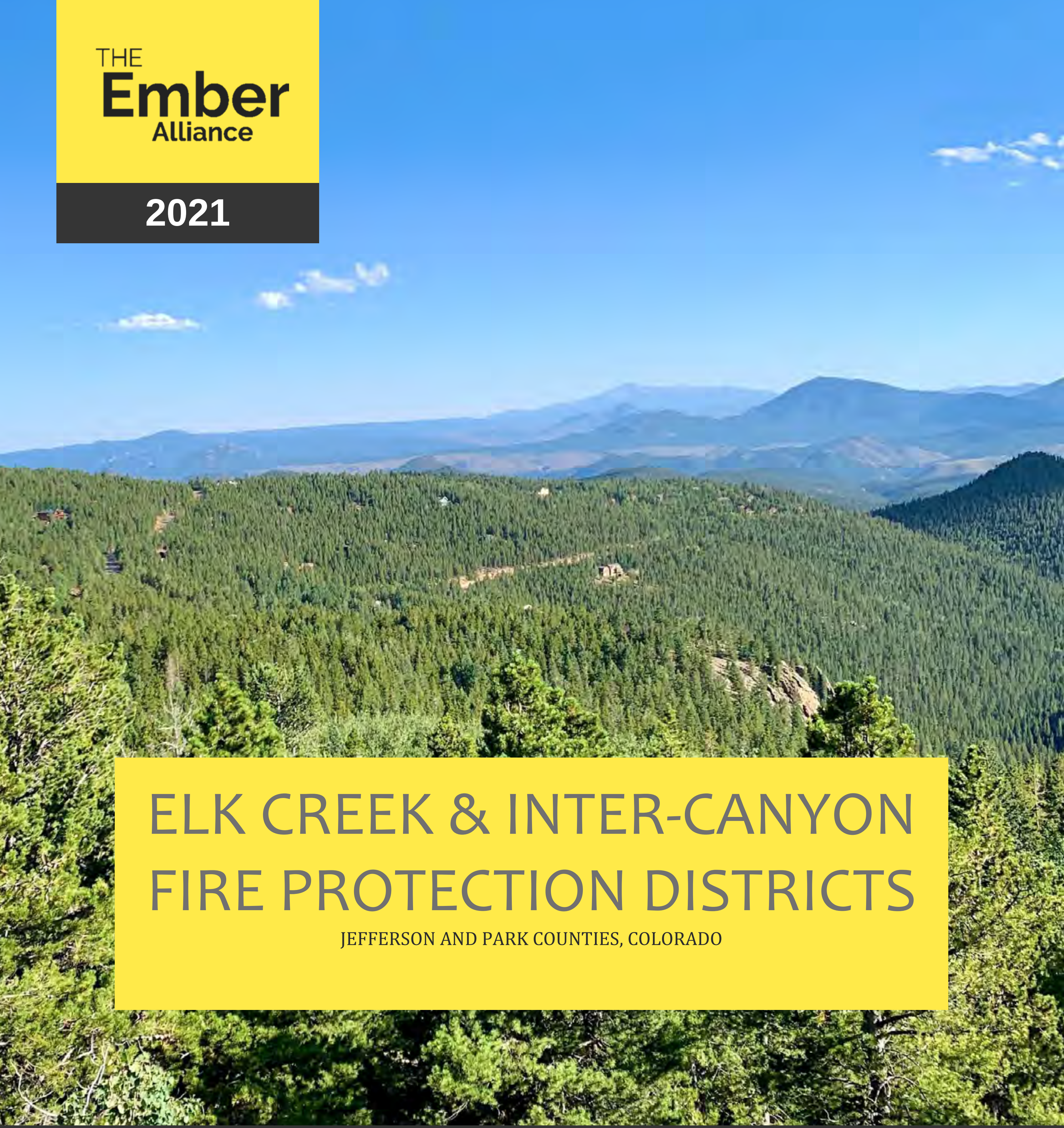
THE Ember Alliance

2021



ELK CREEK & INTER-CANYON FIRE PROTECTION DISTRICTS

JEFFERSON AND PARK COUNTIES, COLORADO

Community Wildfire Protection Plan

Elk Creek & Inter-Canyon Fire Protection Districts Community Wildfire Protection Plan 2021 Update

Prepared for Elk Creek & Inter-Canyon Fire Protection Districts

11993 Blackfoot Rd, Conifer, CO 80433

Prepared by *The Ember* Alliance

170 2nd Street SW, Loveland, CO 80537

APPROVAL AND SIGNATURES

This Community Wildfire Protection Plan (CWPP) was developed in response to the Healthy Forest Restoration Act of 2003 and complies with CWPP standards set forth by the Colorado State Forest Service in 2009. The CWPP is a collaborative effort to guide our wildfire protection. Where possible, we intend to apply the recommended practices to improve our community and increase public safety.

This CWPP is a voluntary, recommended plan and imposes no obligations of the signatories. Executing this document in no way obligates the Elk Creek or Inter-Canyon Fire Protection Districts to take any action requiring the commitment of funds to accomplish the recommendations presented herein.

The following individuals and organizations were engaged in developing the Elk Creek and Inter-Canyon CWPP and approve the 2022 update:

Skip Shirlaw, Chief Inter-Canyon Fire Protection District	2-17-2022 Date	Jacob Ware, Chief Elk Creek Fire Protection District	02/17/2022 Date
Hal Grieb, Director of Emergency Management Jefferson County Sherriff's Office	4/8/22 Date	Brian Banks, District Ranger United States Forest Service	4/6/2022 Date
Allan Gallamore, Supervisory Forester Colorado State Forest Service	3-14-2022 Date		

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How to use this CWPP Document

This document is designed for everyone that lives, works, and manages land within and around the Elk Creek and Inter-Canyon Fire Protection Districts. Different sections will be most helpful to different people; please use this guide to direct you to the resources most relevant to you.

I want to learn the basics about wildfires, my local fire districts, and what a CWPP is.	**Look for:** • Section 1.a to learn about CWPPs • Section 1.c to learn about wildfires • Section 2 to learn about your local fire districts • Section 3.a to learn what your next steps can be
I'm a resident/homeowner and want to learn about protecting my family, home, and property from wildfires.	**Look for:** • Section 2.d to understand why action is important now • Section 3.a to learn about the actions you can take • Section 4.b to find detailed recommendations and research-backed guidance for protecting your home
I want to learn about community-lead wildfire mitigation actions for neighborhoods or HOAs.	**Look for:** • Section 3.b to learn about the actions communities can take together to better protect everyone • Section 4.b to find detailed ratings and recommendations for your neighborhood
I'm with a government agency or cross-boundary organization and want to learn about landscape-scale wildfire mitigation .	**Look for:** • Section 2.e and 2.f to learn about fire history and treatment history in the area • Section 3.c to learn about community-wide recommendations for large organizations • Section 4.a to learn about treatment objectives for this area • Section 4.c to learn about stand-level fuel treatment priorities and recommendations • Section 4.d to learn about roadway treatment priorities and recommendations
I want to learn about the science behind these recommendations and how priorities were made.	**Look for:** • Appendix A to learn about modelling methodology for fire behavior and evacuations • Appendix B to learn about prioritization for plan units, stand treatments, and roadway treatments

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Acronyms

EC & IC FPD	Elk Creek and Inter-Canyon Fire Protection Districts
CSFS	Colorado State Forest Service
CWPP	Community Wildfire Protection Plan
DFPC	Division of Fire Prevention and Control
ECFPD	Elk Creek Fire Protection District
ERC	Energy Release Component
EVT	Existing Vegetation Type
FAC	Fire Adapted Community
HIZ	Home Ignition Zone
HOA	Homeowner's Association
ICFPD	Inter-Canyon Fire Protection District
IIBHS	Insurance Institute for Business & Home Safety
IRPG	Incident Response Pocket Guide
ISO	Insurance Services Office
JCSO	Jefferson County Sherriff's Office
NFPA	National Fire Protection Association
NWCG	National Wildfire Coordinating Group
RAWS	Remote Automatic Weather Stations
TEA	The Ember Alliance
USFS	U.S. Forest Service
WUI	Wildland-Urban Interface

For definitions of the words and phrases used throughout this document, refer to the Glossary.

1. Introduction

1.a. Purpose and Need for a Community Wildfire Protection Plan

Community Wildfire Protection Plans (CWPPs) help communities assess local hazards and identify strategic investments to mitigate risk and promote preparedness (**Figure 1.a.1**). Assessments and discussions during the planning process can assist fire protection districts with fire operations in the event of a wildfire and help residents prioritize mitigation actions. These plans also assist with funding gaps for fuel mitigation projects since many grants require an approved CWPP.

Figure 1.a.1. Elements of a holistic and actionable CWPP.

In 2021 the Elk Creek Fire Protection District (ECFPD) and the Inter-Canyon Fire Protection District (ICFPD) began working toward more collaboration between districts. The 2021 Elk Creek & Inter-Canyon CWPP is a complete update and combination of the plans previously created for ECFPD in 2005 and ICFPD in 2007 and addresses the changing landscape and takes advantage of advances in fire science. It includes a wildfire risk analysis, prioritization of mitigation activities, and implementation recommendations. This document is a tool for the fire district, land managers, residents, communities, and homeowner's associations (HOAs) to begin prioritizing projects that make EC & IC FPDs a safer and more resilient community to wildfire.

The objectives of this project were:

- Produce an actionable CWPP based on robust analyses of fuel hazards, burn probability, evacuation routes, and community values across the fire district.
- Provide recommendations, including prioritization, for reducing fire hazards, hardening homes, and increasing evacuation safety.
- Engage community members during the CWPP process to address local needs and concerns.
- Set the stage for planning and implementation within CWPP plan units to mitigate hazards and promote community preparedness.
- Create strategic and tactical maps to increase community preparedness and safety of firefighters and residents.

This CWPP is a call to action. EC & IC FPDs share some risk factors common to past catastrophic wildfires across the country. The 2021 CWPP provides an assessment of wildfire risk in the EC & IC FPDs and includes suggestions for residents, community leaders, and emergency responders to mitigate risk and enhance community safety.

ICFPD Station 1, headquarters for Inter-Canyon Fire Protection District. Photo from ICFPD.

1.b. Partners

Collaboration is an essential part of CWPPs. Community engagement, partner commitment, and follow through are what make a CWPP successful. The Ember Alliance (TEA)—a Colorado nonprofit dedicated to fire management and community engagement—worked with EC & IC FPDs to write the CWPP. TEA and representatives from EC & IC FPD engaged stakeholders from across the district and neighboring districts to develop the recommendations set forth in this CWPP. They incorporated lessons learned from the challenging 2020 wildfire season in Colorado and considered valuable insights shared by community members and other stakeholders.

TEA and EC & IC FPDs would like to thank the following partners for their time and effort in developing, providing data, providing feedback, and planning implementation projects for this CWPP:

- Colorado Forest Restoration Institute
- Colorado State Forest Service
- Colorado Parks and Wildlife from Staunton State Park
- CORE Electric Cooperative (formerly IREA)
- Denver Mountain Parks
- Denver Water
- Elk Creek & Inter-Canyon Fire Protection Districts Community Ambassadors
- Jefferson Conservation District
- Jefferson County Office of Emergency Management
- Jefferson County Open Space
- Pike-San Isabel National Forest

1.c. Introduction to Wildfire Behavior and Terminology

Many aspects of wildfires are predictable based on known scientific research on the physical processes driving fire. Much of the work in this CWPP is based on scientific research and computer models of wildfire behavior. A basic understanding of fire behavior aids in interpreting the findings and recommendations reported herein. See the **Glossary** at the end of the CWPP for the definition of key terms.

Fire Behavior Triangle

Complex interactions among wildland fuels, weather, and topography determine how wildfires behave and spread. These three factors make up the sides of the fire behavior triangle (**Figure 1.c.1**), and they are the variables that wildland firefighters pay attention to when assessing potential wildfire behavior during an incident (NWCG 2019).

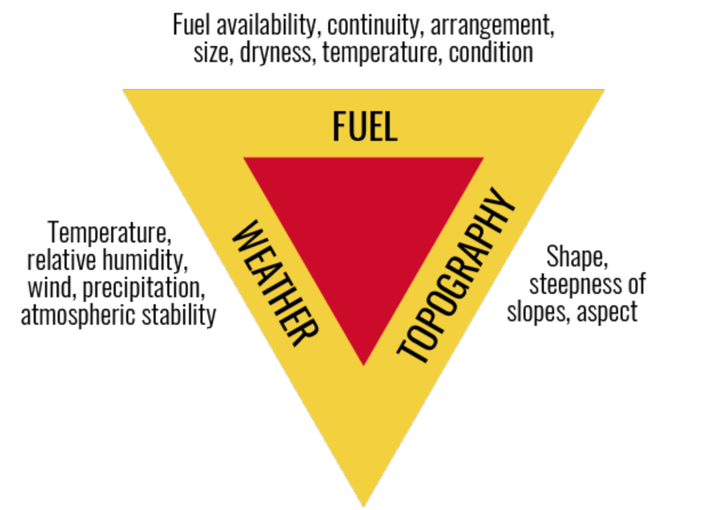


Figure 1.c.1. Interactions between fuels, weather, and topography dictate fire behavior (source: California State University).

Fuels

Fuels include live vegetation such as trees, shrubs, and grasses, dead vegetation like pine needles and cured grass, and materials like houses, sheds, fences, trash piles, and combustible chemicals.

Grasses and pine needles are known as "flashy" fuels because they easily combust and burn the fastest of all fuel types. If you think of a campfire, flashy fuels are the kindling that you use to start the fire. Flashy fuels dry out faster than other fuel types when relative humidity drops or when exposed to radiant and convective heat[1]. Fires in grassy fuel types can be more predictable and easier for firefighters to control, but grassland fires can quickly spread across large areas.

Shrubs, small trees, and downed branches dry out slower than flashy fuels, release more radiant heat when they burn, and take longer to completely combust. The rate of spread is fast to moderate through shrublands depending on their moisture content, and long flame lengths can preclude direct attack by firefighters. Shrubs and small trees can also act as ladder fuels that carry fire from the ground up into the tree canopy.

Large living trees, dead trees (aka, snags), and large downed logs are called "heavy fuels", and they take the longest to dry out when relative humidity drops and when exposed to radiant and convective heat. Heavy fuels release tremendous radiant heat when they burn, and they take longer to completely combust, just like a log on a campfire. Fire spread through a forest is slower than in a grassland or shrubland, but forest fires release more heat and can be extremely difficult and unsafe for firefighters to suppress. An abundance of dead trees killed by drought, insects, or disease can exacerbate fire behavior, particularly when dead trees still have dry, red needles (Moriarty and others 2019; Parsons and others 2014).

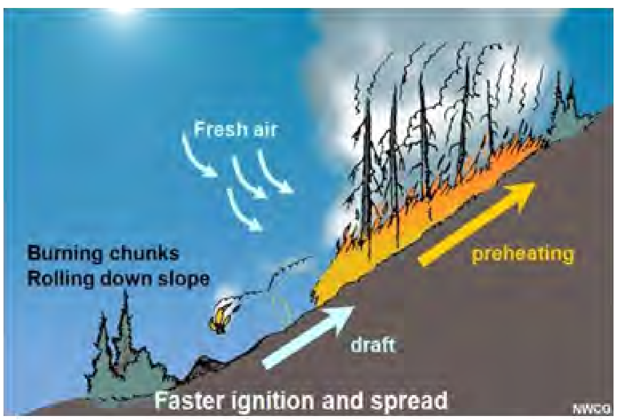
[1]See the **Glossary** at the end of the CWPP for definitions of heat transfer methods.

Topography

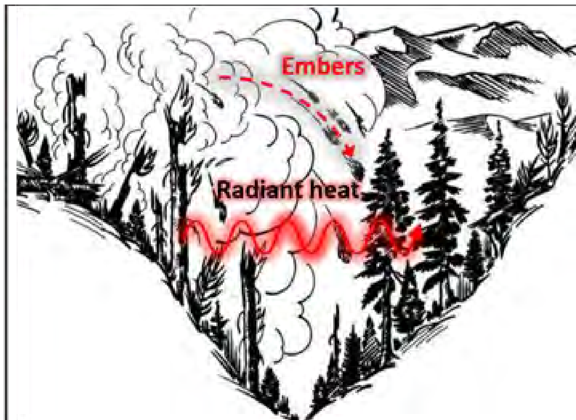
Topography (slope and aspect) influences fire intensity, speed, and spread. In the northern hemisphere, north-facing slopes experience less sun exposure during the day, resulting in higher fuel moistures. Tree density is often higher on north-facing slopes due to higher soil moisture. South-facing slopes experience more sun exposure and higher temperatures and are often covered in grasses and shrubs. The hotter and drier conditions on south-facing slopes mean fuels are drier and more susceptible to combustion, and the prevalence of flashy fuels results in fast rates of fire spread.

Fires burn more quickly up steep slopes due to radiant and convective heating. Fuels are brought into closer proximity with the progressing fire, causing them to dry out, preheat, and become more receptive to ignition, thereby increasing rates of spread. Steep slopes also increase the risk of burning material rolling and igniting unburnt fuels below (**Figure 1.c.2**).

Narrow canyons and gorges[2] can experience increased combustion because radiant heat from fire burning on one side of the canyon can heat fuel on the other side of the canyon. Embers can easily travel from one side of a canyon to the other (**Figure 1.c.2**). Topography also influences wind behavior and can make fire spread unpredictable. Wildfires burning through steep and rugged topography are harder to control due to reduced access for firefighters and more unpredictable and extreme fire behavior.



Slope increases fire spread through radiant and convective heating (source: NWCG).



Fires can easily cross narrow canyons (source: U.S. Forest Service).

Figure 1.c.2. Steep slopes and topographic features such as narrow canyons exacerbate fire behavior and fire effects.

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[2] Canyons are long, deep, and very steep-sided topographic features primarily cut into bedrock and often containing a perennial stream at the bottom. A gorge is a narrow, deep valley with nearly vertical and rocky walls, being smaller than a canyon and more steep-sided than a ravine. [There are no canyons or gorges within the EC & IC FPD, but there are draws and ravines that have relatively steep slopes and can increase fire spread through radiant and convective heating.] Draws and ravines are created when a watercourse cuts into unconsolidated materials. Draws generally have a broader floor and more gently sloping sides than a ravine (NRCS 2017).

Weather

Weather conditions that impact fire behavior include temperature, relative humidity, precipitation, lightning activity, and wind speed and direction. The National Weather Service uses a system called a Red Flag Warning to indicate local weather conditions that can combine to produce increased risk of fire danger and behavior. Red flag warning days indicate increased risk of extreme fire behavior due to a combination of hot temperatures, very low humidity, dry fuels, strong winds, and the presence of thunderstorms (**Table 1.c.1**).

Direct sunlight and hot temperatures can preheat fuels and bring them closer to their ignition point. When relative humidity is low, the dry air can absorb moisture from fuels, especially flashy fuels, making them more susceptible to ignition. Long periods of dry weather can dehydrate heavier fuels, including downed logs, increasing the risk of wildfires in areas with heavy fuel loads.

Wind influences fire behavior by drying out fuels (think how quickly your lips dry out in windy weather), increasing the amount of oxygen feeding the fuel, preheating vegetation through convective heat, and carrying embers more than a mile ahead of an active fire. Complex topography, such as chutes, saddles, and draws, can funnel winds in unpredictable directions, increasing wind speeds and resulting in erratic fire behavior.

Table 1.c.1. Red flag days are warnings issued by the National Weather Service using criteria specific to a region.

National Weather Service – Denver/Boulder Forecast Office Red Flag Warning Criteria	
Option 1	Option 2
Relative humidity less than or equal to 15%	Widely scattered dry thunderstorms
Wind gusts greater than or equal to 25 mph	Dry fuels
Dry fuels	

Strong, gusty wind contributed to rapid growth of the 2020 East Troublesome Fire in Colorado (photo by Jessy Ellenberger, Associated Press).

Categories of Fire Behavior

Weather, topography, and fuels influence fire behavior, and fire behavior in turn influences the tactical options available for wildland firefighters and the risks posed to lives and property. There are three general categories of fire behavior described throughout this CWPP: surface fire, passive crown fire, and active crown fire (**Figure 1.c.3**).

- **Surface fire –** Fire that burns fuels on the ground, which include dead branches, leaves, and low vegetation. Surface fires can be addressed with direct attack using handcrews when flame lengths are less than four feet and with equipment when flame lengths are less than eight feet. Surface fires can emit significant radiant heat, which can ignite nearby vegetation and homes.
- **Passive crown fire –** Fire that arises when surface fire ignites the crowns of trees or groups of trees (aka, torching). Torching trees reinforce the rate of spread, but passive crown fires travel along with surface fires. Firefighters can sometimes address passive crown fires with indirect attack, such as dropping water or retardant out of aircraft or digging fireline at a safe distance from the flaming front. The likelihood of passive crown fire increases when trees have low limbs and when smaller trees and shrubs grow below tall trees and act as ladder fuels. Radiant heat and ember production from passive crown fires can threaten homes during wildfires.
- **Active crown fire –** Fire in which a solid flame develops in the crowns of trees and advances from tree crown to tree crown independently of surface fire spread. Crown fires are very difficult to contain, even with the use of aircraft dropping fire retardant, due to long flame lengths and tremendous release of radiant energy. The likelihood of active crown fires increases when trees have interlocking canopies. Radiant heat and ember production from active crown fires can threaten homes during wildfires.

Passive and active crown fires can result in short- and long-range ember production that can create spot fires and ignite homes. Spot fires are particularly concerning because they can form a new flaming front, move in unanticipated directions, trap firefighters between two fires, and require additional firefighting resources to control. Crown fires are generally undesirable in the wildland-urban interface (WUI, see **Wildland-Urban Interface**) because of the risk to lives and property; however, passive and active crown fires are part of the natural fire regime for some forest types and result in habitat for plant and animal species that require recently disturbed conditions (Keane and others 2008; Pausas and Parr 2018). Passive and active crown fires historically occurred in some lodgepole pine forests and higher-elevation ponderosa pine and mixed-conifer forests on north-facing slopes (Romme 1982; Addington and others 2018).

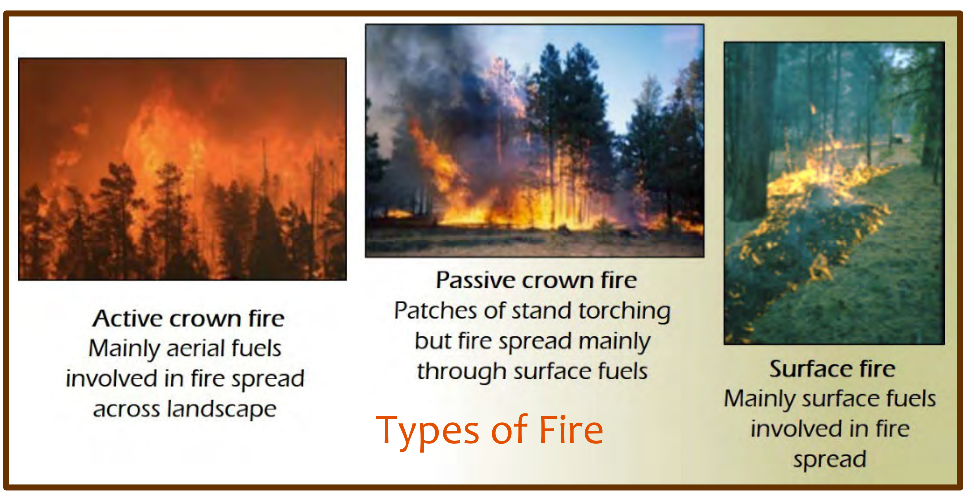

Figure 1.c.3. Active crown fire, passive crown fire, and surface fire are common types of fire behavior.

Wildfire Threats to Homes

Every year, wildfires result in billions of dollars in fire suppression costs and destroy thousands of homes across the United States. Some of the most destructive, deadly, and expensive wildfires in the have occurred in the past several years, partly due to expansion of the wildland-urban interface (WUI) and more severe fire weather perpetuated by climate change (Caton and others 2016).

Wildfires can ignite homes through several pathways: radiant heat, convective heat, and direct contact with flames or embers. The ability for radiant heat to ignite a home is based on the properties of the structure (i.e., wood, metal, or brick siding), the temperature of the flame, the ambient air temperature, and distance from the flame (Caton and others 2016). Ignition from convective heat is more likely for homes built along steep slopes and in ravines and draws. For flames to ignite a structure, they must directly contact the building long enough to cause ignition. Flames from a stack of firewood near a home could cause ignition to the home, but flames that quickly burn through grassy fuels are less likely to ignite the home (although the potential still exists). Some housing materials can burn hotter than the surrounding vegetation, thereby exacerbating wildfire intensity and initiating home-to-home ignition (Mell and others 2010).

Homes built mid-slope and at the top of steep slopes and within ravines and draws are at greater risk of convective heat from wildfires. A wildfire could rapidly spread up this steep, shrubby slope and threaten the home above.

Homes can be destroyed during wildfires even if surrounding vegetation has not burned. During many wildland fires, 50 to 90% of homes ignite due to embers rather than radiant heat or direct flame (Babrauskas 2018; Gropp 2019). Embers can ignite structures when they land on roofs, enter homes through exposed eaves, or get under wooden decks. Embers can also ignite nearby vegetation and other combustible fuels, which can subsequently ignite a home via radiant heating or direct flame contact. Burning homes can release embers that land on and ignite nearby structures causing destructive home-to-home ignitions. Structural characteristics of a home can increase its exposure to embers and risk of combustion, such as wood shingle roofs and unenclosed eaves and vents (Hakes and others 2016; Syphard and Keeley 2019). Embers can also penetrate homes if windows are destroyed by radiant or convective heat. See **Section 4.b** for specific recommendations to harden your home against wildfires.

Firefighting in the WUI

One of the standard firefighter orders is to "fight fires aggressively, having provided for safety first" (NWCG 2018a). Firefighters are committed to protecting lives and property but firefighting is particularly perilous in the WUI. The firefighter community is increasingly committed to safety of wildland firefighters, which can require the difficult decision to cease structure protection when conditions become exceedingly dangerous, particularly around homes with inadequate defensible space, safety zones, and egress routes. Also, with increasing wildfire occurrence in the U.S., firefighting resources are often limited as national resources are spread thin.

High-intensity, fast-moving wildfires in the WUI can quickly overwhelm firefighting resources when homes begin igniting each other (Caton and others 2016). **Firefighters are often forced to perform structure triage to effectively allocate limited resources, and more importantly, to protect the lives of firefighters (NWCG 2018a).** The Incident Response Pocket Guide (IRPG), which is carried by all firefighters certified under the National Wildfire Coordinating Group, explicitly states, "**Do not** commit to stay and protect a structure unless a safety zone for firefighters and equipment has been identified at the structure during sizeup and triage" (NWCG 2018a).

The IRPG outlines four categories of structure triage: (1) defensible – prep and hold, (2) defensible – stand alone, (3) non-defensible – prep and leave, and (4) non-defensible – rescue drive-by (NWCG 2018a). Homes that are less ignitable, surrounded by defensible space, and safely accessible are more likely to receive the protection of firefighters and fire engines; such homes have a greater chance of being successfully defended and pose fewer hazards to the lives of firefighters.

Firefighters conduct structure triage and identify defensible homes during wildfire incidents. Categorization of homes are not pre-determined; triage decisions depend on fire behavior and wind speed due to their influence on the size of safety zones needed to keep firefighters safe. Section 4.b **Home Ignition Zone Recommendations** of this CWPP provides recommendations for how residents can increase the chance of their homes surviving wildfires and enhance the safety of wildland firefighters.

Resources for More Information on Fire Behavior

- Introduction to Fire Behavior from the National Wildfire Coordinating Group (9:57 minute video)
- The Fire Triangle from the National Wildfire Coordinating Group (7:26 minute video)
- Understanding Fire Behavior in the Wildland/Urban Interface from the National Fire Protection Association (20:51 minute video)
- Understanding Fire from California State University (website)
- S-190 Introduction to Wildland Fire Behavior Course Materials from the NWCG (PowerPoints, handouts, and videos)

2. Elk Creek & Inter-Canyon Fire Protection Districts: Background

2.a. General Description

The EC & IC FPDs oversee 154 square miles in Jefferson County and a small portion of eastern Park County. EC & IC FPD consists of two separate districts, the Elk Creek Fire Protection District and the Inter-Canyon Fire Protection District, which began to increase their level of collaboration in 2021 (**Figure 2.a.1**). The districts are located in the foothills of Colorado's Front Range, approximately 30 miles southwest of Denver.

EC & IC FPD is home to approximately 25,000 residents. Compared to the general population of the United States, EC & IC FPD residents are slightly older (38.5 vs 48 years old, respectively) and wealthier than average (annual income of $65,000 vs $130,000, respectively). Two-thirds of the residents are employed and many of them commute from the Conifer area to Golden or west Denver for work (US Census Data).

EC & IC FPDs are bordered by the Evergreen and the Indian Hills Fire Protection Districts to the north, Platte Canyon Fire Protection District to the west, North Fork Fire Protection District to the south, and the South Metro and the West Metro Fire Protection Districts to the east. They often coordinate with these districts to provide mutual aid and respond to calls near the borders of the districts.

15% of the district (approximately 13,300 acres of land) is publicly managed land. Colorado Parks and Wildlife manages Staunton State Park, and JeffCo Open Space manages Bever Ranch Park, Meyer Ranch Park, Flying J Ranch Park, Deer Creek Canyon Park, and Reynolds Park. Denver Mountain Parks manages Newton Park, Legault Mountain, Yeagge Peak, Fenders Park, Double Header Mountain, and Turkey Creek Park. Arapaho-Roosevelt National Forest manages land on the northern side of the district, and Pike-San Isabel National Forest manages land on the southern side (**Figure 2.a5**).

Elevations in the EC & IC FPD range from 5,600 to 10,700 feet above sea level. The district lies within the South Platte Watershed. More than half the district is densely forested by mixed conifer stands, with patches of ponderosa pine, lodgepole pine, and aspen spread throughout, and spruce-fir stands at the highest elevations (**Figure 2.a.2**, **Figure 2.a.3**). Black bear, elk, mountain lion, and mule deer are some of the large wildlife found in the EC & IC FPD.

Fuel loads are primarily moderate to very heavy across the district (**Figure 2.a.4**). Some areas have widely spaced trees with few ladder fuels; these areas would most likely experience surface fires with occasional passive crown fires. Other areas are densely forested on steep north-facing slopes and could experience active crown fires that would be difficult if not impossible for firefighters to contain. Grassy areas across the EC & IC FPD could experience fast-moving surface fires. Homes serve as an additional source of fuel that could produce high-intensity flames, emit embers, and initiate home-to-home ignitions.

Community ambassadors identified schools, the homestead water tanks and pump stations, and wildlife corridors as values at risk in the event of wildfire. There are five schools and eight childcare centers, two post offices, two pharmacies, nine churches, one temple, fourteen communications towers, five electrical substations, and power lines and electrical transmission lines along Highway 285 and across the eastern edge of the district (**Figure 2.a.6**).

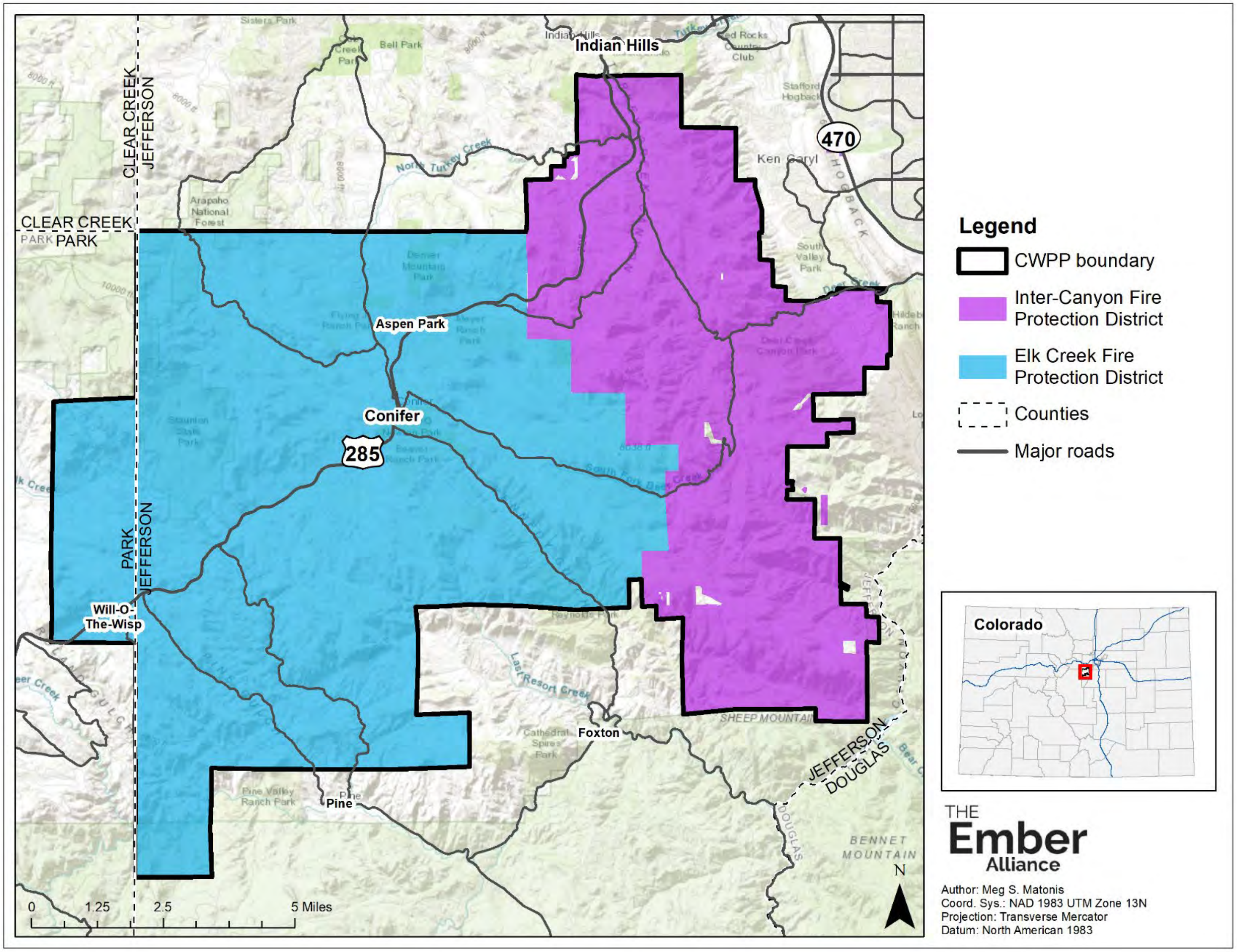

Figure 2.a.1. Boundaries of Elk Creek FPD (blue) and Inter-Canyon FPD (purple), and the outline of the combined districts that will be used throughout the document.

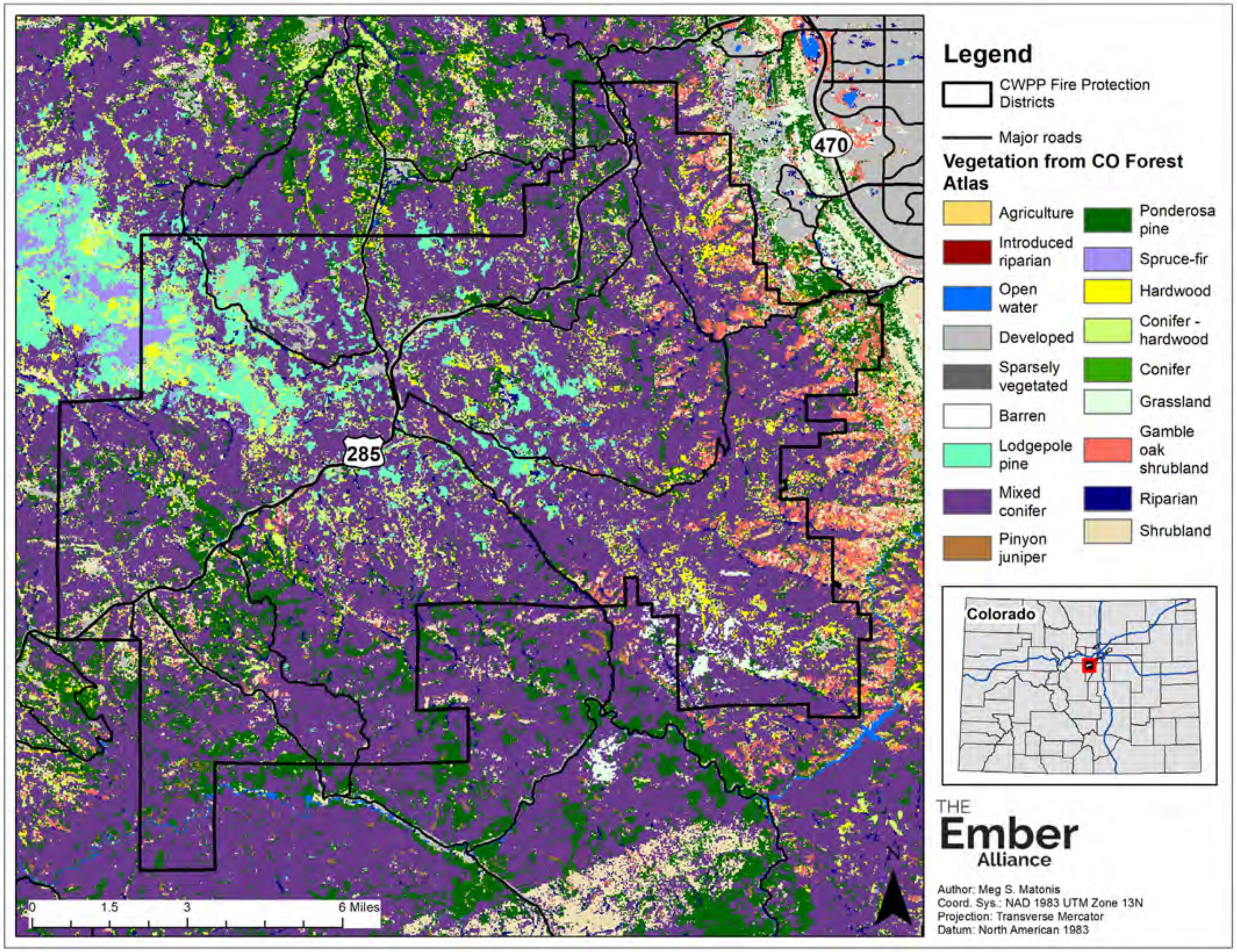

Figure 2.a.2. Map of vegetation across the EC & IC FPD. Vegetation type is one of many inputs that help predict fire behavior across the district, and is one of the inputs to the LANDFIRE fuel model data in the following map in **Figure 2.a.4**. (Source: Colorado State Forest Service)

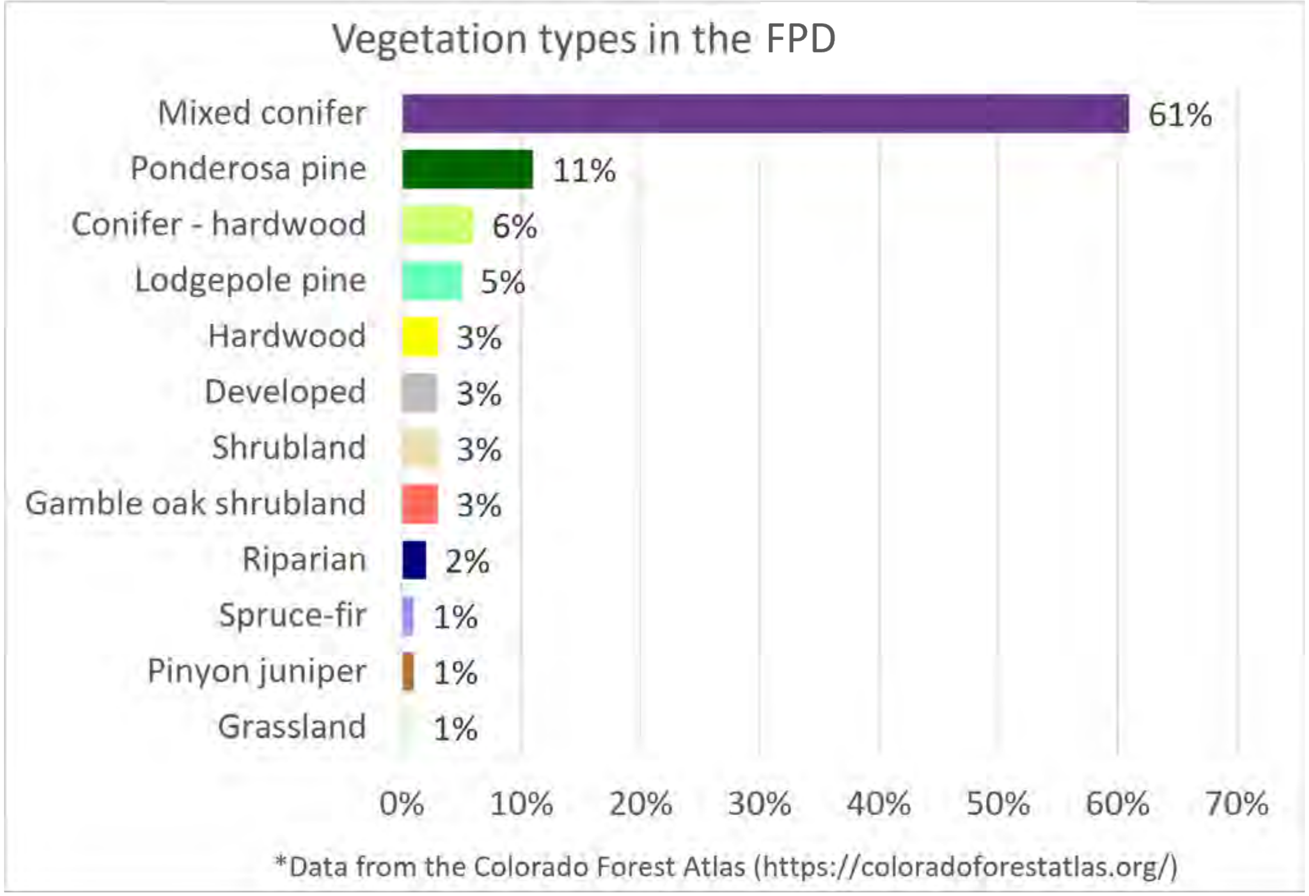

Figure 2.a.3. Graph showing the abundance of vegetation across the district. The district is primarily covered with mixed conifer stands that are comprised of any of the following: white fir, subalpine fir, ponderosa pine, bristlecone pine, limber pine, Douglas-fir, Rocky Mountain juniper, Engelmann spruce, and blue spruce. The species present in conifer-hardwood are bristlecone pine, limber pine, and quaking aspen, with Rocky Mountain Juniper and Douglas-fir also commonly present. Vegetation type is one of many inputs that help predict fire behavior across the district, and is one of the inputs to the LANDFIRE fuel model data in the following map in **Figure 2.a.4**. (Source: Colorado State Forest Service)

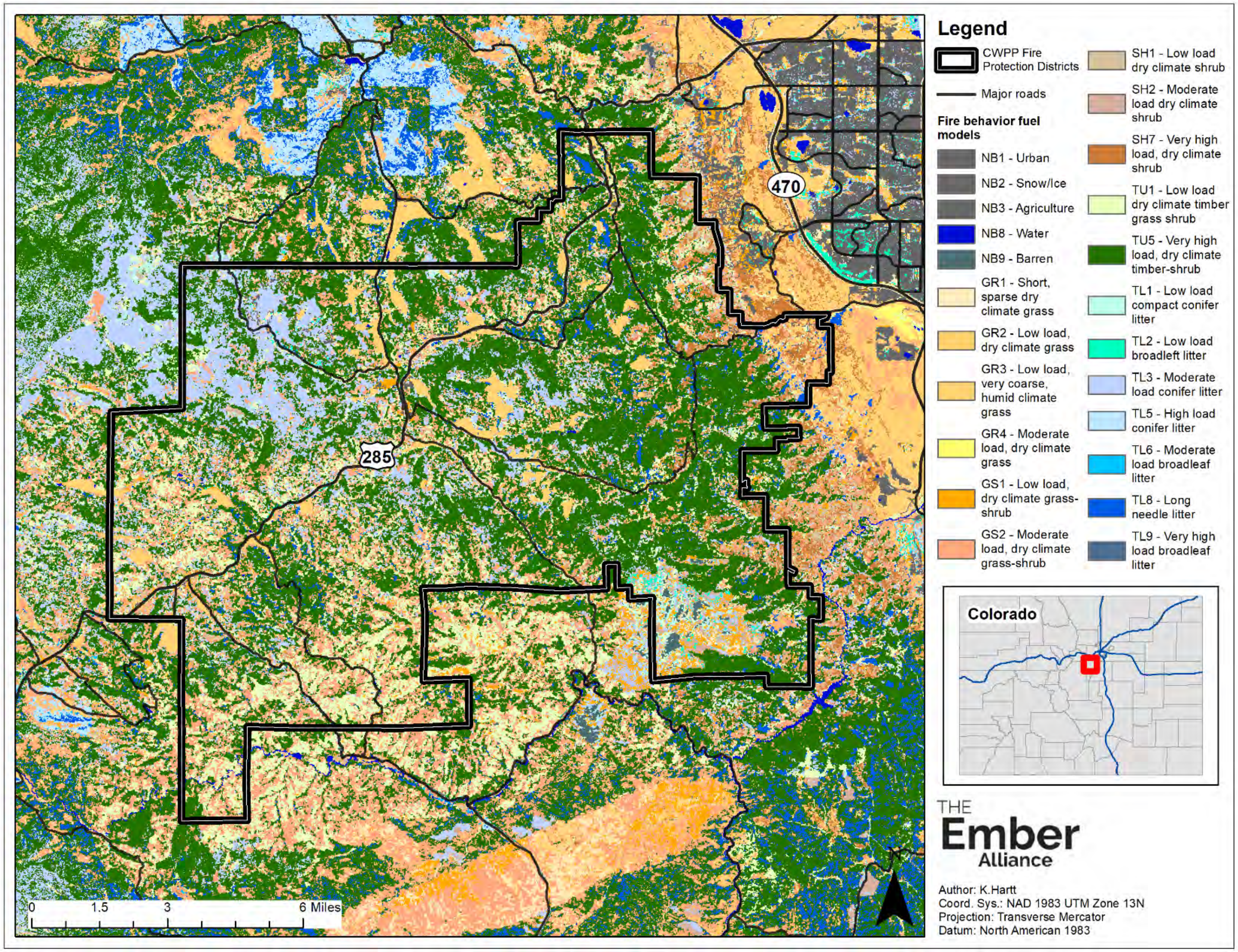

Figure 2.a.4. Nearly half of the EC & IC FPD has very high load dry climate timber-shrub fuels, more heavily concentrated in the eastern side of the district. The rest of the district is primarily low to moderate load grass, shrub, timber, and litter fuels. This fuels layer helps models predict fire behavior across the district. (Source: LANDFIRE)

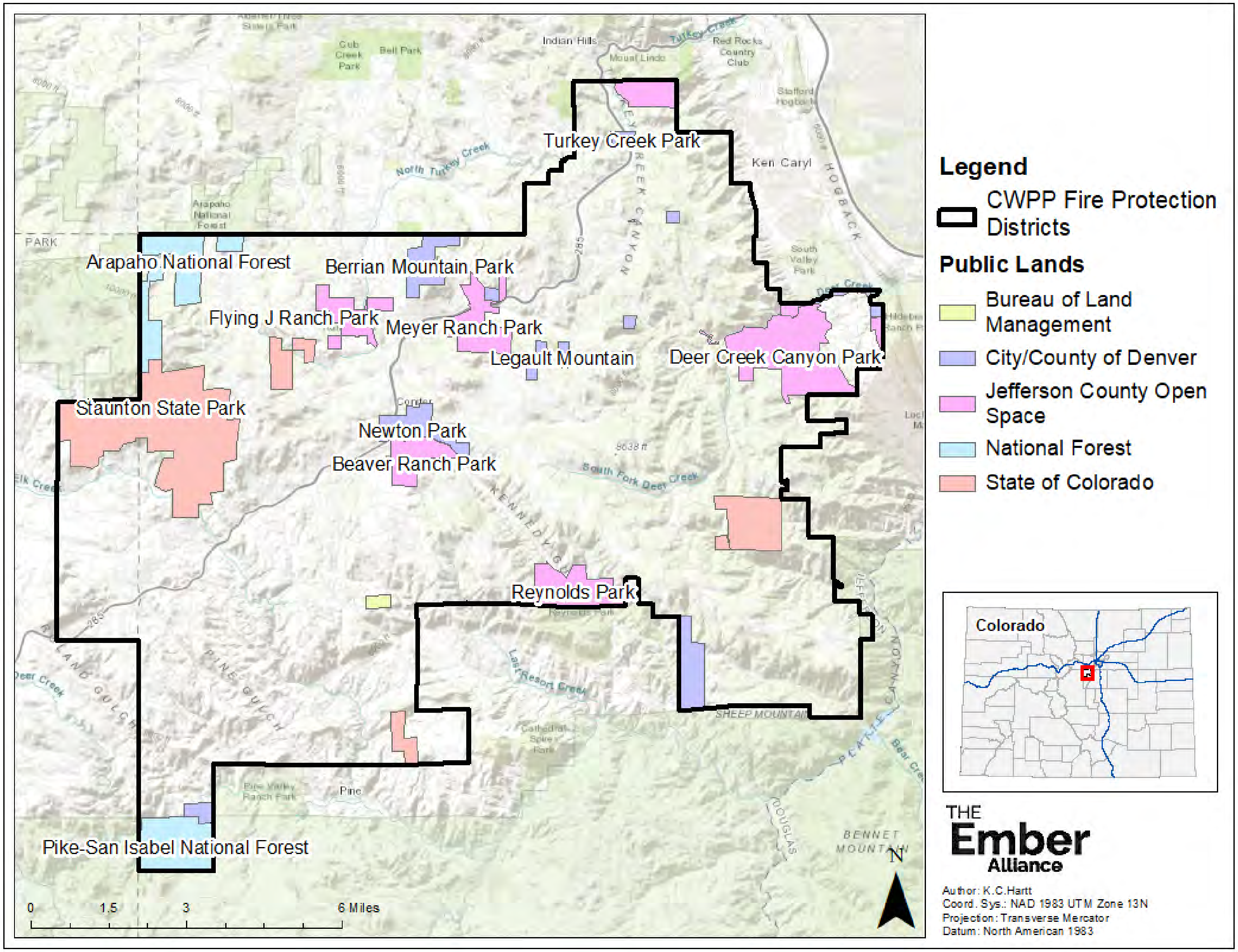

Figure 2.a.5. Publicly owned land across the EC & IC FPD, with major parks called out.

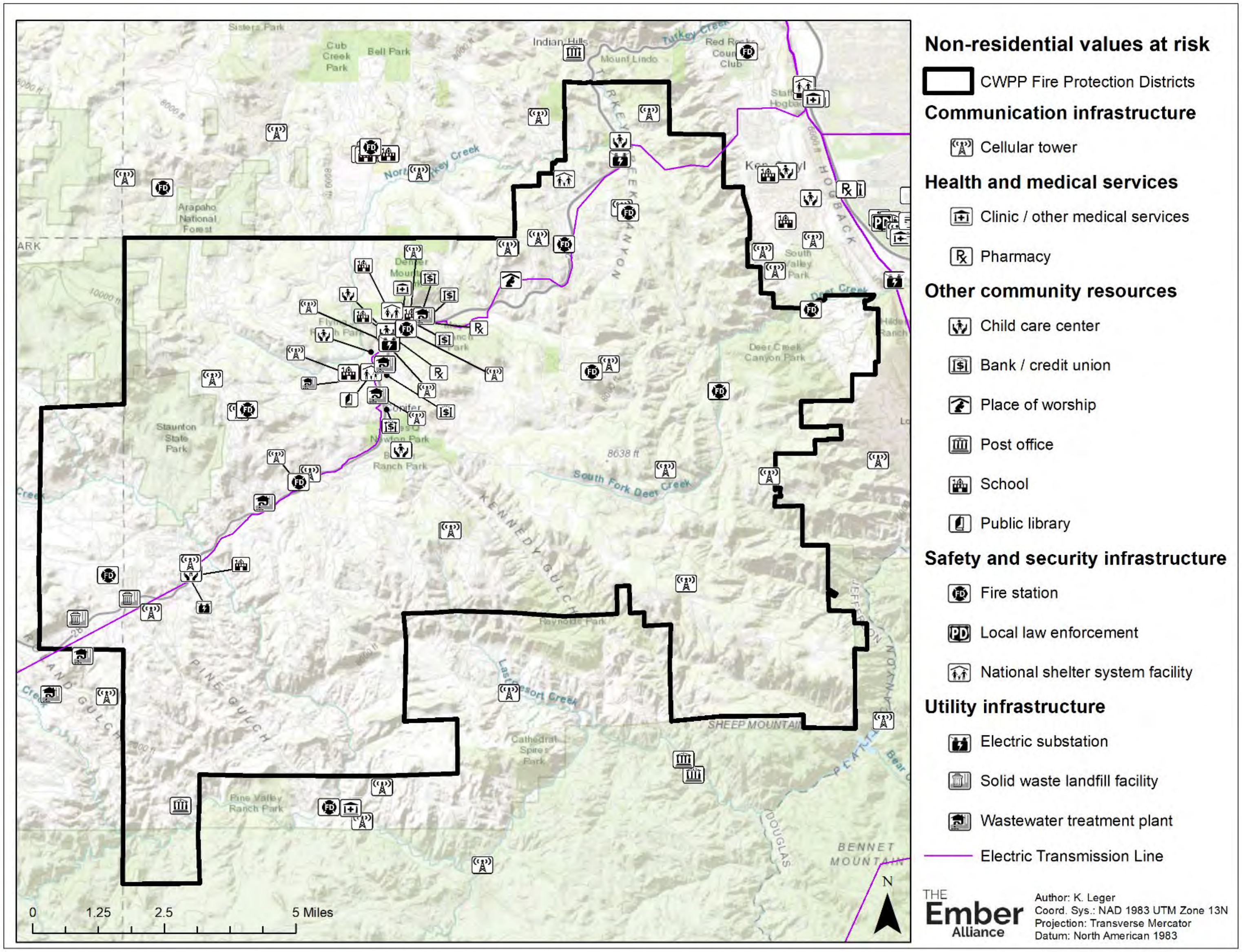

Figure 2.a.6. Non-residential values at risk to wildfire within and around the EC & IC FPD.

2.b. Wildland-Urban Interface

The Wildland-Urban Interface (WUI) is the area where the built environment meets wildfire-prone areas. This exists along a continuum of wildland to urban densities (**Figure 2.b.1**). The WUI is any location where wildland fire can move between natural vegetation and the built environment. All residents of the EC & IC FPD live in the WUI (**Figure 2.b.2**). Over the past 50 years, immigration to the mountains West of Denver has increased the number of occupied structures within this historically forested landscape. This population change increased the density and size of the WUI, and the risk of structure loss from wildfire and the likelihood of fire starts.

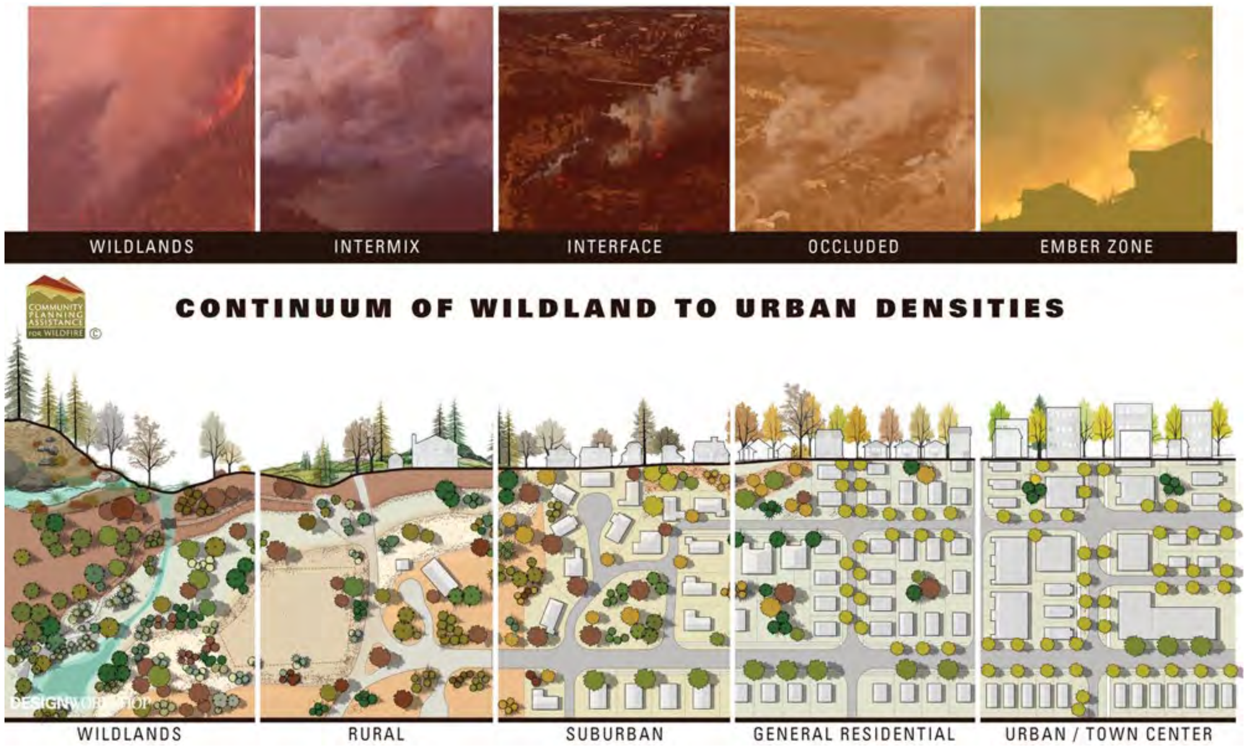

Figure 2.b.1. The wildland-urban interface exists along a continuum of wildland to urban densities.

According to the 2020 Wildfire Risk to Communities analysis by the U.S. Forest Service, homes in Aspen Park and the surrounding areas have a higher risk of fire than 97% of the communities in the state (USFS 2020). High fire risk is common to many WUI communities along the Colorado Front Range (Radeloff and others 2018). Damages from wildfires in the Colorado's WUI can be extensive, as demonstrated by the 2012 Waldo Canyon Fire that destroyed 346 buildings, the 2013 Black Forest Fire that destroyed 511 buildings, the 2020 East Troublesome Fire that destroyed at least 366 buildings, and the 2021 Marshall Fire that destroyed 1084 residential buildings being the most destructive in Colorado history.

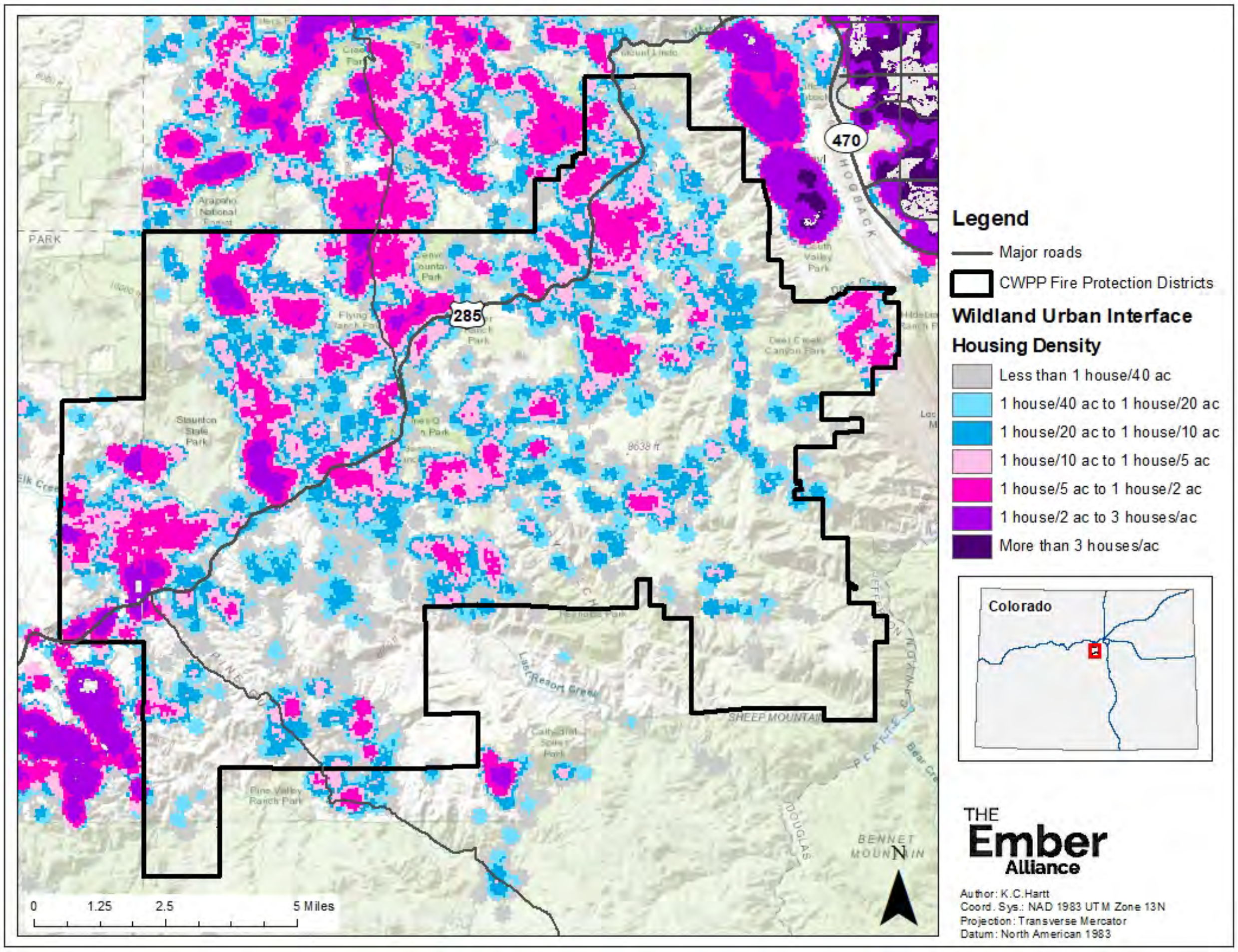

Figure 2.b.2. Wildland-Urban Interface in the Elk Creek & Inter-Canyon Fire Protection Districts, displayed by housing density per acre, from the lowest density of less than 1 house per 40 acres to the highest density of more than 3 houses per acre. (Source: Colorado Forest Atlas)

2.c. Resident Preparedness for Wildfire

EC & IC FPD began a community ambassador program in 2021 to connect the fire department staff with leaders in the communities they serve. These ambassadors share community concerns and issues with the fire department and then share information on mitigation and fire preparedness with their neighbors. The community ambassadors expressed concerns about resident preparedness including neighbors being apprehensive of losing privacy provided by trees, aesthetic changes after tree removal, and a lack of education on the cost of fuel treatments compared to the cost of losing a home.

The EC & IC FPD evaluated each of the communities in the district during the process of writing this CWPP and discovered that many neighborhoods have no or inadequate defensible space around homes, that driveways and roads are too small for a fire engine to drive on, that roadways are not adequately cleared to be survivable during a fire, and that many residents are unaware of the risk that they are at (**Plan Unit Hazard Assessment**).

A 2021 study from the University of Colorado-Boulder showed that homeowners living in the WUI in neighboring city Bailey, CO typically underestimated the level of risk their home is at due to wildfire, and tended to overestimate the amount of work they have done to protect their property (source: CU Boulder Today). Elk Falls Ranch, Valley Hi Estates, the Preserve at Pine Meadows, Ken Caryl Ranch Master Association, Conifer Mountain, and Sampson Road are all certified FireWise Communities. All communities are encouraged to work with their fire protection district and the Wildfire Prepared program to ensure wildfire mitigation continues.

2.d. Extreme Danger in Elk Creek & Inter-Canyon Fire Protection Districts

Many neighborhoods in the EC & IC FPD are in a uniquely dangerous situation regarding their risk from wildfire. Steep slopes, dense forests, and limited road access in and out of the neighborhood create a hazard level that is not easily addressed. In some areas, the fuel density and topography could allow a fire to spread from home to home faster than the fire district could respond, or in some cases, faster than a homeowner could escape. In these areas, wildfire poses more of a threat to life safety than just to property.

Example: This neighborhood is built high up on a steep slope, where fire can move quickly up the hill and rising smoke can obscure the fire. Dense lodgepole/mixed conifer stands cover the hillside, and these forests don't respond well to thinning. Large patch cuts are an appropriate treatment method to reduce wildfire hazards while restoring historical forest conditions, and that is often undesirable to homeowners who want to protect their privacy and views. Steep, narrow roads in this neighborhood make it difficult for first responders and fire engines to access the area and protect homes and lives. Narrow driveways without turnaround space can mean a fire engine cannot get to a home to attempt to protect it during a wildfire event. This neighborhood is at extreme danger in the event of a wildfire. Photo: The Ember Alliance.

While it is always a good idea to invest in defensible space and home hardening for residents in the WUI, it is equally important to understand the limitations these steps have in certain environments. Relying on those actions or expecting the fire department to be able to protect your home and family is naïve in these extreme danger scenarios. Major coordinated action is needed to provide helpful protection against a wildfire in these areas. Working with neighbors to create fuel breaks, mosaic landscapes, and protected roadways must be high priority. For specific recommendations in your area, your community ambassador through Wildfire Prepared or your fire protection district. See **Section 3.a** for Individual Recommendations and **Section 3.b** for your plan unit's recommendations.

Evacuation preparedness is of the utmost importance for residents in these areas, especially before major work is completed. Utilize the earliest warnings for evacuations, have go-bags prepared, and make family emergency plans. Have your family and neighbors review and complete the **Evacuation Preparedness** guidelines.

2.e. Fire History Along the Colorado Front Range

Colorado's Front Range was influenced heavily by fire before the era of fire suppression. This land is the ancestral land of the Cheyenne and Ute First Nations. These indigenous groups utilized fire as a land management tool. Lightning ignited fires were common before European settlement in the 1850's, with low- to mixed-severity fires occurring every 7 to 50 years and occasional severe, stand-replacing fires. This fire regime resulted in a mosaic of widely spaced trees and small tree clumps interwoven with grasslands and shrublands, particularly on drier south-facing slopes. North-facing slopes often supported denser forest stands (Addington and others 2018).

Ponderosa pine and mixed-conifer forests were fire-adapted ecosystems and very resilient to wildfires. Frequent fires would kill many tree seedlings and saplings, thereby preventing the accumulation of ladder fuels and reducing the potential for surface fires to transition into crown fires. Fire spread was more rapid through understory grasses but released far less heat, which allowed many larger trees to survive unscathed. Occasionally dense clumps of trees would experience mortality from passive crown fire, further increasing the diversity of habitat in these ecosystems (**Figure 2.e.1**). Ponderosa pine ecosystems with fewer trees support more abundant and species-diverse understories of grasses, forbs, and shrubs and provide habitat for a variety of wildlife that prefer a more open forest structure (Matonis and Binkley 2018; Kalies and others 2012; Pilliod and others 2006).

Lodgepole pine forests are part of fire-adapted ecosystems that are resilient after infrequent, stand-replacing wildfires. Lodgepoles grow dense and tall, which leaves little light that reaches the understory. They have relatively high canopy base height because they drop their lower branches as they grow and few ladder fuels exist in the understory, meaning they typically burn with high-severity crown fires. They have serotinous cones that open after the heat of a wildfire, creating a dense seedbed that will grow into a new even-aged stand and replace the previously burned stand. Young stands that are in recovery and regeneration stages after wildfires do not have the resources to regenerate after a second wildfire event, so frequent stand-replacing fires can have detrimental effects on this ecosystem (Turner and others 2019; Dennis and others 2009).

Gambel oak is part of many fire-adapted vegetative communities, including mixed conifer forests, montane shrublands, and as a dominant overstory species in sagebrush steppe and grasslands. Gambel oak stands have low resistance and high resilience to fire, and much like quaking aspen, they demonstrate vigorous growth after disturbance because they can sprout new trunks from their extensive root system and do not rely on acorns for reproduction (Abella and Fule 2008, Jester and others 2012). Under moderate or severe burning conditions, Gambel oak can be a heavy and continuous fuel source that is difficult to suppress and has contributed to deadly, fast-moving, and destructive runs on fires such as the 1994 South Canyon Fire and the 2012 Waldo Canyon Fire (Kaufmann and others 2016).

As the initial ranching and logging activities of Euro-American settlers subsided in the region and government-mandated fire suppression began in the late 1800's, trees grew back in a single age class, resulting in many dense forest stands (**Figure 2.e.2**; Addington and others 2018). Although many residents consider dense forest as "natural", these conditions are vastly different from the wildfire-resilient ecosystems that existed before. Landscapes of continuous, dense forests are more prone to high-severity fires that are difficult to suppress and can result in catastrophic losses to lives and property (Hass 2014).

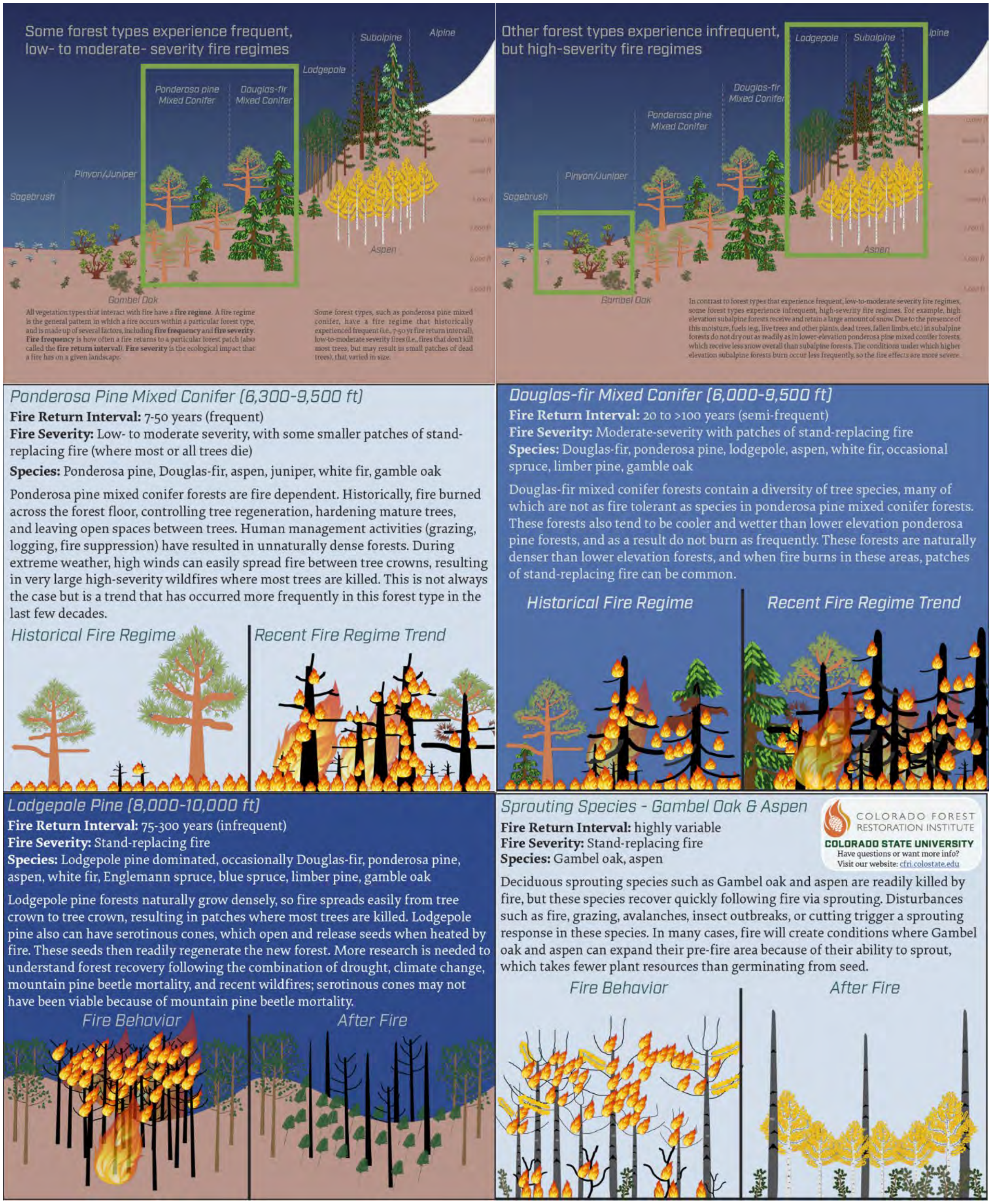

Figure 2.e.1. Ponderosa pine forests along the Colorado Front Range historically experienced frequent fires every 7-50 years and mixed-conifer forests experienced semi-frequent fires every 20 to >100 years, resulting in less dense forest conditions than is seen today. Gambel oak experienced variable fire regimes, but likely more frequent that what they see today, resulting in more frequent regrowth. Infographics from the [Colorado Forest Restoration Institute.](#)

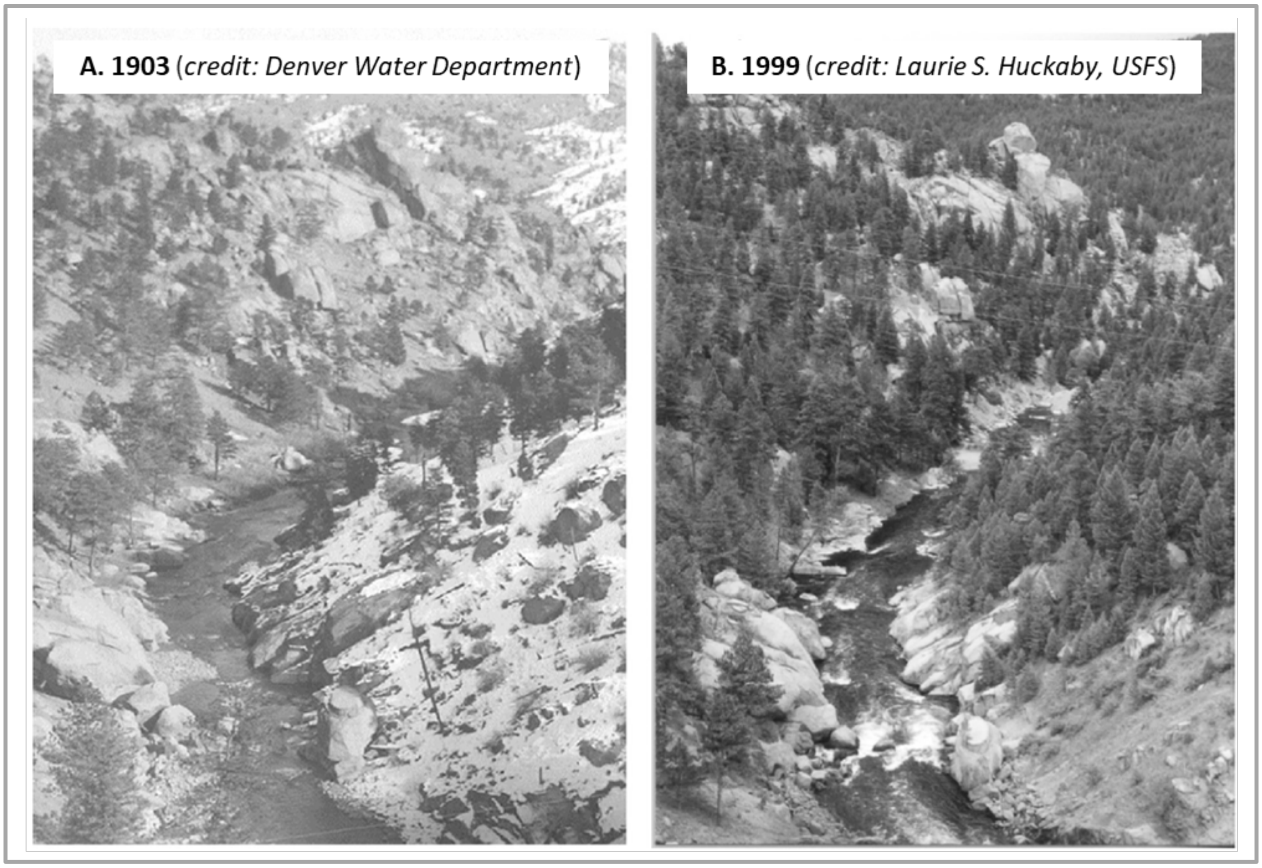

Figure 2.e.2. Tree densities in many ponderosa pine and mixed-conifer forests are higher today than they were historically in part due to fire suppression, as demonstrated by these paired photographs along the South Platte River on the Pike National Forest, Colorado. Images are borrowed from Battaglia and others (2018).

Along the Front Range of Colorado, a combination of extreme fire weather conditions (extreme heat and high winds), unplanned ignitions, and dry, unmitigated wildland vegetation can create catastrophic wildfire scenarios in the WUI. Climate change is further increasing wildfire risk and lengthening fire seasons (Parks and others 2016). Many catastrophic wildfires in Colorado's history have occurred on dry and windy days, resulting in rapid fire spread over short periods of time. On the Front Range, wind can gust over 62 miles/hour, which makes wildfire suppression nearly impossible (Hass and others 2015).

Days with red flag warnings indicate severe fire weather and require extra vigilance by fire departments and residents (see **Table 1.c.1** for red flag warning criteria). The occurrence of red flag warnings is highly variable from year to year due to regional weather patterns and weather anomalies such as El Niño and La Niña. The EC & IC FPD experienced between 0 and 25 red flag warnings per year from 2006 to 2020, with 11 red flag warnings in 2019 and 24 red flag warnings in 2020 (**Figure 2.e.3**). Red flag conditions are most common in March, April, June, and October (**Figure 2.e.4**).

Between 2011 and 2017, there were 252 fire starts in and around the EC & IC FPD. 87% of these were contained to an acre or less, and only 3% grew to over 100 acres. The most notable wildfires in the district were the High Meadows fire in 2000, which burned 10,800 acres and the Lower North Fork fire in 2012 that burned 4,140 acres. The Hayman Fire of 2002 and the Buffalo Creek Fire of 1996 burned nearby and threatened the residents of the EC & IC FPD. Elk Creek and Inter-Canyon provided mutual aid to these fires.

The 2020 wildfires did not get close to the EC & IC FPD district, but the potential for a large wildfire that exceeds the suppression capacity of local firefighting resources is great. In 2020, the three largest wildfires in Colorado history, the Cameron Peak Fire, East Troublesome Fire, and Pine Gulch Fire, started and burned over 540,000 acres (**Figure 2.e.5**).

Take Away Message

The EC & IC FPD is at high risk for large, high-severity wildfires due to dense forest conditions, dry and hot weather, and strong, gusty winds. Increasing drought and warming temperatures exacerbate wildfire risk in the area. EC & IC FPDs and residents in the district must prepare for large wildfire events. Proactive work is imperative.

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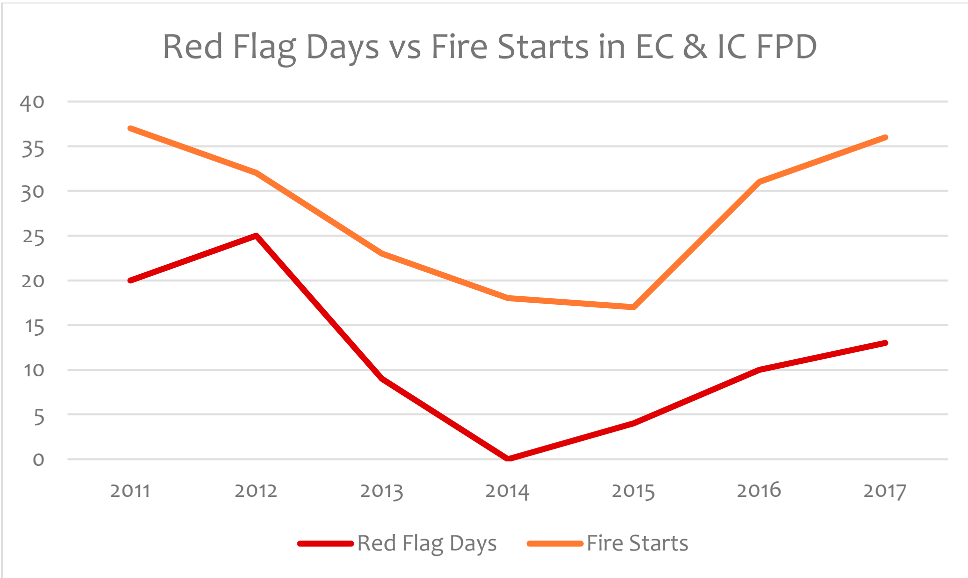


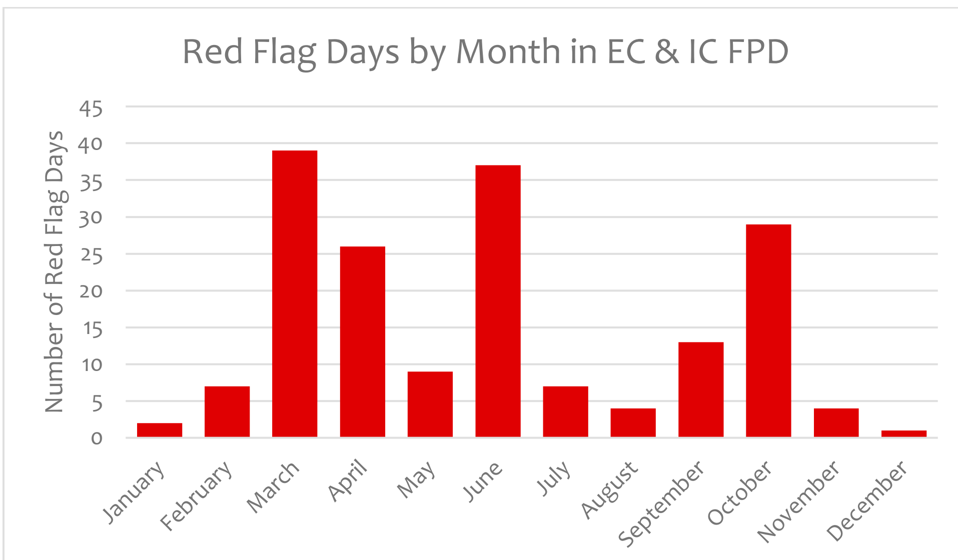


Figure 2.e.3. Top: Red Flag Days and Wildfire Ignitions by year from 2011 to 2017. Bottom: Total number of Red Flag Days in each month from 2006 to 2020. March, June, October, and April and the most common months for experiencing red flag weather. Data on historical red flag warnings were available for 2006 to 2020 and data on fire ignitions were available for 2003 to 2017 (sources: archived NWS watch/warnings from Iowa State University, Iowa Environmental Mesonet; historic ignitions from the Colorado Forest Atlas).

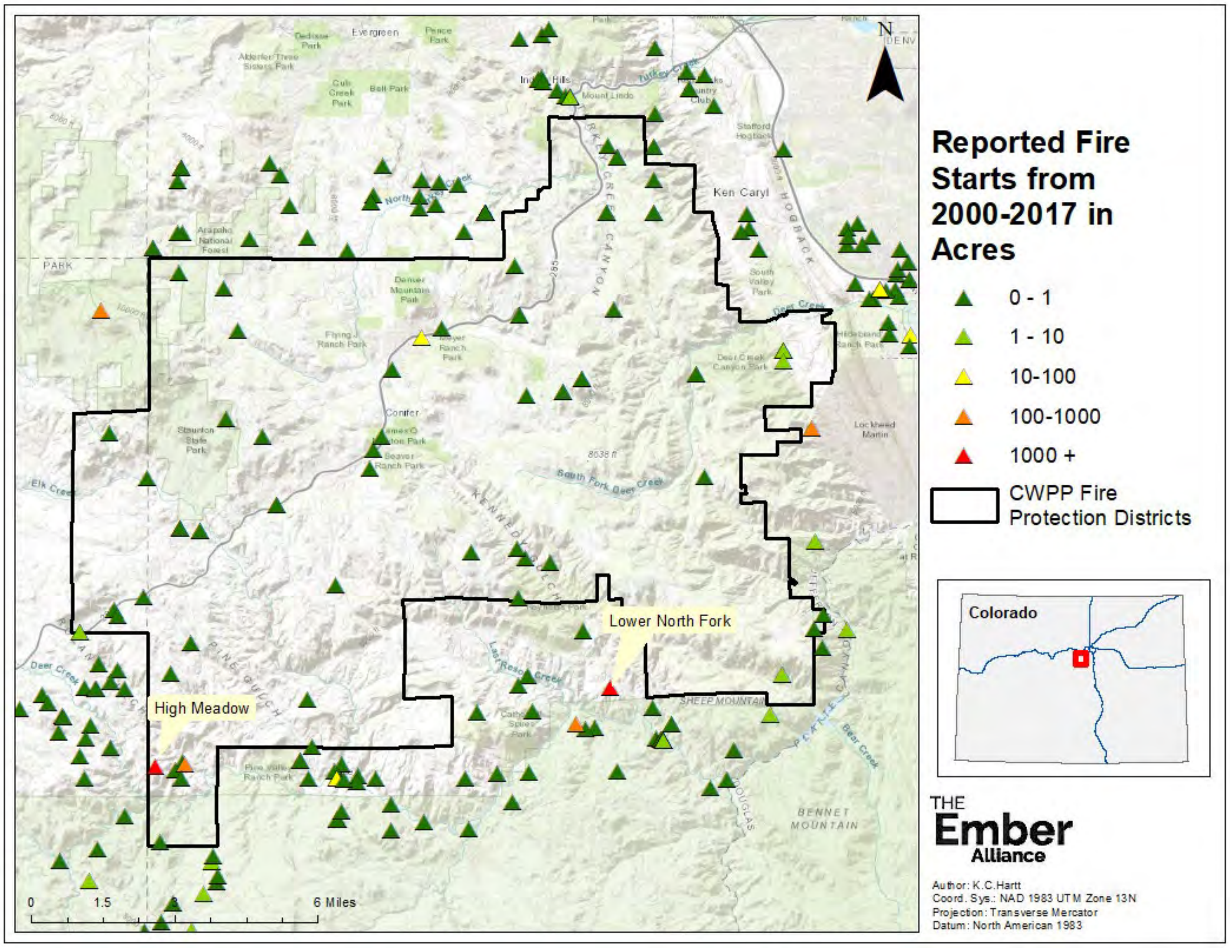


Figure 2.e.4. Fire starts in and around the EC & IC FPD from 2000 to 2017. 87% of ignitions were contained to one acre or smaller, and 3% grew to over 100 acres in size. (Source: Colorado State Forest Service, Colorado Forest Atlas).

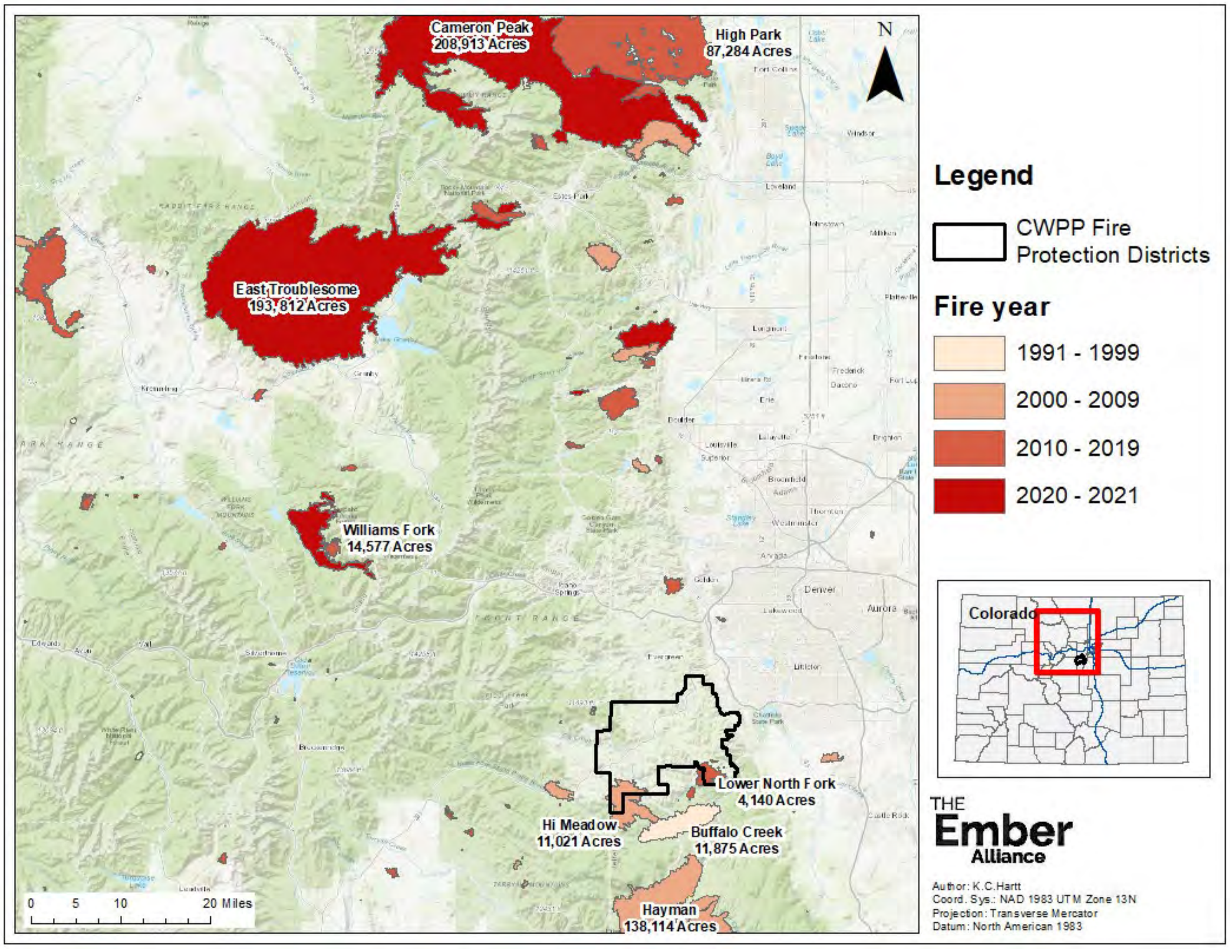


Figure 2.e.5. Extent of 2020 wildfires along the Colorado Front Range. The 2020 wildfires did not approach the EC & IC FPD, but the size of these fires could easily overwhelm the EC & IC FPD district's capacity to respond.

2.*f*. Fuel Treatment History in and around the EC & IC FPD

Forest management has been a part of the landscape in EC & IC FPDs for decades. Between 1995-2016, the Colorado State Forest Service, US Forest Service, Colorado Parks and Wildlife, and Jefferson County Open Space have completed forest health and fuels treatments on over 3,300 acres of land across the district. Denver Mountain Parks, Jefferson Conservation District, and the Colorado Department of Natural Resources also completed work in the district. This work included selective thinning, patch clear-cuts, pile burning, broadcast burning, mastication, dwarf mistletoe treatment, and creating fuelbreaks. Ponderosa pine woodland enhancement and dwarf mistletoe management has been a priority in this work, as well as lodgepole pine thinning and patch cutting. The USFS has authorized precommercial thinning on their lands. CSFS, USFS, and Colorado Parks and Wildlife have participated in prescribed pile or broadcast burns as well. (**Figure 2.f.1**, **Figure 2.f.2**).

Many homeowners have created defensible space around their home and outbuildings. ED and IC FPDs collaborated to host a wildland suppression module and fuels crew. The crew works with private property owners to provide a chipping program, conduct thinning operations, and do wildland suppression when needed.

Elk Creek Fire Protection District demonstrated restoring ponderosa pine stands near Station 2 by thinning to historic conditions and burning the slash piles safely. There are other local landscape scale projects at Foxton Canyon and the Preserve at Pine Meadows that can serve as demonstration sites as well.

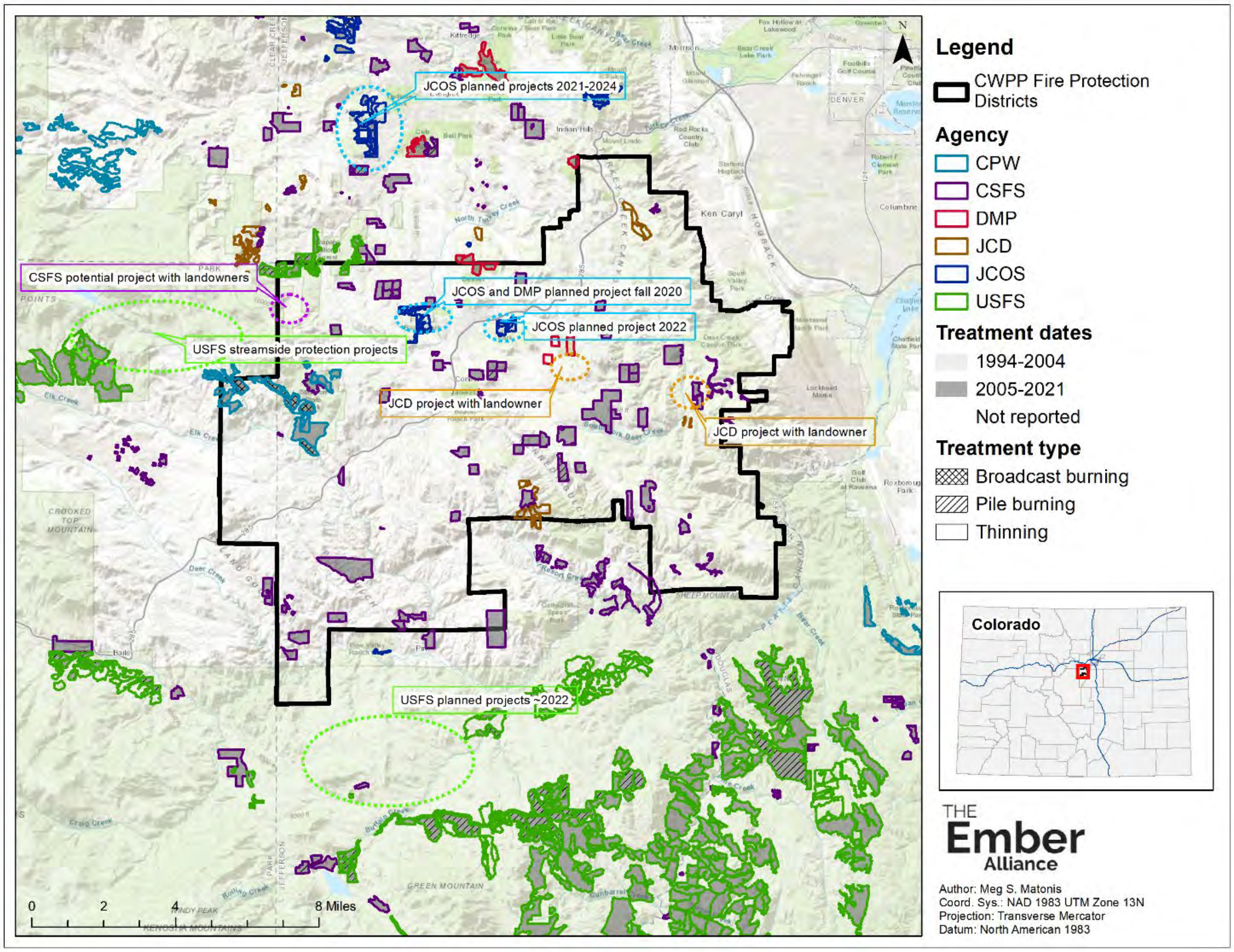


Figure 2.f.1. Locations of forest management treatments in the EC & IC FPD from 1995 - 2016 conducted by Colorado Parks and Wildlife, Colorado State Forest Service, Jefferson County Open Space, US Forest Service, Denver Mountain Parks, and Jefferson Conservation District. Data provided by Colorado Forest Restoration Institute.

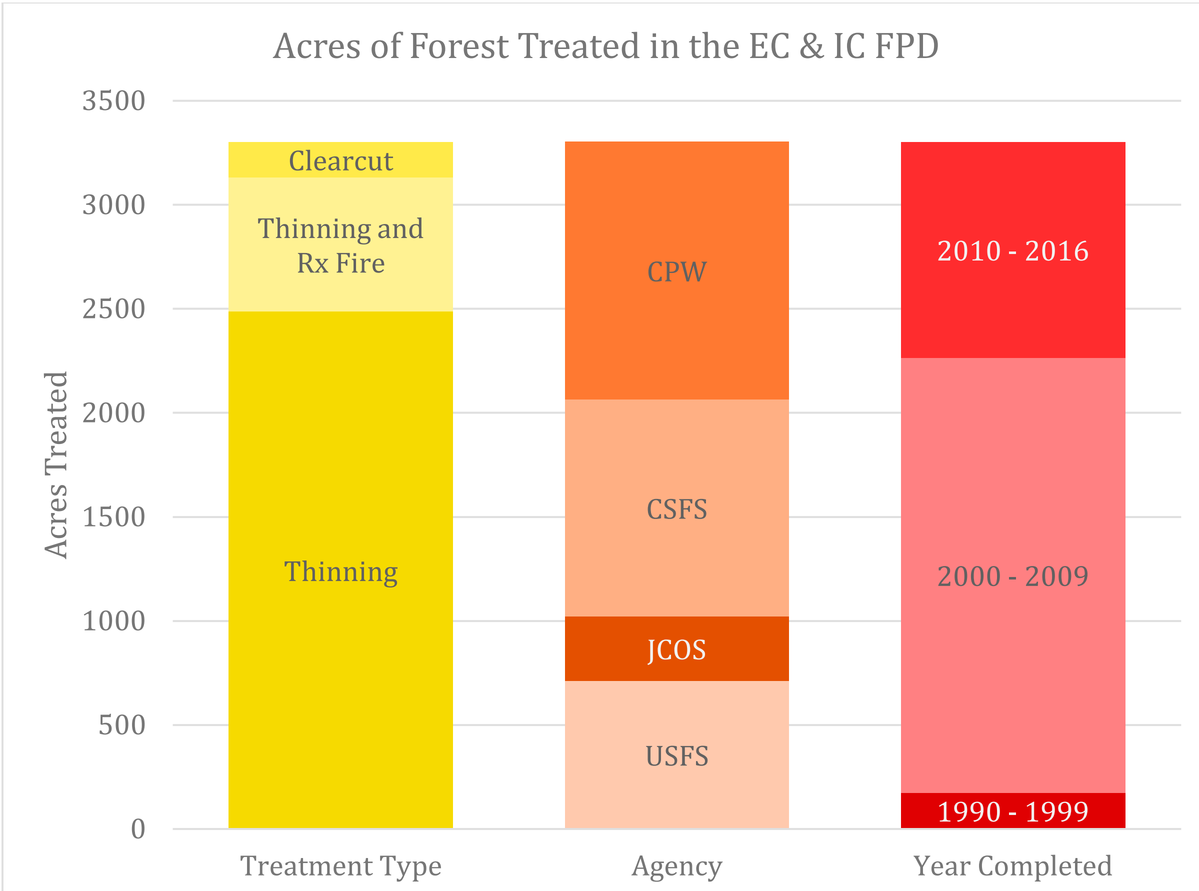


Figure 2.f.2. Acres of forest management treatments in the EC & IC FPD from 1995 - 2016 conducted by Colorado Parks and Wildlife, Colorado State Forest Service, Jefferson County Open Space, and the US Forest Service. Denver Mountain Parks, CO Department of Natural Resources, and Jefferson Conservation District also completed forest treatments in the area, but the data is incomplete so it is not included in this chart. Data provided by the Colorado Forest Restoration Institute.

2.g. Accomplishments Since the Previous CWPP

Elk Creek Fire Protection District

- ECFPD worked with Conifer Mountain, Valley Hi Estates, Elk Falls Ranch, Woodside Park, Douglass Ranch POA, and the Preserve at Pine Meadows to become certified Firewise USA sites.
- ECFPD created a community chipping program for homeowners in 2016. This program was expanded to cover both EC & IC FPD in 2021. The program is part of the foundation for the combined EC & IC FPD wildland suppression module, which has completed 100 acres of thinning between 2019-2020 over steep slopes, in conjunction with the Upper South Platte Partnership (USPP).

Inter-Canyon Fire Protection District

- The 2007 IEC & IC FPD CWPP sparked community action and mitigation. They completed roadway clearing, fuel break projects, and regeneration projects in conjunction with Jefferson County.
- ICFPD supported the Sampson Road Association to become a certified Firewise USA site.
- In 2019 ICFPD supported members of the Upper South Platte Partnership and the Colorado State Forest Service to complete the Heavens mitigation project near Kuehster Rd.

Joint District Accomplishments

- EC & IC FPD worked together to initiate a Fuels Crew to work across the districts in 2021.
- In 2021 the districts initiated the community ambassador program. 25 community members serve as ambassadors for 20 communities across the district at the time of this report.
- The Wildfire Prepared Home Assessment Program started in 2020 as a joint effort between Elk Creek, Inter-Canyon, Evergreen, and Genesee Fire Protection Districts. It offers professional evaluation of residents' homes and properties to analyze their susceptibility to wildfire and share what actions they can take to create a more defensible home and landscape. Approximately 250 homeowners in the districts have taken advantage of this resource since it was launched.
- The districts have worked with the county to offer a slash program to residents.

Call to Action

As awareness about wildfire risk continues to grow in the EC & IC FPD, it is of utmost importance that residents and HOAs help reduce shared risk. Action and community-building centered around mitigation have reduced wildfire risk and increased community resilience across the mountain west. Mitigation work by residents can spur mitigation by their neighbors (Brenkert-Smith and others 2013). The cumulative impact of linked defensible space across private properties can improve the likelihood of home survival and protect firefighters during wildfire events (Jolley 2018; Knapp 2021).

2.*h*. District Capacity

EC & IC FPDs hosts both paid and volunteer staff. They employ six chief officers, seven captains, and two lieutenants. They have twelve line staff, seven permanent wildland positions and ten seasonal wildland positions in the fuels/suppression module. 45 volunteers operate as firefighters, EMTs, and paramedics as needed, and 15 cadets in the fire academy will be fully trained by the end of 2022.

EC & IC FPD have seven structure engines, four tenders, eight wildland engines, and three wildland tenders. They maintain six ambulances and three rescue trucks. The compliment of apparatus are spread out among nine stations. The wildland module has one Type 6 engine, crew carriers, and a UTV. The fuels crew has crew carries and is in the process of procuring a type 6 engine. These resources are based at the wildland work center (ECFPD Station 2). The 11993 Blackfoot Rd station is operational at all times, and the rest are staffed on a volunteer basis. The station at 7939 S. Turkey Creek Road and the wildland work center are staffed Monday-Friday, 8 am until 5pm.

ECFPD received an ISO rating of 5 within 5 miles of a fire station. Properties outside of 5 miles are a 10. ICFPD received an ISO rating of 4/4y.

ICFPD engines, fuels crew, and volunteer firefighters working and training to protect residents.

3. Community Recommendations

This section contains recommendations for actions that residents, communities, and organizations can take. It is split by who the recommendations are directed towards. **Section 3.a** is designed for individual homeowners, residents, and business owners to learn what steps to take to protect their family and home. **Section 3.b** is designed for community leaders in neighborhoods and HOAs to plan work together to reduce shared risk in their community. **Section 3.c** is designed for government agencies, large landowners, and cross-boundary organizations to plan work at landscape-scales and work with the public to reduce shared risk across the districts.

3.a. Individual Recommendations

Mitigate the Home Ignition Zone

> You can increase the likelihood that your home will survive a wildfire and help protect the safety of firefighters by creating defensible space, replacing or altering building materials to make your home less susceptible to ignition, and taking steps to increase firefighter access along your driveway.

During catastrophic wildfires, property loss happens mostly due to conditions in the *home ignition zone* (HIZ). The home ignition zone includes your home and other structures (e.g., sheds and garages) and areas within 100 feet of each structure. The Insurance Institute for Home and Business Safety found that firefighter intervention, adequate defensible space, and home hardening measures were common factors for homes that survived major wildfires in 2017 and 2018. Research following the 2018 Camp Fire showed that homes were more likely to burn down when they were close to other structures that had also burned, when they had vegetation within 100 meters of the home, and when they had combustible materials (firewood or propane tanks) near the home (NWCG 2018b; IIHBS 2019; Knapp 2021).

Defensible space is the area around a building where vegetation, debris, and other types of combustible fuels have been treated, cleared, or reduced to slow the spread of fire and reduce exposure to radiant heat and direct flame. It is encouraged that residents develop defensible space so that during a wildfire, they aren't reliant upon limited firefighter resources, but that their home can stand alone with a great reduction of hazards. See **Section 4.b** to learn about recommended practices for creating defensible space (NWCG 2018b).

Defensible space allowed firefighters to protect this home during the 2016 Cold Springs Fire near Nederland, CO (source: *Cold Springs Fire Success Stories* from Wildfire Partners).

Home hardening is the practice of making a home less likely to ignite from the heat or direct contact with flames or embers. Home hardening involves reducing this risk by changing building materials, installation techniques, and structural characteristics of a home. Home hardening measures are particularly important for WUI homes; 50 to 90% of homes ignite due to embers rather than radiant heat during wildfires. See **Section 4.b** to learn about recommended practices for home hardening (California Safe Council 2020; Babrauskas 2018; Gropp 2019).

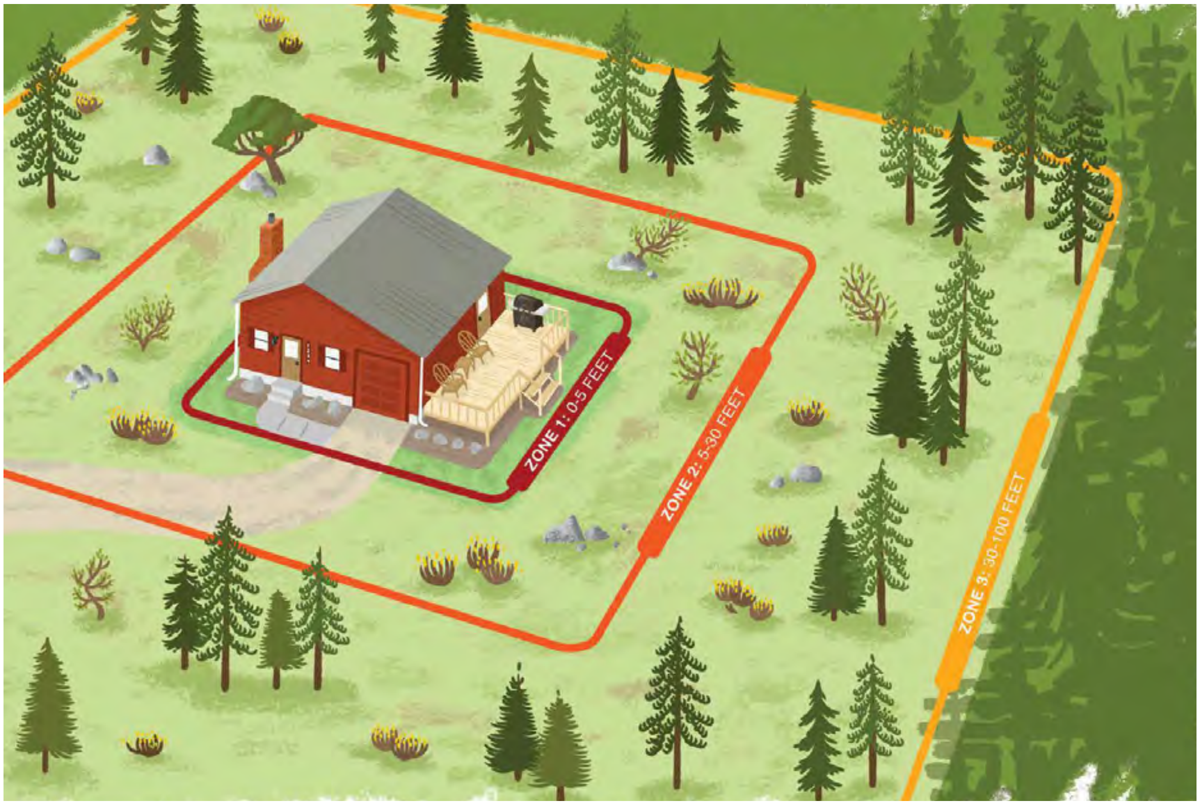


Figure 3.a.1. Defensible space zones recommended by the Colorado State Forest Service. Image from the CSFS, drawn by Bonnie Palmatory.

Mitigation Barriers and Opportunities

Homeowners and residents in the WUI share concerns about creating defensible space and maintaining a defensible HIZ. **Table 3.a.1** proposes several opportunities to address these challenges.

Table 3.a.1. Common concerns from residents in the WUI, and potential solutions to encourage mitigation measures in the home ignition zone.

Concern	Potential solutions
I don't know where to start with creating defensible space.	Talk to neighbors who have taken steps to mitigate fire risk on their property through the EC & IC FPD's Community Ambassador Program and Wildfire Prepared Program. Review **Figure 4.b.1**, **Table 4.b.1**, and read the CSFS publication *Protecting your home from wildfire: Creating wildfire-defensible zones* for mitigation recommendations. Visit Rotary Wildfire Ready and the Colorado State Forest Service for useful information and tips about defensible space creation. Reach out to your fire protection district with questions about the programs above.
I don't have the resources to invest in defensible space.	Creating adequate defensible space can take years and a significant financial investment. Fortunately, there are *effective, low-cost measures* that residents can start with: ✓ Regularly remove leaves, needles, and other vegetation from roofs, gutters, decks, and around the base of homes. ✓ Use hand tools like a pole saw to remove tree branches that hang less than 10 feet above the ground. ✓ Remove combustible materials (dry vegetation, wooden picnic tables, juniper shrubs, etc.) from underneath, on top of, or within 5 feet of decks. ✓ Remove vegetation and combustible materials within 5 feet of windows and doors. ✓ Replace wood mulch within 5 feet of all structures with dirt, stone, or gravel. ✓ Remove downed logs and branches within 30 feet of all structures. ✓ Participate in the fire districts' Chipping Program. ✓ Participate in community slash pickup dates organized by Jefferson County. See https://www.jeffco.us/2493/Slash-Collection for more information. ✓ Apply for cost-sharing grants with your neighbors to subsidize the creation of defensible space (see **Section 4.e**).
I don't have the resources to invest in home hardening.	Retrofitting an existing home to be wildfire-resistant can be expensive, particularly actions like replacing flammable roofs and siding. Some of these costs can be divided and prioritized into smaller projects. If you are building a new home, the cost of using wildfire-resistant materials is roughly the same as using traditional building materials (Quarles and Pohl 2018). Wildfire-resistant

	features often come with additional benefits, such as greater durability and reduced maintenance (Quarles and Pohl 2018). Many home hardening practices are required in Jefferson County per building construction regulations approved in January 2020. New construction and replacement construction that requires a building permit must comply with the new building standards. Fortunately, there are *effective, low-cost measures* that residents can start with to harden their homes: ✓ Install noncombustible metal gutter covers. ✓ Cover vent openings with 1/16th- to 1/8th-inch corrosion-resistant metal mesh. ✓ Cover chimney and stovepipe outlets with 3/8th- to ½-inch corrosion-resistant metal mesh to prevent embers from escaping and igniting a fire. ✓ Caulk and plug gaps greater than 1/16th-inch in siding or around exposed rafters. ✓ Install weather stripping around and under garage doors to reduce gaps to less than 1/16th-inch. ✓ Remove combustible materials from underneath, on top of, and within 5 feet of a deck. ✓ Replace wood mulch within 5 feet of all structures with noncombustible products like dirt, stone, or gravel. ✓ Store all combustible and flammable liquids away from potential ignition sources. ✓ Keep a fire extinguisher and tools such as a shovel, rake, bucket, and hose available in your garage for fire emergencies. Suggestions from CAL FIRE's 2020 Low Cost Retrofit List.
I am afraid that removing trees will destroy the forest and reduce the aesthetic and monetary value of my property.	The reality is that nothing will decrease the value of your home as much as a high-severity wildfire burning all the vegetation in the community, even if your home survives the fire. Drive around the community and look for homes that have followed the guidelines in **Figure 4.b.1** and **Table 4.b.1**. Some properties in the EC & IC FPD have exemplary defensible space and beautiful landscaping at the same time. Read FireWise Plant Materials from Colorado State University Cooperative Extension and Firescaping from FIRESafe MARIN for suggestions on beautiful, fire-resistant landscaping. Learn about the ecology of frequent-fire forests along the Colorado Front Range by reading *Back to the future: Building resilience in Colorado Front Range forests using research findings and a new guide for restoration of ponderosa and dry-mixed conifer landscapes* (Miller 2018). Restored ecosystems can be aesthetically pleasing, benefit wildlife and light-loving wildflowers and grasses, and protect your home from high-severity wildfires.

Fire-resistant landscaping in zone 1 can be aesthetically pleasing. Limbed and thinned trees in zone 2 (as seen in the background of this photo) can create beautiful, open conditions that allow understory vegetation to flourish under higher light conditions and provide habitat for wildlife. Image from Washington State University Master Gardener Program.

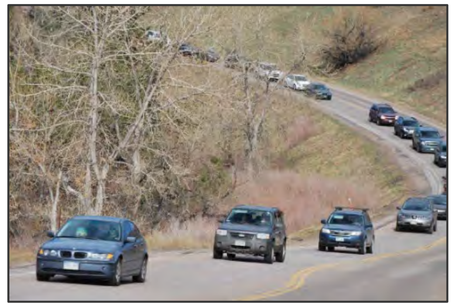
Evacuation Preparedness

The best way to get out quickly and safely during an evacuation is to be prepared. The following steps are recommended for residents to address evacuation concerns in the EC & IC FPD:

- Register your cell phones and email addresses on the Jefferson County Emergency Notifications page to receive evacuation information for the EC & IC FPD in the case of an emergency. Signing up for local emergency notifications can also help you leave quickly.
- Prepare a go-bag and have a family emergency plan *before* the threat of wildfire is in your area. Having a plan in place ahead of time can ensure prompt evacuations and save lives during wildfires. Visit the Rotary Wildfire Ready website to learn about preparing go-bags and evacuation planning.
- Work with your neighbors to develop a plan for helping each other with evacuation if a resident is not at home, school-aged children or pets might be home alone, or residents have mobility impairments and need special assistance. Family members or individuals living alone also need to address the unique needs and vulnerabilities that arise from mobility or hearing impairments during an evacuation.
- Consider evacuating with only one vehicle per household to reduce congestion for everyone.
- Evacuate whenever you feel unsafe, even before receiving mandatory evacuation orders. All residents should leave promptly when they receive a mandatory evacuation order. This means having a family emergency plan already in place and having go- bags prepacked.

<u>Follow evacuation etiquette</u> to increase the chance of everyone exiting the EC & IC FPD in a safe and timely manner during a wildfire incident:

- Leave as quickly as possible after receiving an evacuation notice.
- Have a go-bag packed and ready during the wildfire season, especially on days with red flag warnings.
- Drive as few vehicles as necessary to reduce congestion and evacuation times across the community.
- Drive safely and with headlights on. Maintain a safe and steady pace. Do not stop to take pictures.
- Yield to emergency vehicles.
- Follow directions of law enforcement officers and emergency responders.



Accessibility and Navigability for Firefighters

Driveways

It is important to ensure emergency responders can locate and access your home. A factor firefighters consider when deciding whether they can protect a home is the access to that home. Narrow driveways without turnarounds, tree limbs hanging over the road, and lots of dead and down trees by the road may make firefighters choose to not defend your home during a wildfire event (Brown 1994).

More than half the CWPP plan units in this district have some private road and driveway access issues. This includes narrow widths, inadequate vertical clearance for engines, and heavy fuel loading on the sides of the road. In many of these units, these unsafe road and driveway conditions would turn firefighters away from attempting to defend homes. Driveways and roads should have a minimum of 20 feet of clearance horizontally and 13.5 feet of clearance vertically to allow engines to safely access the roads (NFPA 1).

Many driveways within the EC & IC FPD do not meet current access requirements and pose safety issues that are difficult to mitigate. Long, narrow, steep driveways lacking turnarounds, and dense trees on the sides of the road can create challenges for emergency response vehicles during wildfires. Home hardening and fuel mitigation are particularly important to reduce wildfire risk around homes with accessibility issues. Photo by the FPDs.

Where possible, residents should improve roadway access, and where this is not feasible, it is vital that homeowners take measures to harden their home and create defensible space. Some actions to increase access to your home are simple, such as installing reflective address numbers, and others take time and investment, such as widening driveways to accommodate fire engines.

Private Water Resources

Water resources to fight fire in the mountains can be scarce, especially during the fire season in late summer and fall. Firefighters are skilled at determining the most beneficial ways to use water to protect structures from an approaching fire. Providing clear access to suitable water resources around your home or neighborhood can help them defend your home.

Do not turn sprinklers on around your home as you evacuate. This is counterproductive to protecting your home because continuous use of water before a flame front approaches can drain local wells and cisterns long before the fire reaches your neighborhood. This can leave firefighters with less resources to defend your home, putting their lives and your property at higher risk. Leaving sprinklers out but *turned off* allows the firefighters to determine whether they will be useful or not.

Prepare personal water resources by making them easily accessible and clearly labelling how to access them. Unlock pump house doors and remove vegetation or other obstructions. If you have a generator, leave it in an accessible location in case power is turned off. Notify the fire department of community cisterns or tanks and ensure they are compatible with their firefighting equipment. If you are planning to install or upgrade a cistern on your property or in your neighborhood, contact the fire department *before* installing it. Not all water sources are useful to fire personnel and the fire department can help you choose a cistern or water source that is also compatible with their equipment. If you have questions about cisterns or other water sources, contact your fire department.

Most importantly, create defensible space around your home and buildings so that water resources can be used effectively. Water is not a reliable resource in the Colorado foothills and mountains. Maintaining a property that requires less water and resources to defend is more likely to survive a fire. See **Figure 4.b.1** and **Figure 4.b.4** for guides on defensible space and home hardening recommendations.

Steps to enhance firefighter safety and access to your home:

- ✓ Install reflective address numbers on the street to make it easier for firefighters to navigate to your home under smokey conditions. Make sure the numbers are clearly visible from both directions on the roadway. Use noncombustible materials for your address sign and sign supports. **Installing reflective address numbers can save lives and is inexpensive and easy to accomplish.**
- ✓ Address roadway accessibility for fire engines. Long, narrow, steep, and curving private drives and driveways without turnarounds significantly decrease firefighter access to your property, depending on fire behavior.
- ✓ Fill potholes and eroded surfaces on private drives and driveways.
- ✓ Increase fire engine access to your home by removing trees along narrow private drives and driveways so the horizontal clearance is 20 feet wide, and prune low-hanging branches of remaining trees so the unobstructed vertical clearance is at least 13 feet and 6 inches per the NFPA 1.
- ✓ Park cars in your driveway or garage, not along narrow roads, to make it easier for fire engines to access your home and your neighbors' homes.
- ✓ Clearly mark septic systems with signs or fences. Heavy fire equipment can damage septic systems.
- ✓ Clearly mark well houses or water systems. Leave hoses accessible for firefighters to use when defending your home, but **DO NOT** leave the water running. This can reduce water pressure to hydrants across the community and reduce the ability of firefighters to defend your home. Read this post by FIRESafe Marin about why it is dangerous to leave water running when you evacuate during a wildfire.
- ✓ Post the load limit at any private bridges or culverts on your property.
- ✓ Leave gates unlocked during mandatory evacuations to facilitate firefighter entrance to your property.
- ✓ Leave exterior lights on to increase visibility.
- ✓ If time allows, leave a note on your front door confirming that all parties have evacuated and providing your contact name and phone number.

3.b. Plan Unit Recommendations

Plan units are boundaries that divide up the FPDs into smaller units. The planning units each typically have similar buildings and roads, topography and vegetation, and social groupings such as neighborhoods and HOAs (**Figure 3.b.1**). No plan unit splits a land parcel, ensuring that fuel treatment recommendations within each plan unit can be realistically implemented by landowners.

The hope is that residents in the same CWPP plan unit will discuss joint risk and organize efforts to reduce risk and enhance emergency preparedness. The CWPP is a useful planning document, but it will only affect real change if residents, neighbors, HOAs, and the entire community come together to address shared risk and implement strategic projects.

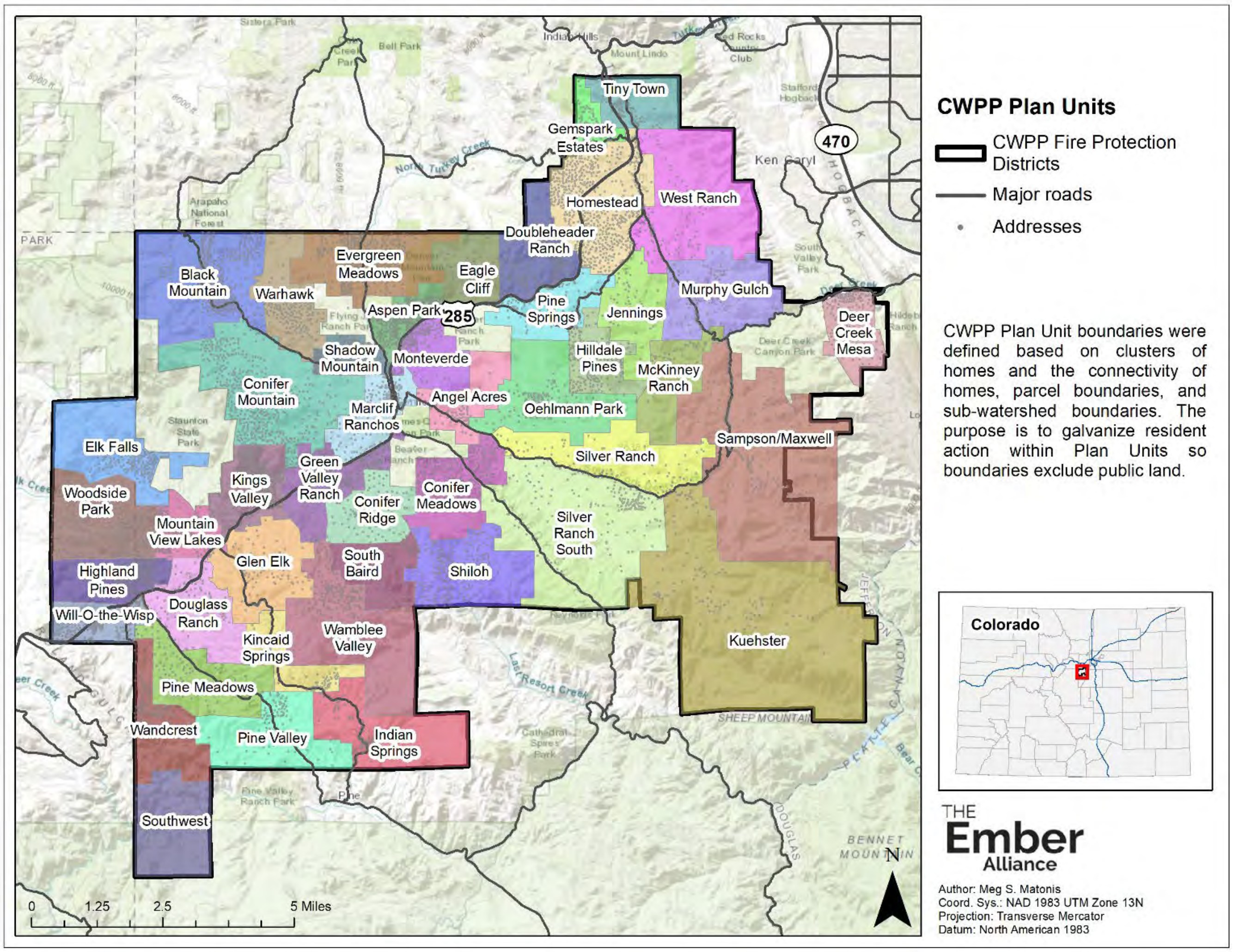


Figure 3.b.1 Plan Units across the FPDs.

Linked Defensible Space

During catastrophic wildfires, property loss happens mostly due to conditions in the **home ignition zone** (HIZ). Homes are most likely to ignite because of embers, and structures that are on fire close to a home can emits significant amounts of embers and endanger the homes and structures near them. Research following the 2018 Camp Fire showed that homes were more likely to burn down when they were close to other structures that had also burned or when they had vegetation within 100 meters of the home (Knapp 2021).

Defensible space refers to the space around individual structures that makes them more likely to survive wildfire, but can be connected to provide additional layers of protection and safety for communities. When multiple neighbors create defensible space around their homes, it creates **linked defensible space** and makes entire neighborhoods defensible. Firefighters and residents attest to the important role defensible space played in allowing homes to survive during previous wildfires in Colorado (Jolley 2018). Homes in close proximity, homes on steep slopes, and homes surrounded by dense trees will benefit significantly from linked defensible space. See **Section 4.b** to learn about recommended practices for creating defensible space, and see (table below) for common concerns about community action from residents in the WUI and potential solutions.

Mitigation Barriers and Opportunities

Table 3.b.1 Common concerns from residents in HOAs and neighborhoods in the WUI, and potential solutions.

Concern	Potential Solutions
HOA rules hinder my ability to establish defensible space around my home.	Contact HOA board members to ask questions about regulations. You might perceive barriers to mitigation that do not exist or are easily addressed. Serve on HOA working teams and speak with HOA leadership to support community-wide action around wildfire mitigation. Advocate for HOA regulations that align with home hardening practices and FireWise landscaping. Reach out to your FPD for examples of working with HOA groups.
My neighbors haven't mitigated risk on their property.	Some residents in the EC & IC FPD are rightfully concerned about high hazards on their neighbors' properties and HOA open space. Your home ignition zone might overlap with your neighbor's property. Given the high fire risk in the area, it is important that residents across the EC & IC FPD create defensible space and harden their homes. Ideas to inspire action by your neighbors include: • Working with your Community Ambassador, your HOA, and other community groups to help educate your community about the benefits of defensible space and home hardening. • Organizing walking tours to visit the property of residents with exemplary defensible space. Witnessing the type of work that can be done, and seeing that a mitigated property can still be aesthetically pleasing, can encourage others to follow suit.

	• Inviting your neighbors over for a friendly conversation about the risk assessment in this CWPP. Review resources about defensible space together, discuss each other's concerns and values, and develop joint solutions to address shared risk. Collective action by residents will magnify the impact of individual defensible space projects, create tactical opportunities for wildland firefighters, and reduce the likelihood that homes will ignite due to embers produced from adjacent, combusting homes. Linked defensible space has greater strategic value, and projects that span ownership boundaries are better candidates for grant funding.
My land borders public land or large privately held land, not other homeowners.	It can be difficult to engage with landowners that you do not know personally. Inviting the landowner or manager for a friendly meeting to discuss your shared risk can lead to open conversations about how to mitigate that risk. Public-private partnerships are common and can be successful in producing valuable outcomes for shared visions. Public land managers have been part of the process for creating this CWPP and are aware of the risks on their lands. Starting a dialogue with the EC & IC FPDs and their agency can open doors to shared mitigation actions that may reduce costs for everyone involved.

Mosaic Landscapes

Varied fuel types are known to slow the spread of fire, and heterogeneous landscapes (landscapes with multiple fuel types and ages) are more typical of historical forest conditions (Duncan 2015). Creating a mosaic landscape in neighborhoods can help slow fires spread by changing the fuel types as it moves across a hill or valley. A mosaic landscape can be created many ways, for example a neighborhood could have a few acres of old growth conifer trees next to a couple acres of aspen stands, and a few acres of young regenerating conifer trees by a large grassy meadow. This can be arranged in many ways for aesthetic and tactical purposes, and will resemble a patchwork quilt or mosaic art (**Figure 3.b.1**).

The homes in these patches still need to have adequate defensible space, but this would create a more diverse landscape where fire may move slower as it transitions between forest types and offers fuel breaks in unforested locations like shrublands or meadows. This can moderate fire behavior which could potentially give fire fighters the opportunity to defend homes. It also creates a diversity of biomes that both residents and wildlife enjoy.

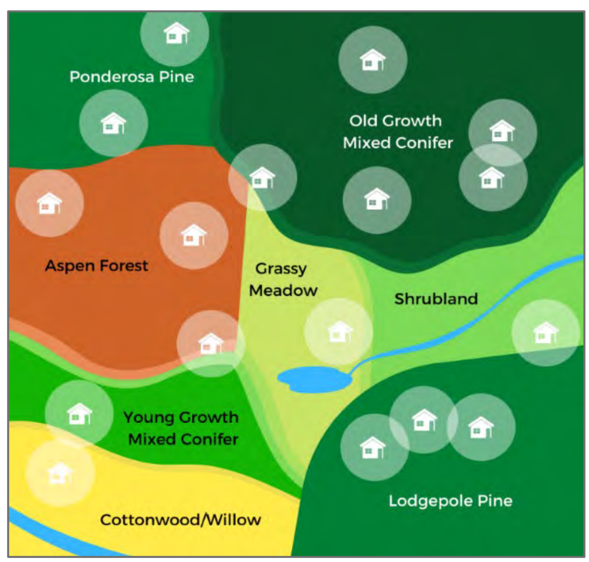


Figure 3.b.2. Example of a mosaic landscape in a neighborhood. Each home has defensible space around it, and the landscape is varied throughout, providing tactical options and reducing fire risk.

Accessibility and Navigability for Firefighters

Shared Driveways and Community Roads

Neighborhoods can work together to ensure emergency responders can locate and access everyone's home. A factor firefighters consider when deciding whether they can protect a home is the access to that home. Narrow roads without turnarounds, tree limbs hanging over the road, and lots of dead and down trees by the road may make firefighters choose to not defend your home during a wildfire event (Brown 1994).

Widening shared driveways and private roads can be time-consuming or expensive. Neighbors and HOAs working together to share costs and applying for community funding grants is an effective way to make safer homes for all residents in an area. More than half the plan units in the FPDs have some roads that are inaccessible to fire engines. Driveways and roads should have a minimum of 20 feet of clearance horizontally and 13.5 feet of clearance vertically to allow engines to safely access the roads (NFPA 1).

Where feasible, HOAs and road associations should improve roadway access. Some actions to increase access to neighborhoods and homes are simple, such as installing reflective address numbers at driveways and road junctions, and others take time and investment, such as widening road networks and creating turnarounds to accommodate fire engines. Working together to update signs and road construction can lower costs for everyone involved as well. Reflective address signs available at your fire protection district.

3.c. Community-Wide Recommendations

Evacuation Planning and Capacity

There is a high likelihood of evacuation congestion and long evacuation times during a wildfire. Evacuation times for individual residents *could* exceed 2.5 hours in some parts of the EC & IC FPD due to the limited number of egress routes.

Reliable technology to provide warnings and information about evacuations can help residents feel confident in their ability to evacuate during a wildfire. Jefferson County Communications Center Authority and emergency alert system to communicate evacuation orders to residents. HOAs, and residents should actively extend awareness signing up for alerts on the Jefferson County Emergency Notifications page

The following steps are recommended for HOAs, community groups, EC & IC FPD and the Jefferson County Sherriff's Office to address evacuation concerns in the EC & IC FPD:

- Conduct tree removal, cut low limbs, and mow grass along roadways to increase the likelihood of survivable conditions during a wildfire. Prioritize the roads with the most traffic and congestion and work out to the less congested roads. (See **Roadway Fuelbreak Recommendations**).
- Coordinate with the Jefferson County Sherriff's Office to conduct evacuation drills to practice safe and effective evacuation for the entire EC & IC FPD.
- Educate residents about warning systems, protocols for evacuation orders, and evacuation etiquette prior to the need to evacuate the community.
- Encourage residents to evacuate whenever they feel unsafe, even before receiving mandatory evacuation orders, and encourage residents to leave with only one vehicle per household to reduce congestion for everyone.
- Encourage all households to develop family evacuation plans and to pack go-bags that are at the ready. Share the Rotary Wildfire Ready website through social media, community newsletters, etc. to educate residents about preparing go-bags and evacuation planning.
- Make sure warnings and alerts can be understood by all residents, including those with English as a second language and with hearing impairments.

New Development Evacuation Planning

Evacuation timing in the EC & IC FPDs is not ideal (see **Evacuation Modeling and Scenarios**). Existing neighborhoods have a significant amount of work to do to be prepared and safe during an evacuation, and new developments within the districts should prioritize evacuation safety when planning and implementing the developments.

New developments and expansions of existing developments should, at minimum, have:

- Multiple egress routes: more than one way in and out of the neighborhood, preferably on opposite sides of the neighborhood, to create options for evacuations. Neighborhoods with only one road to get in or out can be cut off and trap the residents. Multiple helps protect the life safety of the residents.
- Adequate signage: a well-maintained road network that is signed with reflective signs for streets and addresses helps residents navigate during evacuations when thick smoke or weather makes navigation difficult. It also helps law enforcement personnel find homes to assist with evacuations and firefighters navigate the neighborhood more easily and find homes when defending structures. (see **Accessibility and Navigability for Firefighters** for individuals, and **Accessibility and Navigability for Firefighters** for neighborhoods)

- Roadway management with maintenance plans: roadway treatments to create survivable roadway conditions for residents evacuating and firefighters working on wildfires. Roadway treatments need maintenance, and planning for that work initially is important to ensure it happens. Regeneration and tree mortality are natural events that can reduce roadway survivability over time and should be planned for (see **Accessibility and Navigability for Firefighters** and **Roadway Fuelbreak Recommendations**).

Outreach and Education

The EC & IC FPDs should continue to engage with community members through a variety of routes, including community ambassadors, social media, and to visitors through short-term rentals.

Fire Adapted Communities

TEA commends that members of EC & IC FPDs are Fire Adapted Community (FAC) members. This should continue to be a framework for residents to embrace the concept of a Fire Adapted Community (FAC), which is defined by the National Wildfire Coordinating Group as "a human community consisting of informed and prepared citizens collaboratively planning and taking action to safely coexist with wildland fire". This concept can guide residents and communities through a holistic approach to become more resilient to fire (**Figure 3.c.1**). The Fire Adapted Community Learning Network is an online community dedicated to supporting wildfire mitigation and education efforts which the FPDs are part of. Residents can utilize the FAC framework and network when developing local projects and overcoming obstacles to fire mitigation adaptation.

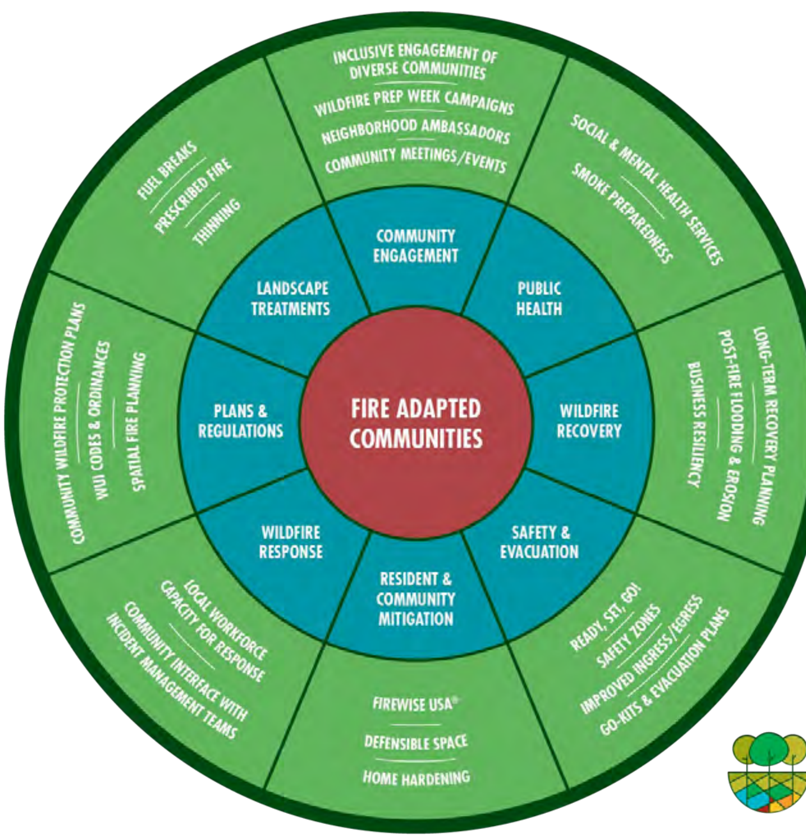


Figure 3.c.1. The Fire Adapted Communities graphic provides specific programs and activities that communities can take to reduce their wildfire risk and increase their resilience (figure from the Fire Adapted Community Learning Network).

This CWPP can only result in on-the-ground change if residents and community groups work the fire protection districts who have strong relationships with other Upper South Platte Partnership members, like the Colorado State Forest Service and Jefferson Conservation District, in order to implement mitigation projects. EC & IC FPDs have a robust the **Community Ambassador Program** involving volunteer residents who help their neighbors better understand wildfire risks and spark coordinated action. EC & IC FPDs have a dedicated staff member who guides the neighborhood ambassadors, and continued support for this program is paramount. See **Table 3.c.1** from the guide *Fire adapted communities neighborhood ambassador approach: Increasing preparedness through volunteers* for effective activities that neighborhood ambassadors can undertake.

Table 3.c.1. Potential activities for the Community ambassador program. Table adapted from Wildfire Adapted Partnership (2018).

Example activity	Ambassador responsibility	Coordinator responsibility
Educational programs about defensible space and home hardening	Gauge interest of neighbors and select topics. Find meeting location. Encourage neighbors to attend.	Arrange for specialists to make presentations. Advertise program through HOA newsletters, social media, etc. Encourage participation in the Wildfire Prepared program.
Emergency planning	Organize an event for people to ask firefighters and law enforcement personnel about emergency planning and evacuation. Encourage residents to work with their neighbors to develop a plan for evacuation if a resident is not at home, school-aged children or pets might be home alone, or residents have mobility impairments and need special assistance.	Provide information to residents about emergency planning and go-bags. Arrange for specialists to make presentations. Advertise program through HOA newsletters, social media, etc.
Community chipping day	Secure HOA buy-in and request financial support. Select a date and organize event logistics. Encourage neighbors to attend. Secure contractor.	Support these community efforts through HOA newsletters, social media, etc.
Defensible-space walking tour	Identify homeowners with exemplary defensible space. Select a date and organize event logistics.	Arrange for fuel treatment specialists to attend and make presentations.

	Encourage neighbors to attend.	Provide handouts and other educational material about defensible space. Advertise program through HOA newsletters, social media, etc.
Defensible space projects	Work with neighbors to identify high-priority project locations using insights from the CWPP (see priority locations in **Priority Plan Unit Recommendations** and **Priority Treatment Locations**. Suggestions for Ecological Restoration and Stand-level Fuel Treatments). Secure HOA buy-in and request financial support. Work with Wildfire Prepared program to identify appropriate contractor and manage project.	Work to share effective treatment location and prescriptions, following guidelines in **Stand-Level Fuel Treatment Recommendations**. Identify potential contractors. Write scope of work for contract. Inspect project upon completion. Celebrate success through social media posts and newspaper articles.
Roadway fuel treatment projects	Work with neighbors to identify roads and driveways with potentially non-survivable conditions using insights from the CWPP (see **Priority Locations**). Secure HOA buy-in and request financial support. Select contractors and solicit bids. Oversee project completion.	Share effective treatment location and prescriptions, following guidelines in **Roadway Fuelbreak Recommendations**. Identify potential contractors. Write scope of work for contract. Inspect project upon completion. Celebrate success through social media posts and newspaper articles.

Social Media

Social media is a powerful tool when used properly to connect with audiences. FEMA has a [Wildfire and Outdoor Fire Safety Social Media Toolkit]() that is a great starting place for districts to begin gaining an audience with their constituents and sharing important fire safety information. [Put Fire to Work]() highlights programs and organizations that are successfully engaging audiences around wildland and prescribed fire work. [CalFire's Ready for Wildfire]() campaign is active and collaboratively created to engage and encourage people to take action on wildfire preparedness.

Collaboration

Collaboration with stakeholders, landowners, local governments, business owners, and community members is the best way to ensure good outcomes from this plan. Stakeholders were engaged in the development of this CWPP and offered input on the recommendations set forth in the following section, and these stakeholders, together with the FPDs, *must work together* to move mitigation projects from paper to on the ground action, keep lines of communication open and messaging consistent, and to support each other's work in the community. Where some organizations may be able to offer incentives to homeowners, others may be able to provide structure and requirements that must be met to keep life safety for residents and firefighters a priority. This multi-faceted approach is only possible through compromise, mutual respect, and collaboration on shared goals.

Stakeholder Engagement

Community engagement is a vital aspect of CWPP development and implementation. TEA and representatives from EC & IC FPD synthesized and interpreted these analyses and engaged stakeholders from across the district and neighboring districts to develop the recommendations set forth in this CWPP. They incorporated lessons learned from the challenging 2020 wildfire season in Colorado and considered valuable insights shared by community members and other stakeholders.

Due to the outbreak of COVID-19, TEA was unable to hold in-person meetings with residents, so virtual community feedback sessions were conducted to provide opportunities for community involvement. In spring of 2021, community leaders shared their perspectives on how best to interact with residents in the EC & IC FPD and for their sense of the community's current awareness, understanding, and commitment to wildfire preparedness.

In fall of 2021, a meeting was held between agencies and organizations with a shared interest in mitigation of wildfire hazards across the EC & IC FPD. Partners like Colorado Parks and Wildlife, the Colorado State Forest Service, the US Forest Service, Jefferson County Open Space, Jefferson County Road and Bridge, Jefferson County Emergency Management, Jefferson Conservation District, Denver Water, Denver Mountain Parks, and CORE Electric Cooperative have valuable assets within and adjacent to the community. During this meeting the fire behavior analyses and prioritization were discussed, along with current and planned fuel treatments. TEA is grateful to CORE Electric Cooperative and Jefferson County for sharing geospatial data about their infrastructure across the EC & IC FPD.

It is recommended that EC & IC FPD host regular meetings with major stakeholders in the district to provide accountability on projects, continue to participate in cross-boundary mitigation programs such as USPP, and support the community ambassador program's growth and maintenance to connect to landowners and HOAs across the district.

A final community meeting was held to share findings with the community at large and to disseminate information about how to take action to reduce risks present in the district. This meeting was held in person and recorded for residents due to the ongoing presence of COVID-19.

4. Implementation Recommendations

4.a. General Objectives and Implementation of Fuel Treatments

> "Given the right conditions, wildlands will inevitably burn. It is a misconception to think that treating fuels can 'fire-proof' important areas... Fuel treatments in wildlands should focus on creating conditions in which fire can occur without devastating consequences, rather than on creating conditions conducive to fire suppression" (Reinhardt and others 2008).

Fuel treatments are a land management tool for reducing wildfire hazard by decreasing the amount and altering the distribution of wildland fuels. Fuel treatment methods include tree thinning, pruning, pile burning, broadcast prescribed burning, and fuel mastication (Hunter and others 2007). Strategic fuel treatments, in tandem with work by individual residents to mitigate hazards in their home ignition zone (see **Home Ignition Zone Recommendations**), can help protect life and property. Many residents, HOAs, and local agencies that manage land within and around the EC & IC FPD are actively reducing wildland fuels. Additional strategic work is required to mitigate wildfire risks across the EC & IC FPD (see **Priority Plan Unit Recommendations** and **Priority Treatment Locations**).

Many fuel treatments focus on reducing the risk of active or passive crown fires and reducing the intensity of the fire. This is primarily achieved by treatments that decrease the tree density, increase crown spacing, and decrease ladder and surface fuels. However, it should be noted that removing trees can increase the growth of grasses, forbs, and shrubs and dry out these fuels by increasing their exposure to sun and wind. Fires burning through abundant, dry grasses have rapid rates of spread; however, the fundamental goal of many fuel treatments is not to reduce the rate of fire spread but to reduce burn severity or increase opportunities for suppressing wildfires (Reinhard and others 2008).

Strategically located, high-quality fuel treatments can create tactical options for fire suppression (Plucinski 2019; Jolley 2018; Reinhardt and others 2008). Fuel treatments alone are incapable of stopping wildfires: they must be used in conjunction with suppression actions. Reduced fire intensity within treated areas allows firefighters opportunities to use direct or indirect suppression techniques.

All fuel treatments are not created equal, and there is no ''one size fits all'' fuel treatment design (Reinhardt and other 2008). Specific fuel treatment recommendations are dependent on forest type, tree density, fuel loads, terrain, land use, and management objectives. The location and purpose of treatments also matter. Treatments in defensible space zone 3 are typically more intensive than treatments outside of the defensible space zones because of the importance of substantially reducing fuels closer to homes. Treatments along roadways often require removal of many trees to create safe and survivable conditions, whereas treatments in large, forested areas can achieve fuel objectives by following principles of ecological restoration in frequent-fire forests and principles of fire mimicry and mosaic landscapes in infrequent-fire forests.

Local knowledge and professional expertise are needed to design effective, site-specific fuel treatments. Science of fuels treatments continues to evolve, so it is recommended to always work with local practitioners to apply the best available science to any new fuels treatment. For assistance in planning and implementing a new fuels treatment, contact the EC&IC FPDs or your community ambassador through the Wildfire Prepared program.

Treatment Categories

Three categories of fuel treatments are discussed and priority locations suggested as well as general guidelines for each:

- **Home Ignition Zone mitigation:** HIZ mitigation is intended to make the protection of structures such as homes less susceptible to ignition. This includes hardening the home, which involves making it more difficult for embers or radiant heat to light the structure on fire, and creating defensible space, which involves treating the vegetation and other fuels in the area surrounding the home to decrease the intensity of fire activity as it nears the home. The recommendations for this work are standardized and outlined in this document as well as in publications from the Colorado State Forest Service. HIZ mitigation recommendations are designed for individual homeowners and HOAs and neighborhoods to work on with the assistance of the local Wildfire Prepared program.
- **Stand-level fuel treatments:** Stand-level fuel treatments are designed to reduce surface fuels, reduce tree density, and increase the distance between surface and canopy fuels within forest stands (Agee and Skinner 2005). These treatments are designed to reduce the likelihood of high-severity, active crown fires. Ideally stand-level fuel treatments follow the principles of ecological restoration and achieve both ecological and fuel reduction objectives. However, stand-level fuel treatments and ecological restoration are not synonymous; some ecosystem restoration treatments reduce fuel hazards, but not all fuel treatments restore ecosystems (Reinhard and others 2008). A forest with widely, evenly spaced trees could serve as an effective fuel treatment, but this configuration would not achieve ecological objectives in most forest types. Ecological restoration is the process of assisting the recovery of an ecosystem that has been damaged, degraded, or destroyed (SER 2004). In ponderosa pine and mixed-conifer forests along the Colorado Front Range, ecological restoration usually achieves fuel reduction objectives (Ziegler and others 2017). Treatments involve converting dense forests into a mosaic of single trees, clumps of trees, and meadows similar to historical forests that were maintained by wildfires and very resilient to them (Addington and others 2018). Stand-level fuel treatments are designed for large landowners, public land managers, and collaborating neighborhoods to implement.
- **Roadway fuel treatments:** Roadway fuel treatments are buffers along roadways with reduced fuel loads to improve fire control opportunities and reduce the chance that non-survivable conditions develop along roadways during a wildfire. Tree removal along narrow roadways can also increase access for fire engines and provide safer egress for firefighters. These are also used along trails, ridgelines, and other features that can be utilized by firefighters to contain fire spread. They are referred to as shaded fuelbreaks when overstory trees are retained in the area. This work can be done by all collaborators in the district. Individuals can implement these recommendations along their driveways, HOAs and neighborhoods can mitigate along their share road networks, and land managers can work with County Road and Bridge and CDOT to implement these on major roads in the district following CSFS recommendations.

Treatment Costs

The cost of fuel treatment depends on management objectives, treatment specifications, slope, accessibility, and treatment method (e.g., mechanical thinning, hand thinning, or prescribed burning). Costs of $1,500 to $2,500 per acre are not uncommon along the Colorado Front Range where there is little biomass or timber industry to provide financial return (Jones and others 2017). (A note on current conditions: while this CWPP was developed in 2021, costs of $12,000 to $20,000 per acre were seen in proposals in Jefferson County due to the complex economic situation that the timber and forestry industry is experiencing.) Costs for follow-up treatments are generally lower than the initial entry and help maintain the original investment in fuel treatments. The cost of fuel treatments underscores the importance of conducting strategic, well-designed, landscape-scale treatments to increase the likelihood that fuel treatments moderate fire behavior.

Fuel treatments can save lives and ecosystems and provide economic returns. Fuel treatments can reduce property damages by making wildfires less damaging and easier to control; this is especially true for prescribed burning which is often cheaper and more effective at altering forest fuel loads than mechanical thinning alone (Prichard and others 2020; Loomis and others 2019; Fulé and other 2012). Fuel treatments can reduce the cost of rehabilitating water sources when wildfires are followed by large storm events that result in massive erosion (Jones and others 2017). In some instances, fuel treatments can reduce suppression costs due to the increased efficiency of firefighting (Loomis and other 2019).

Fuel treatments do not always have positive financial returns on investment. Some treatments are never encountered by wildfires, fuel treatments can be ineffective at altering fire behavior during severe fire weather conditions, and suppression expenditures are often driven by values at risk, fire size, and landownership rather than fuel characteristics (Reinhardt and others 2008). However, when fuel treatments follow the principles of ecological restoration, they result in positive ecological benefits regardless of economic costs.

4.b. Home Ignition Zone Implementation Recommendations

Defensible Space

Residents can create defensible space by reducing the amount of vegetation and flammable materials (i.e., pine needles, stacked firewood, patio furniture) within the HIZ. Removing flammable materials decreases risk to your home and gives firefighters a potential opportunity to defend it. Defensible space creates a buffer between your home and grass, trees, and shrubs that could ignite during a wildland fire. Defensible space can slow the spread of wildfire, prevent direct flame contact, and reduce the chance that embers will ignite material on or near your home (Hakes and others 2016). Substantially reducing vegetation within the HIZ and removing vegetation that overhangs decks and roofs can reduce structure loss, especially for homes on slopes (Syphard and others 2014).

> During a wildland fire, homes that have clear defensible space are identified as potential sites for wildland firefighters to engage in home protection. Properties that are not defensible will not often receive firefighter resources due to unsafe conditions and the higher likelihood of home

Defensible space is divided into multiple zones around a home, and recommended practices vary among zones. The Colorado State Forest Service (CSFS) defines zone one as 0 to 5 feet from the home, zone two as 5 to 30 feet from the home, and zone three as 30 to about 100 feet from the home. Some organizations call zone one the "noncombustible zone" (0 to 5 feet from the home) and zone two the "lean, clean, and green zone" (5 to 30 feet from the home). Residents should establish defensible space around each building on their property, including detached garages, storage buildings, barns, and other structures. See **Figure 4.b.1**, **Table 4.b.1**, and the CSFS publication The Home Ignition Zone for recommendations. For assistance in getting started, please utilize the Wildfire Prepared program.

Homeowners and neighbors should create access for fire engines to their home in coordination with creating defensible space. Driveways should have a minimum of 20 feet of clearance horizontally and 13.5 feet of clearance vertically to allow engines to safely access the roads (NFPA 1).

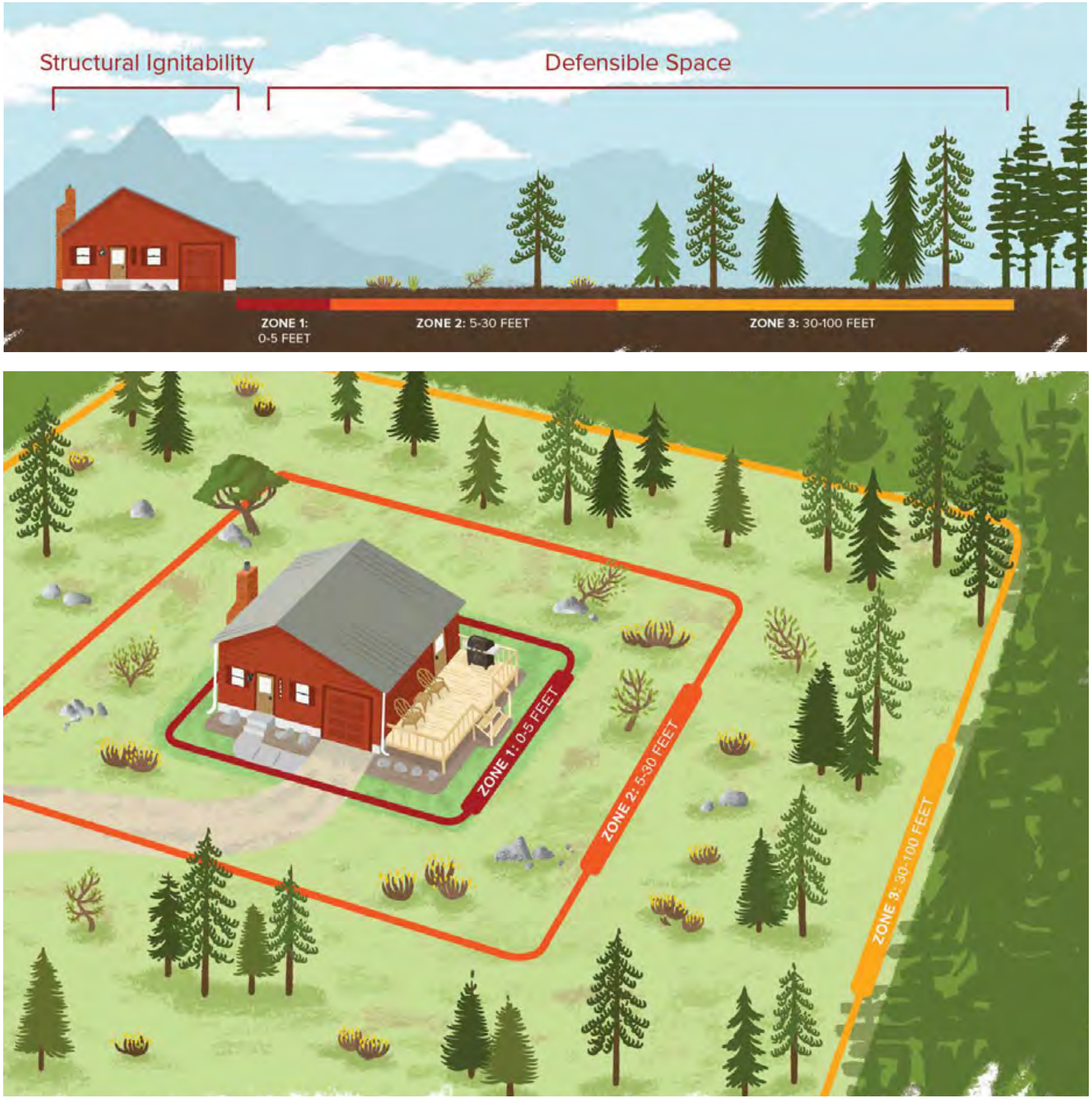


Figure 4.b.1. Defensible space zones recommended by the Colorado State Forest Service. Images from the CFSF, drawn by Bonnie Palmatory.

Tall grass and shrubs, tight crown space, and dense ladder fuels could endanger these upslope homes due to radiant and convective heating and short-range embers during a wildfire. Photos from EC & IC FPD.

It is important for residents to work together as a community to mitigate shared wildfire risk. Structure-to-structure ignition is a major concern in WUI communities and can cause substantial property loss. During the 2018 Camp Fire, homes in Paradise, CA that were within 60 feet of another structure that burned were more than 6 times as likely to burn down as homes further away from other destroyed structures, and homes with overstory trees within 330 feet of the home were almost three times more likely to burn down than homes without that vegetation (Knapp 2021). In the combined FPDs, 75% of homes have home ignition zones that overlap with their neighbors HIZs, meaning that the home is within 100 meters (330 ft) of another home or structure. 60% of homes overlap with multiple other homes HIZs, and more than that are adjacent to overstory trees within 100 meters (**Figure 8.a.13**, **Figure 8.a.14**). Neighbors can increase their homes' chances of survival during a wildfire if they work together to reduce hazards in their overlapping defensible space. Wandcrest, Kuester, and the Southwest plan units have the highest percent of homes with High and Extreme exposure to radiant heat and embers under both 60th and 90th percentile weather conditions. Gemspark Estates, Pine Meadows, Conifer Ridge, and Silver Ranch are also at extreme risk, even under moderate weather conditions (**Table 8.a.7**).

Table 4.b.1. Defensible space recommendations for homes in the WUI based on the CSFS publication The Home Ignition Zone and Rotary Wildfire Ready. This is not an all-inclusive list of activities. Specific measures will depend on the placement and condition of your property.

Zone 1: 0 to 5 feet from your home – the noncombustible zone.

Goal: Prevent flames from having direct contact with your home.

- Create a noncombustible border 5 feet around your home (aka, hardscaping). Replace flammable wood chips with alternatives like dirt, stone, or gravel.
- Remove branches that hang over your roof and drop needles onto your roof and remove all fuels within 10 feet of the chimney.
- Remove combustible materials (dry vegetation, wooden picnic tables, juniper shrubs, etc.) from underneath, on top of, or within 5 feet of decks, overhangs, windows, and doors.
- Annually remove dead or dry leaves, pine needles, and dead plants withing 5 feet of your home and off your deck, roof, and gutters. Farther than 5 feet from structures, raking material will not significantly reduce the likelihood of ignition and can negatively affect other trees.
- Move firewood or other combustible materials to Zone 3.
- Do not use space under decks for storage.

Zone 2: 5 to 30 feet from your home – the lean, clean, and green zone.

Goal: Slow the movement of flames approaching your home and lower the fire intensity.

- Irrigate and mow grasses to 4 inches tall or less.
- Remove any accumulated surface fuels such as logs, branches, slash and mulch
- Remove common junipers because they are highly flammable and tend to hold a layer of flammable material beneath them, and replace with plants that have more fire-resistant attributes, like short-statures, deciduous leaves, and higher moisture content. See FireWise Plant Materials from Colorado State University Cooperative Extension for suggestions.
- Remove enough trees to create at least 10 feet* of space between crowns. Measure from the outermost branch of one tree to the nearest branch on the next tree. Create even more space between trees if your home is on a slope (**Table 4.b.2**). See **Figure 4.b.2** for how to measure crown spacing.
- Small groups of two or three trees may be left in some areas of Zone 2. Spacing of 30 feet* should be maintained between remaining tree groups to ensure fire doesn't jump from one group to another.
- Remove ladder fuels under remaining trees. This is any vegetation that can bring fire from the ground up into taller fuels.
- Prune tree branches to a height of 6-10 feet from the ground or a third of the total height of the tree, whichever is less. See **Figure 4.b.2** for a depiction of how to measure limb height.
- Keep spacing between shrubs at least 2-3 times their height.
- Relocate wood piles and propane tanks to Zone 3.
- Remove stressed, diseased, dead, or dying trees and shrubs. This reduces the amount of vegetation available to burn and improves forest health.
- Keep shrubs at least 10 feet* away from the edge of tree branches.

*Horizontal spacing recommendations are minimums and can be increased to reduce potential fire behavior, particularly on slopes. Consult a forestry, fire, or natural resource professional for guidance with spacing on slopes.

Zone 3: 30 to 100 feet from your home
Goal: Slow movement of flames, move fire to the ground, reduce ember production.
If you live on a slope, this zone may be larger to gain the full benefits of defensible space. • Store firewood and propane tanks at least 30 feet away and uphill from your home and away from flammable vegetation. Store even farther away if your home is on a slope. • Mow or trim grasses to maximum height of 4 inches. • Remove enough trees to create at least 10-foot spacing between the outermost branches of remaining trees. Create even more space between trees if your home is on a slope (Table 4b.2). See Figure 4b.2 for a depiction of how to measure crown spacing. • Remove limbs so branches do not hang below 10 feet above the ground. See **Figure 4.b.2** for a depiction of how to measure limb height. • Remove shrubs and saplings that can serve as ladder fuels. • Remove heavy accumulations of dead trees and branches and piles of fallen leaves, needles, twigs, pinecones, and small branches. Thin trees to increase spacing and remove ladder fuels to reduce the likelihood of torching, crown fires, and ember production. • Consult with **Wildfire Prepared** to develop a plan to manage your property to achieve fuel reduction and other goals, such as creating wildlife habitat. Follow principles of ecological restoration as outlined in **Stand-Level Fuel Treatment Recommendations**.

Table 4.b.2. According to the CSFS, horizontal spacing recommendations are minimums and can be increased to reduce potential fire behavior, particularly on slopes due to the exacerbating impact of slope on fire behavior (Dennis 2003). Consult a forestry, fire or natural resource professional for guidance with spacing on slopes.

Percent slope	Minimum spacing between tree crowns	Minimum spacing between shrubs / small clumps of shrubs
0 to 10 %	10 feet	2.5 x shrub height
11 to 20%	15 feet	3 x shrub height
21 to 40%	20 feet	4 x shrub height
>40%	30 feet	6 x shrub height

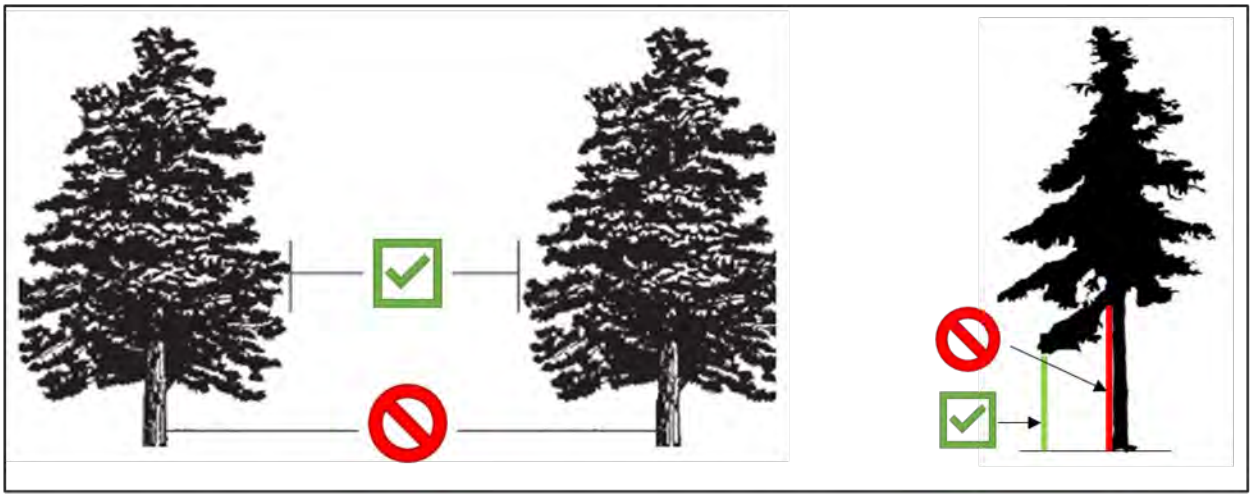


Figure 4.b.2. Spacing between tree crowns is measured from the edge of tree crown to tree crown, NOT from tree stem to tree stem (left). Height of limbs above the ground is measured from the ground to the lowest point of the limb, NOT from where the limb attaches to the tree (right).

Some homeowners in the WUI are concerned that removing trees will destroy the forest and reduce the aesthetic and monetary value of their property. In fact, many dense ponderosa pine forests are unhealthy and greatly diverged from historical conditions that were maintained by frequent wildfires (**Figure 2.e.1**). The reality is that nothing will decrease the aesthetic and monetary value of your home as much as a high-severity wildfire burning all the vegetation in the community, even if your home survives the fire. Forest management can look messy and destructive in the first years following treatment; however, grasses, shrubs, and wildflowers will respond to increased light availability after tree removal and create beautiful ecosystems with lower fire risk (**Figure 4.b.3**).

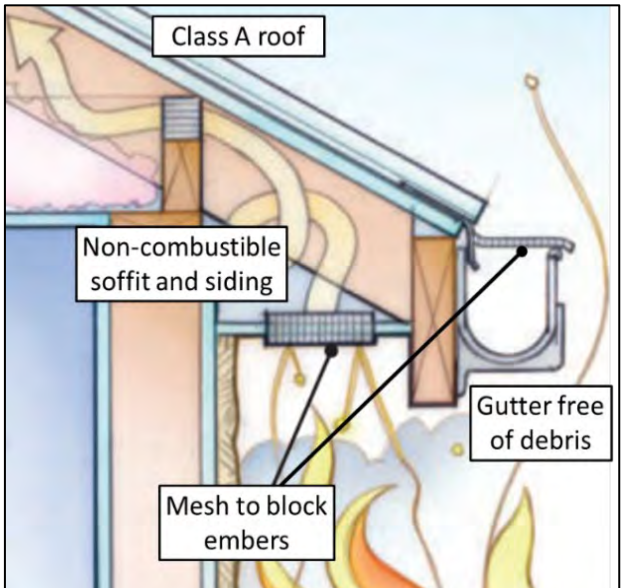
According to the Director for the Jefferson Conservation District, many residents enjoy their land even more after conducting effective fuel treatments. Removing trees can open incredible views of mountains, rivers, and rock formations, and wildlife are often attracted to forests with lower tree densities and a greater abundance of understory plants. Many residents feel safer in a forest that is less dark and more open, and they rest easier knowing firefighters would have a greater chance of safely defending their home. It might even be said that the more trees you cut, the more trees you save from wildfire. Reducing fuel loads and increasing the spacing between trees also increases the chance that your home and your neighbors' homes will survive a wildfire**.** See **Stand-Level Fuel Treatment Recommendations** for more information on treatments that achieve ecological and fuel reduction objectives.

Figure 4.b.3. Grasses, shrubs, and wildflowers quickly respond to increased light availability after tree removal, resulting in beautiful ecosystems with lower fire risk. The green star in each photo indicates the same tree. Image sizes vary due to the use of different cameras over the years. Photos from the Jefferson Conservation District.

Home Hardening

Home hardening involves modifying your home to reduce the likelihood of structural ignition. At least half of the homes in the EC & IC FPD are at risk of long-range embers from nearby burning vegetation under 60% percentile weather conditions, and many of the homes that are in denser neighborhoods are at risk of short-range embers and radiant heat as well. **Buildings cannot be made fireproof, but the chance of your home surviving wildfires increases when you reduce structural ignitability through home hardening in tandem with the creation and maintenance of defensible space. Figure 4.b.4** depicts important home hardening measures.

Roofs, vents, windows, exterior siding, decks, and gutters are particularly vulnerable to wildfires. Research on home survival during wildfires demonstrates that enclosed eaves and vent screens can reduce the penetration of wind-born embers into structures (Hakes and others 2016; Syphard and Keeley 2019). Multi-pane windows have greater resistance to radiant heat. Windows often fail before a home ignites, providing a direct path for flames and airborne embers to enter a home (CSFS 2012).

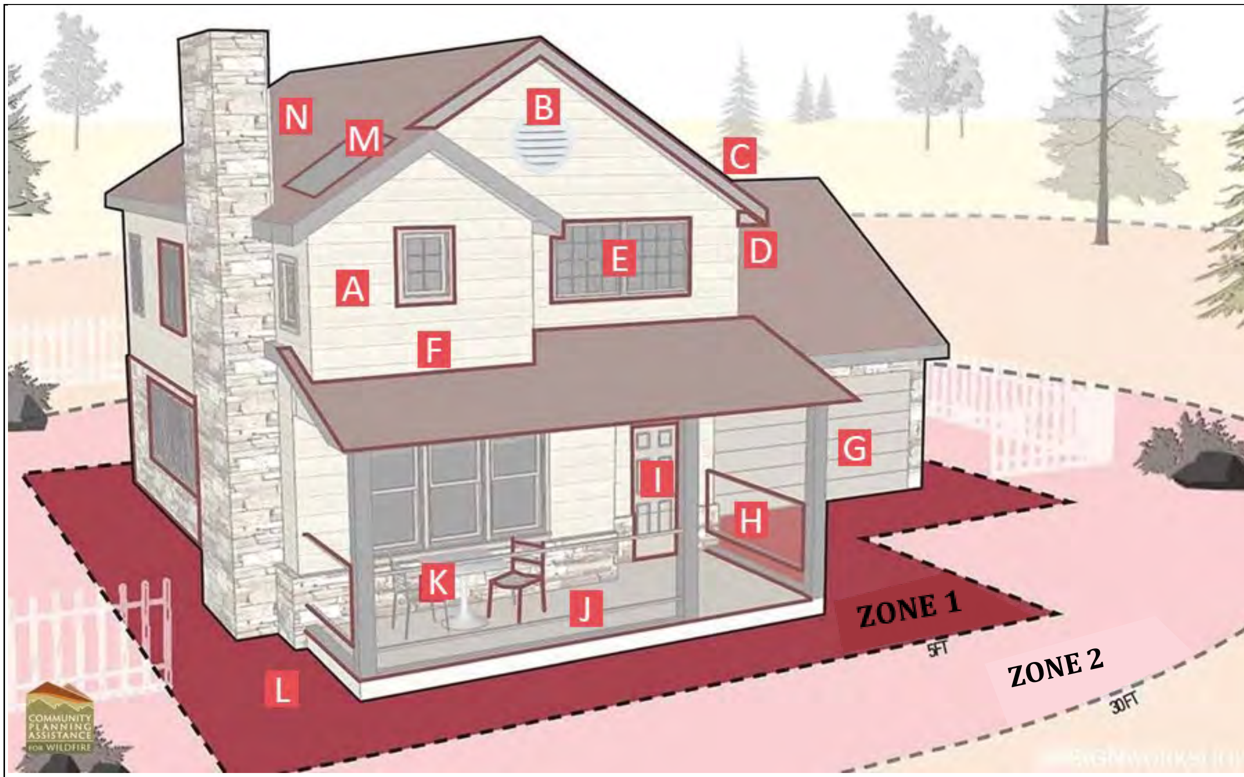


Residents can increase their homes' chance of survival by making it harder for embers to enter and ignite their homes (image from *Healthy Building Science*).

It is important to replace wood or shingle roofs with noncombustible materials [3] such as composition, metal, or tile. Ignition-resistant or noncombustible siding and decking further reduce the risk of home ignition, particularly when homes also have a 5-foot noncombustible border of dirt, stone, or gravel. Non-wood siding and decking are often more durable and require less routine maintenance.

There are many low-cost actions you can start with to harden your home (see **Mitigation Barriers and Opportunities**). Keep home-hardening practices in mind and use ignition-resistant materials if you replace a hail-damaged roof or remodel your home. In January 2020, Jefferson County approved new building construction regulations, and the Jefferson County Department of Development and Transportation provides a list of approved building materials to help address the high potential for home loss in the WUI. New construction and replacement construction that require a building permit must comply with the new building standards.

[3] See the glossary for the definition of terms used the describe the performance of building materials when exposed to fire (e.g., wildfire-resistant, ignition-resistant, and noncombustible).



- **A.** Use noncombustible or ignition resistant siding and trim (e.g., stucco, fiber cement, fire-retardant treated wood).
- **B.** Cover vent openings with 1/16th to 1/8th inch corrosion-resistant metal mesh.
- **C.** Clear debris from roof and gutters regularly. Install noncombustible gutters, gutter covers, and downspouts.
- **D.** Install ignition-resistant or noncombustible roofs (composition, metal, or tile). Use noncombustible eaves and cover eaves with screened vents.
- **E.** Install multi-pane windows with at least one tempered-glass pane and metal mesh screens. Use noncombustible materials for window frames. Limit the size and number of windows facing large areas of vegetation.
- **F.** Install a 6-inch vertical noncombustible surface on all gables above roofs.
- **G.** Install weather stripping around and under garage doors. Consider installing 1-hour fire rated garage doors.
- **H.** Avoid combustible lattice, trellis, or other decorative features.
- **I.** Install weather stripping around and under doors. Consider installing a 1-hour fire rated door.
- **J.** Use ignition-resistant or noncombustible decking. Enclose crawl spaces. Remove combustible materials from underneath, on top of, or within 5 feet of deck.
- **K.** Use noncombustible patio future.
- **L.** Establish and maintain a 5-foot noncombustible buffer around the home. Use noncombustible fencing within this zone.
- **M.** Use glass panes for skylights, not materials that can melt (e.g., plexiglass).
- **N.** Cover chimneys and stovepipe outlets with 3/8th to ½ inch corrosion-resistant metal mesh.

Figure 4.b.4. A home can never be made fireproof, but home hardening practices decrease the chance that flames, radiant heat, and embers will ignite your home. Infographic by Community Planning Assistance for Wildfire with modifications to include information from CAL FIRE (2019).

Annual Safety Measures and Home Maintenance in the WUI

Reviewing safety protocols, creating defensible space, and hardening your home are not one-time actions, but part of *annual* home maintenance when living in the WUI. During a wildland fire, homes that have clear defensible space are more likely to remain in the event of a fast moving wildfire or limited firefighting resources. Homes that are not safely defensible will not usually receive firefighter resources if they are available.

The **Colorado State Forest Service** provides the following recommendations for annual activities to mitigate risks and increase your wildfire preparedness:

- ✓ Check fire extinguishers to ensure they have not expired and are in good working condition.
- ✓ Review your family's evacuation plan and practice family fire and evacuation drills.
- ✓ Verify that your home telephone number, cell phone, and/or email are properly registered for an emergency alert system, more information on this website.
- ✓ Review the contents of your "go-bag" and make sure it is packed and ready to go. Visit the Rotary Wildfire Ready website to learn about preparing go-bags. Your go-bag should include supplies to last at least three days, including cash, water, clothing, food, first aid, and prescription medicines for your family and pets. Keep important documents and possessions in a known and easily accessible location so you can quickly grab them during an evacuation.
- ✓ Pay attention to red flag-day warnings from the National Weather Service and stay vigilant. These are available on Elk Creek Fire Rescue's wildland website under morning briefings. Ensure your family is ready to go in case of an emergency.
- ✓ Walk your property to identify new hazards and ways to maintain and improve current defensible space. Take pictures of your defensible space to help you monitor regrowth and determine when additional vegetation treatments are necessary.
- ✓ Clear roofs, decks, and gutters of pine needles and other debris. Remove all pine needles and flammable debris from around the foundation of your home and deck. Remove trash and debris accumulations within 30 feet of your home. Repeat throughout the year as necessary.
- ✓ Properly thin and prune trees and shrubs that have regrown in your defensible space zones 1 and 2 (0-5 feet and 5-30 feet from your home). Remove branches that overhang the roof and chimney. Prune trees and shrubs that are encroaching on the horizontal and vertical clearance of your driveway.
- ✓ Mow grass and weeds to a height of 4 inches or less within 30 feet of your home. If possible, keep your lawn irrigated, particularly within 30 feet of your home. Repeat throughout the year as necessary.
- ✓ Check the visibility of your address and remove vegetation that obscures it.
- ✓ Dispose of leaves, needles, and branches during slash drop-off dates organized by Jefferson County. See the County Slash Collection website for more information.
- ✓ Check screens over chimneys, eaves, and vents to make sure they are in place and in good conditions.
- ✓ Ensure that an outdoor water supply is available for responding firefighters. Put a hose and nozzle in a visible location. The hose should be long enough to reach all parts of your home.

Priority Plan Unit Recommendations

Colorado CWPPs must include a relative rating of hazards across the Fire Protection District to help prioritize action. **Plan units with higher relative risk are strong candidates for immediate action to mitigate hazardous conditions; however, *plan units with lower relative risk in an FPD still possess conditions that are concerning for the protection of life and property in the case of a wildfire*.** Plan unit relative risk ratings are specific to a FPD and not suitable for comparing hazards among FPDs. Based on an assessment from the USFS (**Figure 4.b.5**) all plan units are in extreme danger from fire, and the districts are at the 99th percentile for fire risk, compared to all other communities across the nation.

On-the-ground observations and summary output were combined from TEA's fire behavior and evacuation analyses when rating plan unit hazards. The cutoffs for different relative risk categories are tailored to an individual FPD based on the range of conditions observed. On-the-ground observations can also inform preplan maps for the FPD. Hazards were assessed in four categories across CWPP plan units (**Figure 4.b.6**): fire risk, fire suppression challenges, evacuation hazards, and home ignition zone hazards. This assessment was based on predictions of fire behavior, radiant heat and spotting potential, roadway survivability, and evacuation time, as well as an on-the-ground assessment of each plan unit using a modified version of the NFPA Wildfire Hazard Severity Form Checklist (NFPA 299 / 1144).

Table 4.b.3 provides priority recommendations for defensible space, home hardening, and road access within each CWPP plan unit (**Figure 3.b.1**) based on the Plan Unit Hazard Assessment outlines in Appendix B. The risk rating scale was developed specifically for the EC & IC FPD. Risk ratings are **relative** to other plan units within the EC & IC FPD and are not suitable for comparing the EC & IC FPD to other communities. Plan units with lower relative risk still possess conditions that are concerning for the protection of life and property in the case of a wildfire. Plan units with higher relative risk are strong candidates for immediate action to mitigate hazardous conditions.

Recommendations in **Table 4.b.3** and focus on the most glaring issues in each plan unit; however, homeowners, HOAs, and other community groups can benefit from all actions outlined in **Section 3.a** and **Section 3.b**. All homes in the EC & IC FPD have the potential for ignition from long-range spotting during wildfires.

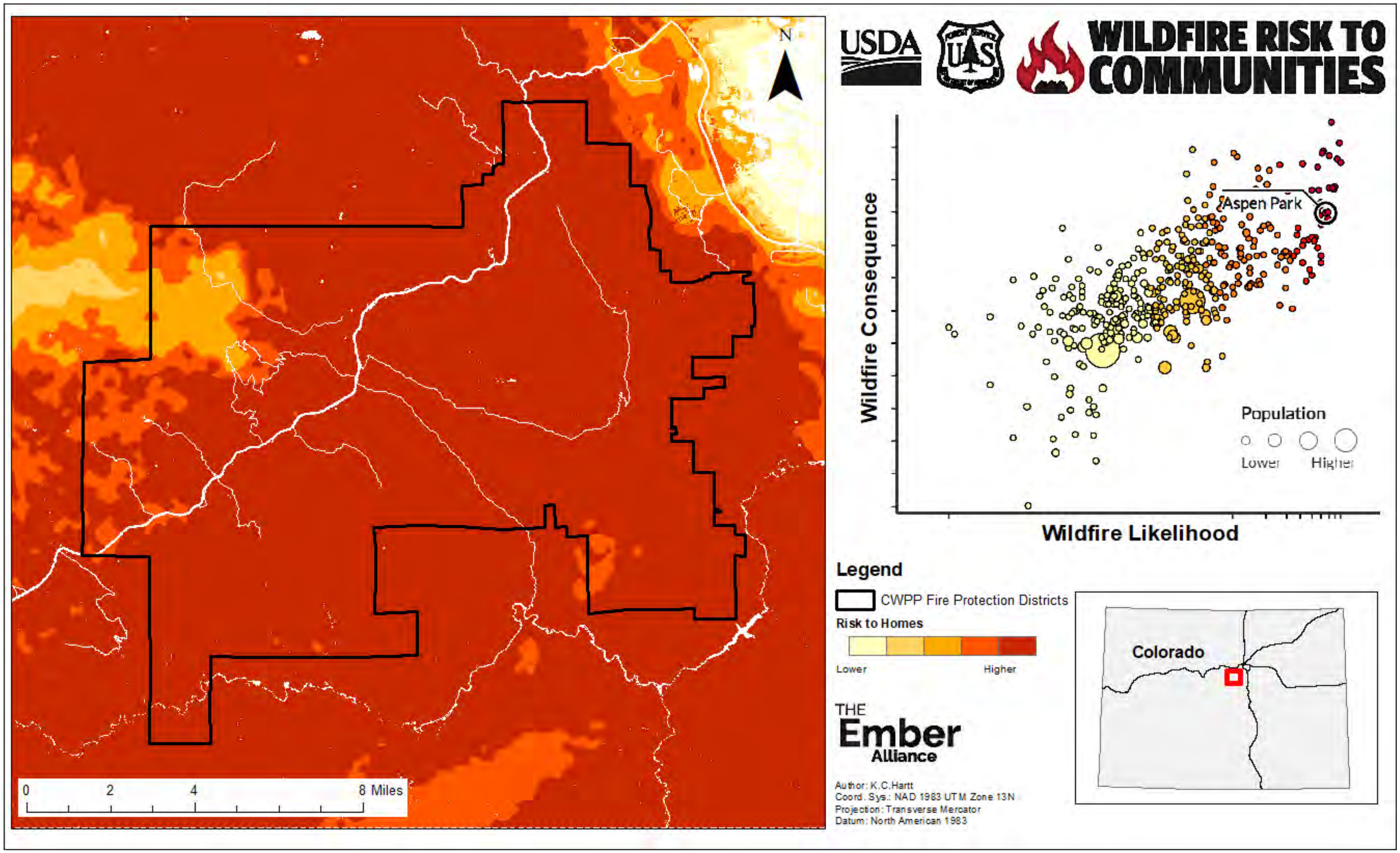


Figure 4.b.5. Wildfire risk to communities, compared to all other communities across the state. Aspen Park and the surrounding areas are at greater risk of wildfire than 99% of communities in both Colorado and the United States.

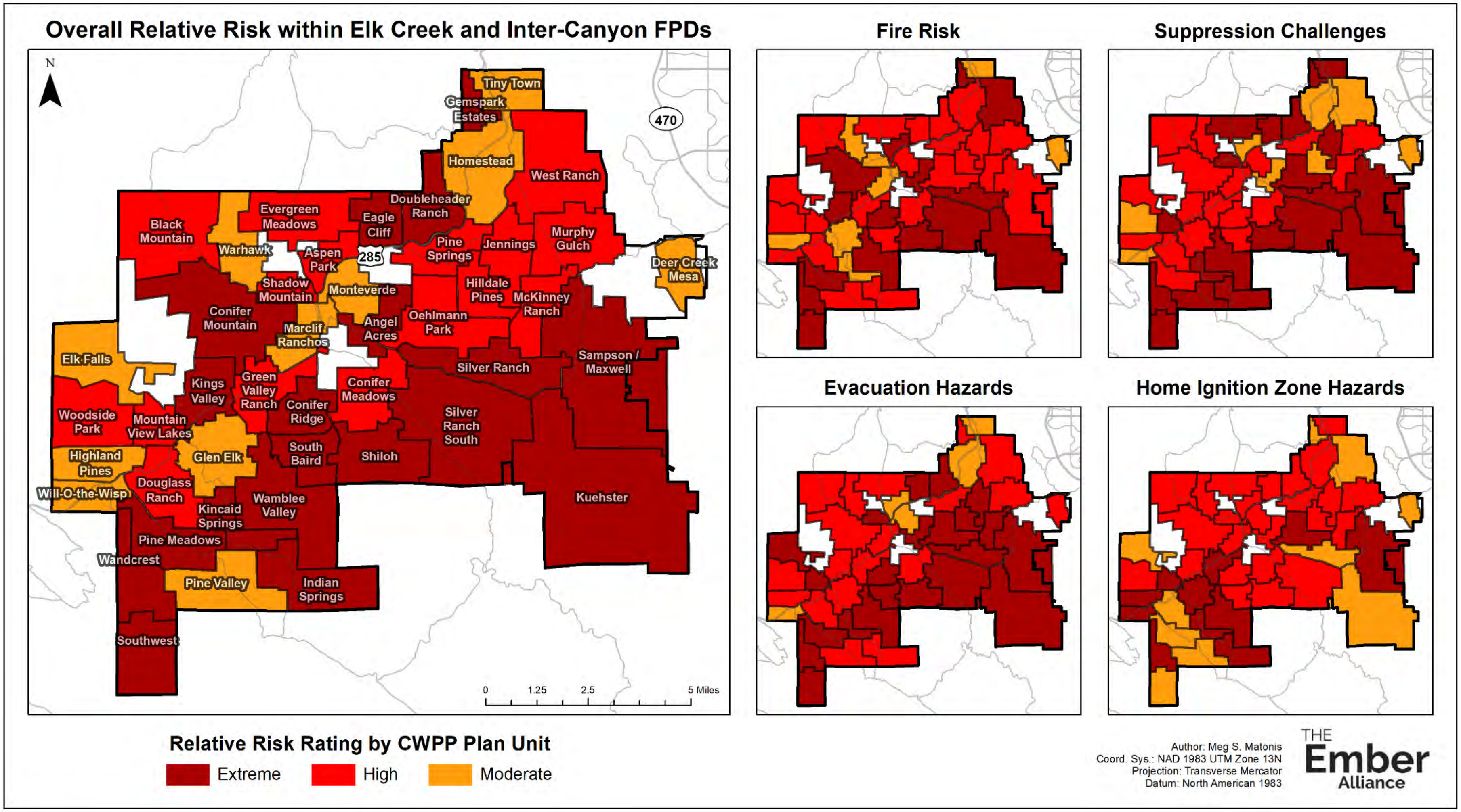


Figure 4.b.6. Relative risk rating for plan units across the districts. Prioritization is based on predicted fire behavior, Moderate fire danger is a relative term – all plan units and communities within the combined FPD boundaries are at an extreme risk of fire danger relative to the entire country and should take recommended actions from **Table 4.b.3** seriously.

Table 4.b.3 Priority recommendations for defensible space, home hardening, and firefighter accessibility within each CWPP plan unit. This table focuses on priority actions for each plan unit; however, homeowners, HOAs, and other community groups across the EC & IC FPD can benefit from all actions outlined in **Section 3.a** and **Section 3.b**.

Plan Unit Name	Relative Risk	Unit Description	Priority Mitigation Suggestions	Potential Fire Behavior
Angel Acres	**Extreme**	This unit has many mid slope homes and a few ridge top homes, and a couple topographic features that make fire behavior unpredictable. There are relatively sparse fuels with meadows and rock outcroppings throughout. There are adequate hydrants and roads are accessible by engines. Home construction is older but maintained. Defensible space is not adequate.	Remove flammable material from the HIZ. Mow grass and clear bushes away from the home Home Hardening Defensible Space	Under 60th percentile weather conditions, 64% of the unit is susceptible to passive or active crown fires, average flame lengths in the unit are 17 feet and can reach a maximum of 107 feet. 43% of the roads are potentially non-survivable and 48% of homes have high to extreme exposure to embers and radiant heat.
Aspen Park	**High**	There are some mid slope homes here and some topography that makes fire behavior unpredictable. There is a lot of mixed conifer, standing dead lodgepole pine, and ponderosa pine. Healthy aspen stands are present too. This is one of the most densely populated units and HazMat sites are present. There are some hydrants and at least one draft site, and the roads are accessible by engines. Defensible space is not adequate and many homes have overlapping HIZs.	Create linked defensible space Community working together to create fuel breaks Remove flammable material from the HIZ.	Under 60th percentile weather conditions, 63% of the unit is susceptible to passive or active crown fires, average flame lengths in the unit are 17 feet and can reach a maximum of 124 feet. 25% of the roads are potentially non-survivable and 52% of homes have high to extreme exposure to embers and radiant heat.
Black Mountain	**High**	The unit contains many homes located mid slope and on ridge tops and many	Lodgepole pine treatments	Under 60th percentile weather conditions, 57% of the unit is

		topographic features that can make fire behavior unpredictable. There is heavy mixed conifer and lodgepole fuels and litter. There are not many hydrants but the roads are accessible to engines. Home construction is relatively good, but defensible space is not adequate.	Landscape-scale mitigation work across the community Home Hardening Defensible Space Roadside mitigation	susceptible to passive or active crown fires, average flame lengths in the unit are 11 feet and can reach a maximum of 138 feet. 14% of the roads are potentially non-survivable and 23% of homes have high to extreme exposure to embers and radiant heat.
Conifer Meadows	**High**	The unit has many homes located mid slope and on ridge tops and many topographic features that can make fire behavior unpredictable. There is heavy mixed conifer and lodgepole fuels and litter. There are also many aspen stands. There are not many hydrants but the roads are mostly accessible to engines. Home construction is relatively good, but defensible space is not adequate.	Lodgepole pine treatments Landscape-scale mitigation work across the community Home Hardening Defensible Space Roadside mitigation	Under 60th percentile weather conditions, 63% of the unit is susceptible to passive or active crown fires, average flame lengths in the unit are 18 feet and can reach a maximum of 131 feet. 19% of the roads are potentially non-survivable and 30% of homes have high to extreme exposure to embers and radiant heat.
Conifer Mountain	**Extreme**	The unit has many homes located mid slope and on ridge tops and many topographic features that can make fire behavior unpredictable. There is heavy mixed conifer and lodgepole fuels and litter on steep slopes. Hydrants are not readily available but there is at least one draft site, and the roads are accessible by engines. Homes overall need home hardening and defensible space is not adequate.	Defensible Space Create linked defensible space Landscape fuel treatments Home Hardening Roadside mitigation	Under 60th percentile weather conditions, 47% of the unit is susceptible to passive or active crown fires, average flame lengths in the unit are 11 feet and can reach a maximum of 121 feet. 27% of the roads are potentially non-survivable and 59% of homes have high to extreme exposure to embers and radiant heat.

Conifer Ridge	**Extreme**	The unit has many homes located mid slope and on ridge tops and many topographic features that can make fire behavior unpredictable. There is heavy mixed conifer and lodgepole fuels and litter. There are also many aspen stands. There are not many hydrants but the roads are mostly accessible to engines. Home construction is good, but defensible space is not adequate.	Home Hardening Defensible Space Roadside mitigation	Under 60th percentile weather conditions, 55% of the unit is susceptible to passive or active crown fires, average flame lengths in the unit are 16 feet and can reach a maximum of 103 feet. 45% of the roads are potentially non-survivable and 69% of homes have high to extreme exposure to embers and radiant heat.
Deer Creek Mesa	**Moderate**	The unit has several homes located mid slope and many topographic features that can make fire behavior unpredictable. The unit has many hydrants and accessible roads for engines. Some homes are made of combustible materials, and few homes have adequate defensible space.	Home Hardening Defensible Space Create linked defensible space by coordinating with HOAs	Under 60th percentile weather conditions, 33% of the unit is susceptible to passive or active crown fires, average flame lengths in the unit are 12 feet and can reach a maximum of 94 feet. 37% of the roads are potentially non-survivable and 5% of homes have high to extreme exposure to embers and radiant heat.
Doubleheader Ranch/ Hillview	**Extreme**	This unit has many mid slope homes and some ridge top homes, and a few challenging topographic features with steep slopes. There are dense conifer stands with interlocking canopies on the steep slopes. The planning unit does not have enough hydrants, and some roads, like around Fairall Road, are not accessible by engines. Many homes have combustible construction and materials near the homes, and there is not adequate defensible space, especially with the steep slopes.	Mow grass and clear bushes away from the home Create linked defensible space Roadside mitigation	Under 60th percentile weather conditions, 68% of the unit is susceptible to passive or active crown fires, average flame lengths in the unit are 16 feet and can reach a maximum of 99 feet. 41% of the roads are potentially non-survivable and 40% of homes have high to extreme exposure to embers and radiant heat.

Douglass Ranch	**High**	The unit has many homes located mid slope and on ridge tops and a couple topographic features that can make fire behavior hard to predict. Vegetation is mainly ponderosa pine, mixed conifer, and juniper bushes. Steep drainages have extremely heavy fuel loads. There are only two water sources available in this unit, but the roads are all accessible to engines. Within the Douglas Ranch HOA, home construction is newer and stronger, and defensible space is still not adequate. Outside the HOA, home construction is older and more combustible, and defensible space is also not adequate.	Defensible Space Home Hardening for homes outside the HOA Maintain and continue stand-level fuel treatments near homes	Under 60th percentile weather conditions, 62% of the unit is susceptible to passive or active crown fires, average flame lengths in the unit are 11 feet and can reach a maximum of 85 feet. 23% of the roads are potentially non-survivable and 29% of homes have high to extreme exposure to embers and radiant heat.
Eagle Cliff	**Extreme**	This unit has many mid slope and ridge top homes on steep slopes with many topographic features that make fire behavior unpredictable. Fuels are heavy and very dense throughout, and even the meadows have tall grass that would spread fire quickly. There are not enough hydrants, and most of the roads are accessible but some roads and many driveways are not accessible to engines. Many homes have combustible construction and materials near the homes, and there is not adequate defensible space, especially with the steep slopes.	Mow grass and clear bushes away from the home Create linked defensible space Roadside mitigation	Under 60th percentile weather conditions, 63% of the unit is susceptible to passive or active crown fires, average flame lengths in the unit are 19 feet and can reach a maximum of 124 feet. 28% of the roads are potentially non-survivable and 28% of homes have high to extreme exposure to embers and radiant heat.
Elk Falls	**Moderate**	This unit has numerous mid slope and several ridge top homes located on steep, densely forested slopes with many	Defensible Space	Under 60th percentile weather conditions, 58% of the unit is susceptible to passive or active

		topographic features that make fire behavior hard to predict. There are dense conifer stands and ponderosa stands throughout. There are not hydrants readily available, but the roads are all accessible by engines. Home construction is varied, and defensible space is varied but overall still not adequate.	Home Hardening Install reflective signage for navigation	crown fires, average flame lengths in the unit are 14 feet and can reach a maximum of 122 feet. 22% of the roads are potentially non-survivable and 14% of homes have high to extreme exposure to embers and radiant heat.
Evergreen Meadows	**High**	This unit has some mid slope and ridge top homes, and a couple topographic features that make fire behavior unpredictable. There is thick conifer canopy cover with lots of downed lodgepole. There are not many hydrants present and there is HazMat material here, but the roads are accessible. Most of the homes in meadows have adequate construction and zone 1-2 defensible space, most of the homes on slopes and in the forests do not have adequate home hardening construction or defensible space.	Meadow homes: Defensible space, especially in zone 3 Forest homes: Home hardening and Defensible space Roadside mitigation on bench roads	Under 60th percentile weather conditions, 61% of the unit is susceptible to passive or active crown fires, average flame lengths in the unit are 14 feet and can reach a maximum of 124 feet. 32% of the roads are potentially non-survivable and 22% of homes have high to extreme exposure to embers and radiant heat.
Gemspark Estates	**Extreme**	This unit has numerous mid slope and several ridge top homes located on steep, densely forested slopes with many topographic features that make fire behavior unpredictable. There are very limited water resources here, but the roads are accessible by engines. Homes tend to have good construction, but there is not adequate defensible space around the homes.	Remove flammable material from the HIZ. Mow grass and clear bushes away from the home Defensible Space	Under 60th percentile weather conditions, 68% of the unit is susceptible to passive or active crown fires, average flame lengths in the unit are 11 feet and can reach a maximum of 69 feet. 44% of the roads are potentially non-survivable and 71% of homes have high to extreme exposure to embers and radiant heat.

Glen Elk	**Moderate**	This unit has many mid slope and ridge top homes, and a couple topographic features that make fire behavior difficult to predict. The vegetation is mixed conifer and a lot of ponderosa pine, with a relatively open canopy and ladder fuels in the understory. Hydrants are not readily available, but most of the roads are accessible to engines. Home construction is generally older and combustible, and defensible space is inadequate.	Defensible Space Home Hardening - major work necessary Roadside mitigation	Under 60th percentile weather conditions, 67% of the unit is susceptible to passive or active crown fires, average flame lengths in the unit are 13 feet and can reach a maximum of 73 feet. 29% of the roads are potentially non-survivable and 9% of homes have high to extreme exposure to embers and radiant heat.
Green Valley Ranch	**High**	This unit contains many mid slope homes and several ridge top homes, and a couple topographic features that make fire behavior unpredictable. There are heavy conifer fuels with standing dead lodgepole throughout, as well as aspen stands an pockets of urban areas with HazMat sites. There are not many hydrants here, but there are draft sites the roads are accessible to engines. Hone construction is varied, but many homes have firewood and other materials near the homes that make them susceptible to ignition. Defensible space is not adequate.	Create linked defensible space Landscape fuel treatments Remove flammable material from the HIZ.	Under 60th percentile weather conditions, 57% of the unit is susceptible to passive or active crown fires, average flame lengths in the unit are 14 feet and can reach a maximum of 91 feet. 18% of the roads are potentially non-survivable and 33% of homes have high to extreme exposure to embers and radiant heat.
Highland Pines	**Moderate**	This unit has some mid slope and ridge top homes, and a couple topographic features that make fire behavior unpredictable. There is a lot of grassy meadow with stands of mixed conifer that has heavy fuels, regen, and juniper understory. The community has few hydrants, but the roads are accessible by engines. There are HazMat materials present. Home construction is average, and	Home Hardening Defensible Space Create linked defensible space	Under 60th percentile weather conditions, 53% of the unit is susceptible to passive or active crown fires, average flame lengths in the unit are 10 feet and can reach a maximum of 89 feet. 21% of the roads are potentially non-survivable and 20% of homes have

		defensible space is inadequate in both residential areas and commercial areas.	Roadside mitigation	high to extreme exposure to embers and radiant heat.
Hilldale Pines	**High**	This unit has many mid slope and ridge top homes, and many topographic features that make fire behavior unpredictable as well as heavy fuels and dense mixed conifer and standing dead lodgepole pine. The community has some cisterns and accessible roads. Home construction is average and defensible space is not adequate.	Defensible Space Landscape-scale mitigation work across the community Community work to create fuel breaks	Under 60th percentile weather conditions, 70% of the unit is susceptible to passive or active crown fires, average flame lengths in the unit are 17 feet and can reach a maximum of 93 feet. 32% of the roads are potentially non-survivable and 30% of homes have high to extreme exposure to embers and radiant heat.
Homestead	**Moderate**	This unit has many mid slope and ridge top homes, and many topographic features that make fire behavior unpredictable as well as heavy fuels and dense vegetation. There are some hydrants across the community, and roads are all accessible to engines, but some driveways would not be. Home construction is varied, and many homes have combustible siding or decks. There is not adequate defensible space around the homes.	Home Hardening Defensible Space Community work to create fuel breaks	Under 60th percentile weather conditions, 68% of the unit is susceptible to passive or active crown fires, average flame lengths in the unit are 15 feet and can reach a maximum of 115 feet. 26% of the roads are potentially non-survivable and 12% of homes have high to extreme exposure to embers and radiant heat.
Indian Springs	**Extreme**	This unit has numerous mid slope and ridge top homes, and many topographic features that make fire behavior unpredictable. There are a lot of dense mixed conifer and dense ponderosa pine stands over steep terrain with lots of ladder fuels. There are no hydrants or draft sites, and less than half the roads are accessible to engines - roads in	Roadside mitigation Road improvements for accessibility and safety Defensible Space	Under 60th percentile weather conditions, 72% of the unit is susceptible to passive or active crown fires, average flame lengths in the unit are 13 feet and can reach a maximum of 90 feet. 17% of the roads are potentially non-survivable and 30% of homes have

		the northern part of the unit are more accessible. There is HazMat present. Home construction is overall older and combustible, and defensible space is inadequate.	Create linked defensible space Home Hardening Have evacuation plans and go-bags ready	high to extreme exposure to embers and radiant heat.
Jennings	**High**	This unit has many mid slope homes and some ridge top homes, as well as many topographic features that make fire behavior unpredictable. There is continuous heavy fuels and grasses leading to ladder fuels, and previously treated forests are abundant with regeneration. There are not enough water sources here and while most of the roads are accessible for engines, they are not wide enough or treated well enough to allow engines to come in while residents are evacuating. Home construction is varied, but defensible space is limited throughout and not maintained.	Road improvements for accessibility and safety Defensible Space Ladder fuel treatments Maintain and continue stand-level fuel treatments near homes	Under 60th percentile weather conditions, 71% of the unit is susceptible to passive or active crown fires, average flame lengths in the unit are 16 feet and can reach a maximum of 93 feet. 40% of the roads are potentially non-survivable and 15% of homes have high to extreme exposure to embers and radiant heat.
Kincaid Springs	**Extreme**	This unit has numerous mid slope and ridge top homes, and many topographic features and steep slopes that make fire behavior unpredictable. Vegetation is mostly mixed conifer with dense ponderosa pines and lots of ladder fuel understories. Hydrants are not available and not all the roads are accessible to engines - vertical clearance is a big issue. HazMat is present here. Home construction is varied but overall worse than average with fewer Class A roofs. Defensible space is not present and inadequate.	Roadside mitigation Road improvements for accessibility and safety Defensible Space Create linked defensible space Home Hardening	Under 60th percentile weather conditions, 76% of the unit is susceptible to passive or active crown fires, average flame lengths in the unit are 12 feet and can reach a maximum of 76 feet. 28% of the roads are potentially non-survivable and 21% of homes have high to extreme exposure to embers and radiant heat.

			Have evacuation plans and go-bags ready	
Kings Valley	**Extreme**	This unit has many mid slope and ridge top homes, and many topographic features and steep slopes that make fire behavior unpredictable. There is dense mixed conifer and lodgepole pines with timber litter. There are hydrants available near some homes but no draft sites and there are HazMat materials. Roads are accessible to engines. Home construction is overall not good and there is not adequate defensible space.	Landscape-scale mitigation work across the community Community working together to create fuel breaks Roadside mitigation Defensible Space	Under 60th percentile weather conditions, 61% of the unit is susceptible to passive or active crown fires, average flame lengths in the unit are 15 feet and can reach a maximum of 110 feet. 29% of the roads are potentially non-survivable and 54% of homes have high to extreme exposure to embers and radiant heat.
Kuehster	**Extreme**	This unit has many mid slope and ridge top homes, and many topographic features that make it difficult to predict fire behavior. A lot of the Lower North Fork Fire burn scar is in this unit. There are conifer stands and grassy meadows and agricultural land on the south side. Mitigation work has been completed in some areas. There are not hydrants and a few draft sites in the unit. Most roads are accessible to engines, but some driveways are too long, narrow, and steep for engines. Home construction is average, and newer in the burn scar. There is no defensible space in the south side.	Defensible Space Home Hardening Roadside and driveway mitigation	Under 60th percentile weather conditions, 60% of the unit is susceptible to passive or active crown fires, average flame lengths in the unit are 19 feet and can reach a maximum of 150 feet. 43% of the roads are potentially non-survivable and 77% of homes have high to extreme exposure to embers and radiant heat.
Marclif Ranchos	**Moderate**	This unit has some mid slope and ridge top homes, and a couple topographic features that make fire behavior unpredictable.	Remove flammable material from the HIZ.	Under 60th percentile weather conditions, 54% of the unit is susceptible to passive or active

		There are patches of dense mixed conifer, open meadows, and open canopy woodlands. There is both residential and commercial structures that have HazMat. Hydrants are not available near most homes, but the roads are generally accessible to engines. Homes in the Belle area have newer construction, but homes elsewhere generally have older and combustible materials. There is not adequate defensible space here.	Mow grass and clear bushes away from the home Defensible Space Home Hardening	crown fires, average flame lengths in the unit are 13 feet and can reach a maximum of 96 feet. 19% of the roads are potentially non-survivable and 11% of homes have high to extreme exposure to embers and radiant heat.
McKinney Ranch	**High**	This unit has many mid slope and some ridge top homes, and many topographic features and steep slopes that make fire behavior unpredictable. There is extremely dense conifer and oak vegetation. There are not water sources near most homes, and while the roads are technically accessible by engines, they are narrow and lined with dense, dangerous fuel levels. Home construction is average and defensible space is not adequate.	Remove flammable material from the HIZ. Mow grass and clear bushes away from the home Home Hardening Defensible Space Roadside mitigation	Under 60th percentile weather conditions, 61% of the unit is susceptible to passive or active crown fires, average flame lengths in the unit are 16 feet and can reach a maximum of 97 feet. 22% of the roads are potentially non-survivable and 7% of homes have high to extreme exposure to embers and radiant heat.
Monteverde	**Moderate**	There are some mid slope homes here but not much difficult topography. There is a lot of mixed conifer, standing dead lodgepole pine, and heavy litter loads. Healthy aspen stands and pockets of urban areas are present too. This is one of the most densely populated units and there are HazMat sites present. There are not many hydrants but there are draft sites available and the roads are accessible to engines. Home	Create linked defensible space Remove flammable material from the HIZ. Landscape-scale mitigation work across the community	Under 60th percentile weather conditions, 60% of the unit is susceptible to passive or active crown fires, average flame lengths in the unit are 16 feet and can reach a maximum of 93 feet. 31% of the roads are potentially non-survivable and 30% of homes have

		construction is fine but there is not adequate linked defensible space in populated areas.	Community working together to create fuel breaks	high to extreme exposure to embers and radiant heat.
Mountain View Lakes	**High**	This unit has many mid slope and some ridge top homes, and many topographic features that can make fire behavior hard to predict. There are mixed conifer stands and ponderosa stands with a lot of regen along roadsides. Hydrants are not available near most homes, but most of the roads are accessible by engines. Home construction is varied, but there are lots of overlapping HIZs and inadequate defensible space.	Defensible Space Home Hardening Install reflective signage for navigation Roadside mitigation Remove flammable material from the HIZ	Under 60th percentile weather conditions, 60% of the unit is susceptible to passive or active crown fires, average flame lengths in the unit are 12 feet and can reach a maximum of 107 feet. 20% of the roads are potentially non-survivable and 5% of homes have high to extreme exposure to embers and radiant heat.
Murphy Gulch	**High**	This unit has many mid slope and ridge top homes, and many topographic features and steep slopes that make fire behavior unpredictable. There is dense mixed conifer and oak vegetation. There are not many water sources, but the roads are mostly accessible by engines. The roads do have heavy fuels on both sides, endangering residents and responders. Home construction is overall old and flammable, and there is not adequate defensible space.	Remove flammable material from the HIZ Mow grass and clear bushes away from the home Defensible Space Home Hardening	Under 60th percentile weather conditions, 59% of the unit is susceptible to passive or active crown fires, average flame lengths in the unit are 15 feet and can reach a maximum of 110 feet. 32% of the roads are potentially non-survivable and 27% of homes have high to extreme exposure to embers and radiant heat.
Oehlmann Park	**High**	This unit has some mid slope and ridge top homes, and a couple topographic features that make fire behavior unpredictable. The unit has lots of grassy meadows and a densely populated area surrounded by lodgepole pine, and other stands of mixed	Defensible Space Home Hardening	Under 60th percentile weather conditions, 60% of the unit is susceptible to passive or active crown fires, average flame lengths in the unit are 16 feet and can reach a maximum of 90 feet. 44%

		conifer throughout. Hydrants are not available near most homes, and while the roads are accessible by engines, many have only one lane without good turnaround points. There are HazMat sites present. Homes overall do not have good construction and share overlapping HIZs without adequate defensible space.	Create linked defensible space Roadside mitigation	of the roads are potentially non-survivable and 49% of homes have high to extreme exposure to embers and radiant heat.
Pine Meadows	**Extreme**	This unit has many mid slope and ridge top homes, and many topographic features that make fire behavior unpredictable. The High Meadows Fire burn scar runs through this unit, and the rest of the unit is covered with conifers and managed ponderosa pine stands. Hydrants are not readily available, but engines can access most of the roads in this unit. Home construction is varied. Homes withing the burn scar tend to have existing defensible space, and homes outside of the scar have varied defensible space.	Defensible Space Maintain and continue stand-level fuel treatments near homes Home Hardening	Under 60th percentile weather conditions, 48% of the unit is susceptible to passive or active crown fires, average flame lengths in the unit are 11 feet and can reach a maximum of 99 feet. 34% of the roads are potentially non-survivable and 70% of homes have high to extreme exposure to embers and radiant heat.
Pine Springs	**High**	This unit has many mid slope and ridge top homes, and many topographic features that make fire behavior unpredictable as well as heavy fuels and dense vegetation. There are not enough hydrants in the community, but most roads are accessible by an engine, save for some long and winding driveways. Home construction is varied, but most homes share a lack of defensible space.	Home Hardening Defensible Space break up continuous fuels Create linked defensible space	Under 60th percentile weather conditions, 64% of the unit is susceptible to passive or active crown fires, average flame lengths in the unit are 16 feet and can reach a maximum of 96 feet. 28% of the roads are potentially non-survivable and 47% of homes have high to extreme exposure to embers and radiant heat.
Pine Valley	**Moderate**	This unit has many mid slope and a couple ridge top homes, and many topographic	Defensible Space	Under 60th percentile weather conditions, 52% of the unit is

		features that make fire behavior hard to predict. The High Meadow Fire burn scar runs through the district, and the rest of the unit has continuous mixed conifer stands with dense housing. Hydrants are not available at most homes, and while engines can access most of the roads, they are not adequate for evacuation and firefighter entry at the same time. Home construction is varied, and defensible space is decent in the southeast, but not present in the northeast.	Home Hardening Roadside mitigation Southwest side: Home hardening and Defensible space, especially zones 1 & 2	susceptible to passive or active crown fires, average flame lengths in the unit are 11 feet and can reach a maximum of 99 feet. 20% of the roads are potentially non-survivable and 10% of homes have high to extreme exposure to embers and radiant heat.
Sampson Maxwell	**Extreme**	This unit has many mid slope and ridge top homes, and many topographic features that make fire behavior unpredictable as well as very heavy fuels and dense conifer and oak vegetation covering steep slopes. There are not many water sources in this unit, and while the roads are mostly accessible, there are heavy fuels lining the roads making them unsafe for residents and responders. Home construction is varied but there are homes with very flammable materials that endanger all structures around. There is not adequate defensible space.	Home Hardening is the first priority here Defensible Space Landscape-scale mitigation work across the community	Under 60th percentile weather conditions, 56% of the unit is susceptible to passive or active crown fires, average flame lengths in the unit are 17 feet and can reach a maximum of 101 feet. 40% of the roads are potentially non-survivable and 37% of homes have high to extreme exposure to embers and radiant heat.
Shadow Mountain	**High**	This unit has many mid slope and ridge top homes, and many topographic features that make fire behavior unpredictable. There are grassy meadows and dense stands of conifer with lots of regen, ladder fuels, and litter. There are not many hydrants, and though most roads are accessible by engines, they	Defensible Space Roadside mitigation	Under 60th percentile weather conditions, 49% of the unit is susceptible to passive or active crown fires, average flame lengths in the unit are 8 feet and can reach a maximum of 82 feet. 18% of the roads are potentially non-

		are not wide enough to accommodate engines during evacuations, and there are heavy fuels lining the roads. Construction is overall average, but lots are small and defensible space is inadequate.	Create linked defensible space	survivable and 0% of homes have high to extreme exposure to embers and radiant heat.
Shiloh	**Extreme**	This unit contains many mid slope and ridge top homes and many topographic features including steep drainages and chimneys that make it difficult to predict fire behavior. There are densely forested conifer stands on steep slopes mixed with ponderosa stands and lodgepole stands, and some large meadows and aspen stands. There are not hydrants near homes, but there is a draft site, and roads are accessible to engines, but many have heavy fuels above and below them. Home construction is varied, but homes have overlapping HIZs and inadequate defensible space.	Defensible Space Home Hardening Create linked defensible space Roadside mitigation	Under 60th percentile weather conditions, 72% of the unit is susceptible to passive or active crown fires, average flame lengths in the unit are 17 feet and can reach a maximum of 131 feet. 50% of the roads are potentially non-survivable and 56% of homes have high to extreme exposure to embers and radiant heat.
Silver Ranch	**Extreme**	This unit contains many mid slope and ridge top homes and many topographic features that make it difficult to predict fire behavior. There are densely forested conifer stands on steep slopes mixed with high alpine meadows. There are not adequate hydrants and no draft sites. Roads are well maintained and accessible to engines. Home construction is relatively new and on average better than elsewhere in the district. Defensible space is better here, but many homes still do not have adequate defensible space.	Defensible Space Landscape-scale mitigation work across the community	Under 60th percentile weather conditions, 69% of the unit is susceptible to passive or active crown fires, average flame lengths in the unit are 19 feet and can reach a maximum of 116 feet. 37% of the roads are potentially non-survivable and 65% of homes have high to extreme exposure to embers and radiant heat.

Silver Ranch South	**Extreme**	This unit contains many mid slope and ridge top homes and many topographic features that make it difficult to predict fire behavior. There are dense conifer stands on steep slopes with ponderosa and lodgepole pines. There are also large meadows and aspen stands. There are no hydrants and no draft site. Roads are accessible though some access roads are gated, slowing down evacuations and firefighting resources. Home construction is varied, with newer construction having some good defensible space. Landscape mitigation has been complete and needs to be maintained to keep its protection value.	Defensible Space Home Hardening Roadside and driveway mitigation Maintain and continue stand-level fuel treatments near homes	Under 60th percentile weather conditions, 70% of the unit is susceptible to passive or active crown fires, average flame lengths in the unit are 22 feet and can reach a maximum of 131 feet. 44% of the roads are potentially non-survivable and 52% of homes have high to extreme exposure to embers and radiant heat.
South Baird	**Extreme**	This unit contains many mid slope and ridge top homes and many topographic features that make it difficult to predict fire behavior. There is a lot of mixed-conifer and lodgepole pine with a lot of standing dead and heavy litter. Healthy aspen stands are present too. There are very few hydrants, but the roads are very accessible. Home construction is varied, and the wooden siding, decks, and fences need to be addressed. There is not adequate defensible space across this unit.	Home Hardening Defensible Space Roadside mitigation Lodgepole pine treatments	Under 60th percentile weather conditions, 63% of the unit is susceptible to passive or active crown fires, average flame lengths in the unit are 13 feet and can reach a maximum of 80 feet. 31% of the roads are potentially non-survivable and 37% of homes have high to extreme exposure to embers and radiant heat.
Southwest	**Extreme**	This unit has many mid slope homes and some ridge top homes, and many topographic features that make fire behavior unpredictable. The burn scar from the High Meadow Fire runs through here. The vegetation is mainly conifer stands with	Home Hardening Defensible Space	Under 60th percentile weather conditions, 57% of the unit is susceptible to passive or active crown fires, average flame lengths in the unit are 14 feet and can reach a maximum of 103 feet. 38%

		grassy meadows, and shrubs and grass in the burn scar. There are not hydrants available and no draft site. Some of the roads are accessible to engines, but some are not and many are very narrow and have gates along the access roads. Defensible space seems to need improvement, but it is difficult to assess because some residents have made it clear that they do not want the FPD entering their property.	Landscape-scale mitigation work across the community, especially to the south	of the roads are potentially non-survivable and 75% of homes have high to extreme exposure to embers and radiant heat.
Tiny Town	**Moderate**	This unit has many mid slope homes and some ridge top homes, and steep slopes. Vegetation is extremely dense in areas, but there are riparian and grassy areas too. Hydrants are not available and there is no draft site in the unit. Most of the roads are accessible by engines but are too narrow to allow engine in while residents are evacuating. Home construction is on average older and defensible space is not adequate.	Remove flammable material from the HIZ. Mow grass and clear bushes away from the home Home Hardening Defensible Space	Under 60th percentile weather conditions, 58% of the unit is susceptible to passive or active crown fires, average flame lengths in the unit are 16 feet and can reach a maximum of 143 feet. 21% of the roads are potentially non-survivable and 17% of homes have high to extreme exposure to embers and radiant heat.
Wamblee Valley	**Extreme**	This unit contains many mid slope and ridge top homes and many topographic features that make it difficult to predict fire behavior. There is a lot of mixed conifer and lodgepole pine with a lot of standing dead and heavy litter. There are very few hydrants and no draft sites, but the roads are very accessible. Newer home construction such as around Wamblee Trail have better kept defensible space, and older construction tends to have	Home Hardening Defensible Space Roadside mitigation	Under 60th percentile weather conditions, 70% of the unit is susceptible to passive or active crown fires, average flame lengths in the unit are 13 feet and can reach a maximum of 80 feet. 39% of the roads are potentially non-survivable and 51% of homes have high to extreme exposure to embers and radiant heat.

		less mitigation work. More homes need to install Class A roofs, and wooden siding, decks, and fences need to be addressed.	Lodgepole pine treatments	
Wandcrest	**Extreme**	This unit has many mid slope and ridge top homes, and many topographic features that make fire behavior difficult to predict. There are dense conifer fuels across the district. Hydrants are not available near most homes and there is no draft site available. Engines can access most of the roads in the unit, but not during an evacuation because the roads are narrow and there are heavy fuels on roadsides. There are HazMat sites in the unit. Home construction in this unit is generally old and flammable, and there are combustible materials within the HIZ for many homes. There is not adequate defensible space.	Remove flammable material from the HIZ. Mow grass and clear bushes away from the home Defensible Space Roadside mitigation Landscape-scale mitigation work across the community	Under 60th percentile weather conditions, 41% of the unit is susceptible to passive or active crown fires, average flame lengths in the unit are 11 feet and can reach a maximum of 99 feet. 66% of the roads are potentially non-survivable and 89% of homes have high to extreme exposure to embers and radiant heat.
Warhawk	**Moderate**	This unit contains many mid slope and ridge top homes and many topographic features that make it difficult to predict fire behavior. The forests of conifer are broken up by meadows and pockets of juniper. Hydrants are not available near most homes, but roads are accessible to engines and well maintained, and large open spaces provide strategic opportunities for firefighters. Many homes are newer construction with more fire-resistant building materials, but there is not adequate defensible space.	Defensible Space Roadside mitigation	Under 60th percentile weather conditions, 54% of the unit is susceptible to passive or active crown fires, average flame lengths in the unit are 9 feet and can reach a maximum of 82 feet. 7% of the roads are potentially non-survivable and 23% of homes have high to extreme exposure to embers and radiant heat.

West Ranch	**High**	This unit has many mid slope and ridge top homes, and a couple topographic features that make fire behavior unpredictable, but also has some open meadows throughout. Not all homes are near hydrants, and some driveways may be inaccessible or difficult to navigate. All roads are accessible by engines. Home construction is varied, and defensible space is not adequate for most homes.	Home Hardening Defensible Space Ladder fuel treatments	Under 60th percentile weather conditions, 43% of the unit is susceptible to passive or active crown fires, average flame lengths in the unit are 13 feet and can reach a maximum of 115 feet. 50% of the roads are potentially non-survivable and 56% of homes have high to extreme exposure to embers and radiant heat.
Will-O-the-Wisp	**Moderate**	This unit has some homes built mid slope and on ridge tops, and has a couple topographic features that make fire behavior unpredictable. Fuel loads are relatively low, with meadows and rock outcroppings throughout. The community has many hydrants and roads are accessible to engines. There are HazMat sites. Home construction is older but maintained. Defensible space is not adequate.	Remove flammable material from the HIZ. Mow grass and clear bushes away from the home Home Hardening Defensible Space	Under 60th percentile weather conditions, 53% of the unit is susceptible to passive or active crown fires, average flame lengths in the unit are 11 feet and can reach a maximum of 89 feet. 12% of the roads are potentially non-survivable and 21% of homes have high to extreme exposure to embers and radiant heat.
Woodside Park	**High**	This unit has many homes built mid slope and some on ridge tops, and has a couple topographic features that make fire behavior unpredictable. The stands of conifer are broken up by meadows and pockets of juniper. Hydrants are not available near most homes, but roads are available near most homes, but roads are accessible to engines and well maintained, and large open spaces provide strategic opportunities for firefighters. Many homes are newer construction with more fire-resistant building materials, but there is not adequate defensible space.	Defensible Space Roadside mitigation	Under 60th percentile weather conditions, 59% of the unit is susceptible to passive or active crown fires, average flame lengths in the unit are 10 feet and can reach a maximum of 86 feet. 19% of the roads are potentially non-survivable and 30% of homes have high to extreme exposure to embers and radiant heat.

Table 4.b.4. Resources for suggested mitigation for each plan unit from **Table 4.b.3**.

Suggestion	Goal	Resources
Home Hardening	Make the home itself less flammable by using non-combustible materials and clearing combustibles away from the home.	See: **Home Hardening**
Defensible Space	Clear combustible materials away from near the home, reduce fire activity and severity as it approaches the home	See: **Defensible Space**
Create linked defensible space	Overlapping HIZs create more opportunity for homes to ignite. Work with neighbors to reduce fire activity and severity near all the homes to protect them all.	See: **Defensible Space; Linked Defensible Space**
Remove flammable material from the HIZ.	Clear combustible materials such as firewood, propane tanks, and wooden lawn furniture away from near the home.	See: **Defensible Space**
Mow grass and clear bushes away from the home	Clear combustible vegetation such as tall grass, bushes, and all junipers away from near the home.	See: **Defensible Space**
Have evacuation plans and go-bags ready	There is significant danger to both life and property in these districts. Residents need to be prepared to leave at any time and not rely on the FPDs to save them.	See: **Evacuation Preparedness**
Roadside mitigation	Main goal: clearing vegetation from around the road to improve access and decrease the amount of fuels that could burn across a roadway while residents are evacuating	See: **Driveways; Roadway Fuelbreak Recommendations**
Road improvements for accessibility and safety	Create a road network that fire engines can safely access and is less likely to trap residents during an evacuation.	See: **Accessibility and Navigability for Firefighters; Roadway Fuelbreak Recommendations**
Install reflective signage for navigation	Make it easier for firefighters to find a home or neighborhood to assist in property defense and evacuations. It can be very difficult to see during major fire events.	See: **Accessibility and Navigability for Firefighters**

Landscape-scale mitigation work across the community	Treat forests to prevent intense fire behavior near homes and increase landscape resilience by restoring historical conditions.	See**: Stand-Level Fuel Treatment Recommendations**
Community work to create fuel breaks	Treat forests to prevent intense fire behavior near homes and increase landscape resilience by restoring historical conditions.	See**: Stand-Level Fuel Treatment Recommendations; Roadway Fuelbreak Recommendations**
Ladder fuel treatments	Prevent fire from moving from the ground to the tree canopy, which reduces fire intensity and speed.	See**: Stand-Level Fuel Treatment Recommendations**
Lodgepole pine treatments	Treat lodgepole pine stands to prevent intense fire behavior near homes and increase landscape resilience.	See**: Lodgepole Pine and Wet Mixed Conifer**
Maintain and continue stand-level fuel treatments near homes	Treat forests to prevent intense fire behavior near homes and increase landscape resilience. Treatments must be maintained to continue to provide defense to homes.	See**: Stand-Level Fuel Treatment Recommendations**

4.c. Stand-Level Fuel Treatment Recommendations

Effective Treatment Design

Restoration-style treatments can meet both ecological and fuel reduction objectives in ponderosa pine and dry-mixed conifer forests along the Front Range of Colorado (Addington and others 2018; Fulé and others 2012). Fuels reduction treatments that create heterogeneous landscapes and decrease the density of trees while increasing diversity in age, size, and species in lodgepole and wet mixed conifer forests can be effective at altering the intensity of fire (Dennis and others 2009). Most of the forested area within and around the EC & IC FPD are mixed-conifer, ponderosa pine, and lodgepole pine forest types (**Figure 2.a.3**), and many of these forests had far fewer trees prior to Euro-American settlement due to a higher frequency of wildfires (**Figure 2.e.1**; Addington and others 2018). The Jefferson Conservation District and other land management agencies encourage an approach to forest management that transforms dense ponderosa forests into a strong and healthy woodland with single trees, clumps of trees, and meadows similar to historical forests that were maintained by wildfires and very resilient to them. They work to create fire-resilient mosaic landscapes in lodgepole and wet mixed conifer forests, and to maintain healthy aspen and other hardwood forests.

A holistic approach to forest restoration reduces crown-fire hazard, increases the abundance and diversity of grasses, shrubs, and wildflowers, and improves habitat for many wildlife species, including deer and elk. This approach is backed by decades of forest, wildlife, and fire ecology research, which is summarized in *Principles and practices for the restoration of ponderosa pine and dry mixed-conifer forests of the Colorado Front Range* published by the U.S. Forest Service Rocky Mountain Research Station (Addington and others 2018). TEA suggest that foresters, other land managers, and landowners reference this document when preparing and implementing forest treatments in and around the EC & IC FPD. Another useful tool for designing restoration treatments is *Visualization of heterogenous forest structures following treatments in the Southern Rocky Mountains*—a document with pictures, graphs, and simulations of different pre- and post-treatment forest structures (Tinkham and others 2017).

Table 4.c.1. According to the CSFS, horizontal spacing recommendations are minimums and can be increased to reduce potential fire behavior, particularly on slopes due to the exacerbating impact of slope on fire behavior (Dennis 2003). Consult a forestry, fire or natural resource professional for guidance with spacing on slopes. When treatments are designed to achieve ecological restoration objectives, it is important to avoid evenly spacing trees. Retaining small clumps of trees with interlocking crowns is acceptable so long as they are adequately spaced from adjacent individual trees and tree clumps.

Percent slope	Minimum spacing between tree crowns
0 to 10 %	10 feet
11 to 20%	15 feet
21 to 40%	20 feet
>40%	30 feet

Treatment Methods

Trees can be removed manually or mechanically, providing for considerations of safety, slope, road access, cost, and potential damage to soil. Use of mechanical equipment is often infeasible on slopes greater than 35% (Hunter and others 2007). Handcrews with chainsaws can operate on steeper slopes, but handcrews usually cover less ground each day than mechanical thinning. Sometimes the only option for tree removal on steep, inaccessible slopes is expensive helicopter logging. Tree cutting with a chainsaw and other forestry equipment should be done by experienced and certified individuals. The Colorado State Forest Service provides guidance for how to select a contractor to conduct forest management treatments on your property.

Broadcast prescribed burning can be an extremely effective method to reduce hazardous fuels and restore ecological conditions across a variety of grassland, shrubland, and forest ecosystems (Stephens and others 2009; Paysen and others 2000). Prescribed burning is challenging in the WUI due to diverse fuel types, proximity to homes, risk of visibility impairments on roads from smoke, health impacts of smoke, and political and social concerns. However, with proper planning and implementation, qualified firefighters can safely conduct prescribed fires, even in the WUI (Hunter and other 2007, Dether and other 2006).

Prescribed burning is generally cheaper to implement than mechanical treatments across large landscapes (Hartsough and others 2008; Hunter and others 2007), and fire has unique impacts on vegetation and soils that cannot be replicated by mechanical treatments alone (McIver and others 2013). Thinning and burning treatments tend to achieve fuel reduction objectives and modify fire behavior to a greater extent than thinning alone (Prichard and others 2020; Fulé and other 2012). In the words of the Director for the Jefferson Conservation District, “not all fires are bad, and not all trees are good.”

Slash Management

Thinning operations often increase surface fuel loads and can fail to achieve fire mitigation objectives if fuels created by the harvest activities (also known as slash) are not addressed (Agee and Skinner 2005). Slash can include small trees, limbs, bark, and treetops. It is unwise, ineffective, and even dangerous to conduct poor-quality fuels treatments that fail to reduce canopy fuels, result in increased surface fuel loads, and do not receive maintenance treatments. Such treatments can lead to a false sense of security among residents and fire suppression personnel (Dennis 2005), and they divert limited funds away from more effective, strategic projects.

Slash removal in this part of Colorado is quite difficult due to limited biomass and timber industries. Methods for managing slash come with different benefits and challenges (**Table 4.c.2**). Lop-and-scatter and mastication are common methods; however, these approaches do not remove surface fuels from the site, they only rearrange them. It can take a decade or more for slash to decompose to a point where it no longer poses a significant fire hazard. Broadcast prescribed burning and pile burning are more effective at removing surface fuels.

Broadcast Prescribed Burning

Prescribed burning can remove surface fuels and ladder fuels and return ecological processes to frequent-fire ecosystems. Firefighters who plan and implement burns must hold rigorous certifications as set by the National Wildfire Coordinating Group (photo credit: Daniel Godwin, The Ember Alliance).

Broadcast prescribed burning is the most effective method to manage biomass, generate healthy forest conditions, and reduce wildfire risk. Prescribed burning mimics naturally occurring wildfire, can treat hundreds of acres at a time, consumes much of the surface fuel, and is relatively cost-effective (Prichard and others 2020; Fulé and other 2012). Prescribed burning can be conducted safely by highly qualified individuals operating under a carefully constructed burn plan. It is extremely uncommon for prescribed burns to escape containment lines (Weir and others 2019), and when they do, the wildland fire community soberly reviews those escapes to produce lessons learned and make improvements (Dether 2005). Unfortunately, one example is the Lower North Fork Fire which happened within this CWPP planning area. This experience has understandably created fear amongst some members of the public and life safety is a top consideration when developing and conducting prescribed burns. Agencies have frequently and successfully conducted prescribed burns in WUI areas (Hunter and others 2007). Where appropriate, it does still need to be a tool to reduce wildfire risks at a landscape scale due to areas of inaccessibility, cost per acre, and the benefits to fire-adapted ecosystems including wildlife habitat (McIver and others 2013). Prescribed burns can reduce property damage during wildfires because they are so effective at altering forest fuel loads (Loomis and others 2019).

Broadcast burning is carefully regulated in Colorado by the Division of Fire Prevention and Control (DFPC), the Colorado Department of Public Health and Environment, local sheriff's offices, and fire departments as outlined in the *Colorado Prescribed Burning Act of 2013* and *2019 Colorado Prescribed*

Fire Planning and Implementation Policy Guide. Firefighters who plan and conduct prescribed burns are highly qualified under national standards set forth by the National Wildfire Coordinating Group.

Pile Burning

Pile burning is different from broadcast burning; the overall complexity of pile burn operations is lower because fire activity is limited to discrete piles, and piles can be burned when snow covers the ground. Burning piles can produce embers, but the risk of these embers igniting spot fires or structures is low. Piles are typically burned on days with snowpack, high fuel moistures, and low to moderate wind speeds. Embers from burn piles travel shorter distances than embers from passive and active crown fires because the burning material is closer to the ground (Evans and Wright 2017). In the rare occurrence that a wildfire encounters unburned piles, unintended ignition of the pile can exacerbate fire behavior, as was observed during the 2010 Fourmile Canyon Fire in Colorado (Evans and Wright 2017).

Pile burning can be a safe and effective method to consume slash created by thinning operations (photo credit: The Ember Alliance).

It is critical to properly construct piles either by hand or with machines and to burn them as soon as conditions allow (see the 2015 *Colorado pile construction guide* from the DFPC and CSFS for guidance). Burning older piles is less effective and does not consume as much material because piles become compact and lose fine fuels over time (Wright and others 2019). Mitigation measures, such as raking the burnt soil and seeding with native plants, are sometimes warranted after pile burning if the soil was completely sterilized by extreme heat or if invasive species are prevalent in the area (Miller 2015).

Individuals must apply for smoke permits from the Colorado Department of Public Health and Environment to burn piles and apply for open burn permits from the Jefferson County Department of Public Health. Pile burning is not allowed in Jefferson County during fire restrictions or burn bans.

DFPC administers a certified burner program that provides civil liability protection to individuals planning and leading burns if smoke or flames cause damage. The burn must have been properly planned, approved, and executed to receive liability protection. The rigorous certification program requires individuals to complete 32-hours of training, pass an exam, lead at least three pile burns, complete a task book, and comply with all legal requirements for pile burning in Colorado.

Table 4.c.2. Several methods are available to remove slash created by forest thinning, each with their own benefits and challenges.

Method	Description	Benefits	Challenges
Broadcast prescribed burning	Broadcast prescribed burning is generally the most effective method to manage slash. Prescribed burning mimics naturally occurring wildfire, can treat hundreds of acres at a time, consumes much of the surface fuel, and is relatively cost-effective (Prichard and others 2020; Fulé and other 2012). Broadcast burning is carefully regulated in Colorado by the Division of Fire Prevention and Control, Department of Public Health and Environment, local sheriff's offices, and fire departments as outlined in the *2019 Colorado Prescribed Fire Planning and Implementation Policy Guide*.	Extremely effective at reducing surface, ladder, and canopy fuel loads (Prichard and others 2020; Fulé and other 2012). Can restore ecosystem function in frequent-fire forests (McIver and others 2013; Addington and others 2018). Generally cheaper than mechanical treatments (Prichard and others 2020). Can be safely and successfully conducted with proper planning and implementation by qualified firefighters. Can reduce property damage during wildfires by effectively reducing fuel loads (Loomis and others 2019).	Requires careful planning and tactical decisions to prevent smoke from impacting sensitive populations and roadways. Public concerns about risk from flames, embers, and smoke. Limited opportunities to conduct burns under appropriate fire weather conditions. Limited resource availability to conduct burns during the wildfire season.
Pile burning	Pile burning involves placing, laying, heaping, or stacking slash into piles that are then ignited to consume the material. Piles can be constructed by hand or with mechanical equipment. See the 2015 *Colorado pile construction guide* for guidance on planning, constructing, and burning piles.	Reduces surface fuel loads. Generally cheaper than removing material from the site. Lower complexity than broadcast prescribed burning because fire activity is limited to discrete piles and burns can be conducted when snow covers the ground.	Requires careful planning and tactical decisions to prevent smoke from impacting sensitive populations and roadways. Public concerns about risk from flames, embers, and smoke. Limited opportunities to conduct burns because of requirements for snowpack and wind ventilation.

Method	Description	Benefits	Challenges
Pile burning (cont.)	Pile burning requires smoke permits and burn permits, and is not allowed during fire restrictions or burn bans in Jefferson County.	Can be safe and successful with proper planning and implementation by qualified firefighters.	Old and improperly constructed piles can be difficult to ignite and experience poor consumption. Unburnt slash piles can become a hazard during wildfires, especially if loose logs catch fire and roll down slopes. Intense heat can sterilize soils and result in slow recovery of plants (Miller 2015).
Lop-and-scatter	Lopping involves cutting limbs, branches, treetops, smaller-diameter trees, or other woody plant residue into shorter lengths, and scattering involves spreading lopped slash so it lies evenly and close to the ground. This method is better suited to areas with low slash accumulations. **Lop-and-scatter should not be used in defensible space zones 1 or 2 or along roadways.**	Reduces the height of slash relative to untreated slash, therefore increasing the distance between surface and canopy fuels (but not as effectively as broadcast prescribed burning or pile burning). Breaks slash up into smaller pieces and distributes it closer to the forest floor, which can encourage faster decomposition.	Does not remove surface fuels from the site, it just restructures the way fuels are arranged. Can contribute to more intense fire behavior by not addressing increased surface fuel loads created by thinning (Hunter and others 2017; Agee and Skinner 2005).
Mastication or chipping	Mastication involves using specialized machines like a hydro-ax to grind up standing saplings and shrubs and cut slash into medium-sized chips. Chipping involves processing slash through a mechanical chipper to break slash into small chips or shreds.	Mastication can increase the distance between canopy fuels by grinding up standing saplings and shrubs. Can reduce fire intensity and slow rates of spread, enhancing suppression efficacy (Kreye and others 2014).	Smoldering fires in masticated and chipped fuels can be difficult to suppress, produce abundant smoke, kill tree roots, and lead to spot fires if high winds reignite masticated fuels and blow them across containment lines (Kreye and others 2014).

Method	Description	Benefits	Challenges
Mastication or chipping (cont.)	Deep layers of masticated and chipped fuels can result in longer periods of smoldering when burned and have detrimental impacts on plant regeneration (Kreye and others 2014; Jain and others 2018).	Reduces the height of slash relative to untreated slash, therefore increasing the distance between surface and canopy fuels (but not as effectively as broadcast prescribed burning or pile burning). Breaks slash up into smaller pieces and distributes it closer to the forest floor, which can encourage faster decomposition. Can produce landscape mulch to be used offsite.	Does not remove surface fuels from the site, it just restructures the way fuels are arranged. Masticated and chipped fuels are unlike natural surface fuels in terms of their shape, depth, and highly compact nature (Kreye and others 2014). Masticated and chipped fuels can impede plant regeneration, particularly when the depth of masticated and chipped fuels exceeds 4 inches (Jain and others 2018).
Slash removal	Removal involves physically dragging and transporting slash away from the site. Where there are active beetle infestations, material might need to be covered with plastic to prevent beetles from emerging and spreading.	Decreases surface fuel loads by removing material from the site.	Can be expensive and labor intensive. Not feasible in areas far from roads. Can spread insects like mountain pine beetles and emerald ash borer to other locations.
Mowing	Mowing involves using equipment or grazing animals to trim the height of grasses and forbs. Some equipment can mow down shrubs and small saplings. Mowing is primarily used to reduce flashy fuels in defensible space zones 1 and 2 and along roadways.	Can decrease flame length by reducing the height and volume of fine flashy fuels (Harper 2011). Can stimulate the regeneration and growth of some native plants.	Does not address woody surface fuels. Labor intensive and cannot be implemented across large areas or in areas with poor access. Requires annual maintenance. Can spread invasive plant species, decrease the regeneration of some native plants, and cause soil compaction (Kerns and others 2011).

Ponderosa Pine and Dry Mixed Conifer

Ponderosa pine forests are called woodlands because they grow in open stands with many understory species and room between the trees. Dry mixed conifer forests are usually found are warm, dry south-facing slopes in Colorado and contain of any of the following species: ponderosa pine, Douglas-fir, white fir, blue spruce, and Rocky Mountain juniper.

Treatments for Ponderosa Pine

Ponderosa pine stand treatments are centered around ecological restoration, or restoring the site to historic conditions. Thinning to create wide spacing between trees with a focus on preserving the largest and oldest trees is common and results in healthier forests post-treatment. Ponderosas and most dry mixed conifer forests respond well to selective thinning and regular maintenance that keeps regeneration levels low and keeps just the healthiest trees.

Broadcast burning is also a highly effective treatment for ponderosa and dry mixed conifer forests. The more mature trees can withstand the fire while the understory is cleared out. Ponderosa pine forests had regular fire intervals of 7-50 years before colonial settlement and restoring that fire regime is ideal. When planning treatments for ponderosa pine and dry mixed conifer sites, TEA recommends the following:

- Follow the principles of ecological restoration as outlined in Addington and others (2018) to help achieve fuel reduction and ecosystem restoration objectives. Restoration treatments in Ponderosa pine and dry mixed conifer forests will result in mosaic patterns of single trees, clumps of trees, and interspersed meadows.
- Increase the spacing between tree crowns to decrease the risk of active crown fire. If the goal is only to reduce fuel loads, remove trees to create at least 15-foot crown spacing. Wider spacing is required on steeper ground due to the exacerbating impact of slopes on fire behavior (**Table 4.c.1**). If treatment objectives also include ecological restoration, it is important to avoid evenly spacing trees. Retaining small clumps of trees with interlocking crowns is acceptable so long as they are adequately spaced from adjacent individual trees and tree clumps.
- Determine appropriate post-treatment tree density depending on ecological and fuel treatment objectives, forest type, and aspect. As a general principle, the more trees removed, the more effective the fuel treatment and the closer the treatment recreates historical, fire-resilient forest structure. Along the Colorado Front Range at lower montane elevations (5,500 to 8,530 feet), tree densities in ponderosa pine forests average 4.5 times higher today than they were in the mid-1800s, and basal areas average 2.8 times higher. Many ponderosa pine forests had less than 100 trees per acre and basal areas less than 40 feet^2/acre in the mid-1800s (Battaglia and others 2018). Forests on north-facing slopes historically had higher tree densities, but it might be necessary to substantially reduce tree densities on some north-facing slopes to protect homes and other values at risk from potential fire effects.
- Reduce ladder fuels to decrease the risk of torching. Remove a substantial portion of seedling, saplings, and shrubs, especially those near overstory trees. Pruning branches that hang less than 10 feet above the ground can further reduce the risk of torching, but it can be expensive and inefficient in areas outside defensible space zones 1 and 2. The pruning height required to effectively reduce the risk of torching is influenced by the moisture content of needles and branches, wind speed, slope, and surface fuel loads. The necessary pruning height can be exorbitant; for example, tree limbs hanging below 20 feet must be removed to prevent dry canopy fuels from igniting when exposed to radiant heat from 8-foot flames (Agee 1996a).
- Reduce surface fuels to decrease fire intensity and flame lengths. Thinning operations produce significant amounts of slash, and rearranging fuels from tree crowns to the surface

without reducing the overall fuel load will rarely achieve fuel reduction objectives. Slash decomposes very slowly in Colorado and proper disposal is essential. See **Table 5c.2** for guidance on slash management.

- Strategically place treatments to facilitate firefighter access, help firefighters establish control lines, and reduce the intensity of wildfires as they spread towards homes and other values at risk.
- Mitigate impacts of tree removal on soil compaction and erosion when treatments occur near streams and riparian ecosystems. The Colorado State Forest Service recommends streamside management zones of at least 50 feet (CSFS 2010).
- Commit to monitoring and maintenance of fuel treatments. Benefits of fuel treatments are transient and decrease overtime, with treatment "lifespan" depending on forest type, topography, rates of seedling regeneration (which is often influenced by precipitation), and the number of trees removed during treatments. Many forests require more than one treatment to reduce fuels and restore ecosystem structure. Some areas might require mechanical tree removal followed by prescribed burning, and then a maintenance treatment with tree removal and/or prescribed burning 10 to 20 years later. With a single pulse of tree regeneration, the risk of torching returns to near pre-treatment levels within 10 to 35 years in ponderosa pine forests in Colorado. As the number of regenerating seedlings increases, treatment longevity decreases by about 5 years per 550 seedlings (Tinkham and others 2016).
- Monitor treatments for invasive, weedy plant species that might require control after forest treatments.
- Take pictures of the treatment before and after to help evaluate effectiveness and monitor changes over time (see **Figure 4.b.3** for an example of repeat photographs pre- and post-treatment).

Ponderosa Pine in Defensible Space

Ponderosas are well adapted to living in spaced out woodlands and are easily thinned to create beautiful and effective defensible space. Homeowners often enjoy the more open forest around their home because it lets in more light which encourages more understory grasses and shrubs to grow and, in turn, can increase wildlife sightings near their home. Clear all ponderosa pines from sone 1, and thin and limb all ponderosas in zones 2 and 3 to create a minimum of 15-foot crown spacing and at least 6 feet of vertical clearance to the lowest hanging branches.

Lodgepole Pine and Wet Mixed Conifer

Lodgepole pine and wet mixed conifer are common across the EC & IC FPDs. They typically grow in dense, even-age stands and very few species grow under the canopy or within the stands. Wet mixed conifer is typically found on north-facing slopes with cooler and moister weather and soil. They consist of any of the following species: lodgepole pine, subalpine fir, Engelmann spruce, Douglas-fir, limber pine, bristlecone pine. Lodgepoles are a fire-adapted species and rely on fire to move it through its life cycles. Lodgepole pines are relatively thin and tall trees, competing for light in the dense stands. Because of the competition, continuous regeneration is not normal for lodgepole and wet mixed conifer, and they are adapted to stand-replacing fires every 75-300 years (Colorado Forest Restoration Institute). Lodgepole cones are serotinous, meaning they are coated in resin that only opens under high heat, such as during a wildfire. Most of these species are not resistant to fire and will burn easily. The cones will open and leave a dense seedbed in the ground after a fire, which will grow into a new stand in the old stand's place.

Treatments for Lodgepole Pine

Goals for lodgepole pine, wet mixed conifer, and spruce-fir forest treatments involve lowering the density of trees and fuel loads (this must be done in a way that protects the remaining trees from windthrow), and increasing the diversity of tree ages, sized, and species, where possible. Treatments should also be conscious of mountain pine beetle activity in the area and plan treatments accordingly (Dennis and others 2009). Thinning and broadcast burns that focus on surface and passive crown fire is not feasible in lodgepole stands. The trees density protects them against wind and thinning frequently results in widespread blow-down in the years after thinning is completed, so it is not recommended. Lodgepole pines are susceptible to active crown fire that is not easily managed in prescribed burning scenarios and is not typically used either. Forest health treatments that focus on fire prevention and restoring historic conditions to lodgepole pines focus on patch cuts and creating mosaic landscapes. Patch cuts remove every overstory tree in a certain area, leaving an open section of forest. Aspen typically grows in quickly after the patch cut, followed by lodgepole pine. This mimics a stand-replacing fire event without the risk of active crown fire in the forest that could escape and damage property. The drawback to thinning is that the nutrients that the trees have absorbed over the centuries of grown do not return to the soil as they would have following a fire. Read the Lodgepole Pine Management Guidelines for Land Managers in the Wildland-Urban Interface publication from Colorado State Forest Service for more information.

When planning treatments for lodgepole pine and wet mixed conifer sites, TEA recommends the following, adapted from recommendations by Dennis and other (2009):

- Thin existing mature stands to achieve density levels required for wildfire hazard mitigation and MPB resistance. This is difficult to accomplish in one entry due to windthrow and stem breakage, so plan on multiple entries. Remove no more than 25 percent of the stand's basal area during each cut, and carefully monitor stands to ensure proper timing of the necessary re-entries.
- Generally, maintain average stem diameters of < 8 inches and stand densities of < 80 square feet of basal area per acre for higher resistance to mountain pine beetle. This requires more frequent use of silvicultural actions designed to regenerate lodgepole. To do so, incorporate small clearcuts or patch cuts when possible. This will achieve age and size diversity.
- In stands of mixed species, retain species other than lodgepole pine. Use caution during treatments to avoid damaging the desired residual trees.
- Avoid developing multi-storied stands. If this situation begins to develop: a. Remove the emerging understory to reduce ladder fuels, or b. Remove the overstory early enough to avoid damaging the developing understory, or c. Combine a and b in different areas to achieve greater diversity across the landscape.
- If an entire stand is infected with dwarf mistletoe, remove the most severely infected trees during each thinning entry. Retain alternate coniferous species and aspen. Create small openings and begin planting alternate species within the openings. If only portions of the stand are infected with dwarf mistletoe, clearcut or patch cut infected areas.
- Maintain aspen and encourage its development by removing conifers from within aspen stands removing conifers from around the edge of aspen pockets, particularly on the south and west sides.
- Remove trees that have been severely damaged by lightning, windthrow, and insect and disease infestations as soon as possible. Retain other snags for habitat.
- Remove larger woody material from the forest and use proper slash-disposal techniques such as piling and burning, chipping, or low-depth, discontinuous lop and scatter.

Lodgepole Pine in Defensible Space

Lodgepole pines around the home should be managed carefully, and under the direction of a forestry expert. CSFS recommends avoiding selective thinning where possible, but if you choose to thin near your home, leave the taller and more mature trees and thin the younger and smaller ones. Thinning trees while they are young is healthier than thinning older trees. CSFS also recommends leaving small stands, or clumps, of trees. Leaving a clump of 30-50 trees protects those trees from windthrow, but can open more space around your home to help protect it from radiant heat and short-range embers. Patch cutting lodgepole and wet mixed conifer around a home to create 100 feet of defensible space is an adequate mitigation goal, and homeowners can encourage aspens stands or other windthrow-resistant trees with 15-foot crown spacing in zones 2 and 3.

When thinning and removing woody material from around the home, follow the CSFS defensible space guidelines outlined in Section 4b. More information can be found in the Lodgepole Pine Management Guidelines for Land Managers in the Wildland-Urban Interface publication from Colorado State Forest Service.

Gambel Oak

Gambel oak is a common and widespread shrub across Colorado and is found in dense stands on the eastern side of EC & IC FPDs (Landfire 2020). This common species can be a potent wildfire fuel, but much of the research on fire history, fuel mitigation, defensible space, and management does not include Gambel oak. Research is limited on pre-colonization fire regimes in Gambel oak ecosystems, so recommendations are correlated with the species that it grows with, such as ponderosa pine or sagebrush. Current research indicates that Gambel oak is more widespread and established that it was before the era of fire exclusion, similar to ponderosa pines (Kaufmann and others 2016). This indicates that reducing the density of Gambel oak vegetation is a step toward establishing historical fire regimes and reducing the risk of wildfires in the WUI. Because of the lack of readily available resources on this species, TEA compiled recommendations from leading researchers and practitioners on effective Gambel oak fuel treatments.

Treatments for Oak Stands

Gambel oaks have varied growth habits and can present as trees or as shrubs. They grow quickly and resprout vigorously after grazing, wildfire, or mechanical thinning. Management recommendations vary greatly, depending on the desired future conditions.

- A reduction in the density of Gambel oak is recommended to reduce wildfire risk. Eradication of Gambel oak is not recommended because it is an important forage species for ungulates throughout the year, and the acorns are an important food for mammals such as black bears in the fall.
- Protection of large, old Gambel oaks can help maintain diversity in the ecosystem after treatments. Thinning near these established trees, similar to thinning ponderosa pine woodlands to increase the vigor, can help maintain the species health (Abella and Fule 2008).
- Mastication and prescribed fire both are effective at removing the existing woody material. However, aggressive sprouting occurs unless herbicide is used, or multiple follow-up thinning or burning sessions are completed. Herbicide such as triclopyr (sold often as Garlon) can be used in conjunction with mechanical thinning as a stump treatment to prevent sprouting. It can also be used independently as a foliar spray to prevent the crop of new sprouts that follows mechanical or prescribed burning treatments (Jester and others 2012, Kaufmann and others 2016).
- Seasonality and frequency of prescribed fire treatments are important for reducing Gambel oak density. Prescribed fire during the growing season – particularly later growing season,

when the stored sugar levels in the roots are lowest – can reduce the volume of resprouting (Harrington 1989).

- Follow-up treatments during this same period can further suppress Gambel oak. Similarly, other oak species with similar resprouting strategies can be suppressed using firing strategies that maximize fire residence time.
- Goats that consume woody material for food are an increasing opportunity to manage wildland vegetation. There are companies that bring goats to an area to help with shrubland management and could be an effective method in Gambel Oak.

Gambel Oak in Defensible Space

The key to Gambel oak management in the defensible space zones around homes in the WUI is consistent and regular treatment. CSFS recommends two options for treatment around the home to protect life and property from wildfire: persistent, aggressive mechanical treatment, and herbicide.

Because this species readily propagates more shoots after disturbance, multiple rounds of mechanical thinning, every 3-5 years, are required to prevent it from coming back just as thick or thicker than before. Removal of the bulk of the stems and shoots is recommended, because that will not kill the plant, but it will reduce its capacity to grow quickly, and will remove ladder fuels from near the home. Triclopyr is recommended as the most effective herbicide when applied to the stump directly after cutting the stem (Jester and others 2012).

When thinning and removing woody material from around the home, follow the CSFS defensible space guidelines outlined in Section 4b. More information can be found in the Gambel Oak Management publication from Colorado State University Extension.

Other Forest Types

For the most accurate information regarding the trees and vegetation on your land, consult a forestry professional who can write a forest management plan or prescribe the best treatments for you.

Aspen and Other Riparian Hardwood Species

Aspen groves are important food and habitat for mountain fauna. They are fire resistant and do not respond well to fuel treatments. Aspen groves should be left alone and not thinned or managed for fire, unless they are right next to or hanging over a structure. Aspen is a resilient, early-succession species that will grow in quickly after fuels treatments in other forest types, such as lodgepole patch cuts.

Cottonwood and willow trees are excellent at stabilizing river banks and wetland habitat. They grow quickly and provide habitat and forage for many species. These trees should generally be left alone unless they are very close to or hanging over a structure. More information can be found in the Cottonwood Management publication from the Colorado State Forest Service.

Spruce-Fir

Subalpine spruce-fir forests are most similar to Lodgepole and wet mixed conifer forests. They grow in relatively even-aged stands and burn with high-severity fires every 100-500 years. Patch cutting and creating mosaic landscapes within the forests is the recommended treatment for spruce-fir forests. See the **Lodgepole Pine and Wet Mixed Conifer** section for recommendations.

Piñon-Juniper

Rocky Mountain juniper and common juniper are quick to ignite and should be cleared out of zone 1 and under decks. In zones 2 and 3, these trees should be thinned and kept away from other overstory trees. More information can be found in the Piñon-Juniper Management publication from Colorado State Forest Service

Shrublands

Shrubs should be managed as a ladder fuel in the HIZ. They should be kept away from defensible space zone 1 and cleared from under trees in zones 2 and 3. Dense shrubs and dry shrubs like sagebrush should be thinned and cleared around a structure, especially on hillslopes below a home.

Priority Treatment Locations

Potential locations for ecological restoration and/or stand-level fuel treatments were located and prioritized within and around the combined FPDs (**Figure 4.c.1**). In August 2021, TEA shared the assessment with land managers from the USFS, CSFS, Jefferson County, and Denver Water for their input. **These treatment areas cross ownership boundaries and will require collaboration between private landowners, public land managers, and forestry professionals to create successful outcomes.**

Our prioritization scheme assigned higher priority to locations that could expose homes to short-range spotting and radiant heat under 60th percentile fire weather, contained priority roadsides (see Roadway Fuelbreak Recommendations), could support extreme fire behavior under 60th percentile fire weather, and contained a greater percentage of operable ground (slopes less than 50 percent). The boundaries of the proposed treatment units follow the edges of topographic features. See Appendix B for a full description of the prioritization methods.

Within the EC & IC FPD boundaries, there are 180 first-priority treatment units (**Figure 4.c.2**), 412 second priority treatment areas (**Figure 4.c.3**), and 365 third priority treatment areas (**Figure 4.c.4**). These treatment areas cover approximately 63% of the land area in the FPDs.

TEA focused on high-priority treatment recommendations, but this does not discourage ecological restoration and fuel mitigation in other areas. Prior to treatment, forestry professionals should visit these locations to assess current conditions and delineate unit boundaries. EC & IC FPD, HOAs, residents, and land managers should re-evaluate fire risks and re-prioritize treatment units as conditions change over time. Many areas not identified as priority locations in **Figure 4.c.1** could benefit from treatments to reduce fire risks and protect homes and other values at risk. If multiple neighbors work together to mitigate fire risk across ownership boundaries, it could attract funding and increase the priority and effectiveness of treating those areas.

Altering potential wildfire behavior and restoring ecological conditions requires a landscape-scale approach to treatments (Addington and others 2018). Most of the priority treatment units fall on privately-owned land and span multiple ownerships, which can create a challenge for designing and implementing treatments. Community-wide commitment and coordination are required to implement strategic treatments that decrease shared fire risk.

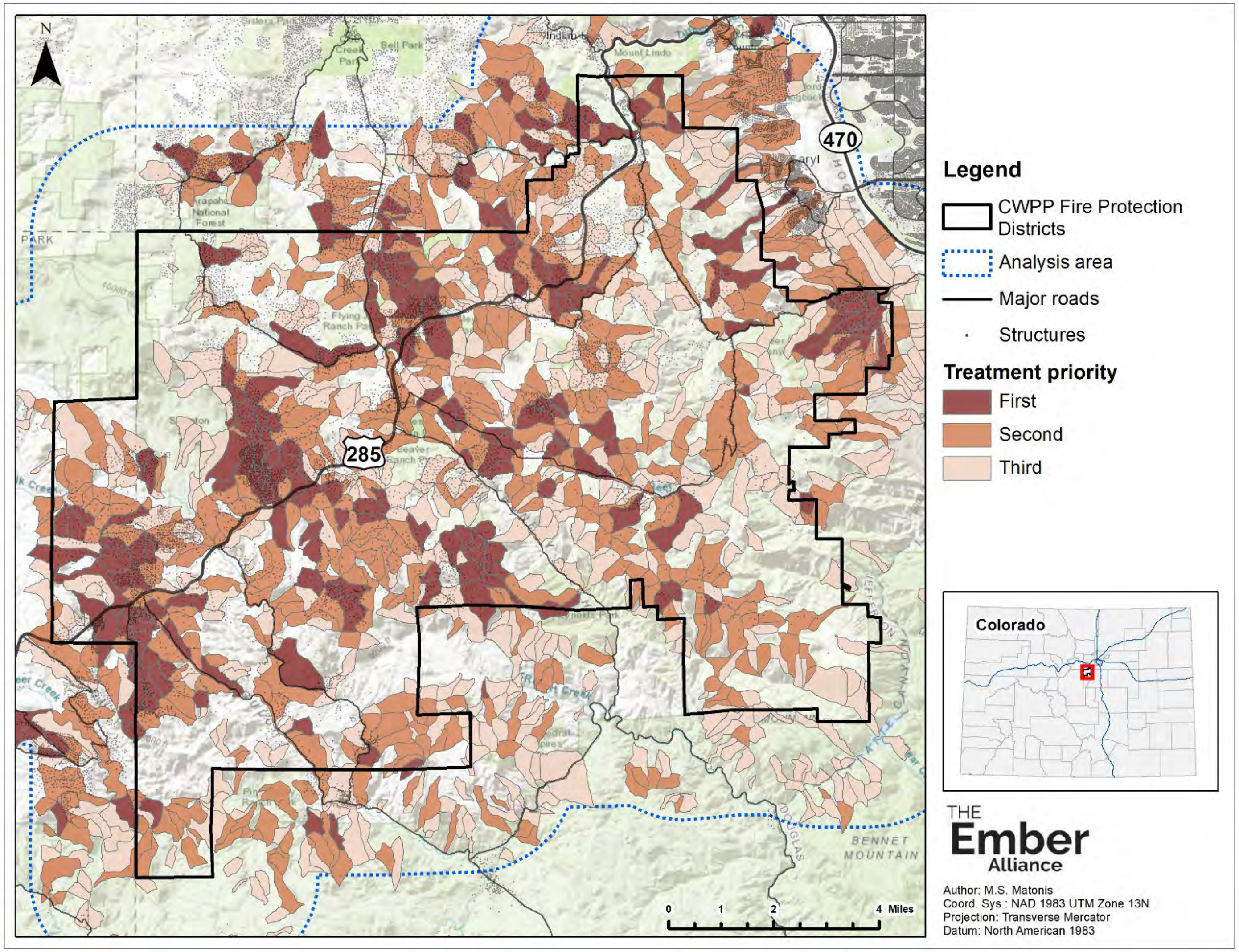


Figure 4.c.1. Potential priority locations for ecological restoration and/or stand-level fuel treatments based on predicted fire behavior, conditional burn probability, the abundance of threatened structures, operability based on slope, occurrence of previous fuel treatments, and presence of non-survivable roadway conditions. Boundaries of potential treatment units follow the edges of forest cover and topographic features. See [Appendix B](#) for a full description of prioritization methods

First-Priority Areas (15,248 acres total): First priority treatment areas cover approximately 15% of the FPDs land and average 85 acres in size (**Figure 4.c.2**). These stands have some of the worst potential fire behavior and highest potential for impacts to lives and property. These priority treatment areas are where limited resources should be directed first and where they will likely have the greatest impact.

A cluster of first-priority treatment areas are in the Deer Creek Canyon area due to an abundance of homes with potential exposure to extreme radiant heat from burning shrubby fuel on steep slopes and moderate potential for roadway congestion during evacuations. Another cluster of first-priority locations abuts Staunton State Park due to potential for crown fire behavior and high potential for roadway congestion under non-survivable conditions.

Many of the first-priority treatment areas identified in this CWPP are also priority locations for other land management agencies, such as Colorado Division of Parks & Wildlife, Denver Mountain Parks, and Jefferson County Open Space, creating opportunities for cost-sharing and cost-boundary management. It is recommended that homeowners in these areas begin working together with forestry professionals and their local community ambassadors to implement large-scale thinning and mitigation projects, and that these homeowners work on individual home hardening and defensible space to protect themselves and their neighbors

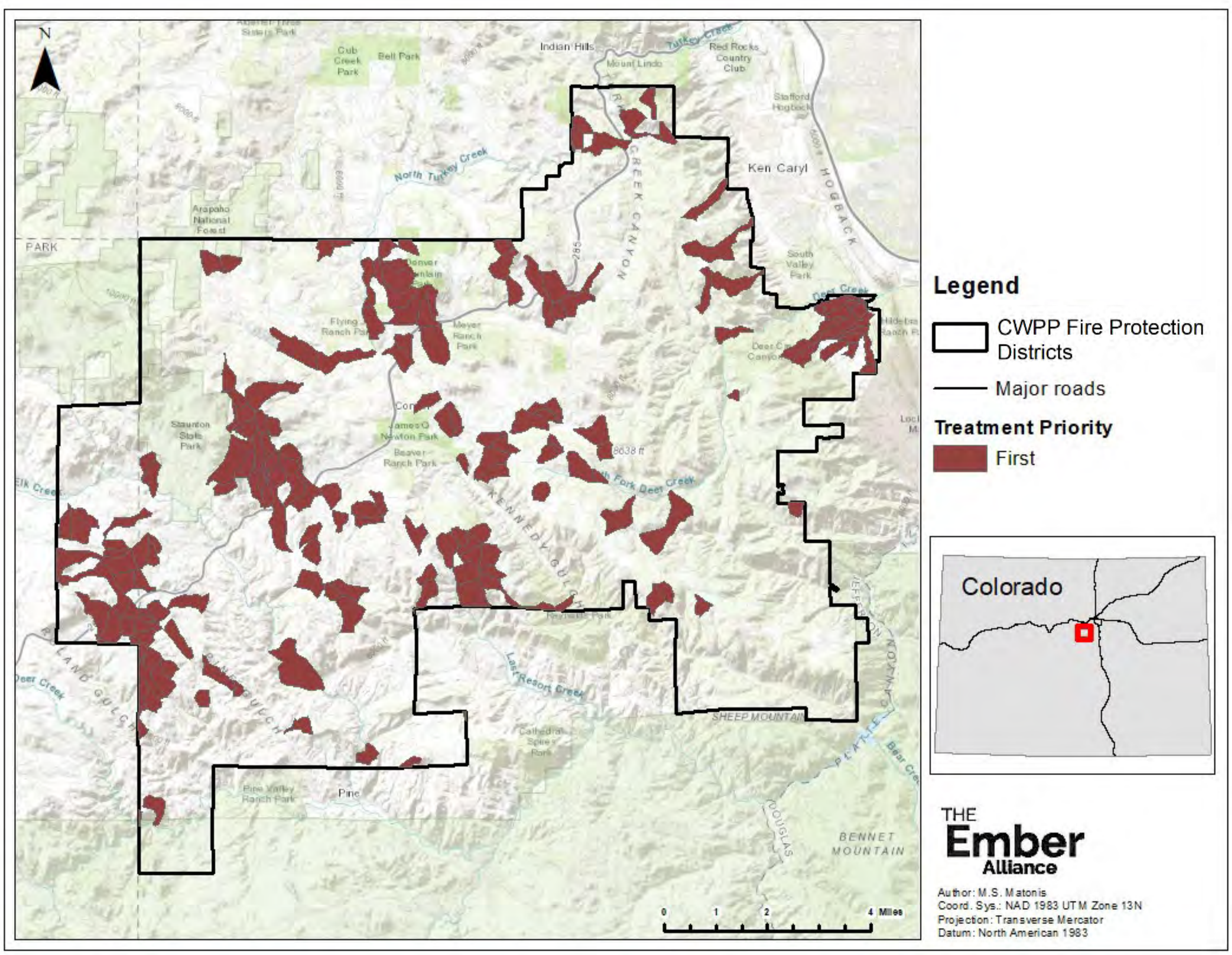


Figure 4.c.2. First priority treatment areas within the EC & IC FPDs.

Second-Priority Areas (27,787 acres total): Second priority treatment areas cover approximately 27% of the FPDs land and average in 67 acres in size (**Figure 4.c.3**). These areas have some potential to expose homes to short-range spotting and extreme radiant heat and contain roads that could become moderate evacuation pinch points with non-survivable conditions under 60th percentile fire weather. The units are frequently adjacent to other priority treatment areas, making it possible to cover multiple priority areas in one project (and share costs) if landowners work together. Homeowners in these areas should work together to mitigate overlapping HIZs and build linked defensible space, and private landowners and public lands managers should collaborate to reduce shared risk.

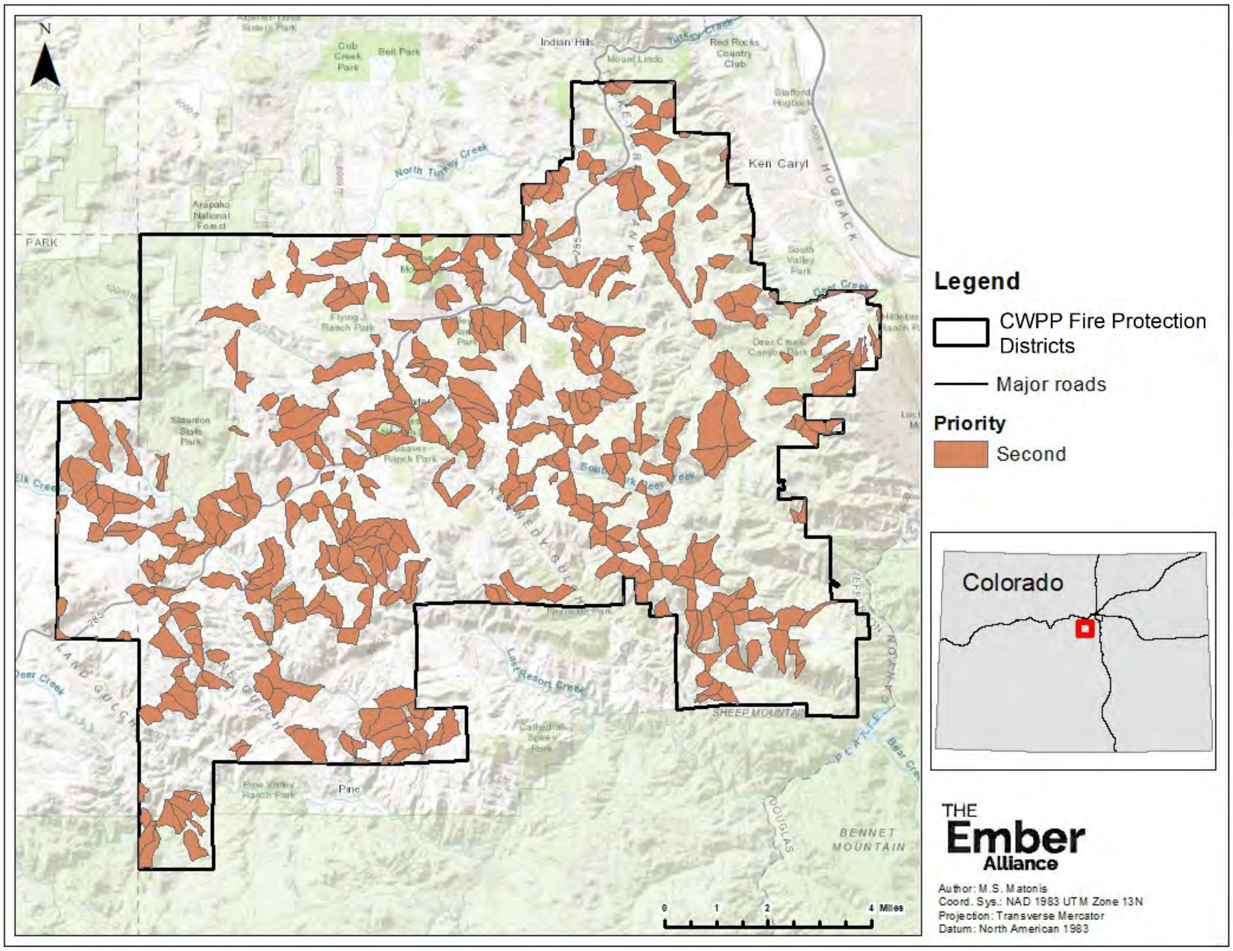


Figure 4.c.3. Second priority treatment areas within the EC & IC FPDs.

Third-Priority Areas (21,701 acres total): Third priority treatment areas cover approximately 21% of the FPDs land and average 60 acres in size (**Figure 4.c.4**). These areas have some potential to expose homes to short-range spotting and extreme radiant heat, but they do not contain roads that could become evacuation pinch points with non-survivable conditions under 60th percentile fire weather. The units are frequently adjacent to other priority treatment areas, making it possible to cover multiple priority areas in one project (and share costs) if landowners work together. Homeowners in these areas should work together to mitigate overlapping HIZs and build linked defensible space, and private landowners and public lands managers should collaborate to reduce shared risk.

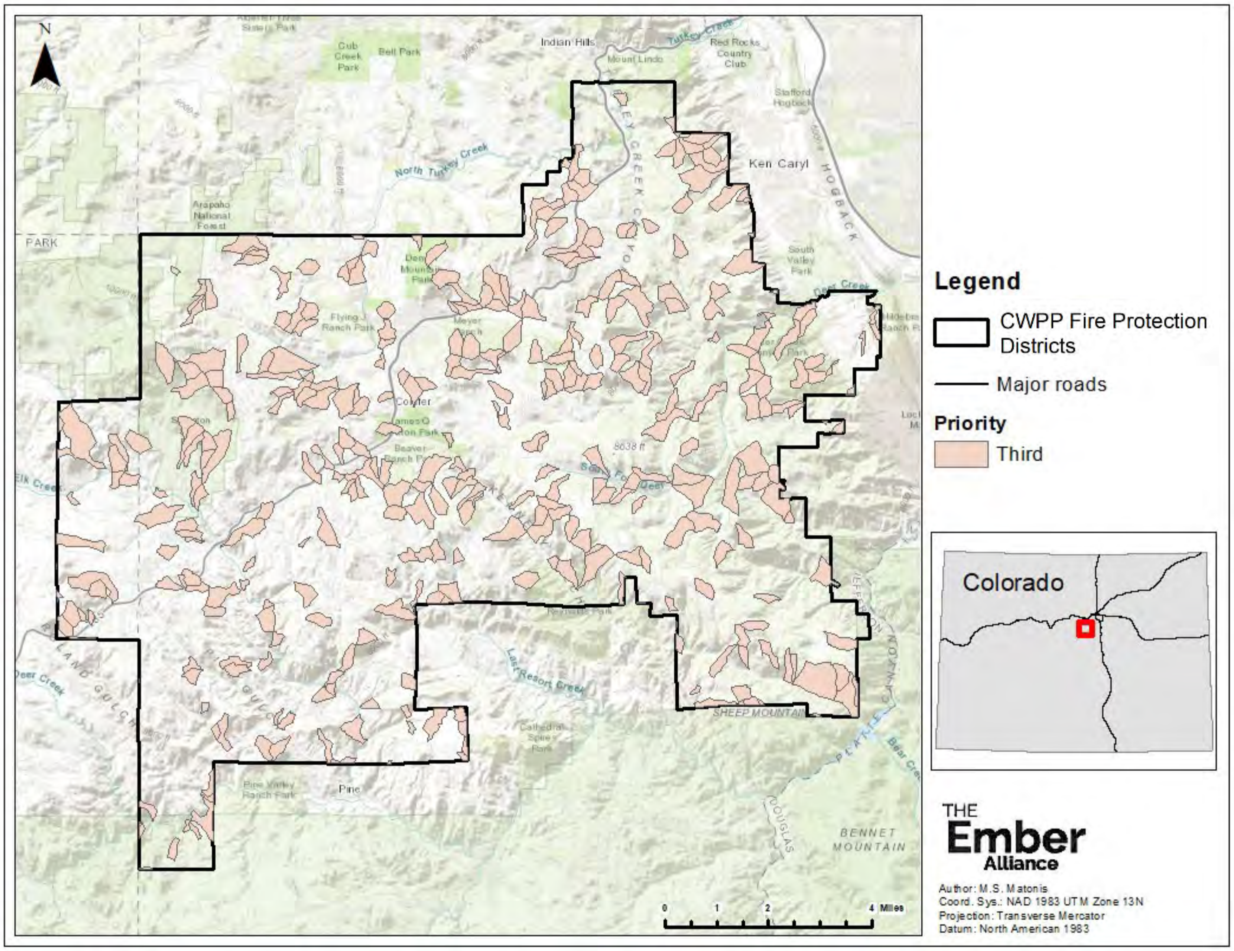


Figure 4.c.4. Third priority stand treatment areas within the EC & IC FPDs.

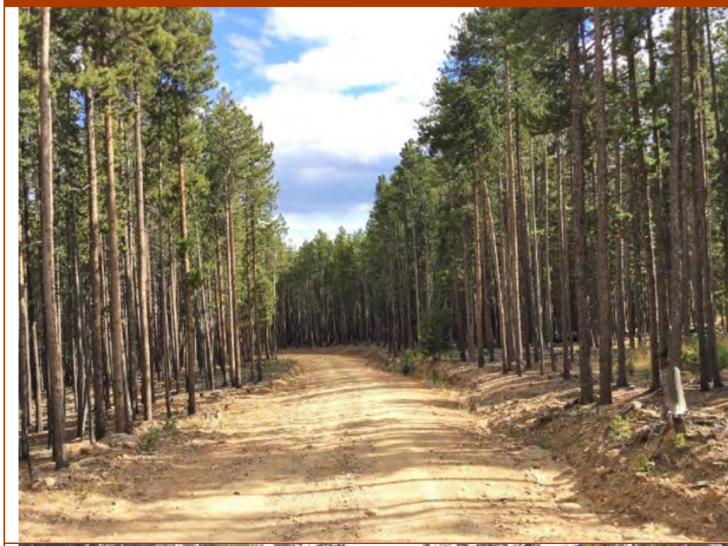
4.d. Roadway Fuel Treatment Recommendations

Effective Treatment Design

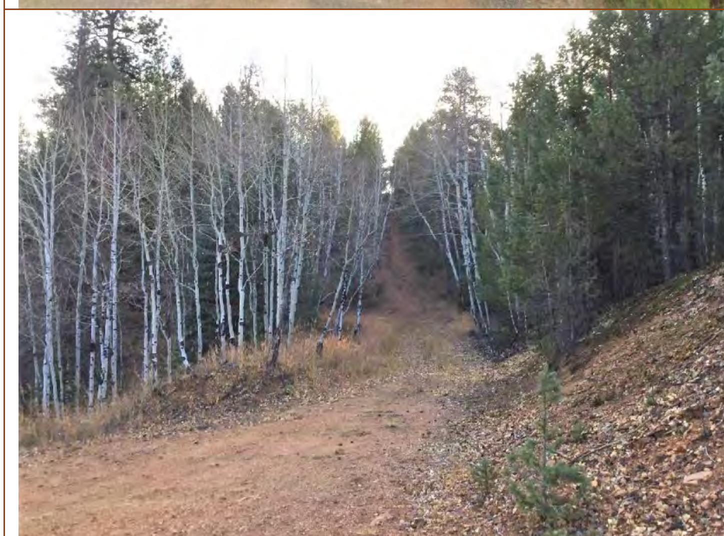
The primary objective within fuelbreaks is to dramatically reduce fuels to create potentially survivable conditions along roadways during wildfires to allow for safer evacuation. Treatments can follow principles of ecological restoration, but guidelines for shaded fuelbreaks (Dennis 2005) or even complete removal of trees is sometimes the most appropriate approach, especially in evacuation pinch points. General guidelines for creating and maintaining roadway fuelbreaks are provided below. **Table 4.d.1** includes pictures of roadways from EC & IC FPD with suggestions for improvement.

- The width of an effective roadway fuel treatment (distance to the left and right of a road) is dependent on slope, forest type, stand density, and the amount and arrangement of fuels. CSFS recommends that treatments extend 150 to 240 feet off the downhill side of the road and 100 to 150 feet off the uphill side (**Figure 4.d.1**). Wider treatments are necessary on the downhill side on steeper slopes due to the exacerbating effect of slope on fire intensity when fires travel uphill (Dennis 2005; **Table 4.d.2**).
- Eliminate ladder fuels by removing seedlings, sapling, and tall shrubs to reduce the risk of torching. Prune branches on remaining trees to at least 10 feet.
- Facilitate fire engine access by removing trees along narrow driveways so the horizontal clearance is at least 20 feet. Prune low-hanging branches of remaining trees so the unobstructed vertical clearance is at least 13 feet and 6 inches.
- Increase the spacing between tree crowns to decrease the risk of active crown fire. Remove trees to create at least 15-foot crown spacing on flat ground. Wider spacing is required on steeper ground due to the exacerbating impact of slopes on fire behavior (**Table 4.c.1**).
- Reduce surface fuels to decrease fire intensity and flame lengths. Thinning operations produce significant amounts of slash, and rearranging fuels from tree crowns to the surface without reducing the overall fuel load will rarely achieve fuel reduction objectives. Slash decomposes very slowly in Colorado and proper disposal is essential. See **Table 4.c.2** for guidance on slash management.
- Reduce the height of flashy fuels every year by burning or mowing grasses that are close to the road.
- Strategically place treatments to provide tactical opportunities for firefighters, increase the chance of survivable conditions along high-use roadways, and facilitate greater firefighter access to properties.
- Mitigate potential impacts of tree removal on soil compaction and erosion when treatments occur near streams and riparian ecosystems. The Colorado State Forest Service recommends streamside management zones of at least 50 feet (CSFS 2010).
- Commit to monitoring and maintenance of fuel treatments. Benefits of fuel treatments are transient and decrease overtime, with treatment "lifespan" depending on forest type, topography, rates of seedling regeneration (which is often influenced by precipitation), and the number of trees removed during treatments.
- Monitor treatments for invasive, weedy plant species that might require control after forest treatments.
- Take pictures of the treatment before and after to help evaluate effectiveness and monitor changes over time (see **Figure 4.b.3** for an example of repeat photographs pre- and post-treatment).

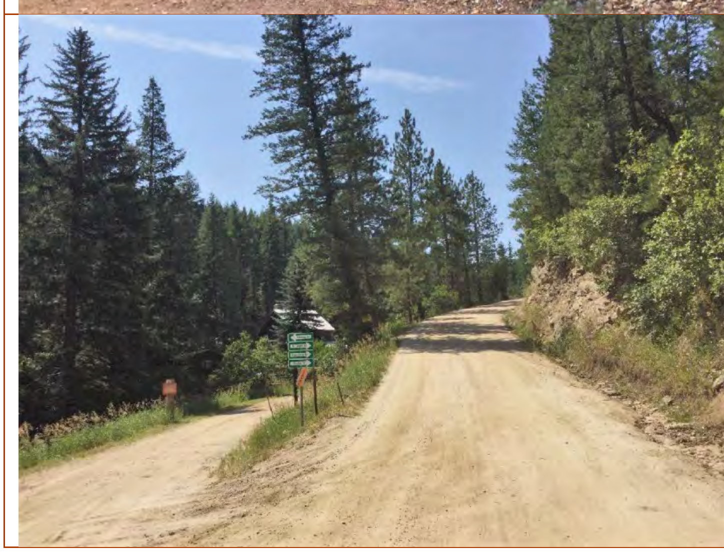
Table 4.d.1. Examples of conditions occurring along roadways in the EC & IC FPD and suggestions for improvement.

Roadway example	Suggestions for improvement
	• Clear all trees away from roadway • Create space for turnarounds
	• Clear trees and tall shrubs away from the roadways • Clear extra space on the downhill side • Create regular pullouts and turnaround locations for engines • Remove trees that are leaning over the roadway

- Mowing along the side of the road is recommended for the tall grasses
- The trees along this roadway are back from the road and upslope of the road. Trees should be removed to further away, but this would be lower priority than other roadways



- Clear conifer trees away from the roadway
- Clear aspen trees to make 20 feet of space around the road and clear overhanging branches
- Install clear, reflective signage on driveway entries
- Remove trees that are leaning over the roadway



- Remove trees that are leaning over the roadway because they could fall and trap residents during an evacuation
- Clear all trees on the sides of the roadways
- Install mirrors on switchbacks to improve visibility

Table 4.d.2. Minimum fuelbreak distances uphill and downhill from roads depend on the slope along the roadway[1]. Recommendations from the Colorado State Forest Service (Dennis 2005).

Percent slope (%)	Downhill distance (feet)	Uphill distance (feet)	Total fuelbreak width (feet)
0	150	150	300
10	165	140	305
20	180	130	310
30	195	120	315
40	210	110	320
50	225	100	325
60	240	100	340

[1]Measurements are from the toe of the fill for downhill distances and above the road cut for uphill distances. Distances are measured parallel to flat ground, not along the slope. See **Figure 4.d.1** for a visual representation of roadway fuelbreak measurements.

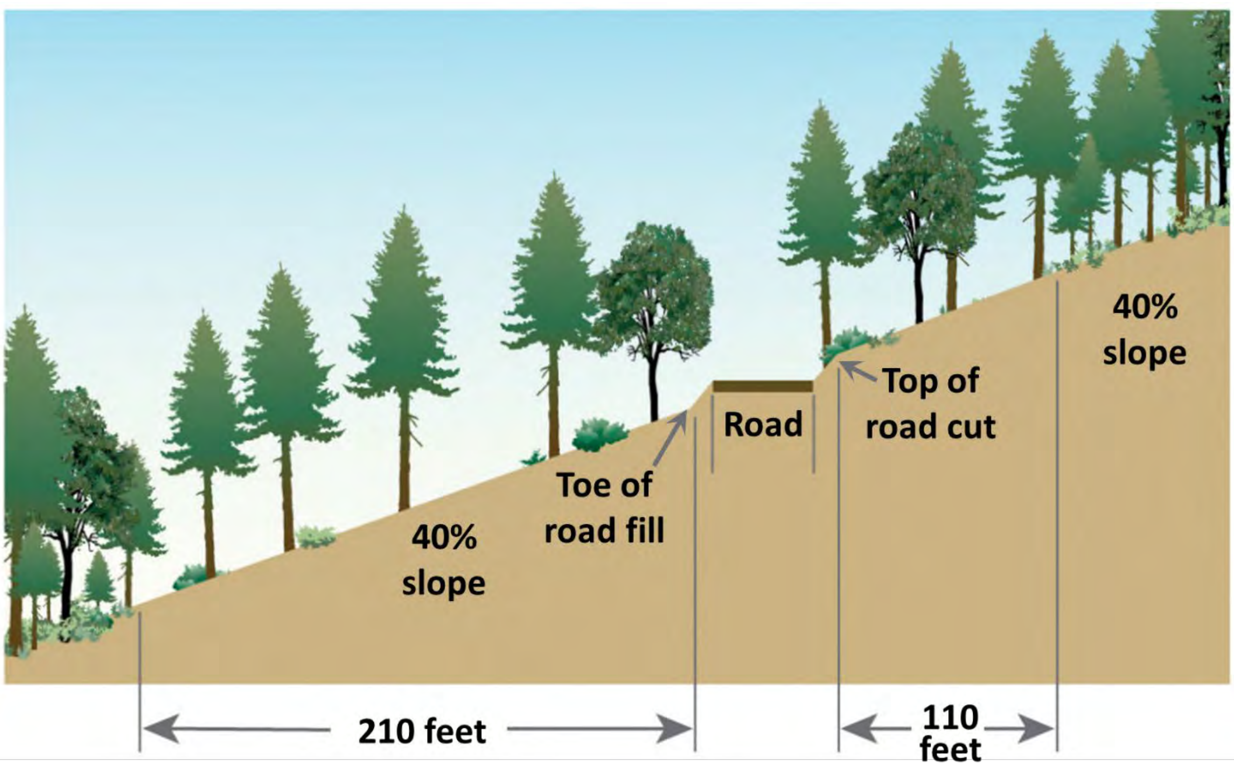


Figure 4.d.1. Fuelbreak width must be greater on the downhill side of the road due to the exacerbating impact of slope on fire intensity when fires travel uphill. Figure modified from Bennett and others (2010).

Slash Management

Thinning operations often increases surface fuel loads and can fail to achieve fire mitigation objectives if slash is not addressed (Agee and Skinner 2005). Leaving untreated slash within roadway fuelbreaks is particularly counterproductive. The risk of active crown fire might be lower after a thinning operation, but untreated slash in fuelbreaks can burn at high intensities and endanger the lives of residents stuck on roadways during a wildfire. Slash is easier and cheaper to manage along roadways due to access, and roads can serve as highly effective holding features for controlled burning of grass in the spring and fall and pile burning in the winter. Chipping and masticating, physical removal, and mowing can also be appropriate slash management techniques along roadways (see **Table 4.c.2**).

Table 4.d.3. Slash management benefits and challenged for roadway operations in the EC & IC FPD.

Method	Description	Benefits	Challenges
Mastication or chipping	Mastication involves using specialized machines like a hydro-ax to grind up standing saplings and shrubs and cut slash into medium-sized chips. Chipping involves processing slash through a mechanical chipper to break slash into small chips or shreds. Deep layers of masticated and chipped fuels can result in longer periods of smoldering when burned and have detrimental impacts on plant regeneration (Kreye and others 2014; Jain and others 2018).	Mastication can increase the distance between canopy fuels by grinding up standing saplings and shrubs. Can reduce fire intensity and slow rates of spread, enhancing suppression efficacy (Kreye and others 2014). Reduces the height of slash relative to untreated slash, therefore increasing the distance between surface and canopy fuels (but not as effectively as broadcast prescribed burning or pile burning). Breaks slash up into smaller pieces and distributes it closer to the forest floor, which can encourage faster decomposition. Can produce landscape mulch to be used offsite.	Smoldering fires in masticated and chipped fuels can be difficult to suppress, produce abundant smoke, kill tree roots, and lead to spot fires if high winds reignite masticated fuels and blow them across containment lines (Kreye and others 2014). Does not remove surface fuels from the site, it just restructures the way fuels are arranged. Masticated and chipped fuels are unlike natural surface fuels in terms of their shape, depth, and highly compact nature (Kreye and others 2014). Masticated and chipped fuels can impede plant regeneration, particularly when the depth of masticated and chipped fuels exceeds 4 inches (Jain and others 2018).

Slash removal	Removal involves physically dragging and transporting slash away from the site. Where there are active beetle infestations, material might need to be covered with plastic to prevent beetles from emerging and spreading.	Decreases surface fuel loads by removing material from the site.	Can be expensive and labor intensive. Not feasible in areas far from roads. Can spread insects like mountain pine beetles and emerald ash borer to other locations.
Mowing	Mowing involves using equipment or grazing animals to trim the height of grasses and forbs. Some equipment can mow down shrubs and small saplings, which is particularly relevant for gambel oak. Mowing is primarily used to reduce flashy fuels in defensible space zones 1 and 2 and along roadways.	Can decrease flame length by reducing the height and volume of fine flashy fuels (Harper 2011). Can stimulate the regeneration and growth of some native plants.	Does not address woody surface fuels. Labor intensive and cannot be implemented across large areas or in areas with poor access. Requires annual maintenance. Can spread invasive plant species, decrease the regeneration of some native plants, and cause soil compaction (Kerns and others 2011).

Priority Locations

Proactive work to reduce fuel loads along roadways can increase the chance of survival for residents in the horrible instance that they become stranded in their vehicles during a wildfire. Clearing vegetation along narrow roads can also increase access for fire engines and create safer egress for firefighters and residents. It is important to reduce fuels along roadways where evacuation could proceed slowly due to congestion.

Potential locations for fuelbreaks along roads, private drives, and driveways were located and prioritized within and around the EC & IC FPD (**Figure 4.d.2**). Treatments along roadway corridors were prioritized based on predicted roadway survivability under 60th percentile fire weather conditions and evacuation congestion. See Appendix B for a full description of the prioritization methods.

A total of 49.7 miles of roadways were identified as first-priority sections for fuel mitigation (**Table 4.d.4**). First-priority roadways include sections of Pleasant Park Road, Richmond Hill, South Wamblee Valley Road, Shadow Mountain Drive, Country Road 3053, Pine Valley Road, and sections of S. Elk Creek Road north and south of US 285. First-priority roadways are also found along Kings Valley Drive and adjoining roads due to an abundance of homes, high fuel loads, and steep switch backs.

Emergency personnel and forestry professionals should visit these priority locations to assess current conditions and determine specific locations for fuelbreak treatments. This fire behavior analyses occurred at the scale of 0.2 acres (30 x 30 meters), so locations of priority treatments are approximate.

Table 4.d.4. Segments of roads, private drives, and roadways within and closely adjacent to the EC & IC FPD that are priority candidates for fuelbreaks.

Treatment priority	First priority	Second priority	Third priority
Total length of road segments	49.7 miles	87.9 miles	228.1 miles

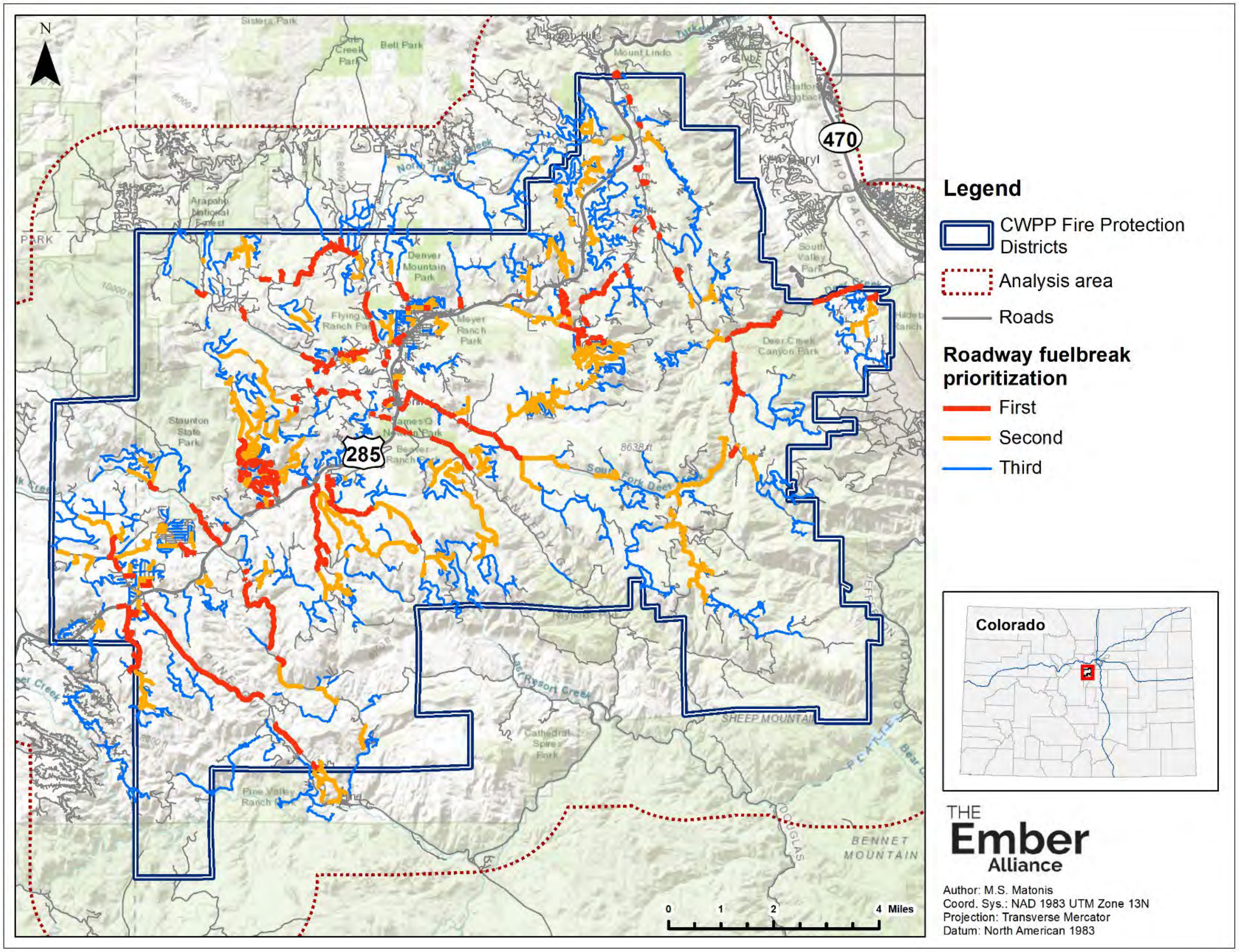


Figure 4.d.2. Priority locations for fuelbreaks along roadways and driveways based on potential fire behavior and evacuation congestion. This fire behavior analyses occurred at the scale of 0.2 acres (30 x 30 meters), so locations of priority treatments are approximate. See Appendix B for a full description of prioritization methods.

4.e. Funding Opportunities for Wildfire Hazard Mitigation and Emergency Preparedness

Opportunities from Colorado Agencies

- The Colorado State Forest Service (CSFS) **Forest Restoration and Wildfire Risk Mitigation (FRWRM)** program provides funding for projects focused on fuel reduction, forest health, and capacity building on non-federal lands in Colorado. Eligible applicants include local community groups, local government entities such as fire protection districts, public and private utilities, state agencies, and non-profit groups.
- CSFS administers programs for landowner and community assistance, including the **Colorado Forest Ag Program** and **Colorado Tree Farm Program**.
- CSFS regularly updates their **Natural Resources Grants & Assistance Database** to help residents, agencies, and other partners find funding for natural resource projects.
- The Colorado Department of Revenue provides a **Wildfire Mitigation Measures Subtraction** whereby individuals, estates, and trusts may claim a subtraction on their Colorado income tax return for certain costs incurred in performing wildfire mitigation measures on property in the WUI.
- The **Jefferson Conservation District** helps landowners navigate forestry projects to promote forest health and complete wildfire mitigation projects

Funding from the Federal Emergency Management Agency (FEMA)

- **Building Resilient Infrastructure and Communities (BRIC) grant program** supports states, local communities, Tribes, and territories as they undertake large-scale projects to reduce or eliminate risk and damage from future natural hazards. Homeowners, business operators, and non-profit organizations cannot apply directly to FEMA, but they can be included in sub-applications submitted by an eligible sub-applicant (local governments, Tribal governments, and state agencies).
- **Hazard Mitigation Assistance Grants Program (HMGP)** provides funding to state, local, Tribal, and territorial governments so they can rebuild in a way that reduces, or mitigates, future disaster losses in their communities. This grant funding is available after a presidentially declared disaster.
- **Assistance to Firefighters Grants (AFG)** help firefighters and other first responders obtain critical resources necessary for protecting the public and emergency personnel from fire and related hazards.
- **Fire Prevention & Safety (FP&S) Grants** support projects that enhance the safety of the public and firefighters from fire and related hazards.
- **Staffing for Adequate Fire and Emergency Response (SAFER)** grants directly fund fire departments and volunteer firefighter organizations to help increase their capacity.

Opportunities from Non-Governmental Organizations

- The Western Forestry Leadership Coalition administers the **Landscape Scale Restoration Competitive Grant Program** which focuses on activities that address priority areas, challenges, and opportunities facing Western lands, including wildfire risk reduction, watershed protection and restoration, and the spread of invasive species, insect infestation and disease**.** Grant submissions must go through state forestry agencies, but projects can include local governments and private entities.
- Coalitions and Collaboratives, Inc. manages the **Action, Implementation, and Mitigation Program (AIM)** to increase local capacity and support wildfire risk reduction activities in

high-risk communities. AIM provides direct support to place-based wildfire mitigation organization with pass-through grant funding, on-site engagement, technical expertise, mentoring, and training on mitigation practices to help high-risk communities achieve their wildfire adaptation goals.

- Coalition for the Upper South Platte can aid with small-acreage wildfire mitigation measures through their **Neighborhood Fuels Reduction Program**.
- Fire Adapted Colorado (FACO) manages the **FACO Opportunity Fund**, which is a matching mini-grant program to support projects, build capacity, and address local needs with funding from the National Fire Adapted Communities Learning Network.

Supporting the Fire Protection Districts

The EC & IC FPDs strive to be supportive of forestry projects that improve forest health and wildfire safety in their districts. Creating, managing, and implementing fuels mitigation projects takes time and effort that is often unfunded to the district. Education and outreach are incredibly important to the districts – connecting with their constituents is a vital part of building relationships and providing the highest quality services. This work requires time and resources that the FPDs do not always have to spare.

- The **Staffing for Adequate Fire and Emergency Response (SAFER)** grants can help fund staff capacity for fire departments.
- The **Assistance to Firefighters Grants (AFG)** can provide critical response resources for firefighters and emergency responders.
- Community support is also vital to the success of the fire stations:
    - ECFPD and ICFPD are supported by volunteer responders who respond to fires, medical emergencies, and rescues every day of the year. Learn more about how you can volunteer by contacting your local fire department.
    - Financial support in the form of monetary donations or support of local ballot measures that provide tax revenue for the FPDs is vital to their success in responding to residents in their time of need.
    - Attend events hosted by the FPDs. Outreach about fire safety can be a challenge in a community as spread out as the greater Conifer area. Seeking out information to protect your home from fire danger can also help protect your local firefighters. Sharing this information within your community can build community resilience and can help lower implementation costs for individual homeowners for many projects.

5. Glossary

20-foot wind speed: The rate of sustained wind over a 10-minute period at 20 feet above the dominant vegetation. The wind adjustment factor to convert surface winds to 20-foot wind speeds depends on the type and density of surface fuels slowing down windspeeds closer to the ground (NWCG 2021).

Active crown fire: Fire in which a solid flame develops in the crowns of trees and advances from tree crown to tree crown independently of surface fire spread (NWCG 2018b).

ArcCASPER: An intelligent capacity-aware evacuation routing algorithm used in the geospatial information system mapping program ArcMap to model evacuation times and congestion based on roadway capacity, road speed, number of cars evacuating per address, and the relationship between roadways congestion and reduction in travel speed (Shahabi and Wilson 2014).

Basal area: Cross sectional area of a tree measured at breast height (4.5 feet above the ground). Used as a method of measuring the density of a forest stand in units such as ft^2/acre (USFS 2021).

Broadcast prescribed burning (aka, prescribed burn, controlled burn): A wildland fire originating from a planned ignition in accordance with applicable laws, policies, and regulations to meet specific objectives (NWCG 2018b).

Canopy base height (CBH): The average height from the ground to a forest stand's canopy bottom. CBH is the lowest height in a stand at which there is sufficient forest canopy fuel to propagate fire vertically into the canopy. Ladder fuels such as lichen, dead branches, and small trees are incorporated into measurements of CBH. Forests with lower canopy base heights have a higher risk of torching (NWCG 2019).

Canopy bulk density (CBD): The density of available canopy fuels in a stand (the mass of available canopy fuel per canopy volume unit). Typical units are either kg/m^3 or lb/ft^3. Stands with higher CBD have a higher likelihood of active crown fire (NWCG 2019).

Canopy cover: The ground area covered by the crowns of all trees in an area as delimited by the vertical projection of their outermost crown perimeters (NWCG 2019).

Canopy fuels: The stratum of fuels containing the crowns of the tallest vegetation (living or dead), usually above 20 feet (NWCG 2018b).

Canopy height: The average height of the top of the vegetated canopy (NWCG 2019).

Canopy: The more or less continuous cover of branches and foliage formed collectively by adjacent tree crowns (USFS 2021).

Canyon: A long, deep, very steep-sided topographic feature primarily cut into bedrock and often with a perennial stream at the bottom (NRCS 2017).

Chute: A steep V-shaped drainage that is not as deep as a canyon but is steeper than a draw. Normal upslope air flow is funneled through a chute and increases in speed, causing upslope preheating from convective heat, thereby exacerbating fire behavior (NWCG 2008).

Community Wildfire Protection Plan (CWPP): A plan developed in the collaborative framework established by the Wildland Fire Leadership Council and agreed to by state, Tribal, and local governments, local fire departments, other stakeholders, and federal land management agencies in the vicinity of the planning area. CWPPs identify and prioritize areas for hazardous fuel reduction treatments, recommend the types and methods of treatment on Federal and non-Federal land that will protect one or more at-risk communities and essential infrastructure, and recommend measures to reduce structural ignitability throughout the at-risk community. A CWPP may address issues such as wildfire response, hazard mitigation, community preparedness, and structure protection (NWCG 2018b).

Conduction: A type of heat transfer that occurs when objects of different temperatures contact each other directly and heat conducts from the warmer object to the cooler one until their temperatures equalize. During wildfires, flames in contact with a metal structure rapidly conduct heat into the rest of the structure. Wood is a poor conductor of heat, as illustrated by the fact that a wooden handle on a hot frying pan remains cool enough to be held by bare hands. Conduction has a limited effect on the spread of fires in wildland fuels.

Convection: A type of heat transfer that occurs when a fluid, such as air or a liquid, is heated and travels away from the source, carrying heat along with it. Air around and above a wildfire expands as it is heated, causing it to become less dense and rise into a hot convection column. Cooler air flows in to replace the rising gases, and in some cases, this inflow of air creates local winds that further fan the flames. Hot convective gases move up slope and dry out fuels ahead of the flaming front, lowering their ignition temperature and increasing their susceptibility to ignition and fire spread. Homes located at the top of a slope can become preheated by convective heat transfer. Convection columns from wildfires carry sparks and embers aloft.

Crown (aka, tree crown): Upper part of a tree, including the branches and foliage (USFS 2021).

Defensible space: The natural and landscaped area around a structure that has been modified and maintained to reduce fire danger by treating, clearing, and reducing the abundance of natural and manmade fuels. Defensible space reduces the risk that fire will spread from surrounding vegetation to the structure, and it enhances firefighter access and safety. The Colorado State Forest Service defines three zones of defensible space: zone 1 (0 to 30 feet from a home), zone 2 (30 to 100 feet from a home), and zone 3 (greater than 100 feet from a home). Some organizations further divide zone 1 into zone 1a (0 to 5 feet from a home). The presence of defensible space can increase the likelihood that firefighters will be able to defend a home (CSFS 2012).

Draws: Topographic features created by a small, natural watercourse cutting into unconsolidated materials. Draws generally have a broader floor and more gently sloping sides than a ravine or gulch (NRCS 2017).

Ecological restoration: The process of assisting the recovery of an ecosystem that has been damaged, degraded, or destroyed (SER 2004). In ponderosa pine and dry mixed-conifer forests of the Colorado Front Range, ecological restoration involves transforming dense forests into a mosaic of single trees, clumps of trees, and meadows similar to historic forests that were maintained by wildfires and very resilient to them (Addington and others 2018).

Embers: Small, hot, and carbonaceous particles. In this document we utilize this term to refer to particles carried airborne that pose wildfire risks and are a huge factor in home ignition. embers can travel 12 to 15 miles from the flaming front and ignite spot fires (Caton and others 2016). The number of embers reaching an area decreases exponentially with distance traveled, and the likelihood of structure ignition increases with the number of embers landing on the structure (Caton and others 2016).

Energy Release Component (ERC): The computed total heat release per unit area (British thermal units per square foot) within the flaming front at the head of a moving fire based on moisture content of the various fuels present, both live and dead. ERC is a composite fuel moisture value that reflects the contribution of all live and dead fuels to potential fire intensity (NWCG 2018b).

Fire behavior: The manner in which a fire reacts to the influences of fuel, weather, and topography. Characteristics of fire behavior include rate of spread, fire intensity, fire severity, and fire behavior category (NWCG 2018b).

Fire history: A general term referring to the historic fire occurrence in a specific geographic area (NWCG 2018b).

Fire intensity (aka, fireline intensity): (1) The product of the available heat of combustion per unit of ground and the rate of spread of the fire, interpreted as the heat released per unit of time for each unit length of fire edge, or (2) the rate of heat release per unit time per unit length of fire front (NWCG 2018b).

Fire regime: Description of the patterns of fire occurrences, frequency, size, and severity in a specific geographic area or ecosystem. A fire regime is a generalization based on fire histories at individual sites. Fire regimes can often be described as cycles because some parts of the histories usually get repeated, and the repetitions can be counted and measured, such as fire return interval (NWCG 2018b).

Fire severity. Degree to which a site has been altered or disrupted by fire; loosely, a product of fire intensity and residence time (NWCG 2018b). Fire severity is determined by visually inspecting or measuring the effects that wildfire has on soil, plants, fuel, and watersheds. Fire severity is often classified as low-severity (less than 20% of overstory trees killed) and high severity (more than 70% of overstory trees kills). Moderate-severity or intermediate fire severity falls between these two extremes (Agee 1996b). Specific cutoffs for fire severity classifications differ among researchers. For example, Sherriff and others (2014) define high-severity fires as those killing more than 80% of overstory trees.

Fire weather conditions: Weather conditions that influence fire ignition, behavior, and suppression, for example, wind speed, wind direction, temperature, relative humidity, and fuel moisture (NWCG 2018b).

Firebreak: A natural or constructed barrier where all vegetation and organic matter have been removed down to bare mineral soil. Firebreaks are used to stop or slow wildfires or to provide a control line from which to work (NWCG 2018b; Bennett and others 2010).

FireFamilyPlus: A software application that provides summaries of fire weather, fire danger, and climatology for one or more weather stations extracted from the National Interagency Fire Management Integrated Database (NWCG 2018b).

Fireline: (1) The part of a containment or control line that is scraped or dug to mineral soil, or (2) the area within or adjacent to the perimeter of an uncontrolled wildfire of any size in which action is being taken to control fire (NWCG 2018b).

Flame length: The distance between the flame tip and the midpoint of the flame depth at the base of the flame (generally the ground surface). Flame length is measured on an angle when the flames are tilted due to effects of wind and slope. Flame length is an indicator of fire intensity (NWCG 2018b).

FlamMap: A fire analysis desktop application that can simulate potential fire behavior and spread under constant environmental conditions (weather and fuel moisture) (Finney 2006). FlamMap is one of the most common models used by land managers to assist with fuel treatment prioritization, and it is often used by fire behavior analysts during wildfire incidents.

Fuel model: A stylized set of fuel bed characteristics used as input for a variety of wildfire modeling applications to predict fire behavior (Scott and Burgan 2005).

Fuel reduction: Manipulation, combustion, or removal of fuels to reduce the likelihood of ignition and/or to lessen potential damage from wildfires and resistance to control (NWCG 2018b).

Fuelbreak: A natural or manmade change in fuel characteristics which affects fire behavior so that fires burning into them can be more readily controlled. Fuelbreaks differ from firebreaks due to the continued presence of vegetation and organic soil. Trees in shaded fuelbreaks are thinned and pruned to reduce the fire potential but enough trees are retained to make a less favorable microclimate for surface fires (NWCG 2018b). The term "roadway fuelbreak" is used for fuelbreaks built along roadways.

Fuels mitigation / management: The act or practice of controlling flammability and reducing resistance to control of wildland fuels through mechanical, chemical, biological, or manual means, or by fire, in support of land management objectives (NWCG 2018b).

Fuels: Any combustible material, most notably vegetation in the context of wildfires, but also including petroleum-based products, homes, and other man-made materials that might combust during a wildfire in the wildland-urban interface. Wildland fuels are described as 1-, 10-, 100-, and 1000-hour fuels. One-hour fuels are dead vegetation less than 0.25 inch in diameter (e.g., dead grass), ten-hour fuels are dead vegetation 0.25 inch to 1 inch in diameter (e.g., leaf litter and pine needles), one hundred-hour fuels are dead vegetation 1 inch to 3 inches in diameter (e.g., fine branches), and one thousand-hour fuels are dead vegetation 3 inches to 8 inches in diameter (e.g., large branches). Fuels with larger diameters have a smaller surface area to volume ratio and take more time to dry out or become wetter as relative humidity in the air changes (NWCG 2018b).

Gorge: A narrow, deep valley with nearly vertical, rocky walls, smaller than a canyon, and more steep-sided than a ravine (NRCS 2017).

Hazards: Any real or potential condition that can cause injury, illness, or death of personnel, or damage to, or loss of equipment or property (NWCG 2018b).

Home hardening: Steps taken to improve the chance of a home and other structures withstanding ignition by radiant and convective heat and direct contact with flames or embers. Home hardening involves reducing structure ignitability by changing building materials, installation techniques, and structural characteristics of a home (California Safe Council 2020). A home can never be made fireproof, but home hardening practices in conjunction with creating defensible space increases the chance that a home will survive a wildfire and increases the chance that firefighters can safely stay and defend a home.

Home ignition zone (HIZ): The characteristics of a home and its immediate surroundings within 100 feet of structures. Conditions in the HIZ principally determine home ignition potential from radiant heat, convective heat, and embercast (NWCG 2018b).

Ignition-resistant building materials: Materials that resist ignition or sustained flaming combustion. Materials designated ignition-resistant have passed a standard test that evaluates flame spread on the material (Quarles 2019; Quarles and Pohl 2018).

Incident Response Pocket Guide (IRPG): Document that establishes standards for wildland fire incident response. The guide provides critical information on operational engagement, risk management, all hazard response, and aviation management. It provides a collection of best practices that have evolved over time within the wildland fire service (National Wildfire Coordinating Group 2018a).

Ladder fuels: Fuels that provide vertical continuity between strata, thereby allowing fire to carry from surface fuels into the crowns of trees with relative ease. Ladder fuels help initiate torching and crowning and assure the continuation of crowning. Ladder fuels can include small trees, brush, and lower limbs of large trees (NWCG 2018b).

LANDFIRE: A national program spearheaded by the U.S. Department of the Interior and the U.S. Department of Agriculture to provide spatial products characterizing vegetation, fuels, fire regimes, and disturbances across the entire United States. LANDFIRE products serve as standardized inputs for fire behavior modeling. More information about the program is available online at https://www.landfire.gov/.

Long-range spotting: When large glowing firebrands are carried high into the convection column and fall out downwind beyond the main fire, starting new fires. The distance used to differentiate short-range and long-range spotting varies among sources. NWCG (2018b) classifies long-range spotting as firebrands that travel more than 0.25 miles and ignite new fires, whereas Beverly and others (2010) use a threshold of 0.06 to 0.3 miles. The Beverly et al. (2010) definition was used in this CWPP. The number of embers reaching an area decreases exponentially with distance traveled, and the likelihood of structure ignition increases with the number of embers landing on receptive fuels (Caton and others 2016).

Lop-and-scatter: Cutting (lopping) branches, tops, and unwanted boles into shorter lengths and spreading that debris evenly over the ground such that resultant logging debris will lie close to the ground (NWCG 2018b).

Mastication: A slash management technique that involves using a machine to grind, chop, or shred vegetation into small pieces that then become surface fuel (Jain and others 2018).

Mitigation actions: Actions that are implemented to reduce or eliminate (mitigate) risks to persons, property, or natural resources. These actions can be undertaken before and during a wildfire. Actions before a fire include fuel treatments, creation of fuelbreaks or barriers around critical or sensitive sites or resources, vegetation modification in the home ignition zone, and structural changes to increase the chance a structure will survive a wildfire (aka, home hardening). Mitigation actions during a wildfire include mechanical and physical tasks, specific fire applications, and limited suppression actions, such as constructing firelines and creating "black lines" through the use of controlled burnouts to limit fire spread and behavior (NWCG 2018b).

Mosaic landscape: A heterogeneous area composed of different communities or a cluster of different ecosystems that are similar in function and origin in the landscape. It consists of ‘patches’ arranged in a ‘matrix’, where the patches are the different ecosystems and the matrix is how they are arranged over the land. (Wiley 1986; Pielow 1974)

National Wildfire Coordinating Group (NWCG): An operational group established in 1976 through a Memorandum of Understanding between the U.S. Department of Agriculture and Department of the Interior to coordinate programs of the participating agencies to avoid wasteful duplication and to provide a means of constructively working together. NWCG provides a formalized system and agreed upon standards of training, equipment, aircraft, suppression priorities, and other operational areas. More information about NWCG is available online at https://www.nwcg.gov/.

Noncombustible building materials: Material of which no part will ignite or burn when subjected to fire or heat, even after exposure to moisture or the effects of age. Materials designated noncombustible have passed a standard test (Quarles 2019; Quarles and Pohl 2018).

Non-survivable road: Portions of roads adjacent to areas with predicted flame lengths greater than 8 feet under severe fire weather conditions. Drivers stopped or trapped on these roadways would have a low chance of surviving radiant heat from fires of this intensity. Non-survivable conditions are more common along roads that are lined with thick forests, particularly with trees that have limbs all the way to the ground and/or abundant saplings and seedlings.

Overstory: Layer of foliage in a forest canopy, particularly tall mature trees that rise above the shorter immature understory trees (USFS 2021).

Passive crown fire: Fire that arises when surface fire ignites the crowns of trees or groups of trees (aka, torching). Torching trees reinforce the rate of spread, but passive crown fires travel along with surface fires. (NWCG 2018b).

Pile burning: Piling slash resulting from logging or fuel management activities into manageable piles that are subsequently burned during safe and approved burning conditions (NWCG 2018b).

Radiation: A method of heat transfer by short-wavelength energy through air (aka, infrared radiation). Surfaces that absorb radiant heat warm up and radiate additional short-wavelength energy themselves. Radiant heat is what you feel when sitting in front of a fireplace. Radiant heat preheats and dries fuels adjacent to the fire, which initiates combustion by lowering the fuel's ignition temperature. The amount of radiant heat received by fuels increases as the fire front approaches. Radiant heat is a major concern for the safety of wildland firefighters and can ignite homes without direct flame contact.

Rate of spread: The relative activity of a fire in extending its horizontal dimensions. It is expressed as rate of increase of the total perimeter of the fire, as rate of forward spread of the fire front, or as rate of increase in area, depending on the intended use of the information. Rate of spread is usually expressed in chains or acres per hour for a specific period in the fire's history (NWCG 2018b).

Ravine: Topographic features created by streams cutting into unconsolidated materials and that are narrow, steep-sided, and commonly V-shaped. Ravines are steeper than draws (NRCS 2017).

Remote Automatic Weather Stations (RAWS): A weather station that transmits weather observations via satellite to the Wildland Fire Management Information system (NWCG 2018b).

Risk: (1) The chance of fires starting as determined by the presence and activity of causative agents (e.g., lightning), (2) a chance of suffering harm or loss, or (3) a causative agent (NWCG 2018b).

Roadway fuelbreak: A natural or manmade change in fuel characteristics along a roadway which affects fire behavior so that fires burning into them can be more readily controlled, survivable conditions with shorter flame lengths are more likely during a wildfire, and firefighter access is enhanced (NWCG 2018b).

Saddle: A low point on a ridge or interfluve, generally a divide or pass between the heads of streams flowing in opposite directions. The presence of a saddle funnels airflow and increases windspeed, thereby exacerbating fire behavior (NRCS 2017).

Safety zones: An area cleared of flammable materials used by firefighters for escape in the event the line is outflanked or spot fires outside the control line render the line unsafe. In firing operations, crews progress so as to maintain a safety zone close at hand, allowing the fuels inside the control line to be consumed before going ahead. Safety zones may also be constructed as integral parts of fuelbreaks; they are greatly enlarged areas which can be used with relative safety by firefighters without the use of a fire shelter (NWCG 2018b).

Shaded fuelbreak: Fuelbreaks built in timbered areas where the trees on the break are thinned and pruned to reduce fire potential yet enough trees are retained to make a less favorable microclimate for surface fires (NWCG 2018b).

Short-range spotting: When firebrands, flaming sparks, or embers are carried by surface winds and start new fires beyond the zone of direct ignition by the main fire (NWCG 2018b). The distance used to differentiate short-range and long-range spotting varies among sources. NWCG (2018b) classifies short-range spotting as firebrands that travel less than 0.25 miles and ignite new fires, whereas

Beverly and others (2010) use a threshold of 0.06 miles. The Beverly and others (2010) definition was used in this CWPP. The number of embers reaching an area decreases exponentially with distance traveled, and the likelihood of structure ignition increases with the number of embers landing on receptive fuels (Caton and others 2016).

Slash: Debris resulting from natural events such as wind, fire, or snow breakage or from human activities such as road construction, logging, pruning, thinning, or brush cutting. Slash includes logs, bark, branches, stumps, treetops, and broken understory trees or brush (NWCG 2018b).

Smoldering combustion: The combined processes of dehydration, pyrolysis, solid oxidation, and scattered flaming combustion and glowing combustion, which occur after the flaming combustion phase of a fire; often characterized by large amounts of smoke consisting mainly of tars (NWCG 2018b).

Spot fire: Fire ignited outside the perimeter of the main fire by a firebrand (NWCG 2018b). Spot fires are particularly concerning because they can form a new flaming front, move in unanticipated directions, trap firefighters between two fires, and require additional firefighting resources to control.

Spotting: Behavior of a fire producing sparks or embers that are carried by the wind and start new fires beyond the zone of direct ignition by the main fire. Spotting is classified as short-range or long-range spotting (NWCG 2018b).

Stand: An area of forest that possesses sufficient uniformity in species composition, age, size, structural configuration, and spatial arrangement to be distinguishable from adjacent areas (USFS 2021).

Structure protection: The protection of homes or other structures from an active wildland fire (NWCG 2018b).

Structure triage: The process of inspecting and classifying structures according to their defensibility or non-defensibility, based on fire behavior, location, construction, and adjacent fuels (CalFire 2014). Structure triage involves a rapid assessment of a dwelling and its immediate surroundings to determine its potential to escape damage by an approaching wildland fire. Triage factors include the fuels and vegetation in the yard and adjacent to the structure, roof environment, decking and siding materials, prevailing winds, topography, etc. (NWCG 2018b). There are four categories used during structure triage: (1) defensible – prep and hold, (2) defensible – stand alone, (3) non-defensible – prep and leave, and (4) non-defensible – rescue drive-by. The most important feature differentiating defensible and non-defensible structures is the presence of an adequate safety zone for firefighters (NWCG 2018a). Firefighters conduct structure triage and identify defensible homes during wildfire incidents. Categorization of homes are not pre-determined; triage decisions depend on fire behavior and wind speed due to their influence on the size of safety zones needed to keep firefighters safe.

Suppression: The work and activity used to extinguish or limit wildland fire spread (NWCG 2018b).

Surface fire: Fire that burns fuels on the ground, which include dead branches, leaves, and low vegetation (NWCG 2018b).

Surface fuels: Fuels lying on or near the ground, consisting of leaf and needle litter, dead branch material, downed logs, bark, tree cones, and low stature living plants (NWCG 2018b).

Task book: A document listing the performance requirements (competencies and behaviors) for a position in a format that allows for the evaluation of individual (trainee) performance to determine if an individual is qualified in the position. Successful performance of tasks, as observed and recorded by a qualified evaluator, will result in a recommendation to the trainee's home unit that the individual be certified in the position (NWCG 2018b).

Torching: The burning of the foliage of a single tree or a small group of trees from the bottom up. Torching is the type of fire behavior that occurs during passive crown fires and can initiate active crown fires if tree canopies are close to each other (NWCG 2018b).

Values at risk: Aspects of a community or natural area considered valuable by an individual or community that could be negatively impacted by a wildfire or wildfire operations. These values can vary by community and include diverse characteristics such as homes, specific structures, water supply, power grids, natural and cultural resources, community infrastructure, and other economic, environmental, and social values (NWCG 2018b).

Watershed (aka, drainage basin or catchment): An area of land where all precipitation falling in that area drains to the same location in a creek, stream, or river. Smaller watersheds come together to create basins that drain into bays and oceans (National Ocean Service 2021).

Wildfire-resistant building materials: A general term used to describe a material and design feature that can reduce the vulnerability of a building to ignition from wind-blown embers or other wildfire exposures (Quarles 2019; Quarles and Pohl 2018).

Wildland-urban interface (WUI): The area where structures and development meet with wildland fuels and vegetation. WUI is subdivided into intermix, areas where housing and wildland vegetation intermingle, and interface, areas where housing is in the vicinity of larger areas of dense wildland vegetation (Martinuzzi and others 2015).

6. Index of Figures

7. References

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Appendix A. Community Risk Assessment and Modelling Methodology

Assessments of wildfire risk are based on fire behavior and evacuation modeling and on-the-ground observations from across the EC & IC FPD. Results from the community risk assessment informed recommendations about priority treatment to protect lives, property, infrastructure, and ecosystems in and around the EC & IC FPD.

A.1 CWPP Plan Units

There were several considerations that factored into delineating EC & IC FPDs plan units. Clusters of address points and the connectivity of roads were used to assume geographically and socially distinct units. Topographic features were considered by utilizing sub-watershed boundaries to guide plan unit boundaries. Topographic features were included in the delineation process to ensure that different units encompass areas with similar fire behavior. Land ownership also played a role in establishing unit boundaries. No plan unit splits a land parcel, ensuring that fuel treatment recommendations within each plan unit can be realistically implemented by landowners. Amendments were made to boundaries following feedback from the EC & IC FPDs, including those based on social distinctions and groupings that would enable neighbors to work together to effectively mitigate hazardous fuels within plan unit boundaries.

The hope is that residents in the same CWPP plan unit will discuss joint risk and organize efforts to reduce risk and enhance emergency preparedness. The CWPP is a useful planning document, but it will only affect real change if residents, neighbors, HOAs, and the entire community come together to address shared risk and implement strategic projects.

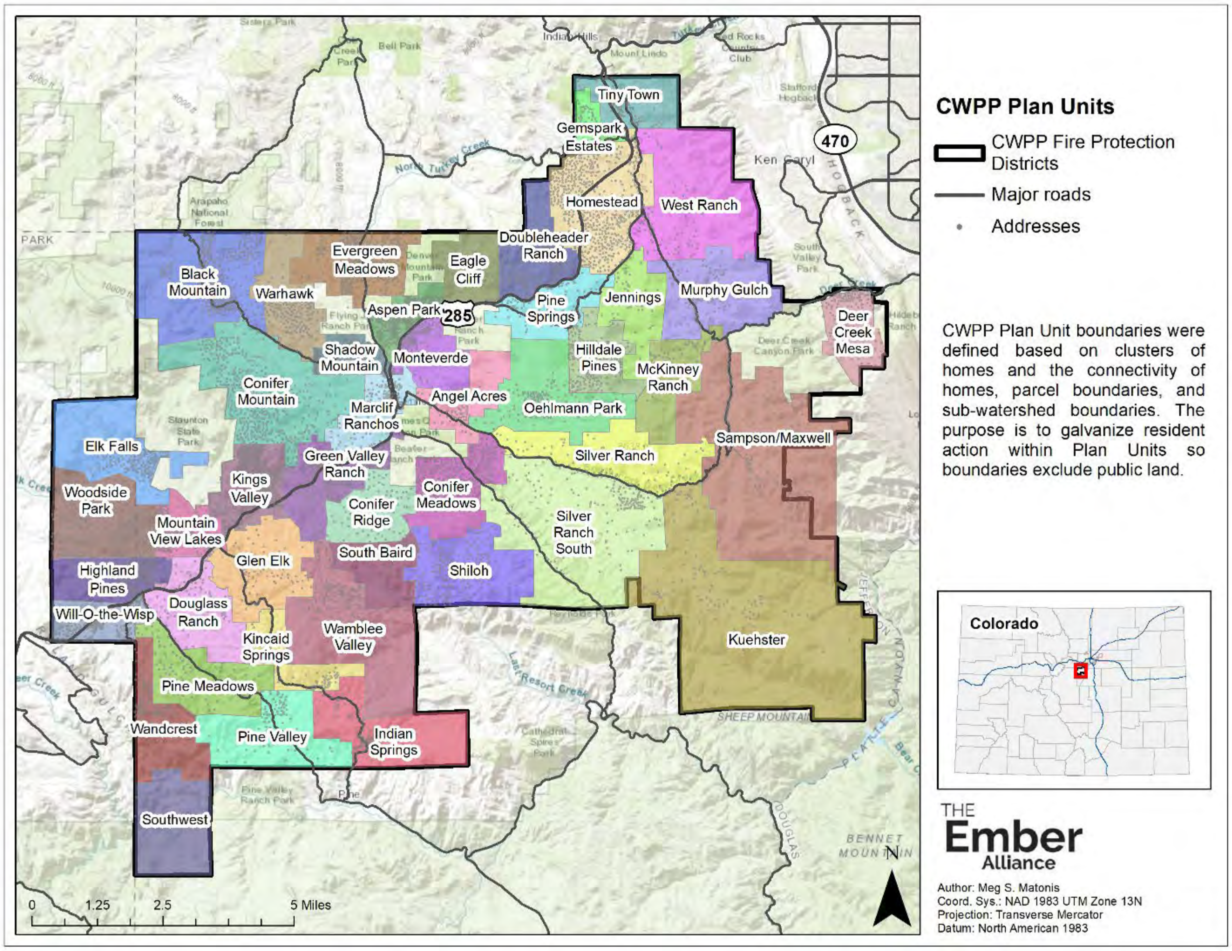


Figure 8.a.1. The CWPP assessed relative risk among CWPP plan units and made strategic recommendations to address wildfire risk across the Elk Creek & Inter-Canyon Fire Protection Districts.

A.2 Fire Behavior Analysis

Interpretations and Limitations

Fire behavior models have been rigorously developed and tested based on over 40 years of experimental and observational research (Sullivan 2009). Fire behavior modeling helps identify areas that could experience high-severity wildfires and pose a risk to lives, property, and other values at risk.

> With high-quality input data, fire behavior models can provide reasonable estimates of relative wildfire behavior across a landscape. However, wildfire behavior is complex, and models are a simplification of reality. It is recommended to use fire behavior analyses to assess relative risk across the entire EC & IC FPD. Models cannot produce specific and precise predictions of what will occur in the vicinity of an individual home during a wildfire incident.

This report relies on analyses completed in the software package FlamMap, a fire analysis desktop application that simulates potential fire behavior and spread under constant weather and fuel moisture (Finney 2006). FlamMap is one of the most common models used by land managers to assist with fuel treatment prioritization, and it is often used by fire behavior analysts during wildfire incidents. Fire spread was modeled with FlamMap's "minimum travel time" algorithm to predict fire growth between cells and account for fire spread through spotting. Fire growth was modeled for 10,000 random ignitions across the landscape; fires were allowed to grow for 4 hours in the absence of firefighter suppression and control measures. The area of analysis was seven times larger than the combined district to capture the landscape-scale movement of fire.

FlamMap utilizes two methods for calculating crown fire initiation and spread: the Scott and Reinhardt method and the Finney method. The Scott and Reinhardt method was used in this analysis; This method resulted in predictions of crown fire occurrence more consistent with expectations and has been found more reliable than the Finney method (Scott 2006). Model specifications are provided in Table A.1.

LANDFIRE (2016) and Colorado Forest Atlas spatial fuels data were composited and used as the basis for fire behavior fuel modeling. Some hand editing of fuels was conducted to account for grasslands that were underrepresented and to provide error corrections around roadways. LANDFIRE is a national program spearheaded by the U.S. Department of the Interior and the U.S. Department of Agriculture to provide spatial products characterizing vegetation, fuels, fire regimes, and disturbances across the entire United States. LANDFIRE products serve as standardized inputs for fire behavior modeling.

Fire behavior fuel models have inherent limitations. Although useful for many applications, it is impossible to predict every combination of fire weather conditions, ignition locations, and suppression activities that might occur during a wildfire. Because of the complexity of the fire environment, fire behavior is difficult to predict. The processes described in this report follow established best practices in the field.

It is recommended to use fire behavior analyses to assess relative risk across the entire EC & IC FPD and not to assess specific fire behavior in the vicinity of individual homes. **FlamMap cannot account for fine-scale variation in surface fuel loads, defensible space created by individual homeowners, or the ignitability of building materials.**

Specifically for EC & IC FPDs, the Landfire data used for FlamMap modelling does not reflect the high density of Gambel oak in the eastern portion of the district. Though the models cannot account for this, ground-truthing locations before treatment is recommended, and adaptations to treatment plans to account for fine-scale fuel differences necessary to ensure good outcomes. Additional discussion is provided regarding Gambel oak in the recommendations section.

Wind Estimates

Winds across the Front Range of Colorado are unpredictable and can be extremely gusty in mountainous areas. The Bailey RAWS was used to estimate winds. Winds primarily came from the west-southwest and east, and frequently line up with the valleys in the district, according to local firefighters in the EC & IC FPDs. Potential fire spread was modeled for winds blowing out of the East (90°) and blowing out of the West-Southwest (245°).

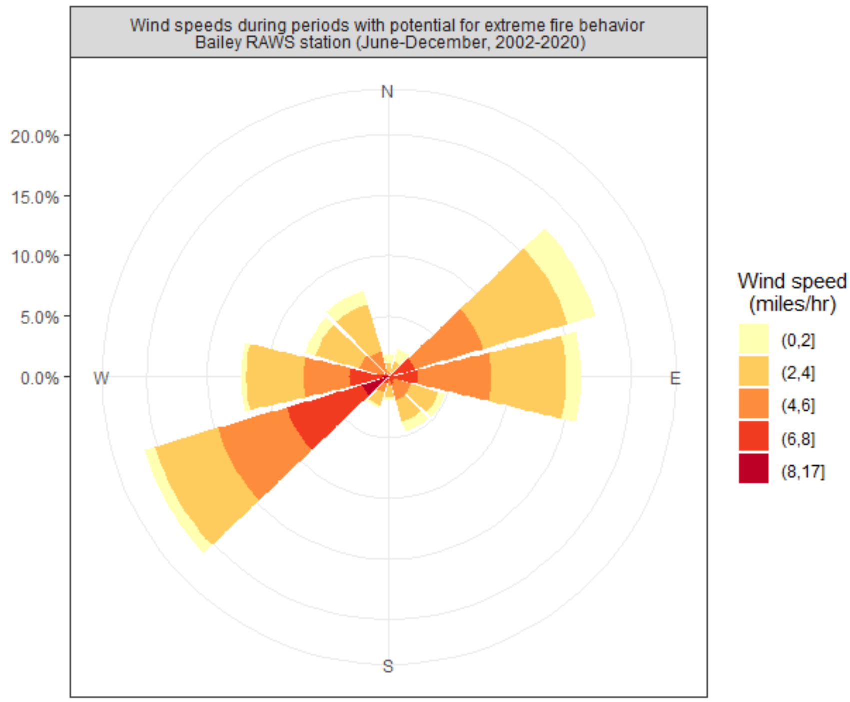


Figure 8.a.2. Wind rose showing the distribution of 20-foot windspeeds and wind directions during periods with potential for extreme fire behavior (RH <15% between 1200-1600).

Model Specifications and Inputs

FlamMap was used to model flame length, crown fire activity, potential fire sizes, and conditional burn probability. FlamMap requires information on topography and fuel loads across the area of interest (**Figure 8.a.4**). See **Table 8.a.1**and **Table 8.a.2** for details on model inputs and specifications.

Fire behavior fuel model inputs were thoroughly quality controlled; EC & IC FPD staff assessed the reasonableness of model predictions. Maps of fire behavior predictions include areas indicated as "unburnable / not modeled"—parking lots, roadways, bodies of water, and barren areas are considered unburnable; areas dominated by homes and buildings were classified as "not modeled" because fire behavior models do not include structures as a fuel type (Scott and Burgan 2005).

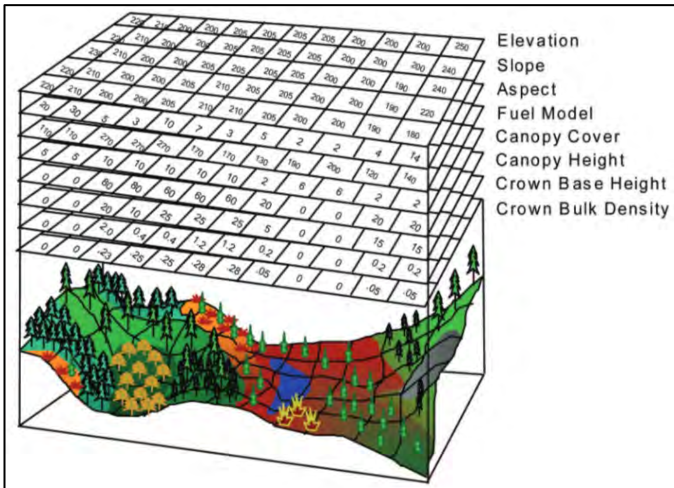


Figure 8.a.3. FlamMap requires a variety of information about topography and fuels. Image from Finney (2006).

Fire behavior models require estimates of fire weather conditions, and a common practice is to model fire behavior under hot, dry, and windy conditions for an area—not the average conditions, but extreme conditions. Wildfires that grow to large sizes, exhibit high-severity behavior, and overwhelm suppression capabilities tend to occur under extreme fire weather conditions (Williams 2013).

Potential wildfire behavior under 60th and 90th percentile fire weather conditions was modeled. 60th percentile weather condition are average fire weather conditions. 60% of days in the fire season have milder weather and 40% have more extreme weather. Under 90th percentile weather conditions, only 10% of days in the fire season have more extreme fire weather. These two benchmarks support analyses of both an average and more extreme fire season. Weather parameters came from data collected at the Bailey Remote Automatic Weather Station (RAWS) and fuel moisture conditions from FireFamilyPlus (**Table 8.a.2**).

Ninetieth percentile weather conditions are more extreme than Red Flag Warning days. During a red flag warning, 10-hour fuel moistures are at 8% or less, relative humidity is under 25%, and 20-foot wind speeds are at 15mph. Under 90th percentile weather conditions in EC & IC FPD, 10-hour fuel moistures are around 3%, relative humidity is at 11%, and 20-foot wind speeds are at 19mph. (**Table 1.c.1**) (**Figure 2.e.3**)

Prevailing winds in the EC & IC FPD on days that experienced 60th and 90th percentile weather conditions were blowing in from approximately 245° West-Southwest, and sometimes from 90° East. Flame length, crown fire activity, and burn probability were modeled based on 245° West-Southwest wind.

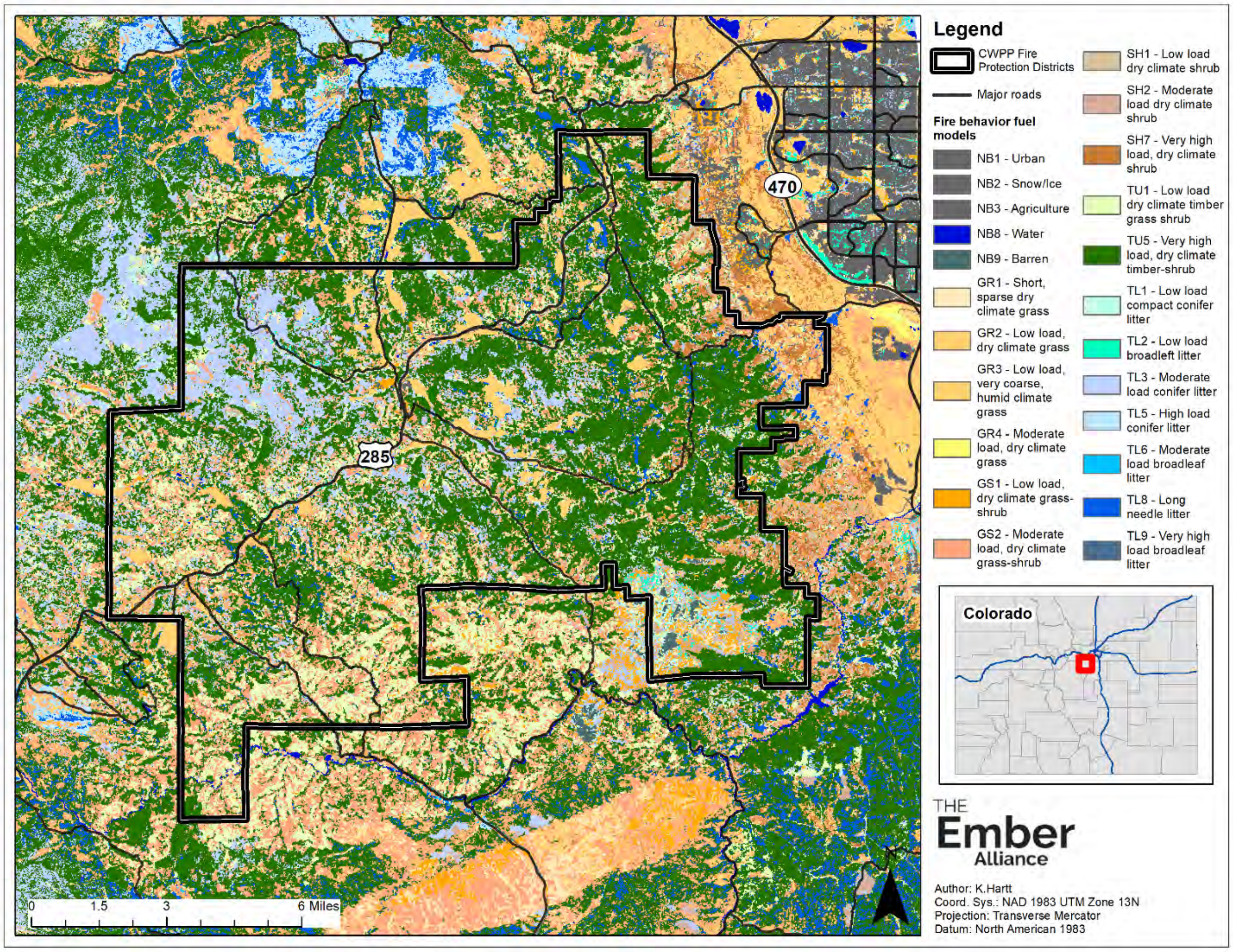


Figure 8.a.4. Fire behavior fuel models within the Elk Creek & Inter-Canyon Fire Protection Districts and the surrounding area. NB = non-burnable, GR = grass-dominated, GS = grass-shrub, SH = shrub, TL = timber litter, and TU = timber understory fuel models. See Scott and Burgan (2005) for a description of each fuel model. (Source: LANDFIRE)

Table 8.a.1. Model specifications used for fire behavior analyses with FlamMap for the 2021 Elk Creek & Inter-Canyon Fire Protection Districts CWPP.

Model specification	Value
Crown fire calculation method	Scott/Reinhardt (2001)
Wind options	Gridded winds
Wind grid resolution	60 meters
Number of random ignitions	10,000*
Resolution of calculations	30 meters
Maximum simulation time	240 minutes
Minimum travel paths	500 meters
Spot probability	0.7
Spotting delay	15 minutes
Lateral search depth	6 meters
Vertical search depth	4 meters

*The same random ignition locations for fire spread analysis under 60^{th} and 90^{th} fire weather conditions were used.

Table 8.a.2. Fire weather conditions utilized for fire behavior modeling are based on weather observations from the Bailey Remote Automatic Weather Station between 2002 and 2020, fuel moisture predictions from FireFamilyPlus, and wind speeds and directions from the Bailey RAWS. Average weather conditions on June 9, 2002 during the Hayman Fire are presented for comparison.

Variable	60th percentile	90th percentile	Hayman Fire (for comparison)
Temperature	77° Fahrenheit	84° Fahrenheit	83° Fahrenheit
Relative humidity	21%	11%	8%
Wind Direction	90° East and 245° West-Southwest	90° East and 245° West-Southwest	194° South-Southwest
20-foot wind speed[1]	15 mph	19 mph	14 mph, gusting up to 44
Fuel moisture[2]	-	-	-
1-hour	4%	2%	1.6%
10-hour	5%	3%	2.5%
100-hour	9%	6%	6.5%
1000-hour[3]	11%	9%	10.8%
Live woody	80%	73%	84%
Live herbaceous	30%	30%	48%
Crown foliage	100%	80%	

[1]20-foot wind speeds are approximately 5 times larger than winds at ground level in fully sheltered fuels; vegetation and friction slow down windspeeds closer to ground level (NWCG 2021).

[2]One-hour fuels are dead vegetation less than 0.25 inch in diameter (e.g., dead grass), ten-hour fuels are dead vegetation 0.25 inch to 1 inch in diameter (e.g., leaf litter and pine needles), one hundred-hour fuels are dead vegetation 1 inch to 3 inches in diameter (e.g., fine branches), and one thousand-hour fuels are dead vegetation 3 inches to 8 inches in diameter (e.g., large branches). Fuels with larger diameters have a smaller surface area to volume ratio and take more time to dry out or to become wetter as relative humidity in the air changes.

[3]1000-hour fuel is moisture not used by FlamMap for predicting fire behavior, but is included here to provide additional context.

Predicted Flame Lengths

Flame length is the distance measured from the average flame tip to the middle of the flaming zone at the base of the fire. Flame length is measured on an angle when the flames are tilted due to effects of wind and slope (see image at right). Flame length is an indicator of fireline intensity, and it is utilized by firefighters to guide tactical decisions following the Haul Chart (**Table 8.a.3**).

Under 60th percentile weather conditions, about 7% of the EC & IC FPD is considered unburnable, and 42% can experience very high to extreme fire behavior with flame lengths over 12 feet. Under 90th percentile weather conditions, only 4% of the EC & IC FPD is considered unburnable and 60% can experience very high to extreme fire behavior with flame lengths over 12 feet (**Table 8.a.4**, **Figure 8.a.5**).

It is difficult to define the locations with highest risk for extreme flame length, because so much of the district is subject to extreme fire behavior with flame lengths of up to 150 feet. Much of the eastern half of the district is more likely to experience non-survivable flame lengths under 60th percentile weather conditions than the west half, but neighborhoods to the west including King Valley, Kincaid Springs, and Wandcrest are likely to experience large areas of long flame lengths as part of extreme fire behavior. Under 90th percentile conditions, there are no neighborhoods that are at low risk of extreme fire behavior. Flame lengths over 200 feet are possible and there are few breaks where a fast-moving fire with extreme flaming fronts would be able to slow down and return to a more moderate behavior (**Table 8.a.4**, **Figure 8.a.5**).

Table 8.a.3. Description of fire behavior and tactical interpretations for firefighters from the Haul Chart (NWCG 2019).

Fire behavior class	Flame length (feet)	Rate of spread (chains*/hour)	Tactical interpretation
Very Low	0-1	0-2	Direct attack with handcrews
Low	1-4	2-5	Direct attack with handcrews
Moderate	4-8	5-20	Direct attack with equipment
High	8-12	20-50	Indirect attack
Very High	12-25	50-150	Indirect attack
Extreme	25+	150+	Indirect attack

**Note:* 1 chain = 66 feet. Chains are commonly used in forestry and fire management as a measure of distance. Chains were used for measurements in the initial public land survey of the U.S. in the mid-1800s. 1 chain / hour = 1.1 feet / minute.

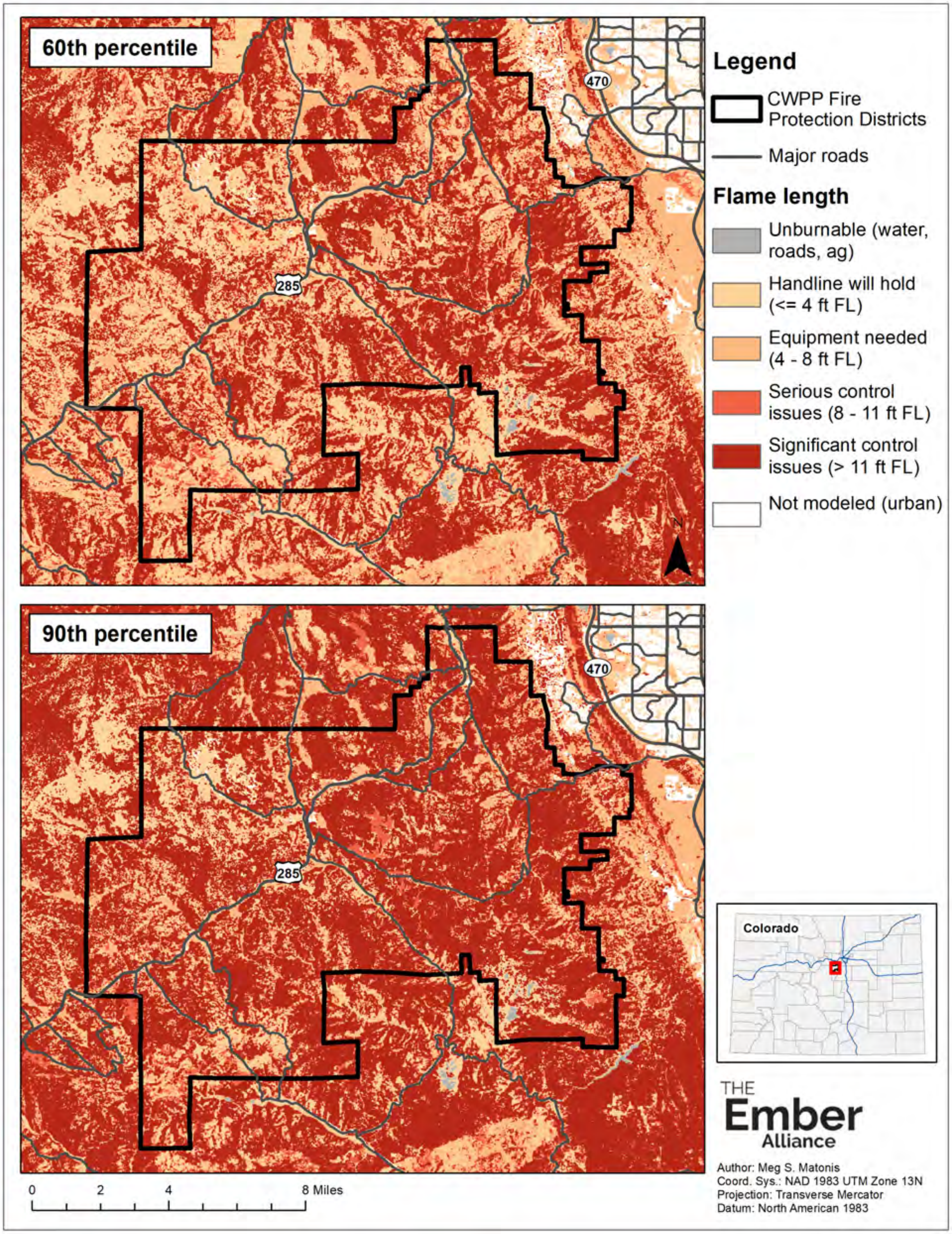


Figure 8.a.5. Flame lengths in the Elk Creek & Inter-Canyon Fire Protection Districts under 60th and 90th percentile fire weather conditions, categorized by the Haul Chart (Table 3b.2).

Table 8.a.4. Average flame length for each plan unit across the district. Potentially non-survivable flame lengths start at 8 feet according to the NWCG haul chart.

	60th Percentile		90th Percentile	
	Average Flame Length (in feet)	Maximum Flame Length (in feet)	Average Flame Length (in feet)	Maximum Flame Length (in feet)
Combined Districts	15	150	26	210
Angel Acres	17	107	32	156
Aspen Park	17	124	32	179
Black Mountain	11	138	21	203
Conifer Meadows	18	131	33	178
Conifer Mountain	11	121	22	176
Conifer Ridge	16	103	31	146
Deer Creek Mesa	12	94	20	131
Doubleheader Ranch/ Hillview	16	99	30	147
Douglass Ranch	11	85	20	127
Eagle Cliff	19	124	35	179
Elk Falls	14	122	26	176
Evergreen Meadows	14	124	26	179
Gemspark Estates	11	69	21	99
Glen Elk	13	73	23	106
Green Valley Ranch	14	91	27	132
Highland Pines	10	89	21	128
Hilldale Pines	17	93	31	139
Homestead	15	115	27	166
Jennings	16	93	29	139
Indian Springs	13	90	24	127
Kincaid Springs	12	76	22	112
Kings Valley	15	110	29	159
Kuehster	19	150	33	210
Marclif Ranchos	13	96	24	140
McKinney Ranch	16	97	28	137
Monteverde	16	93	31	139
Mountain View Lakes	12	107	22	144
Murphy Gulch	15	110	28	159
Oehlmann Park	16	93	32	132
Pine Meadows	11	99	21	147
Pine Springs	16	96	31	139
Pine Valley	11	99	19	146
Sampson Maxwell	17	101	28	144
Shadow Mountain	8	82	15	141
Shiloh	17	131	31	178
Silver Ranch	19	116	35	168
Silver Ranch South	22	131	39	187
South Baird	13	80	26	119
Southwest	14	103	23	147
Tiny Town	16	143	27	175
Wamblee Valley	13	80	25	119
Wandcrest	11	99	20	147
Warhawk	9	82	17	141
West Ranch	13	115	22	166
Will-O-the-Wisp	11	89	21	128
Woodside Park	10	86	21	125

Predicted Crown Fire Activity

FlamMap models three types of fire activity: surface fires, passive crown fires, and active crown fires. See a discussion about fire behavior in the introduction of the CWPP (Section 1c. Introduction to Wildfire Behavior and Terminology). Both passive and active crown fires pose a significant risk to the safety of firefighters and residents and can destroy homes through radiant and convective heating and ember production.

Under 60th percentile weather conditions, 56% of the EC & IC FPD can experience passive crown fire, and 3% can experience extreme fire behavior with active crown fire (**Figure 8.a.6**, **Table 8.a.5**).. Areas predicted for crown fire under 60th percentile weather occur around Black Mountain, parts of Staunton State Park and the neighborhoods east of there, across steep slopes to the east of Turkey Creek Canyon and east of West Ranch Trail, along South Ridge Road, and around Riley Peak due to dense mixed-conifer forests and steep slopes.

Under 90th percentile weather conditions, 52% can experience passive crown fire, and 13% of the district is subject to extreme fire behavior and active crown fire. Even under 90th percentile weather, surface fire is predicted within much of the 1996 Buffalo Creek burn scar, 2000 High Meadows burn scar, and 2012 Lower North Fork burn scar due to an abundance of grass and shrub fuel types. Surface fire is also predicted on south-east facing slopes along the northwestern boundary of the FPDs due to drier conditions that support Gamble oak shrubland rather than mixed-conifer forests; however, these shrubby fuels can produce extremely high flame lengths and emitting substantial radiant heat, especially under high winds.

Monteverde, Shiloh, Silver Ranch, Silver Ranch South, and Kuehster plan units are all predicted to have extreme fire behavior and relatively large patches of active crown fire under both 90th and 60th percentile weather conditions. Kincaid Springs, Wambelee Valley, and Indian Springs are all subject to over 70% of their land burning from passive crown fires in both 60th and 90th percentile conditions. The fire danger in plan units across the EC & IC FPD cannot be overstated; it is extreme and risking the lives of residents of the EC & IC FPD (**Figure 8.a.6**, **Figure 8.a.7**, **Table 8.a.5**)

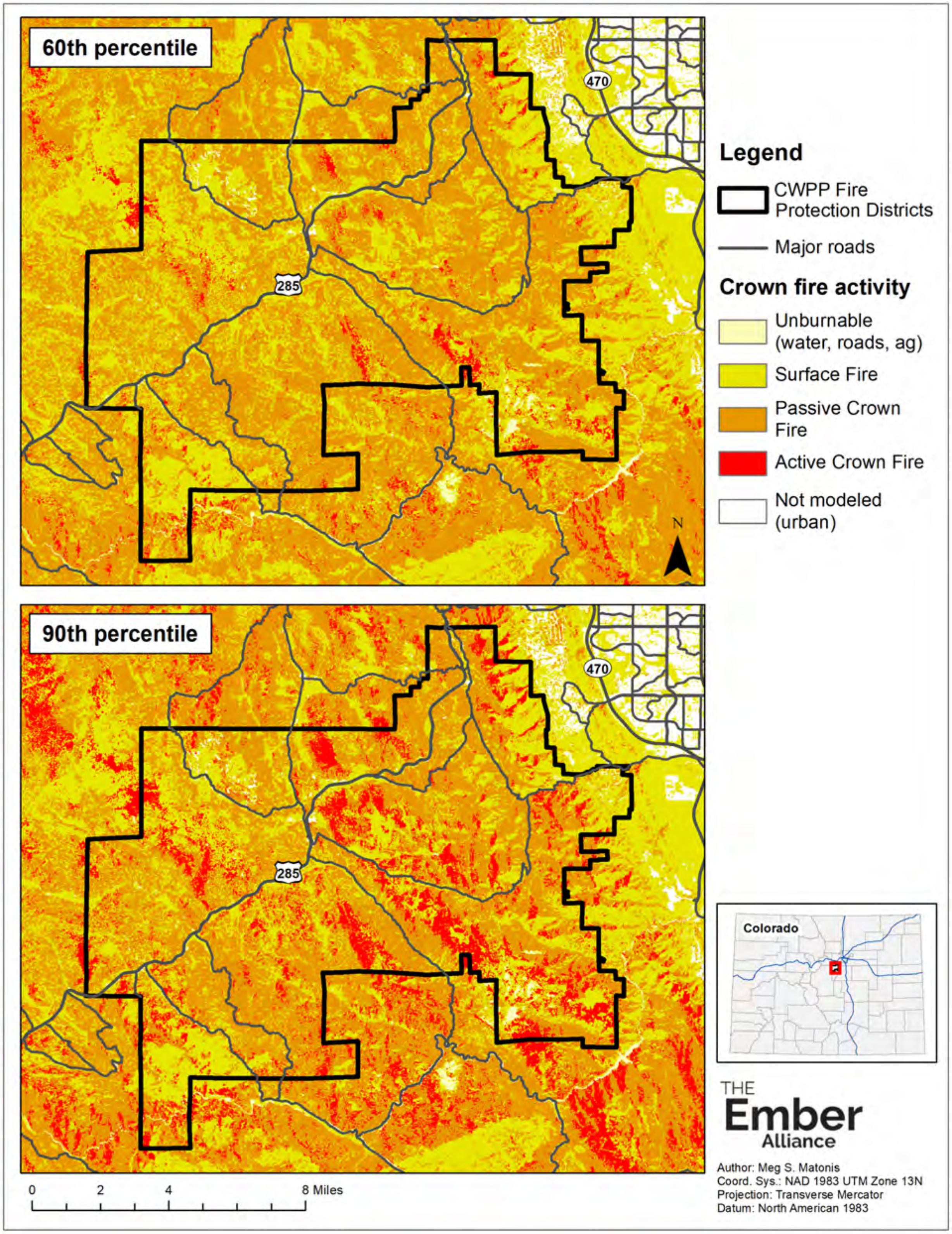


Figure 8.a.6. Crown fire activity under 60th and 90th percentile fire weather conditions in the EC & IC FPD.

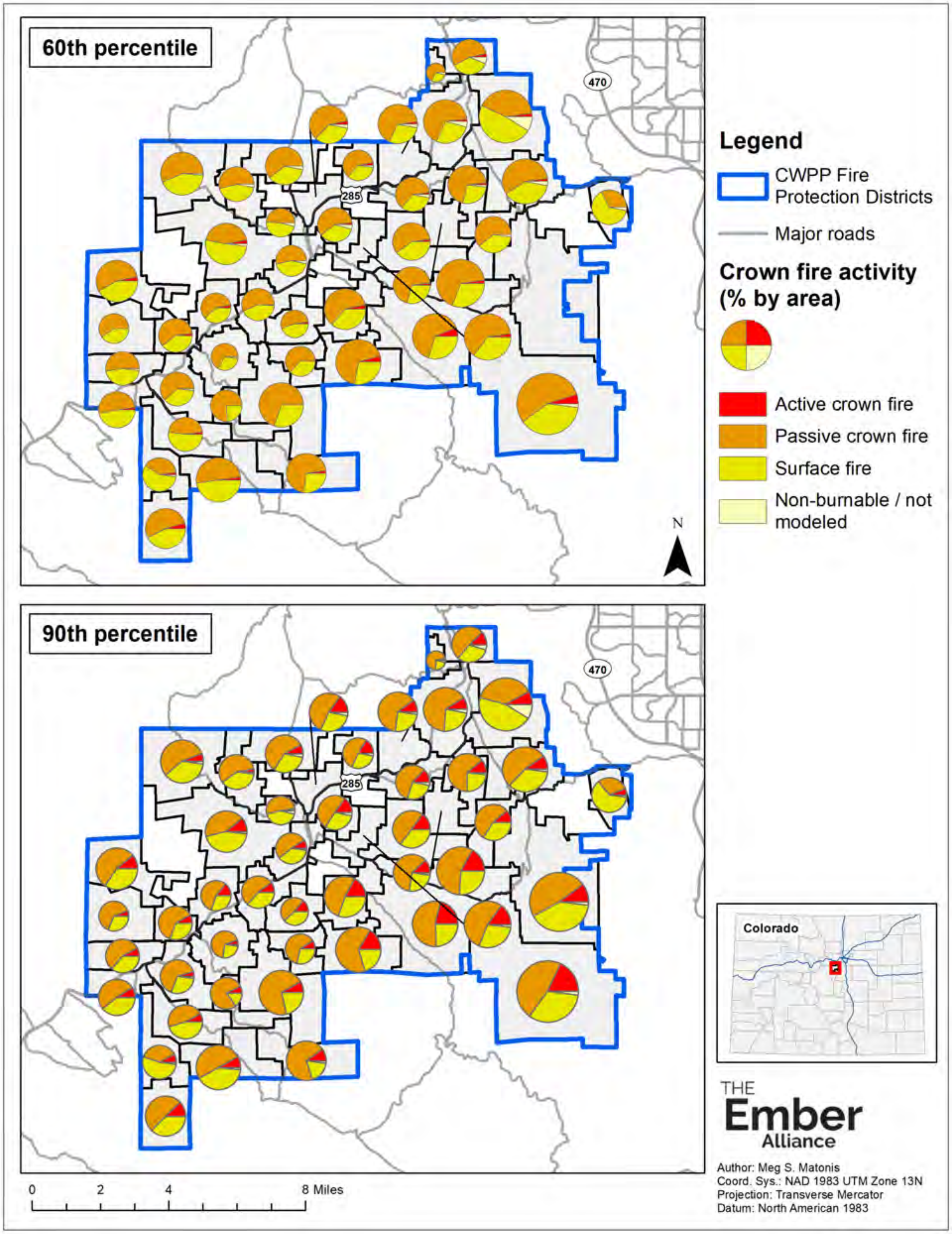


Figure 8.a.7. Relative crown fire activity in each plan unit across the FPDs. Also see **Table 8.a.5**

Table 8.a.5. Percent of each plan unit that is predicted to experience each category of fire activity.

	60th Percentile				90th Percentile			
	Active Crown Fire	Passive Crown Fire	Surface Fire	Unburn able	Active Crown Fire	Passive Crown Fire	Surface Fire	Unburn able
Combined Districts	**3%**	**54%**	**41%**	**2%**	**12%**	**51%**	**35%**	**2%**
Angel Acres	2%	62%	35%	1%	15%	54%	29%	2%
Aspen Park	3%	60%	34%	3%	15%	53%	29%	3%
Black Mountain	1%	56%	42%	1%	6%	55%	37%	2%
Conifer Meadows	3%	60%	36%	1%	17%	52%	30%	1%
Conifer Mountain	3%	44%	51%	2%	11%	43%	44%	2%
Conifer Ridge	2%	53%	44%	1%	14%	47%	38%	1%
Deer Creek Mesa	1%	32%	64%	3%	6%	30%	62%	2%
Doubleheader Ranch/Hillview	2%	66%	29%	3%	10%	63%	25%	2%
Douglass Ranch	1%	61%	36%	2%	5%	64%	29%	2%
Eagle Cliff	3%	60%	35%	2%	16%	52%	29%	3%
Elk Falls	3%	55%	42%	0%	11%	55%	35%	0%
Evergreen Meadows	1%	60%	36%	3%	8%	58%	31%	3%
Gemspark Estates	1%	67%	28%	4%	3%	71%	22%	4%
Glen Elk	0%	67%	31%	2%	5%	68%	25%	2%
Green Valley Ranch	1%	56%	42%	1%	10%	53%	36%	1%
Highland Pines	1%	52%	45%	2%	8%	55%	36%	1%
Hilldale Pines	2%	68%	29%	1%	12%	61%	25%	2%
Homestead	2%	66%	28%	4%	9%	65%	23%	3%
Jennings	2%	69%	27%	2%	11%	64%	23%	2%
Indian Springs	2%	70%	27%	1%	10%	70%	18%	2%
Kincaid Springs	1%	75%	24%	0%	7%	78%	15%	0%
Kings Valley	3%	58%	38%	1%	14%	55%	30%	1%
Kuehster	5%	55%	38%	2%	18%	47%	33%	2%
Marclif Ranchos	1%	53%	43%	3%	9%	52%	37%	2%
McKinney Ranch	1%	60%	37%	2%	11%	54%	34%	1%
Monteverde	2%	58%	36%	4%	15%	51%	31%	3%
Mountain View Lakes	2%	58%	39%	1%	8%	61%	30%	1%
Murphy Gulch	2%	57%	38%	3%	10%	53%	35%	2%
Oehlmann Park	2%	58%	40%	0%	15%	49%	35%	1%
Pine Meadows	2%	46%	51%	1%	8%	46%	45%	1%
Pine Springs	2%	62%	33%	3%	13%	57%	27%	3%
Pine Valley	2%	50%	47%	1%	8%	50%	40%	2%
Sampson Maxwell	2%	54%	43%	1%	10%	48%	40%	2%
Shadow Mountain	0%	49%	47%	4%	2%	52%	42%	4%
Shiloh	4%	68%	28%	0%	16%	63%	20%	1%
Silver Ranch	2%	67%	31%	0%	17%	58%	26%	0%
Silver Ranch South	6%	64%	30%	0%	21%	54%	24%	1%
South Baird	1%	62%	37%	0%	9%	62%	29%	0%
Southwest	4%	53%	42%	1%	12%	50%	37%	1%
Tiny Town	3%	55%	36%	6%	12%	52%	31%	5%
Wamblee Valley	1%	69%	30%	0%	8%	70%	21%	1%
Wandcrest	2%	39%	57%	2%	8%	37%	53%	2%
Warhawk	0%	54%	43%	3%	3%	57%	38%	2%
West Ranch	2%	41%	48%	9%	8%	38%	45%	9%
Will-O-the-Wisp	2%	51%	46%	1%	9%	51%	39%	1%
Woodside Park	0%	59%	40%	1%	6%	62%	31%	1%

Predicted Conditional Burn Probability and Fire Sizes

Conditional burn probability indicates how likely an area is to burn during a wildfire. Conditional burn probability is calculated as the percentage of simulated fires that burn each 30-meter by 30-meter (0.2 acre) area under specified fire weather conditions, wind directions, and wind speeds. Ten thousand random ignitions were simulated in an area that is seven times larger than and centered on the EC & IC FPD, allowing each of these simulated wildfires to burn for 4-hours in the absence of firefighter suppression and control measures. Areas with higher estimates of conditional burn probability experienced more simulated fires, indicating a higher risk for experiencing wildfires than other areas. For example, an area with a conditional burn probability of .25% was burned by 25 of the 10,000 simulated fires.

Deer Creek Mesa and Eagle Cliff have the highest relative burn probability in the districts under 60th and 90th percentile weather conditions (**Table 8.a.6**, **Figure 8.a.8**). Wind direction strongly affects burn probability, carrying fires quickly up slopes facing toward the incoming winds.

(**Table 8.a.2**, **Figure 8.a.9**) Unpredictable wind conditions along the Colorado Front Range make it difficult to predict potential fire spread, making it imperative for residents across the EC & IC FPD to take measures to mitigate their home ignition zone (see Section 4b. Mitigating the Home Ignition Zone).

Topography, non-burnable barriers such as wide rivers, interstates, and highways, and fuel loads also influence conditional burn probability by dictating how fire spreads across the landscape. Short-range transport of embers can cause spot fires to ignite even across unburnable barriers such as Highway 285. Rapid fire growth and spotting across roadways is more likely under higher windspeeds and with drier fuel conditions.

There is a significant potential for wildfires to spread across large swaths of the EC & IC FPD given uncontrollable fire behavior and extreme fire weather conditions, such as those experienced across the Colorado Front Range in 2020. **During red flag warnings, all residents need to be prepared for evacuations in the case of a wildfire, just as the fire department will be preparing for wildfire response.**

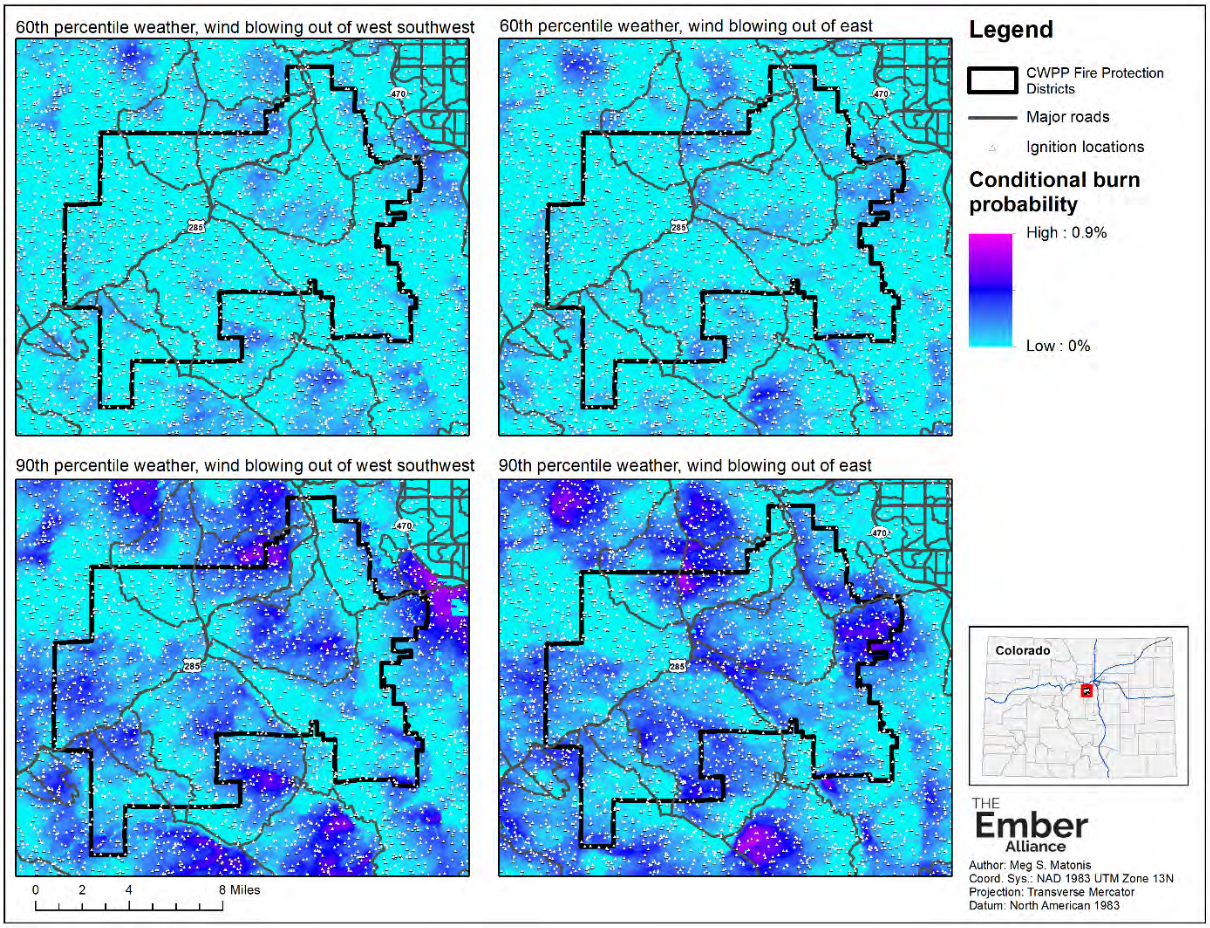


Figure 8.a.8. Conditional burn probability under 60th and 90th percentile fire weather conditions. Wildfire spread was simulated for 4-hours without suppression activities from 10,000 random ignition locations across an area seven times larger than and centered on the EC & IC FPD.

Table 8.a.6. Average burn probability by each plan unit across the districts.

	60th Percentile	90th Percentile
	Average Burn Probability	Average Burn Probability
Combined Districts	**.09%**	**.20%**
Angel Acres	.10%	.20%
Aspen Park	.09%	.21%
Black Mountain	.05%	.10%
Conifer Meadows	.09%	.20%
Conifer Mountain	.04%	.12%
Conifer Ridge	.09%	.20%
Deer Creek Mesa	.15%	.29%
Doubleheader Ranch/Hillview	.14%	.33%
Douglass Ranch	.09%	.23%
Eagle Cliff	.14%	.31%
Elk Falls	.08%	.23%
Evergreen Meadows	.08%	.18%
Gemspark Estates	.12%	.32%
Glen Elk	.06%	.17%
Green Valley Ranch	.08%	.17%
Highland Pines	.09%	.25%
Hilldale Pines	.12%	.28%
Homestead	.09%	.22%
Jennings	.10%	.22%
Indian Springs	.08%	.15%
Kincaid Springs	.07%	.15%
Kings Valley	.07%	.18%
Kuehster	.08%	.15%
Marclif Ranchos	.06%	.16%
McKinney Ranch	.11%	.24%
Monteverde	.10%	.21%
Mountain View Lakes	.08%	.24%
Murphy Gulch	.10%	.20%
Oehlmann Park	.12%	.25%
Pine Meadows	.09%	.20%
Pine Springs	.12%	.26%
Pine Valley	.07%	.17%
Sampson Maxwell	.09%	.19%
Shadow Mountain	.03%	.08%
Shiloh	.10%	.24%
Silver Ranch	.11%	.22%
Silver Ranch South	.09%	.16%
South Baird	.11%	.24%
Southwest	.09%	.22%
Tiny Town	.08%	.16%
Wamblee Valley	.09%	.18%
Wandcrest	.09%	.19%
Warhawk	.04%	.08%
West Ranch	.09%	.18%
Will-O-the-Wisp	.09%	.23%
Woodside Park	.11%	.31%

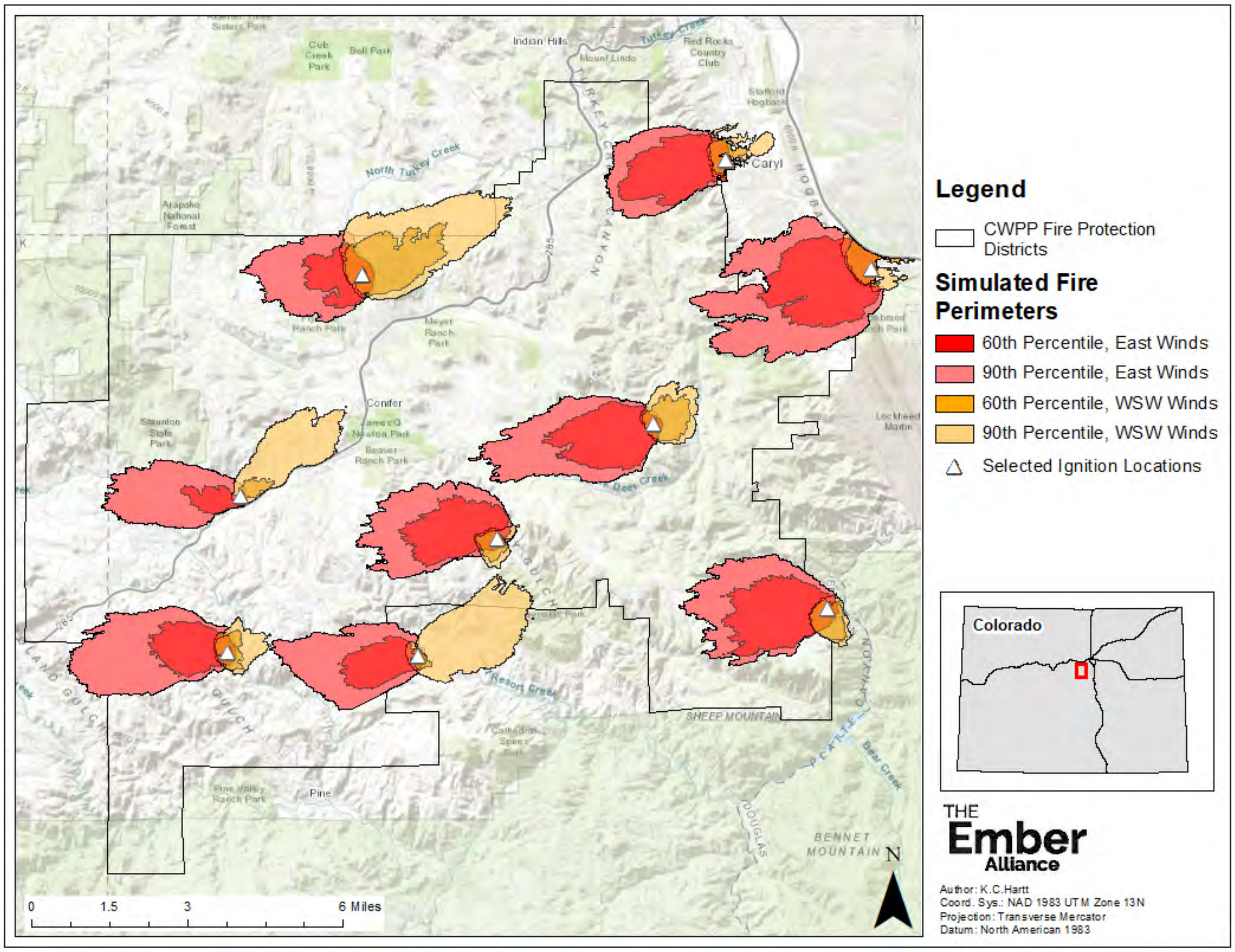


Figure 8.a.9. Simulated fire perimeters after 4-hours of fire growth without suppression activities originating from 9 of the 10,000 randomly generated ignition locations across the EC & IC FPD. Fire growth was modeled using FlamMap's minimum travel time algorithm and 60th and 90th percentile fire weather conditions under prevailing winds out of the west-southwest and the east. Each fire perimeter is a unique run from an ignition, multiple are shown to demonstrate the variety of sizes, shapes, and travel paths that can happen around the EC & IC FPD.

A.3 Predicted Radiant Heat and Spotting Potential

The risk that radiant heat and short-range and long-range spotting pose to structures was assessed. See **Introduction to Wildfire Behavior and Terminology** for a description of how wildfires can ignite homes. Ember production and transport and their ability to ignite recipient fuels are guided by complex processes, so TEA utilized the simplified approach of Beverly and others (2010) to assess home exposure to radiant heating and short-and long-range spotting (**Figure 8.a.10**). Exposure is based on distance from long flame lengths and potential active crown fire assuming:

- Radiant heat can ignite homes when extreme fire behavior (flame lengths > 8 feet) occurs within 33 yards (30 meters) of structures.
- Short-range embers can reach homes within 0.06 miles (100 meters) of active crown fires.
- Long-range embers can reach homes within 0.3 miles (500 meters) of active crown fires.

Embers can ignite homes even when the flaming front of a wildfire is far away. See **Mitigate the Home Ignition Zone** for tangible and relatively simple steps you can take to harden your home against embers. Mitigation practices, such as removing pine needles from gutters and installing covers over vents, can make ignition less likely and make it easier for firefighters to defend your property.

Distance thresholds used by Beverly and others (2010) are based on observations from actual wildfires, but their estimates are lower than those from some researchers. Studies on wildfires burning eucalyptus forests in Australia and wildfires burning chaparral in California demonstrated that embers can travel 12 to 15 miles from the flaming front and ignite spot fires (Caton and others 2016), but these fuel types are very different from conifer forests in Colorado. Embers from ponderosa pine trees tend to ignite fuels at a much lower rate than embers from other tree species (Hudson and others 2020). In addition, the number of embers reaching an area decreases exponentially with distance traveled, and the likelihood of structure ignition increases with the number of embers landing on the structure (Caton and others 2016). Therefore, using conservative estimates of distance allowed for identification of areas with the greatest risk of ignition from short- and long-range embers.

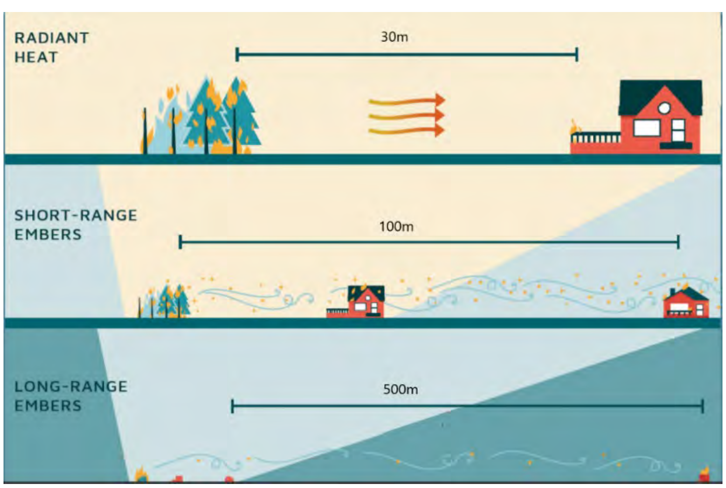


Figure 8.a.10. Research by Beverly and others (2010) suggest that homes are exposed to radiant heat, short-range embers, and long-range embers depending on their distance from the flaming front.

Areas with the greatest exposure to short- and long-range spotting were highlighted to help identify priority areas for mitigation measures. TEA determined whether exposure to radiant heat and short- and long-range spotting from active crown fires was possible within the home ignition zone (HIZ; 100-feet radius) of each structure in the EC & IC FPD. Structures for which greater than 50% of the HIZ was exposed to radiant heat, short-range spotting, and/or long-range spotting were defined as "at risk" from that hazard[4]. Exposure potential was categorized into four categories:

- Low: Potential exposure to long-range spotting only.
- Moderate: Potential exposure to long- and short-range spotting.
- High: Potential exposure to long-range spotting and radiant heat.
- Extreme: Potential exposure to long- and short-range spotting and radiant heat.

97% of the district has long-range spotting potential under 90th percentile weather conditions, up from 77% under 60th percentile conditions (**Figure 8.a.11**). Homes with Class B and C roofs and those that have flammable siding, decks, and litter on their roof can ignite from embers sent over a quarter mile away.

Almost 50% of homes are subject to extreme exposure even under 60th percentile weather conditions in Wandcrest and Kuester. Under 90th percentile conditions, more than 75% of homes can have extreme exposure in Conifer Ridge, Kuester, Silver Ranch, and Wandcrest. Homes in Deer Creek Mesa and Kincaid Springs have the lowest potential exposure across the district (**Table 8.a.7**, **Figure 8.a.12**) It is important to remember that embers can ignite homes even when the flaming front of a wildfire is far away.

75% of homes withing the combined districts have overlapping home ignition zones with at least one other home. More than half of homes in the districts share HIZs with two or more neighbors, and with as many as 34 of their neighbors (**Figure 8.a.13**, **Figure 8.a.14**). This much overlap requires community action and collaboration. Homes within 100 feet of each other have a greater risk of home-to-home ignition from radiant heat and short-range embers (Syphard and others 2012). Fuel treatments within HIZs and surrounding undeveloped areas could help reduce the exposure of homes to radiant heat and short-range spotting.

Potential exposure to radiant heating and long- and short-range embers is widespread across the EC & IC FPD, and this awareness should encourage residents and business owners to complete home hardening practices to reduce the risk of ignition.

[4] It is recommended to use this analysis to assess relative risk across the entire EC & IC FPD and not to evaluate absolute risk to individual homes. FlamMap and the approach of Beverly and others (2010) cannot account for defensible space, the fire resistance of materials used in home construction, and other fine-scale variation in fuel loads that contribute to the ignition potential of individual homes.

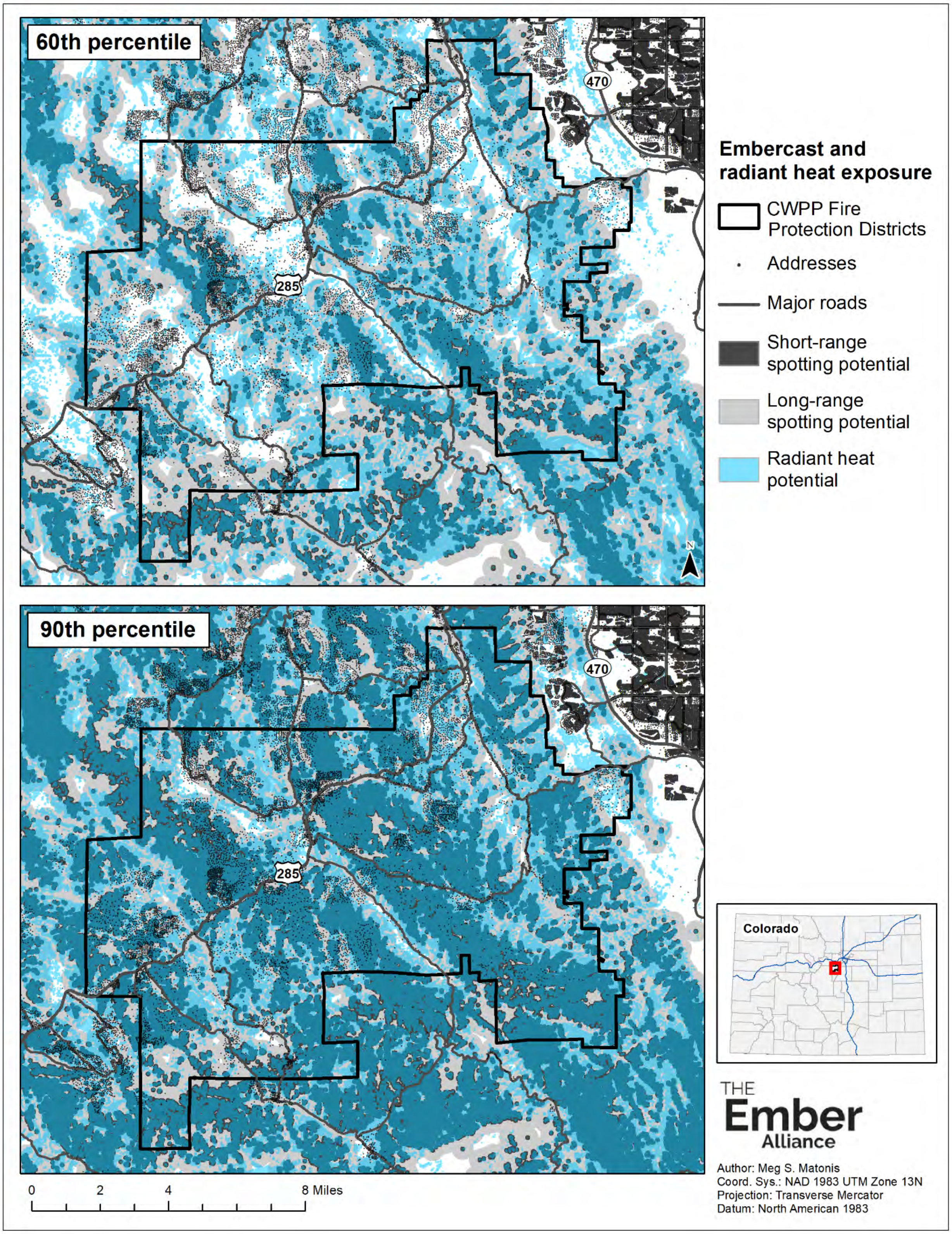


Figure 8.a.11. Predicted exposure to short-and-long range embers and radiant heat under 60th and 90th percentile fire weather conditions in the Elk Creek & Inter-Canyon Fire Protection Districts.

Table 8.a.7. Percentage of structures in each plan unit at risk of exposure to radiant heat, short range embers, and/or long range embers.

	60th Percentile				90th Percentile			
	Low Exposure	Moderate Exposure	High Exposure	Extreme Exposure	Low Exposure	Moderate Exposure	High Exposure	Extreme Exposure
Combined Districts	**33%**	**33%**	**11%**	**23%**	**0%**	**44%**	**33%**	**23%**
Angel Acres	0%	52%	31%	17%	0%	22%	21%	57%
Aspen Park	3%	45%	36%	16%	0%	21%	17%	62%
Black Mountain	45%	32%	16%	7%	15%	35%	20%	30%
Conifer Meadows	23%	47%	24%	6%	0%	27%	36%	37%
Conifer Mountain	9%	32%	25%	34%	1%	12%	19%	68%
Conifer Ridge	2%	29%	49%	20%	0%	5%	5%	90%
Deer Creek Mesa	49%	46%	5%	0%	13%	52%	33%	2%
Doubleheader Ranch/Hillview	14%	46%	32%	8%	0%	11%	41%	48%
Douglass Ranch	19%	52%	22%	7%	0%	19%	41%	40%
Eagle Cliff	23%	49%	26%	2%	0%	26%	38%	36%
Elk Falls	32%	54%	13%	1%	0%	26%	56%	18%
Evergreen Meadows	38%	40%	17%	5%	1%	27%	39%	33%
Gemspark Estates	0%	29%	47%	24%	0%	11%	17%	72%
Glen Elk	52%	39%	9%	0%	0%	14%	63%	23%
Green Valley Ranch	26%	41%	25%	8%	0%	28%	26%	46%
Highland Pines	32%	48%	16%	4%	0%	34%	32%	34%
Hilldale Pines	19%	51%	27%	3%	0%	15%	29%	56%
Homestead	54%	34%	10%	2%	7%	35%	48%	10%
Jennings	37%	48%	15%	0%	0%	35%	48%	17%
Indian Springs	22%	48%	24%	6%	8%	23%	25%	44%
Kincaid Springs	30%	49%	19%	2%	1%	56%	34%	9%
Kings Valley	1%	45%	33%	21%	0%	12%	27%	61%
Kuehster	1%	22%	33%	44%	0%	4%	13%	83%
Marclif Ranchos	67%	22%	11%	0%	7%	57%	25%	11%
McKinney Ranch	57%	36%	5%	2%	19%	36%	26%	19%
Monteverde	0%	70%	18%	12%	0%	33%	23%	44%
Mountain View Lakes	64%	31%	5%	0%	0%	43%	34%	23%
Murphy Gulch	31%	42%	15%	12%	9%	35%	31%	25%
Oehlmann Park	4%	47%	46%	3%	0%	7%	25%	68%
Pine Meadows	1%	29%	39%	31%	0%	14%	13%	73%
Pine Springs	0%	53%	38%	9%	0%	24%	46%	30%
Pine Valley	23%	67%	9%	1%	0%	66%	19%	15%
Sampson Maxwell	22%	41%	26%	11%	2%	31%	33%	34%
Shadow Mountain	77%	23%	0%	0%	1%	29%	51%	19%
Shiloh	10%	34%	21%	35%	0%	21%	24%	55%
Silver Ranch	1%	34%	48%	17%	0%	5%	20%	75%
Silver Ranch South	13%	35%	33%	19%	3%	14%	36%	47%
South Baird	23%	40%	32%	5%	0%	21%	32%	47%
Southwest	0%	25%	55%	20%	0%	5%	30%	65%
Tiny Town	23%	60%	13%	4%	12%	56%	21%	11%
Wamblee Valley	11%	38%	36%	15%	0%	10%	28%	62%
Wandcrest	0%	11%	40%	49%	0%	1%	6%	93%
Warhawk	42%	35%	23%	0%	0%	30%	29%	41%
West Ranch	22%	22%	34%	22%	0%	21%	25%	54%
Will-O-the-Wisp	5%	74%	15%	6%	0%	47%	25%	28%
Woodside Park	26%	44%	25%	5%	0%	13%	26%	61%

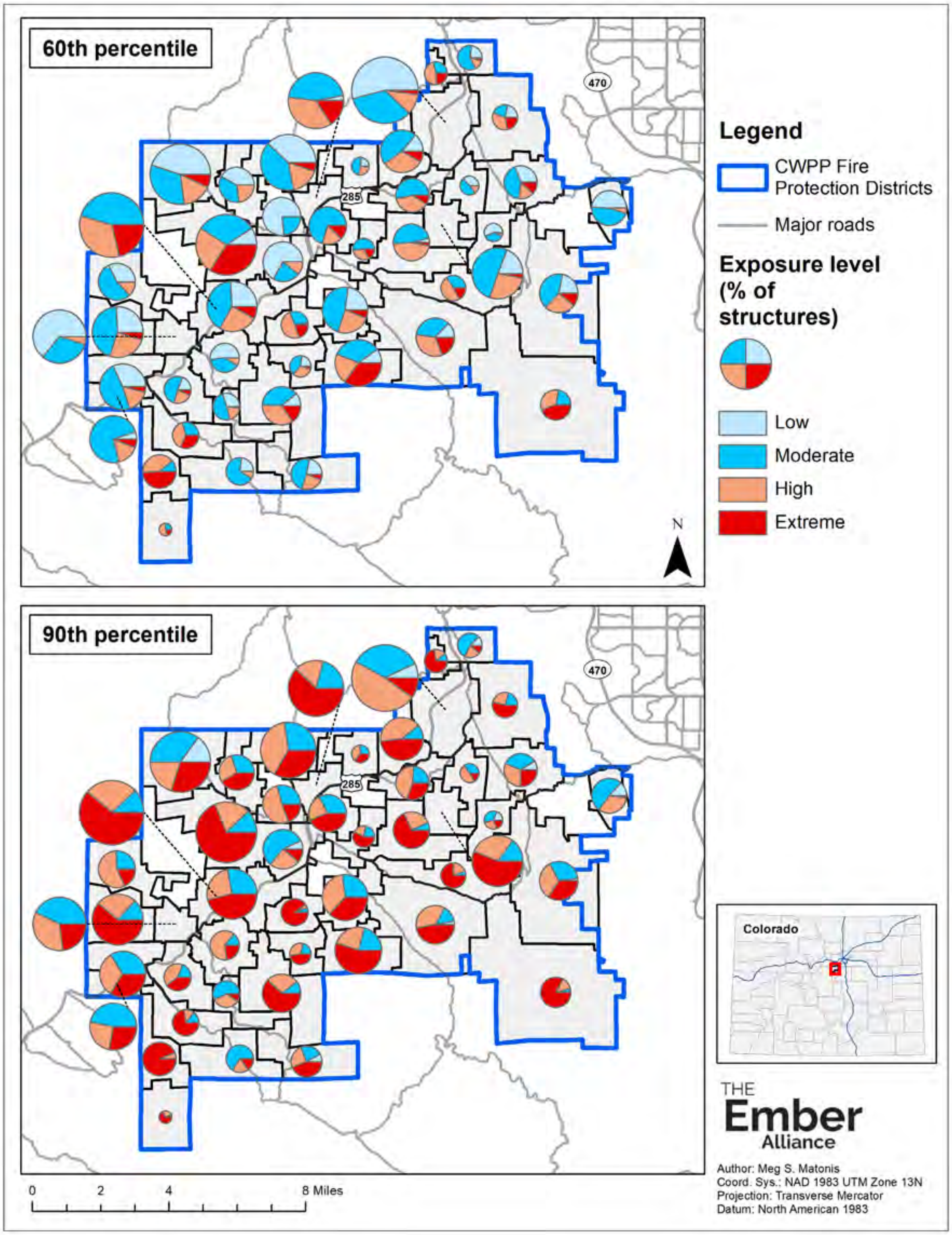


Figure 8.a.12. Percentage of homes within CWPP plan units with different levels of exposure to embers and radiant heat under 60th and 90th percentile fire weather conditions. Structure exposure ratings are as follows: low ratings indicate potential exposure to long-range spotting only, moderate ratings indicate potential exposure to short- and long-range spotting, high ratings indicate potential exposure to long-range spotting and radiant heat, and extreme ratings indicate potential exposure to short- and long-range spotting and radiant heat.

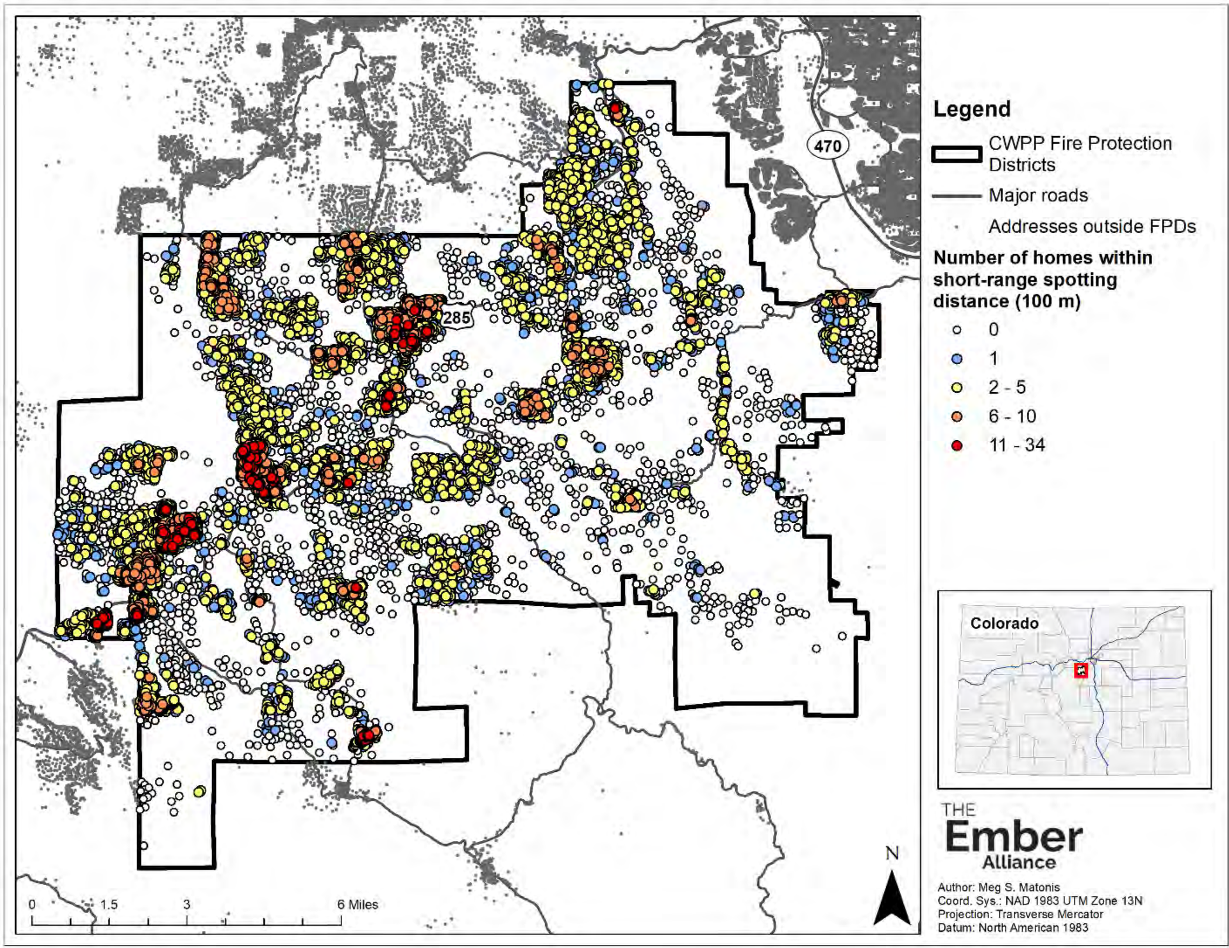


Figure 8.a.13. 75% of homes have home ignition zones (HIZ) overlapping with at least one neighboring home. Homes with overlapping HIZs are at greater risk of home-to-home ignitions from radiant heat and short-range spotting. This analysis looked at structures rather than addresses, so apartment buildings count as one structure even if they have multiple addresses.

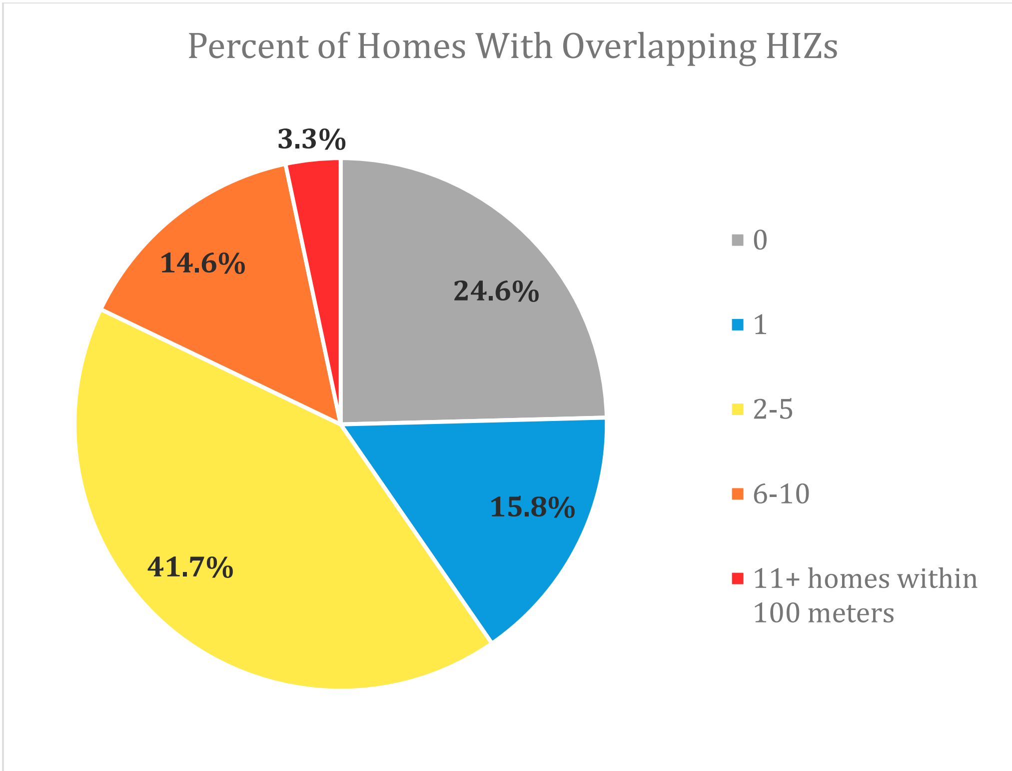


Figure 8.a.14. Percent of homes within the combined FPDs that are within 100 meters of other structures, as seen in **Figure 8.a.13**. Homes that are destroyed in wildfires tend to be spatially autocorrelated, meaning that they are more likely to burn down if another structure nearby has also burned down. Neighbors working together to mitigate their shared HIZs is vital to help firefighters protect neighborhoods.

A.4 Evacuation

Evacuation concerns can weigh heavily on the minds of many residents in the EC & IC FPD. The death of 86 people in Paradise, California during the 2018 Camp Fire, many of whom were stranded on roadways during evacuation, underscores the importance of evacuation preparedness and fuel mitigation along evacuation routes.

Evacuation Modeling and Scenarios

Evacuation time and roadway congestion using was modeled using ArcCASPER (Shahabi and Wilson 2014). The ArcCASPER model considers roadway capacity, road speed, number of cars evacuating per address, and the relationship between roadway congestion and reduction in travel speed.

The model assumes simultaneous departure of vehicles, but it starts by determining evacuation routes for vehicles with the longest distance to travel. The ArcCASPER algorithm dynamically updates the order of evacuees and their travel routes until it minimizes the global evacuation time (i.e., the time it takes for all evacuees to reach a safe evacuation location). ArcCASPER does not account for unpredictable events, such as roadway blockage from accidents or reduced visibility from smoke. It also does not consider emergency vehicles traveling the opposite direction of evacuation traffic.

Keep in mind: Simulation models cannot account for all variables present during an evacuation, so these results are useful as a guide for strategic planning rather than a depiction of what will occur in any specific evacuation event.

This analysis of evacuation modeling is **NOT** equivalent to an evacuation plan, and it is **NOT** intended to identify evacuation routes. The purpose of the analysis is to inform prioritization of roadside treatments and relative risk among plan units.

For this analysis, TEA used an exponential traffic model with a critical density of 10 and saturation density of 50. The critical density is the maximum number of cars that can be on a road with two lanes (one lane in each direction) without a reduction in travel speed, and saturation density is the number of cars on the road at which the traversal speed reduces to half the original speed.

Individual evacuation assessments were conducted for twelve evacuation groups across the EC & IC FPDs (**Figure 8.a.15**). The evacuation groups combined four to eight plan units as delineated by the 2021 CWPP (**Figure 8.a.1**). Evacuation scenarios also included 1,029 addresses located directly adjacent to the EC & IC FPD boundary to simulate realistic traffic coming from neighborhoods that are likely to evacuate simultaneously with those inside the FPD boundary. Two vehicles leaving each residential address and ten vehicles departing from each business address were modeled. Evacuees were routed to the nearest of four predetermined locations along Rt 285 or to West Deer Creek Canyon Road at the eastern edge of Inter Canyon FPD. Additional traffic that might be on the road from visitors, recreationists, and commuters not residing in or immediately adjacent to the EC & IC FPD was not included.

Estimates of evacuation times for each of the twelve evacuation groups are likely on the low end of potential evacuation times (**Figure 8.a.18**). It is unlikely that all residents in an evacuation unit would evacuate before the next unit begins evacuating. It is more likely that evacuation orders would be staggered but overlap in time, resulting in greater traffic on the roads.

Estimates from ArcCASPER are useful for determining relative evacuation capacity and congestion across the EC & IC FPD and are not intended to predict household-specific evacuation times. Law enforcement personnel will direct traffic during a wildfire event, so this evacuation modeling is not meant to suggest alternate routes for individual residents. **Residents need to follow guidance from law enforcement personnel during evacuation events, practice safe driving, and practice good evacuation etiquette (e.g., allowing cars to merge and not texting or stopping to take photographs)** (See **Evacuation Preparedness** to learn about evacuation etiquette).

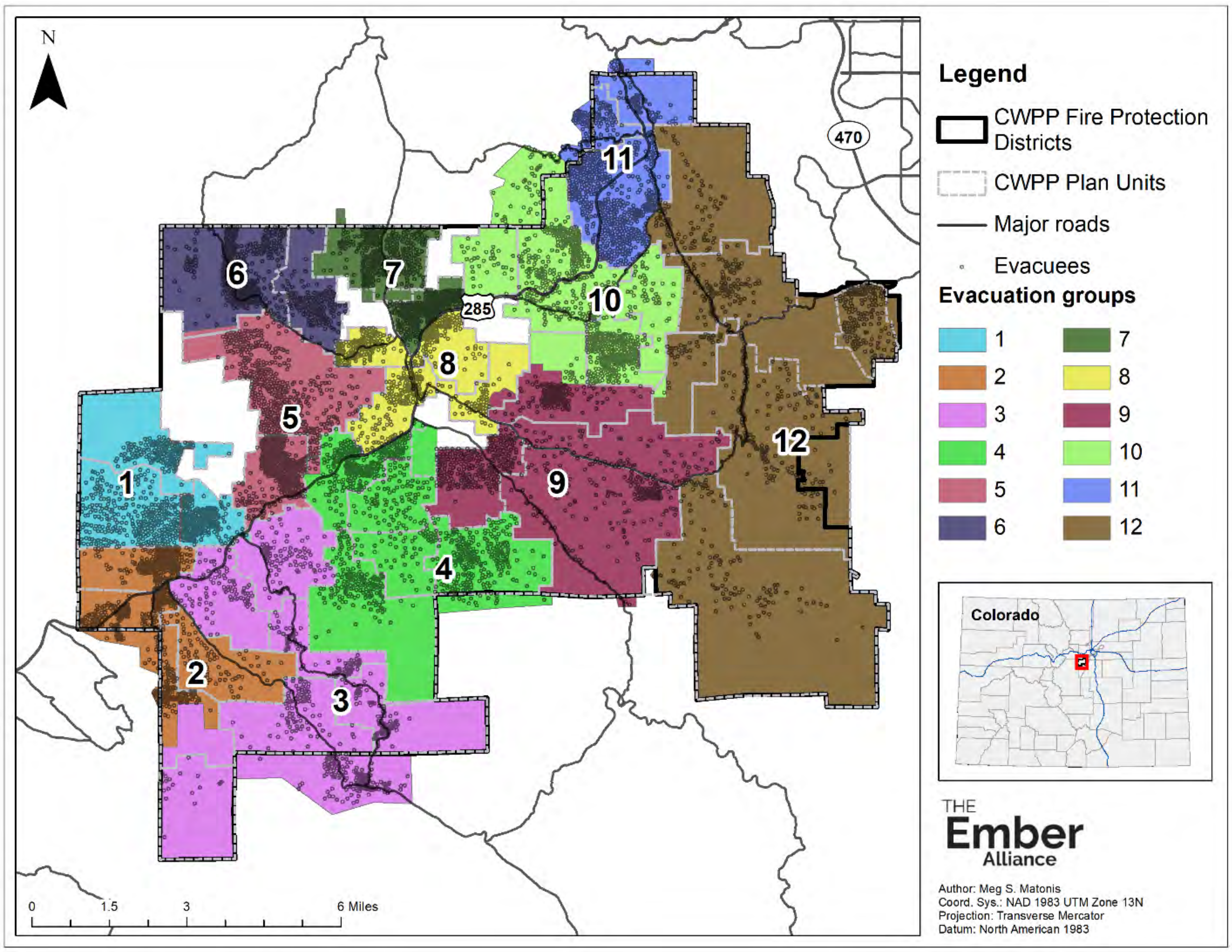


Figure 8.a.15. The Ember Alliance combined several plan units as defined by Elk Creek & Inter-Canyon FPDs (colored and numbered) to create twelve evacuation zones for evacuation modeling as part of the CWPP.

Evacuation Congestion

Evacuation congestion was evaluated to help prioritize roadside fuel treatments and to provide information to the EC & IC FPDs and law enforcement about areas that could experience exceptionally high congestion during an evacuation (**Figure 8.a.16**). This analysis of evacuation modeling is **NOT** equivalent to an evacuation plan, and it is **NOT** intended to identify evacuation routes.

Roads were categorized by how much congestion may occur, and how much longer it may take to evacuate compared to everyday scenarios without evacuation traffic. Portions of US 285 and roads in the northern half of Conifer can have extreme congestion (2.5-4x longer) during evacuations (**Figure 8.a.16**). Roads with extreme congestion include the northern portion of Pine Valley Road, South Parker Avenue, southwestern portions of US 285, Rand Road, Richmond Hill Road, Shadow Mountain Drive, North Turkey Creek Road (west of 285), and West Deer Creek Canyon Road.

It is important to reiterate that congestion modeling does not account for unexpected barriers such as cars breaking down, car accidents, road closures, etc. It also does not take into consideration additional traffic aside from individual evacuation groups; if an evacuation were ordered over a weekend, these congestion indices would increase dramatically. However, this does show, even under the best-case scenario, areas that are prone to traffic build up.

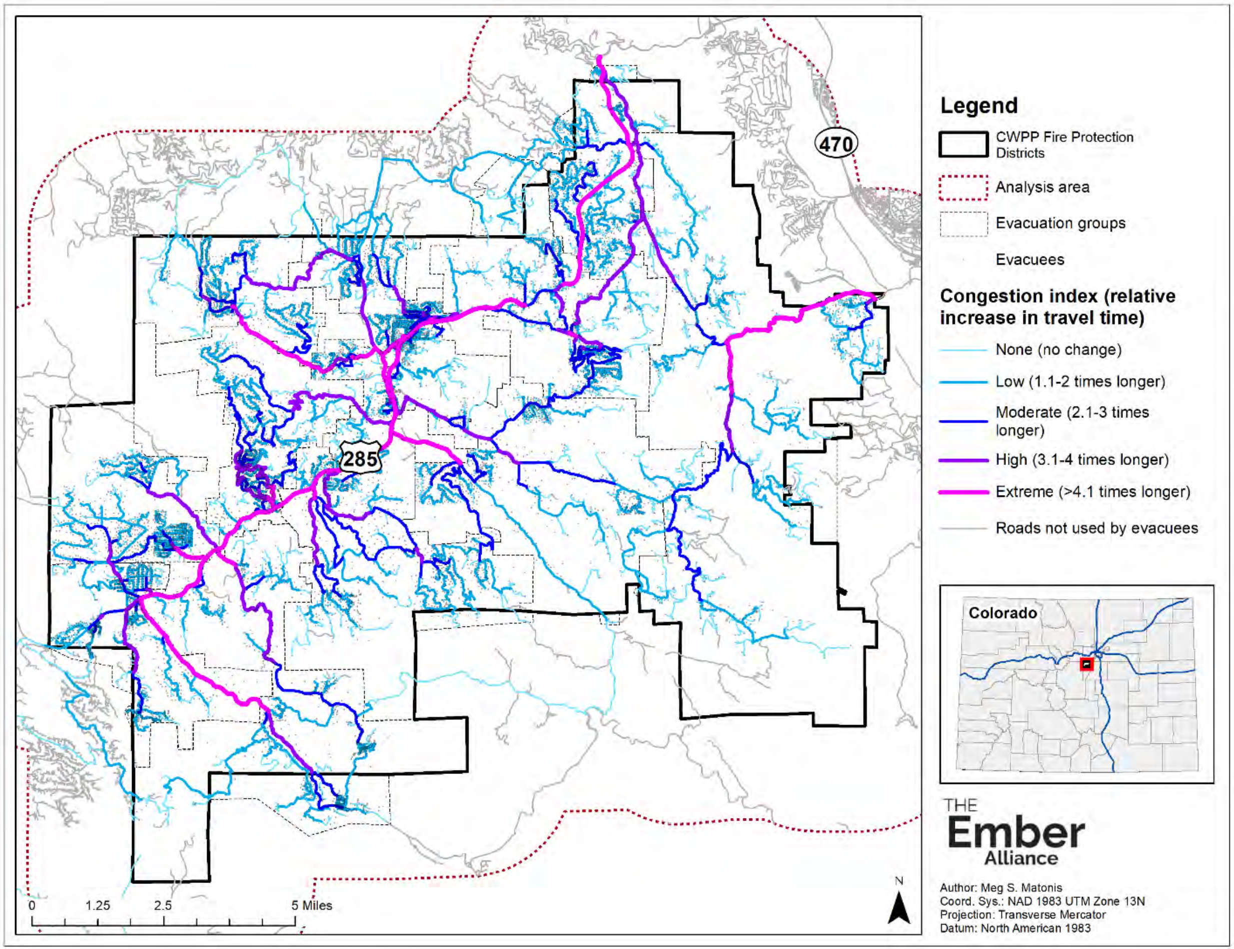


Figure 8.a.16. Predicted congestion across the EC & IC FPD under a simultaneous district-wide evacuation order. Congestion categories (none, low, moderate, high, extreme) are based on the ratio between the time required to traverse a segment of road with congestion vs. without congestion. Evacuation times were simulated with two vehicles leaving each residency and ten vehicles leaving each business address and driving to the nearest predetermined location on main thoroughfares (four locations along Rt 285 and one at the eastern edge of Inter Canyon FPD on West Deer Creek Canyon Road).

Evacuation Time

Evacuation time indicates how long it might take for a vehicle to receive an evacuation order, depart from an address, and reach an evacuation site (in this case, high-capacity roadways such as Highway 285). Based on research by Beloglazov and others (2016), TEA assumed that it takes 30 minutes for individuals to mobilize and depart their homes after receiving a mandatory evacuation order. Estimates of evacuation times informed the relative risk rating of plan units in the EC & IC FPDs.

> The actual time it would take to evacuate during a specific incident is influenced by a variety of factors not considered in this modeling effort, such as the staggering of evacuation orders, the nature of evacuation orders (i.e., voluntary versus mandatory), traffic accidents, delays from people stopping to take photographs, reduced visibility from smoke, etc.

Neighborhoods directly adjacent to Highway 285 and Deer Creek Canyon have the shortest evacuation times, while neighborhoods along the perimeter of the EC & IC FPDs have longer evacuation times. Evacuation times range from 30 minutes to 2 hours and 25 minutes under these evacuation scenarios, with the longest times expected for residents in the southeast corner of the EC & IC FPDs (**Figure 8.a.18**).

Evacuation group 5 had the shortest estimated evacuation time (<60 minutes for all residents to reach major egress routes), while evacuation group 8 had evacuation times extending over 2.5 hours. The Monteverde, Aspen Park, and Tiny Town CWPP plan units had the shortest projected evacuation time (~30-40 minutes), while Kuehster, Sampson/Maxwell, Silver Ranch, and Silver Ranch South had the longest projected evacuation times, extending over 2 hours (**Figure 8.a.18**)

These model results should be interpreted as relative ratings showing which neighborhoods may take longer than others to evacuate. It is important to note that these times are given under the best-case scenario in which residents are safely and efficiently evacuating, there are no accidents blocking the roads, there is no smoke hindering visibility, and evacuation groups are departing individually. Evacuation times indicate how long it might take to leave a residency and reach a main egress route. These model results do not estimate the time it would take to leave the boundary of the EC & IC FPDs or reach an area of safety. Congestion along Highway 285 and Deer Creek Canyon outside of the district would create substantially longer evacuation times to fully evacuate from the FPDs. It is important for residents to be prepared so they can leave promptly in the case of an evacuation order.

However, as noted before, evacuation estimates for individual zones could be on the low end of potential evacuation times; it is unlikely that one evacuation zone would fully evacuate before evacuation orders begin in another zone.

> **How realistic are estimated evacuation times from ArcCASPER?**
>
> The estimates TEA present make assumptions about the number of vehicles leaving each residency and the time it takes for residents to mobilize and depart after receiving an evacuation order. Unpredictable events were not account for in this modeling effort, such as roadway blockage from accidents or reduced visibility from smoke. It is impossible to know what actual evacuation times might be during a wildfire incident, especially since large-scale evacuation drills have not been conducted in this area. There has never been an actual district-wide evacuation, and law enforcement personnel make evacuation decisions based on specific fire behavior during an incident.

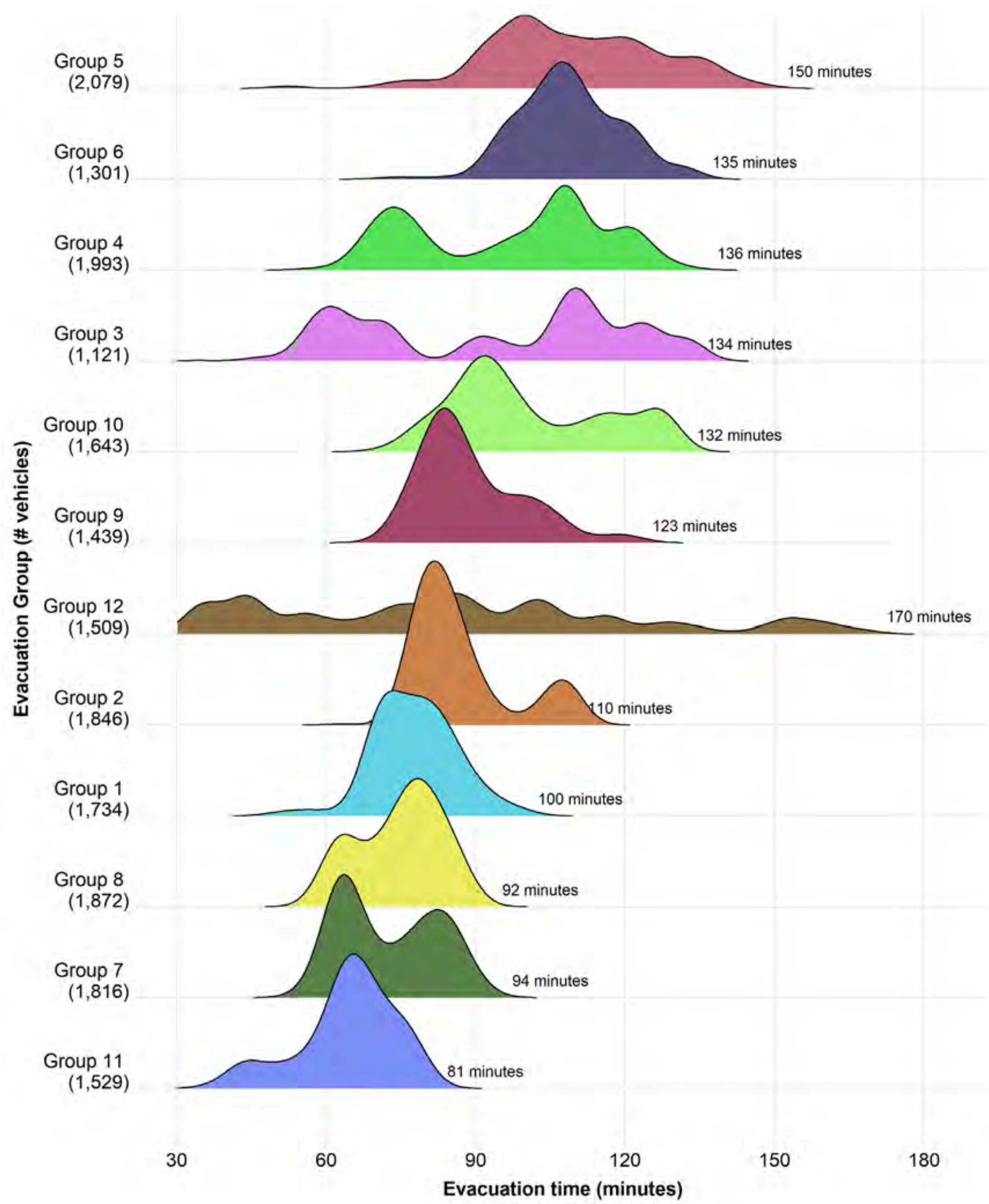


Figure 8.a.17. Distribution of predicted evacuation times under a simultaneous district-wide evacuation order. It was assumed that it takes 30 minutes for individuals to mobilize and depart after receiving an evacuation order. Two vehicles leaving residential addresses and ten vehicles leaving business addresses were modeled. Colors correspond to evacuation zones in **Figure 8.a.15**.

A.5 Roadway Survivability

Tragedies have occurred when flames from fast-moving wildfires burn over roads while residents are evacuating. Residents can perish in their vehicles trapped on the road, and egress routes can become blocked from flames. **Mitigation actions along sections of road with high risk for non-survivable conditions during a wildfire can increase the chances of survival for residents stranded in their vehicles during a wildfire and decrease the chance that roadways become impassable due to flames.**

Fire behavior predictions were utilized to identify road segments that could experience non-survivable conditions during a wildfire. “Non-survivable roadways” were identified as portions of roads adjacent to areas with predicted flame lengths greater than 8 feet. Drivers stopped or trapped on these roadways could have a low chance of survival due to radiant heat emitted from fires of this intensity. This assumption is based on the Haul Chart, which is a standard tool used by firefighters to relate flame lengths to tactical decisions (**Table 8.a.2**). Direct attack of a flaming front is no longer feasible once flame lengths exceed about 8 feet due to the intensity of heat output. Flames greater than 8 feet could also make roads impassable and cut residents off from egress routes. Non-survivable conditions are more common along roads lined by thick forests with abundant ladder fuels, such as trees with low limbs and saplings and tall shrubs beneath overstory tress (**Figure 8.a.19**).

Just under 30% of the roads in the combined FPDs could experience non-survivable conditions under moderate 60th-percentile fire weather, and this jumps to just under 50%. In three of the plan units, at least half of the roads are potentially non-survivable under moderate fire weather conditions, and under extreme weather conditions that becomes 25 out of the 46 plan units (**Figure 8.a.20**). Some non-survivable road segments are part of key evacuation routes and a high priority for mitigation to reduce fuels and potential flame lengths, including small portions of Highway 285 and major roads that connect to 285. These areas were identified as evacuation pinch points and incorporated them into recommendations for roadway fuelbreaks across the EC & IC FPD (see **Roadway Fuelbreak Recommendations**).

Survivable Roadways	Potentially Non-Survivable Roadways
	
	

Figure 8.a.18. Some roads in the EC & IC FPD could experience potentially non-survivable conditions because they are lined with thick forests that have an abundance of ladder fuels (left images). Other roads have been well mitigated by removing tall trees and saplings, removing limbs on the remaining trees, and keeping grass mowed (right images). Photographs from EC & IC FPD.

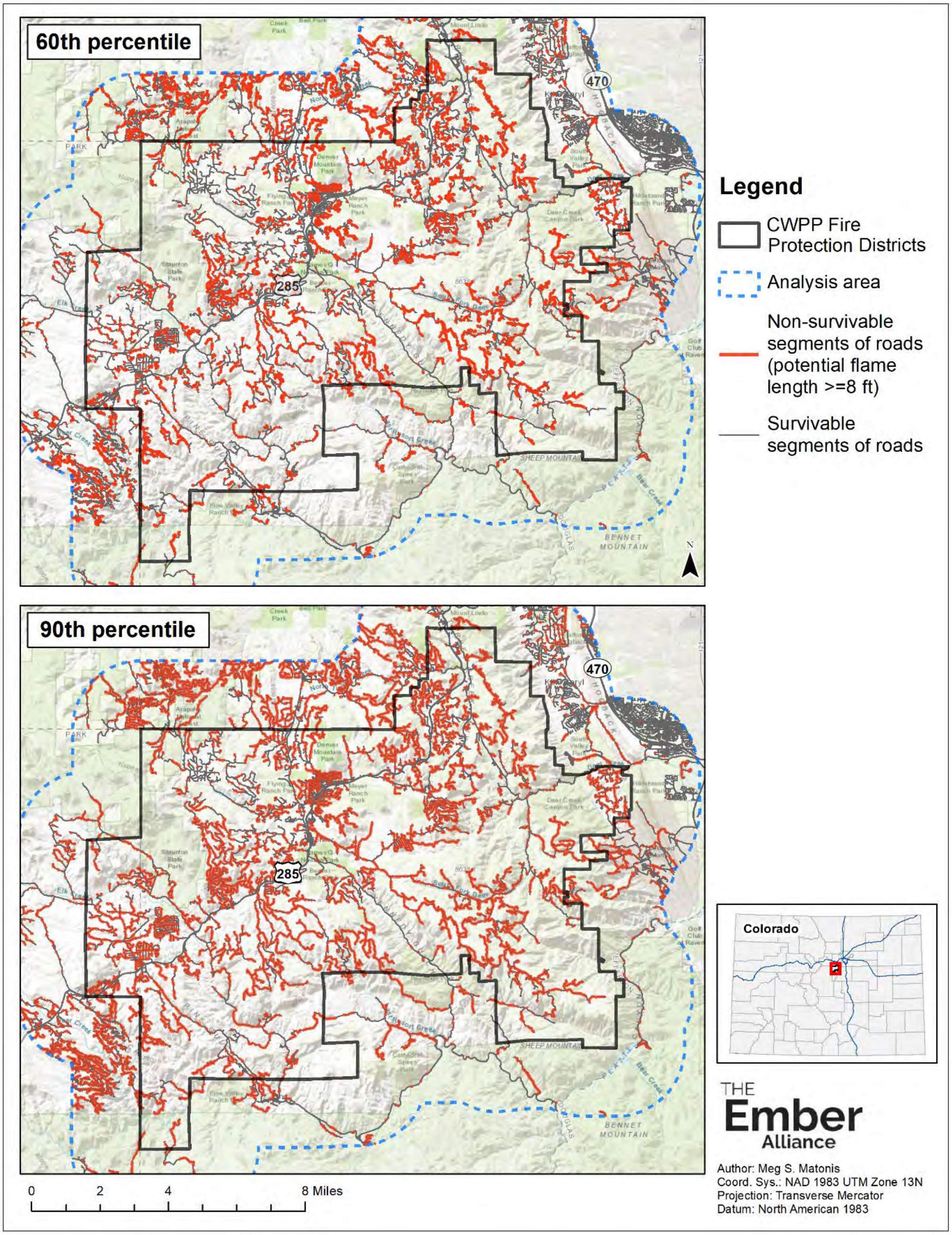


Figure 8.a.19. Under 60th percentile fire weather conditions, 29% of roads and driveways in the Elk Creek & Inter-Canyon Fire Protection Districts could potentially experience non-survivable conditions during wildfires (i.e., flame lengths over 8 feet). This percentage rises to 49% under 90th percentile fire weather conditions.

Table 8.a.8. Percentage of potentially non-survivable roads in plan units across the districts.

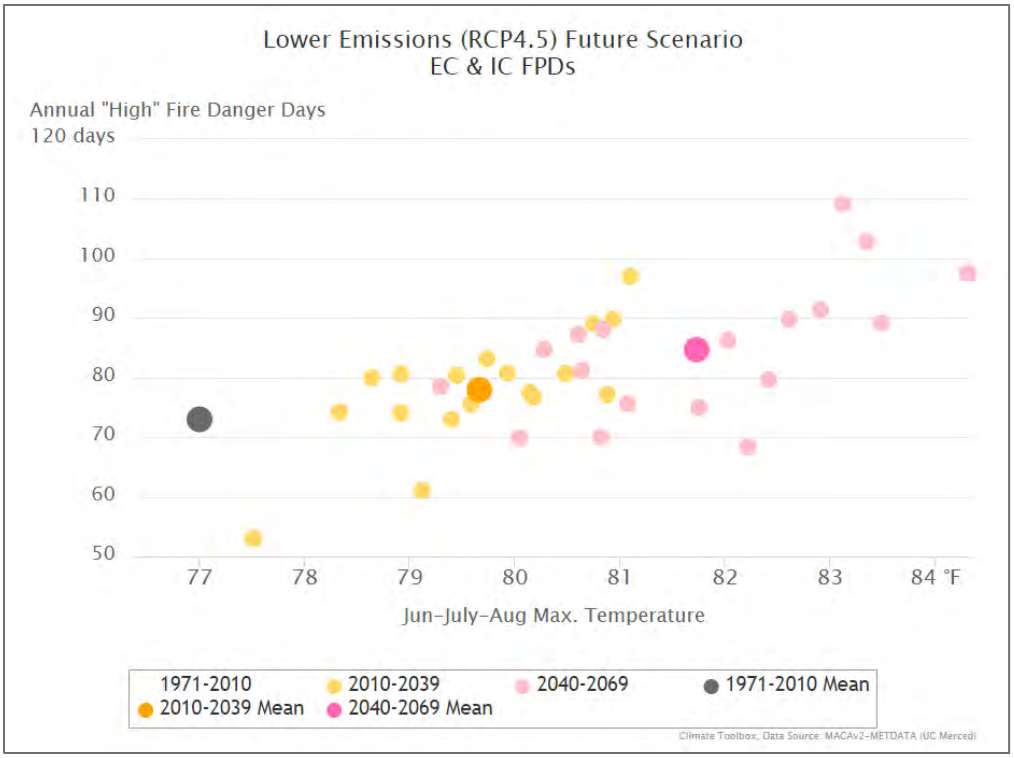
	% of Non-Survivable Roads	
	60th Percentile	90th Percentile
Combined Districts	**29%**	**49%**
Angel Acres	43%	71%
Aspen Park	25%	40%
Black Mountain	14%	26%
Conifer Meadows	19%	46%
Conifer Mountain	27%	51%
Conifer Ridge	45%	70%
Deer Creek Mesa	37%	56%
Doubleheader Ranch/Hillview	41%	65%
Douglass Ranch	23%	41%
Eagle Cliff	28%	53%
Elk Falls	22%	46%
Evergreen Meadows	32%	49%
Gemspark Estates	44%	54%
Glen Elk	29%	56%
Green Valley Ranch	18%	35%
Highland Pines	21%	50%
Hilldale Pines	32%	57%
Homestead	26%	44%
Jennings	40%	58%
Indian Springs	17%	38%
Kincaid Springs	28%	48%
Kings Valley	29%	53%
Kuehster	43%	62%
Marclif Ranchos	19%	37%
McKinney Ranch	22%	42%
Monteverde	31%	46%
Mountain View Lakes	20%	42%
Murphy Gulch	32%	47%
Oehlmann Park	44%	66%
Pine Meadows	34%	56%
Pine Springs	28%	45%
Pine Valley	20%	40%
Sampson Maxwell	40%	57%
Shadow Mountain	18%	34%
Shiloh	50%	69%
Silver Ranch	37%	66%
Silver Ranch South	44%	60%
South Baird	31%	65%
Southwest	38%	61%
Tiny Town	21%	33%
Wamblee Valley	39%	67%
Wandcrest	66%	83%
Warhawk	7%	18%
West Ranch	50%	61%
Will-O-the-Wisp	12%	36%
Woodside Park	19%	52%

A.6 Climate Change Assessment

Climate change has a measurable impact on fire intensity and frequency, and this is likely to continue given current trajectories. To assess how different climate scenarios might affect the fire district, TEA used the Climate Toolbox's Future Climate Scatter to project future weather scenarios for EC & IC FPDs. This tool models climate scenarios for the next fifty years using the Representative Concentration Pathways 4.5 and 8.5. These two models forecast future climate scenarios based on different levels of global greenhouse gas emissions. Four variables were analyzed: expected maximum temperature each year and the number of days expected to be "high fire danger" days, and annual 100-hour fuel moisture levels and days with a heat index over 90° Fahrenheit.

The models predict that under moderate or intense greenhouse gas concentrations, EC & IC FPD will experience hotter summer temperatures and an increased number of days considered to be high fire danger. In the next 50 years, it would be reasonable to expect maximum summer temperatures to increase by 5-7° Fahrenheit, and **the number of high fire danger days is likely to increase by 13-17 more days per year (Figure 8.a.20, Figure 8.a.21)**.

Fire behavior models from **Section A.2** account for RAWS weather inputs from 2002-2020. They do not include future weather predictions. These predictions are presented to add a layer of depth regarding the future of fire danger in the EC & IC FPD, but are not used in conjunction with other models. Fire behavior has the potential to be extreme based on the weather from the past twenty years, and it may be even more extreme and frequent under the future conditions presented here. This behavior could include longer flame lengths, faster rates of spread, higher fire severity, and more crown fire activity. More extreme fire behavior increases danger to the life safety of residents, as well as to their homes, businesses, and community resiliency.



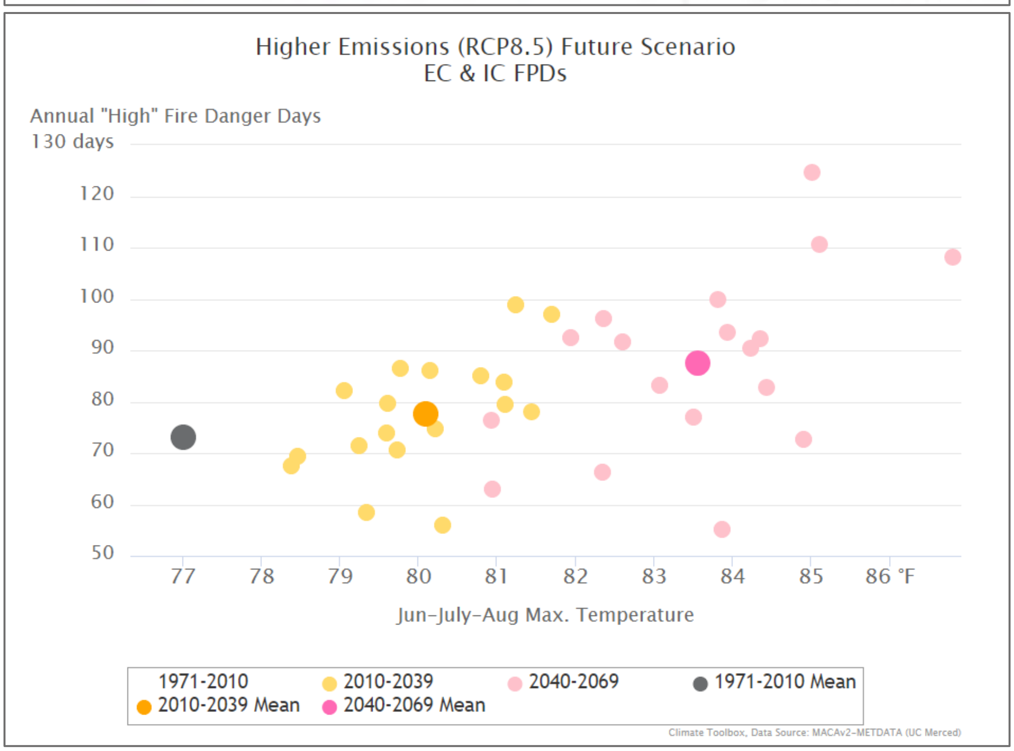


Figure 8.a.20. Potential future weather conditions in the Elk Creek & Inter-Canyon Fire Protection Districts modelled with the Climate Toolbox Future Climate Scatter (Hegewisch and others). The top graph is modelled under the RCP 4.5 scenario, where greenhouse gas emissions stabilize before the year 2100, peaking around 2040. The bottom graph is modelled under the RCP 8.5 scenario, where greenhouse gas emissions are not curtailed by 2100.

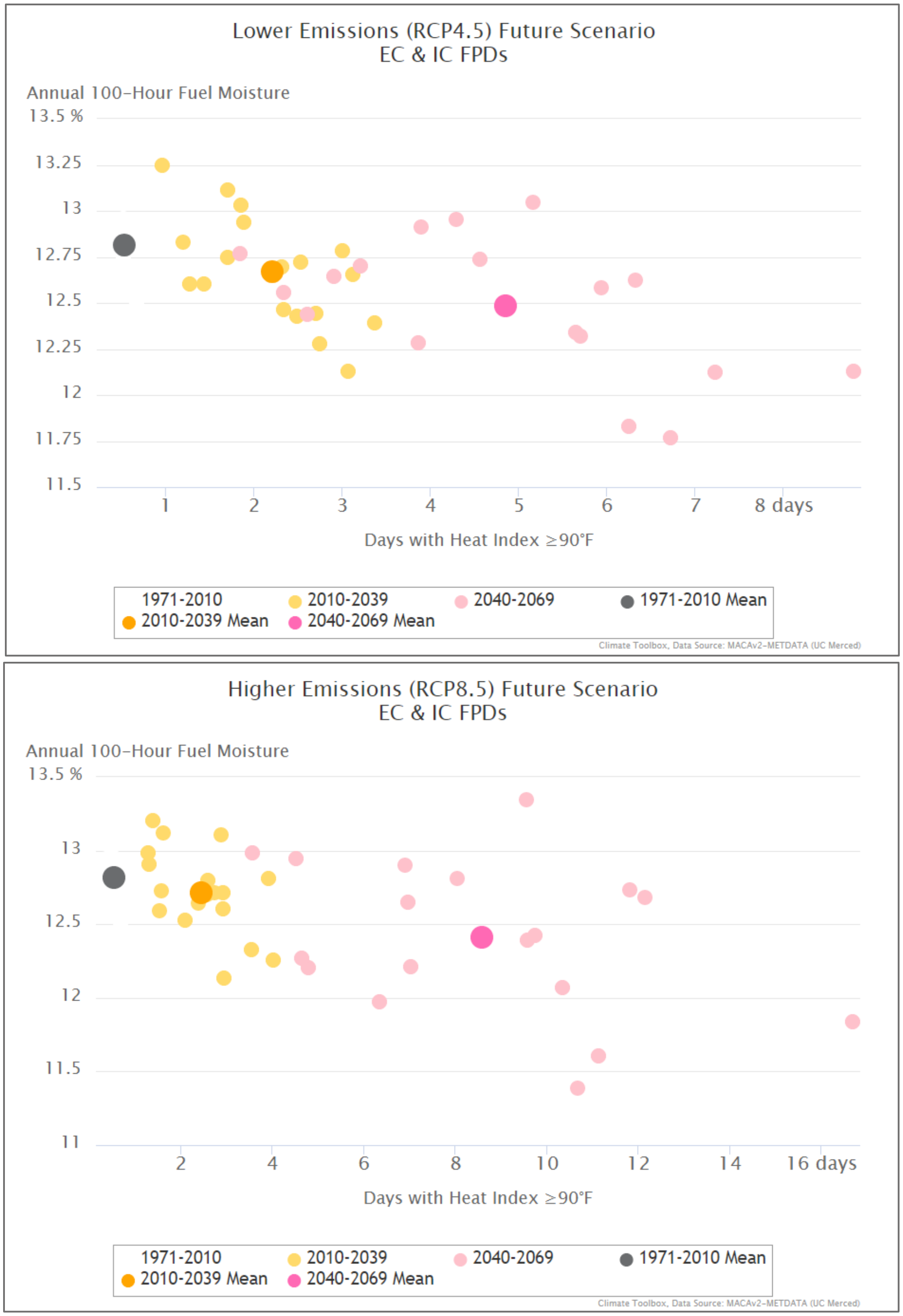


Figure 8.a.21. Potential future conditions that impact fire behavior and suppression activities in the Elk Creek & Inter-Canyon Fire Protection Districts modelled with the Climate Toolbox Future Climate Scatter (Hegewisch and others). The top graph is modelled under the RCP 4.5 scenario, where greenhouse gas emissions stabilize before the year 2100, peaking around 2040. The bottom graph is modelled under the RCP 8.5 scenario, where greenhouse gas emissions are not curtailed by 2100.

Appendix B. Treatment Prioritization Methodology

B.1 Plan Unit Hazard Assessment

The **relative** risk that wildfires pose to life and property were compared in 46 plan units across the EC & IC FPD (**Figure 8.a.1**). Homes across the EC & IC FPD have high risk from wildfire damage, but to help prioritize hazard mitigation, TEA developed a rating of relative risk. A plan unit receiving a relative rating of "moderate risk" has risk factors that are lower than risk factors in other plan units, but it is still an area with extreme wildfire hazards compares to the rest of the state and country, and 97% of land in the district is at risk of long-range spotting under 90th percentile weather conditions (**Figure 8.a.12**). Long-range spotting is still a significant danger during a wildfire event, as demonstrated by the 2020 East Troublesome Fire when it spotted one and a half miles over the continental divide. Hazards were assessed in four categories: fire risk, fire suppression challenges (e.g., limited hydrant availability and engine access), evacuation hazards, and home ignition zone hazards. The ratings of relative risk were developed specifically for the EC & IC FPD, so the assessment is not suitable for comparing EC & IC FPD to other communities.

Our assessment was based on predictions of fire behavior, radiant heat and spotting potential, roadway survivability, and evacuation time, as well as an on-the-ground assessment of each plan unit. In summer and fall of 2021, the Inter Canyon Captain for Wildland/Training (John Mandl) and the Elk Canyon Wildfire Captain (Benjamin Yellin) drove around the EC & IC FPD and used a modified version of the NFPA Wildfire Hazard Severity Form Checklist (NFPA 299 / 1144) to rate home ignition zone hazards within each plan unit.

Relative Ratings

Plan units were categorized into Moderate, High, and Extreme relative risk ratings. These descriptions were chosen to reinforce that nowhere in the combined FPDs is at low risk of fire, and the entire district needs mitigation work completed to protect life safety, property, and ecological resilience (**Figure 8.b.1**). Extreme risk ratings indicate that fuel mitigation, home construction, roadways, and suppression opportunities are so inadequate that it may be too dangerous to send responders into that area during a wildfire event to attempt to fight the fire. Moderate risk ratings indicate that there are fewer barriers to protecting lives and property, but all the plan units ranked as Moderate still are at high to extreme risk in at least one of the risk categories.

Keep in mind: The Plan Unit Hazard Assessment describes ***relative*** risk among plan units within the EC & IC FPDs. Plan units with lower relative risk still possess conditions that are concerning for the protection of life and property in the case of a wildfire. The need to mitigate hazardous conditions is ubiquitous across the EC & IC FPD. Plan units with higher relative risk are strong candidates for immediate action to mitigate hazardous conditions.

Only three plan units (Will-O-the-Wisp, Deer Creek Mesa, and Angel Acres) have an adequate number of hydrants to protect the homes, and 10 of the plan units have no hydrants or dip/draft sites within the unit and received an Extreme risk rating for fire suppression capabilities.

Kincaid Springs and Indian Springs have the most extreme road access issues for engines, and Eagle Cliff, Shadow Mountain, and Mountain View Lakes have the most roads with only one lane, which is an evacuation and firefighter access issue. Eagle Cliff, Wandcrest, Jennings, Sampson/Maxwell, Kuehster, and McKinney Ranch each have only one ingress/egress route, and each of them received and Extreme evacuation risk rating. Every planning unit except four (Indian Springs, Warhawk, Black Mountain, and Will-O-the-Wisp) have a high percentage of potentially non-survivable roads, even under 60th percentile weather conditions (**Table 8.a.8**).

Home Ignition Zone mitigation is lacking across the districts. Homeowners on all districts should work on defensible space and home hardening. Less than 75% of homes in Wandcrest have Class A roofs. In all plan units except four (Deer Creek Mesa, Gemspark Estates, West Ranch, and Douglass Ranch) more than half the homes have combustible siding and/or deck material. Less than 50% of homes have adequate defensible space around them in all plan units except three (Pine Meadows, Southwest, and Pine Valley), and in these three units, 25-50% of homes do not have adequate defensible space.

See **Table 8.b.1** for common concerns identified in plan units with high to extreme relative ratings and **Priority Plan Unit Recommendations** for specific recommendations to address hazards in each plan unit.

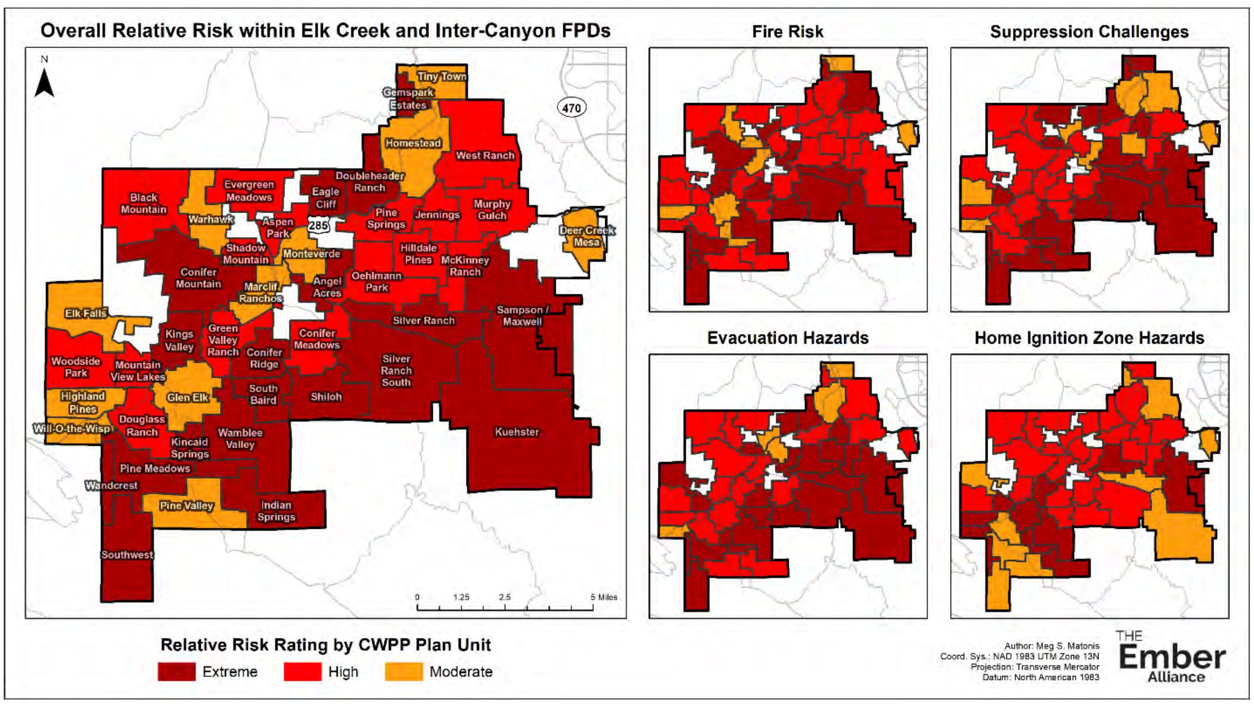


Figure 8.b.1. Relative hazards were assessed in four categories: fire risk, fire suppression challenges (e.g., limited hydrant availability and road access for fire engines), evacuation hazards, and home ignition zone hazards. Wandcrest, Wamblee Valley, Silver Ranch South, and the Southwest plan units have the most extreme risk within the combined districts. Plan units with moderate relative risk still possess conditions that are concerning for the protection of life and property in the case of a wildfire.

Table 8.b.1. Notable concerns in plan units with high to extreme relative hazard ratings.

Hazard rating category	Notable concerns in plan units with extreme relative hazard ratings
Fire risk	• Continuous fuels, such as whole hillsides with dense mixed conifer and ponderosa pine stands that have not been thinned. • Heavy ladder fuels such as shrubs and tall grass leading up to overstory trees or near homes. • Steep slopes and terrain with ravines and chimneys that make fire behavior unpredictable.
Fire suppression challenges	• Poorly maintained roads, and roads that are only one lane can prevent engine access. • Lack of hydrants and/or a lack of a dip or draft site within the unit. • Homes and streets do not have legible and reflective road and address signs.
Evacuation limitations	• Many plan units only have one way in and out of the neighborhood, which limits evacuation times and options, and can prevent responders from entering the unit while residents are evacuating. • Many units have one-lane roads and homes with narrow and steep driveways. • Roads with significant roadside fuels can create non-survivable conditions. • Homes and streets do not have legible and reflective road and address signs, which can make evacuation navigation difficult in thick smoke.
Home ignition zone hazards	• Homes located along steep slopes and on ridgetops. • Homes that have older construction that is combustible, such as wood roofs and siding. • Wooden fences within 5 feet of the home. • Firewood and combustible furniture on or under decks. • Propane tanks within 30 feet of the home. • Lack of defensible space, especially in conjunction with steep slopes below the home.

Hazard Rating Scale

A rating scale was developed specifically for the EC & IC FPDs based on the range of values observed across the community (**Table 8.b.2**). The purpose of the assessment is to compare relative hazards within the community and is not suitable for comparing the EC & IC FPD to other communities.

Table 8.b.2. Relative hazard rating matrix for the ED & IC FPDs.

	Points		**Relative hazard rating**		
Hazard category	Max. possible	Range of values observed in EC & IC FPD plan units	Moderate	High	Extreme
A. Fire risk	55	9-54	<15	15-40	≥40
B. Fire suppression challenges	45	0-40	<15	15-19	≥20
C. Evacuation hazards	40	5-35	<10	11-19	≥20
D. Home ignition zone hazards	47	17-41	<31	31	≥32
Overall risk	187	55-154	<80	80-99	≥100

B.2 Relative Risk Rating Form

A. Fire Risk	**Points**
1. Flame length[1]	
<11 feet	0
11-16 feet	6
>16 feet	12
2. Crown fire activity (percent area predicted for passive or active crown fire)[1]	
<55%	0
55-65%	6
>65%	12
3. Exposure to extreme radiant heat from grass/shrub and shrub fuel types (percent area with flame lengths > 8 feet)[1]	
<10%	0
10-14%	6
>14%	12
4. Conditional burn probability[1]	
<0.07%	0
0.07-0.11%	3
>0.11%	6
4. Additional risk factors	
Mid-slope homes	2
Homes on ridge tops	2
Saddles / ravines / chimneys	4
Utilities (gas / electric) placement	
All underground	0
Infrequent overhead powerlines	3
Frequent overhead powerlines	5
A. Total points possible	**55**

[1]Mean predictions from FlamMap under 60^{th} percentile fire weather conditions for plan unit and adjacent watersheds.

B. Fire Suppression Challenges	**Points**
1. Average response time[2]	
<5 minutes	0
5-10 minutes	3
>10 minutes	5
2. Percentage of homes near hydrants	
>75%	0
25-75%	5
<25%	10
3. Presence of dip / draft sites	
Not necessary due to hydrant availability	0
At least one dip / draft site	0
No dip / draft site	5
4. Road/driveway accessibility for Type 3 engines (percent of roads/driveways)	
>90%	0
75-90%	5
50-75%	10
<50%	15
5. Presence of legible and reflective signs (percent of roads and homes)	
>90%	0
75-90%	3
<75%	5
6. Presence / absence of HazMat	
Absent	0
Present	5
B. Total points possible	**45**

[2] Response time estimated using Service Area analysis in ArcMap.

C. Evacuation Hazards	Points
1. Number of lanes in each direction	
At least 1 lane on >75% of roads	0
At least 1 lane on >50-75% of roads	5
Less than 1 lane on >50% of roads	10
2. Number of major egress directions from plan unit	
3-4	0
2	5
1	10
3. Mean household evacuation time[3]	
<70 minutes	0
70-90 minutes	5
>90 minutes	10
4. Non-survivable roads—90th percentile conditions	
<20%	0
20-39%	5
>39%	10
C. Total points possible	**40**

[3]Estimates from ArcCASPER (see Appendix A.4. for methodology and assumptions).

D. Home Ignition Zone Hazards	Points
1. Roof construction material	
Class B or C on <10% of homes	0
Class B or C on 10-15% of homes	5
Class B or C on >25% of homes	10
Class C on >50% of homes	15
2. Percent of homes with combustible siding / decking	
<10%	0
10-50%	5
>50%	10
3. Percent of homes with wooden fences within defensible space zone 1	
<10%	0
10-25%	1
>25%	2
4. Percent of homes with adequate mitigation of ladder and canopy fuels in defensible space zones 1 and 2	
>90%	0
75-90%	3
50-75%	6
<50%	10
5. Percent of homes with adequate maintenance of defensible space	
>90%	0
75-90%	1
50-75%	3
<50%	5
6. Percent of homes with additional hazards in zones 1 and 2 (e.g., wood piles, flammable lawn furniture)	
<10%	0
10-25%	1
25-50%	3
>50%	5
D. Total points possible	**47**

B.3 Fuel Treatment Prioritization Methodology

Foresters often conduct fuels treatments across forest stands—areas with similar tree sizes, species compositions, topography, and soils types. To create stand boundaries for the fuel treatment prioritization, small watersheds were delineated (i.e., an area of land where all precipitation falling in that area drains to the same location) and subdivided these into three hillslopes—one on each side of a stream or river and one above the headwaters of the watershed (**Figure 8.b.2**). Hillslopes were delineated in ArcGIS using a modified version of the WEPP Hillslope Toolbox, which is based on TOPAZ (Topographic Parameterization Software) from the USDA Agricultural Research Service.

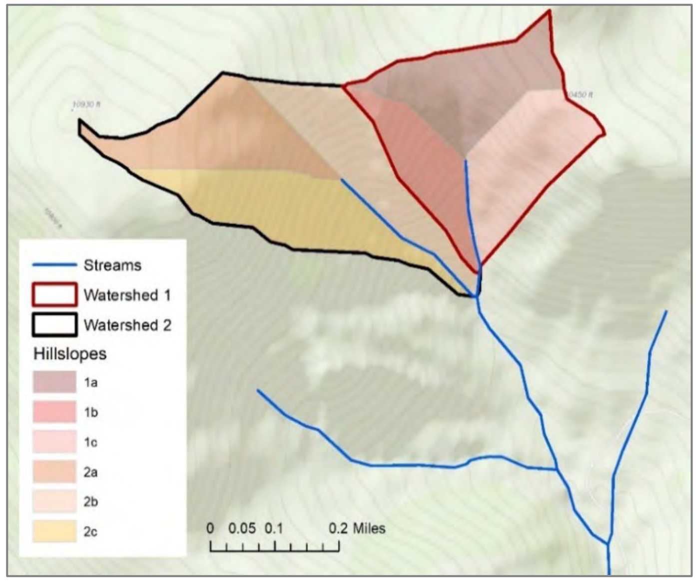


Figure 8.b.2. Depiction of small watersheds and their subdivided hillslopes.

A 30 m resolution digital elevation models was obtained from the U.S. Geological Service, and delineated hillslopes with a critical source area of 49.5 acres (2 hectares) and a minimum source channel length of 330 feet (100 meters), as recommended by Elliot et al. (2016). Critical source area is the minimum allowable area above the head of a first-order channel, and minimum source channel length is the minimum length of a channel used to delineate watersheds. Areas that were less than 10 acres in size were combined with the largest adjacent hillslope. Final hillslopes for Conifer FPD averaged 56 acres in size and ranged from 10 to 350 acres—reasonable sizes for forest management projects in the WUI.

A prioritization scheme was developed to weight potential treatment units based on exposure of homes to short-range spotting and radiant heat under 60th percentile fire weather, presence of priority roadsides, potential for extreme fire behavior under 60th percentile fire weather, and percentage of operable ground (slopes less than 50 percent) (**Table 8.b.3**.). According to Hunter and others (2007), use of mechanical equipment is generally infeasible on slopes greater than 35%. It was assumed that hand crews can thin forests on slopes up to 50%. Since it is less feasible to treat steep areas, the weighting was lowered for priority of stands that had high percentages of inoperable slopes.

Roadside treatments were prioritized based on non-survivable conditions (predicted flame lengths >8 feet) under 60th percentile fire weather conditions and road segments that could become evacuation pinch points (congestion ratio ≥3). Treatments were prioritized following the scheme presented in **Table 8.b.4**.

Table 8.b.3. Prioritization scheme for ranking potential treatment units to mitigate fire hazards within and adjacent to the EC & IC FPD.

Prioritization category	Maximum weight		First priority	Second priority	Third priority
Number of homes exposed to short-range spotting and/or radiant heat from the hillslope (60th percentile fire weather)	30%	Cutoff	≥10 homes	1-10 homes	0 homes
		Weight	30	15	0
Presence of priority roadways (non-survivable evacuation pinch points)	20%	Cutoff	At least one 1st priority roadway	At least one 2nd priority but no 1st priority roadways	No 1st or 2nd priority roadways
		Weight	20	10	0
Percent active crown fire (60th percentile fire weather)	15%	Cutoff	≥10%	2 - <10%	<2%
		Weight	15	8	0
Percent area as grass/shrub or shrub fuel types with flame lengths > 8 feet (60th percentile fire weather)	15%	Cutoff	≥33%	10 - <33%	<10%
		Weight	15	8	0
Average conditional burn probability (60th percentile fire weather, average BP of 18 mph east winds and 18 mph west southwest winds)	15%	Cutoff	≥0.15%	0.10 - <0.15%	<0.10%
		Weight	15	8	0
Percent operable slopes in hillslope (<50%)	5%	Cutoff	≥75%	33 - <75%	<33%
		Weight	5	3	0
Overall priority			**First priority**	**Second priority**	**Third priority**
		Cutoff	≥50	35 - 49	25 - 34

Table 8.b.4. Prioritization scheme for ranking potential roadside treatments to mitigate fire hazards along roadways.

Prioritization category	Conditions
First	• Non-survivable conditions (flame lengths >8 feet) under 60th percentile fire weather conditions • Extreme evacuation pinch points (congestion ratio ≥3) • Non-survivable portions of US-285
Second	• Non-survivable conditions (flame lengths >8 feet) under 60th percentile fire weather conditions • Major evacuation pinch points (congestion ratio ≥2 to <3)
Third	• Non-survivable conditions (flame lengths >8 feet) under 60th percentile fire weather conditions • Moderate evacuation pinch points (congestion ratio >1 to <2)