during fuelbreak construction.

Area-wide forest thinnings are recommended for any subdivisions. Such thinning is not as severe as a fuelbreak thinning, but generally should be completed to fuelbreak specifications along the roads (as outlined on page 6.) In addition, "defensible space thinnings" are highly recommended around all structures (see CSU Coop. Extension Fact sheet 6.302, *Creating Wildfire-Defensible Zones*).

Debris Removal

Limbs and branches left from thinning (slash) can add significant volumes of fuel to the forest floor, especially in lodgepole pine, mixed-conifer, or spruce/fir timber types. These materials can accumulate and serve as ladder fuels, or can become "jackpots," increasing the difficulty of defending the fuelbreak during a wildfire. **Slash decomposes very slowly in Colorado and proper disposal is essential.** Proper treatment reduces fire hazard, improves access for humans and livestock, encourages establishment of grasses and other vegetation, and improves aesthetics.

Three treatment methods are commonly used. These are lopping-and-scattering, piling and burning, and chipping. Mulching of small trees and slash using equipment similar to Hydro-axes or Timbcos equipped with mulching heads are becoming a popular method of treatment. Size, amount, and location of slash dictates the method used, in addition to cost and the final desired appearance. The method chosen will also depend on how soon an effective fuelbreak is needed prior to construction in new developments.

Lop and scatter: slash should be no deeper than 12" above ground surface.

Chipping is the most desirable, but also the most expensive method of slash disposal.

Piled slash can be burned but only during certain conditions, such as after a snowfall.

Fuelbreak Maintenance

Following initial thinning, trees continue to grow (usually at a faster rate). The increased light on the forest floor encourages heavy grass and brush growth where, in many cases, where little grew before. The site disturbance and exposed mineral soil created during fuelbreak development is a perfect seed bed for new trees that, in turn, create new ladder fuels. Thus, in the absence of maintenance, fuelbreak effectiveness will decrease over time.

Fuelbreak maintenance is essential. Ingrowth, shown above, will minimize the effectiveness of this fuelbreak within a few years.

Fuelbreak maintenance problems are most often the result of time and neglect. Misplaced records, lack of follow-up and funding, and apathy caused by a lack of fire events are some of the major obstacles. In addition, the responsibility for fuelbreak maintenance projects is often unclear. For example, control of a fuelbreak completed by a developer passes to a homeowner's association, usually with limited funds and authority to maintain fuelbreaks.

If fuelbreak maintenance is not planned and completed as scheduled, consider carefully whether the fuelbreak should be constructed. An un-maintained fuelbreak may lead to a false sense of security among residents and fire suppression personnel.

Conclusion

An image of well-designed communities for Colorado includes:

- Forested subdivisions where the total forest cover is well-managed through carefully planned, designed, and maintained thinnings. This contributes to reduced wildfire hazards and a much healthier forest — one that is more resistant to insects and disease.
- A system of roads and driveways with their associated fuelbreaks that break up the continuity of the forest cover and fuels. These help keep fires small, while also providing safer locations from which to mount fire suppression activities. In addition to allowing fire personnel in, they will allow residents to evacuate if necessary.
- Individual homes that all have defensible space around them, making them much easier to defend and protect from wildfire, while also protecting the surrounding forest from structure fires.

Creation of such communities is entirely feasible if recognition of the fire risks, a spirit of cooperation, an attitude of shared responsibility, and the political will exists.

Colorado's mountains comprise diverse slopes, fuel types, aspects, and topographic features. This variety makes it impossible to develop general fuelbreak prescriptions for all locations. ***The previous recommendations are guidelines only.*** *A professional forester with fire suppression expertise should be consulted to "customize" fuelbreaks for particular areas.*