THE Ember Alliance

2022

ESTES VALLEY FIRE PROTECTION DISTRICT

LARIMER COUNTY, COLORADO

Community Wildfire Protection Plan

Estes Valley Fire Protection District Community Wildfire Protection Plan 2022 Update

Prepared for Estes Valley Fire Protection District
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Funded by Estes Valley Fire Protection District, Town of Estes Park, Estes Valley Watershed Coalition, and Visit Estes Park

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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 Estes Valley Fire Protection District. 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 wildfire
- Section 2 to learn about the Estes Valley FPD
- Section 3.a to learn what your next steps can be
- Appendix C to learn about resident perceptions of wildfire risk in my community

I'm a resident / homeowner and want to learn about protecting my family, home, and property from wildfires.

Look for:

- Section 2.g to learn why action is important now
- Section 3.a to learn about the actions you can take, including detailed recommendations and research-backed guidance for protecting your home and family
- Section 3.c to find detailed hazard ratings and recommendations for your neighborhood

I want to learn about community-lead wildfire mitigation actions for neighborhoods or HOAs.

Look for:

- Sections 3.b, 3.e, 3.f., and 3.g. to learn about the actions communities can take together to better protect everyone, including funding opportunities
- Section 3.c to find detailed hazard 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.b and 2.c to learn about fire history and treatment history in the area
- Section 4.a to learn about fuel treatment objectives
- Section 4.b and 4.c. to learn about fuel treatment priorities and recommendations
- Section 4.d. to learn about slash management options
- Section 4.e. to see the project implementation plan

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

Acronyms

CSFS	Colorado State Forest Service
CWPP	Community Wildfire Protection Plan
DFPC	Division of Fire Prevention and Control
EVFPD	Estes Valley Fire Protection District
FAC	Fire Adapted Community
FEMA	Federal Emergency Management Agency
FPD	Fire Protection District
HIZ	Home Ignition Zone
HOA	Homeowner's Association
IIBHS	Insurance Institute for Business & Home Safety
IRPG	Incident Response Pocket Guide
ISO	Insurance Services Office
LCSO	Larimer County Sherriff's Office
NCFC	Northern Colorado Fireshed Collaborative
NFPA	National Fire Protection Association
NWCG	National Wildfire Coordinating Group
RAWS	Remote Automatic Weather Stations
TEA	The Ember Alliance
RMNP	Rocky Mountain National Park
USFS	U.S. Forest Service
VFD	Volunteer Fire Department
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 2022, the Estes Valley Fire Protection District (EVFPD) completed an update of the 2009 CWPP that addresses the changing landscape and takes advantage of advances in fire science. This collaborative effort was led by the Estes Valley Fire Protection District, the Town of Estes Park, Larimer County, the Colorado State Forest Service, and the Estes Valley Watershed Collaboration. 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 EVFPD a safer and more resilient community to wildfire. The objectives of this project were to:

- 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.

This CWPP is a call to action. Estes Valley Fire Protection District shares some risk factors common to past catastrophic wildfires across the country. The 2022 CWPP provides an assessment of wildfire risk in the Estes Valley Fire Protection District and includes suggestions for residents, community leaders, and emergency responders to mitigate risk and enhance community safety.

1.b. Partners and Stakeholder Engagement

Collaboration is an essential part of CWPPs. Community engagement, partner commitment, and follow through are what make a CWPP successful. The Ember Alliance—a Colorado nonprofit dedicated to fire management and community engagement—worked with many local organizations to manage and write the CWPP. The CWPP Core and Advisory Teams engaged stakeholders from across the district and neighboring District 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.

Core Team Members:

- Colorado State Forest Service
- Estes Valley Fire Protection District
- Estes Valley Watershed Coalition
- Larimer County Sheriff's Office – Emergency Services
- Town of Estes Park

Advisory Team Members:

- Big Thompson Watershed Coalition
- Colorado Forest Restoration Institute
- Larimer Conservation District
- Larimer County Office of Emergency Management
- Northern Colorado Fireshed Collaborative
- Northern Water
- Rocky Mountain National Park
- Town of Estes Park - Power and Communications
- United States Forest Service

The CWPP team 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 Parks and Wildlife
- Colorado State Forest Service
- Estes Valley Fire Protection District
- Estes Valley Watershed Coalition
- Larimer Conservation District
- Larimer County Office of Emergency Management
- Larimer County Sheriff's Office – Emergency Services
- Larimer Emergency Telephone Authority (LETA)
- Northern Colorado Fireshed Collaborative
- Rocky Mountain National Park
- Town of Estes Park
    - Estes Park Power and Communications
- USFS: Arapaho-Roosevelt National Forest

TEA is grateful to Larimer County, Colorado Forest Restoration Institute, and the State of Colorado for sharing geospatial data across the EVFPD.

Community engagement is a vital aspect of CWPP development and implementation. The Estes Valley CWPP Update is a collaborative effort lead by the Core Team: the Estes Valley Fire Protection District, the Town of Estes Park, Larimer County, the Colorado State Forest Service, and the Estes Valley Watershed Coalition. They incorporated lessons learned from the challenging 2020 wildfire season in Colorado and considered valuable insights shared by community members and other stakeholders.

The Core Team provided opportunities for community involvement throughout the process. In fall of 2021, community leaders shared their perspectives on how best to interact with residents in the EVFPD and for their sense of the community's current awareness, understanding, and commitment to wildfire preparedness. A community survey was created to capture feedback from residents unable to attend. See **Appendix C. Focus Group and Survey** for community leader feedback analysis. Questions developed by the Wildfire Research group (WiRē) were instrumental in conducting the survey.

Multiple meetings were held between agencies and organizations with a shared interest in mitigation of wildfire hazards across the EVFPD.

- Core Team meeting September 10th to review initial findings of fire behavior.
- Core Team meeting October 6th to review the focus group plan and fire behavior analyses.
- Core Team meeting January 24th to discuss mitigation prioritization.
- Advisory Team meeting March 7th to discuss mitigation prioritization.
- Northern Colorado Fireshed Collaborative meetings April 13th and June 18th to discuss mitigation implementation and collaboration.

A final community meeting was held on May 26th to share findings with the community at large and to disseminate information about how to take action to reduce risks present in the district.

Station 1, Dannels Fire Stations, headquarters for the Estes Valley Fire Protection District. Photo credit: The Ember Alliance.

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).

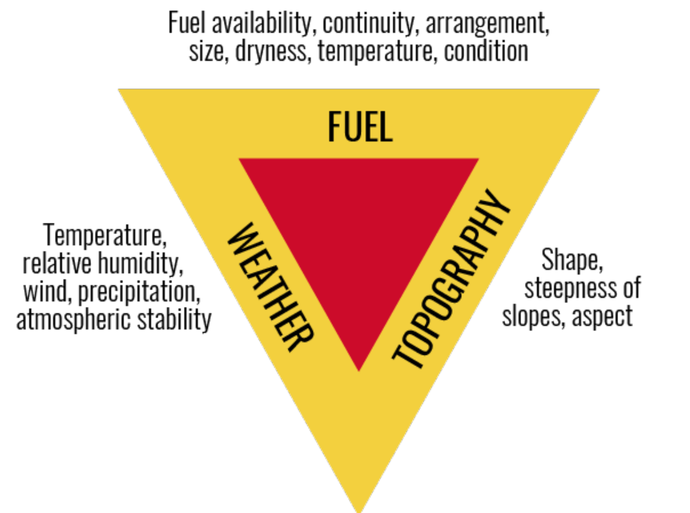


***Figure 1.c.1**. Interactions between fuels, weather, and topography dictate fire behavior (source: California State University).*

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. Flashy fuels dry out faster than other fuel types when relative humidity drops or when exposed to radiant and convective heat[1]. If you think of a campfire, flashy fuels are the kindling that you use to start the fire. Fires in grassy fuel types can spread quickly across large areas, and fire behavior can change rapidly with changes in weather conditions.

Dead branches on the surface 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.

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 et al., 2019; Parsons et al., 2014).

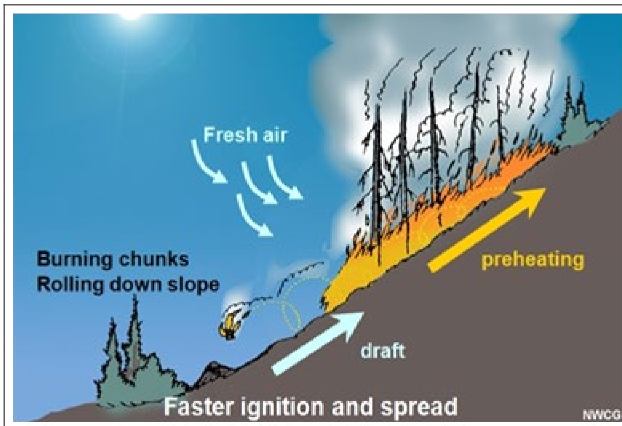
[1]See the **Glossary** at the end of the CWPP for definitions of heat transfer methods.

Topography

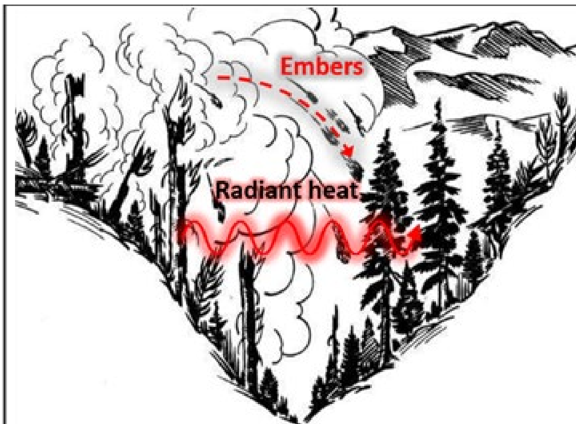
Topography (slope and aspect) influences fire intensity, speed, and spread. In the northern hemisphere, north-facing slopes experience less sun exposure during the day, resulting in higher fuel moistures. Tree density is often higher on north-facing slopes due to higher soil moisture. South-facing slopes 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 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.*

Weather

Weather conditions that impact fire behavior include temperature, relative humidity, precipitation, and wind speed and direction. The National Weather Service uses a designation 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 impact how ready fuels are to ignite. Warm air preheats fuels and brings 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) 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 et al., 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 (Addington et al., 2018; Romme, 1982).

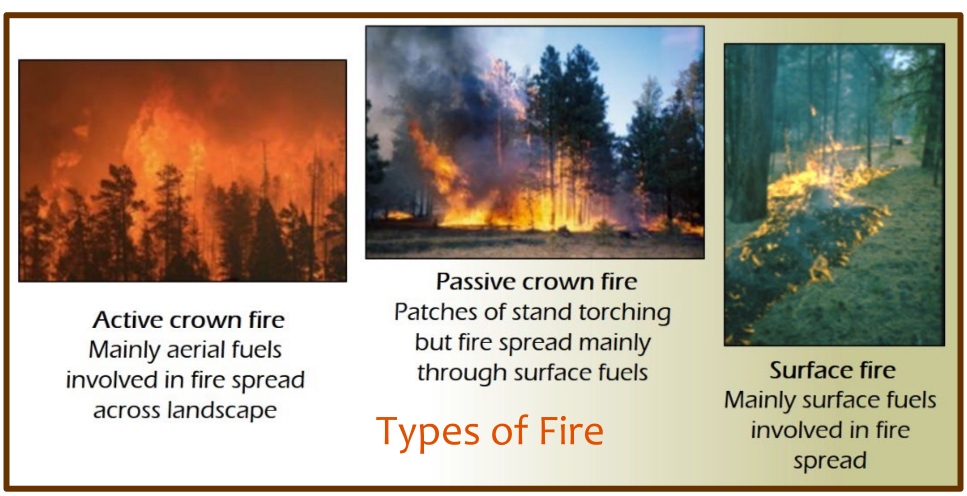


Figure 1.c.3. *Active crown fire, passive crown fire, and surface fire are common types of fire behavior.*

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 et al., 2016).

The Wildland-Urban Interface (WUI) is any area where the built environment meets wildfire-prone areas—places where wildland fire can move between natural vegetation and the built environment and result in negative impacts on the community (Forge, 2018). WUI exist along a continuum of wildland to urban densities (**Figure 1.c.4**). Over the past 50 years, immigration to the mountains along the Colorado Front Range 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.

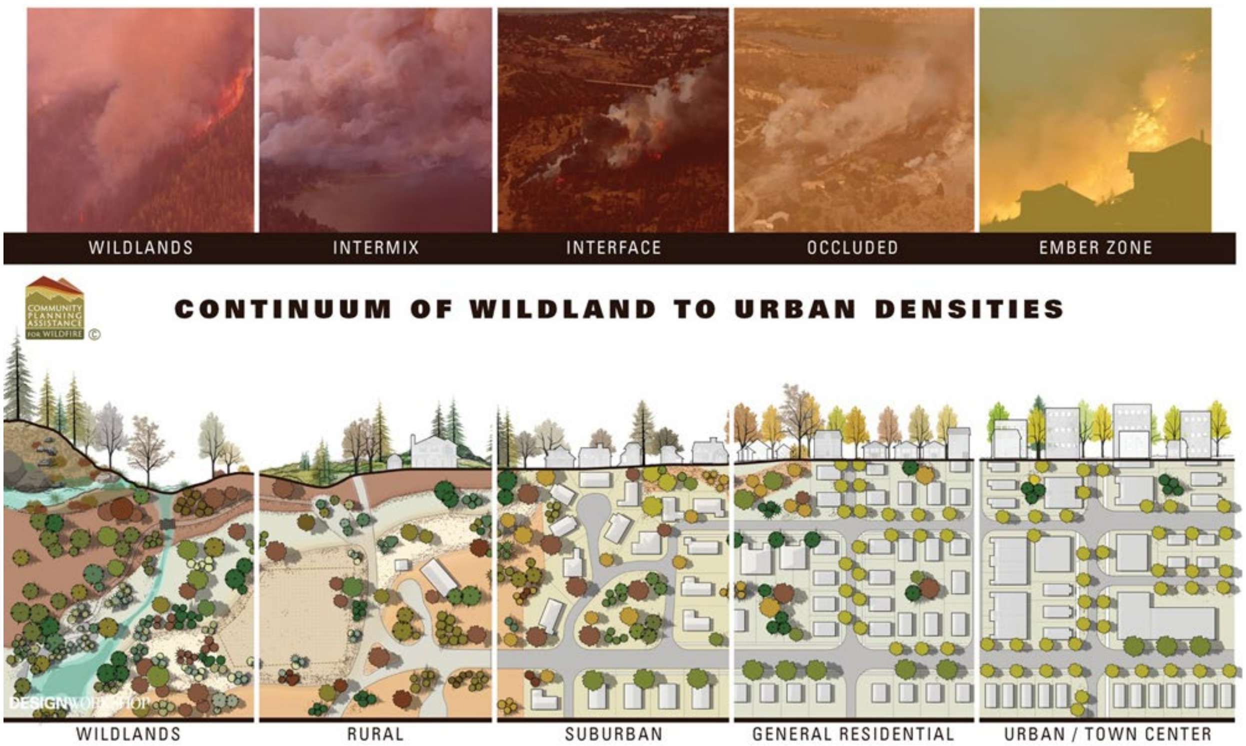


***Figure 1.c.4**. The wildland-urban interface exists along a continuum of wildland to urban densities. (Source: Community Planning Assistance for Wildfire).*

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 et al., 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). Fires can also travel between structures along fuel pathways such as a fence or row of shrubs connecting a shed and a home (Maranghides et al., 2022). Some housing materials can burn hotter than the surrounding vegetation, thereby exacerbating wildfire intensity and initiating home-to-home ignition (Mell et al., 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 slope and threaten the home above. Photo credit: The Ember Alliance.

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, as evidenced by the destructive 2021 Marshall Fire in Boulder County. 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 et al., 2017; Syphard and Keeley, 2019). Embers can also penetrate homes if windows are destroyed by radiant or convective heat. See the section on **Home Hardening** 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.

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 during an incident, and more importantly, to protect the lives of firefighters. 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.

Do not count on firefighters staying to defend your home—your home should be able to survive a wildfire on its own. There are never enough firefighters to stay and defend every single home during large incidents. Section **Mitigate the Home Ignition Zone** 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. Estes Valley Fire Protection District: Background

2.a. General Description

The EVFPD covers approximately 66 square miles in southwest Larimer County, Colorado (**Figure 2.a.1**). It lies in the Front Range and is a popular destination for tourists from across the state, country, and internationally. It centers around Estes Park, at the intersection of US Highway 36 from Boulder and US Highway 34 from Loveland. The west side abuts Rocky Mountain National Park (RMNP), and Arapaho-Roosevelt National Forest lands surround it to the north, east, and south, interspersed with rural mountain communities.

In the Estes Valley, the average resident age is 62 years, making it one of the oldest communities in the state. 47% of the population is part of the workforce, and many residents are retired (U.S. Census Bureau, 2020). Approximately 11,500 people live in the valley year-round, and there is a large population of seasonal summer residents and workforce. The Town of Estes Park itself has about 6,000 year-round residents. The district covers 9,000 housing units, and there is a large hospitality industry due to Rocky Mountain National Park. Annual visitation to the park is increasing and hit a record high number of visitors (4.6 million) in 2019. 80% of these visitors come in through Estes Park every year.

The EVFPD works with neighboring districts when needed. It is bordered by Glen Haven Volunteer Fire Department to the north, Loveland Fire Rescue Authority to the east, Pinewood Springs Fire Protection District, Volunteer Fire Department of Big Elk, and Lyons Fire Protection District to the southeast, and Allenspark Fire Protection District to the south. Arapaho-Roosevelt National Forest manages 15,500 acres of land in the EVFPD, about 37% of its area. Larimer County manages 1,300 acres of land at Hermit Park Open Space. The Town of Estes Park operates 13 public parks within Town limits. The Bureau of Reclamation maintains water resources and power plants at Lake Estes and Mary's Lake (**Figure 2.a.2**). All the land management agencies in the district cooperated with RMNP and federal wildfire coordinators during the 2020 fire season to respond to threats from the Cameron Peak Fire and the East Troublesome Fire.

The EVFPD encompasses a widespread valley where the Town of Estes Park is seated, and the surrounding hills and valleys. Elevations range from 7,000 to 10,700 feet above sea level. The district is at the headwaters of the Big Thompson Watershed, which is an important source of water for Front Range communities including Fort Collins and Loveland. Most of the district is vegetated with mixed conifer forests and ponderosa pine woodlands. Lodgepole pine stands, montane shrublands, and conifer-hardwood stands make up the rest of the valley. Much of the historic montane meadow land has been developed into downtown Estes Park and housing (**Figure 2.a.3**; **Figure 2.a.4**). Black bear, elk, mountain lion, mule deer, and bald eagles are some of the large wildlife commonly found in the EVFPD. The valley is part of the headwaters for the Big Thompson River which provides drinking and irrigation water to residents of the Estes Valley, the Big Thompson Canyon, Loveland, Greeley, and other communities downstream.

Fuel loads vary from light to very heavy across the EVFPD (**Figure 8.a.2**). 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 or canyons and could experience active crown fires that would be difficult if not impossible for firefighters to contain. Grassy areas are interspersed across the EVFPD and 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.

Estes Valley has significant values to protect from wildfire. In addition to private homes and commercial buildings, there are the Estes Park Schools and Eagle Rock School, the community center, many churches, a hospital, two urgent care centers, and a long-term senior care facility. The top of Prospect Mountain houses essential communications towers, critical support infrastructure like power distribution and water treatment for Estes and downstream users exist throughout the valley, and both Lake Estes and Mary's Lake are home to powerplants (**Figure 2.a.5**). Rocky Mountain National Park is a world-class tourism destination and the main attraction for Estes Park visitors. "Because Estes Park is a resort town, much of the local revenue is derived from tourism. Sales tax revenue is the primary source of government funding. Large wildfires in the Estes Park WUI and the Estes Valley have the potential to cause a significant and lengthy interruption of tourism which could damage the Town's ability to provide the current level of municipal services" (Town of Estes Park, 2009).

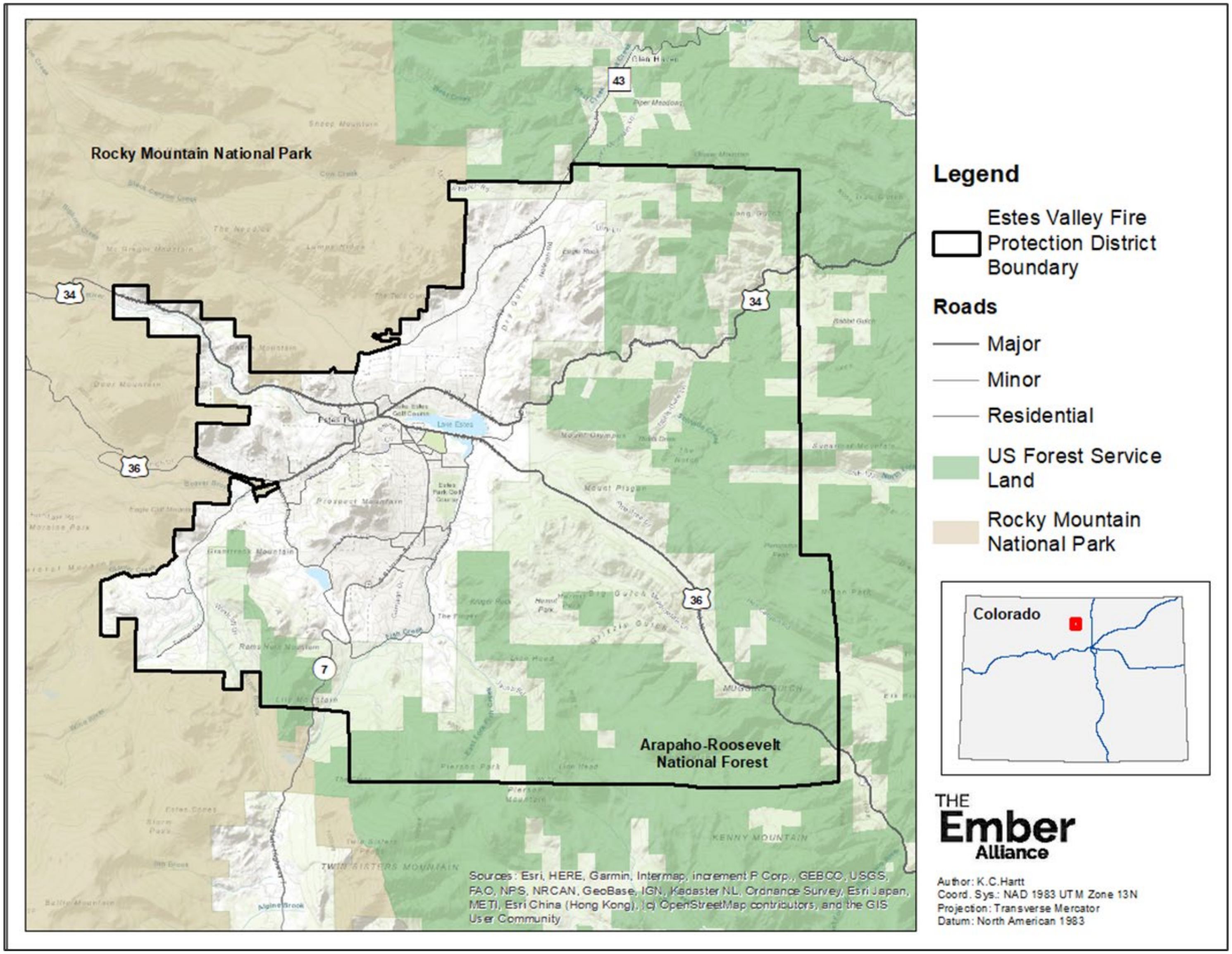


Figure 2.a.1. *Boundary of Estes Valley Fire Protection District in Larimer County, Colorado. (Source: Colorado Department of Local Affairs and OpenStreetMap).*

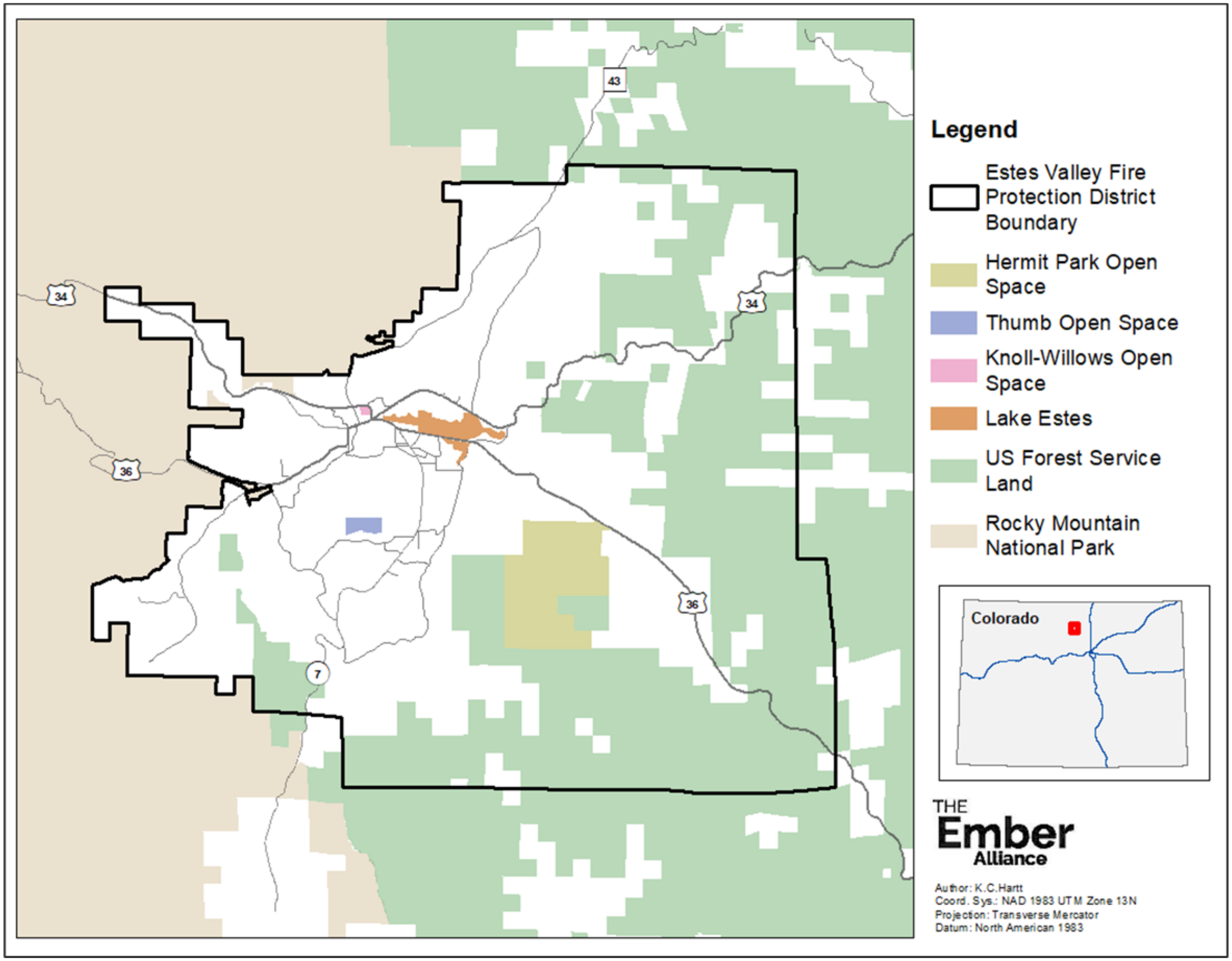


Figure 2.a.2. *Publicly owned land across the Estes Valley Fire Protection District. (Source: U.S. Geological Survey, Protected Areas Database of the United States).*

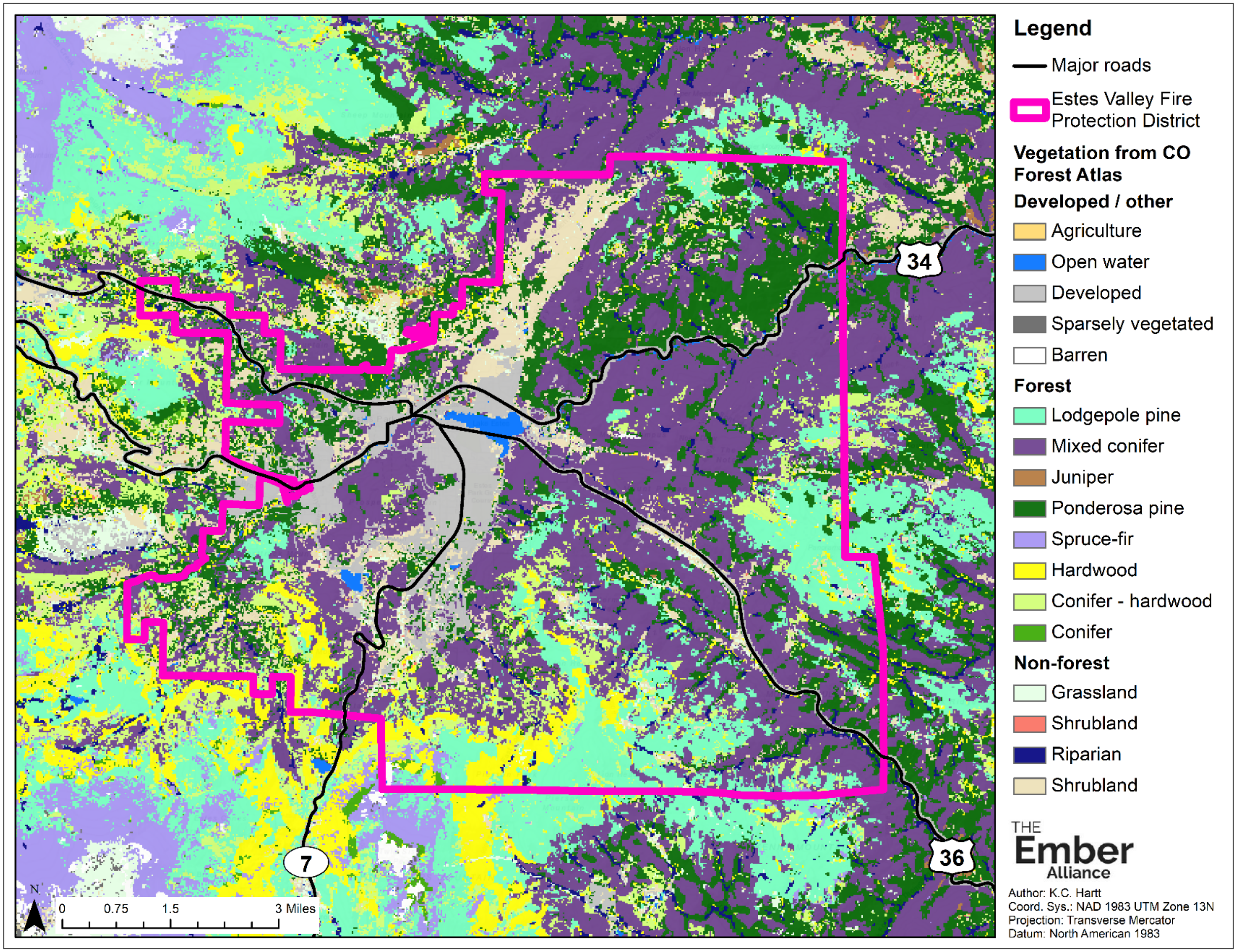


Figure 2.a.3. *Map of vegetation across the Estes Valley Fire Protection District. (Source: Colorado State Forest Service, Colorado Forest Atlas).*

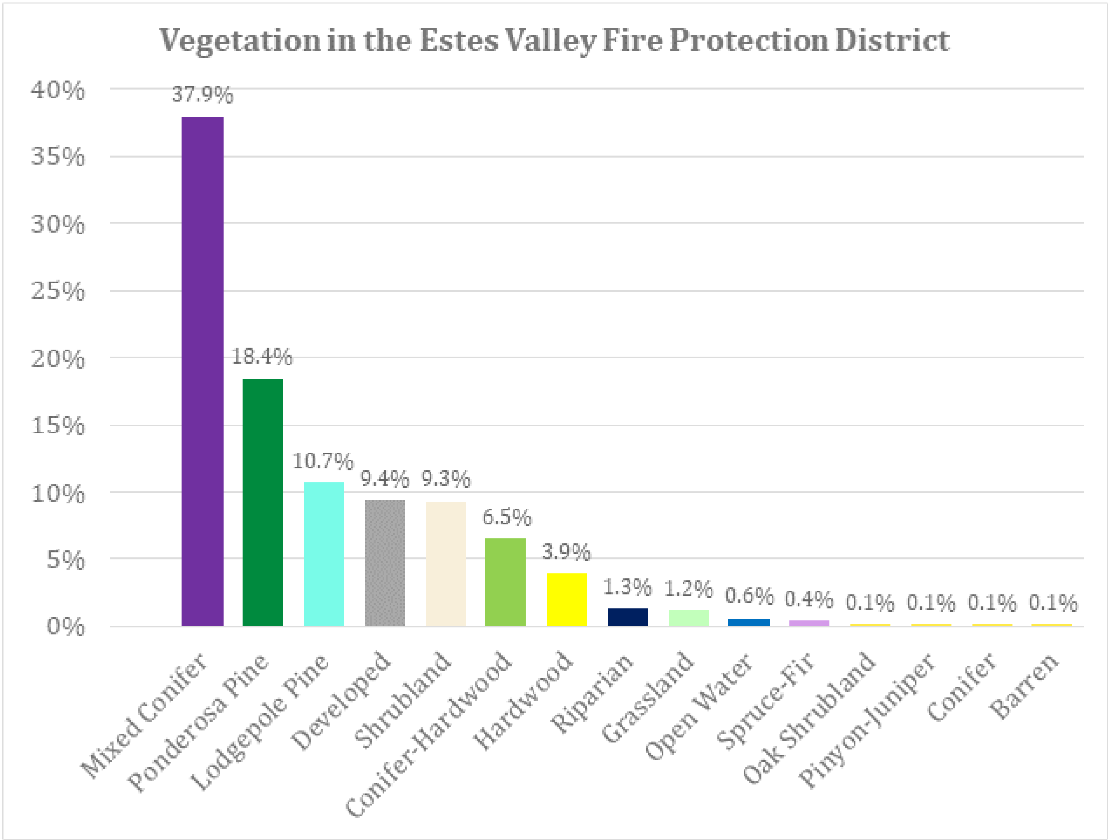


Figure 2.a.4. *The Estes Valley Fire Protection District is primarily covered with mixed conifer stands that are comprised of any of the following: white fir, subalpine fir, ponderosa pine, bristlecone pine, limber pine, Douglas-fir, Rocky Mountain juniper, Engelmann spruce, and blue spruce. The species present in conifer-hardwood are bristlecone pine, limber pine, and quaking aspen, with Rocky Mountain Juniper and Douglas-fir also commonly present. Colors correspond to the symbol legend in* ***Figure 2.a.3****. (Source: Colorado State Forest Service, Colorado Forest Atlas).*

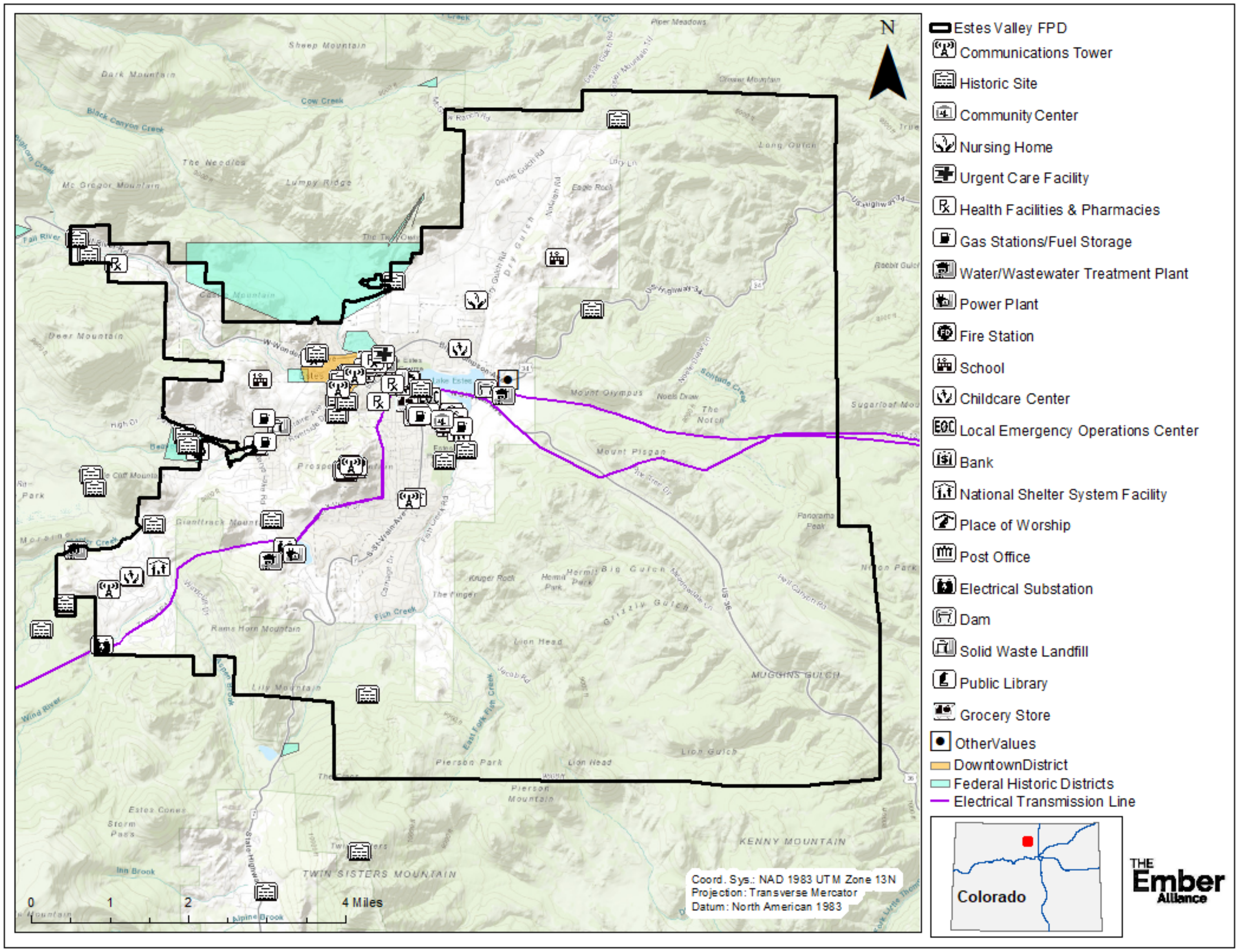


Figure 2.a.5. *Non-residential values at risk to wildfire within and around the Estes Valley Fire Protection District. (Sources: CO Department of Public Health and Environment, CO Division of Oil and Public Safety, Homeland Infrastructure Foundation-Level Data, Federal Deposit Insurance Corporation, U.S. Environmental Protection Agency, U.S. Geological Survey, and feedback from the CWPP Core Team).*

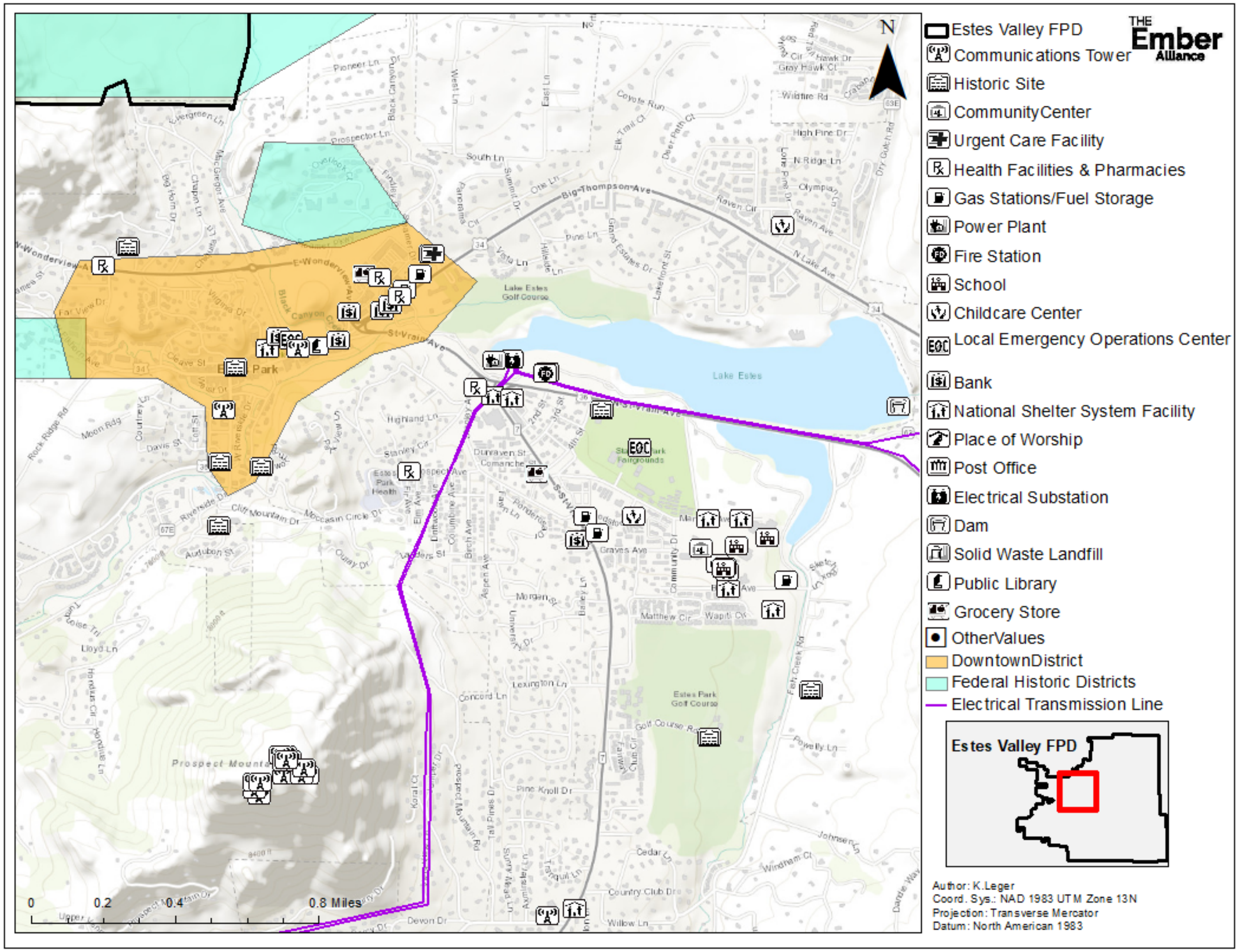


Figure 2.a.6. *Non-residential values at risk to wildfire within and around the EVFPD (focused on downtown Estes Park).*

2.b. 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 Arapaho, Cheyenne, and Ute First Nations. These indigenous groups utilized fire as a land management tool. Lightning ignited fires were common in ponderosa pine and mixed-conifer forests before European settlement in the 1850's.

Ponderosa pine and mixed-conifer forests were fire-adapted ecosystems and very resilient to wildfires. Low- to mixed-severity fires occurred every 7 to 50 years and occasional severe, stand-replacing fires (**Figure 2.b.1**). 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, which included 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 et al., 2018). 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 more open forest structure (Kalies et al., 2012; Matonis and Binkley, 2018; Pilliod et al., 2006).

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.b.2**) (Addington et al., 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 (Haas et al., 2015).

Lodgepole pine forests are part of fire-adapted ecosystems that are resilient after infrequent, stand-replacing wildfires. Research on historical conditions in lodgepole pine forests suggest they experienced high-severity wildfires every couple of centuries in northern Colorado and southern Wyoming (Higuera et al., 2021) (**Figure 2.b.1**). 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 burned previous 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 (Dennis et al., 2009; Turner et al., 2019). Fires are becoming more common in high elevation lodgepole pine and wet mixed-conifer forests due to climate change (Higuera et al., 2021).

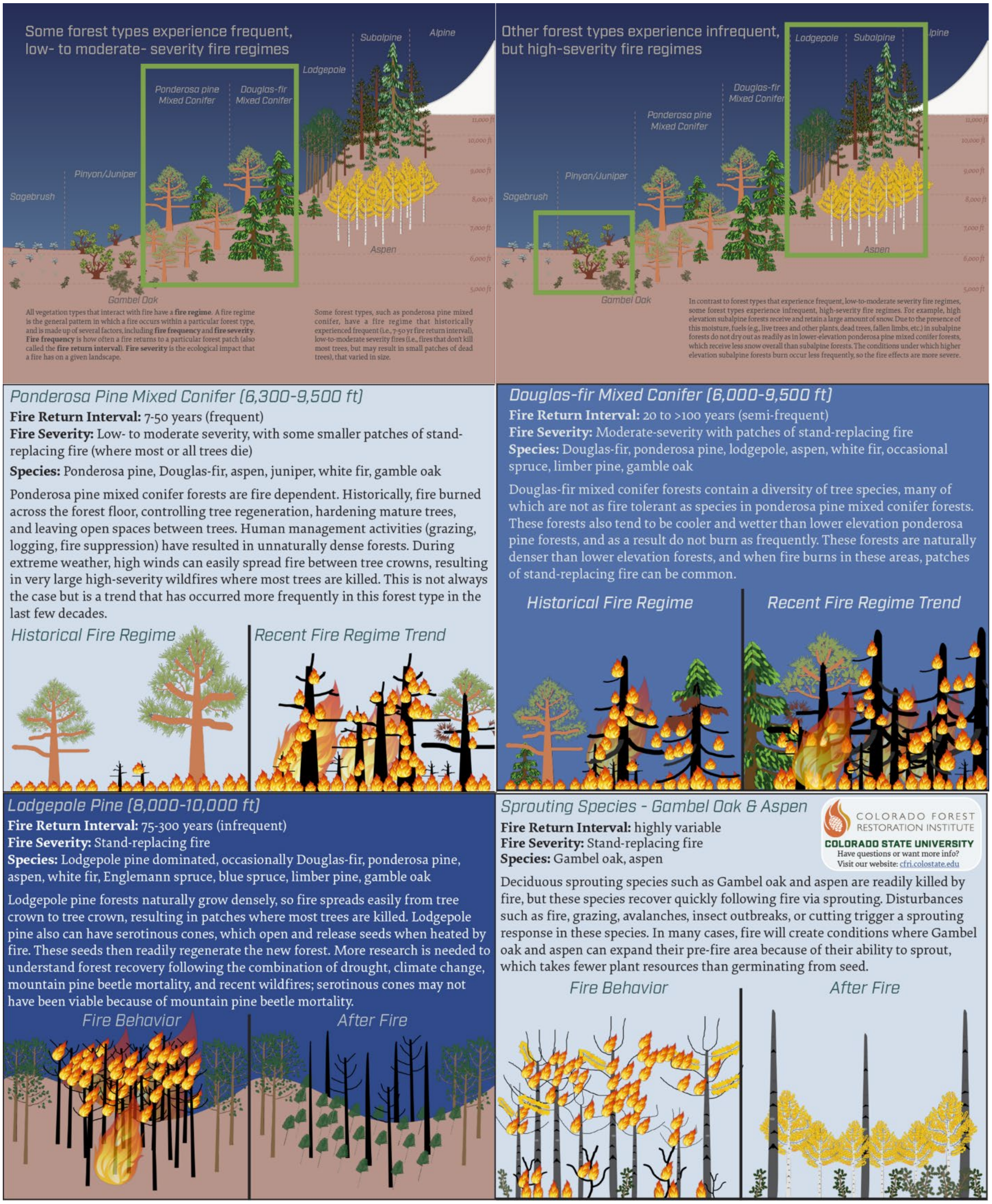


Figure 2.b.1. *Ponderosa pine forests along the Colorado Front Range historically experienced frequent fires every 7-50 years and mixed-conifer forests experienced semi-frequent fires every 20 to >100 years, resulting in less dense forest conditions than we see today. Gambel oak experienced variable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

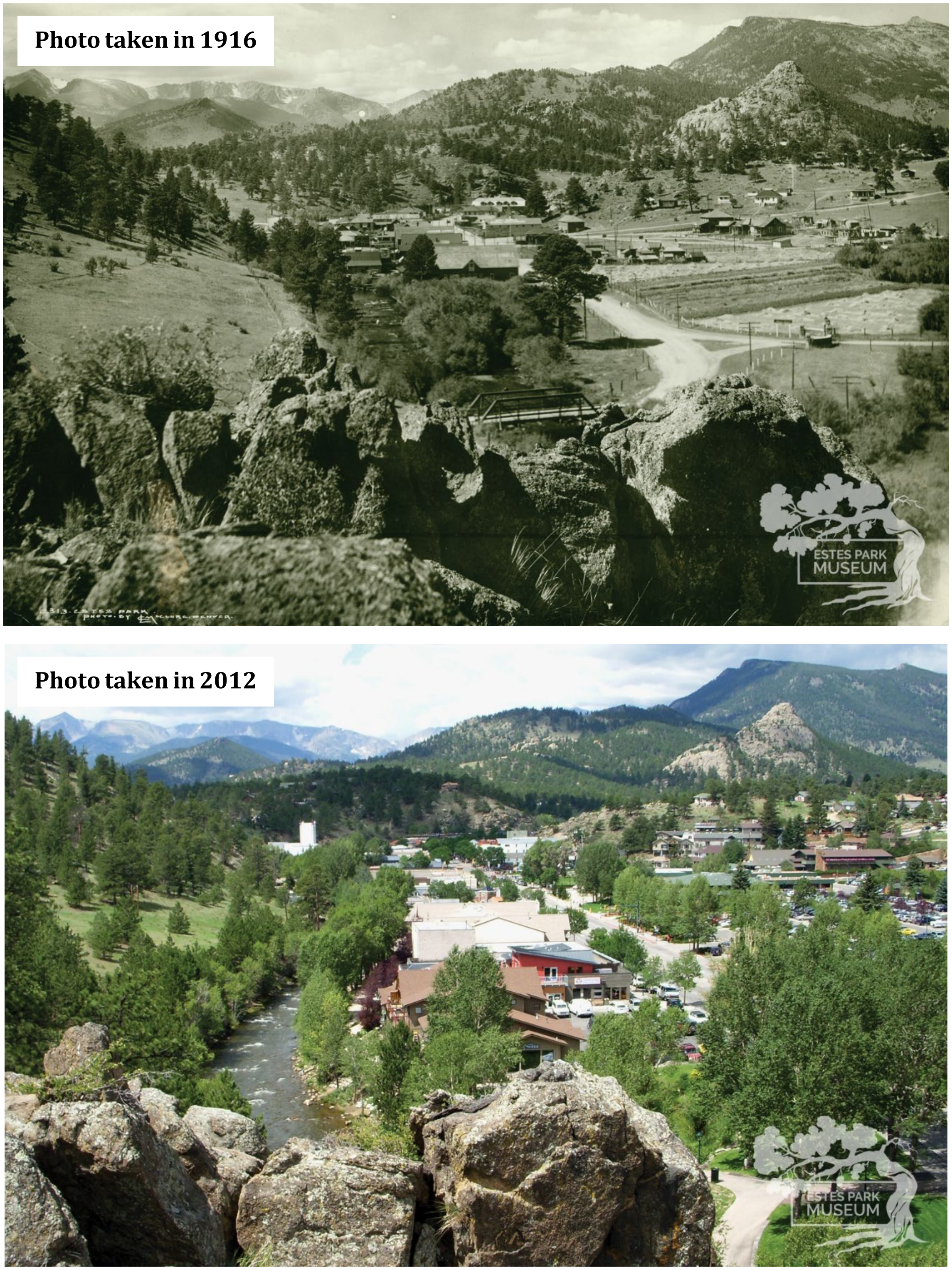


Figure 2.b.2. *Tree densities in many ponderosa pine and mixed-conifer forests are higher today than they were historically in part due to fire suppression, as demonstrated by these paired photographs taken nearly 100 years apart on the east side of downtown Estes Park. Credit: Estes Park and Rocky Mountain National Park: Then & Now; Revised Edition, copyright 2019 Estes Park Museum Friends Press, courtesy Estes Park Museum.*

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 et al., 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 (Haas et al., 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 EVFPD 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.b.3**). Red flag conditions are most common in March, April, June, and October

From 2006-2017, there were 162 fires starts in and around the EVFPD, most commonly occurring in May, June, and July, and 92% of ignitions were contained to less than 1 acre (**Figure 2.b.4**). In 2000 the Bobcat Fire burned almost 10,000 acres The 2002 Big Elk Fire burned over 4,000 acres and took the lives of three pilots. It was caused by cars parking on dry grasses. The 2010 Cow Creek Fire burned 1,000 acres on the north side of RMNP. The 2012 Fern Lake Fire, started by an illegal campfire, burned 3,500 acres in RMNP and prompted evacuations in Estes Park, and the same year the Woodland Heights Fire burned homes and prompted evacuations on the west side of Estes Park.

2020 was a critical year for residents of the EVFPD. The Cameron Peak Fire loomed over the horizon for months, and the East Troublesome Fire spotted over the continental divide, prompting a valley-wide evacuation and threatening the town. These two fires became the two largest wildfires in state history, and though they never entered the district's boundaries, they hung heavy on the community for months as they grappled with evacuations, park closures, and additional lost tourism revenue on top of the pandemic. EVFPD responded to both fires for an extended period of time, along with numerous other agencies, to protect the district. The East Troublesome Fire was stopped less than half a mile from the edge of the district boundary.

The potential for a large wildfire that exceeds the suppression capacity of local firefighting resources remains high. 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.b.5**).

Take Away Message

The Estes Valley Fire Protection District 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. The Estes Valley Fire Protection District and residents in the EVFPD must prepare for large wildfire events. Proactive work is imperative.

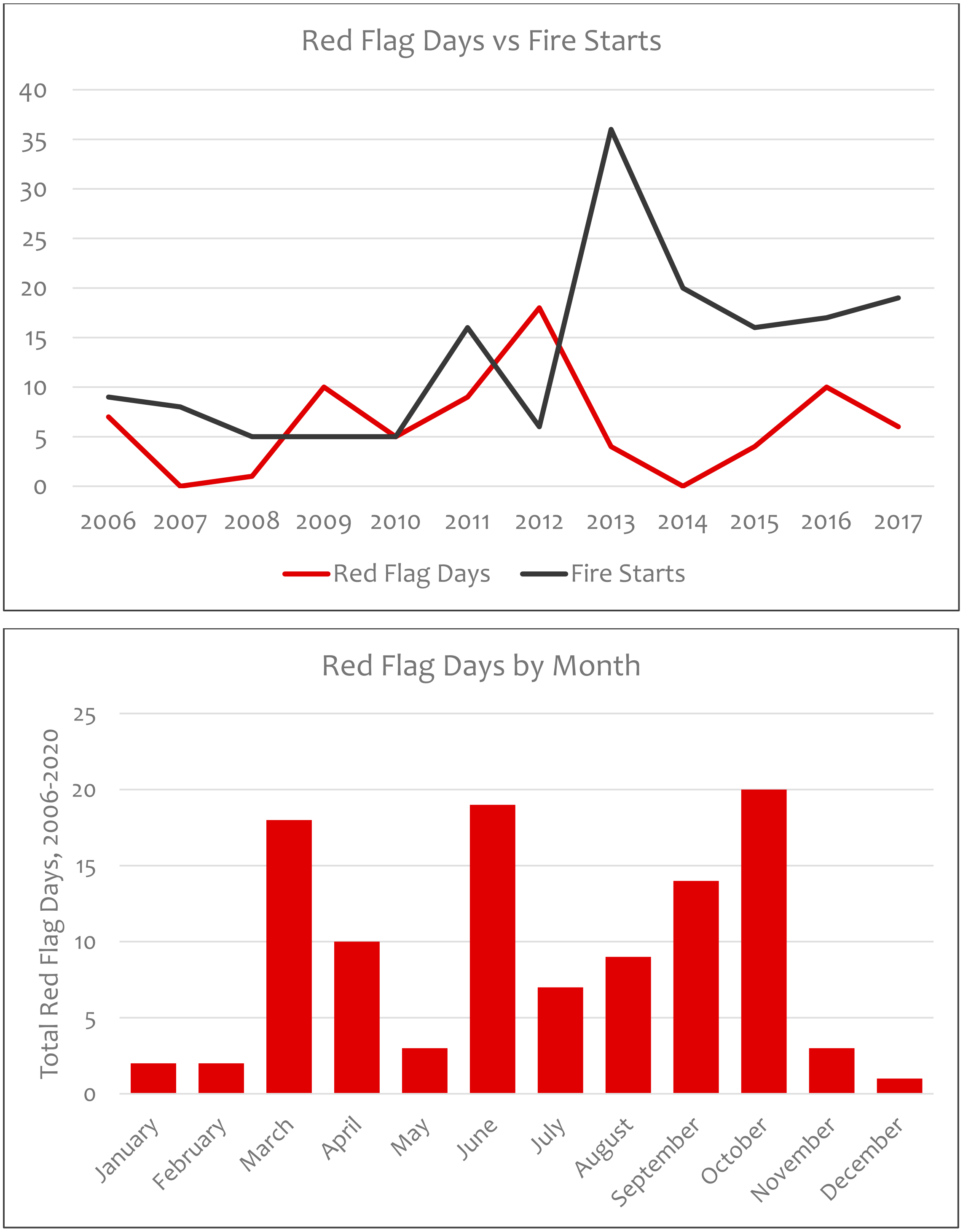


Figure 2.b.3. *Top: Red flag days and wildfire ignitions by year from 2006 to 2017. Bottom: Total number of red flag days in each month from 2006 to 2020. March, April, June, and October and the most common months for experiencing red flag weather. Data on historical red flag warnings were available for 2006 to 2020 and data on fire ignitions were available for 2003 to 2017. (Sources: Iowa State University, Iowa Environmental Mesonet, and Colorado State Forest Service, Colorado Forest Atlas).*

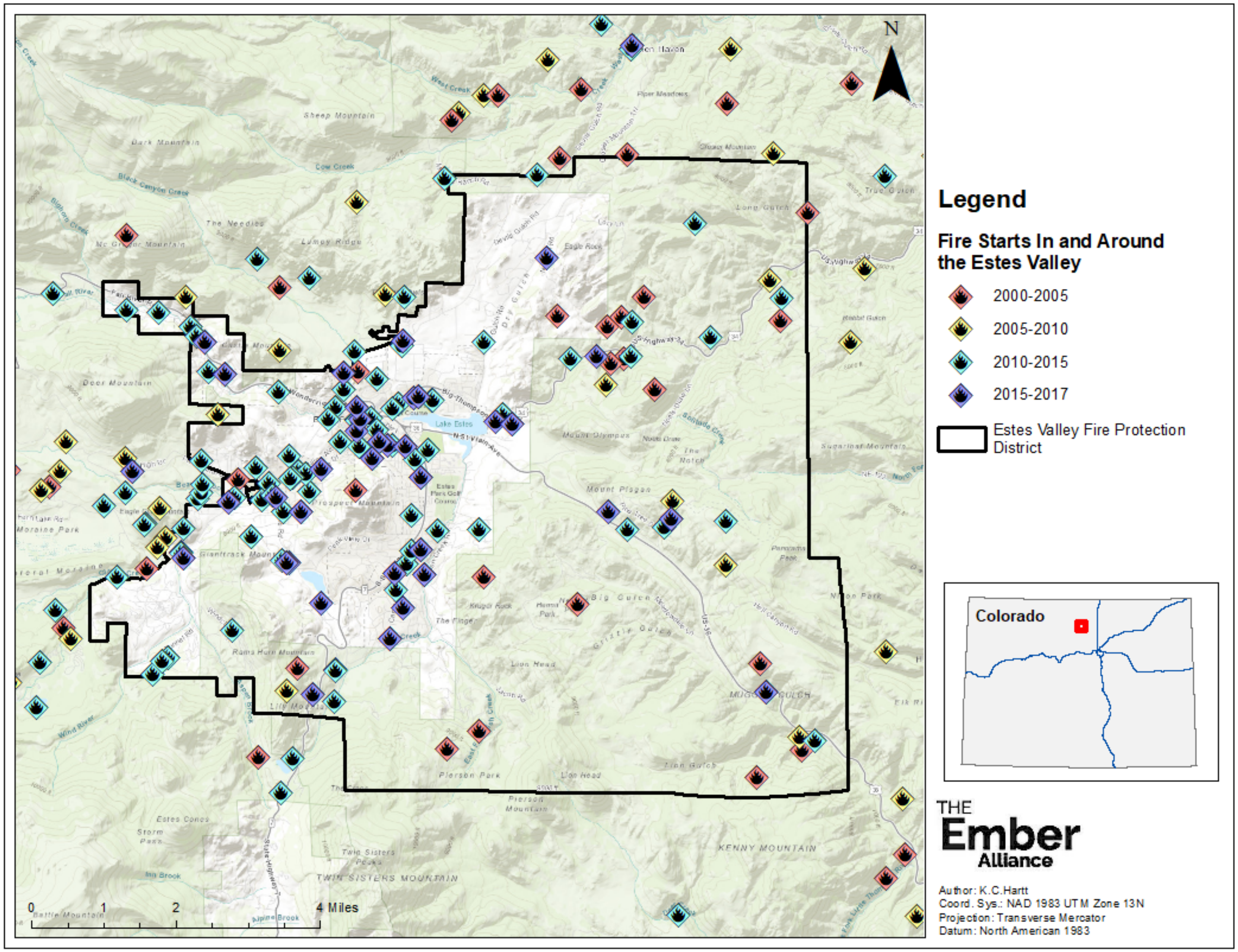


Figure 2.b.4. *Fire starts in and around the Estes Valley Fire Protection District from 2000 to 2017. 92% of ignitions were contained to one acre or smaller. (Source: Colorado State Forest Service, Colorado Forest Atlas).*

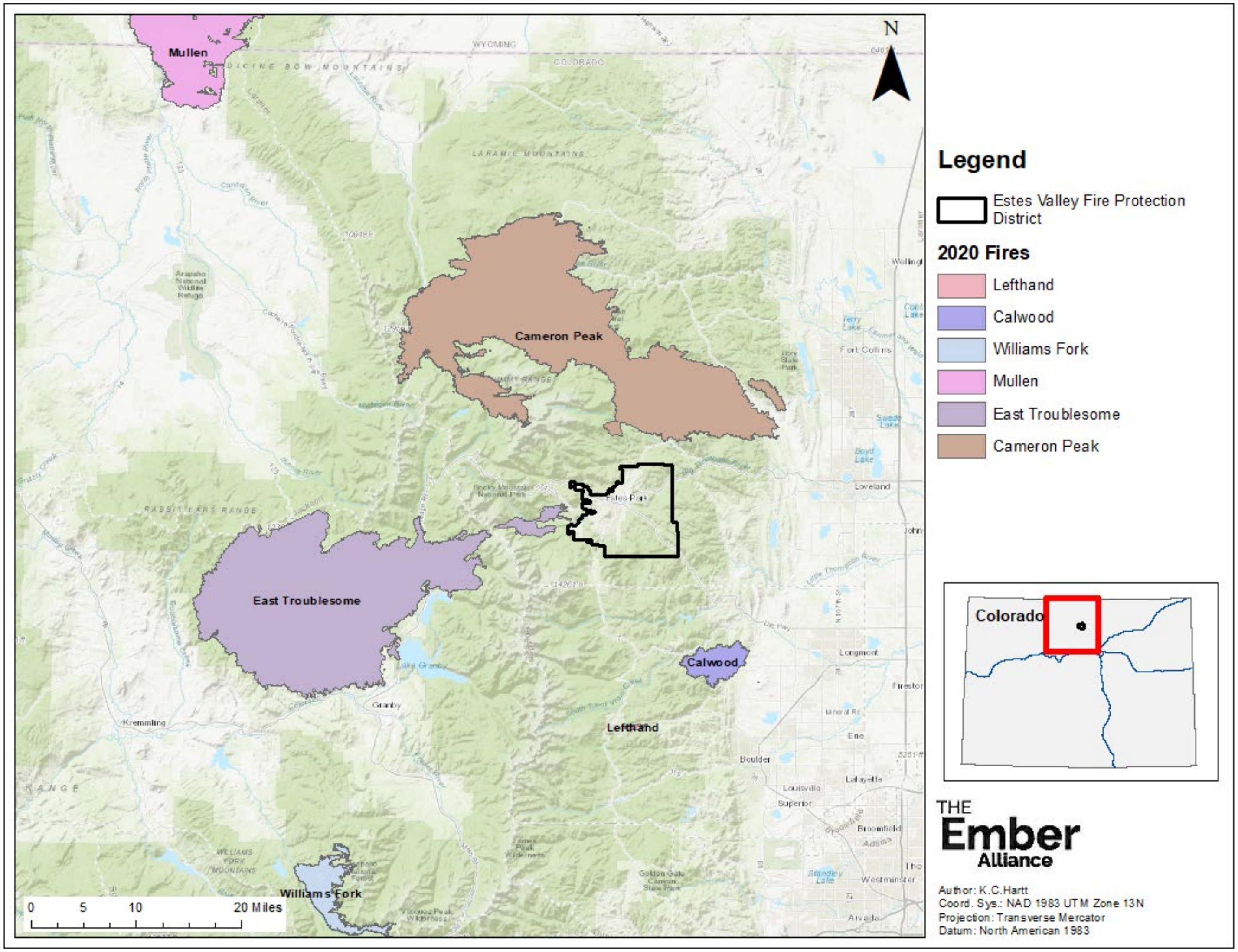


Figure 2.b.5. *Extent of 2020 wildfires along the Colorado Front Range relative to the Estes Valley Fire Protection District. The East Troublesome Fire burned within a quarter mile of the EVFPD and prompted valley-wide evacuations in 2020. (Source: National Interagency Fire Center).*

2.c. Fuel Treatment History in and Around the EVFPD

Forests have been actively managed in the Estes Valley for decades. Multiple agencies and landowners have engaged in a variety of fuels management strategies to reduce wildfire risk and improve forest health (**Figure 2.c.1; Figure 2.c.2**). Some key programs are highlighted below.

Fuel treatments in Rocky Mountain National Park create opportunities for firefighters to engage with wildfires along tactical features like Bear Lake Road. Photo credits: National Park Service (top) and Colorado Forest Restoration Institute (bottom).

Rocky Mountain National Park has active fuels management and forest health programs. Much of RMNP's work has been focused on the eastern edge of the park boundary to protect Estes Park from fires leaving the park. Much of this work is focused on burning slash piles in areas where thinning has occurred, but some broadcast burning has been conducted around the Beaver Meadows Visitor Center and the surrounded grasslands and timber. Firefighters benefitted from using these fuel treatments as tactical features during the 2020 East Troublesome Fire, and it is possible these treatments helped prevent wildfire damage in Estes Park (Good, 2020).

The United States Forest Service likewise has active fuels and forest management programs in the Estes Valley area. Most USFS land is to the east and northeast of the district, but significant thinning and pile burning has been completed in these areas. Although much of the work to date has involved burning machine piles, ongoing work as of 2022 focuses on the burning of smaller hand piles in the Cedar Park area.

Although not a significant landowner in the area, Estes Park Power & Communications (EPP&C) manages infrastructure and right-of-ways with the potential to either contribute to or be impacted by wildfires. EPP&C engages in proactive and reactive fuels management to mitigate hazards fuels and the potential for ignitions. This involves identifying and mitigating trees that could impact electric supply lines, brushing, mowing, and tree-removal around distribution lines, and other activities.

Private landowners have worked on their own and with organizations such as CSFS and Larimer Conservation District to implement fuels treatments on private lands. Projects range from less than an acre to hundreds of acres, and while this work cannot be captured on all our maps, it has nonetheless improved the resiliency of the Estes Valley.

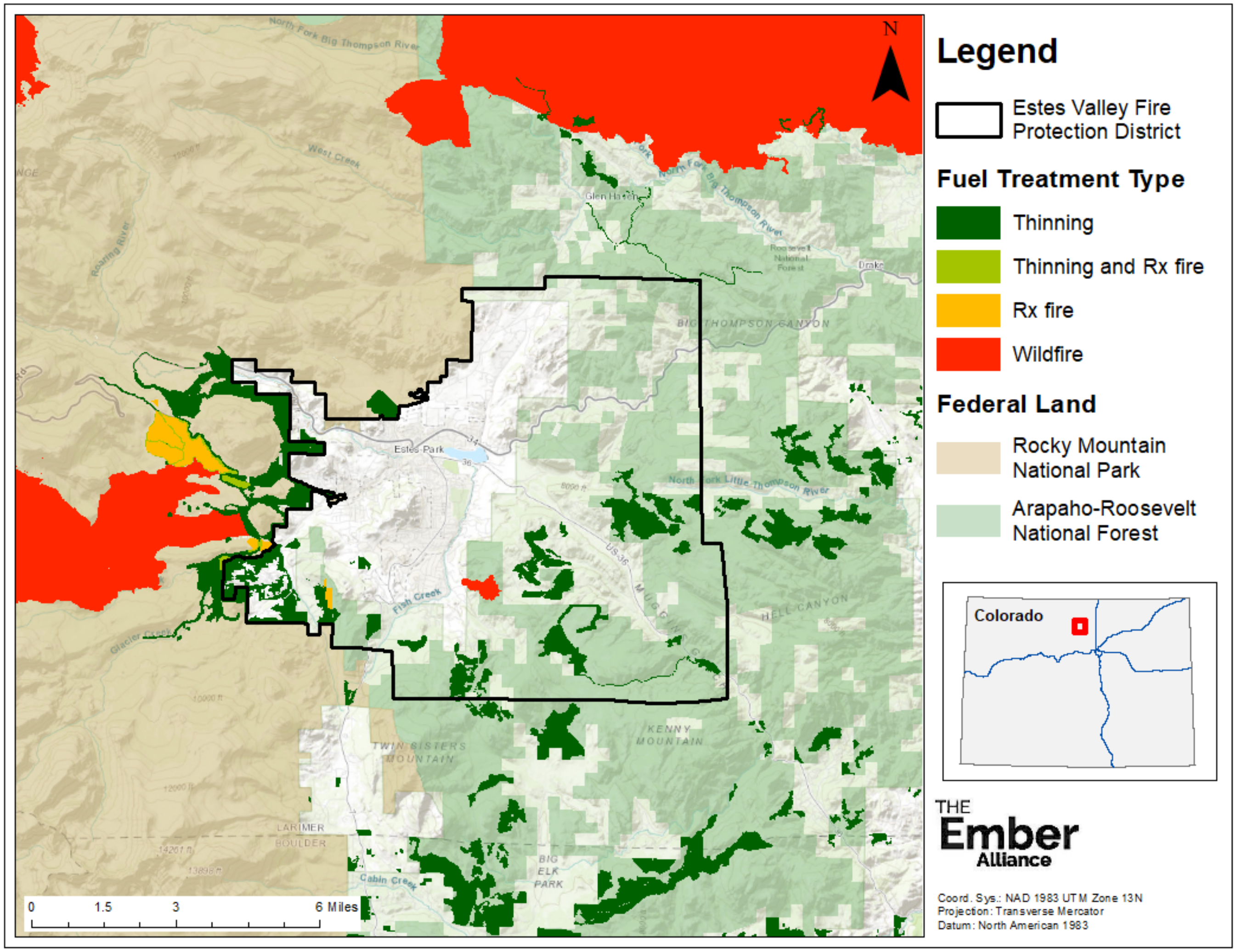


Figure 2.c.1. *Locations of forest management treatments conducted by the USFS, RMNP, CSFS, and private landowners in and around the EVFPD. RMNP has completed extensive fuels treatments inside the park at the eastern border to assist in protecting the town of Estes Park. Wildfires that occurred in the past 10 years are included: Cameron Peak, East Troublesome, Fern Lake, and Kruger Rock (Source: Colorado Forest Restoration Institute, data available through 2018; U.S. Forest Service, data available through 2021; National Park Service, data available through 2018).*

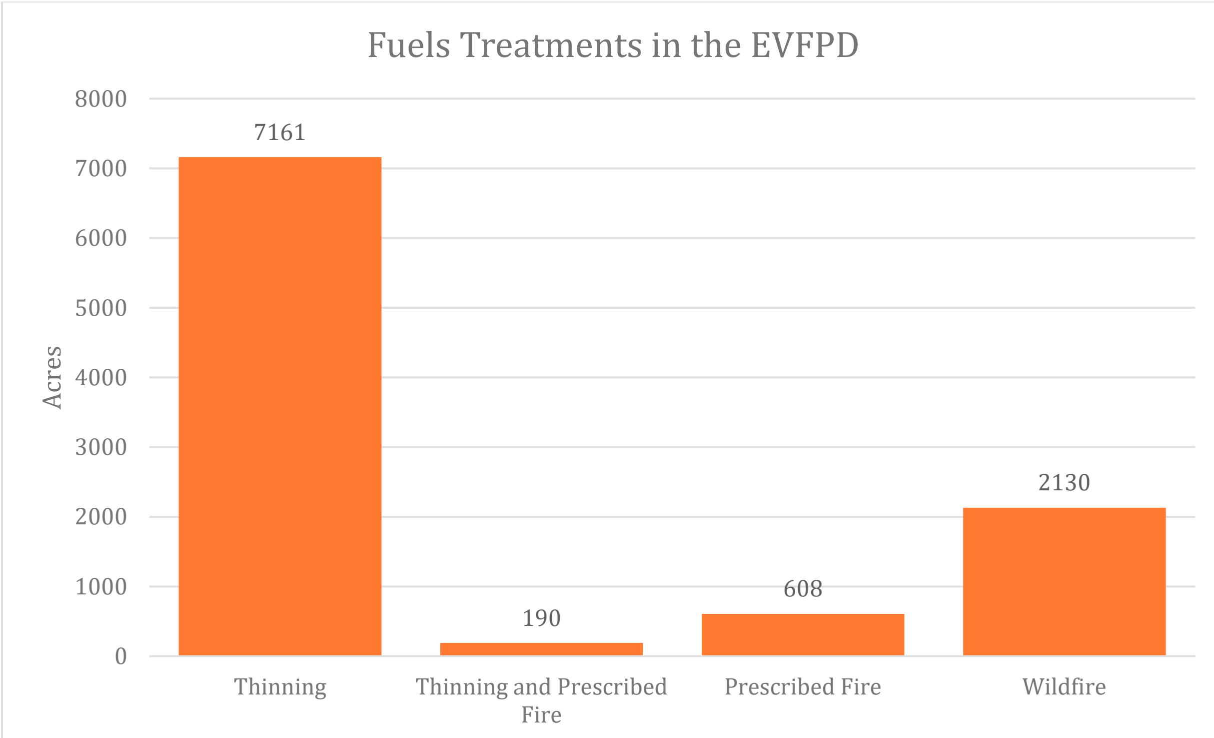


Figure 2.c.2. *Acres of forest management treatments from conducted by the USFS, RMNP, and private landowners within two miles of the EVFPD. (Source: Colorado Forest Restoration Institute, data available through 2018).*

2.d. Wildland-Urban Interface

The Wildland-Urban Interface (WUI) is any area where the built environment meets wildfire-prone areas—places where wildland fire can move between natural vegetation and the built environment (Forge, 2018). People that live and work in the WUI must be aware of the effect that ecosystem processes and disturbances, such as wildland fire, have on their lives. WUI exists along a continuum of wildland to urban densities (**Figure 1.c.4**). Wildland-urban intermix refers to areas where housing and wildland vegetation intermingle, while wildland-urban interface refers to areas where housing is in the vicinity of a large area of dense wildland vegetation (Martinuzzi et al., 2015).

All residents of the Estes Valley Fire Protection District live in the WUI (**Figure 2.d.1**). Over the past 50 years, immigration to the mountains along the Colorado Front Range has increased the number of occupied structures within this historically forested landscape. This population change has increased not only the density and size of the WUI, but also increased the risk of structure loss from wildfire and the likelihood of fire starts.

According to the 2020 Wildfire Risk to Communities analysis by the U.S. Forest Service, homes in Estes Park and the surrounding areas have a higher risk of fire than 89% of the communities in the state of Colorado (USFS, 2021a). High fire risk is common to many WUI communities along the Colorado Front Range (Radeloff et al., 2018). Damages from wildfires in the Colorado's WUI can be extensive, as demonstrated by the 2013 Black Forest Fire that destroyed 511 structures, and the 2020 East Troublesome Fire that destroyed at least 366 structures, and the 2021 Marshall Fire that destroyed over 1,000 structures.

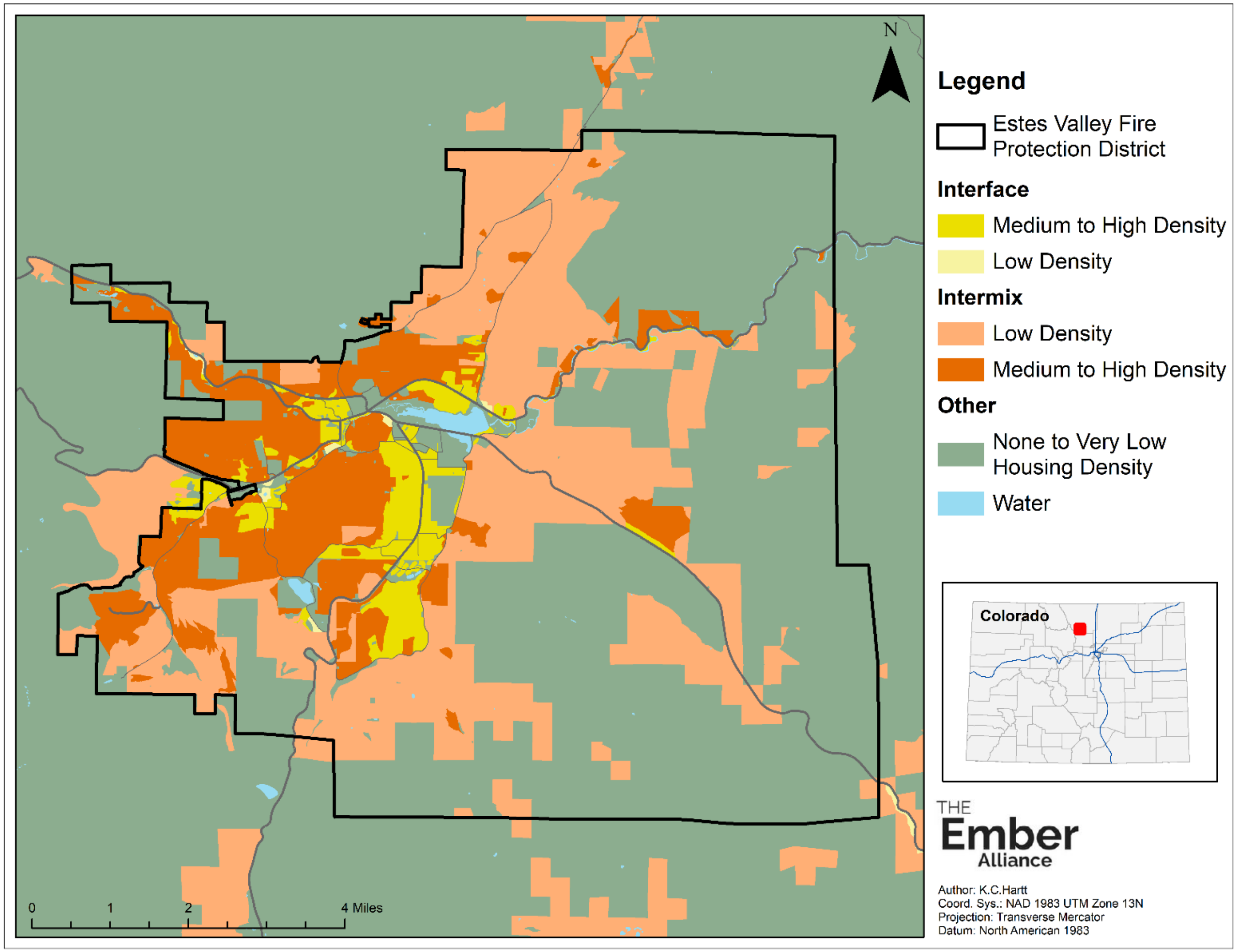


Figure 2.d.1. *Wildland-Urban Interface and Intermix in the Estes Valley Fire Protection District displayed by housing density, proximity to wildland vegetation, and cover of wildland vegetation, as defined and mapped by the U.S. Forest Service. (Source: Martinuzzi et al., 2015 with modifications based on local knowledge).*

2.*e.* Resident Preparedness for Wildfire

Residents in the EVFPD are generally not adequately prepared for wildfires. This varies from home to home, but most homes surveyed in on-the-ground driving assessments conducted by TEA do not have adequate defensible space and home hardening measures. Residents were prepared enough for emergency evacuations during the 2020 fires and the evacuation went as smoothly and quickly as the fire district and county anticipated. This was under favorable conditions, where there were very few visitors because RMNP was closed, school was not in session that day, and the community had been bracing for a large wildfire for weeks with the Cameron Peak Fire burning to the north. Under different conditions, evacuations could be significantly less smooth and timely.

The EVFPD evaluated each of the communities in the district during the process of writing this CWPP and discovered that most neighborhoods have no or inadequate defensible space around homes, that some driveways and roads are too small for a Type 3 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; Appendix C. Focus Group and Survey).** Increasing resident preparedness is a primary goal of this CWPP, and specific recommendations for residents to take are outlined in the document.

2.*f.* District Capacity

EVFPD was a volunteer fire department from 1907 to 2009. They have had paid staff since 2010 and currently have seven full time staff members: a Fire Chief, Chief of Staff, Division Chief of Operations, Division Chief of Support Services, Training Lieutenant, and two Fire Inspectors. They also employ a part-time Administrative Assistant. There are 35 volunteer firefighters that include two Captains, four Lieutenants, and four squads of firefighters.

EVFPD maintains a fleet for structural and wildland firefighting. They have two Type 1 engines, one Ladder Engine, two Type 3 engines, one Type 6 engine, two wildland water tenders, a technical rescue squad, a utility pickup, two command vehicles, and two support vehicles. They operate at stations, primarily out of Station 71 at 901 N Saint Vrain Ave and occasionally out of Station 72, which is shared with Rocky Mountain National Park's fire fleet at 1600 Mills Drive in Estes Park. They operate a regional training facility at 640 Elm Road with a three-story Class A burn building and other infrastructure to support firefighter training. Staff and volunteers train weekly and advanced trainings are offered regularly. On average, volunteers receive 200 hours of training per year in structural and wildland firefighting. For more details on district capacity, see **Description of District Capacity** in the appendix.

As of 2022, the EVFPD holds an ISO rating of 3/10 for homes within 5 miles of a fire station and 10/10 for homes further than 5 miles away. The ISO rating is given by the Insurance Services Office that assesses a fire department's capacity to respond to structure fires. A 1/10 is the highest rating and a 10/10 is the lowest rating.

EVFPD Engine 31, a Type 3 wildland firefighting engine. Photo courtesy of EVFPD.

2.g. Community Values at Risk

Healthy forests provide a variety of ecosystem services such as the provisioning of clean water, flood regulation, carbon sequestration, wildlife habitat, recreational opportunities, and cultural and spiritual value (Millennium Ecosystem Assessment, 2003). These ecosystem services generate revenue for communities in the wildland urban interface, such as Estes Park. Severe wildfire poses a direct threat to a forest's ability to provide these services and can have detrimental economic impacts on communities such as Estes Park.

Rocky Mountain National Park (RMNP) is one of the most visited National Parks in the country. Due to its proximity to RMNP, tourism is a staple of Estes Park's economy. 2020 saw a significant decrease in RMNP visitation due to both COVID-19 and the Cameron Peak and East Troublesome wildfires. From 2019 to 2020, there was a drop of over 1.3 million visitors to Rocky Mountain National Park (NPS, 2021). As a result, the local economy of Estes Park suffered. According to Estes Park's Annual Financial Report for 2020, sales tax collections dropped 7.4% in 2020 compared to 2019 (Town of Estes Park, 2021). Fortunately, the local economy started to bounce back once height of the pandemic's impact passed. Nevertheless, 2020 can give us insight into more permanent impacts that a severe wildfire would have on the local economy.

From a recreation perspective, wildfires can significantly compromise the tourist experience. People from all around the country, and the world, are drawn to RMNP for its lush forests and diverse wildlife. When forests are decimated by severe wildfires, and wildlife habitat destroyed, this decreases the value of the natural area for visiting tourists. According to Lee, wildfires that have occurred throughout the western US resulted in significant decreases in campsite reservations for six years following a wildfire. This decrease was due to the altered aesthetic of the campsites, as well as unsafe conditions in the forest from standing dead trees (Lee, 2020). For a town like Estes Park that relies so heavily on tourism, this decrease in visitation will have serious impacts on the local economy. Similarly, a study by Kim and Jakus looked at wildfire impacts on National Park visitation in Utah and found that local economies lost between $2.7-4.5 million during wildfire season, as well as about 50 jobs (Kim and Jakus, 2019).

In addition to tourism, the provisioning of clean water and flood regulation are two critical ecosystem services that are adversely impacted by wildfire. Extreme wildfires can result in soil that is hydrophobic (i.e., the soil is not able to absorb water). This means that, when heavy rains occur following an extreme wildfire, the water will run off the soil's surface and cause a flash flood. In 2013, Northern Colorado experienced an extreme rainfall event that resulted in flooding of the Big Thompson Canyon that caused millions of dollars in damages and impacted the local economy of Estes Park. The two months following the flooding (September and October 2013) saw a 26.25% decline in sales tax revenue—a combined loss of $462,723 (Mosier, 2020). This figure doesn't account for the millions of dollars in post-flood recovery costs, such as infrastructure damages. For example, it took a total of five years, and over $300 million for flood damages along Highway 34 to be repaired (Blumhardt, 2021). Wildfire mitigation can prevent future flooding events and should therefore be prioritized in communities such as Estes Park.

Another important thing to consider is the adverse health impacts of smoke from wildfires. A study conducted by Gellman et al. (2022) revealed that across 30 National Parks in the western US, smoke affects 1 million visitors annually. This same study showed that wildfire smoke often doesn't deter tourists from visiting parks with poor air quality, which results in adverse health impacts over time (Gellman et al., 2022). This makes wildfires in towns such as Estes Park not only an economic concern, but a public health concern as well.

Gatlinburg, Tennessee serves as an example of just how destructive wildfire can be to a tourism economy. Gatlinburg is the gateway to the Great Smoky Mountains National Park—the most visited National Park in the country. Like Estes Park, the economy of Gatlinburg relies on tourism. In 2016, The Chimney Tops 2 Fire devastated the town of Gatlinburg. It burned a total of 18,000 acres (11,000 acres within the Great Smoky Mountains National Park), 2,400 structures, and killed 14 people (Barrett, 2016). In total, the fire resulted in $500 million in damages to the town of Gatlinburg (Barrett, 2016). It has taken years for the town's economy to recover, and it may never return to the level it was pre-Chimney Tops fire. Gatlinburg serves as a cautionary tale, and emphasizes the importance of wildfire mitigation, especially in towns that rely on tourism.

Without doing an extensive quantitative economic assessment, it cannot accurately be predicted the revenue that would be lost as a result of extreme wildfire in Estes Park. However, it is safe to say that the local economy would suffer greatly from a significant decline in sales tax revenue from visiting tourists, and damages to infrastructure and natural resources that would result from such an event. Even though wildfire mitigation efforts can be expensive, they are nothing compared to the detrimental economic losses that occur following extreme wildfires. Wildfires are only expected to increase in severity and frequency in the years ahead. Towns like Estes Park must prioritize wildfire mitigation and preparedness to protect their invaluable natural resources and tourist economy.

There are many different approaches to assessing risk, and the analyses used for this assessment are informed by fire behavior modeling and burn probability. These approaches are limited by the spatial unit of analysis for fire behavior simulations (30 m^2), industry shortcomings in simulating extreme fire behavior, and ongoing research into contributing factors for structure loss. Nevertheless, risk assessments can help inform planning and decision making as they relate to prevention and mitigation and are thus a useful tool for addressing complex coupled socio-ecological systems like the fire environment.

Critical infrastructure is generally minimally exposed, with a few key exceptions (**Figure 2.g.1**). Communication equipment are at potentially very high risk on Prospect Mountain. This presents a significant risk to responders and emergency communications to the public. Radio equipment has been damaged during other wildfires elsewhere in the country and despite communication equipment construction materials, mitigation efforts should focus within this area.

Some energy infrastructure, such as the East Portal and Mary's Lake Powerplant, are exposed to either elevated flame lengths, burn probability, or both. Energy infrastructure is critically important for long-term recovery within a community and mitigation of these areas could provide significant benefits in the event of a large wildfire.

Cultural and historic sites are spatially disparate but highly exposed to wildfires. Although important for economic and cultural reasons, they do not contribute to immediate life safety or stabilization concerns. Mitigation for these values could contribute to longer term economic vitality due to their tourism value; cultural impacts of these values, while less readily quantified, should be considered as well.

Various educational, youth, and medical facilities are at risk. The YMCA has significant elements at risk, as does the UNC campus and the Eagle Rock School. While many medical facilities are more centrally located in town and more protected from embers and fire behavior, the Harmony Foundation facility is at risk from both.

Ultimately, any wildfire risk assessment should be considered as describing the *minimum* potential risk. Fire behavior is notoriously difficult to predict and underprediction of flame lengths and rates of spread are common. These limitations ultimately underpredict burn probability as well as derived metrics such as ember cast potential. Processes like the FEMA stabilization guide and others are important for prioritizing how to balance the needs of a community with information derived from risk assessments.

Structures across the EVFPD could be exposed to radiant heat, short-range ember cast, or long-range ember cast. Radiant heat can ignite homes when extreme fire behavior (flame lengths > 16 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 structures in advance of the flaming front of a fire. Under extreme fire weather conditions, 24% of homes in the EVFPD are at risk of short-range ember cast and 87% are at risk of long-range ember cast (**Figure 2.g.2**). Potential exposure to long-range ember cast is ubiquitous across the EVFPD, underscoring the importance of home hardening measures even in the interior of the EVFPD. Recommendations to residents for reducing wildfire risk to their homes are covered in the **Individual Recommendations** section of this CWPP.

The analysis of potential exposure to radiant heat and ember cast is useful for informing estimating potential economic losses during a wildfire. During the 2018 Camp Fire, greater than 90% of structures were in Paradise, CA were destroyed (Knapp et al., 2021). Assuming conservatively that only structures with exposure to radiant heat and short-range and/or long-range ember cast are impacted by a similar scenario and an average home value of $630,000 (Zillow Inc., 2021), assessed structure losses could exceed $1 billion in the EVFPD. This could result in valuation lost to revenue for special Districts, leading to as much as $5,250,000 in lost tax revenue for schools, recreation, the library, and fire districts. See **Non-Residential Values At Risk** and **Values at Risk** in the appendix for more information.

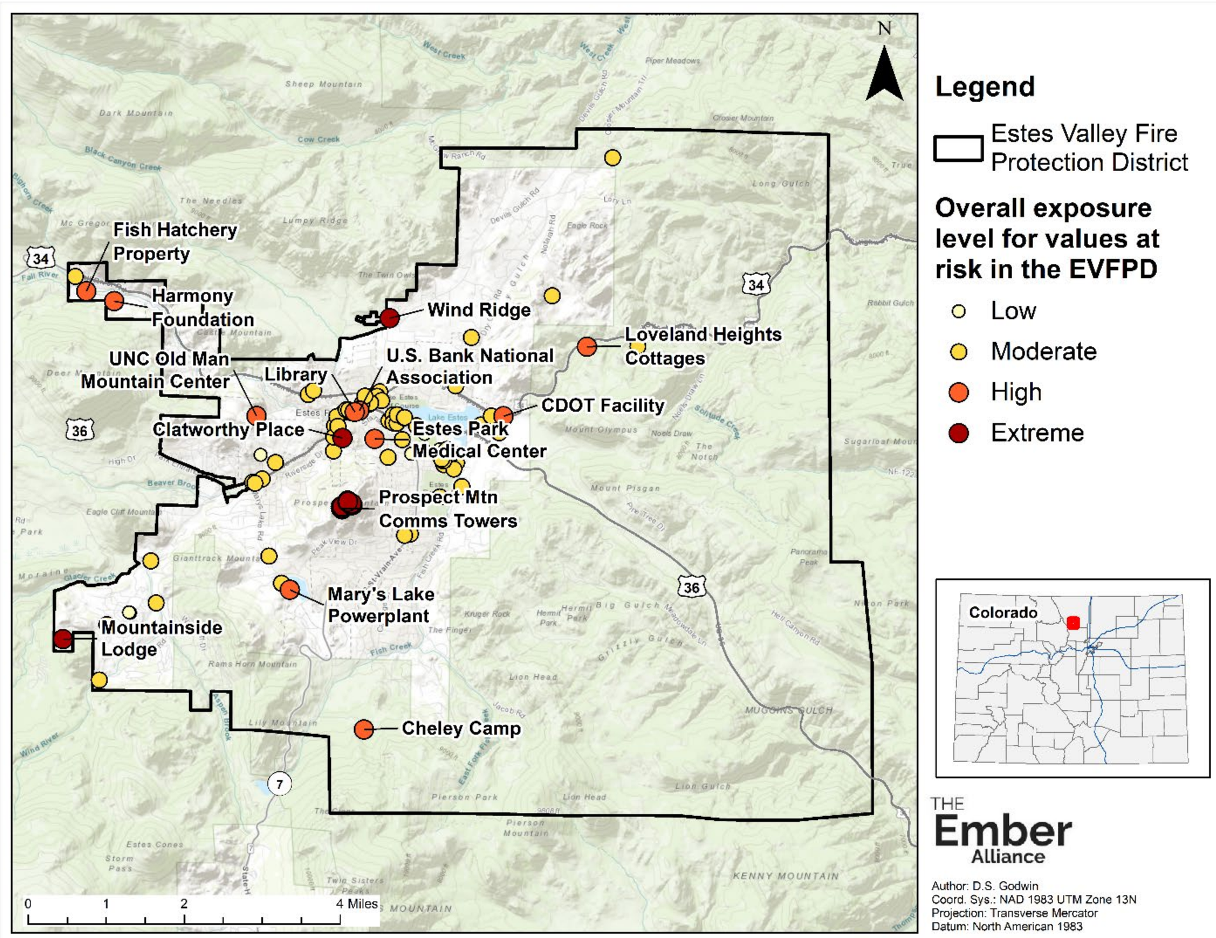


Figure 2.g.1. *Values at risk of exposure to embers and radiant heat. Only values that experienced "high" or "extreme" exposure are labeled. Low exposure = potential exposure to long-range ember cast. Moderate exposure = potential exposure to long-rang ember cast and short-range ember cast. High exposure = potential exposure to long-range ember cast or short-range ember cast and radiant heat. Extreme exposure = potential exposure to long- and short-range ember cast and radiant heat.*

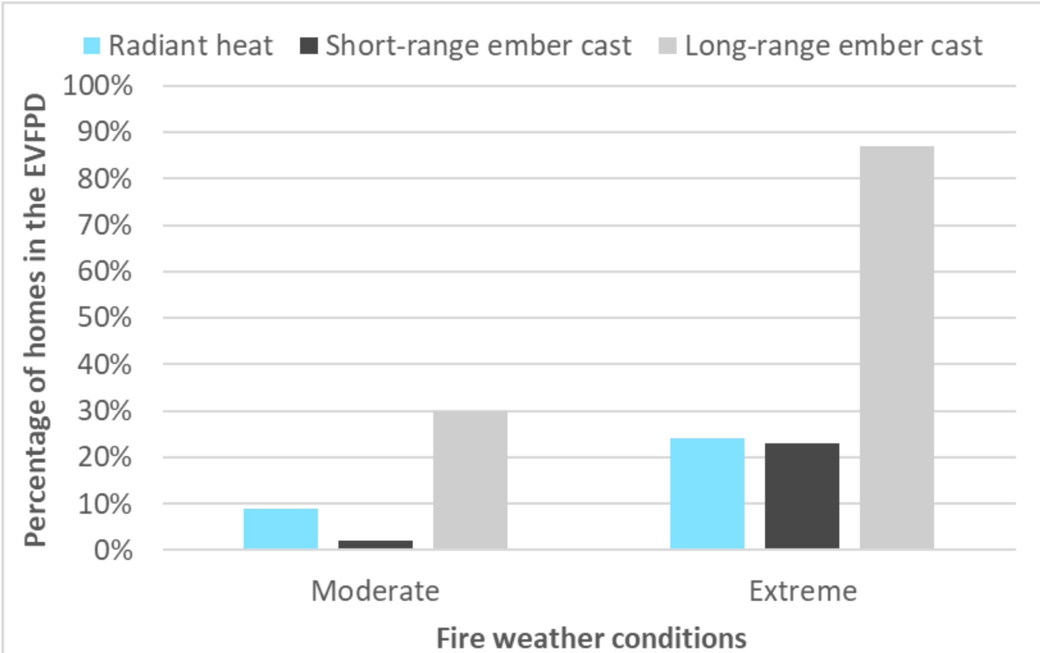


Figure 2.g.2. *Percentage of homes potentially exposed to radiant heat and short-and long-range ember cast under moderate and extreme fire weather conditions in the EVFPD. See Appendix A.3.* ***Predicted Radiant Heat and Ember Cast Exposure*** *for analysis methodology.*

2.*h.* Accomplishments Since the Previous CWPP

Estes Valley Fire Protection District

- Estes Valley Fire Protection District became a special district in 2010, following the 2009 CWPP which was created when Estes Valley Fire was still a part of the Town of Estes Park. This expanded their response area and funding.
- EVFPD was an all-volunteer organization from 1907 until 2009, and they hired their first Fire Marshall in 2010. They are still primarily volunteer run, but now also have seven full time staff members.
- In 2011, EVFPD adopted the International Fire Code. They continue to adopt the updated editions as they come out and are currently working under the 2018 edition which was adopted in 2019.
- In 2016, EVFPD hired the first full time Fire Inspector.
- In 2017 EVFPD began planning for large-scale incidents. They hosted a planning workshop in which stakeholders and community leaders gathered to respond to a simulated massive wildfire event. They built evacuation and traffic management plans for large scale incidents as well. This was all part of an emergency response plan that ended up being the basis for their response to the 2020 wildfires and evacuations.
- In 2019 EVFPD hosted a follow-up workshop on fire prevention, response, resiliency, and recovery that added to their 2017 emergency response plan.
- In 2020 EVFPD won an International Association of Fire Chiefs' Ready, Set, Go! grant to increase and improve marketing and education to visitors in Estes Park.
- In 2021 the Town of Estes Park won a Community Planning Assistance for Wildfire grant, and EVFPD added a second full-time Fire Inspector who focuses on Community Risk Reduction education.
- EVFPD continues to increase their operational capabilities by certifying their volunteer firefighters in wildland firefighting and adding a second Type 3 engine and second tactical tender to their fleet in 2022.

3. Becoming a Fire Adapted Community

It is recommended that that Estes Valley Fire Protection District, HOAs, and residents embrace the concept of Fire Adapted Communities (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, fire practitioners, and communities through a holistic approach to become more resilient to fire (**Figure 3.1**).

Your community's CWPP sets the stage for fire adaptation, and the next step is on-the-ground action and an ongoing commitment to risk mitigation at all levels of the community, from individual homeowners to neighborhoods and HOAs to the EVFPD to land managers and other partners. This section of the CWPP includes recommendations and resources for mitigating wildfire risk and enhancing emergency preparedness. The EVFPD and public land managers have an important role to play in implementing the recommendations in this CWPP, and they have made commitments to take on-the-ground action as outlined in **Section 4. Implementation Recommendations for Fuel Treatments**.

Individual homeowners, neighborhoods, and HOAs have a vital role to play in addressing shared wildfire 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 et al., 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 et al., 2021).

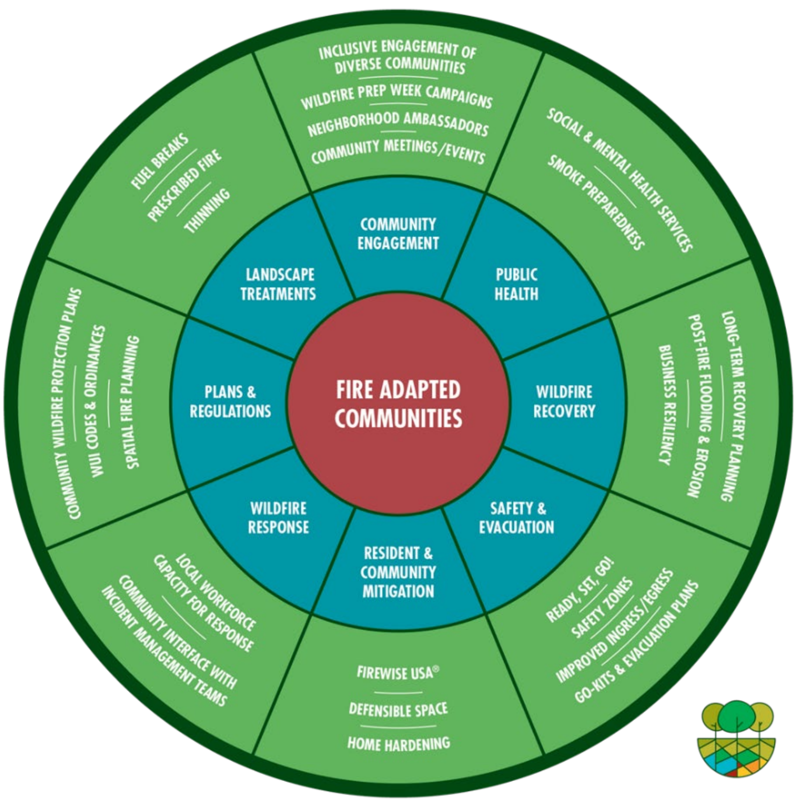


Figure 3.1. *The Fire Adapted Communities graphic provides specific programs and activities that communities can take to reduce their wildfire risk and increase their resilience (Source: Fire Adapted Community Learning Network).*

3.a. Individual Recommendations

Mitigate the Home Ignition Zone

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 area within 100 feet of each structure. Firefighter intervention, adequate defensible space, and home hardening measures were common factors for homes that survive major wildfires (IIBHS, 2019; Maranghides et al., 2022). 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 (Knapp et al., 2021).

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.

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 their home can stand alone without relying upon limited firefighter resources due to the great reduction in hazards they have undertaken.

Home hardening is the practice of making a home less likely to ignite from the heat or direct contact with flames or embers. It is important to remember that embers can ignite homes even when the flaming front of a wildfire is far away. 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 (Babrauskas, 2018; Gropp, 2019).

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).

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. 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 et al., 2017). Substantially reducing vegetation within the HIZ and removing vegetation that overhangs decks and roofs can reduce structure loss, especially for homes on slopes (Syphard et al., 2014).

Do not count on firefighters staying to defend your home—your home should be able to survive a wildfire on its own. There are never enough firefighters to stay and defend every single home during large incidents. 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.

A 2021 study from the University of Colorado-Boulder showed that homeowners living in the WUI in 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 (Simpkins, 2021). Make sure you are informed about best practices for protecting your home. See **Figure 3.a.1**, **Table 3.a.1**, and the CSFS publication The Home Ignition Zone for recommendations. Section **4.b. Stand-Level Fuel Treatment Recommendations** includes specific defensible space recommendations by forest type.

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. Under 60^{th} percentile weather, about 2% of homes are at risk of short-range ember cast and 30% are at risk of long-range ember cast. Under 90^{th} percentile weather, 24% of homes are at risk of short-range ember cast and 87% are at risk of long-range ember cast (**Figure 2.g.2**). Neighbors can increase their homes' chances of survival during a wildfire if they work together to reduce hazards in their overlapping defensible space.

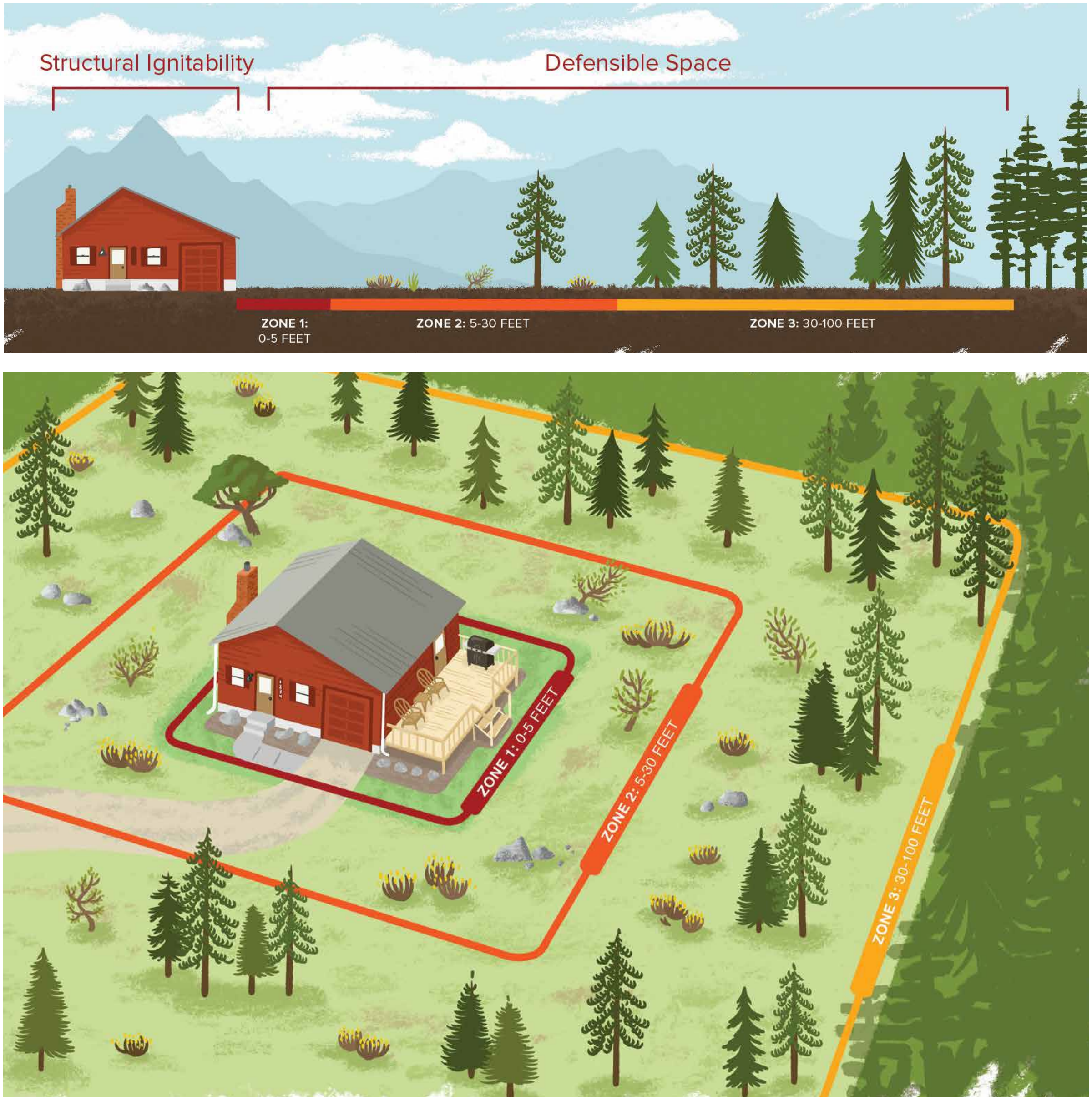


Figure 3.a.1. *Defensible space zones recommended by the Colorado State Forest Service. (Source: Colorado State Forest Service, Bonnie Palmatory).*

Top two photos: 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. Bottom two photos: Trees and shrubs near the homes are thinned, there is a 5-foot noncombustible zone around the structures, and the grass is mowed, making these homes more defensible and resistant to fire. Photos credits: The Ember Alliance.

Table 3.a.1. *Defensible space recommendations for homes in the WUI based on the CSFS publication [The Home Ignition Zone](). This is not an all-inclusive list of activities. Specific measures will depend on the placement and condition of your property. Section* ***4.b. Stand-Level Fuel Treatment Recommendations*** *includes specific defensible space recommendations by forest type.*

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. If you are unable to irrigate, replace dry grasses with FireWise Plant Materials that are more drought tolerant and less flammable. • 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 3.a.2**). See **Figure 3.a.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 3.a.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.

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 6 inches. Grasses can be taller in zone 3 than zone 2 because of the greater distance from your home, but shorter grass is always better for reducing potential flame lengths and therefore radiant heat exposure. • 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 4.b.1**). See **Figure 3.a.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 3.a.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 a qualified forester 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**.

*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.

Table 3.a.2. *Minimum recommended spacing between tree crowns and shrubs is greater for properties on steeper slopes due to the exacerbating impact of slope on fire behavior (Dennis, 2003).*

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

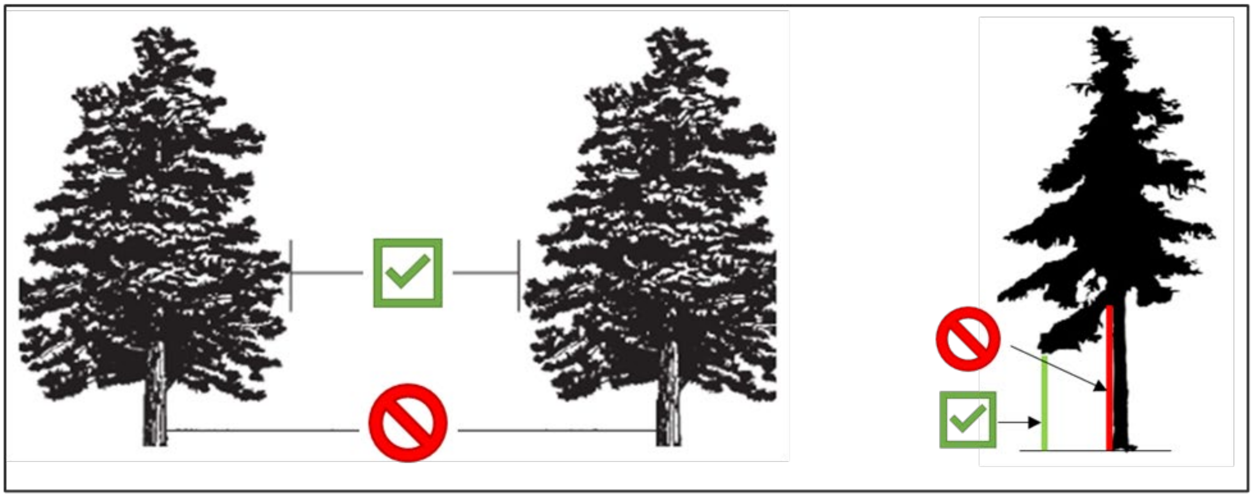


Figure 3.a.2. *Spacing between tree crowns is measured from the edge of tree crown to tree crown, NOT from tree stem to tree stem (left). Height of limbs above the ground is measured from the ground to the lowest point of the limb, NOT from where the limb attaches to the tree (right).*

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.b.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 3.a.3**).

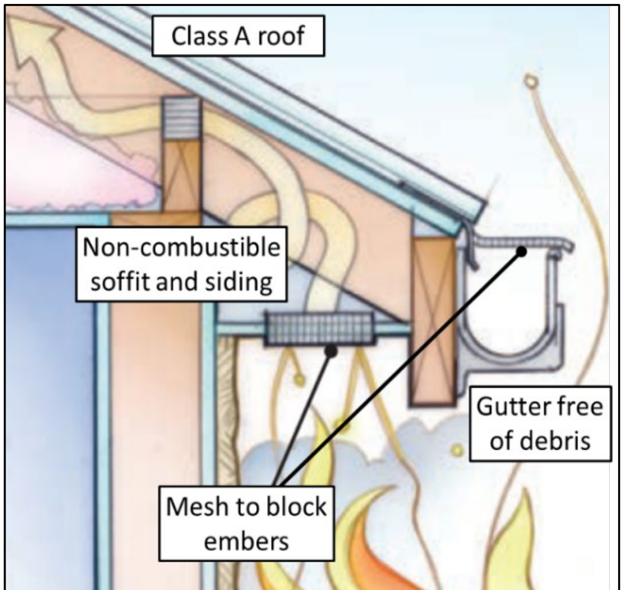
Some residents enjoy their land even more after conducting effective fuel treatments. Removing trees can open incredible views of mountains, rivers, and rock formations, and wildlife are often attracted to forests with lower tree densities and a greater abundance of understory plants. Many residents 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 **Section 4.b. Stand-Level Fuel Treatment Recommendations** for more information on treatments that achieve ecological and fuel reduction objectives.

__Figure 3.a.3.__ A fuels treatment project in the Estes Valley. Grasses, shrubs, and wildflowers quickly respond to increased light availability after tree removal, resulting in beautiful ecosystems with lower fire risk and healthy wildlife habitat. The red circle in each set of photos indicates the same tree. Photos from the Larimer Conservation District.

Home Hardening

At least half of the homes in the EVFPD 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 3.a.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 et al., 2017; 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, 2021).

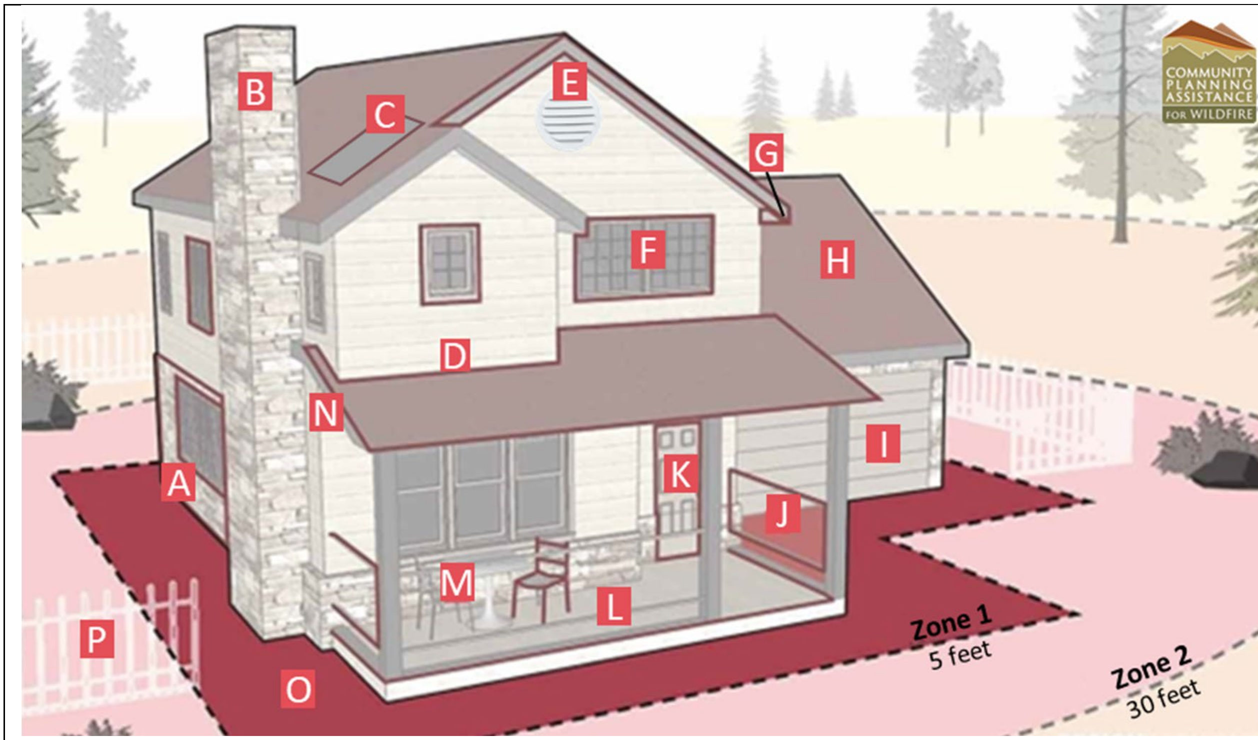


Residents can increase their homes' chance of survival by making it harder for embers to enter and ignite their homes (image from *Healthy Building Science*).

It is important to replace wood or shingle roofs with noncombustible materials[2] 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 **Table 3.a.3**). Keep home-hardening practices in mind and use ignition-resistant materials if you replace a hail-damaged roof or remodel your home. Many home hardening practices are required in Larimer County per building construction regulations effective as of February 2019 for homes within the Wildfire Hazard Area. New construction and expansions adding 50% or more area must comply with the new building standards.

[2] 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).



Low-cost actions:

B. Cover chimneys and stovepipe outlets with 3/8th to ½ inch corrosion-resistant metal mesh.

C. Minimize debris accumulation under and next to solar panels.

E. Cover vent openings with 1/16th to 1/8th inch corrosion-resistant metal mesh. Install dryer vents with metal flappers and keep closed unless in use.

G. Clear debris from roof and gutters regularly.

I. Install metal flashing around and under garage doors that goes up at least 6 inches inside and outside the door.

J. Use noncombustible lattice, trellis, or other decorative features.

K. Install weather stripping around and under doors.

L. Remove combustible materials from underneath, on top of, or within 5 feet of deck.

M. Use noncombustible patio future.

N. Cover all eaves with screened vents.

O. Establish and maintain a 5-foot noncombustible buffer around the home.

Actions to plan and save for:

A. Use noncombustible or ignition resistant siding and trim (e.g., stucco, fiber cement, fire-retardant treated wood) at least 2 feet up around the base of your home.

C. Use multipaned glass for skylights, not materials that can melt (e.g., plexiglass), and use metal flashing.

D. Install a 6-inch vertical noncombustible surface on all gables above roofs.

F. Install multi-pane windows with at least one tempered-glass pane and metal mesh screens. Use noncombustible materials for window frames.

G. Install noncombustible gutters, gutter covers, and downspouts.

H. Install ignition-resistant or noncombustible roofs (composition, metal, or tile).

I. Install 1-hour fire rated garage doors.

K. Install a 1-hour fire rated doors.

L. Use ignition-resistant or noncombustible decking. Enclose crawl spaces.

N. Use noncombustible eaves.

P. Replace wooden fences with noncombustible materials and keep at least 8 feet away from the home. Keep double combustible fences at least 20 feet away from the home.

Figure 3.a.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 CALFIRE 2019 and Maranghides et al. 2022.*

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 identified as sites for wildland firefighters to engage in structure protection, and homes that are not safely defensible will not usually receive firefighter resources.

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 through NoCoAlert. Visit the NoCoAlert website for more information.
- ✓ Review the contents of your "go-bag" and make sure it is packed and ready to go. Visit the Larimer County Emergency Preparedness page to learn about preparing go-bags and evacuation planning. 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. 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. Slash can be brought to the Meeker sort yard at 8200 Highway 7 in Allenspark.
- ✓ Mow grass 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. Consider replacing dry grasses with FireWise Plant Materials that are more drought tolerant and less flammable.
- ✓ Check the visibility of your address and remove vegetation that obscures it.
- ✓ Utilize community slash sites.
- ✓ 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.

Mitigation Barriers and Opportunities

Homeowners and residents in the WUI share concerns about creating defensible space and maintaining a defensible HIZ. **Table 3.a.3** proposes several opportunities to address these challenges (**Appendix C. Focus Group and Survey**).

Table 3.a.3. *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.	Review **Figure 3.a.1**, **Table 3.a.1**, and read the CSFS publication *Protecting your home from wildfire: Creating wildfire-defensible zones* for mitigation recommendations. Visit the Colorado State Forest Service for useful information and tips about defensible space creation. Talk to neighbors who have taken steps to mitigate fire risk on their property. Reach out to the Estes Valley Fire Protection District to learn about defensible space and home hardening tactics from their qualified specialists. A Wildland Mitigation Specialist can come provide guidance, see more information here.
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: ✓ Annually 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. ✓ Utilize community slash sites – the Meeker sort yard in Allenspark is the closest available slash disposal site to the Estes Valley. ✓ Apply for cost-sharing grants with your neighbors to subsidize the creation of defensible space (see **Section 3.g. Funding Opportunities for Wildfire Hazard Mitigation and Emergency Preparedness**) ✓ Research tax credits that will offset the costs or the work you want to do. The EVFPD has information on tax credits for mitigation on their website.

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. Many home hardening practices are required in Larimer County per building construction regulations effective as of February 2019 for homes within the Wildfire Hazard Area. New construction and expansions adding 50% or more area 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 3.a.1** and **Table 3.a.1**. Some properties in the EVFPD 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. As an added benefit, fire-resistant landscape is often more drought tolerant.

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 and more drought tolerant, requiring less watering during the summer. 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

100% of deaths during the 2020 East Troublesome Fire were preventable, but they occurred after residents chose to stay in their homes after an evacuation order was given. Being prepared for evacuations and following guidance from local authorities on when and where to evacuate is of the utmost importance for residents living in the WUI.

The best way to get out quickly and safely during an evacuation is to be prepared. Prepare a go-bag and have a family emergency plan **before** the threat of wildfire is in your area. Talk to children and elderly family members about what they would be expected to do. Visit the Larimer County Emergency Preparedness page to learn about go-bags and evacuation planning, including tips for preparing your pets and livestock for evacuation. Signing up for local emergency notifications can also help you leave quickly. Residents should register their cell phones and email addresses on the LETA 911 website.[3]

Understand the differences between voluntary and mandatory evacuations. The following definitions are provided by the Larimer County Sherriff's Office:

Voluntary Evacuation	Mandatory Evacuation
When to leave: Leave if you are concerned for your safety, you need additional time to exit the area, or you have health conditions that may be aggravated by the incident.	**When to leave:** Immediately! You are ordered to leave due to an imminent or immediate threat to your safety.
What to do: Gather essential items to add to an Emergency go-bag such as medications and items you may need if away for an extended period.	**What to do:** Grab your go-bag and leave the area immediately.
Other considerations: Create a plan for transporting animals out of the area if needed.	**Other considerations:** You may not be allowed to return until the emergency is resolved.

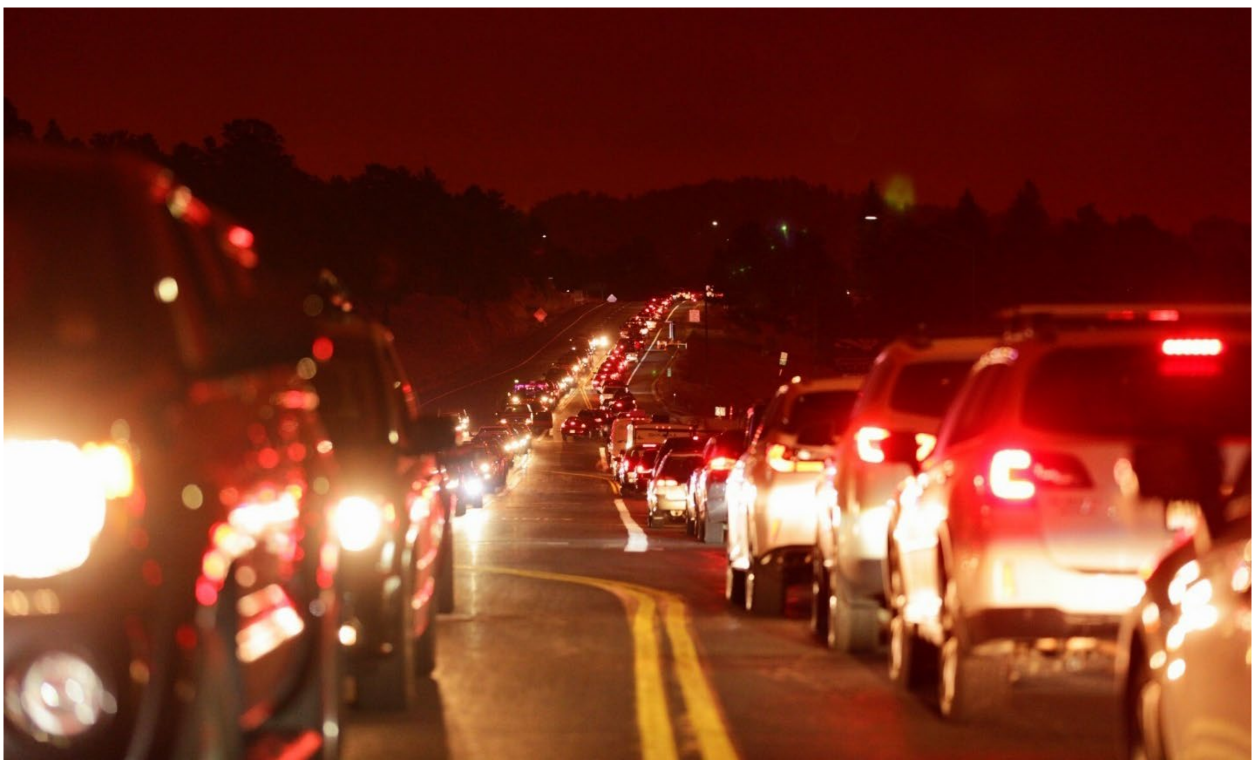
Some residents have family members or neighbors with physical limitations who might struggle to evacuate in a timely manner. Family members or individuals living alone also need to address the unique needs and vulnerabilities that arise from mobility or hearing impairments during an evacuation. Other residents are concerned about school-aged children who might be home alone during an evacuation. Parents should work with their neighbors to develop a plan for how their children would evacuate if home alone. Residents with livestock trailers or large camper vehicles should plan to leave during voluntary evacuation notices to allow time for their preparations and create more space on the roads for other residents during mandatory evacuation. Having a plan in place ahead of time can ensure prompt evacuations and save lives during wildfires. Families with these concerns should put extra time into having go bags ready and using the earliest evacuation warnings to leave in the event of a wildfire, rather than waiting for mandatory evacuation orders.

Visitor preparedness must also be considered for this community which experiences millions of tourists every year mostly during the summer months. There is good consistency between the Estes Valley Fire District and the Estes Park Visitor Center websites on Guest Resources and Evacuation Resources. The Town of Estes Park is recommended to add the same evacuation materials or direct to the Estes Valley Fire District website on their Emergency Information page.

[3] NoCo Alert is the official emergency notification system for Larimer County as of the writing of the Estes Valley CWPP in June 2022.

***Follow evacuation etiquette** to increase the chance of everyone exiting the EVFPD in a safe and timely manner during a wildfire incident:*

- Register for Larimer County Emergency Alerts to receive evacuation notifications.
- 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.
- Leave with 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.



Traffic came to a near standstill as people evacuated Estes Park during the East Troublesome Fire on October 22, 2020. Image was taken at 2:15 pm, but the sky is dark as night due to wildfire smoke. Following orders of the Larimer County Sheriff's Office during evacuations is critical to keep residents and first responders safe. Photo credit: Kevin J. Beaty/Denverite.

Accessibility and Navigability for Firefighters

Driveways

It is important to ensure emergency responders can locate and access your 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).

Some roads in the EVFPD have accessibility and navigability issues, such as narrow widths, inadequate vertical clearance for engines, and heavy fuel loading on the sides of the road. These unsafe road and driveway conditions could 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 (O'Connor, 2021). It is recommended that residents order reflective address numbers from Estes Valley Fire, found here.

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.

Many driveways within the EVFPD 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 credit: The Ember Alliance.

Private Water Resources

Water resources to fight fire in the foothills 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 EVFPD of community cisterns or tanks **before** a fire event and ensure they are compatible with their firefighting equipment.

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 **Table 3.a.1** and **Figure 3.a.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.** You can order these from Estes Valley Fire here.
- ✓ 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 National Fire Protection Association (O'Connor, 2021).
- ✓ 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. Neighborhood Recommendations

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 et al., 2021).

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. Defensible space that is connected from home to home provides additional layers of protection for entire neighborhoods and increases the safety of firefighters. 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. According to James White, the Prescribed Fire and Fuels Specialist for the Arapaho/Roosevelt National Forests, "Broadcast burning, mechanical thinning, and other treatments are proven to mitigate wildfire risk, but they are even more effective when we work together to integrate treatments across the landscape, across borders and ownerships" (Avitt, 2021).

See **Defensible Space** to learn about recommended practices for creating defensible space, and see **Table 3.b.1** for common concerns about community action from residents in the WUI and potential solutions.

Mosaic Landscapes

Varied fuel types are known to slow the spread of fire, and heterogeneous landscapes (landscapes with multiple fuel types and trees of different sizes and ages) are more typical of historical forest conditions (Duncan et al., 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 unforested locations like shrublands or meadows. Slower fire movement means firefighters have time to defend more homes in the neighborhood. It also creates a diversity of biomes that both residents and wildlife enjoy.

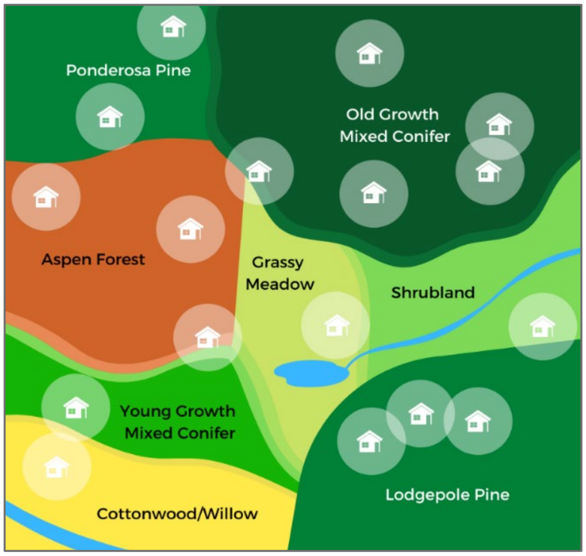


Figure 3.b.1. *Example of a mosaic landscape in a neighborhood. Each home has defensible space around it, and the landscape is varied throughout, providing tactical opportunities for firefighters working to defend homes.*

Mitigation Barriers and Opportunities

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

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. FireWise plants are less flammable and drought tolerant so they require less watering during the summer. Ask the EVFPD for assistance communicating the need for homeowner mitigation in the neighborhood.
My neighbors haven't mitigated risk on their property.	Some residents in the EVFPD are rightfully concerned about high hazards on their neighbors' properties and surrounding public land. 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 EVFPD create defensible space and harden their homes. Ideas to inspire action by your neighbors include: • Working with 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	It can be difficult to engage with landowners that you do not know personally. Inviting the landowner or manager for a friendly

held land, not other homeowners.	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 between your community and their agency can open doors to shared mitigation actions that may reduce costs for everyone involved.

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. 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 apply for grants are effective ways to make safer homes for all residents in an area. Some roads in the EVFPD are inaccessible to fire engines. According to the National Fire Protection Association, 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 (O'Connor, 2021).

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. A cost-effective place to start is removing trees along driveways and pruning low-hanging branches to increase horizontal and vertical clearance. Working together to update signs and road construction can lower costs for everyone involved as well.

3.c. Priority Plan Unit Recommendations

CWPP Plan Units

TEA and the Estes Valley Fire Protection District created CWPP Plan Units, which are areas with shared fire risk where residents can organize and support each other to effectively mitigate hazardous fuels (**Figure 3.c.1**). The planning units each typically have similar buildings and roads, topography and vegetation, and social groupings such as neighborhoods and HOAs. See **8.a CWPP Plan Units** for methodology used to delineate plan units.

Residents in the same CWPP plan unit will be able to 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.

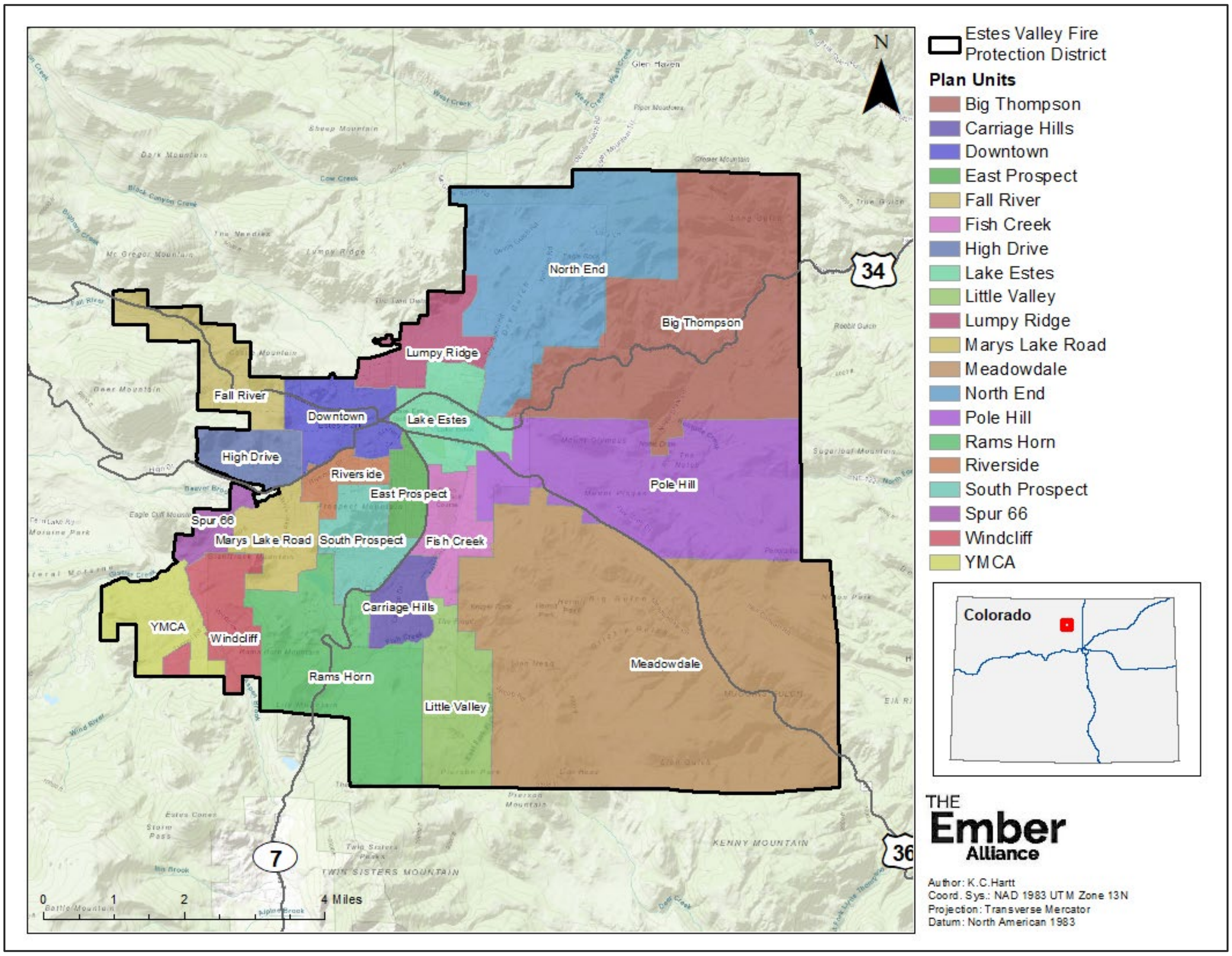


Figure 3.c.1. *TEA assessed relative risk among CWPP plan units and made strategic recommendations to address wildfire risk across the Estes Valley Fire Protection District. See **8.a CWPP Plan Units** for methodology used to delineate plan units.*

Relative Hazard Ratings

Colorado CWPPs must include a relative rating of hazards within 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 Estes Valley Fire Protection District still possess conditions that are concerning for the protection of life and property in the case of a wildfire.

> **Keep in mind:** The Plan Unit Hazard Assessment describes ***relative*** risk among plan units within the Estes Valley Fire Protection District – this is only comparing areas of the valley to other areas of the valley. 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. The need to mitigate hazardous conditions is ubiquitous across the EVFPD.

The Ember Alliance combines on-the-ground observations and summary output from our fire behavior analyses to assess hazards in four categories across CWPP plan units: fire risk, fire suppression challenges, evacuation hazards, and home ignition zone hazards (**Figure 3.c.2**). See **Appendix B.1. Plan Unit Hazard Assessment** for a description of hazard rating methodology. The cutoffs for different relative risk categories are tailored to an individual FPD based on the range of conditions observed. Plan unit hazard ratings are specific to the EVFPD and not suitable for comparing hazards among FPDs.

Table 3.c.1 provides priority recommendations for defensible space, home hardening, and road access within each CWPP plan unit based on our plan unit hazard assessment. Recommendations in **Table 3.c.1** focus on the most glaring issues in each plan unit; however, homeowners, HOAs, and other community groups can benefit from all actions outlined in **3.a Individual Recommendations** and **3.b Neighborhood Recommendations.** Even homes in the interior of the EVFPD have the potential for ignition from long-range ember cast during wildfires.

Plan units with extreme relative risk are clustered in the northeast, south east, and western portions of EVFPD (**Figure 3.c.2**). A strip of plan units in the central portion of the EVFPD have moderate relative risk due to the abundance of urban development; however, as the 2021 Marshall Fire in Boulder County demonstrated, urbanized areas in the WUI can still experience catastrophic losses during wildfires.

The highest relative fire risk is found in the southern and eastern plan units. Relative fire risk is lower in the northwestern portion of the EVFPD due to a vegetation transition from dry mixed-conifer to lodgepole pine. Lodgepole pine forest have the potential to burn in high-severity wildfires with extreme flame lengths and active crown fire, but only when fuels are very dry and winds are strong, such as during the 2020 East Troublesome Fire. When lodgepole pine forest ignite under these conditions, they are difficult if not impossible for firefighters to contain. Under milder conditions, particularly with lower winds, these forests are harder to burn because of the distance between surface fuels and tree branches and the lack of understory vegetation, resulting in low-intensity, creeping, surface fires (Lotan et al., 1985).

Suppression challenges are extreme in the northeastern portion of the EVFPD and in the Little Valley, High Drive, and Riverside plan units due to limited hydrant availability near homes and the prevalence of roads with accessibility issues for emergency vehicles. Extreme evacuation challenges are found in Little Valley and the western part of the EVFDP because the abundance of potentially non-survivable roadways (**A.5. Roadway Survivability**) and/or limited egress directions coupled with high housing density. Home ignition zone hazards are particularly prevalent in Big Thompson and the northwestern part of the EVFP because of combustible decking and siding, an abundance of ladder and canopy fuels near homes, inadequate defensible space maintenance, and additional hazards near homes, such as wood piles, flammable furniture, and propane tanks.

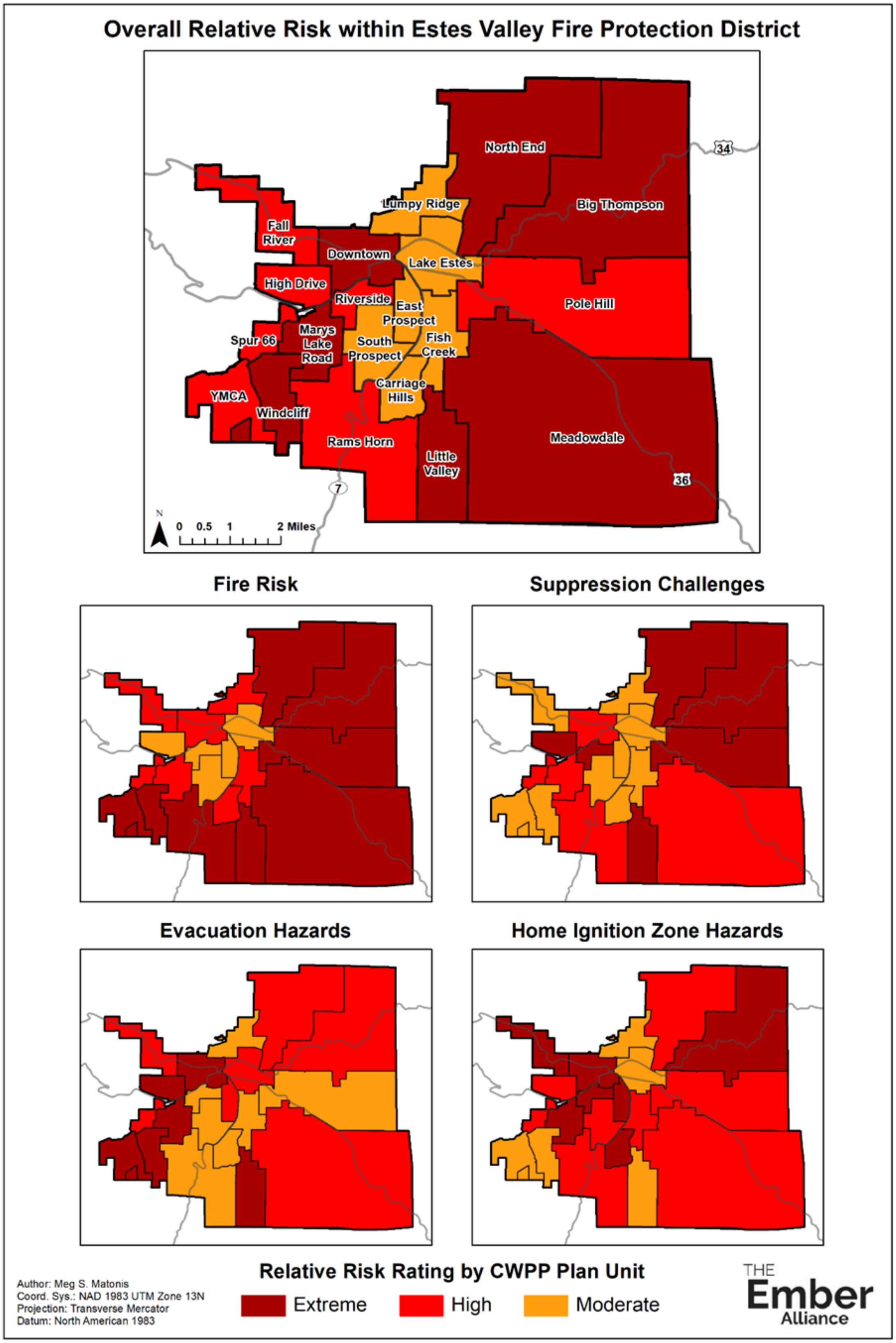


__Figure 3.c.2__. Relative risk rating for plan units across the Estes Valley Fire Protection District. "Moderate" risk is a relative term – all plan units and communities within the Estes Valley Fire Protection District are at high risk of loss from wildfires and should take recommended actions from this CWPP seriously.

Table 3.c.1 *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 Estes Valley Fire Protection District can benefit from all actions outlined in* ***3.a Individual Recommendations*** *and* ***3.b. Neighborhood Recommendations****. Potential fire behavior is presented for 60th percentile fire weather, with flame lengths and crown fire activity summarized for the plan unit and adjacent topographic areas that could contribute to fire behavior within the plan unit.*

Plan Unit Name	Relative Risk	Unit Description	Priority Mitigation Suggestions	Potential Fire Behavior
Big Thompson	**Extreme**	This unit has numerous mid-slope homes and numerous topographic features in and around the canyon that make fire behavior unpredictable. Fuels consist of dense, untreated forests on steep slopes, tall grasses, and ladder fuels. There are not adequate hydrants and the river through the canyon is not a reliable water source. Highway 34 is accessible, but almost all the roads and communities branching off the highway are not accessible by engines. Home construction is generally older and poorly fit to be defended with lots of wood siding and flammable hazards within 30 feet of the homes. Defensible space is not adequate, bridges across the river do not have posted weight limits and certifications, and the canyon's topography would make fighting a fire in here dangerous to firefighters.	Set evacuation plans and have go bags for everyone. Home hardening, especially for homes existing before the 2013 floods. Defensible space Remove wood outbuildings and hazards near homes. Certify and post bridge weight limits. Widen roads and create turnarounds for engines.	Under 60th percentile weather conditions, 78% of the unit is susceptible to passive or active crown fires, average flame lengths in the unit are 14 feet and can reach up to 123 feet. 19% of the roads are potentially non-survivable and 25% of homes have high to extreme exposure to embers and radiant heat.
Carriage Hills	**Moderate**	This unit has some mid-slope homes and no topographic features that make fire behavior unpredictable. Fuels consist of mostly tall grass and ponderosa pines. There is some regeneration, and lots of shrubs and juniper near homes and under decks. There are adequate	Remove firewood, junipers, and wood furniture from on and under decks. Mow grasses near homes	Under 60th percentile weather conditions, 50% of the unit is susceptible to passive or active crown fires, average flame lengths in the unit are 11 feet and can reach up to 139 feet. Less than 1% of the roads are potentially non-

		hydrants and roads are accessible by engines. Home construction is average with some homes needing to replace siding and remove wood fences near the homes. Defensible space is not adequate, and this unit in particular has a significant amount of homes with firewood, flammable furniture, propane tanks, and junipers within 5 feet of the home.	Home hardening Defensible space	survivable and none of the homes have high to extreme exposure to embers and radiant heat.
Downtown	**Extreme**	This unit has some mid-slope homes and some topographic features that make fire behavior unpredictable. Business center has relatively few fuels but storefronts have wood and shake siding, Stanley district has good mitigation and newer construction, and the other neighborhoods in and around downtown have older construction, more fuel, and little mitigation. There are adequate hydrants and most roads are accessible by engines, but there are a few neighborhoods where they are not. Home construction is varied, but this unit has the fewest class-A roofs in the valley. Defensible space is not adequate.	Replace roofs with Class A roofs Home hardening Defensible space Linked defensible space	Under 60th percentile weather conditions, 43% of the unit is susceptible to passive or active crown fires, average flame lengths in the unit are 7 feet and can reach up to 114 feet. 1% of the roads are potentially non-survivable and 1% of homes have high to extreme exposure to embers and radiant heat.
East Prospect	**Moderate**	This unit has numerous mid-slope homes but no topographic features that make fire behavior unpredictable. Vegetation consists of lots of ponderosa pines that are dense with regeneration along the sides of roads. There are lots of shrubs and juniper in this unit. There are adequate hydrants and roads are accessible by engines. Home construction is not good, many homes have flammable siding and fences. Defensible space is not adequate with numerous ladder fuels and unmowed tall grasses.	Remove firewood, junipers, and wood furniture from on and under decks. Mow grasses near homes Home hardening Defensible space	Under 60th percentile weather conditions, 12% of the unit is susceptible to passive or active crown fires, average flame lengths in the unit are just over a foot and can reach up to 41 feet. None of the roads are potentially non-survivable and none of homes have high to extreme exposure to embers and radiant heat.

Fall River	**High**	This unit has some mid-slope homes and numerous topographic features that make fire behavior unpredictable. This river canyon has steep slopes and mixed conifer throughout, with aspen and cottonwood nearer the river. There are adequate hydrants and though many roads are accessible by engines, not all of them are. Most of the bridges across the river do not have posted weight rating or certifications. Home construction is average and there are a number of homes with Class B or C roofs and flammable siding and decks. Defensible space is not adequate. and small lot sizes here will require community coordination for functional defensible space.	Certify and post bridge weight limits. Replace roofs with Class A roofs Home Hardening Defensible space Linked defensible space	Under 60th percentile weather conditions, 48% of the unit is susceptible to passive or active crown fires, average flame lengths in the unit are 8 feet and can reach up to 114 feet. Less than 1% of the roads are potentially non-survivable and 3% of homes have high to extreme exposure to embers and radiant heat.
Fish Creek	**Moderate**	This unit has numerous mid-slope homes but no topographic features that make fire behavior unpredictable. Properties on the east side of Fish Creek Rd have denser fuels, more slopes, and less mitigation. The west side of the road has the golf course as a large break in fuels. There are adequate hydrants and roads are mostly accessible by engines. Home construction is overall very good. Defensible space is not adequate, and there are numerous ladder fuels.	Defensible space Home hardening Mow grass near homes Reduce ladder fuels and litter loads	Under 60th percentile weather conditions, 40% of the unit is susceptible to passive or active crown fires, average flame lengths in the unit are 9 feet and can reach up to 119 feet. 7% of the roads are potentially non-survivable and 5% of homes have high to extreme exposure to embers and radiant heat.
High Drive	**High**	This unit has numerous mid-slope homes and no topographic features that make fire behavior unpredictable. The unit is covered with a grassy understory and ponderosa pine. Most homes in the flatter southern side have good tree spacing and limbing and are at lower risk than the homes further north on the	Ensure proper storage of all hazardous materials in the commercial area Widen roads and create turnarounds for engines.	Under 60th percentile weather conditions, 36% of the unit is susceptible to passive or active crown fires, average flame lengths in the unit are 5 feet and can reach up to 114 feet. None of the roads are potentially non-survivable and 1% of homes have high to extreme

		slope. There are adequate hydrants and southern roads are largely accessible by engines, but the northern end of the unit has inaccessible roads without turnarounds. Home construction is average with lots of flammable siding and wood fences near homes. Defensible space is not adequate. The commercial area in the eastern part of the unit is cause for concern with lots of hazardous fuels and materials and concerns about improper storage of these materials.	Defensible space Home hardening	exposure to embers and radiant heat.
Lake Estes	**Moderate**	This unit has no mid-slope or ridge-top homes, and no topographic features that make fire behavior unpredictable. This unit has more commercial business than residential and has little vegetation and fuels. Some residential areas appear to have HOA-managed landscaping with little fuels, and other residential areas have older construction, little defensible space, and lots of litter and tall grasses. There are adequate hydrants and an accessible water source with the lake, and roads are accessible by engines. Home construction is average with lots of flammable siding and wood fences near homes. Defensible space is not adequate near the residential areas.	Ensure proper storage of all hazardous materials in the commercial area Mow grass near homes, reduce ladder fuel and litter loads Home Hardening Defensible space	Under 60th percentile weather conditions, 42% of the unit is susceptible to passive or active crown fires, average flame lengths in the unit are 8 feet and can reach up to 84 feet. Less than 1% of the roads are potentially non-survivable and none of homes have high to extreme exposure to embers and radiant heat.
Little Valley	**Extreme**	This unit has numerous mid-slope homes and a few ridge-top homes, and lots of topographic features that make fire behavior unpredictable. This unit has very dense mixed conifer forests with interlocking canopies and regeneration. There are not adequate hydrants and no other water sources, and some roads further into the unit are not accessible by	Set evacuation plans and have go bags for everyone. Defensible space Roadway treatments	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 up to 139 feet. 45% of the roads are potentially non-survivable and 67% of homes have high to extreme

		engines. Home construction is very good, however defensible space is not adequate. The thick vegetation, steep slopes, deep and hidden home locations further into the unit, and the single road in and out of the neighborhood makes for a dangerous place to live and to fight fires.	Linked defensible space Landscape-scale mitigation on the southeast side	exposure to embers and radiant heat.
Lumpy Ridge	**Moderate**	This unit has no mid-slope or ridge-top homes, and no topographic features that make fire behavior unpredictable. Vegetation consists of mixed conifer with a grassy understory, where some locations have been thinned and limbed and others have been left alone and need mitigation. There are adequate hydrants and roads are accessible by engines. Home construction is very good. Defensible space is not adequate with lots of ladder fuels and unmitigated ponderosa pine stands.	Defensible space Mow grasses near homes Linked defensible space in high-density neighborhoods Remove ladder fuels	Under 60th percentile weather conditions, 48% of the unit is susceptible to passive or active crown fires, average flame lengths in the unit are 8 feet and can reach up to 97 feet. 4% of the roads are potentially non-survivable and 14% of homes have high to extreme exposure to embers and radiant heat.
Mary's Lake Road	**Extreme**	This unit has numerous mid-slope homes and some topographic features that make fire behavior unpredictable. Vegetation consists of dense forests of ponderosa pine and mixed conifers with interlocking canopies, mostly unmitigated. There are not adequate hydrants or water sources and some roads are not accessible by engines. Home construction is generally poor, with many home having flammable siding and Class B or C roofs and wood fences near the home. Defensible space is not adequate and there are heavy loads of ladder fuels.	Replace roofs with Class A roofs Defensible space Home hardening Widen roads and create turnarounds for engines. Linked defensible space	Under 60th percentile weather conditions, 35% of the unit is susceptible to passive or active crown fires, average flame lengths in the unit are 6 feet and can reach up to 113 feet. 2% of the roads are potentially non-survivable and 2% of homes have high to extreme exposure to embers and radiant heat.

Meadowdale	**Extreme**	This unit has some mid-slope homes and numerous topographic features that make fire behavior unpredictable. Vegetation is mostly mixed conifer and grassy meadows with some mitigation work completed. There are not hydrants available but there are some water sources, and not all roads are accessible by engines. Residential home construction is very good. Defensible space is not adequate. This unit is mostly large parcels with few residents, and includes Hermit Park Open Space, which has many cabins for visitors. These wood cabins have propane tanks, fire pits, and large trees within 30 feet of the cabins and slow dirt roads, making for a potentially dangerous situation for unknowing campers.	Hermit Park buildings need defensible space and home hardening to any extent possible. Landscape-scale mitigation Roadway treatments	Under 60th percentile weather conditions, 67% of the unit is susceptible to passive or active crown fires, average flame lengths in the unit are 15 feet and can reach up to 119 feet. 32% of the roads are potentially non-survivable and 56% of homes have high to extreme exposure to embers and radiant heat.
North End	**Extreme**	This unit has some mid-slope homes and no topographic features that make fire behavior unpredictable. Vegetation is primarily montane meadow with tall grasses and some densely forested hillslopes. There are some hydrants but no additional water sources, and roads are accessible by engines. Home construction is average, with many homes having flammable siding. Defensible space is not adequate.	Mow grass near homes Conduct landscape-scale mitigation on hillslopes Home hardening Defensible space	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 up to 122 feet. 21% of the roads are potentially non-survivable and 24% of homes have high to extreme exposure to embers and radiant heat.
Pole Hill	**High**	This unit has numerous mid-slope homes and a few ridge-top homes, as well as numerous topographic features that make fire behavior unpredictable. Vegetation is mostly dense mixed conifer with interlocking canopies and a grassy understory with ladder fuels. There are	Widen roads and create turnarounds for engines. Set evacuation plans and have go bags for everyone.	Under 60th percentile weather conditions, 68% of the unit is susceptible to passive or active crown fires, average flame lengths in the unit are 14 feet and can reach up to 123 feet. 13% of the roads are potentially non-survivable and 11%

		some hydranted areas and many roads are not accessible by engines. Home construction is average with many homes that have flammable siding. Defensible space is not adequate, there are ladder fuels, shrubs, and other hazards near many homes.	Home hardening Defensible space Linked defensible space	of homes have high to extreme exposure to embers and radiant heat.
Rams Horn	**High**	This unit has numerous mid-slope homes and some ridge-top homes, and a few topographic features that make fire behavior unpredictable. Half of the unit is flat, open meadows with tall grass and well-spaced trees, the other half is forested hillslopes with heavy litter loading. Some stands have been mitigated and some have not. There are not adequate hydrants, but roads are accessible by engines. Home construction is very good, excluding the Cheley Camp buildings. Defensible space is not adequate, and there are lots of ladder fuels.	Defensible space Mow grass near buildings Home hardening of Cheley Camp buildings	Under 60th percentile weather conditions, 54% of the unit is susceptible to passive or active crown fires, average flame lengths in the unit are 13 feet and can reach up to 139 feet. 8% of the roads are potentially non-survivable and 9% of homes have high to extreme exposure to embers and radiant heat.
Riverside	**High**	This unit has some mid-slope homes and some topographic features that make fire behavior unpredictable. Vegetation consists of dense ponderosa pines which is well mitigated on the north side of the unit and not mitigated in the south side of the unit. There are not adequate hydrants and roads are not all accessible by engines. Home construction is average with some homes with flammable siding and wood fences by the homes. Excluding the mitigated neighborhoods on the north side, defensible space is not adequate, and may be some of the worst in the district.	Defensible space Linked defensible space Home hardening Reduce ladder fuels and litter loads	Under 60th percentile weather conditions, 26% of the unit is susceptible to passive or active crown fires, average flame lengths in the unit are 4 feet and can reach up to 83 feet. Less than 1% of the roads are potentially non-survivable and 5% of homes have high to extreme exposure to embers and radiant heat.

South Prospect	**Moderate**	This unit has numerous mid-slope homes and some ridge-top homes, and numerous topographic features that make fire behavior unpredictable. Vegetation is varied, with some well-mitigated ponderosa pine stands and mowed grasses near homes in some flatter areas and dense, unmitigated regeneration in others. There are not enough hydrants available but roads are generally accessible by engines. Home construction is average. Defensible space is not adequate, and there are lots of ladder fuels.	Defensible space Home hardening	Under 60th percentile weather conditions, 30% of the unit is susceptible to passive or active crown fires, average flame lengths in the unit are 4 feet and can reach up to 83 feet. Less than 1% of the roads are potentially non-survivable and 1% of homes have high to extreme exposure to embers and radiant heat.
Spur 66	**High**	This unit has some mid-slope and ridge-top homes, and many topographic features that make fire behavior unpredictable. Vegetation is mostly mixed conifers with some mitigation but lots of dense and unmitigated stands with ladder fuels and many shrubs near the homes. There are adequate hydrants but some roads are not accessible by engines. Home construction is average. Defensible space is not adequate, with ladder fuels and vegetation near homes, and there are other hazards near homes such as propane tanks and waste.	Set evacuation plans and have go bags for everyone. Defensible space Home hardening Widen roads and create turnarounds for engines. Reduce ladder fuels and litter loads	Under 60th percentile weather conditions, 41% of the unit is susceptible to passive or active crown fires, average flame lengths in the unit are 8 feet and can reach up to 81 feet. Less than 1% of the roads are potentially non-survivable and 19% of homes have high to extreme exposure to embers and radiant heat.
Windcliff	**Extreme**	This unit has numerous mid-slope homes and numerous topographic features that make fire behavior unpredictable. Vegetation is mostly tall grasses with treated forests near the bottom of the hills and denser forests near the top. There are no adequate hydrants or other water sources, but roads are generally accessible by engines. Home construction is generally very good. Defensible space is not adequate, considering the slope	Set evacuation plans and have go bags for everyone. Defensible space Linked defensible space	Under 60th percentile weather conditions, 55% of the unit is susceptible to passive or active crown fires, average flame lengths in the unit are 12 feet and can reach up to 113 feet. 31% of the roads are potentially non-survivable and 36% of homes have high to extreme exposure to embers and radiant heat.

		and slow roads to evacuate. Mitigation work has been done lower in the neighborhood, but further up the vegetation gets more dangerous.		
YMCA	**High**	This unit has some mid-slope homes and ridge-top homes, and no topographic features that make fire behavior unpredictable. The unit has mostly tall grass, sagebrush and shrubs, and ponderosa pine. The center of the unit is well mitigated but the outer edges, including the southwest corner, are not well mitigated. There are no adequate hydrants or other water sources, but roads are generally accessible by engines. Building construction is very good. Defensible space is not adequate, but is closer than most units, and ladder fuels are less dense here.	Set evacuation plans and directions for visitors in place.	Under 60th percentile weather conditions, 54% of the unit is susceptible to passive or active crown fires, average flame lengths in the unit are 13 feet and can reach up to 111 feet. 24% of the roads are potentially non-survivable and 40% of homes have high to extreme exposure to embers and radiant heat.
			Defensible space	
			Mow grass near homes	

Table 3.c.2. *Resources for suggested mitigation for each CWPP Plan Unit (**Figure 3.c.1**).*

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 EVFPD. Residents need to be prepared to leave at any time and not rely on the FPD to save them.	See: **Evacuation Preparedness**
Roadway fuel treatments	Clear 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 Fuel Treatment Recommendations**
Widen roads and create turnarounds for engines	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 Fuel Treatment Recommendations**
Certify and post bridge weight limits	Have an engineer certify the weight limits of each bridge and post it in a visible location on both entrances to the bridge.	See: **Accessibility and Navigability for Firefighters**

Landscape-scale mitigation	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 treatments adjacent to residential areas and along roadways	Treat forests to prevent intense fire behavior near homes and increase landscape resilience by restoring historical conditions.	See: **Stand-Level Fuel Treatment Recommendations; Roadway Fuel Treatment 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**
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**
Ensure proper storage of all hazardous material	Properly store fuels, chemicals, waste, and other flammable materials in bulk according to federal and local	See: State of Colorado Hazardous Materials Management
Replace roofs with Class A roof	Make the home itself less flammable by using non-combustible roofing materials and clearing combustibles off the roof regularly.	See: NFPA Roofing Material Fact Sheet

3.d. Recommendations to Enhance EVFPD Capacity

District Capacity Assessment

District capacity was evaluated through qualitative and quantitative approaches. Arrival times across the districted were modeled and varied from 15 min to 107 min across the analysis area. Because many areas in the district have limited road access, many areas have significant hike in costs. These result in heterogenous distributions of fire sizes and perimeters based on differing arrival times. Fire sizes were generally constrained closer to roads due to reduced response time, but significant variability exists. This variability shows the degree to which response time is not the entire driver of fire size due to the effects of wind, weather, topography, and fuel (see **Appendix A.7 District Capacity Assessment** for methodology and maps).

Interviews with local fire program managers provided useful insights on district and local fire capacity. Generally, EVFPD was assessed to have high quality overhead who provide clear size-ups for incoming resources. Because most wildfires require mutual aid, this is essential for helping brief responders and helps in determinations around additional resources. However, interviewees felt that the department is challenged by variability in response numbers from volunteers. This is compounded by the challenges of many local cooperator agencies that are also volunteer supported, which can create variability in response numbers. Volunteers also can vary in their wildland firefighter training and skills due to differing experience relative to full-time firefighters. This creates an additional layer of uncertainty for fire managers while managing incidents.

Subject matter experts highlighted the lack of local handcrews and dedicated air resources. Many air resources are on seasonal contracts despite fire no longer being seasonally constrained (e.g., the Marshall Fire occurring on 30 December 2021). These resources are particularly important for rapidly growing emerging incidents.

During rapidly emerging wildfire incidents, particularly in the wildland-urban interface, any fire district would face challenges. Estes Valley has multiple areas throughout the district where wildfires could grow rapidly and exceed local capacity for response. This analysis highlighted some key areas where this challenge is most acute due to accessibility, terrain, fuels, and local weather conditions. Many of these areas are only accessible by air or handcrew resources, which are limited in both availability and operational capacity.

Mutual aid and resource ordering between departments and agencies helps buttress suppression capabilities. Significant numbers of engine resources are available from local agencies. Although engine operations are important for structure protection, many areas require handcrews for initial or extended attack. There is a shortage of available handcrews locally, with many crews dedicated to extended attack. Reconfiguring engine crews into ersatz handcrews is less efficient than utilizing dedicated handcrews for many reasons.

Aerial resources are similarly limited and limiting. While useful when available, air resources are often unable to be used during high wind events, which often drive large fires in the area. The local helitack crew is at times deployed on national assignments, limiting their availability further.

Availability and training level of resources is a challenge. For emerging incidents, overhead must be flexible and capable, and firefighting resources must be well-trained and adaptable. Volunteer firefighters, who provide much of the immediate response capacity for Estes Valley, may face significant challenges in these environments, especially due to limited availability to be exposed to the wide variety of fire behavior that full-time firefighters may encounter.

Ultimately, the areas where fires are likely to grow the largest coincide with areas where the most limited firefighting resources are necessary for effective response. This creates additional complexity by requiring resources that are either unavailable locally or must be built from other resources.

Recommendations

- Invest in professional development and training opportunities to increase the availability and redundancy of overhead resources. This will initially require squadboss and single resource boss-level training opportunities (e.g., crewboss academies, engine academies) to expand the pipeline of potential midlevel leadership transitioning to overhead. This will require coordination between agencies to implement a multi-stakeholder regional wildland fire training strategy.
- Expand cross-training of local engine resources as handcrew resources to improve suppression skills when creating ad hoc handcrews. Integrating local resources on interagency handcrews like Mid-Plains and Shadow Canyon that have explicit capacity building and training goals would support this outcome.
- Hire dedicated full-time firefighters for EVFPD that can pursue higher-level wildland firefighter qualifications.
- Together with other stakeholders, create a local slash collection/disposal location that is free and accessible to all residents of the valley. Air curtain burners can efficiently dispose of all yard waste and slash year-round with very few burning restrictions.
- Support the creation and funding of standing handcrew resources.
- Support commitment for local air resources.
- Support the creation of an internal Fuels Mitigation crew with paid personnel.
- Adopt the International Wildland Urban Interface Code to support defensible space. Consider amending the code recommendations to match current research recommendations (Maranghides et al., 2022):
    - Home and structure setbacks should be structure-centric, not parcel-centric. Cross-boundary structure separation should always be a consideration.
    - Existing high-density housing areas should prioritize home hardening before defensible space.
    - New high-density developments should have complete defensible space and buildings that are extremely resistant to ignition. They should have HOAs or other forms of financial and regulatory collaboration set up to maintain community wildfire protection.
    - Combustible fences should not be double-wide or placed less than 3 feet apart in parallel.
    - Defensible space analyses should evaluate fuel pathways between structures and vegetation and other combustible material in the HIZ.

3.e. Community-Wide Emergency Preparedness

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 5 hours in some parts of the EVFPD due to the high density of homes and 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. Larimer Emergency Telephone Authority (LETA) uses NoCoAlert, also known as reverse 911, to communicate evacuation orders to residents. HOAs, and residents should actively extend awareness about NoCoAlert to neighbors that are unaware of the program. NoCoAlert also uses Wireless Emergency Alerts to push notifications to cell phones near certain cell towers, and the Emergency Alert System to push information through radio and TV channels. Neither of these alerts require opt-in.

NoCoAlert is the reverse 911 system used by Larimer County to contact residents during emergencies, including during wildfire evacuations. Residents can sign up online to choose how and where they want to receive alerts, they can opt-in to specific alert categories via text, they can receive notifications in over 100 languages through the Reachwell app. Residential landlines are automatically registered unless their phone uses VoIP (voice-over internet protocol). Residents can register their cell phones and email addresses on the NoCoAlert website.

The following steps for residents, HOAs, community groups, Estes Valley Fire Protection District, and the Larimer County Sherriff's Office are recommended to address evacuation concerns in the EVFPD:

- 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 **Section 4.c**).
- Coordinate with LETA to increase participation in NoCoAlert across the EVFPD. Regularly test the system to ensure timely and accurate communication could occur during an evacuation.
- Continue encouragement for tourists to opt in to the two-week NoCoAlert system.
- Educate residents about warning systems, protocols for evacuation orders, and evacuation etiquette prior to the need to evacuate the community. Communicate the importance of following evacuation orders; **failing to leave the community in a timely manner during a wildfire emergency can put first responders at risk.**
- Push out consistent guidance for tourists at every tourist interaction point like visitor centers, businesses, rentals, hotels, and gas stations.
- Encourage residents to leave with only one vehicle per household to reduce congestion.
- Encourage all households to develop family evacuation plans and to pack go-bags that are at the ready. Residents should work with their 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. Visit the Larimer County Emergency Preparedness page or the Estes Valley Fire District Evacuation Resources page to learn about preparing go-bags and evacuation planning.
- Encourage residents to evacuate whenever they 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.
- Make sure warnings and alerts can be understood by all residents, including those with English as a second language and with hearing impairments.

3.f. Outreach and Education

The Estes Valley Fire Protection District should continue to engage with community members using a variety of methods, including community organizations, social media, and education materials for visitors of short-term rentals. The following priority recommendations may fall to different entities or partners within and around Estes Valley. As your community makes progress on the top-priority actions outlined below, refer to the fire adapted communities' "wheel" (**Figure 3.1**) and seek additional ideas and resources from the Fire Adapted Community Learning Network and Fire Adapted Colorado (FACO). Visit their websites for more information on their programs and upcoming events.

Community Ambassador Program

This CWPP can only result in on-the-ground change if residents and community groups work with forestry professionals such as the Colorado State Forest Service and Larimer Conservation District to address shared risk. Developing a **Community Ambassador Program** could help residents better understand wildfire risks and spark coordinated action that effects positive change in the EVFPD. This program can be connected to and supported by Larimer Connects, a county-wide community-based support and engagement network. The neighborhood ambassador approach requires engaged volunteer ambassadors and a dedicated lead coordinator. See **Table 3.f.1** from the guide *Fire adapted communities neighborhood ambassador approach: Increasing preparedness through volunteers* for effective activities that neighborhood ambassadors can undertake (Wildfire Adapted Partnership, 2018).

***Table 3.f.1**. Potential activities for the neighborhood 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.
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.	Secure fuels module availability and grants or other financial support.

	Encourage neighbors to attend.	Address liability and safety concerns. Advertise program through HOA newsletters, social media, etc.
Defensible-space walking tour	Identify homeowners with exemplary defensible space. Select a date and organize event logistics. Encourage neighbors to attend.	Arrange for fuel treatment specialists to attend and make presentations. 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. Select contractors and solicit bids. Oversee project completion.	Work with a certified forester for insights about 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.	Work with a certified forester for insights about effective treatment location and prescriptions, following guidelines in **Roadway 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.

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. All engaged stakeholders in this region should take part in a unified message on social media, sharing the same content.

Visitor Outreach

Estes Park is a travel destination and tourism-based economy, so working with visitors and visitor-facing entities is vital to preparing them for wildfire. Sharing information on wildfire preparedness before and when they enter the Valley is the best time. The EVFPD and their partners should work with agencies like Visit Estes Park, the YMCA, and RMNP to coordinate wildfire communication both during the traditional fire season and during the rest of the year.

Working with partners can engage the visitors where they are planning to be – campers in RMNP can receive information about fire safety when they make reservations, local lodging owners can automatically register visitor's phone numbers to the temporary emergency alert line for the duration of their stay, and the visitor center can host information on general fire safety, evacuation planning, and local fire information.

Short-Term Rental Licensing

Short-term rentals are home or apartment rentals that are leased for 30 days or less at a time. These are frequently called vacation rentals, Airbnb's, or VRBOs. Local governments have struggled to regulate short-term rentals, and a study published in 2018 found that 20% of short-term rentals in the US did not have smoke detectors and 58% didn't have fire extinguishers. Many of these short-term rentals offer escapes from city life to rural, mountainous areas of the EVFPD with dense trees and unmaintained road networks. Visitors are often unaware of the risks that come with their vacation location. Short term rentals without defensible space, clearly defined escape routes, or basic fire safety measures put visitors and neighbors at high risk in the event of a wildfire.

The Estes Valley Fire Protection District has operational permits following Short Term Rental Inspections in place, the Town of Estes Park has Vacation Home Licensing, and Larimer County has Short Term Rental requirements.

TEA suggests that local districts and governments implement more rigorous and unified short-term rental guidelines to protect the life safety of visitors as well as the properties of the homeowners in their district.

Table 3.f.2 and **Figure 3.f.2** contain recommendations that were adapted from Boulder County's Wildfire Partners program.

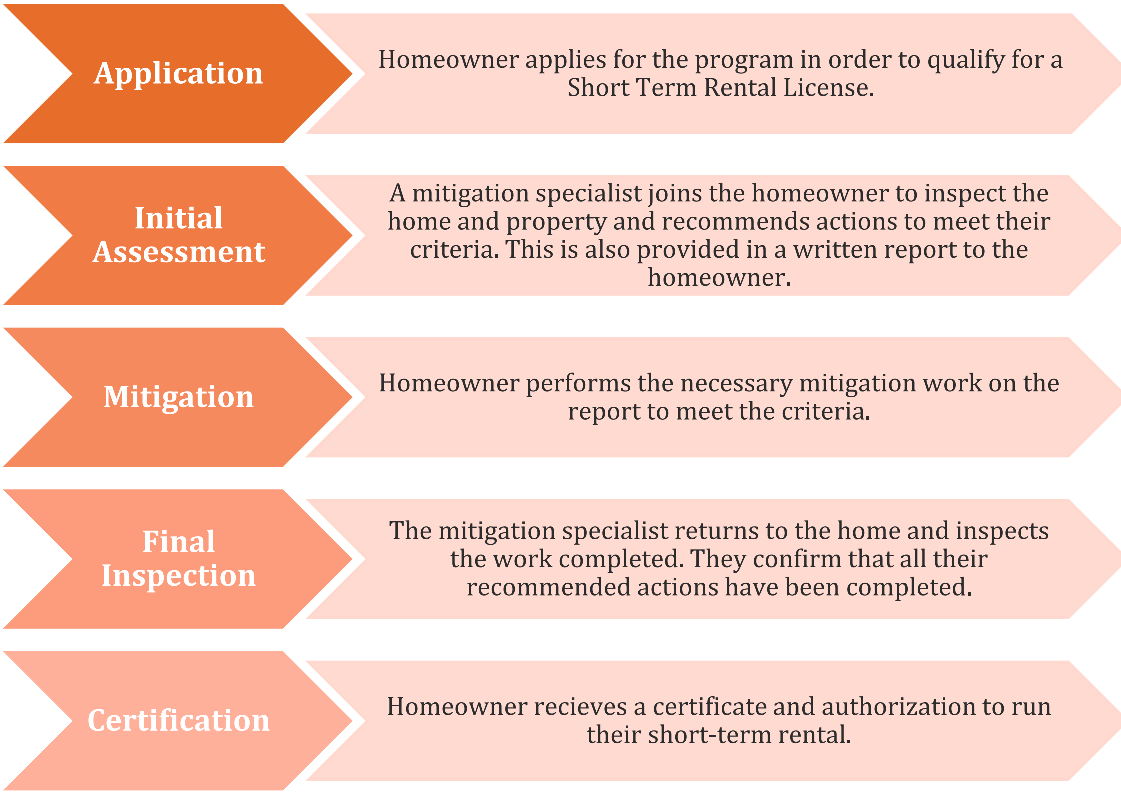


Figure 3.f.1. *Proposed short-term rental licensing process. Homes that are currently operating as short-term rentals could be giving a grace period to complete the mitigation to maintain their business as they complete required mitigation. Process adapted from Wildfire Partners.*

Table 3.f.2. Recommended mitigation goals for obtaining Short Term Rental Licenses in the Estes Valley Fire Protection District. Goals are adapted from FireWise USA.

Mitigation Measure	Goals
Home Ignition Zones	Create defensible space around homes and outbuildings according to the CSFS Guidelines. See **Figure 3.a.1** and **Table 3.a.1** for specific recommendations.
Landscaping	Maintain Zone 1 (0-5 feet from the home) to clean, unburnable conditions with litter and duff removed regularly.
Roofing and Vents	Install and maintain a Class-A roof with mesh covers on vents.
Decks and Porches	Keep decks free of flammable materials such as propane tanks or firewood piles. Use non-combustible deck materials when possible.
Siding and Windows	Clean and maintain windows and siding. Use fire-resistant siding and tempered multi-paned windows when building or remodeling.
Emergency Responder Access	Maintain a 20-foot-wide driveway with 13.5 feet of overhead clearance for emergency vehicles. Ensure that street and house numbers are clearly marked from the road, and there is enough turnaround space for fire trucks in front of your house.
Informed Renters	Provide evacuation maps to renters with multiple ways out of the neighborhood. Require renters to sign up for NoCoAlert emergency alerts for the duration of their stay. Share current fire ban information with renters before they visit, and close off outdoor fire pits when they are not allowed to be used. Provide content from the Estes Valley Fire District website about evacuation.

Collaboration

Collaboration with stakeholders, landowners, local governments, business owners, and community members is the best way to ensure good outcomes from this plan. Stakeholders (see **1.b Partners and Stakeholder Engagement**) were engaged in the development of this CWPP and offered input on the recommendations set forth in this CWPP. It is recommended that the EVFPD continue meetings with major stakeholders in the district to provide accountability on projects, continue to participate in cross-boundary mitigation programs such as the Northern Colorado Fireshed Collaborative (NCFC), and support the community ambassador program's growth and maintenance.

Stakeholders in and around the Estes Valley must work to move mitigation projects from paper to on the ground action, keep lines of communications 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.

3.g. Funding Opportunities for Wildfire Hazard Mitigation and Emergency Preparedness

There are many funding opportunities from federal, state, and local agencies as well as non-profits to assist in forest health and wildfire mitigation projects. These funds can increase capacity but cannot cover all the costs of fire mitigation needed within the valley. Local residents and stakeholders must put forth funds and time to complete this work.

Opportunities from Local and State Agencies in Colorado

- The Colorado State Forest Service (CSFS) **Forest Restoration and Wildfire Risk Mitigation (FRWRM)** is a competitive grant program designed to assist with funding community-level actions across the entire state to: reduce the risk to people, property and infrastructure from wildfire in the wildland-urban interface (WUI); promote forest health and the utilization of woody material including for traditional forest products and biomass energy; and encourage forest restoration projects.
- 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 **Larimer Conservation District** helps landowners navigate forestry projects to promote forest health and complete wildfire mitigation projects.
- The **Larimer County Office of Emergency Management** offers community mitigation grants to increase a community's long-term resilience to natural hazards.

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-sale 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

- 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.
- 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 District

The Estes Valley Fire Protection District strives to be supportive of forestry projects that improve forest health and wildfire safety. 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 district – 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 district:
  - EVFPD is supported by volunteer firefighters who respond to fires, medical emergencies, and rescues every day of the year. Learn more about how you can volunteer by contacting the fire department.
  - Support for local ballot measures that provide tax revenue for the FPD is vital to their success in responding to residents in their time of need. EVFPD has a diverse mix of funding from both sales tax and property tax, allowing them to maintain a relatively low mill levy for residents in the valley.
  - Support local code changes that the district advocates for. Stronger WUI codes mean that future developments will be more fire-resistant and the land they are on will be more resilient, which can reduce the work and cost for the EVFPD to protect residents in the long run.
  - Attend events hosted by the EVFPD. 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.

4. Implementation Recommendations for Fuel Treatments

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 et al. 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 et al., 2007). Strategic fuel treatments, in tandem with work by individual residents to mitigate hazards in their home ignition zone (see **Mitigate the Home Ignition Zone**), can help protect life and property. Many residents, HOAs, and local agencies that manage land within and around the EVFPD are actively reducing wildland fuels. Additional strategic work is required to mitigate wildfire risks across the EVFPD (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 (Reinhardt et al., 2008).

Strategically located, high-quality fuel treatments can create tactical options for fire suppression (Jolley, 2018; Plucinski, 2019; Reinhardt et al., 2008). <u>Fuel treatments are most effective when used in conjunction with suppression actions.</u> Reduced fire intensity within treated areas allows firefighters opportunities to use direct or indirect suppression techniques. Firefighters benefitted from using fuel treatments west of Estes Park as tactical features during the 2020 East Troublesome Fire, and it is possible these treatments helped prevent wildfire damage in the town (Good, 2020).

All fuel treatments are not created equal, and there is no ''one size fits all'' fuel treatment design (Reinhardt et al., 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 three 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. Homeowners are responsible for fuel mitigation on their own lands – you as a landowner must initiate and follow through on this work, but that does not mean you must do it alone. For assistance in planning and implementing a new fuels treatment, contact the Larimer Conservation District, Colorado State Forest Service, or other wildfire mitigation specialists.

Treatment Categories

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 Property Assessment 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 (Reinhardt et al., 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 et al., 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 et al., 2018). Stand-level fuel treatments are designed for large landowners, public land managers, and collaborating neighborhoods to implement.

Roadway fuel treatments: Roadway 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. Fuel treatments along trails, ridgelines, and other features can be utilized by firefighters to contain fire spread. This work can be done by all collaborators in the district. Individuals can implement these recommendations along their driveways, Coordinate with your HOA, Larimer County Road & Bridge, and the Colorado Department of Transportation to learn about regulations and opportunities to mitigate hazards along roadways in your community.

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 $2,500 to $10,000 per acre are not uncommon along the Colorado Front Range where there is little biomass or timber industry to provide financial return (Gannon et al., 2019). 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 (Fulé et al., 2012; Loomis et al., 2019; Prichard et al., 2020). Fuel treatments can reduce the cost of rehabilitating water sources when wildfires are followed by large storm events that result in massive erosion (Jones et al., 2017). In some instances, fuel treatments can reduce suppression costs due to the increased efficiency of firefighting (Loomis et al., 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 et al., 2008). However, when fuel treatments follow the principles of ecological restoration, they result in positive ecological benefits regardless of economic costs.

4.b. 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 et al., 2018; Fulé et al., 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 et al., 2009). Most of the forested area within and around the EVFPD are mixed-conifer, ponderosa pine, and lodgepole pine forest types (**Figure 2.a.4**), and many of these forests had far fewer trees prior to Euro-American settlement due to a higher frequency of wildfires (**Figure 2.b.1**) (Addington et al., 2018). The Larimer 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 et al., 2018). It is suggested that foresters, other land managers, and landowners reference this document when preparing and implementing forest treatments in and around the EVFPD. 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 et al., 2017).

Table 4.b.1. *Minimum recommended spacing between tree crowns is greater for properties on steeper slopes due to the exacerbating impact of slope on fire behavior (Dennis, 2003). 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 et al., 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 (Paysen et al., 2000; Stephens et al., 2009). 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 et al., 2007).

Prescribed burning is generally cheaper to implement than mechanical treatments across large landscapes (Hartsough et al., 2008; Hunter et al., 2007), and fire has unique impacts on vegetation and soils that cannot be replicated by mechanical treatments alone (McIver et al., 2013). Thinning and burning treatments tend to achieve fuel reduction objectives and modify fire behavior to a greater extent than thinning alone (Fulé et al., 2012; Prichard et al., 2020).

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). See **Section 4.d. Slash Management** for options to mitigate surface fuel loads created by fuel management.

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 this area and contain ponderosa pine, Douglas-fir, and Rocky Mountain juniper, with occasional blue spruce.

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, the following is recommended:

- Follow the principles of ecological restoration as outlined in Addington et al., 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.b.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 et al., 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 **Section 4.d. Slash Management** 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 et al., 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 3.a.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 EVFPD. 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 (CFRI, 2021). 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 et al., 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 areas open for regeneration of aspen and understory plants. 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, the following is recommended, adapted from recommendations by (Dennis et al.) 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 3.a. Defensible Space**. 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.

Other Vegetation 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.

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

This CWPP process located and prioritized potential locations for ecological restoration and/or stand-level fuel treatments within and around the EVFPD (**Figure 4.b.1**; **Table 4.b.2**). The Core Team met with the Northern Colorado Fireshed Collaborative twice in April and June 2022 to plan and prioritize implementation projects. **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 was based on predicted fire behavior, the abundance of threatened structures, the likelihood of fires passing through a treatment unit and entering residential areas, presence of non-survivable roadway conditions, and operability based on slope. The boundaries of the proposed treatment units follow topographic features and major roadways. See **Appendix B.2. Fuel Treatment Prioritization Methodology** for a full description of our prioritization methods.

32 first-priority treatment units were identified that are fully or partially within the Estes Valley Fire Protection District for a total of about 9,400 acres and 7 first-priority treatment units adjacent to the district for a total of 1,350 acres (**Figure 4.b.1**). First-priority treatment units fall in the western half of the EVFPD due to the high potential for wildfires to impact residential and non-residential values at risk. There are numerous second and third priority units within and surrounding the EVFPD in which treatments could reduce the risk of high-severity wildfires, protect lives, and enhance safety within the EVFPD (**Figure 4.b.1; Table 4.b.2**). See **Section 4.e. Implementation Plan** for details about fuel treatments ready for implementation immediately (1-2 years), in the short-term (3-5 years), or in the mid-term (6-10 years).

This document focuses 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. The Estes Valley Fire Protection District, 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.b.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 et al., 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 implementing strategic treatments that decrease shared fire risk.

Table 4.b.2. *Total area and number of first, second, and third priority treatment units within and around the EVFPD.*

Treatment priority	First priority	Second priority	Third priority
Total area	10,738 acres	8,333 acres	17,665 acres
Number of treatment units	39	44	127

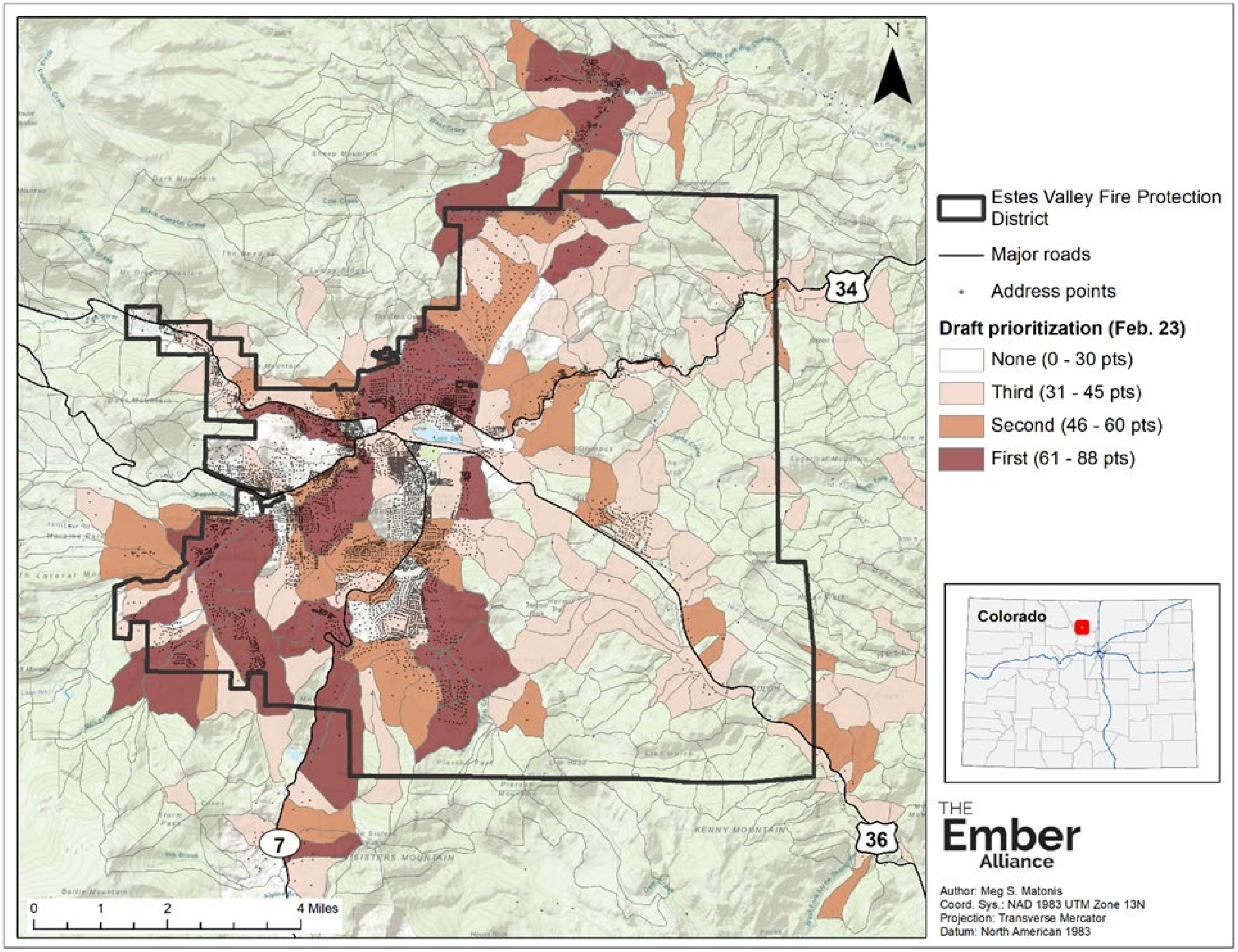


Figure 4.b.1. *Potential priority locations for ecological restoration and/or stand-level fuel treatments based on predicted fire behavior, the abundance of threatened structures, the likelihood of fires passing through a treatment unit and entering residential areas, presence of non-survivable roadway conditions, and operability based on slopes. See* ***Appendix B.2. Fuel Treatment Prioritization Methodology*** *for a description of hillslopes and a full description of our prioritization method.*

4.c. Roadway Fuel Treatment Recommendations

Effective Treatment Design

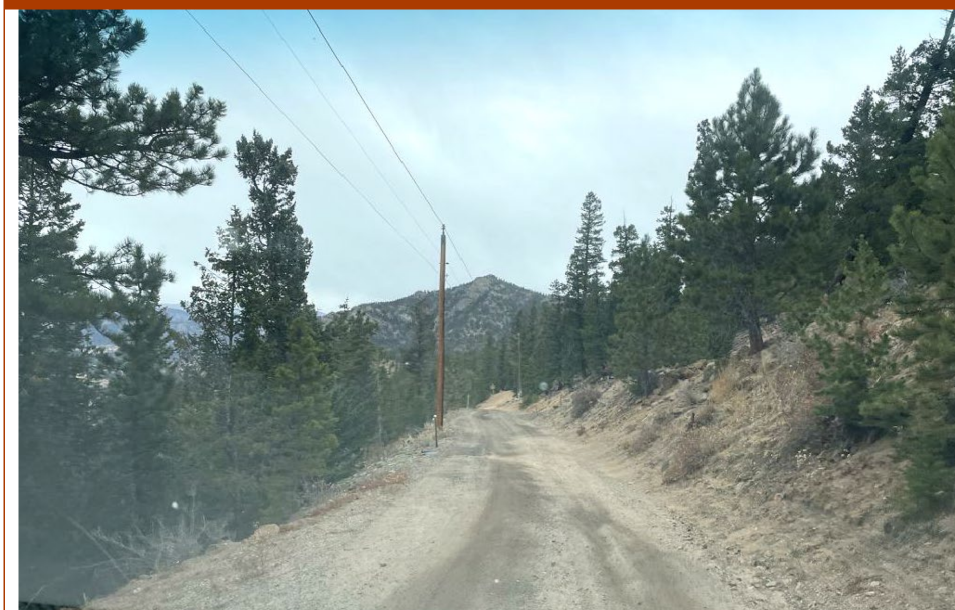
The primary objective within roadway treatments is to dramatically reduce fuels to create potentially survivable conditions along roadways during wildfires to allow for safer evacuation. Treatments can follow principles of ecological restoration, but guidelines for shaded fuelbreaks (Dennis, 2005) or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

- Coordinate with your HOA, Larimer County Road & Bridge, Town of Estes Park Street Division, and the Colorado Department of Transportation to learn about regulations and opportunities to mitigate hazards along roadways in your community.
- 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.c.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 (**Table 4.c.2**) (Dennis, 2005).
- 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.b.1**).
- Remove trees that are leaning over roads and all dead trees near roads that could fall and block access during a wildfire.
- 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 **Section 4.d, Slash Management** 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 3.a.3** for an example of repeat photographs pre- and post-treatment).

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). See **Section 4.d. Slash Management** for options to mitigate surface fuel loads created by fuel management.

***Table 4.c.1**. Examples of conditions occurring along roadways in the EVFPD and suggestions for improvement.*

Roadway example	Suggestions for improvement
	• Clear trees away from roadway on downhill side • Remove any uphill trees that could fall and trap residents during an evacuation • Create space for turnarounds and pullouts • Grade road regularly
	• Clear trees and tall shrubs away from the roadway • Widen roads in this area where possible • Grade road regularly • Create regular pullouts and turnaround locations for engines • Install mirrors on switchbacks

Roadway example	Suggestions for improvement
	• Clear trees from near road on both sides. • Thin areas surrounding the roads
	• Post clear, reflective road signs and address signs throughout • Create turnarounds for engines

Roadway example	Suggestions for improvement
	• No work necessary, road in good condition • Maintain mowed grasses near road
	• No mitigation necessary; this road is accessible and not lined by burnable vegetation

Table 4.c.2. *Minimum fuel treatment width 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 fuel treatment 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.c.1** for a visual representation of measurements for roadway fuel treatments.

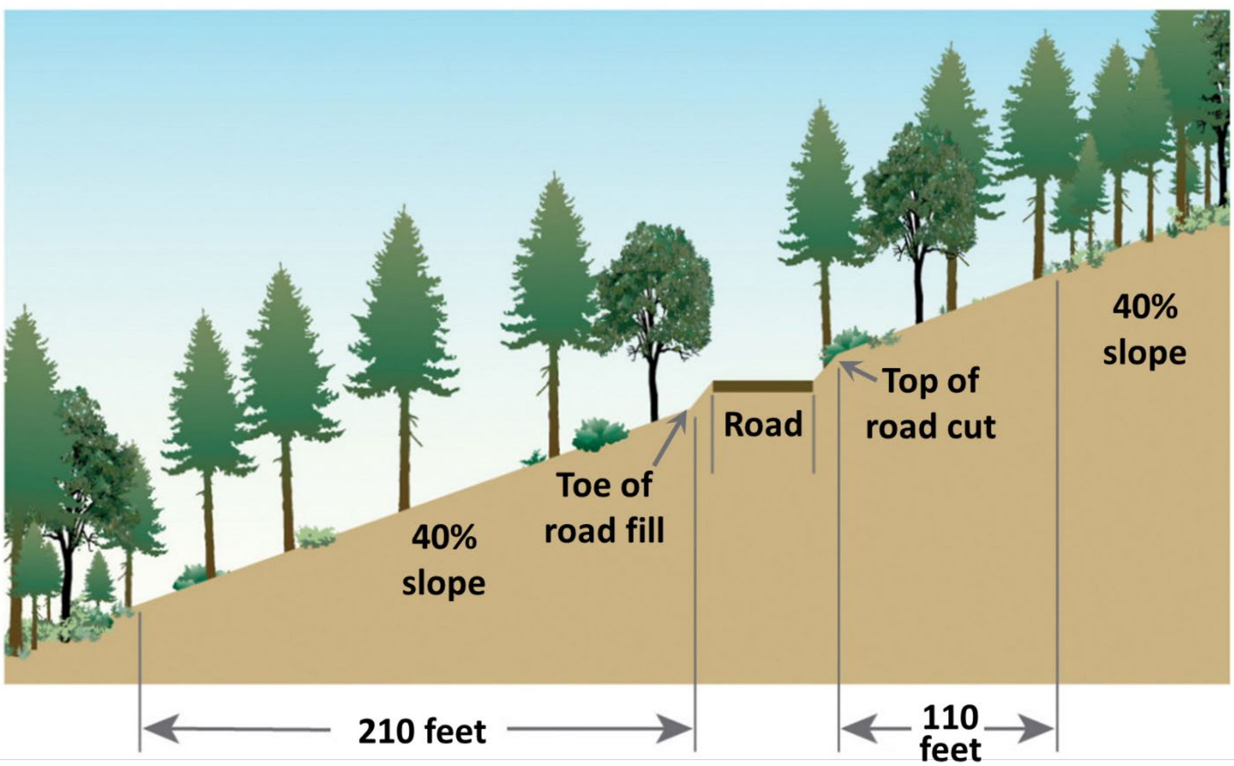


Figure 4.c.1. *Fuel treatment width must be greater on the downhill side of the road due to the exacerbating impact of slope on fire intensity when fires travel uphill. Figure modified from Bennett et al., (2010).*

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. In this process, TEA located and prioritized potential locations for fuel treatments along roads, private drives, and driveways within and around the EVFPD (**Figure 4.c.2**). TEA prioritized treatments along roadway corridors based on predicted roadway survivability under 60th and 90th percentile fire weather conditions and potential evacuation congestion. It is important to reduce fuels along roadways where evacuation could proceed slowly due to congestion. See **Appendix B.2. Fuel Treatment Prioritization Methodology** for a full description of our prioritization methods.

In total 11 miles of first-priority and 11 miles of second-priority roadways were identified for fuel treatments to protect lives and property (**Table 4.c.3**). Emergency personnel and forestry professionals should visit these priority locations to assess current conditions and determine specific locations for fuel treatments. Our fire behavior analyses occurred at the scale of 0.2 acres (30 x 30 meters), so locations of priority treatments are approximate. See **Section 4.e. Implementation Plan** for details about fuel treatments ready for implementation immediately (1-2 years), in the short-term (3-5 years), or in the mid-term (6-10 years).

Table 4.c.3. *Total length of first, second, and third priority roads, private drives, and driveways for roadside fuel treatments within the Estes Valley Fire Protection District, and the names of several roads in each category with longer priority segments.*

Treatment priority	First priority	Second priority	Third priority
Total length of road segments	11 miles	11 miles	62 miles
Road names	Highway 36 Highway 34 Little Valley Road Highway 66/Tunnel Road Windcliff Drive Eaglecliff Drive Wind River Road	Highway 66 Windcliff Drive Highway 7/St Vrain Avenue Fish Creek Road Pole Hill Road Devils Gulch/Macgregor Avenue	Covers portions of most roads on the outer edges of the district

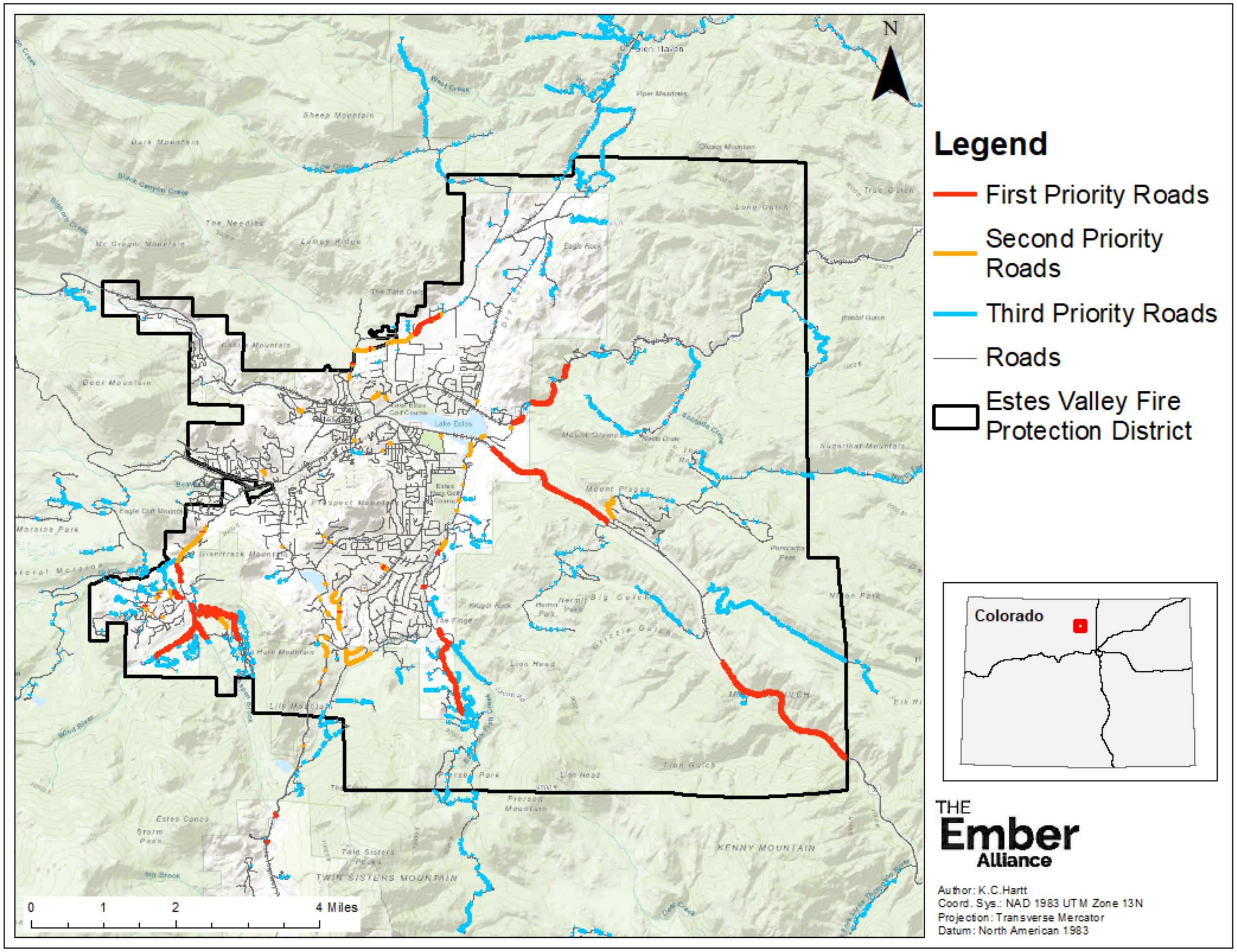


Figure 4.c.2. *Priority locations for fuel treatments along roadways and driveways in the EVFPD based on potential fire behavior and evacuation congestion. Our fire behavior analyses occurred at the scale of 0.2 acres (30 x 30 meters), so locations of priority treatments are approximate. See* ***Appendix B.2. Fuel Treatment Prioritization Methodology*** *for a full description of our prioritization methods.*

4.d. Slash Management

Thinning, harvesting, or other forest management 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. Slash management is a critical step in the forest management process, and 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.

Leaving untreated slash within roadway treatments is particularly counterproductive. The risk of active crown fire might be lower after a thinning operation, but untreated slash in fuel treatments 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.

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.d.1**). 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

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 (Fulé et al., 2012; Prichard et al., 2020). 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 et al., 2019) and when they do, the wildland fire community soberly reviews those escapes to produce lessons learned and make improvements (Dether, 2005). Agencies have frequently and successfully conducted prescribed burns in WUI areas (Hunter et al., 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 et al., 2013). Prescribed burns can reduce

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).

property damage during wildfires because they are so effective at altering forest fuel loads (Loomis et al., 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 et al., 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 Larimer County Department of Health and Environment. In Larimer County, pile burning above 6,000 feet in elevation can only occur between October 1st and May 1st, when winds are less than 10 mph, and there are at least 3 inches of snow on the ground.

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.d.1. 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 (Fulé et al., 2012; Prichard et al., 2020). 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 (Fulé et al., 2012; Prichard et al., 2020). Can restore ecosystem function in frequent-fire forests (Addington et al., 2018; McIver et al., 2013). Generally cheaper than mechanical treatments (Prichard et al., 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 et al., 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. See regulations for pile burning on the burn permit website for the Larimer County Department of Health and Environment.	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.)		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).
Air curtain burner	Air curtain burners are machines that burn woody material cleanly in contained space. They typically consist of a box or trench into which slash is loaded and ignited. A strong fan blows a curtain of air down and over the burning material in a way that keeps oxygen flowing through the fire and keeps smoke from escaping out the top. Carbon from the smoke is filtered out of the air and kept inside the box.	Air curtain burners can be used under a much wider range of conditions and locations than pile burning or broadcast burning and can be contained and extinguished quickly and easily. They produce significantly less smoke than open burns and can be placed in accessible locations in the WUI. Air curtain burners can burn more kinds of slash than pile burning, including green wood, lumber, and general yard waste. They can be an acceptable form of burning slash where there is not social license for pile or broadcast burning. Ash from the burner can be redistributed and return nutrients to the ground.	Air curtain burners are expensive to obtain and require professionals to operate them. Slash material needs to be transported from locations throughout the community to where the burner is located. If the ash is not distributed, it won't return the nutrients to the ground.

Method	Description	Benefits	Challenges
Community slash piles	Residents take slash from their property to a designated location that is managed by the community. The community manages the slash for the residents via pile burning or chipping.	Residents are not responsible for burning or chipping their own material. It immediately reduces the fuel loading on their properties. If the material is chipped or burned, it can be redistributed to the community as mulch or ash to return the nutrients to the ground.	The success of this is dependent on the managers of the community slash piles to properly burn the piles. The community piles must have a plan to be burned. If they are left in the community, they can pose a fire risk. If the material is not distributed, it won't return the nutrients to the ground.
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 (Agee and Skinner, 2005; Hunter et al., 2007).
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 et al., 2014). Breaks slash up into smaller pieces and distributes it closer to the forest floor, which can encourage faster decomposition.	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 et al., 2014). Does not remove surface fuels from the site, it just restructures the way fuels are arranged.

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 (Jain et al., 2018; Kreye et al., 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). Can produce landscape mulch to be used offsite.	Masticated and chipped fuels are unlike natural surface fuels in terms of their shape, depth, and highly compact nature (Kreye et al., 2014). Masticated and chipped fuels can impede plant regeneration, particularly when the depth of masticated and chipped fuels exceeds 4 inches (Jain et al., 2018).
Utilizing material for firewood	Wood leftover from thinning operations can be used as firewood for home fireplaces or outdoor fire pits. Firewood needs to be "seasoned" before use, which involves splitting the wood into usable logs and drying it for 6-18 months so it burns cleanly and doesn't produce much smoke. **Firewood that is aging or ready for use should not be stored in defensible space zones 1 or 2.**	Can be an inexpensive way to reduce fuel loading on the property. Locally sourced firewood reduces the chances of introducing non-native insects and diseases to the ecosystem that cause outbreaks and damage forest health. Homeowners can often manage preparing firewood themselves.	Improperly stored firewood can create hazardous conditions near structures during a wildfire event. While firewood is being stored, it does not reduce the fuel load of the land. Firewood does not use all the woody material from felled trees. Needles, bark, and small branches need to be dealt with separately.
Hauling material away	Hauling material away involves loading the thinned fuels on trucks and removing them completely from the site. The materials can be taken to mills to be turned into boards, taken to yard waste disposal sites where it is composted and turned into garden soil or mulch, or taken to a landfill. Wherever it is taken, the material is completely removed from the site.	This is an extremely effective way to reduce fuel loading. The fuel is completely removed, not just rearranged. The fuel load decrease is immediate. There is no waiting period for ground fuels to decompose or become unburnable.	Not feasible in areas far from roads. Can spread insects like mountain pine beetles and emerald ash borer to other locations. This can be expensive and difficult depending on the size and location of the project.

Method	Description	Benefits	Challenges
Mowing / grazing	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 et al., 2011).

4.e. Implementation Plan

The following implementation plan was developed by the Core Team and project partners based on the CWPP treatment prioritization, ongoing fuel treatment work in and around the EVFPD, potential funding sources, and other considerations that influence the feasibility of treatment implementation. The relative importance and feasibility of treatments is reflected in their timeline—partners aim to conduct treatments for immediate action in the next 1-2 years, short-term treatments are targeted for the next 3-4 years, and mid-term projects for the for the next 5-10 years. Mid-term projects will require more coordination, funding, and other enabling conditions before implementation can begin.

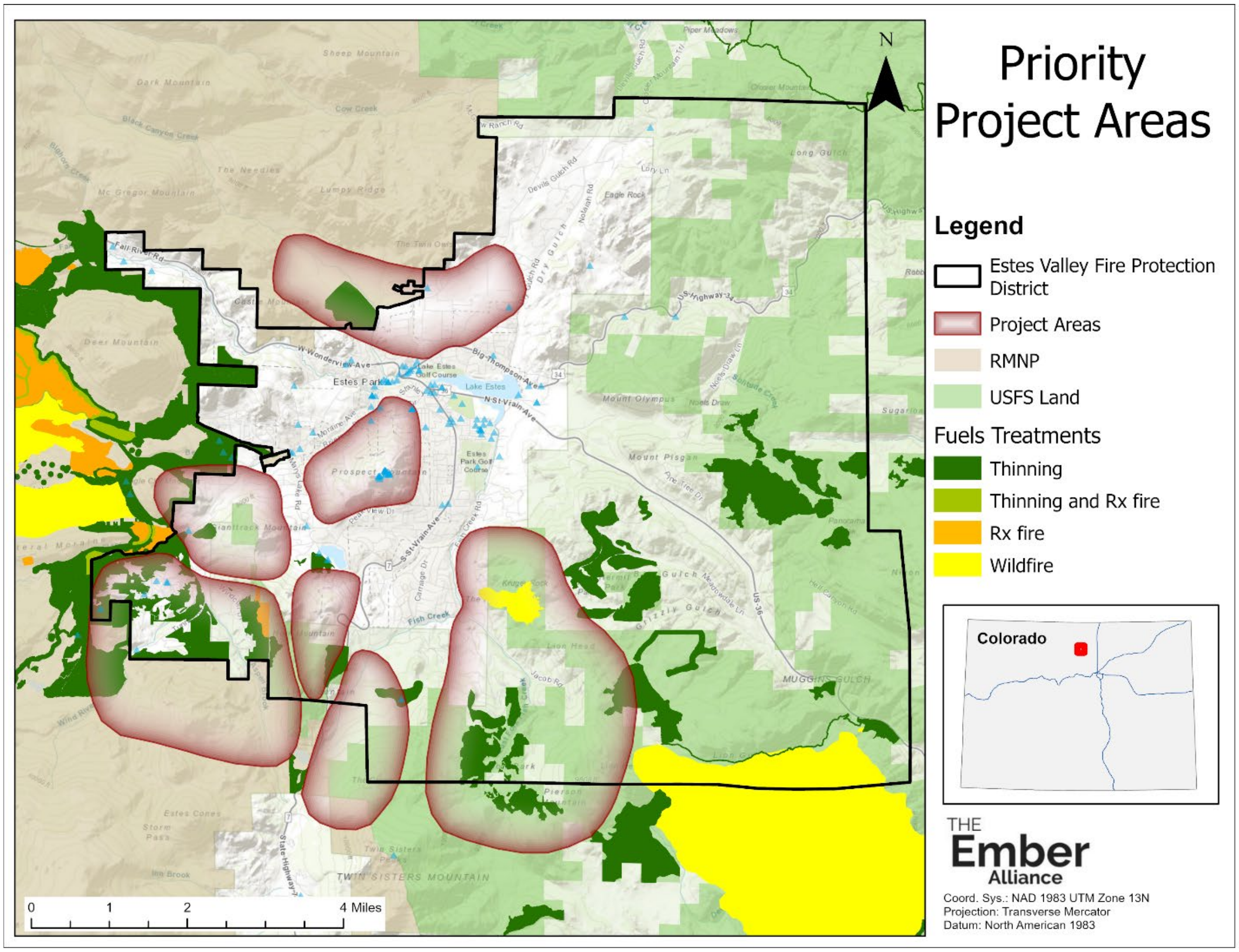
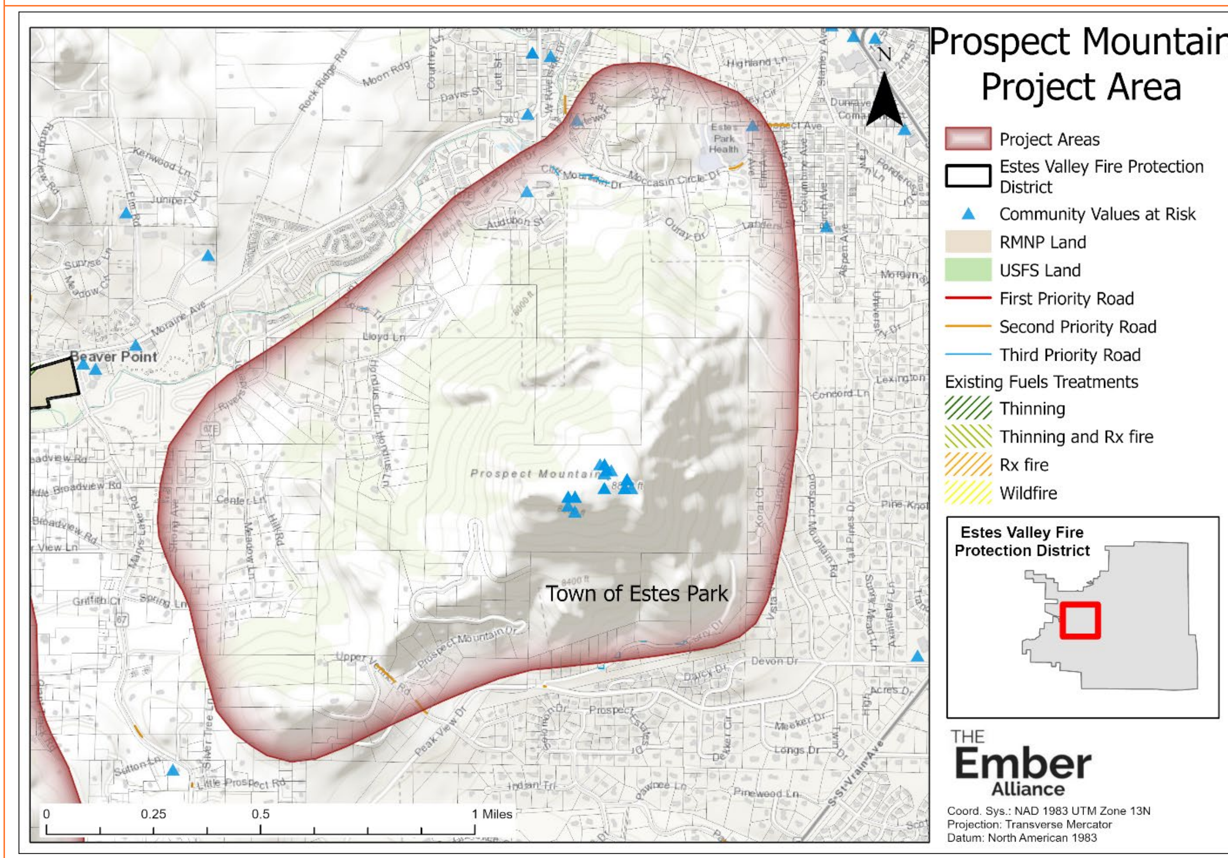


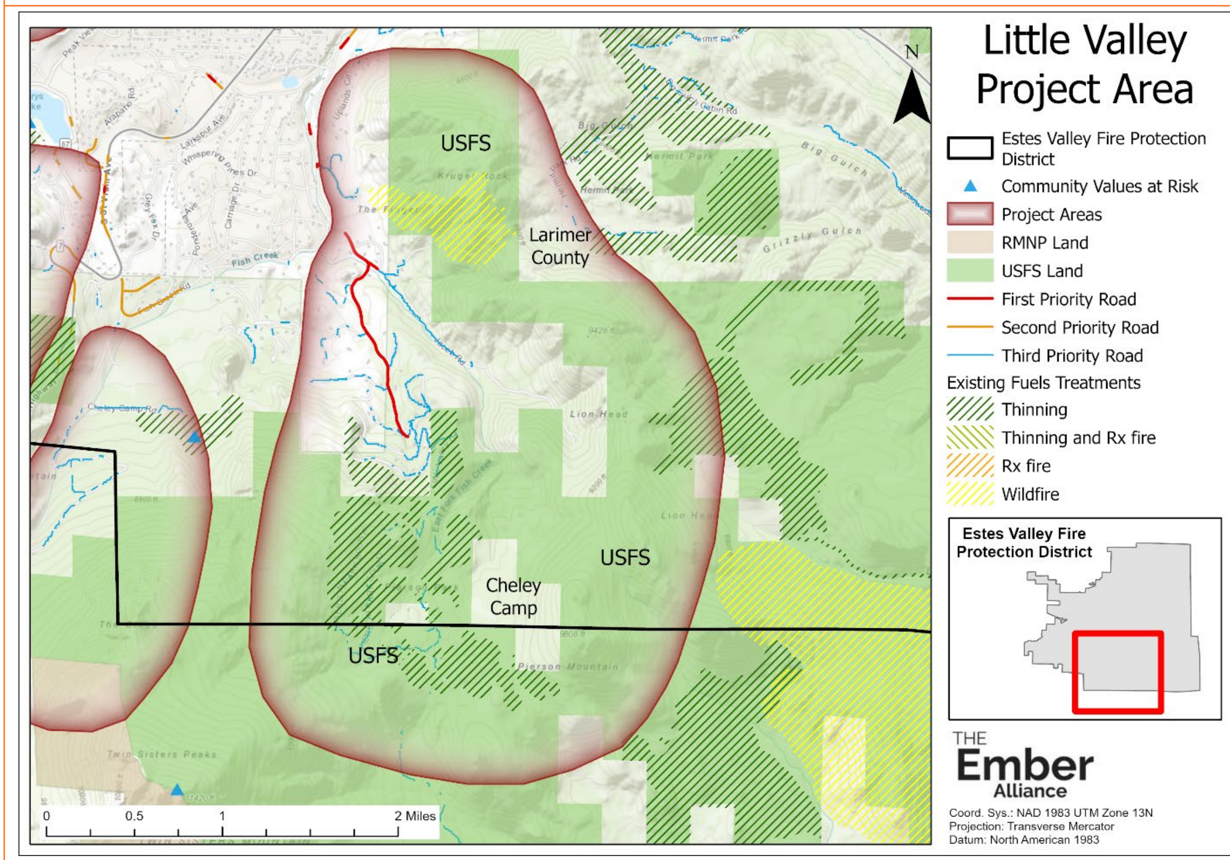
Figure 4.e.1. *Map of all the priority project areas in the EVFPD. Individual project areas are detailed in the following pages.*

Stand-Level Fuel Treatments

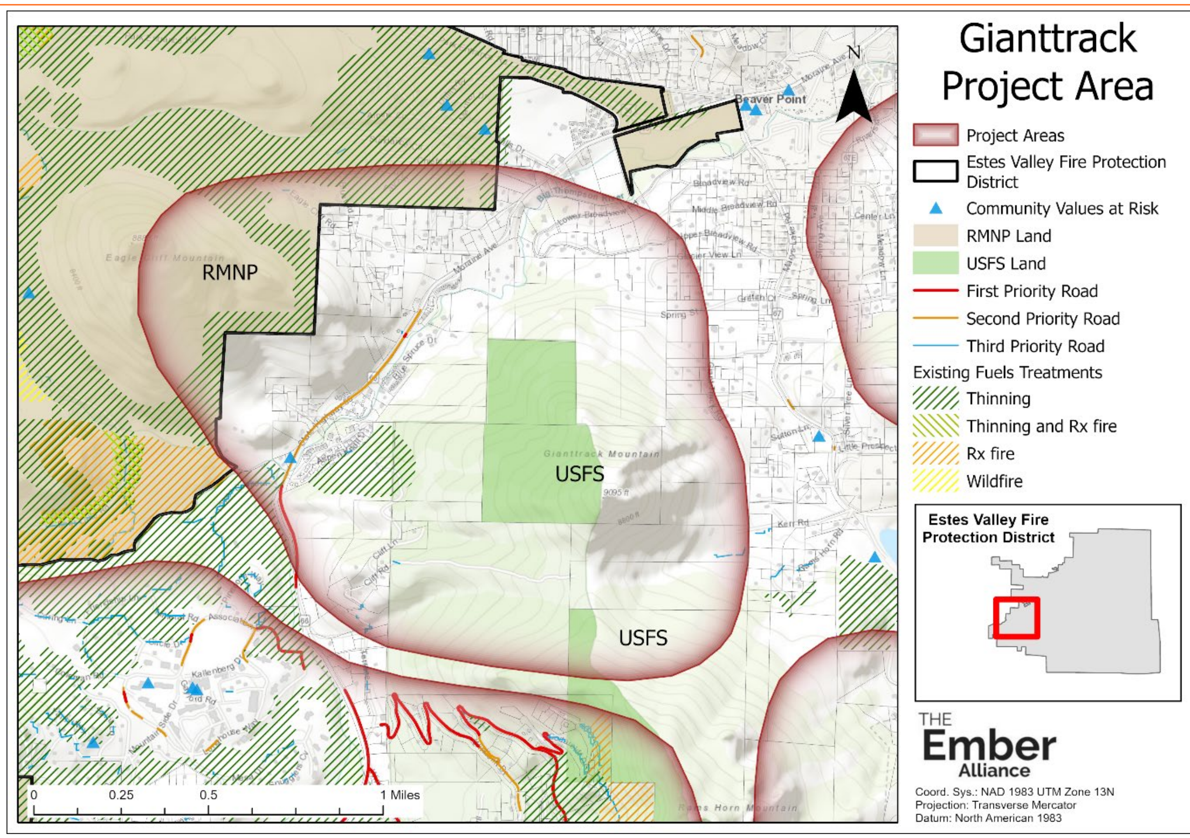
Prospect Mountain Project Area	
Description:	1,042 acres of top-priority treatment in the center of the district. This area contains at least one one-way-in/one-way-out neighborhood, and is directly south of downtown Estes Park. This unit is primarily dense mixed conifer forests on northern aspects and ponderosa pine woodland on southern aspects. There are significant amounts of juniper throughout.
Treatment objectives:	The first goal is to create healthy forest conditions that are more resistant and resilient to fire. The second goal is to protect the communication towers on Prospect Mountain, Estes Park Hospital, Crags Lodge, and Clatworthy Place.
Treatment type:	Mechanical thinning and pile burning. Off-site removal of junipers and other shrubs across the unit is important. Linked defensible space between landowners is necessary.
Priority:	Immediate action, work starting within 1-2 years
Lead and support organizations:	**Estes Valley Watershed Coalition**, Town of Estes Park, **Estes Valley Fire Protection District**, Estes Park Health



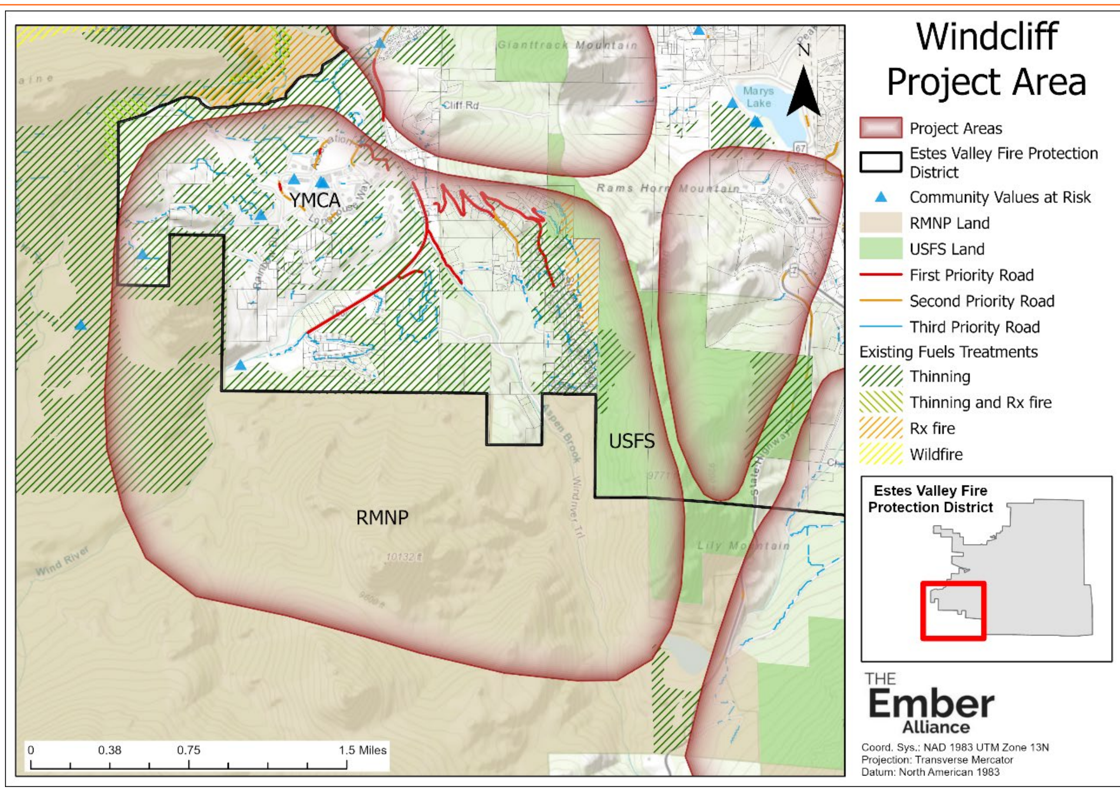
Little Valley Project Area	
Description:	5,364 acres of first-priority treatment units in a fire-prone, one-way-in/one-way-out neighborhood on the west side of the district. This area covers part of one of the most concerning parts of the district. Vegetation is dense and access is limited with a one-lane exit road for all residents. The Kruger Rock fire of 2021 burned within the unit (see the boundary on the map) and forced evacuations for all residents in the area. This unit is primarily mixed conifer, getting denser as you move south. There are lots of lodgepole in the southern side of the unit.
Treatment objectives:	The first goal is to create healthy forest conditions that are more resistant and resilient to fire.
Treatment type:	Forest thinning in ponderosa and mixed conifer habitat, patch cuts in lodgepole-dominated habitat.
Priority:	Immediate action, work starting withing 1-2 years
Lead and support organizations:	**US Forest Service**, Larimer Conservation District, Estes Valley Fire Protection District



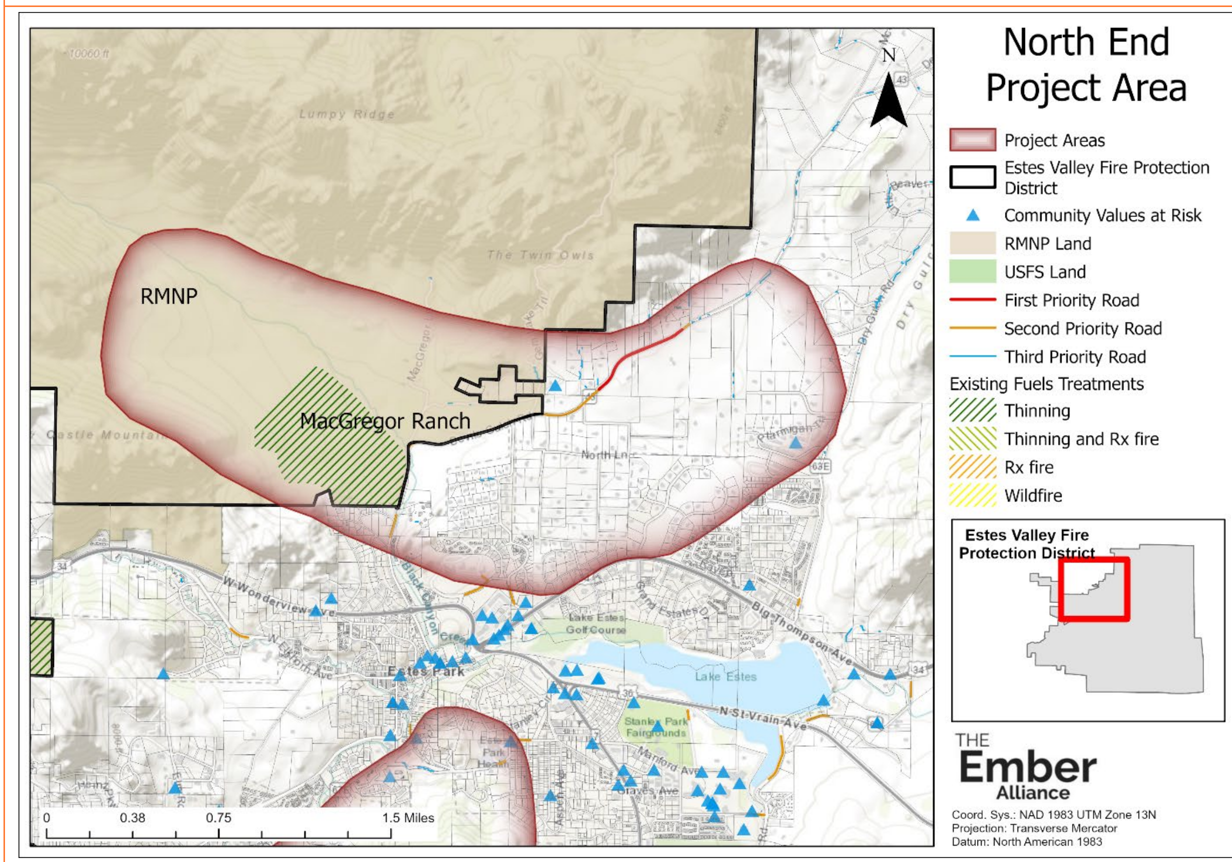
Gianttrack Project Area	
Description:	1,278 acres in a fire-prone are with one-way-in/one-way-out neighborhoods on the west side of the district. This project covers part of one of the most concerning parts of the district. Both the Fern Lake and East Troublesome fires threatened to leave the boundary of RMNP and enter the district in this area, and it has a one-lane exit road with lots of visitor lodging along the route. This unit is primarily mixed conifer, with lodgepole pine on the northern aspects and ponderosa pine in the flatter areas. There is some aspen in the southeast corner and montane shrublands throughout.
Treatment objectives:	The first goal is to create healthy forest conditions that are more resistant and resilient to fire. The second goal is to protect the original site of the Dunraven Inn, a locally significant historic site.
Treatment type:	Mechanical thinning and pile burning
Priority:	Short-term, work starting in 3-4 years
Lead and support organizations:	**Estes Valley Watershed Coalition,** Rocky Mountain National Park, US Forest Service



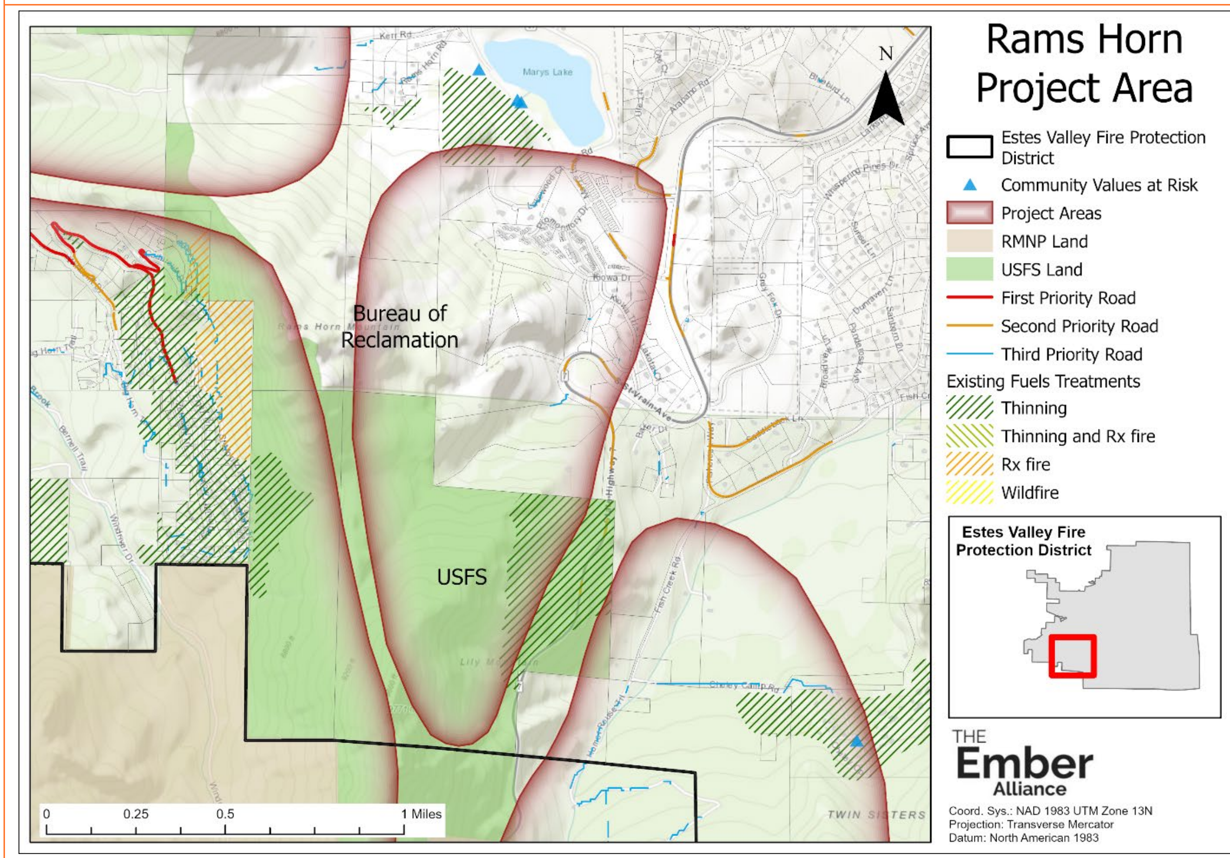
Windcliff Project Area	
Description:	3,760 acres covering at least two fire-prone, one-way-in/one-way-out neighborhoods on the southwest side of the district. This area covers part of one of the most concerning parts of the district. Both the Fern Lake and East Troublesome fires threatened to enter the district in this area, and it has a one-lane exit road with visitor lodging. This unit is primarily mixed conifer and aspen. Canopy density varies greatly and some thinning projects have already been completed.
Treatment objectives:	The first goal is to create healthy forest conditions that are more resistant and resilient to fire. The second goal is to protect the electrical substation at East Portal, the Town's water treatment plant, and YMCA historical resources. The third goal is to connect fuels treatments on the southeast side of RMNP that protect residents and create tactical firefighting opportunities.
Treatment type:	Mechanical thinning and pile burning in denser mixed conifer forests, broadcast burns where appropriate, continue follow up treatments
Priority:	Short-term, work starting in 3-4 years
Lead and support organizations:	**Rocky Mountain National Park, Estes Valley Fire Protection District,** US Forest Service, YMCA of the Rockies, Town of Estes Park



North Estes Project Area	
Description:	2,091 acres of flashy, potentially fast-moving fuels in a south-facing area on the northwest side of the district. This area covers a popular residential area in the North End and part of downtown. This unit is primarily mixed conifer, ponderosa pine, and montane shrublands and grasslands. It is relatively flat and has fine, flashy fuels that could create fast-moving fires across the area.
Treatment objectives:	The first goal is to create healthy forest conditions that are more resistant and resilient to fire. The second goal is to protect the downtown area, the Good Samaritan facility, the Lifelong Learning childcare center, the Stanley Historic District, and Wind Ridge historic site. The third goal is to create tactical firefighting operations for fires threatening to enter Estes Park from Black Canyon
Treatment type:	Mechanical thinning and pile burning in forested areas, and broadcast burning in grasslands and ponderosa pine woodlands
Priority:	Mid-term, begin work in 5-10 years
Lead and support organizations:	**Larimer Conservation District**, MacGregor Ranch, Rocky Mountain National Park, Estes Valley Watershed Coalition

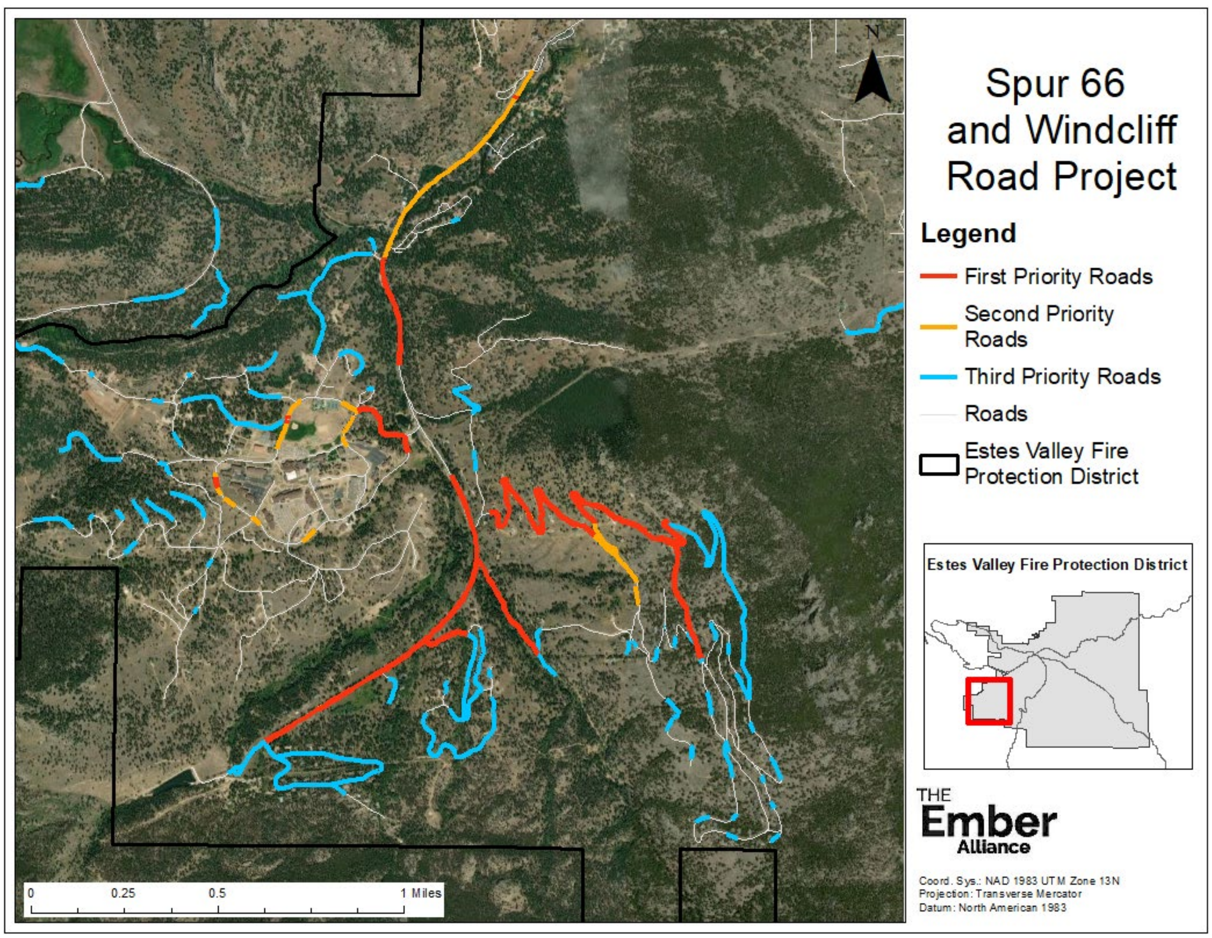


Rams Horn Project Area	
Description:	650 acres in a fire-prone on the west side of the district. Some USFS land and at least one one-way-in/one-way-out neighborhood. This area covers a northeast facing hillslope with homes at the bottom of the slope and dangerous fuels to the west of them. This unit is primarily mixed conifer, with aspen stands at the west end.
Treatment objectives:	The first goal is to create healthy forest conditions that are more resistant and resilient to fire.
Treatment type:	Mechanical thinning and pile burning in mixed conifer stands
Priority:	Mid-term, begin work in 5-10 years
Lead and support organizations:	**Estes Valley Watershed Coalition**, US Forest Service, Colorado State Forest Service, Bureau of Reclamation

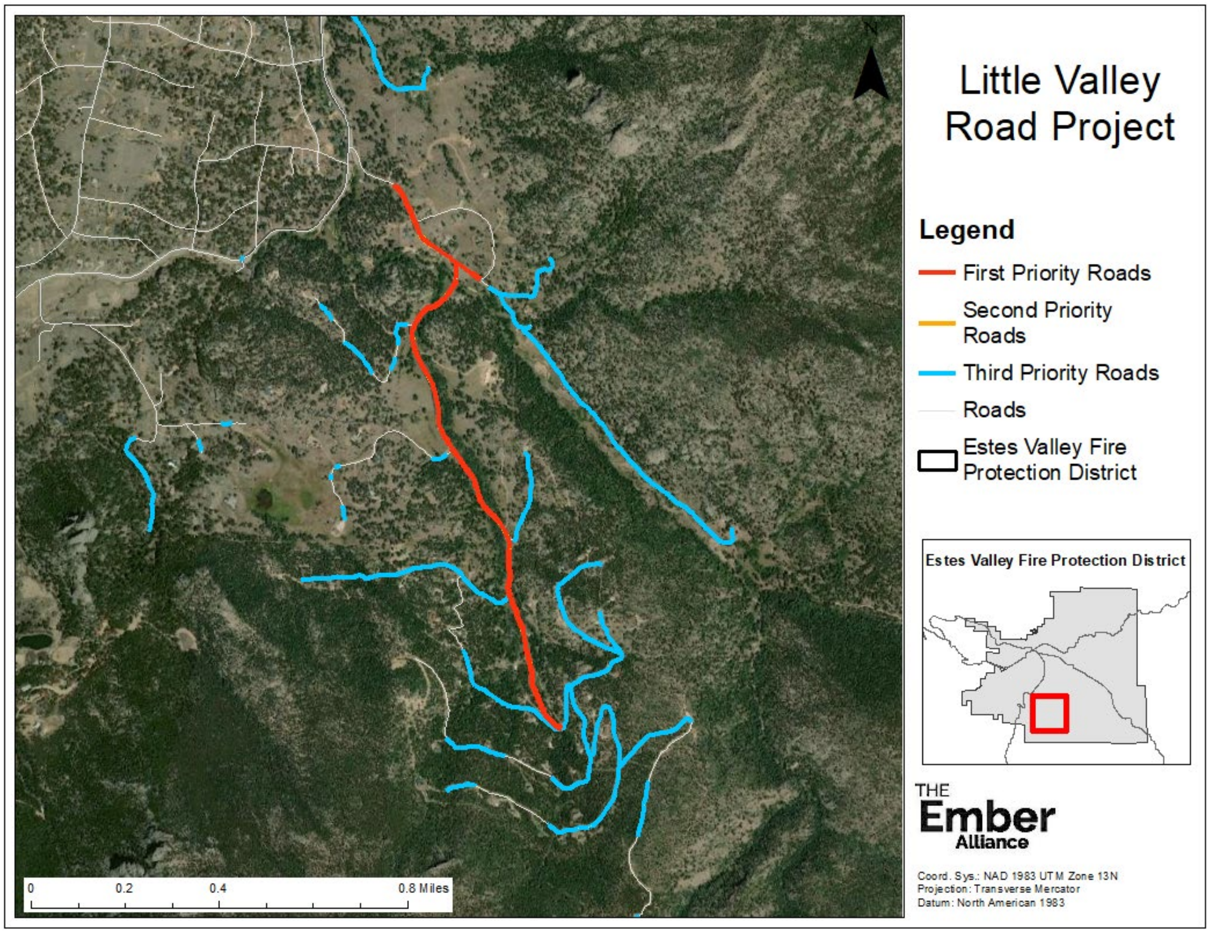


Roadside Fuel Treatments

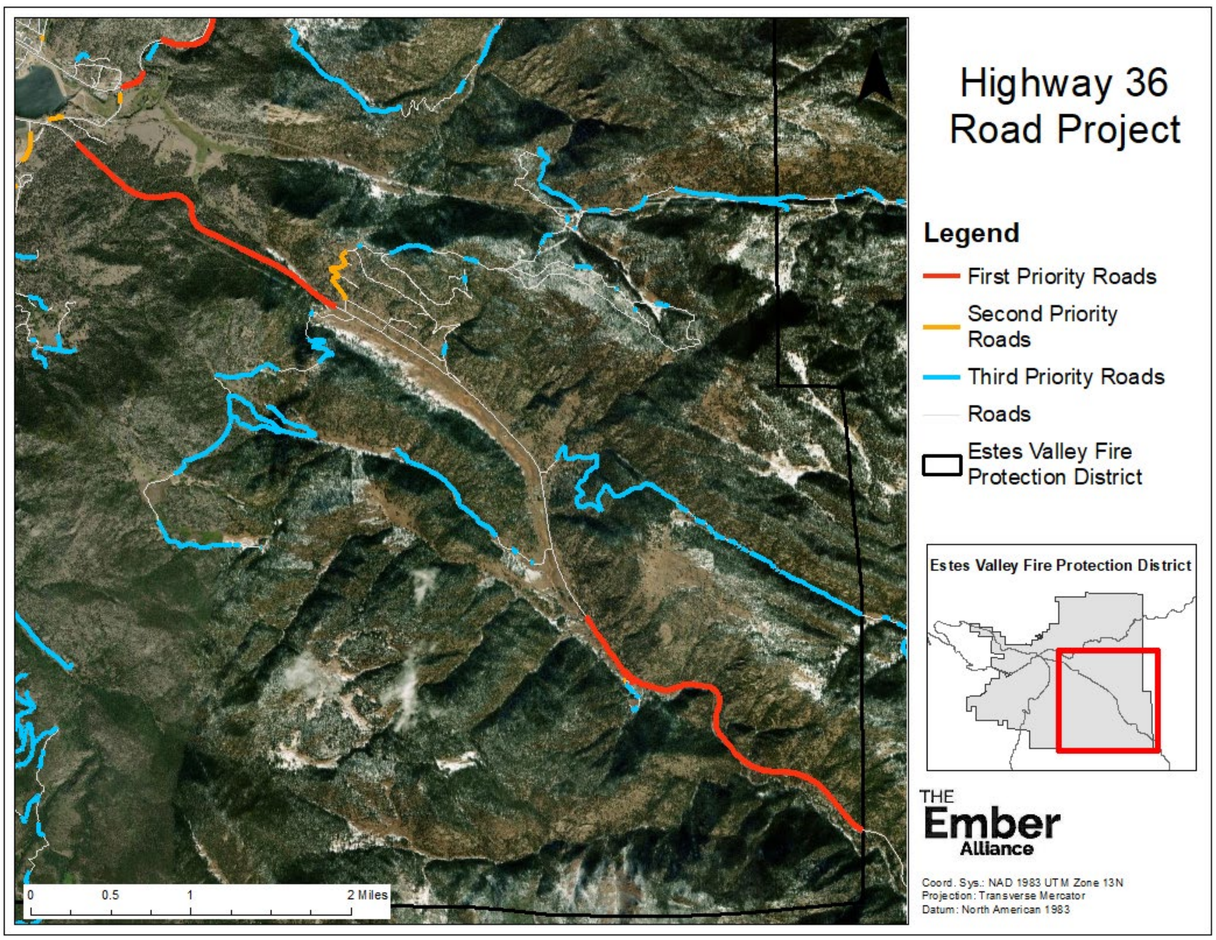
Spur 66 and WIldcliff Road Project Area	
Description:	2 miles of first- and second-priority roadway along southern Spur 66/Tunnel Road. 2 miles of first-priority roads in Windcliff, about 0.5 miles of first priority roads in YMCA properties. These roads occur in one of the most concerning parts of the district. Both the Fern Lake and East Troublesome fires threatened to leave the boundary of RMNP and enter the district in this area, and it has a one-lane exit road with lots of visitor lodging along the route.
Treatment objectives:	The first goal is to create survivable road conditions for residents evacuating. The second goal is to create a holding feature that can potentially be used in tactical operations.
Treatment type:	Mechanical thinning and slash removal



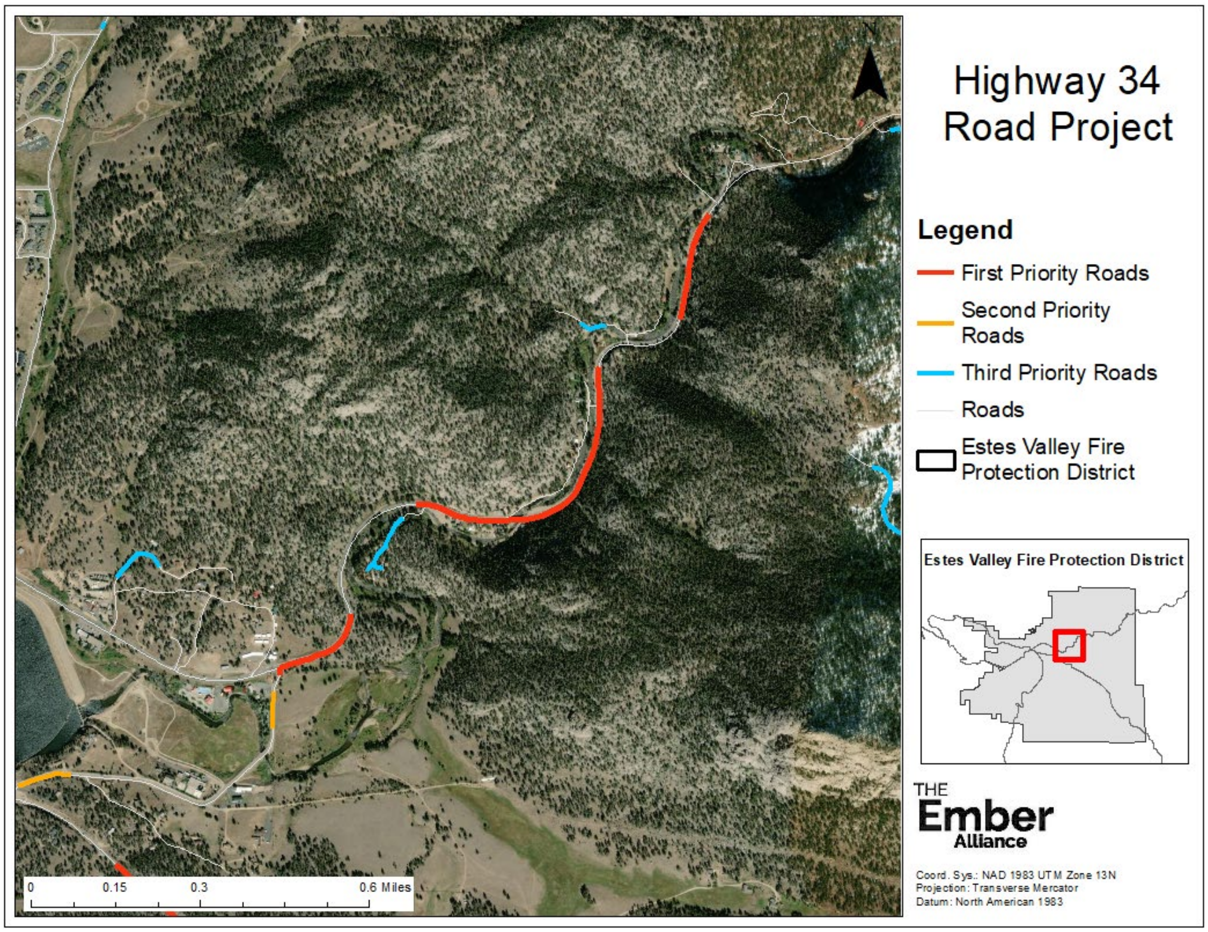
Little Valley Road Project Area	
Description:	1.5 miles of first-priority roadway along Little Valley Drive. Little Valley is a community with extreme relative fire risk and only one road for ingress and egress.
Treatment objectives:	The first goal is to create survivable road conditions for residents evacuating and responder ingress at the same time.
Treatment type:	Mechanical thinning and slash removal



Highway 36 Road Project Area	
Description:	2 miles of first-priority roadway from the edge of town and southeast, 2.5 miles further southeast to the edge of the EVFPD along a primary evacuation route, Highway 36. This project can be pursued in coordination with other road work where the highway may be closed to traffic and work can safely be completed.
Treatment objectives:	The first goal is to create survivable road conditions for residents evacuating. The second goal is to create a holding feature that can potentially be used in tactical operations.
Treatment type:	Mechanical thinning and slash removal



Highway 34 Road Project Area	
Description:	1 mile of first-priority roadway at the mouth of the Thompson Valley within along Highway 34, a primary evacuation route. This work would be more difficult to complete than work along Highway 36 due to the steep, narrow canyon and constant traffic. This project can be pursued in coordination with other road work where the highway may be closed to traffic and work can safely be completed.
Treatment objectives:	The first goal is to create survivable road conditions for residents evacuating.
Treatment type:	Mechanical thinning and slash removal



4.f. The Future of the CWPP and Implementation Plan

The CSFS requires CWPPs to be updated on a regular basis. It is recommended to update them every five years, at minimum. CWPPs greater than 10 years old are outdated and can exclude communities from successfully applying for competitive funding opportunities.

The update to this plan can either be a preface to this document or a new document that integrates with this one. The update to this plan must include:

- A description of progress made since the CWPP was created
- A description of demographic changes in the community and other important infrastructure changes.
- Identification of new risks in the community.
    - Updated risk analysis if major changes have happened between revisions.
- Updated and prioritized projects for the community with maps and descriptions

The suggested review process by CSFS involves:

- Reviewing the existing CWPP
- Engaging stakeholders that have a vested interest in the plan
- Hosting collaborative meetings
- Documenting completed projects and demographic and landscape changes
- Developing updated wildfire risk reduction priorities
- Updating maps
- Distributing updated drafts to key stakeholders for review and input prior to final approval
- Finalizing with core team signatures and submit to CSFS State Office

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, 2021a).

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, 2021b).

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

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

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

Chain: Chains are commonly used in forestry and fire management as a measure of distance. 1 chain is equivalent to 66 feet. Chains were used for measurements in the initial public land survey of the U.S. in the mid-1800s.

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, 2021b).

Defensible space: 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 their home can stand alone without relying upon limited firefighter resources due to the great reduction in hazards they have undertaken. 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) (CSFS, 2021).

Direct attack: Any treatment applied directly to burning fuel such as wetting, smothering, or chemically quenching the fire or by physically separating the burning from unburned fuel (NWCG, 2018b).

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 et al., 2018).

Ember: Small, hot, and carbonaceous particles. The term “firebrand” is also used to connote a small, hot, and carbonaceous particle that is airborne and carried for some distance in an airstream (Babrauskas, 2018).

Ember cast: The process of embers/firebrands/flaming sparks being transported downwind beyond the main fire and starting new spot fires and/or igniting structures. Short-range ember cast is when embers are carried by surface winds and long-range ember cast is when embers are carried high into the convection column and fall out downwind beyond the main fire. 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 et al., 2016). The distance used to differentiate short-range and long-range ember cast varies among sources. NWCG (2018b) classifies short-range ember cast as embers that travel less than 0.25 miles and long-range ember cast as embers that travel more than 0.25 miles, whereas Beverly et al., (2010) use a threshold of 0.06 miles. We use the Beverly et al., (2010) definition in this CWPP.

Extended attack: Actions taken on a wildfire that has exceeded the initial response (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 et al. (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 (Bennett et al., 2010; NWCG, 2018b).

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).

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).

Handcrews: A number of individuals that have been organized and trained and are supervised principally for operational assignments on an incident (NWCG, 2018b).

Handline: Fireline constructed with hand tools (NWCG, 2018b).

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 Fire 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.

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 (NWCG, 2018a).

Indirect attack: A method of suppression in which the control line is located some considerable distance away from the fire's active edge. Generally done in the case of a fast-spreading or high-intensity fire and to utilize natural or constructed firebreaks or fuelbreaks and favorable breaks in the topography. The intervening fuel is usually backfired; but occasionally the main fire is allowed to burn to the line, depending on conditions (NWCG, 2018b).

Initial attack: An aggressive action to put the fire out by the first resources to arrive, consistent with firefighter and public safety and values to be protected (NWCG, 2018b).

Insurance Services Office (ISO) rating: ISO ratings are provided to fire departments and insurance companies to reflect how prepared a community is for fires in terms of local fire department capacity, water supply, and other factors (see more information online at https://www.isomitigation.com/ppc/fsrs/).

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/.

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 et al., 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, 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 (Hansson et al., 1995).

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. Potentially non-survivable flame lengths start at 8 feet according to the Haul Chart, which is a standard tool used by firefighters to relate flame lengths to tactical decisions (NWCG, 2019). 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, 2021b).

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).

Red card (aka, incident qualifications card): A card issued to persons showing their incident management and trainee qualifications to fill specified fire management positions in an incident management organization (NWCG, 2018b).

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 fuel treatment: 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: Fuel treatments 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).

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 an ember (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 (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, 2021b).

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. 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 (NOAA, 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): Any area where the built environment meets wildfire-prone areas—places where wildland fire can move between natural vegetation and the built environment and result in negative impacts on the community (Forge, 2018).

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7. References

Addington, R.N., Aplet, G.H., Battaglia, M.A., Briggs, J.S., Brown, P.M., 2018. Principles and practices for the restoration of ponderosa pine and dry mixed-conifer forests of the Colorado Front Range (General Technical Report No. RMRS-GTR-373). U.S. Department of Agriculture, U.S. Forest Service, Rocky Mountain Research Station, Fort Collins, CO.

Agee, J.K., 1996a. The influence of forest structure on fire behavior, in: Proceedings of the 17th Annual Forest Vegetation Management Conference. Presented at the 17th Annual Forest Vegetation Management Conference; 16-18 January 1996; Redding, CA, University of California, Agriculture and Natural Resources, Berkely, CA, pp. 52–68.

Agee, J.K., 1996b. Fire Ecology of Pacific Northwest Forests, 2nd ed. Island Press, Washington, DC.

Agee, J.K., Skinner, C.N., 2005. Basic principles of forest fuel reduction treatments. Forest Ecology and Management 211, 83–96.

Andrews, P.L., 2018. The Rothermel surface fire spread model and associated developments: A comprehensive explanation. Gen. Tech. Rep. RMRS-GTR-371. Fort Collins, CO: US Department of Agriculture, Forest Service, Rocky Mountain Research Station. 121 p. 371.

Andrews, P.L., 2012. Modeling wind adjustment factor and midflame wind speed for Rothermel's surface fire spread model. Gen. Tech. Rep. RMRS-GTR-266. Fort Collins, CO: US Department of Agriculture, Forest Service, Rocky Mountain Research Station. 39 p. 266.

Aven, T., Ben-Haim, Y., Boje Andersen, H., Cox, T., Droguett, E.L., Greenberg, M., Guikema, S., Kröger, W., Renn, O., Thompson, K.M., Zio, E., 2018. Society for Risk Analysis glossary. Society for Risk Analysis, Herndon, VA.

Avitt, A., 2021. Cameron Peak: Fighting fire together. U.S. Forest Service Feature Stories.

Babrauskas, V., 2018. Firebrands and embers, in: Manzello, S. (Ed.), Encyclopedia of Wildfires and Wildland-Urban Interface (WUI) Fires. Springer, Cham, Switzerland. https://doi.org/10.1007/978-3-319-51727-8_3-1.

Barrett, K., 2016. Tennessee wildfires: Now is the time to plan [WWW Document]. Headwaters Economics. URL https://headwaterseconomics.org/wildfire/homes-risk/wildfires-now-is-the-time-to-plan/ (accessed 11.18.21).

Battaglia, M.A., Gannon, B., Brown, P.M., Fornwalt, P.J., Cheng, A.S., Huckaby, L.S., 2018. Changes in forest structure since 1860 in ponderosa pine dominated forests in the Colorado and Wyoming Front Range, USA. Forest Ecology and Management 422, 147–160.

Bennett, M., Fitzgerald, S., Parker, B., Main, M., Perleberg, A., Schnepf, C., Mahoney, R., 2010. Reducing fire risk on your forest property (Pacific Northwest Extension Publication No. PNW 618). Oregon State University, University of Idaho, and Washington State University.

Beverly, J.L., Bothwell, P., Conner, J., Herd, E., 2010. Assessing the exposure of the built environment to potential ignition sources generated from vegetative fuel. International journal of wildland fire 19, 299–313.

Blumhardt, M., 2021. Rare September 2013 flood was one of Colorado's worst natural disasters. The Coloradoan.

Brenkert-Smith, H., Champ, P.A., Telligman, A.L., 2013. Understanding change: Wildfire in Larimer County, Colorado (Research Note No. RMRS-RN-58). U.S. Department of Agriculture, U.S. Forest Service, Rocky Mountain Research Station, Fort Collins, CO.

Brown, K., 1994. Structure triage during wildland/urban interface/intermix fires: Strategic analysis of fire department operations. U.S. Fire Administration, National Fire Academy, Executive Fire Officer Program, Emmitsburg, MD.

Broyles, G., 2011. Fireline production rates. US Forest Service, San Dimas Technology and Development Center.

CAL FIRE, 2019. Hardening your home [WWW Document]. California Natural Resources Agency, California Department of Forestry and Fire Protection. URL https://www.readyforwildfire.org/prepare-for-wildfire/get-ready/hardening-your-home/

California Fire Safe Council, 2020. Fire safety information for residents [WWW Document]. California Fire Safe Council. URL https://cafiresafecouncil.org/resources/fire-safety-information-for-residents/.

Caton, S.E., Hakes, R.S.P., Gorham, D.J., Zhou, A., Gollner, M.J., 2016. Review of pathways for building fire spread in the wildland urban interface part I: Exposure conditions. Fire Technology 54, 429–473.

CFRI, 2021. Fires behavior differently in different forest types [WWW Document]. Colorado State University, Colorado Forest Restoration Institute. URL https://cfri.colostate.edu/wp-content/uploads/sites/22/2021/01/FireEd-Infographic-Web_Print-1.pdf

CSFS, 2021. The home ignition zone: A guide to preparing your home for wildfire and creating defensible space. Colorado State University, Colorado State Forest Service, Fort Collins, CO.

CSFS, 2010. Forestry best management practices to protect water quality in Colorado. Colorado State University, Colorado State Forest Service, Fort Collins, CO.

Dennis, F.C., 2005. Fuelbreak guidelines for forested subdivisions and communities. Colorado State University, Colorado State Forest Service, Fort Collins, CO.

Dennis, F.C., 2003. Creating wildfire-defensible zones (Natural Resources Series No. 6.302). Colorado State University, Cooperative Extension, Fort Collins, CO.

Dennis, F.C., Burke, J., Duda, J., Green, C., Hessel, D., Kaufmann, M., Lange, D., Lee, B., Rinke, H., Sheppard, W., Sturtevant, B., Thinnes, J., Underhill, J., Woodmansee, B., 2009. Lodgepole pine management guidelines for land managers in the wildland-urban interface. Colorado State Forest Service, Colorado State University, Fort Collins, CO.

Dether, D.M., 2005. Prescribed fire lessons learned: Escaped prescribed fire reviews and near miss incidents (Report for the Wildland Fire Lessons Learned Center).

Duncan, B.W., Schmalzer, P.A., Breininger, D.R., Stolen, E.D., 2015. Comparing fuels reduction and patch mosaic fire regimes for reducing fire spread potential: A spatial modeling approach. Ecological Modelling 314, 90–99.

Evans, A.M., Wright, C.S., 2017. Unplanned wildfire in areas with slash piles (Unpublished report for the Joint Fire Science Program No. 11-1-8–4).

FEMA, 2019. FEMA incident stabilization guide (Operational Draft). U.S. Department of Homeland Security, Federal Emergency Management Agency, Washington, DC.

Finney, M.A., 2006. An overview of FlamMap fire modeling capabilities, in: In: Andrews, Patricia L.; Butler, Bret W., Comps. 2006. Fuels Management-How to Measure Success: Conference Proceedings. 28-30 March 2006; Portland, OR. Proceedings RMRS-P-41. Fort Collins, CO: US Department of Agriculture, Forest Service, Rocky Mountain Research Station. p. 213-220.

Finney, M.A., 2005. The challenge of quantitative risk analysis for wildland fire. Forest Ecology and Management 211, 97–108.

Forge, P., 2018. Basics of wildland fire behavior & the wildland-urban interface (CPAW Planner Training Materials). Community Planning Assistance for Wildfire, Bozeman and Helena, MT.

Fulé, P.Z., Crouse, J.E., Rouccaforte, J.P., Kalies, E.L., 2012. Do thinning and/or burning treatments in western USA ponderosa or Jeffrey pine-dominated forests help restore natural fire behavior? Forest Ecology and Management 269, 68–81.

Gannon, B.M., Wei, Y., MacDonald, L.H., Kampf, S.K., Jones, K.W., Cannon, J.B., Wolk, B.H., Cheng, A.S., Addington, R.N., Thompson, M.P., 2019. Prioritising fuels reduction for water supply protection. International Journal of Wildland Fire 28, 785–803. https://doi.org/10.1071/WF18182_CO

Gellman, J., Walls, M., Wibbenmeyer, M., 2022. Wildfire, smoke, and outdoor recreation in the western United States. Forest Policy and Economics 134, 102619. https://doi.org/10.1016/j.forpol.2021.102619

Good, S., 2020. Fuel treatments west of Estes Park help save town from destructive East Troublesome Fire. Parks to People Water Fund. URL https://peakstopeople.org/blog/2020/11/02/fuel-treatments-west-of-estes-park-help-save-town-from-destructive-east-troublesome-fire/

Gropp, C., 2019. Embers cause up to 90% of home & business ignitions during wildfire events (News Release No. 12 March 2019). Insurance Institute for Business & Home Safety, Richburg, SC.

Haas, J.R., Calkin, D.E., Thompson, M.P., 2015. Wildfire risk transmission in the Colorado Front Range, USA. Risk Analysis 35, 226–240.

Hakes, R.S., Caton, S.E., Gorham, D.J., Gollner, M.J., 2017. A review of pathways for building fire spread in the wildland urban interface part II: response of components and systems and mitigation strategies in the United States. Fire technology 53, 475–515.

Hansson, L., Fahrig, L., Merriam, G. (Eds.), 1995. Mosaic Landscapes and Ecological Processes. Springer, Dordrecht, Netherlands.

Harper, J.M., 2011. Benefits of grazing and wildfire risk [WWW Document]. University of California, Agriculture and Natural Resources. URL https://ucanr.edu/blogs/blogcore/postdetail.cfm?postnum=5463

Hartsough, B.R., Abrams, S., Barbour, R.J., Drews, E.S., McIver, J.D., 2008. The economics of alternative fuel reduction treatments in western United States dry forests: Financial and policy implications from the National Fire and Fire Surrogate Study. Forest Policy & Economics 10, 344–354.

Hegewisch, K.C., Abatzoglou, J.T., Gross, J., 2021. Future Climate Analogs Web Tool, Climate Toolbox.

Heinsch, F.A., Andrews, P.L., 2010. BehavePlus fire modeling system, version 5.0: design and features. Gen. Tech. Rep. RMRS-GTR-249. Fort Collins, CO: US Department of Agriculture, Forest Service, Rocky Mountain Research Station. 111 p. 249.

Higuera, P.E., Shuman, B.N., Wolf, K.D., 2021. Rocky Mountain subalpine forests now burning more than any time in recent millennia. Proceedings of the National Academy of Sciences 118, e2103135118.

Hudson, T.R., Bray, R.B., Blunck, D.L., Page, W., Butler, B., 2020. Effects of fuel morphology on ember generation characteristics at the tree scale. International Journal of Wildland Fire 29, 1042–1051.

Hunter, M.E., Shepperd, W.D., Lentile, L.B., Lundquist, J.E., Andreu, M.G., Butler, J.L., Smith, F.W., 2007. A comprehensive guide to fuel treatment practices for ponderosa pine in the Black Hills, Colorado Front Range, and Southwest (General Technical Report No. RMRS-GTR-198). U.S. Department of Agriculture, U.S. Forest Service, Rocky Mountain Research Station, Fort Collins, CO.

IIBHS, 2019. California Wildfires of 2017 and 2018 [WWW Document]. Insurance Institute for Business & Home Safety. URL https://ibhs.org/wildfire/ibhs-post-event-investigation-california-wildfires-of-2017-2018/

Jain, T., Sikkink, P., Keffe, R., Byrne, J., 2018. To masticate or not: Useful tips for treating forest, woodland, and shrubland vegetation (General Technical Report No. RMRS-GTR-381). U.S. Department of Agriculture, U.S. Forest Service, Rocky Mountain Research Station, Fort Collins, CO.

Jolley, A., 2018. Is investing in defensible space worth it? Six examples point to yes! [WWW Document]. Fire Adapted Communities Learning Network. URL https://fireadaptednetwork.org/is-investing-in-defensible-space-worth-it-six-examples-point-to-yes/

Jones, K.W., Cannon, J.B., Saavedra, F.A., Kampf, S.K., Addington, R.N., 2017. Return on investment form fuel treatments to reduce severe wildfire and erosion in a watershed investment program in Colorado. Journal of Environmental Management 198, 66–77.

Kalies, E.L., Dickson, B.G., Chambers, C.L., Covington, W.W., 2012. Small mammal community occupancy responses to restoration treatments in ponderosa pine forests, northern Arizona, USA. Ecological Applications 22, 204–217.

Keane, R.E., Agee, J., Fulé, P., Keeley, J.E., Key, C., Kitchen, S.G., Miller, R., Schulte, L.A., 2008. Ecological effects of large fires in the United States: Benefit or catastrophe? International Journal of Wildland Fire 17, 696–712.

Kerns, B.K., Buonopane, M., Thies, W.G., Niwa, C., 2011. Reintroducing fire into a ponderosa pine forest with and without cattle grazing: Understory vegetation response. Ecosphere 2, 1–23.

Kim, M.-K., Jakus, P.M., 2019. Wildfire, national park visitation, and changes in regional economic activity. Journal of Outdoor Recreation and Tourism 26, 34–42. https://doi.org/10.1016/j.jort.2019.03.007

Knapp, E.E., Valachovic, Y.S., Quarles, S.L., Johnson, N.G., 2021. Housing arrangement and vegetation factors associated with single-family home survival in the 2018 Camp Fire, California. Fire Ecology 17, 1–19.

Kreye, J.K., Brewer, N.W., Morgan, P., Varner, J.M., Smith, A.M.S., Hoffman, C.M., Ottmar, R.D., 2014. Fire behavior in masticated fuels: A review. Forest Ecology and Management 314, 193–207.

Lee, M., 2020. Burn scars and burnt s'mores: the impact of wildfire on camping demand in the years after a fire occurs (Text). Colorado State University.

Loomis, J., Sánchez, J.J., González-Cabán, A., Rideout, D., Reich, R., 2019. Do fuel treatments reduce wildfire suppression costs and property damages? Analysis of suppression costs and property damages in U.S. National Forests, in: Proceedings of the Fifth International Symposium on Fire Economics, Planning, and Policy: Ecosystem Services and Wildfires. General Technical Report PSW-GTR-261. U.S. Department of Agriculture, U.S. Forest Service, Pacific Southwest Research Station, Albany, CA, pp. 70–84.

Lotan, J.E., Brown, J.K., Neuenschwander, L.F., 1985. Role of fire in lodgepole pine forests, in: Baumgartner, D. (Ed.), Lodgepole Pine: The Species and Its Management Symposium Proceedings. Washington State University, Pullman, WA, pp. 133–152.

Martinuzzi, S., Stewart, S.I., Helmers, D.P., Mockrin, M.H., Hammer, R.B., Radeloff, V.C., 2015. The 2010 wildland-urban interface of the conterminous United States (Research Map No. NRS-RM-8). U.S. Department of Agriculture, U.S. Forest Service, Northern Research Station, Newtown Square, PA.

Matonis, M.S., Binkley, D., 2018. Not just about the trees: Key role of mosaic-meadows in restoration of ponderosa pine ecosystems. Forest Ecology and Management 411, 120–131.

McIver, J.D., Stephens, S.L., Agee, J.K., Barbour, J., Boerner, R.E.J., Edminster, C.B., Erickson, K.L., Farris, K.L., Fettig, C.J., Fiedler, C.E., Haase, S., Hart, S.C., Keeley, J.E., Knapp, E.E., Lehmkuhl, J.F., Moghaddas, J.J., Otrosina, W., Outcalt, K.W., Schwilk, D.W., Skinner, C.N., Waldrop, T.A., Weatherspoon, C.P., Yaussy, D.A., Youngblood, A., Zack, S., 2013. Ecological effects of alternative fuel-reduction treatments: highlights of the National Fire and Fire Surrogate study (FFS). International Journal of Wildland Fire 22, 63–82.

Mell, W.E., Manzello, S.L., Maranghides, A., Butry, D., Rehm, R.G., 2010. The wildland–urban interface fire problem – current approaches and research needs. International Journal of Wildland Fire 19, 238–251.

Millennium Ecosystem Assessment, 2003. Ecosystems and Human Well-being: A Framework for Assessment. Island Press, Washington, DC.

Miller, S., 2018. 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 (Science You Can Use Bulletin No. Issue 28). U.S. Department of Agriculture, U.S. Forest Service, Rocky Mountain Research Station, Fort Collins, CO.

Miller, S., 2015. Slash from the past: Rehabilitating pile burn scars (Science You Can Use Bulletin No. Issue 15). U.S. Department of Agriculture, U.S. Forest Service, Rocky Mountain Research Station, Fort Collins, CO.

Moriarty, K., Cheng, A.S., Hoffman, C.M., Cottrell, S.P., Alexander, M.E., 2019. Firefighter observations of "surprising" fire behavior in mountain pine beetle-attacked lodgepole pine forests. Fire 2, 34.

Mosier, T., 2020. Economic impact of Coronavirus could have lasting implications for Estes Park. Estes Park Trail-Gazette.

National Academies of Sciences, Engineering, and Medicine, 2018. Emergency Alert and Warning Systems: Current Knowledge and Future Research Directions. The National Academies Press, Washington, DC. https://doi.org/10.17226/24935

NOAA, 2021. What is a watershed? [WWW Document]. U.S. Department of Commerce, National Oceanic and Atomspheric Administration, National Ocean Service. URL https://oceanservice.noaa.gov/facts/watershed.html

NPS, 2021. Stats report viewer for Rocky Mountain NP [WWW Document]. National Park Service Visitor Use Statistics. URL https://irma.nps.gov/STATS/SSRSReports/Park%20Specific%20Reports/Annual%20Park%20Recreation%20Visitation%20(1904%20-%20Last%20Calendar%20Year)?Park=ROMO (accessed 9.3.21).

NRCS, 2017. Glossary of landforms and geologic terms, in: National Soil Survey Handbook. U.S. Department of Agriculture, National Resources Conservation Service, Washington, DC, p. Part 629.

NWCG, 2022. NWCG position catalog [WWW Document]. National Wildfire Coordinating Group. URL https://www.nwcg.gov/positions

NWCG, 2021a. Midflame windspeed. Section 8.2 [WWW Document]. Firefighter Math, National Wildfire Coordinating Group. URL https://www.nwcg.gov/course/ffm/fire-behavior/82-midflame-windspeed

NWCG, 2021b. NWCG standards for wildland fire resource typing (No. PMS 200). National Wildfire Coordinating Group, Boise, ID.

NWCG, 2019. Fire behavior field reference guide.

NWCG, 2018a. Incident Response Pocket Guide (No. PMS 461 / NFES 001077). National Wildfire Coordinating Group.

NWCG, 2018b. NWCG glossary of wildland fire.

NWCG, 2008. S-190: Introduction to wildland fire behavior. National Wildfire Coordinating Group, Training Development Program, Boise, ID.

O'Connor, B., 2021. Fire apparatus access roads [WWW Document]. National Fire Protection Association. URL https://www.nfpa.org/News-and-Research/Publications-and-media/Blogs-Landing-Page/NFPA-Today/Blog-Posts/2021/01/08/Fire-Apparatus-Access-Roads

Parks, S.A., Miller, C., Abatzoglou, J.T., Holsinger, L.M., Parisien, M.A., Dobrowski, S.Z., 2016. How will climate change affect wildland fire severity in the western US? Environmental Research Letters 11, 035002. https://doi.org/10.1088/1748-9326/11/3/03500.

Parsons, R., Jolly, M., Langowski, P., Matonis, M.S., Miller, S., 2014. Post-epidemic fire risk and behavior [Chapter 3], in: Matonis, M.S., Hubbard, R., Gebert, K., Hahn, B., Miller, S., Regan, C. (Eds.), Proceedings RMRS-P-70. Presented at the Future Forests Webinar Series, U.S. Department of Agriculture, U.S. Forest Service, Rocky Mountain Research Station, Fort Collins, CO, pp. 19–28.

Pausas, J.G., Parr, C.L., 2018. Towards an understanding of the evolutionary role of fire in animals. Evolutionary Ecology 32, 113–125.

Paysen, T.E., Ansley, R.J., Brown, J.K., Gotffried, G.J., Haase, S.M., Harrington, M.G., Narog, M.G., Sackett, S.S., Wilson, R.C., 2000. Chapter 6: Fire in western shrubland, woodland, and grassland ecosystems (General Technical Report No. RMRS-GTR-42-vol 2.). U.S. Department of Agriculture, U.S. Forest Service, Rocky Mountain Research Station, Fort Collins, CO.

Pilliod, D.S., Bull, E.L., Hayes, J.L., Wales, B.C., 2006. Wildlife and invertebrate response to fuel reduction treatments in dry coniferous forests of the Western United States: A synthesis (General Technical Report No. RMRS-GTR-173). U.S. Department of Agriculture, U.S. Forest Service, Rocky Mountain Research Station, Fort Collins, CO.

Plucinski, M.P., 2019. Contain and control: Wildfire suppression effectiveness at incidents and across landscapes. Current Forestry Reports 5, 20–40.

Prichard, S.J., Povak, N.A., Kennedy, M.C., Peterson, D.W., 2020. Fuel treatment effectiveness in the context of landform, vegetation, and large, wind-driven wildfires. Ecological Applications 30, e02104.

Quarles, S.L., 2019. Fire ratings for construction materials [WWW Document]. eXtension Foundation. URL https://surviving-wildfire.extension.org/fire-ratings-for-construction-materials/

Quarles, S.L., Pohl, K., 2018. Building a wildfire-resistant home: Codes and costs. Headwaters Economics, Bozeman, MT.

Radeloff, V.C., Helmers, D.P., Kramer, H.A., Mockrin, M.H., Alexandre, P.M., Bar-Massada, A., Butsic, V., Hawbaker, T.J., Martinuzzi, S., Syphard, A.D., others, 2018. Rapid growth of the US wildland-urban interface raises wildfire risk. Proceedings of the National Academy of Sciences 115, 3314–3319.

Reinhardt, E.D., Keane, R.E., Calkin, D.E., Cohen, J.D., 2008. Objectives and considerations for wildland fuel treatments in forested ecosystems of the interior western United States. Forest Ecology and Management 256, 1997–2006.

Romme, W.H., 1982. Fire and landscape diversity in subalpine forests of Yellowstone National Park. Ecological Monographs 52, 199–221.

Scott, J.H., 2006. Comparison of crown fire modeling systems used in three fire management applications (Research Paper No. RMRS-RP-58). U.S. Department of Agriculture, U.S. Forest Service, Rocky Mountain Research Station, Fort Collins, CO.

Scott, J.H., Burgan, R.E., 2005. Standard fire behavior fuel models: a comprehensive set for use with Rothermel's surface fire spread model. US Department of Agriculture, Forest Service, Rocky Mountain Research Station.

Scott, J.H., Thompson, M.P., Calkin, D.E., 2013. A wildfire risk assessment framework for land and resource management. Gen. Tech. Rep. RMRS-GTR-315. US Department of Agriculture, Forest Service, Rocky Mountain Research Station. 83 p. 315.

SER, 2004. SER International Primer on Ecological Restoration. Society of Ecological Restoration, Washington, DC.

Shahabi, K., Wilson, J.P., 2014. CASPER: Intelligent capacity-aware evacuation routing. Computers, Environment and Urban Systems 46, 12–24. https://doi.org/10.1016/j.compenvurbsys.2014.03.004.

Sherriff, R.L., Platt, R.V., Veblen, T.T., Schoennagel, T.L., Gartner, M.H., 2014. Historical, observed, and modeled wildfire severity in montane forests of the Colorado Front Range. PLoS One 9, e106971.

Simpkins, K., 2021. Mountain residents underestimate wildfire risk, overestimate preparedness. CU Boulder Today.

Stephens, S.L., Moghaddas, J.J., Edminster, C., Fiedler, C.E., Haase, S., 2009. Fuel treatment effects on vegetation structure, fuels, and potential fire severity in western U.S. forests. Ecological Applications 19, 305–320.

Sullivan, A.L., 2009. Wildland surface fire spread modelling, 1990–2007. 1: Physical and quasi-physical models. International Journal of Wildland Fire 18, 349–368.

Sullivan, P.R., Campbell, M.J., Dennison, P.E., Brewer, S.C., Butler, B.W., 2020. Modeling wildland firefighter travel rates by terrain slope: results from GPS-tracking of type 1 crew movement. Fire 3, 52.

Syphard, A.D., Brennan, T.J., Keeley, J.E., 2014. The role of defensible space for residential structure protection during wildfires. International Journal of Wildland Fire 23, 1165–1175.

Syphard, A.D., Keeley, J.E., 2019. Factors associated with structure loss in the 2013-2018 California wildfires. Fire 2, 2030049. https://doi.org/10.3390/fire2030049.

Syphard, A.D., Keeley, J.E., Massada, A.B., Brennan, T.J., J., T., Radeloff, V.C., 2012. Housing arrangement and location determine the likelihood of housing loss due to wildfire. PLoS ONE 7, e33954. https://doi.org/10.1371/journal.pone.0033954.

Tinkham, W.T., Dickinson, Y., Hoffman, C.M., Battaglia, M.A., Ex, S., Underhill, J., 2017. Visualization of heterogenous forest structures following treatment in the Southern Rocky Mountains (General Technical Report No. RMRS-GTR-365). U.S. Department of Agriculture, U.S. Forest Service, Rocky Mountain Research Station, Fort Collins, CO.

Tinkham, W.T., Hoffman, C.M., Ex, S.A., Battaglia, M.A., Saralecos, J.D., 2016. Ponderosa pine forest restoration treatment longevity: Implications of regeneration on fire hazard. Forests 7, 137.

Town of Estes Park, 2021. Annual Financial Report [WWW Document]. Town of Estes Park. URL https://estespark.colorado.gov/departments/finance/annual-financial-report (accessed 9.3.21).

Town of Estes Park, 2009. Community Wildfire Protection Plan for Estes Park. Town of Estes Park, Estes Park, CO.

Turner, M.G., Braziunas, K.H., Hansen, W.D., Harvey, B.J., 2019. Short-interval severe fire erodes the resilience of subalpine lodgepole pine forests. Proceeding of the National Academy of Scienced of the United States of America 116, 11319–11328.

U.S. Census Bureau, 2022. American Community Survey 2016-2020. Estes Park and Colorado summary population and housing characteristics. U.S. Department of Commerce, Economics and Statistics Administration, U.S. Census Bureau, Washington, DC.

USFS, 2021a. Wildfire risk to communities [WWW Document]. U.S. Department of Agriculture, U.S. Forest Service, Washington, DC. URL https://wildfirerisk.org/

USFS, 2021b. Glossary of forest engineering terms [WWW Document]. U.S. Department of Agriculture, U.S. Forest Service, Southern Research Station, Forest Operations Research. URL https://www.srs.fs.usda.gov/forestops/glossary/

Wagenbrenner, N.S., Forthofer, J.M., Lamb, B.K., Shannon, K.S., Butler, B.W., 2016. Downscaling surface wind predictions from numerical weather prediction models in complex terrain with WindNinja. Atmospheric Chemistry and Physics 16, 5229–5241.

Weir, J.R., Kreuter, U.P., Wonkka, C.L., Twidwell, D., Stroman, D.A., Russell, M., Taylor, C.A., 2019. Liability and prescribed fire: Perception and reality. Rangeland Ecology & Management 72, 533–538.

Wildfire Adapated Partnership, 2018. Fire adapted communities neighborhood ambassador approach: Increasing preparedness through volunteers. Wildfire Adapted Partnership, Durango, CO.

Williams, J., 2013. Exploring the onset of high-impact mega-fires through a forest land management prism. Forest Ecology and Management 294, 4–10.

Wright, C.S., Evans, A.M., Grove, S., Haubensak, K.A., 2019. Pile age and burn season influence fuelbed properties, combustion dynamics, fuel consumption, and charcoal formation when burning hand piles. Forest Ecology and Management 439, 146–158.

Ziegler, J.P., Hoffman, C., Battaglia, M., Mell, W., 2017. Spatially explicit measurements of forest structure and fire behavior following restoration treatments in dry forests. Forest Ecology and Management 386, 1–12.

Zillow Inc., 2021. Estes Park CO Home Prices & Home Values [WWW Document]. Zillow. URL https://www.zillow.com/estes-park-co/home-values/ (accessed 12.1.21).

Appendix A. Community Risk Assessment and Modelling Methodology

Our assessment of wildfire risk is based on fire behavior and evacuation modeling and on-the-ground observations from across the Estes Valley Fire Protection District. Results from the community risk assessment informed recommendations about priority treatment to protect lives, property, infrastructure, and ecosystems in and around the EVFPD.

A.1. CWPP Plan Units

The goal of delineating plan units is to identify areas with shared fire risk where residents can organize and support each other to effectively mitigate hazardous fuels across the plan unit (**Figure 3.c.1**). To delineate plan units in the EVFPD, the team considered clusters of addresses, connectivity of roads, topographic features, land parcels, and local knowledge of community organization. used clusters of address points and the connectivity of roads to assume geographically and socially distinct units. Topographic features were considered by utilizing sub-watershed boundaries to guide plan unit boundaries. The process included topographic features into 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.

Boundaries were also based on social distinctions and groupings that would enable neighbors to work together to effectively mitigate hazardous fuels within plan unit boundaries. The YMCA and Windcliff plan units cross over each other to keep Thunder Mountain Estates grouped with Wildcliff Estates due to their similarity, and to keep the YMCA property that sits on the east side of Tunnel Rd together with the main YMCA campus.

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 models allow us to identify areas that could experience high-severity wildfires and pose a risk to lives, property, and other values at risk.

The process used the fire behavior model FlamMap, which is 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 behavior analyses are useful for assessing relative risk across the entire EVFPD and are not intended to assess specific fire behavior in the vicinity of individual homes. It is not feasible to predict every combination of fire weather conditions, ignition locations, and suppression activities that might occur during a wildfire. Uncertainty will always remain about where and how a wildfire might behave until a fire is actually occurring, and even then, fire behavior can be erratic and unpredictable.

> 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 EVFPD. Models cannot produce specific and precise predictions of what will occur in the vicinity of an individual home during a wildfire incident.

Fire behavior models like FlamMap do not include structures as a fuel type. Structures like homes, sheds, fences, and other buildings are absolutely a source of fuel during wildland fires and can produce massive amounts of embers that contribute to home-to-home ignitions (Maranghides et al., 2022). However, FlamMap cannot account for fine-scale variation in surface fuel loads, defensible space created by individual homeowners, and the ignitability of building materials, nor are these data available at the scale of individual homes across an entire fire protection district. In the absence of this information and a deeper quantitative understanding of interactions between structures and wildland vegetation during a wildfire, fire behavior cannot be modeled for areas dominated by homes in the same fashion as areas dominated by grassland, shrubland, or forest vegetation. For this reason, TEA conducted a separate analysis to predict potential exposure of homes to radiant heat and ember cast (see **Appendix A.3**).

Model Specifications and Inputs

TEA used FlamMap 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.1**). See **Table 8.a.1** and **Table 8.a.2** for details on model inputs and specifications.

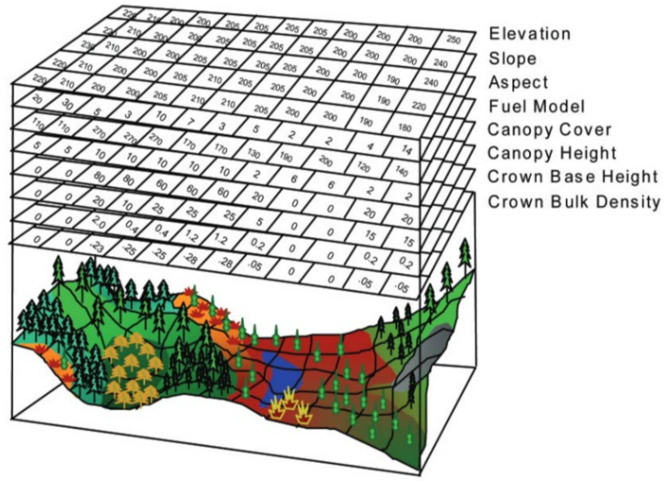

Figure 8.a.1*. FlamMap requires a variety of information about topography and fuels. Image from Finney (2006).*

TEA used LANDFIRE data modified by the Colorado Forest Restoration Institute in 2021 as the basis for our modeling. 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. CFRI modified LANDFIRE data by assigning TL5 fire behavior fuel model to lodgepole pine forests and reducing canopy base height by 30% to more closely replicate observed crown fire activity in this forest type. They also modified surface and canopy fuels in areas that experienced fuel treatments and/or wildfires since 2016. TEA thoroughly quality controlled fuel data and worked with Estes Valley Fire Protection District to assess the reasonableness of model predictions.

Figure 8.a.2 depicts the fire behavior fuel models present across the EVFPD. Fuel models are 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). The area in and around the EVFPD 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. Our 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).

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).

TEA modeled potential wildfire behavior under 60^{th} and 90^{th} percentile fire weather conditions. 60^{th} percentile weather condition are average fire weather conditions. 60th percentile conditions are like a normal summer day, whereas 90th percentile conditions are extremely hot, dry days—days that would qualify for red flag warnings and result in large-fire growth, such as conditions in early September 2020 during the Cameron Peak fire. These two benchmarks allow us to analyze where an average fire in the district may burn so the EVFPD can prioritize outreach and treatment under regular circumstances, as well as what can be expected under more extreme circumstances, as was seen in 2020.

Weather parameters for this analysis came from data collected at the Estes Park RAWS and fuel moisture conditions from FireFamilyPlus. Under 90th percentile weather conditions in the EVFPD, relative humidity is 13%, temperature is 82°F, 1-hour fuel moisture is 3%, and 10-hour fuel moisture is 4%, and 100-hour fuel moisture is 7% (**Table 8.a.2**).

Winds across the Front Range of Colorado are unpredictable and can be extremely gusty in mountainous areas. TEA modeled 20-foot windspeeds of 15 mph for 60th percentile fire weather conditions and 25 mph for 90th percentile fire weather conditions. Wind speeds of 25 mph qualify as red flag warnings when occurring with low relative humidity and dry fuels (**Table 1.c.1**). TEA modeled potential fire spread under winds blowing out of the east (90°) and blowing out of the west-southwest (245°) based on observations from the Estes Park RAWS and observations of local firefighters. TEA modeled flame length and crown fire activity based on west-southwest winds, and we modeled burn probability based on both these prevailing winds.

FlamMap offers two methods for calculating crown fire initiation and spread: the Scott and Reinhardt method and the Finney method. TEA used the Scott and Reinhardt method as 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).

Fire spread was modeled with FlamMap's "minimum travel time" algorithm to predict fire growth between cells and account for fire spread through spotting. We modeled fire growth under 10,000 random ignitions across the landscape, and we allowed fires to grow for 4 hours in the absence of firefighter suppression and control measures. We modeled fire behavior in an area 13 times larger than the EVFPD and centered on the EVFPD to capture the landscape-scale movement of fire. Conditional burn probability is calculated as the percentage of simulated fires that burn each 30-meter by 30-meter (0.2 acre) area under specific fire weather conditions, wind directions and speeds.

Table 8.a.1. *Model specifications used for fire behavior analyses with FlamMap for the 2022 Estes Valley Fire Protection District 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

*We used the same random ignition locations for fire spread analysis under 60th and 90th fire weather conditions.

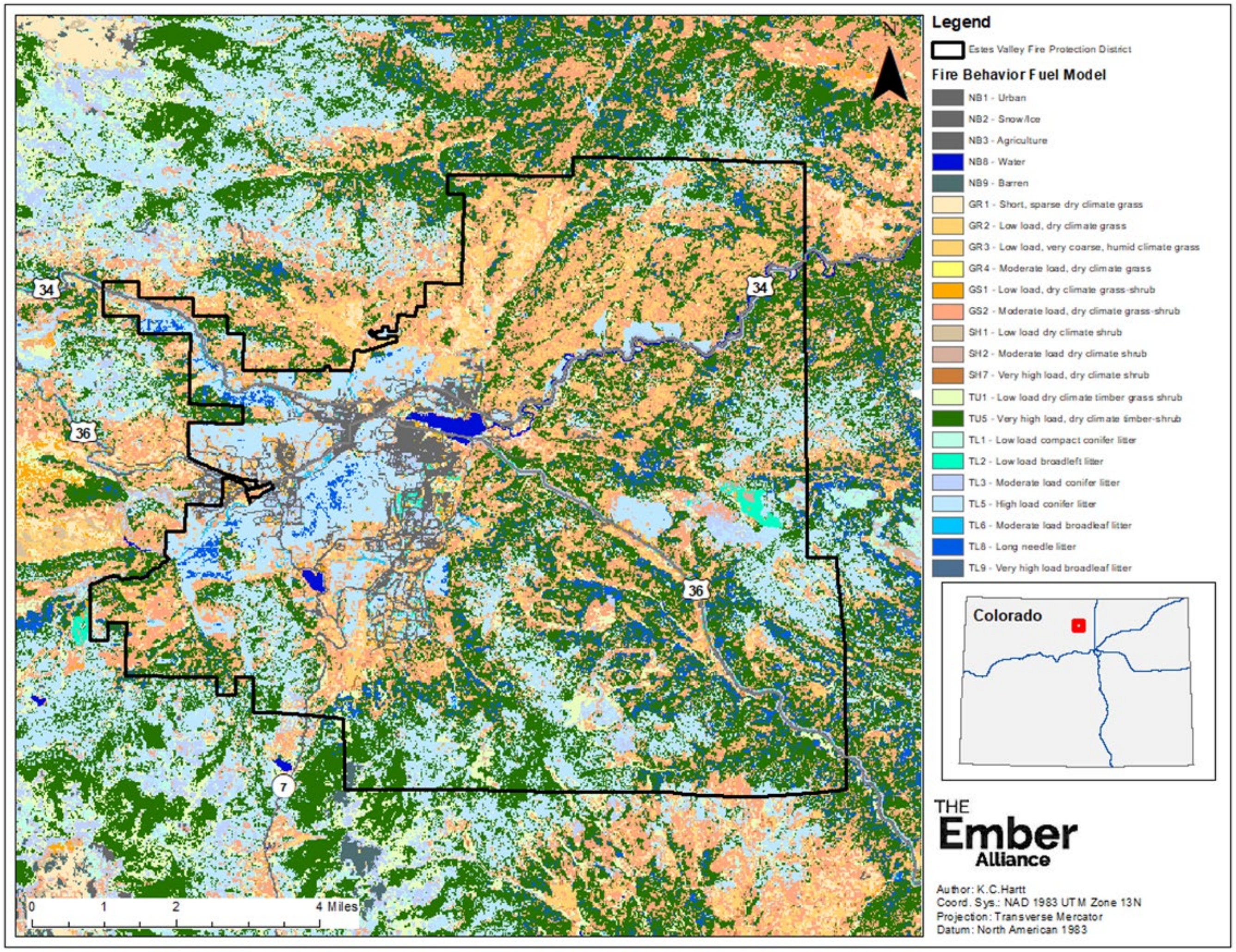

Figure 8.a.2. *Nearly half of the Estes Valley Fire Protection District has very high load dry climate timber-shrub fuels, more heavily concentrated in the eastern side of the district. The rest of the district is primarily low to moderate load grass, shrub, timber, and litter fuels. Fire behavior fuel models are an important input for making fire behavior predictions. See Scott and Burgan (2005) for a description of each fuel model. (Source: Source: LANDFIRE with modifications by the Colorado Forest Restoration Institute)*

Table 8.a.2. *Fire weather conditions utilized for fire behavior modeling are based on weather observations from the Estes Park Remote Automatic Weather Station between June 15-October 15, 2001-2020, and fuel moisture predictions from FireFamilyPlus. Weather conditions on October 21, 2020 during the East Troublesome Fire are presented for comparison.*

Variable	60th percentile	90th percentile	East Troublesome Fire (for comparison)
Temperature	74° Fahrenheit	82° Fahrenheit	67° Fahrenheit
Relative humidity	25%	13%	14%
Wind direction	West (270°) and east (90°)	West (270°) and east (90°)	South-southwest (235°)
20-foot wind speed[1]	15 mph	25 mph	6 mph, gusting to 30 mph
Fuel moisture[2]			
1-hour	5%	3%	13.2%
10-hour	6%	4%	4.5%
100-hour	9%	7%	9.7%
1000-hour[3]	12%	10%	
Live woody	84%	71%	60%
Live herbaceous	49%	35%	3.2%
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, 2021a).

[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, 32% of the EVFPD an experience very high to extreme fire behavior with flame lengths over 11 feet. Under 90th percentile weather conditions, 60% can experience very high to extreme fire behavior with flame lengths over 11 feet (**Figure 8.a.3**). Flame lengths are notably higher east of Dry Gulch Road in the north-central part of the EVFPD where vegetation transitions from shrublands and developed land into mixed conifer and ponderosa pine forests. Under 60th percentile fire weather, flame lengths consistently exceed 11 feet on steep north-west facing slopes covered in dense forest. Under 90th percentile fire weather, extreme fire behavior is observed even on flatter terrain. The East Troublesome Fire killed trees and removed surface fuels, creating areas of reduced predicted flame length west of the EVFPD even under 90th percentile fire weather.

Under 60th percentile fire weather, average flame lengths are above 11 feet in all plan units along the southern and eastern boundaries of the EVFPD (**Table 8.a.4**). Under 90th percentile fire weather, average flame lengths are greater than 11 feet across all plan units, indicating extreme challenges for fire suppression, with the exception of the East Prospect CWPP plan unit where average flame lengths are 6 feet (**Table 8.a.4**).

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	8-11	20-50	Indirect attack
Very High	11-25	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.

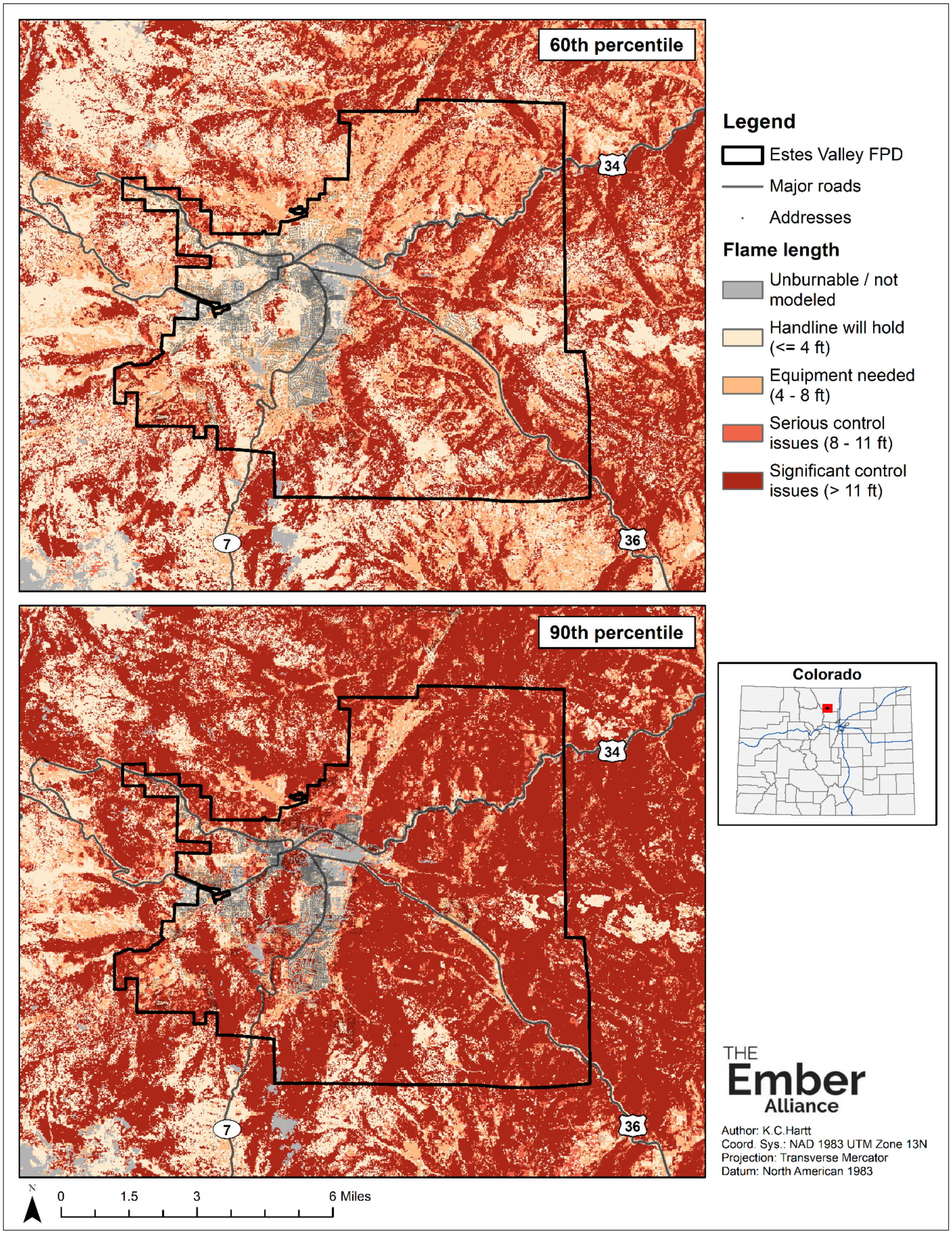

Figure 8.a.3. *Flame lengths in the Estes Valley Fire Protection District under 60th and 90th percentile fire weather conditions, categorized by the Haul Chart (**Table 8.a.3**).*

Table 8.a.4. *Average flame length across the entire Estes Valley Fire Protection District and in each CWPP plan unit. Potentially non-survivable flame lengths start at 8 feet according to the Haul Chart (**Table 8.a.3**). Flame lengths are summarized for the plan unit and adjacent topographic areas that could contribute to fire behavior within the plan unit. Colors correspond with the legend in **Figure 8.a.3**.*

	60th Percentile		90th Percentile	
	Average Flame Length (feet)	Maximum Flame Length (feet)	Average Flame Length (feet)	Maximum Flame Length (feet)
Entire EVFPD	**12**	**139**	**31**	**258**
Big Thompson	14	123	34	181
Carriage Hills	11	139	29	186
Downtown	7	114	21	193
East Prospect	1	41	6	109
Fall River	8	114	23	193
Fish Creek	9	119	22	174
High Drive	5	114	16	186
Lake Estes	8	84	22	174
Little Valley	16	139	38	234
Lumpy Ridge	8	97	23	193
Mary’s Lake Rd	6	113	18	229
Meadowdale	15	119	39	234
North End	13	122	27	181
Pole Hill	14	123	37	185
Rams Horn	13	139	37	258
Riverside	4	83	16	140
South Prospect	4	83	18	217
Spur 66	8	81	19	154
Windcliff	12	113	28	258
YMCA	13	111	26	258

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 **Section 1.c. 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, 59% of the EVFPD can experience passive crown fire, and only 1% can experience extreme fire behavior with active crown fire. Under 90th percentile weather conditions, 19% of the district is subject to extreme fire behavior with active crown fire (**Figure 8.a.4**; **Table 8.a.5**). Active crown fire is less likely to occur during days with higher fuel moistures and lower wind speeds, but under extremely hot, dry conditions, active crown fires are possible on steep slopes with dense forest.

Notable areas in the EVFPD that could support active crown fire near houses are around Propsect Mountain, Gianttrack Mountain, Rams Horn Mountain, Lily Mountain, and north of The Crags due to steep slopes and dense forests. The East Troublesome Fire killed trees and removed surface fuels, creating areas unlikely to support active crown fire west of the EVFPD even under 90th percentile fire weather.

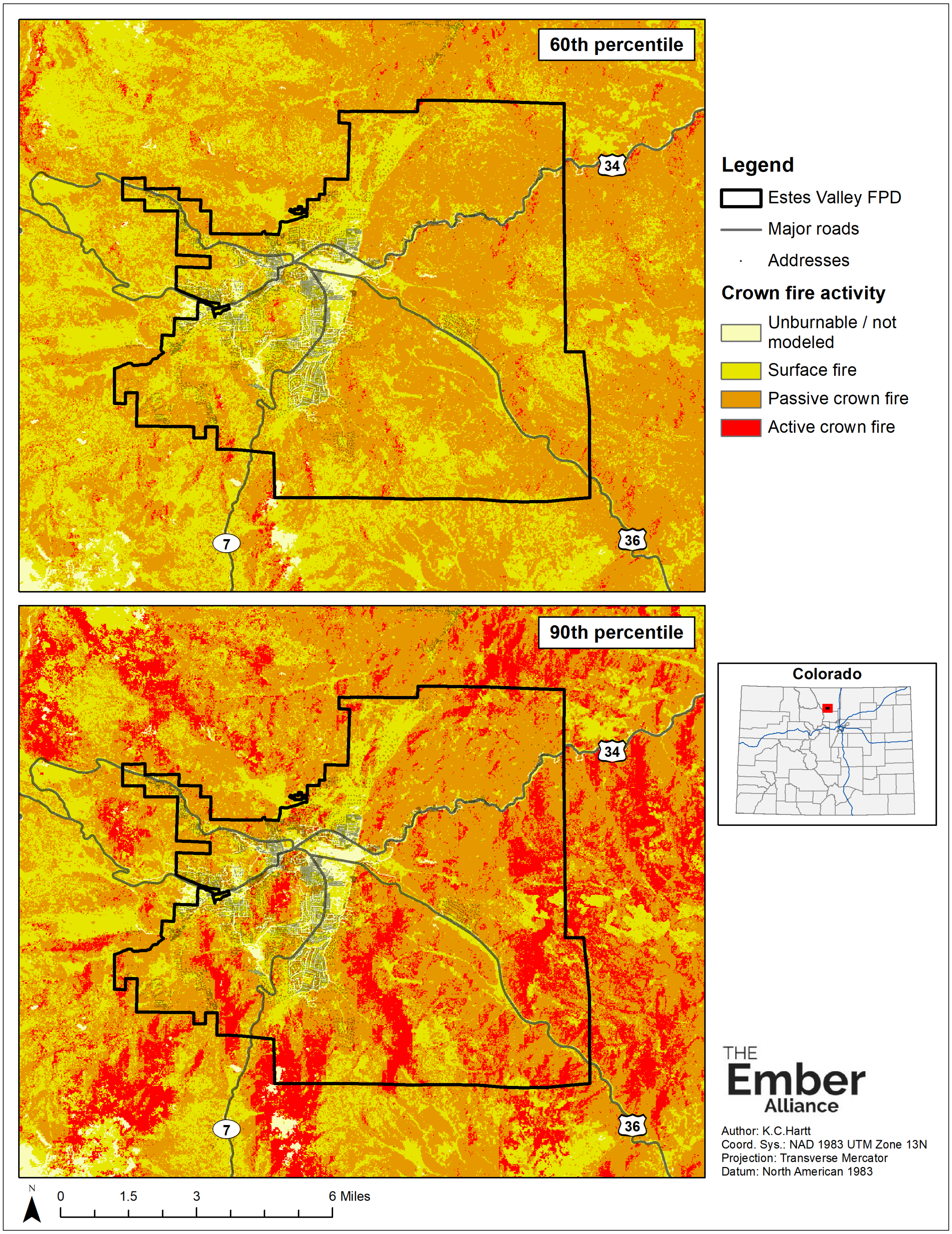

Figure 8.a.4. *Crown fire activity under 60th and 90th percentile fire weather conditions in the Estes Valley Fire Protection District.*

__Table 8.a.5__. Percent of the entire Estes Valley Fire Protection District and each CWPP plan unit predicted to experience each category of fire activity. Crown fire activity is summarized for the plan unit and adjacent topographic areas that could contribute to fire behavior within the plan unit. Colors correspond with the legend in __Figure 8.a.4__.

	60th Percentile				90th Percentile			
	Un-burnable	Surface Fire	Passive Crown Fire	Active Crown Fire	Un-burnable	Surface Fire	Passive Crown Fire	Active Crown Fire
Entire EVFPD	**5%**	**35%**	**59%**	**1%**	**5%**	**21%**	**55%**	**19%**
Big Thompson	3%	19%	77%	1%	3%	9%	69%	19%
Carriage Hills	15%	35%	50%	1%	15%	25%	41%	19%
Downtown	9%	49%	42%	1%	9%	29%	48%	14%
East Prospect	45%	43%	12%	0%	45%	29%	23%	3%
Fall River	3%	49%	48%	1%	3%	30%	53%	14%
Fish Creek	25%	35%	39%	1%	25%	25%	35%	15%
High Drive	12%	52%	36%	0%	12%	30%	49%	9%
Lake Estes	23%	35%	42%	0%	23%	26%	38%	12%
Little Valley	3%	36%	59%	2%	3%	23%	50%	24%
Lumpy Ridge	2%	50%	47%	1%	2%	34%	50%	14%
Mary's Lake Rd	14%	51%	35%	0%	14%	32%	44%	11%
Meadowdale	2%	30%	66%	1%	2%	17%	54%	26%
North End	3%	27%	69%	1%	3%	18%	69%	10%
Pole Hill	4%	27%	67%	1%	4%	14%	56%	26%
Rams Horn	5%	41%	52%	2%	5%	24%	47%	24%
Riverside	25%	49%	25%	1%	25%	24%	37%	15%
South Prospect	21%	50%	29%	0%	21%	29%	38%	13%
Spur 66	8%	51%	41%	0%	8%	37%	48%	7%
Windcliff	3%	43%	53%	1%	3%	23%	58%	16%
YMCA	1%	45%	53%	1%	1%	30%	56%	13%

Predicted Conditional Burn Probability and Fire Sizes

Conditional burn probability indicates how likely an area is to burn during a wildfire. Wind direction strongly affects burn probability, carrying fires quickly up slopes facing toward the incoming winds (**Figure 8.a.5**; **Figure 8.a.6**). 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 U.S. Highway 36 and CO Highway 7), particularly when the head of the fire is being pushed by wind directly at the road (see potential burn perimeters that spot over these highways in **Figure 8.a.6**). Rapid fire growth and spotting across roadways is more likely under higher windspeeds and with drier fuel conditions.

Conditional burn probabilities are relatively low across the EVFPD under 60th percentile fire weather due to lower predicted rates of spread and therefore smaller predicted fire perimeters. Under 90th percentile fire weather, the northern and eastern portions of the EVFPD have elevated conditional burn probabilities relative to more densely populated portions of the EVFPD with less flammable fuel types (i.e., developed properties). Remember that fire behavior models do not account for homes and other buildings as a fuel type, so the risk of wildfires is not negligible in downtown Estes, it just cannot be adequately captured by fire behavior modeling (**Figure 8.a.5**). CWPP plan units with elevated conditional burn probability under 90th percentile fire weather include Big Thompson, Lumpy Ridge, Meadowdale, North End, and Pole Hill (**Table 8.a.6**).

Unpredictable wind conditions along the Colorado Front Range make it difficult to predict potential fire spread, making it imperative for residents across the EVFPD to take measures to mitigate their home ignition zone (see **Section 3.a. Mitigate the Home Ignition Zone**).

There is a real potential for wildfires to spread across large swaths of the Estes Valley Fire Protection District 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.**

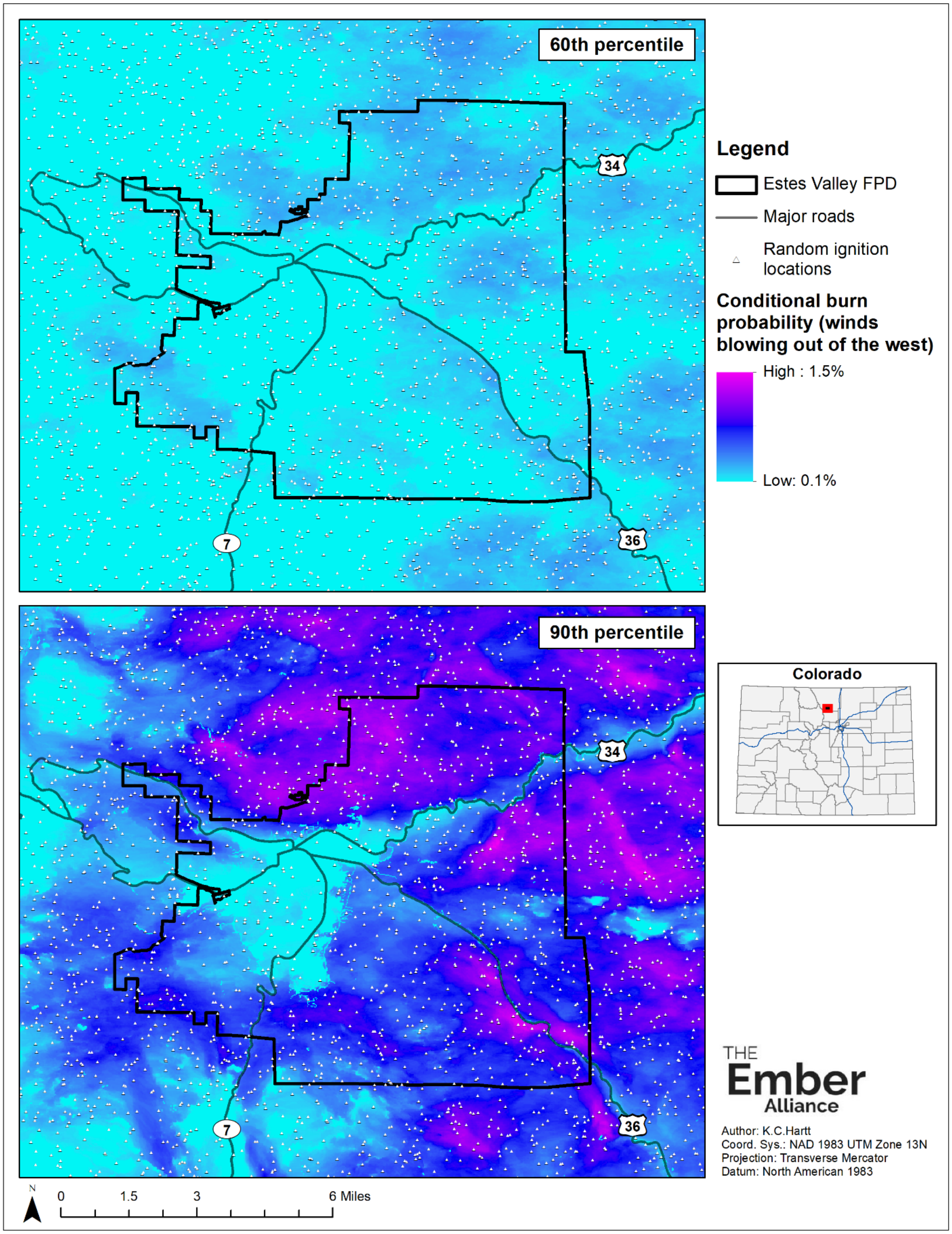

Figure 8.a.5. *Conditional burn probability under 60th and 90th percentile fire weather conditions with winds blowing out of the west. Wildfire spread was simulated for 4-hours without suppression activities from 10,000 random ignition locations across an area 13 times larger than and centered on the Estes Valley Fire Protection District.*

***Table 8.a.6**. Conditional burn probability for the entire Estes Valley Fire Protection District and each CWPP plan unit with winds blowing from the west. Conditional burn probability is summarized for the plan unit and adjacent topographic areas that could contribute to fire behavior within the plan unit. Colors correspond with the legend in **Figure 8.a.5**.*

	60th Percentile		90th Percentile	
	Average Burn Probability	**Maximum Burn Probability**	**Average Burn Probability**	**Maximum Burn Probability**
Entire EVFPD	**0.13%**	**0.39%**	**0.65%**	**1.47%**
Big Thompson	0.19%	0.39%	0.84%	1.47%
Carriage Hills	0.06%	0.23%	0.42%	0.93%
Downtown	0.08%	0.35%	0.48%	1.39%
East Prospect	0.01%	0.12%	0.03%	0.22%
Fall River	0.09%	0.35%	0.57%	1.39%
Fish Creek	0.04%	0.19%	0.28%	0.82%
High Drive	0.05%	0.20%	0.28%	0.83%
Lake Estes	0.08%	0.33%	0.40%	1.19%
Little Valley	0.09%	0.23%	0.59%	0.96%
Lumpy Ridge	0.13%	0.37%	0.73%	1.39%
Mary's Lake Rd	0.05%	0.33%	0.24%	0.74%
Meadowdale	0.12%	0.38%	0.69%	1.42%
North End	0.21%	0.39%	0.91%	1.33%
Pole Hill	0.13%	0.35%	0.70%	1.47%
Rams Horn	0.09%	0.34%	0.49%	0.96%
Riverside	0.01%	0.10%	0.08%	0.36%
South Prospect	0.03%	0.28%	0.16%	0.69%
Spur 66	0.10%	0.33%	0.40%	0.78%
Windcliff	0.12%	0.34%	0.53%	0.88%
YMCA	0.11%	0.35%	0.52%	0.88%

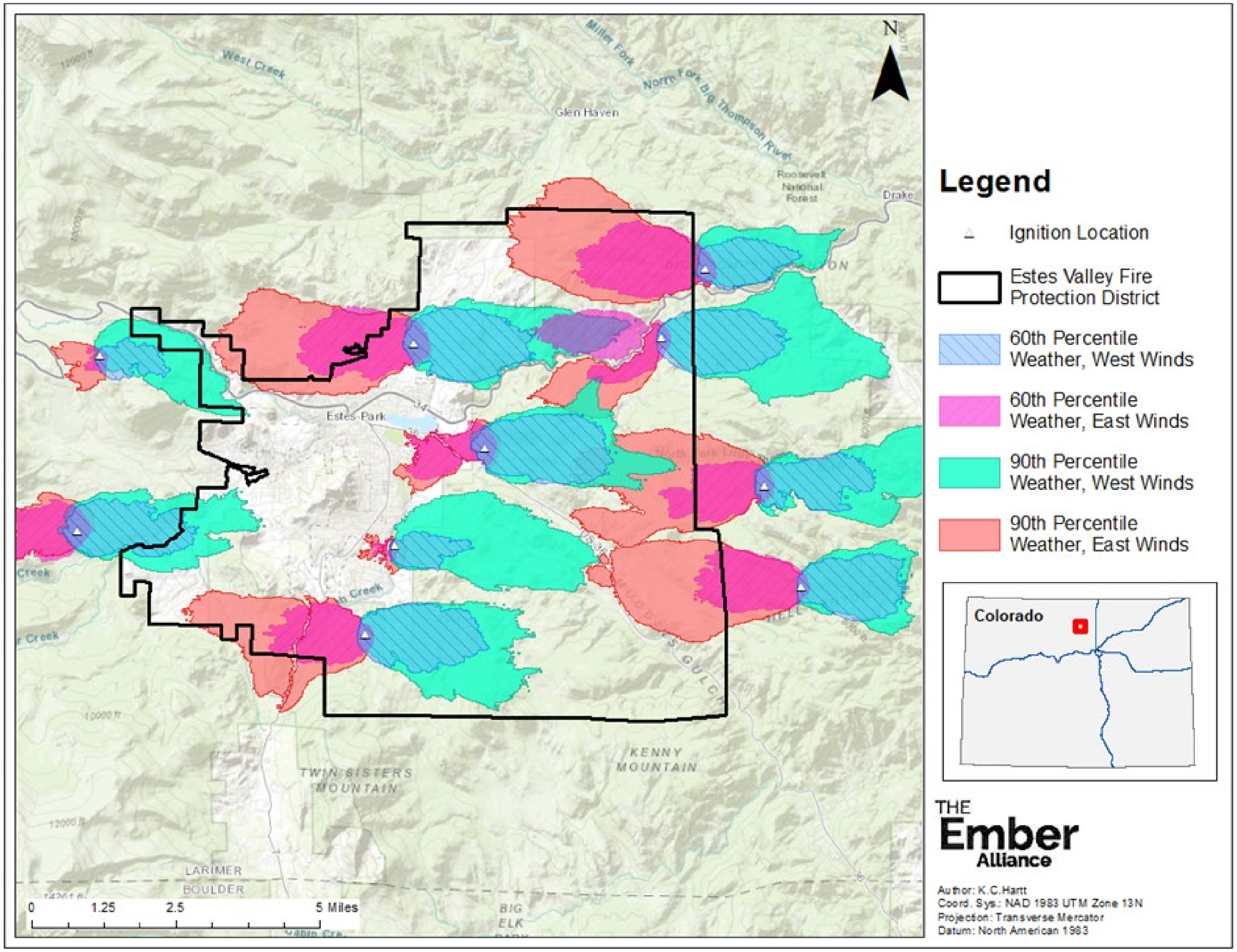

***Figure 8.a.6**. Simulated fire perimeters after 4-hours of fire growth without suppression activities originating from 10 of the 10,000 randomly generated ignition locations across the Estes Valley Fire Protection District. We modeled fire growth using FlamMap's minimum travel time algorithm and 60th and 90th percentile fire weather conditions under prevailing winds out of the west and the east. Each fire perimeter is a unique run from an ignition, ad multiple fire perimeters are shown to demonstrate the variety of sizes, shapes, and travel paths that can happen around the EVFPD.*

A.3. Predicted Radiant Heat and Ember Cast Exposure

TEA assessed the risk that radiant heat and short-range and long-range embercast pose to structures. See **Section 1.c. 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 we utilized the simplified approach of Beverly et al., (2010) to assess home exposure to radiant heating and short-and long-range embercast (**Figure 8.a.7**). 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 > 16 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 et al., (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 et al., 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 et al., 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 et al., 2016). Therefore, using conservative estimates of distance allows us to identify areas with the greatest risk of ignition from short- and long-range embers.

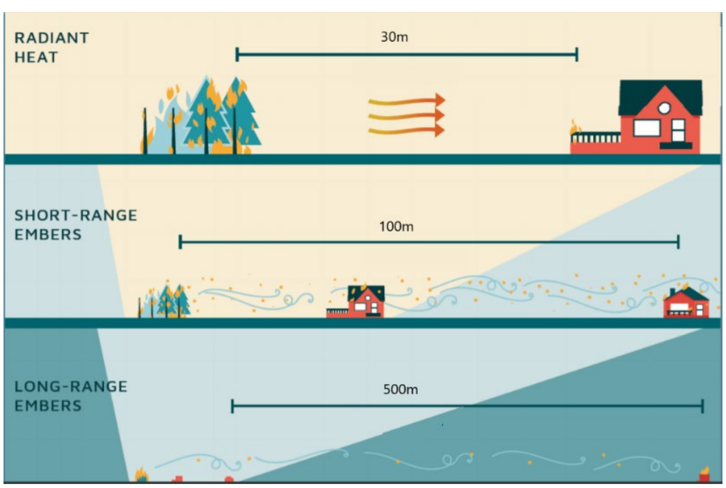

Figure 8.a.7*. Research by Beverly et al. (2010) suggest that homes are exposed to radiant heat, short-range embers, and long-range embers depending on their distance from the flaming front.*

TEA

TEA determined whether exposure to radiant heat and short- and long-range ember cast from active crown fires was possible within the home ignition zone (HIZ; 100-feet radius) of each structure in the EVFPD[4].

Potential exposure to radiant heat, short-range ember cast, and long-range ember cast is widespread across the EVFPD (**Figure 8.a.8**). Under moderate fire weather, 9% of homes in the EVFPD are at risk of exposure to radiant heat and 30% to long-range ember cast, and these percentages increase to 24% of homes potentially exposed to radiant heat and 87% potentially exposed to long-range ember cast under extreme fire weather (**Table 8.a.7**). Under moderate fire weather, more than half of the structures in Little Valley and Meadowdale plan units are at risk of radiant heat, and more than half the homes in Big Thompson, Fall River, Little Valley, Meadowdale, Riverside, Spur 66, Windcliff, and the YMCA plan units are at risk of long-range ember cast. Under extreme fire weather, majority of homes in Lumpy Ridge, Meadowdale, and Little Valley are at extreme risk of embers and radiant heat (**Table 8.a.7**). It is important to remember that embers can ignite homes even when the flaming front of a wildfire is far away.

Most structures in EVFPD could be exposed to short-range ember cast from at least one other home. On average, homes could be exposed to short-range ember cast from 16 other homes, which puts all those homes as risk of home-to-home ignition, especially if they are not mitigated or hardened (**Figure 8.a.9**) (Syphard et al., 2012). Some homes could be exposed to short-range ember cast from 88 other structures. Fuel treatments within HIZs and surrounding undeveloped areas could help reduce the exposure of homes to radiant heat and short-range ember cast.

Potential exposure to radiant heating and long- and short-range ember cast is widespread across the Estes Valley Fire Protection District, 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 Fire Protection District and not to evaluate absolute risk to individual homes. FlamMap and the approach of Beverly et al. (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.

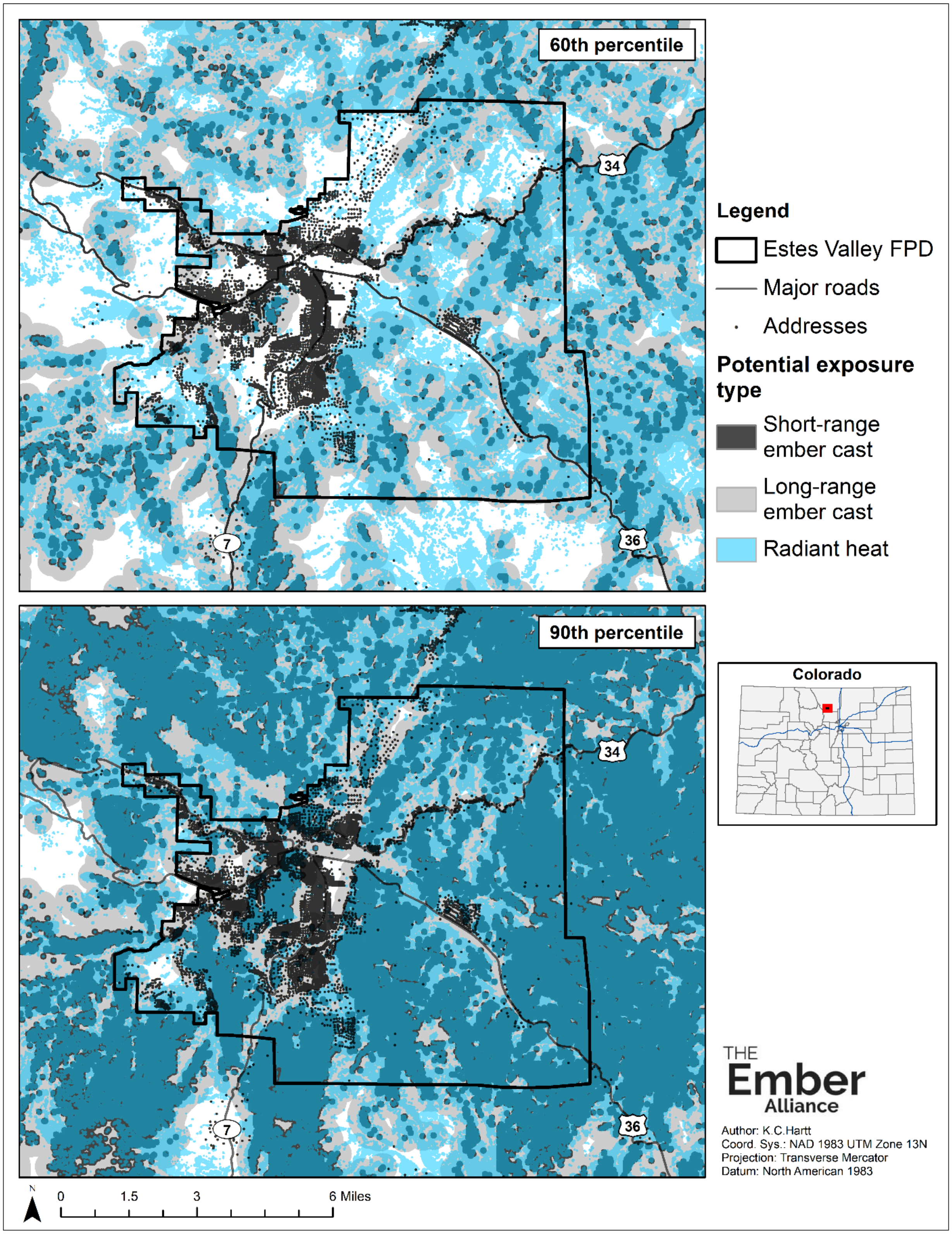

Figure 8.a.8. *Predicted exposure to short-and long-range ember cast and radiant heat under 60th and 90th percentile fire weather conditions in the Estes Valley Fire Protection District.*

Table 8.a.7*. Percentage of structures in the entire Estes Valley Fire Protection District and each CWPP plan unit at risk of exposure to radiant heat, short-range ember cast, and/or long-range ember cast.*

	60th Percentile Weather			90th Percentile Weather		
	Radiant Heat	Short-Range Ember Cast	Long-Range Ember Cast	Radiant Heat	Short-Range Ember Cast	Long-Range Ember Cast
Entire EVFPD	**9%**	**2%**	**30%**	**24%**	**23%**	**87%**
Big Thompson	28%	5%	81%	41%	19%	100%
Carriage Hills	0%	0%	18%	5%	7%	96%
Downtown	2%	0%	18%	24%	27%	99%
East Prospect	0%	0%	0%	3%	7%	58%
Fall River	4%	1%	66%	16%	16%	100%
Fish Creek	9%	1%	15%	18%	16%	48%
High Drive	1%	0%	4%	4%	2%	62%
Lake Estes	1%	0%	19%	13%	16%	82%
Little Valley	76%	4%	86%	84%	45%	100%
Lumpy Ridge	18%	12%	25%	77%	77%	100%
Mary's Lake Road	5%	1%	21%	16%	23%	99%
Meadowdale	58%	18%	84%	82%	64%	100%
North End	38%	2%	35%	57%	39%	98%
Pole Hill	16%	4%	46%	43%	32%	99%
Rams Horn	13%	1%	12%	37%	16%	100%
Riverside	5%	2%	82%	32%	57%	100%
South Prospect	1%	0%	10%	31%	30%	98%
Spur 66	9%	15%	59%	15%	27%	89%
Windcliff	42%	3%	71%	73%	37%	100%
YMCA	49%	3%	61%	51%	17%	73%

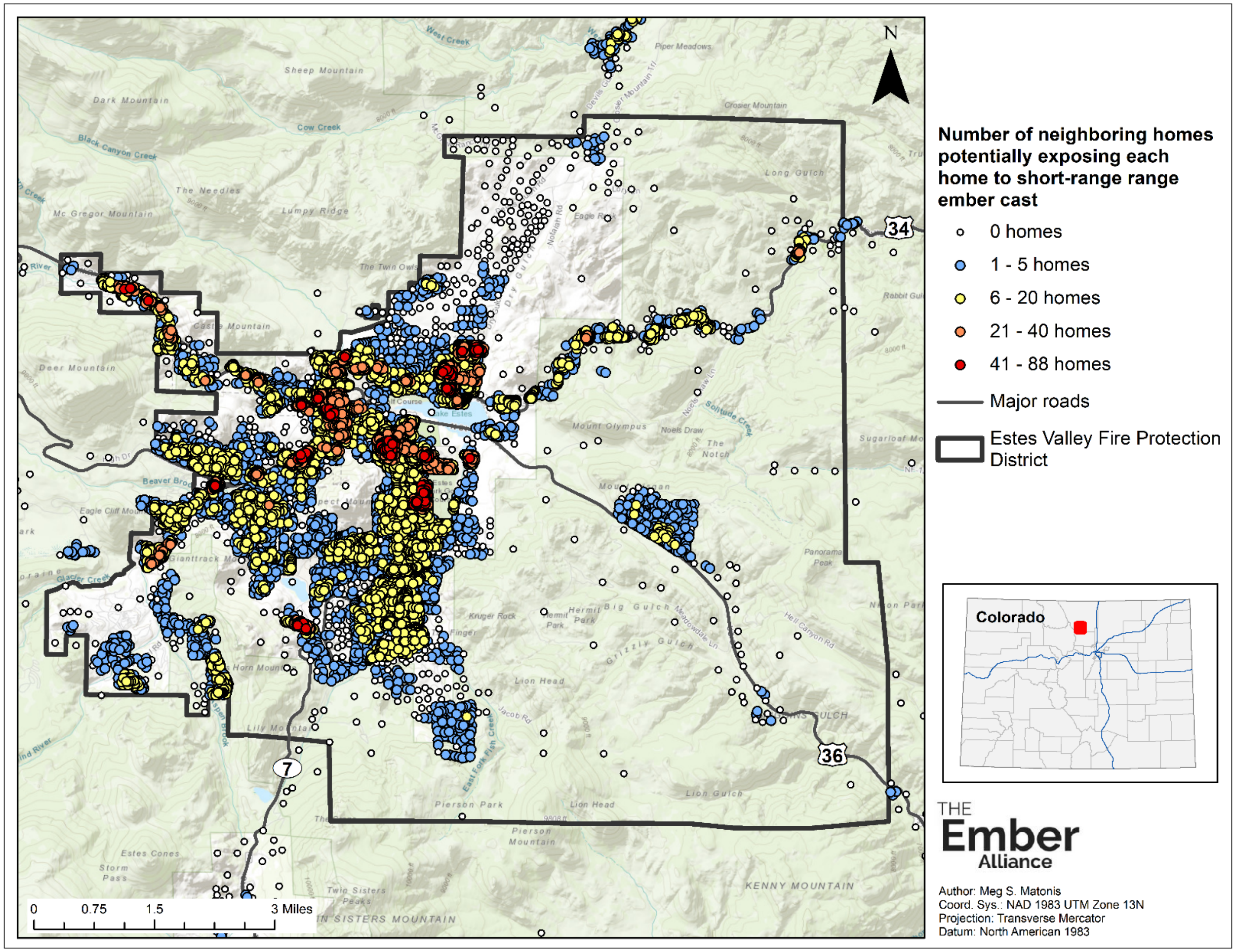

__Figure 8.a.9.__ Most homes could be exposed to short-range ember cast from at least one neighboring home, with the average home in EVFPD potentially exposed to short-range ember cast from 16 other homes. Homes within 100-meters of other homes are at greater risk of home-to-home ignitions from short-range ember cast (Syphard et al., 2012).

A.4. Evacuation

Evacuation concerns can weigh heavily on the minds of many residents in the Estes Valley Fire Protection District. 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 Congestion

Law enforcement personnel must plan for areas of high congestion when making decisions about how to conduct actual evacuations in the Estes Valley Fire Protection District (**Figure 8.a.10**). Roads were categorized by where areas of high congestion could occur during an evacuation, and what did occur during the valley-wide evacuations in October of 2020. Staff from EVFPD and LCSO that manage evacuation planning and were part of the evacuation in 2020 helped identify locations that could experience the most extreme congestion. Roads with the most congestion included the main evacuation routes going east on US Highway 34 and US Highway 36, and back up through town. Major intersections such as Mall Road and highway intersections all experienced congestion, as well as major road connections to the evacuation routes. Considerations were made for future evacuations that may focus cars to the west, northeast, or south.

It is important to state that congestion planning does not account for unexpected barriers such as cars breaking down, car accidents, road closures, etc. It also cannot fully account for events like school field trips, major tourism weekends such as Elk Fest or the Highland Festival, or the evacuation of families who do not own vehicles. If an evacuation were ordered over a summer weekend, the congestion would increase dramatically. However, this analysis does highlight areas that are prone to traffic build up even under the best-case scenario.

When law enforcement personnel plan for evacuations, they use models to predict evacuation times and routes. Typically the EVFPD expects 1,000-1,250 cars per hour per lane of travel, flowing at five miles per hour. This was approximately what they saw during the valley-wide evacuations that occurred in October of 2020.

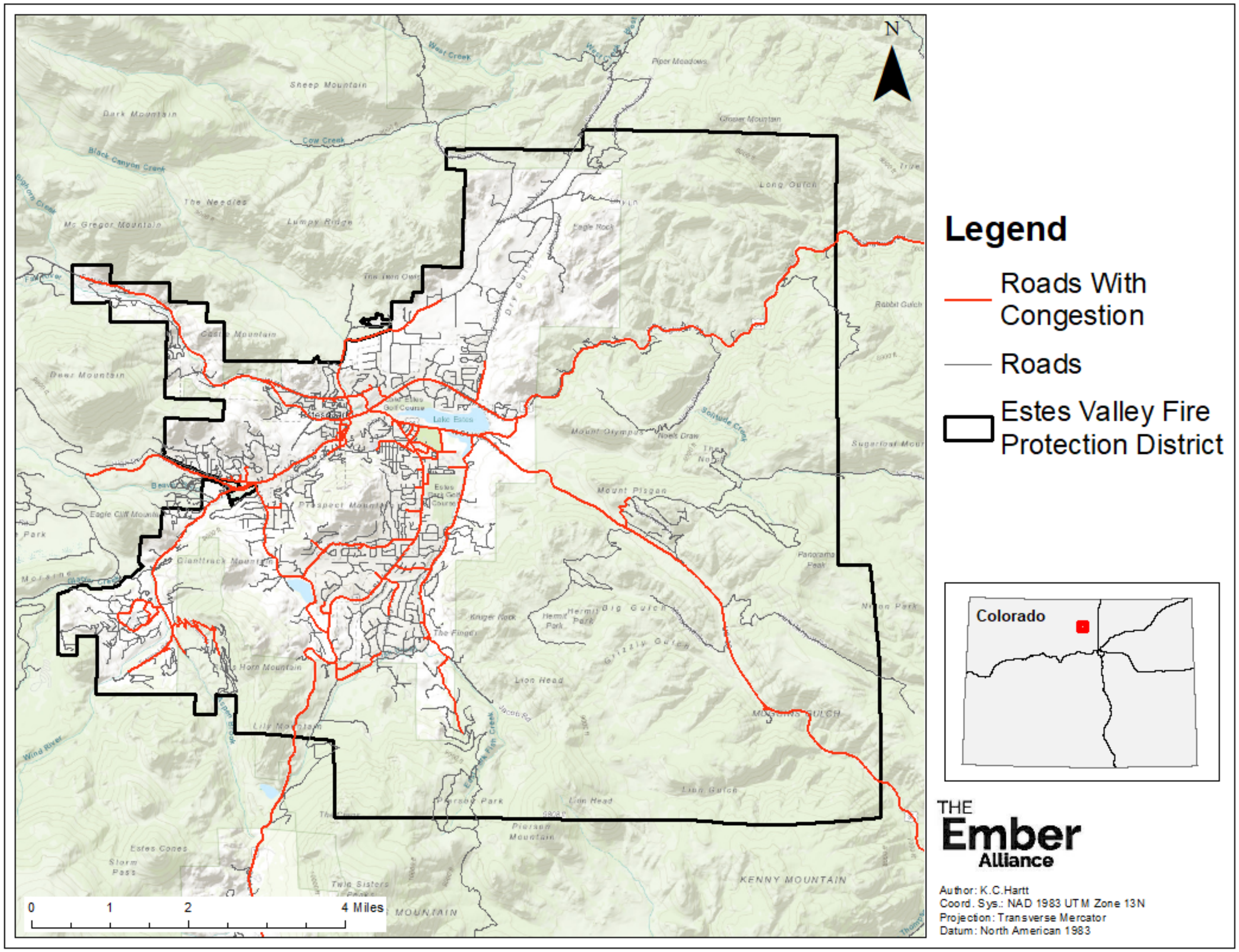

Figure 8.a.10. *Roads that could experience extreme congestion during a wildfire evacuation for the Estes Valley Fire Protection District. Staff from EVFPD and LCSO that manage evacuation planning and were part of the evacuation in 2020 identified locations that could experience the most extreme congestion.*

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.**

TEA utilized fire behavior predictions to identify road segments that could experience non-survivable conditions during a wildfire. We used roadway data from OpenStreetMap and the Colorado Department of Transportation, with modifications to the road network based on local expertise. We identified "non-survivable roadways" 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**) (NWCG, 2019). 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.11**).

Under moderate 60^{th} percentile fire weather, 11% of the roads in the EVFPD could experience non-survivable conditions, and this percentage rises to 32% under extreme 90^{th} percentile fire weather. Under moderate fire weather conditions, Little Valley is the only CWPP plan unit where over a third of roads could become potentially non-survivable, but under extreme weather conditions, over a third of roads could become potentially in 9 of 20 plan units (**Figure 8.a.12**). 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 portions of U.S. Highway 34, U.S. Highway 36, and County Road 43 (Devils Gulch Road). We incorporated information about roadway survivability into recommendations for roadway fuel treatments across the EVFPD (see **Section 4.c. Roadway Fuel Treatment** Recommendations).

Survivable Roadways	Potentially Non-Survivable Roadways
	
	

Figure 8.a.11. *Some roads in the Estes Valley Fire Protection District have been well mitigated by removing tall trees and saplings, removing limbs on the remaining trees, and keeping grass mowed (left images). Other roads could experience potentially non-survivable conditions because they are lined by thick forests that have an abundance of ladder fuels (right images). Photo credits: The Ember Alliance.*

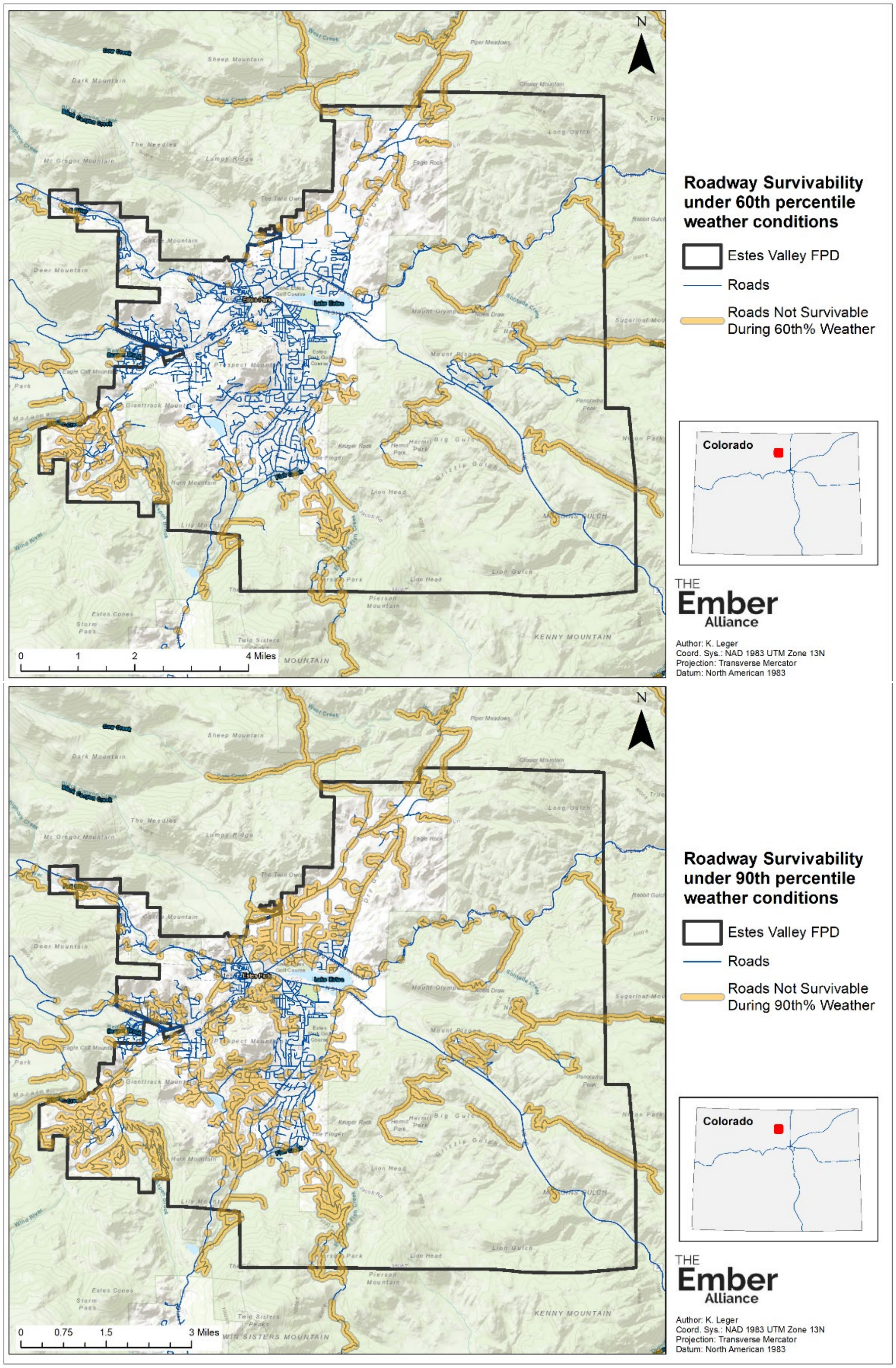

Figure 8.a.12. *Under 60th percentile fire weather conditions, 11% of roads and driveways in the Estes Valley Fire Protection District could potentially experience non-survivable conditions during wildfires. This rises to 32% under 90th percentile conditions.*

Table 8.a.8. *Percentage of potentially non-survivable roads in plan units across the Estes Valley Fire Protection District. Darker colors indicate plan units with higher miles and/or percentages of non-survivable roads.*

	60th Percentile		90th Percentile	
	Miles of Roads	**Percent of Roads**	**Miles of Roads**	**Percent of Roads**
Entire EVFPD	**26.8**	**11%**	**76.7**	**32%**
Big Thompson	2.3	19%	3.3	27%
Carriage Hills	0.1	1%	0.4	3%
Downtown	0.1	1%	2.9	14%
East Prospect	0.0	0%	0.6	5%
Fall River	0.1	1%	1.5	17%
Fish Creek	0.9	7%	2.6	20%
High Drive	0.0	0%	1.0	10%
Lake Estes	0.1	1%	2.9	16%
Little Valley	5.1	45%	7.0	61%
Lumpy Ridge	0.3	4%	5.1	63%
Mary's Lake Road	0.2	2%	1.4	14%
Meadowdale	4.6	31%	7.4	50%
North End	3.2	21%	7.0	47%
Pole Hill	2.1	13%	8.4	51%
Rams Horn	1.0	8%	4.1	33%
Riverside	0.1	1%	1.6	24%
South Prospect	0.1	1%	4.3	41%
Spur 66	0.1	1%	0.4	7%
Windcliff	3.4	31%	7.3	67%
YMCA	3.3	24%	7.5	53%

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, we used the Climate Toolbox's Future Climate Scatter to project future weather scenarios for Estes Valley Fire Protection District. 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. We analyzed four variables: 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, EVFPD 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 5-15%, **resulting in 12-15 more high fire danger days per year (Figure 8.a.13, Figure 8.a.14)**.

Fire behavior models from **Model Specifications and Inputs** 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 EVFPD 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.13*. Potential future weather conditions in the Estes Valley Fire Protection District modelled with the Climate Toolbox Future Climate Scatter (Hegewisch et al., 2021). 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.*

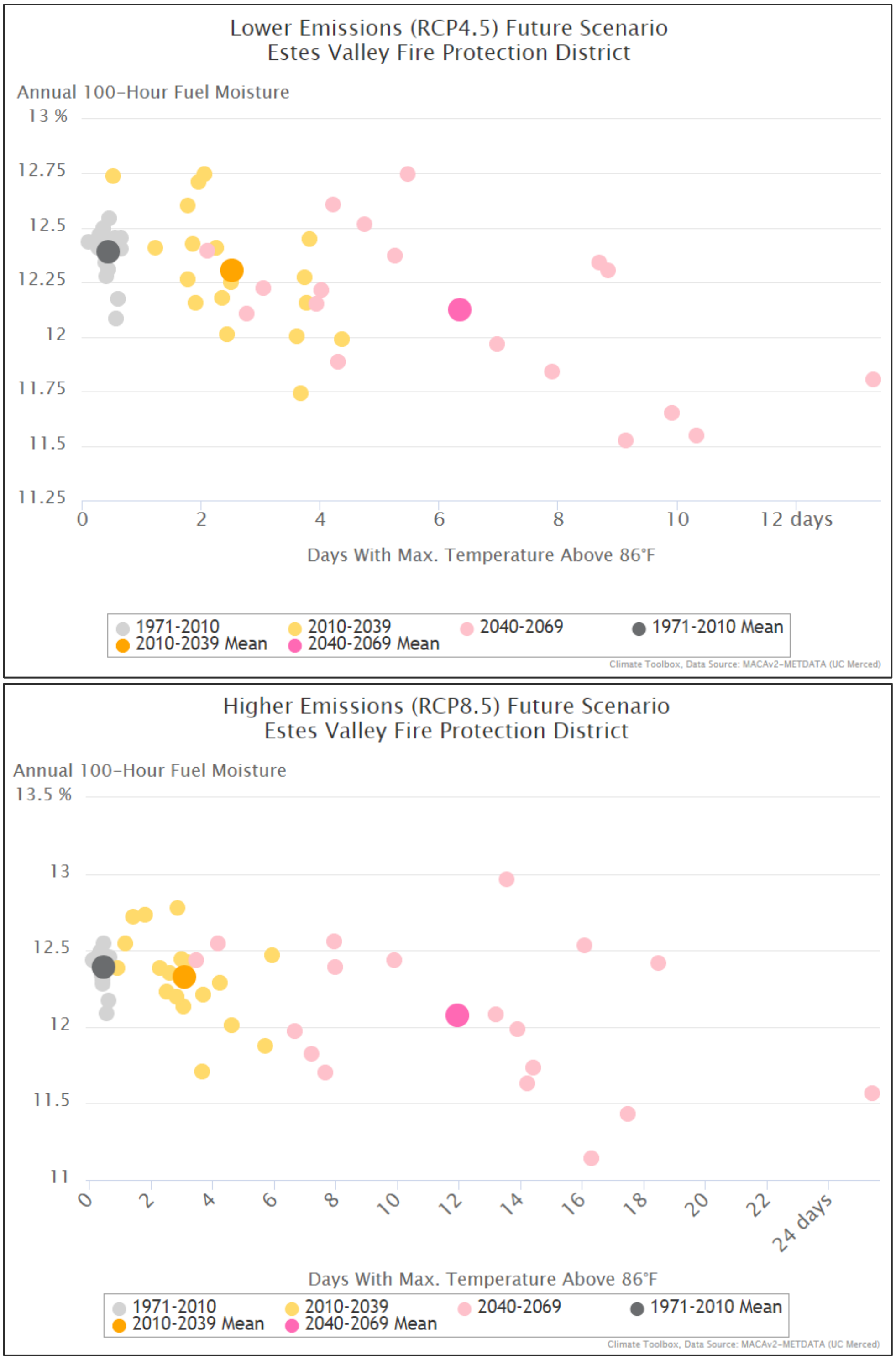

Figure 8.a.14. *Potential future conditions that impact fire behavior and suppression activities in the Estes Valley Fire Protection District modelled with the Climate Toolbox Future Climate Scatter (Hegewisch et al., 2021). The top graph is modelled under the RCP 4.5 scenario, where greenhouse gas emissions 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.*

A.7. District Capacity Assessment

A district's suppression capacity can be estimated or measured variably depending on different logical frameworks. To better understand suppression challenges, this analysis first assessed where fire suppression would be the most hampered by fire behavior and response times. This analysis was used to inform minimum resource needs, which were in turn compared to district and local level suppression capacity. Recommendations were drawn from these analyses and interviews with local subject matter experts. Recommendations and results can be found in **Section 3.d. Recommendations to Enhance EVFPD Capacity.**

Quantitative Assessment

Response times can be calculated in multiple ways. This assessment combines two methods for a hybrid approach. First, a network model of the roads in Estes Valley was built and quality controlled. This network model was used to generate a service area model using ArcGIS. Service area models are based on driving times and roadway speeds. Travel times were calculated from Estes Park Station 71 to every location in network model; a ten-minute mobilization time, based on District assessment of call processing time, volunteer response, and gear up time, was added to the travel time. Second, this was supplemented by a calculated "hike in" time. Distance to road was calculated at a 30 m resolution and arrival times were calculated for every location in the district using a 2.5 mph hiking speed (Sullivan et al., 2020). Although this overpredicts hiking speed in steep terrain, it will underpredict in flatter areas. These two calculations were summed to create a response time surface that estimates potential arrive times for crews leaving from the Station 71 to every location in the district.

Calculating Fire Sizes and Perimeters

Fire sizes were calculated at every location in the response area. Notably, the fire sizes are point estimates and do not consider the fuels around them. Fire sizes follow the revised Rothermel methods (Andrews, 2018) that underpin fire behavior tools like BEHAVE (Heinsch and Andrews, 2010). Ninetieth percentile weather and 25 mph twenty-foot west winds were used in the initial calculations. Ellipse length-to-width ratio, a key variable for estimating fire size, was calculated using spatially-explicit, terrain-influenced wind speed outputs from FLAMMAP (Finney, 2006) and WindNinja (Wagenbrenner et al., 2016). A constant wind adjustment factor of 0.5 was used; this overpredicts midflame windspeed in some areas, but that was assessed as more useful than underpredicting (Andrews, 2012). Flanking and backing rates of spread and distances were calculated using these values as they relate to FLAMMAP's forward rates of spread. Fire perimeters were estimated using a simplified elliptical area formula which results in minor deviation from values calculated in BEHAVE (Equation 1).

Equation 1. Simplified function for estimating fire perimeters from elliptical fire perimeters.

$$\pi(\frac{Length}{2} \times Flanking\ Distance)$$

Calculating Resource Needs

Firefighting resource needs were assessed by mean flame lengths and mean fire perimeters. Values were aggregated at a "fireshed" level, which were built from hillslopes as bisected by roads and waterways (see Appendix **B.2. Fuel Treatment Prioritization Methodology** for a description of hillslopes). Firesheds were subdivided initially by mean flame length into those where direct attack might be successful (≤ 8 ft mean flame lengths) and where indirect attack would be necessary (> 8 ft mean flame lengths) (NWCG, 2019). Mean fire perimeters, multiplied by three to account for forward spread during suppression actions, were divided by the average number of chains a "type 2" handcrew[5] could produce in a 16-hour shift. This line production rate does not take into account slope or variable fuel types and assumes a conifer litter fuel model. Per Broyles 2011, for firesheds where direct attack is possible, a rate of 6.8 ch/hr/crew was used; for firesheds where indirect attack is required, 5.7 ch/hr/crew was used (Broyles, 2011).

Results

Arrival times varied from 15 min to 107 min across the modeled area (**Figure 8.a.15**). Because many areas in the district have limited road access, many areas have significant hike in costs. These result in heterogenous distributions of fire sizes and perimeters based on differing arrival times. Fire sizes were generally constrained closer to roads due to reduced response time (**Figure 8.a.16**), but significant variability exists (**Figure 8.a.17**). This variability shows the degree to which response time is not the entire driver of fire size due to the effects of wind, weather, topography, and fuel. Fire sizes and perimeters across the district follow distributions generally seen in fire sizes distributions with many small fires and fewer large fires.

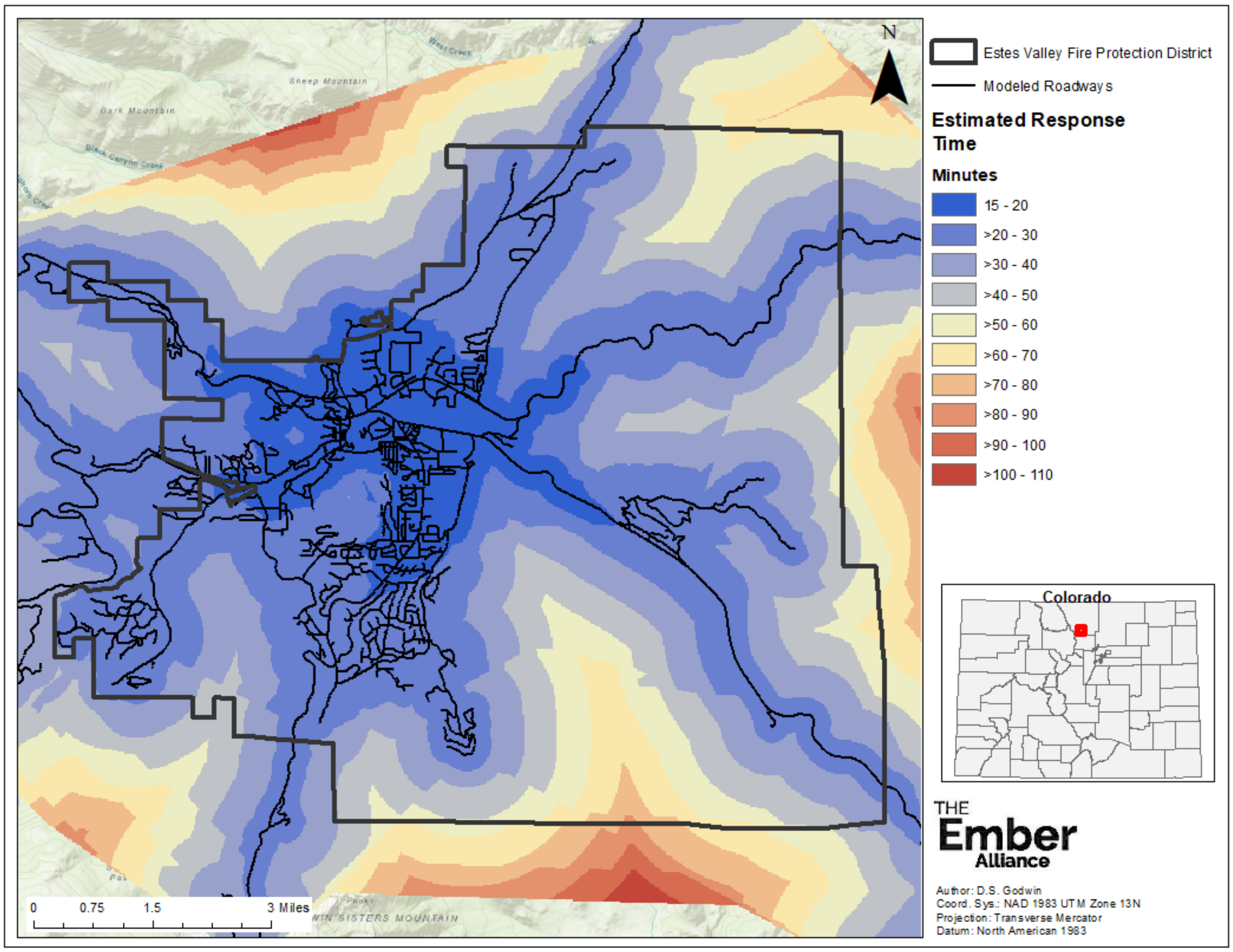

Figure 8.a.15. Response time estimates across the fire district. Hard breaks are present at the edge of the modeling area due to spatial estimates in the network analyst geoprocessing tool.

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[5] See *NWCG standards for wildland fire resource typing* for a description of resource types (NWCG, 2021b).

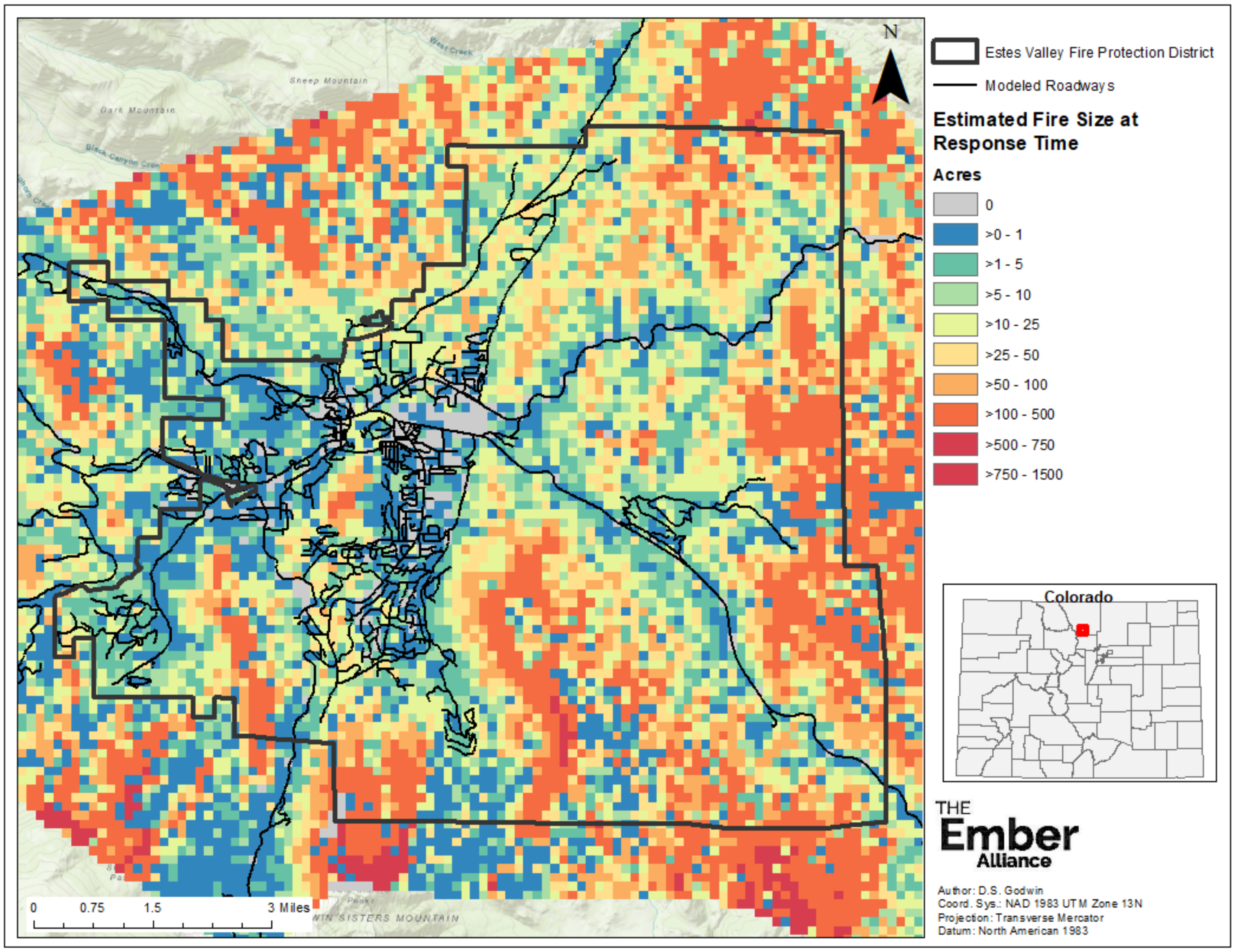

Figure 8.a.16. *Estimated fire size at arrival time under 90th percentile weather conditions.*

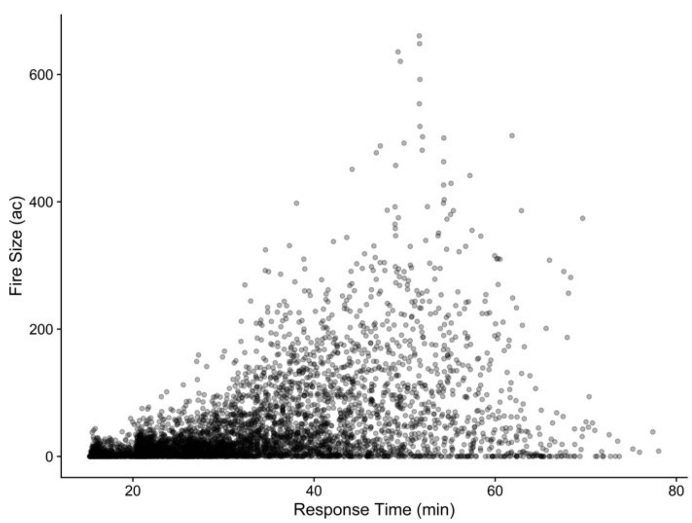

Figure 8.a.17*. Bivariate plot of estimated pixel-level fire size relative to response time. This shows variability in fire size is related to but not entirely dependent on response time.*

Fireshed-level fire sizes (**Figure 8.a.18**) and perimeters (**Figure 8.a.19**) at predicted time of arrival show how despite the variability, patterns are apparent when aggregated in meaningful spatial units. Mean fire sizes are largest in areas with poor road accessibility. Access is limited in designated Wilderness in Lumpy Ridge and the area west of Lily Lake and in the USFS Roadless Area around Crosier Mountain Although not roadless areas, access up Pole Hill and Hells Canyon roads requires slow four-wheel drive along unimproved roads. Although Hermit Park and North Twin Sisters areas are relatively more accessible than the previous examples, access to these remote recreation areas can still be difficult and time consuming, as demonstrated by the Kruger Rock Fire that burned in this area in 2021.

Minimum resources requirements vary across firesheds (Figure 8.a.20). In addition to increased response times, areas closest to roadways generally have lower fuel loads compared to areas farther away from development. A mix of resource types (heavy equipment, engines, handcrews, and aircraft) are suggested for any extended attack fire. The estimates for resource needs should be considered extremely coarse and are provided for identifying trends in response capacity across the district. The resource recommendations shown below have significant assumptions and should not supersede the expert opinion of on-scene incident commanders or duty officers.

Under 90th percentile weather conditions, many areas in the district have the potential for extreme fire spread that would quickly challenge containment resources for the district and the local area. Large areas of the district will require indirect attack. Although weather changes can provide opportunity for containment after an initial push (e.g., East Troublesome Fire, Kruger Rock Fire, Marshall Fire), favorable changes in weather cannot be relied upon. In many areas, multiple handcrews (or a configuration of other resources that can achieve equivalent line production rates) are necessary to quickly contain fast moving, intense fires. Ultimately, any fire start under 90th percentile weather conditions will likely challenge the capability of local resources and will require quick mobilization of outside resources.

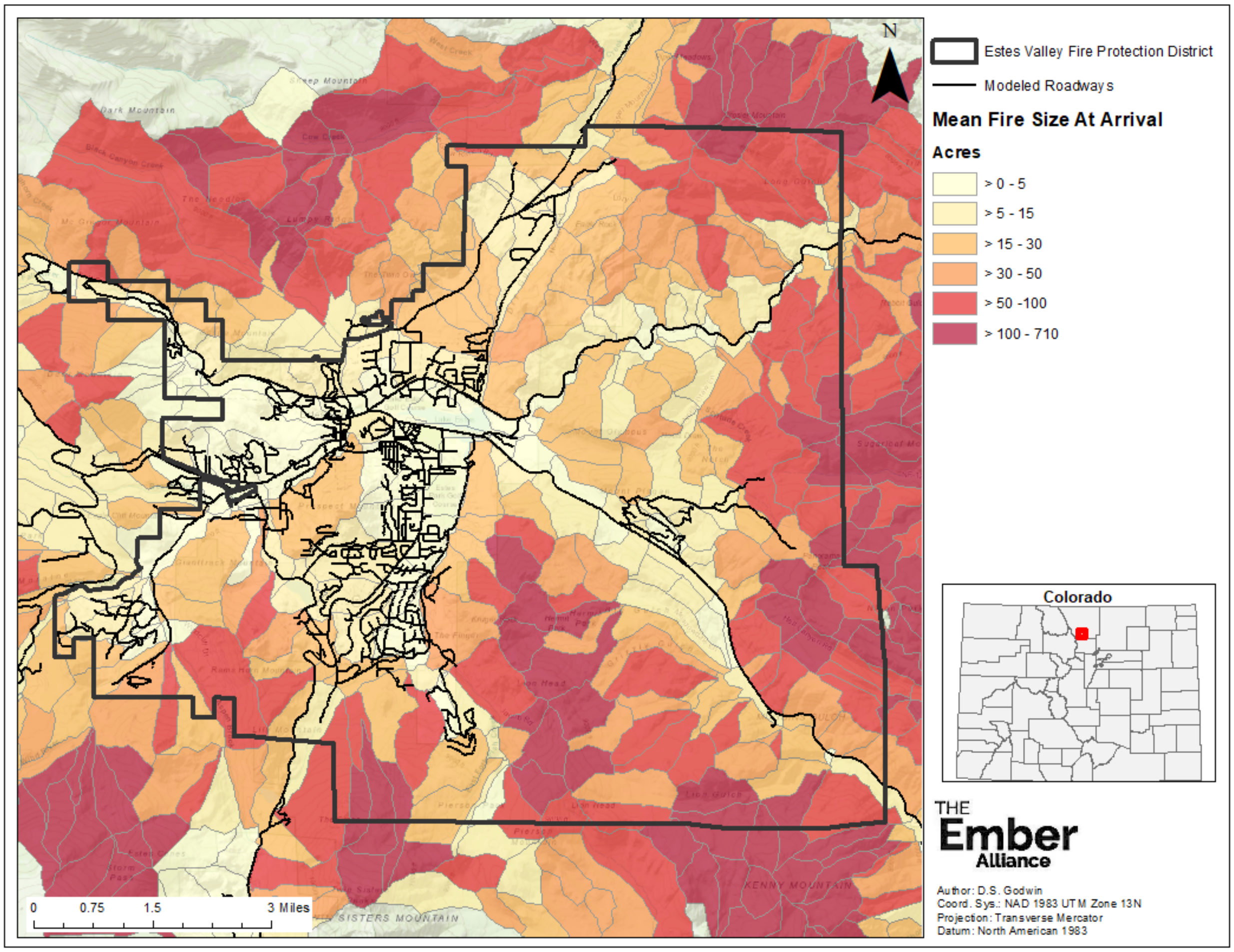

Figure 8.a.18. *Mean fire size at arrival time aggregated at the fireshed level.*

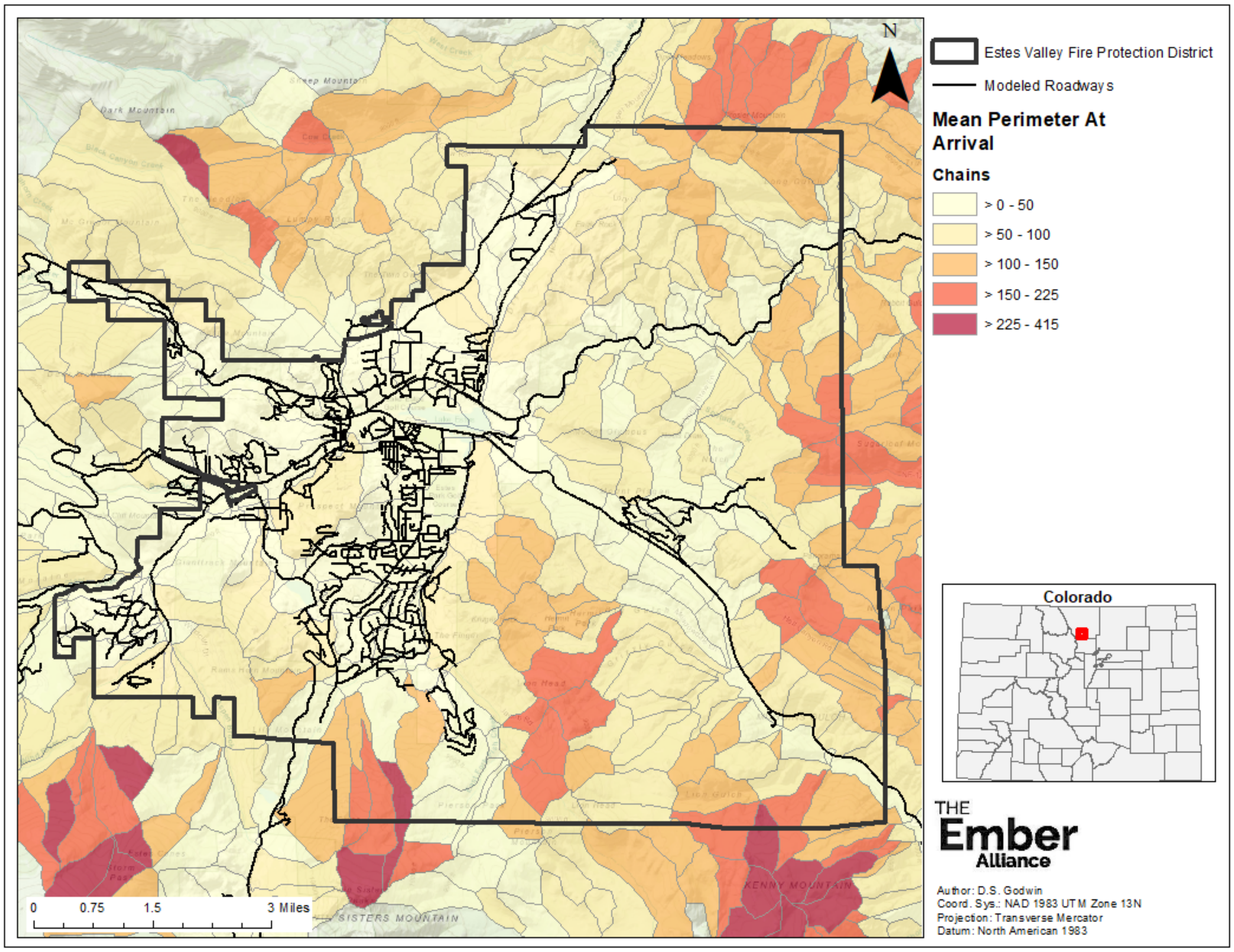

Figure 8.a.19. *Mean fire perimeter in chains at arrival time aggregated at the fireshed level.*

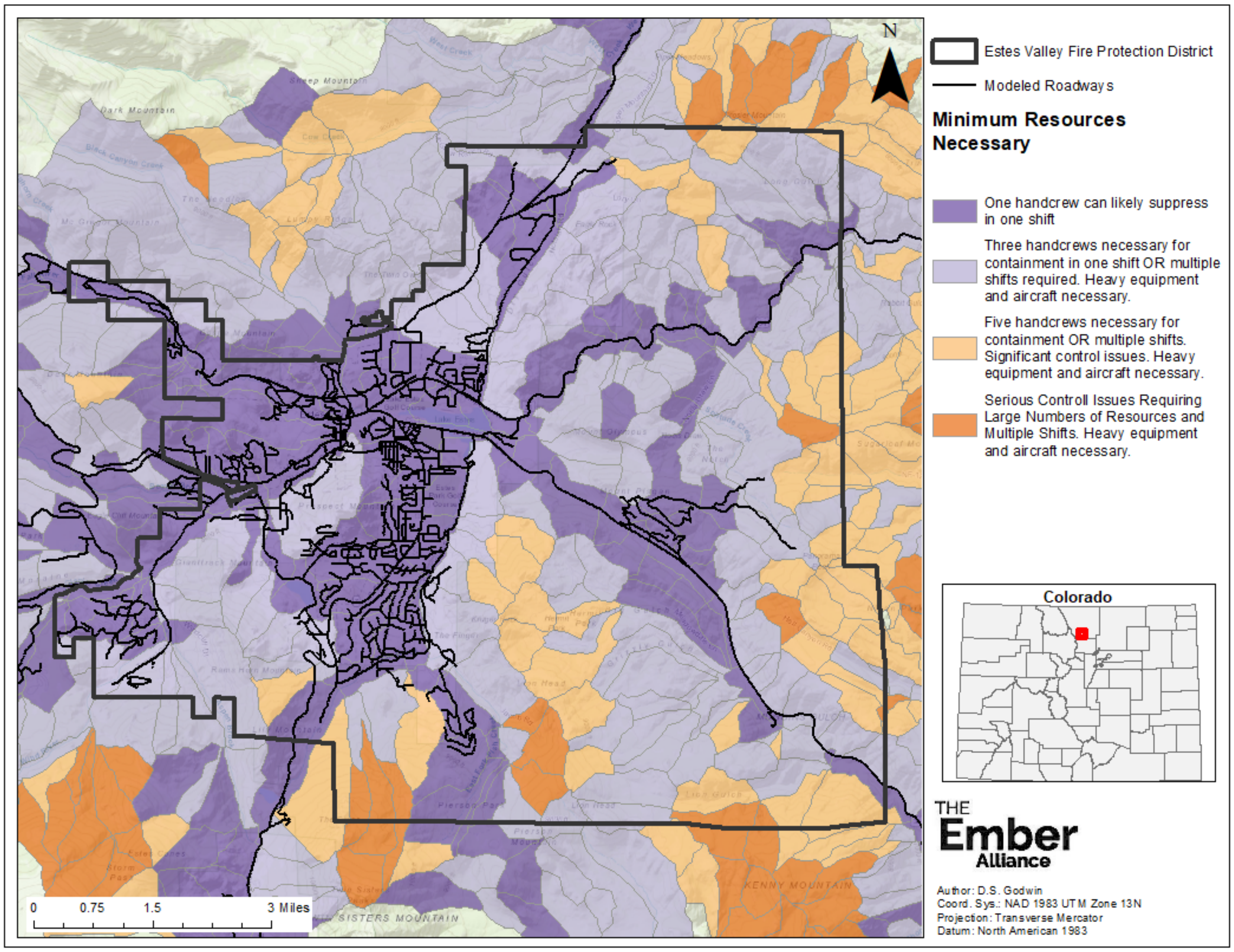

Figure 8.a.20. Minimum resource requirements estimated by fireshed.

Qualitative Assessment

District and local capacity were assessed through interviews with local fire managers and by inventorying local fire resources. Interviews focused on capacity to provision fire resources and estimated response times for resources coming into Estes Valley.

Description of District Capacity

Estes Valley Fire Protection District is responsible for initial attack on wildfires in their district. There is always an on-duty duty officer or battalion chief, but all other resources respond from home. Self-reported average response time is six minutes from initial page. Currently, thirty members of the district are "red carded" as Firefighter Type 2 (FFT2), making them available as wildland firefighting resources. EVFPD has one qualified engine boss and one qualified ICT4/Task Force Leader[6]. The district has two tenders and three wildland engines (**Table 8.a.9**).

[6] See the NWCG position catalog for a description of the duties and qualification standards for fireline positions (NWCG, 2022).

EVFPD firefighting resources focus primarily on engine operations. Due to the volunteer, respond-from-home nature of their staffing model, handcrew roles can be challenging to fill. Furthermore, like many fire departments, overhead resources (taskforce leader, division supervisor, etc.) are limited. This adds challenges for providing span of control during emerging or transitioning incidents.

Rocky Mountain National Park will self-dispatch up to two miles outside the park boundary. They have multiple firefighting resources but are limited by seasonal staffing (**Table 8.a.11**).

Table 8.a.9. *Estes Valley FPD firefighting resources. Data current as of January 2022. See NWCG standards for wildland fire resource typing for a description of resource types (NWCG, 2021b).*

Unit ID	Resource Type
Engine 713	Engine T3
Engine 723	Engine T3
Engine 716	Engine T6
Tender 71	Tactical Tender
Tender 72	Tactical Tender
Tender 73	Support Tender

Water Sources

There are plentiful water resources close to structures in the EVFPD (**Figure 8.a.21**). Hydrants are available throughout the EVFPD, and dip sites for helicopters are available with short turn-around times. However, fewer water resources are available in remote areas where response time is long. This contributes to fire control challenges by requiring longer hoselays for water delivery.

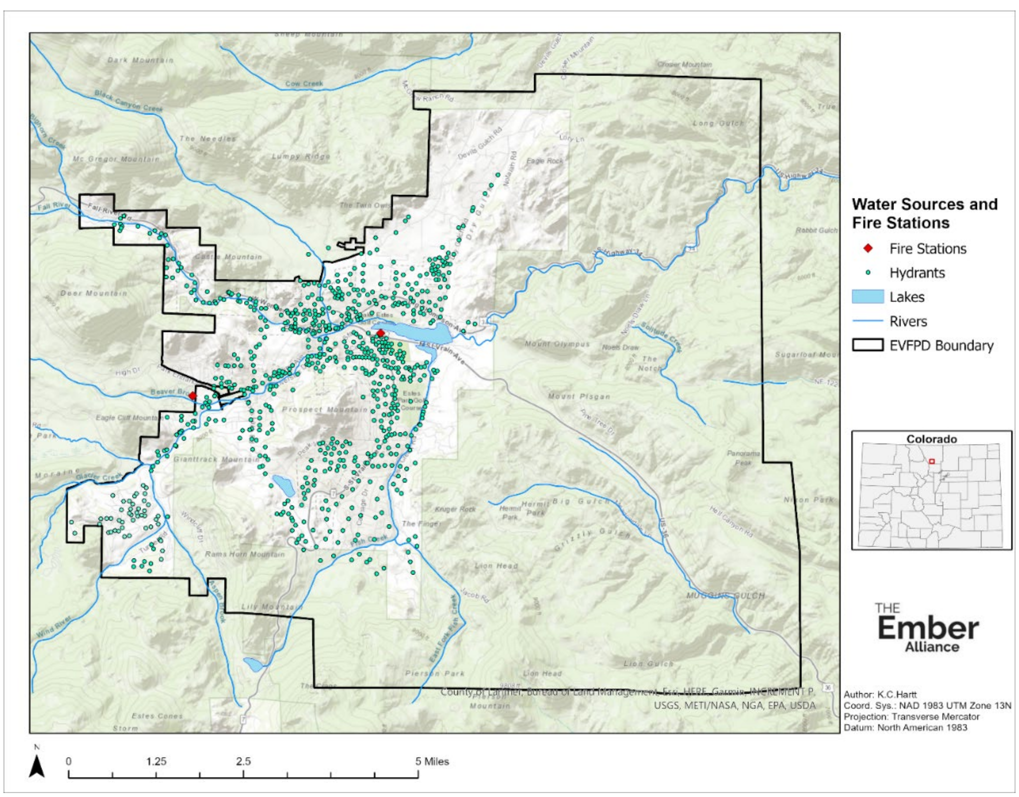

Figure 8.a.21. Water resources in the Estes Valley Fire Protection District

Local Capacity

Significant local firefighting resources are available (**Table 8.a.10**, **Table 8.a.11**). Air resources are available from JeffCo Tanker Base and the NOCO Seat Base, including heavy air tankers, type 1 helicopters, and SEATs. Large numbers of engine resources are available (notably, 38 type six wildland engines), particularly from fire protection districts. Only two type 1 handcrews (i.e., hotshot crews) are within local dispatch and, as national resources, they are often unavailable due to out of area assignments; the same can be said of the local type 2-IA crew in Boulder County, Shadow Canyon. Multiple initial attack modules (smaller handcrew resources) in the area provide additional line production in areas where engines or heavy equipment are unable to access.

***Table 8.a.10**. Local wildland firefighting resources, count, minimum travel time for one resource, and average travel time. Data current as of January 2022. See NWCG standards for wildland fire resource typing for a description of resource types (NWCG, 2021b).*

Resource Type	Count	Min. Travel Time (minutes)	Average Travel Time (minutes)
Crew T1	2	10	39
Crew T2	1	57	57
Engine T1	1	18	18
Engine T2	2	90	90
Engine T3	9	3	52
Engine T4	6	22	48
Engine T5	5	22	30
Engine T6	38	3	59
Engine T7	1	18	18
Helicopter T1	1	12	12
Helitack	1	12	12
IA Module	8	8	64
Large Air Tanker	1	6	6
Seat	2	10	10
Tactical Tender	6	3	24
Tender	16	5	59

Table 8.a.11. Local resources and estimated travel time to Estes Valley. Resources are sorted by travel time. Data current as of January 2022. See NWCG standards for wildland fire resource typing for a description of resource types (NWCG, 2021b).

Agency	Resource	ICS Type	Duty Station	Travel Time (mins.)	Availability
Estes Valley	Engine 713	Engine T3	Estes Park	3	Local
Estes Valley	Engine 723	Engine T3	Estes Park	3	Local
Estes Valley	Engine 716	Engine T6	Estes Park	3	Local
Estes Valley	Tender 71	Tactical Tender	Estes Park	3	Local
Estes Valley	Tender 72	Tactical Tender	Estes Park	5	Local
Estes Valley	Tender 73	Support Tender	Estes Park	5	Local
Jefferson County Tanker Base (USFS)	Tanker 10	Large Air Tanker	Broomfield	6	National
Rocky Mountain National Park	Squad 33	Ia Module	Estes Park	8	Local
Rocky Mountain National Park	Engine 632	Engine T6	Estes Park	8	Local
NOCO SEAT Base	T-862	Seat	Loveland (FNL)	10	National
NOCO SEAT Base	T-864	Seat	Loveland (FNL)	10	National
Rocky Mountain National Park	Alpine IHC	Crew T1	Estes Park	10	National (seasonal with some off-season staffing)
Jefferson County Tanker Base (Interagency)	Northern Colorado Helitack	Helitack	Broomfield	12	National
Jefferson County Tanker Base (USFS)		Helicopter T1	Broomfield	12	National
Glen Haven FD	Tender 33	Tactical Tender	Glen Haven	14	Local
Glen Haven FD	Engine 6-30	Engine T6	Glen Haven	14	Local
Pinewood Springs VFD	Tender 5141	Tactical Tender	Lyons	18	Local
Pinewood Springs VFD	Engine 5131	Engine T6	Lyons	18	Local
Pinewood Springs VFD	Engine 5132	Engine T6	Lyons	18	Local
Pinewood Springs VFD	UTV 5154	Engine T7	Lyons	18	Local
Pinewood Springs VFD	Engine 5101	Engine T1	Lyons	18	Local
Loveland Fire Rescue Authority	Engine 48	Engine T3	Drake	20	Local
Loveland Fire Rescue Authority	Engine 486	Engine T6	Drake	20	Local
Loveland Fire Rescue Authority	Tender 48	Tactical Tender	Drake	20	Local
Glen Haven FD	Engine 5-24	Engine T5	Glen Haven	22	Local
Glen Haven FD	Engine 4-1	Engine T4	Glen Haven	22	Local

Agency	Resource	ICS Type	Duty Station	Travel Time (mins.)	Availability
Allenspark FPD	Engine 5231	Engine T5	Allenspark	23	Local
Allenspark FPD	Engine 5232	Engine T5	Allenspark, C0	23	Local
Allenspark FPD	Engine 5233	Engine T5	Allenspark	23	Local
Allenspark FPD	Tender 5242	Tender	Allenspark	23	Local
Big Elk VFD	Engine 4931	Engine T6	Lyons	29	Local
Big Elk VFD	Tender 4940	Tender	Lyons	29	Local
Big Elk VFD	Tender 4941	Tender	Lyons	29	Local
Loveland Fire Rescue Authority	Engine 494	Engine T4	Drake	29	Local
Loveland Fire Rescue Authority	Engine 496	Engine T6	Drake	29	Local
Lyons FPD	Engine 4011	Engine T4	Lyons	29	Local
Lyons FPD	Engine 4031	Engine T6	Lyons	29	Local
Lyons FPD	Engine 4032	Engine T6	Lyons	29	Local
Lyons FPD	Engine 4033	Engine T6	Lyons	29	Local
Lyons FPD	Tender 4041	Tender	Lyons	29	Local
Lyons FPD	Tender 4042	Tender	Lyons	29	Local
Lyons FPD	Engine 4051	Engine T6	Lyons	29	Local
Loveland Fire Rescue Authority	Engine 474	Engine T4	Loveland	34	Local
Loveland Fire Rescue Authority	Engine 476	Engine T6	Loveland	34	Local
Loveland Fire Rescue Authority	Engine 426	Engine T6	Loveland	41	Local
Loveland Fire Rescue Authority	Engine 433	Engine T3	Loveland	43	Local
Loveland Fire Rescue Authority	Tender 43	Tactical Tender	Loveland	43	Local
Berthoud FPD	Engine 623	Engine T3	Berthoud	44	Local
Berthoud FPD	Engine 626	Engine T6	Berthoud	44	Local
Loveland Fire Rescue Authority	Engine 416	Engine T6	Loveland	47	Local
Loveland Fire Rescue Authority	Tender 45	Tactical Tender	Loveland	48	Local
Loveland Fire Rescue Authority	Engine 466	Engine T6	Loveland	51	Local
Berthoud FPD	Engine 613	Engine T3	Berthoud	53	Local
Berthoud FPD	Engine 616	Engine T6	Berthoud	53	Local
Berthoud FPD	Tender 62	Tender	Berthoud	53	Local
Arapaho-Roosevelt NF - South Zone	Squad 1-2	IA Module	Nederland	57	Local

Agency	Resource	ICS Type	Duty Station	Travel Time (mins.)	Availability
Arapaho-Roosevelt NF - South Zone	Squad 1-1	IA Module	Nederland	57	Local
Boulder County Fire Management	6533	Engine T6	Boulder	57	Local
Boulder County Fire Management	6531	Engine T6	Boulder	57	Local
Boulder County Fire Management	Shadow Canyon	Crew T2	Boulder	57	Local (seasonal)
Boulder County Fire Management	6532	Engine T6	Boulder	57	Local
Loveland Fire Rescue Authority	Engine 505	Engine T5	Johnstown	57	Local
Poudre Fire Authority	Engine 146	Engine T6	Fort Collins	57	Local
Poudre Fire Authority	Tender 02	Tender	Fort Collins	59	Local
Larimer County Sheriff's Office Emergency Services	E-691	Engine T6	Fort Collins	63	Local
Larimer County Sheriff's Office Emergency Services	E-692	Engine T6	Fort Collins	63	Local
Larimer County Sheriff's Office Emergency Services	Initial Attack Module	IA Module	Fort Collins	63	Local
Poudre Fire Authority	Tender 11	Tender	Loveland	63	Local
Poudre Fire Authority	Engine 273	Engine T3	Laporte	65	Local
Poudre Fire Authority	Engine 286	Engine T6	Fort Collins	66	Local
CO Div. of Fire Prevention and Control (Northeast Region)	Overland Module	IA Module	Windsor	67	Local
Poudre Fire Authority	Engine 126	Engine T6	Fort Collins	67	Local
Poudre Fire Authority	Tender 12	Tender	Fort Collins	67	Local
Arapaho & Roosevelt NF - North Zone	Engine 653	Engine T6	Fort Collins	68	Local
Arapaho & Roosevelt NF - North Zone	Engine 654	Engine T6	Fort Collins	68	Local
Arapaho & Roosevelt NF - North Zone	Squad 55	IA Module	Fort Collins	68	Local
Arapaho-Roosevelt NF & Pawnee NG	Roosevelt IHC	Crew T1	Fort Collins	68	National (seasonal with some off-season staffing)
Poudre Fire Authority	Engine 266	Engine T6	Fort Collins	68	Local
Poudre Fire Authority	Tender 06	Tender	Fort Collins	68	Local
CO Div. of Fire Prevention and Control (Northeast Region)	Engine 3111	Engine T3	Hudson	82	Local
Livermore FPD	Engine 631	Engine T6	Livermore	85	Local

Agency	Resource	ICS Type	Duty Station	Travel Time (mins.)	Availability
Livermore FPD	Tender 1	Tender	Livermore	85	Local
Livermore FPD	Engine 632	Engine T6	Livermore	85	Local
Livermore FPD	Engine 432	Engine T4	Livermore	85	Local
Livermore FPD	Engine 3	Engine T6	Livermore	85	Local
Livermore FPD	Tender 4	Tender	Livermore	85	Local
CO Div. of Fire Prevention and Control (Northeast Region)	James Peak Module	IA Module	Black Hawk	86	Local
CO Div. of Fire Prevention and Control (Northeast Region)	E-6121	Engine T6	Black Hawk	86	Local
Glacier View FD	Engine 501	Engine Type 2	Livermore	90	Local
Glacier View FD	Engine 502	Engine Type 2	Livermore	90	Local
Glacier View FD	Engine 302	Engine Type 4	Livermore	90	Local
Glacier View FD	Tender 1	Tender	Livermore	90	Local
Glacier View FD	Tender 2	Tender	Livermore	90	Local
Arapaho-Roosevelt NF - South Zone	E-612	Engine T6	Idaho Springs	105	Local
Arapaho & Roosevelt NF - North Zone	Squad 56	Crew (other)	Red Feather Lakes	107	Local
Arapaho & Roosevelt NF - North Zone	Engine 651	Engine T6	Red Feather Lakes	107	Local
Crystal Lakes FPD	Tender 1	Tender	Red Feather Lakes	135	Local
Crystal Lakes FPD	Brush 1	Engine T6	Red Feather Lakes	135	Local
Crystal Lakes FPD	Brush 2	Engine T6	Red Feather Lakes	135	Local
CO Div. of Fire Prevention and Control (Northeast Region)	Engine 3141	Engine T3	Sterling	158	Local
Arapaho-Roosevelt NF - South Zone	E-681	Engine T6	Grand Lake	200	Local

A.8. Community Values at Risk Assessment – Quantitative Methodology

Risk assessments can help inform planning and decision making as they relate to prevention and mitigation and are thus a useful tool for addressing complex coupled socio-ecological systems like the fire environment. We evaluated risk to identified values in the Estes Valley Fire Protection District based on fire behavior modeling and burn probability. These approaches are limited by the spatial unit of analysis for fire behavior simulations (30 m^2), industry shortcomings in simulating extreme fire behavior, and ongoing research into contributing factors for structure loss. However, output is useful to identifying areas of highest risk and directing limited funding to strategic actions to mitigate risk.

Non-Residential Values At Risk

Methodology

Risk assessments involve quantifying the potential for loss (probability and intensity) as they relate to human life, health, property, and the environment, which are generally called "values" (Aven et al., 2018). Values used for this risk assessment were identified through a collaborative process with the CWPP working group. Multiple spatial datasets were used as a starting point for communication equipment, emergency services locations, healthcare equipment, etc. These were further refined by stakeholder input. To reduce the complexity of this analysis and provide more value for emergency management, housing was not included in this specific analysis.

Values were grouped by the FEMA community lifelines framework (FEMA, 2019). This framework classifies community components necessary for the continuous operation of critical government and business functions. Community lifelines include:

1. Safety and Security
2. Food, Water, Shelter
3. Health and Medical
4. Energy
5. Communications
6. Transportation
7. Hazardous Material

Each community lifeline has multiple components and subcomponents. For instance, "Safety and Security" includes obvious components such as "Law Enforcement" and "Fire Service", but also less obvious ones like "Government Service", which includes such subcomponents as "Government Offices". For further information on community lifelines, components, and subcomponents, cross-reference Appendix E of the FEMA Incident Stabilization Guide (FEMA, 2019).

Analysis followed methods modified from wildfire risk assessments techniques widely adopted by federal land management agencies (Scott et al., 2013). Identified values were overlayed with the modeled flame lengths (intensity of impact) and normalized burn probability (probability of impact) under 90th percentile weather conditions. To simplify the process, value "response functions" were not included (Finney, 2005); all fire impacts on values at risk were considered to be negatively impactful, with increasing flame lengths considered increasingly negative. Burn probability was normalized between 0-1. Values at risk were plotted against "haul chart" flame length categories which are based on the requisite tools or tactics needed for wildfire suppression (**Table 8.a.3**) (NWCG, 2019).

We also assessed values to risk based on potential exposure to radiant heat, short-range ember cast, and long-range ember cast. Radiant heat can ignite structures when extreme fire behavior occurs within near proximity to structures, but embers can ignite structures even when the flaming front is far away. Following the analysis approach outlined in Appendix **A.3. Predicted Radiant Heat and Ember Cast** , we assessed exposure within the home ignition zone (HIZ; 100-foot radius) of values at risk.

Key Findings

Under 90th percentile weather conditions, cultural resources (which fall within the FEMA lifeline category "Safety and Security") have the highest risk in terms of probability and intensity (**Figure 8.a.22**). Perhaps the greatest concerns are various youth educational facilities that are exposed to high burn probability and flame lengths – notably, the Eagle Rock School, the UNC Old Man Mountain Center, and the YMCA facilities. Other values within the "Safety and Security" lifeline category (e.g., fire stations) were exposed to low burn probability and low flame lengths (**Figure 8.a.23**).

Communication towers on Prospect Mountain were exposed to potentially very high flame lengths, but burn probability was estimated to be low (

Table 8.a.12). The potential impact of losing these critical tools is very high, especially during an emerging incident. Communications are critical for safe incident response, whether for responders or for communicating vital information to the public. Notably, the YMCA Comms Tower is at elevated burn probability, but has less immediate impact on emergency communications during a wildfire incident.

Some values were exposed to relatively low flame lengths but had elevated burn probability. The East Portal Substation, the K47EC analog television tower, and the Harmony Foundation Rehabilitation Clinic are notable examples of these situations.

Some values at risk have low burn probabilities but are still at risk from wildfires due to ember exposure (

Table 8.a.12). Based on this analysis, four values at risk have the potential for extreme exposure to embercast: Clatworthy Place, Mountainside Lodge, Prospect Mountain communications towers, and Wind Ridge.

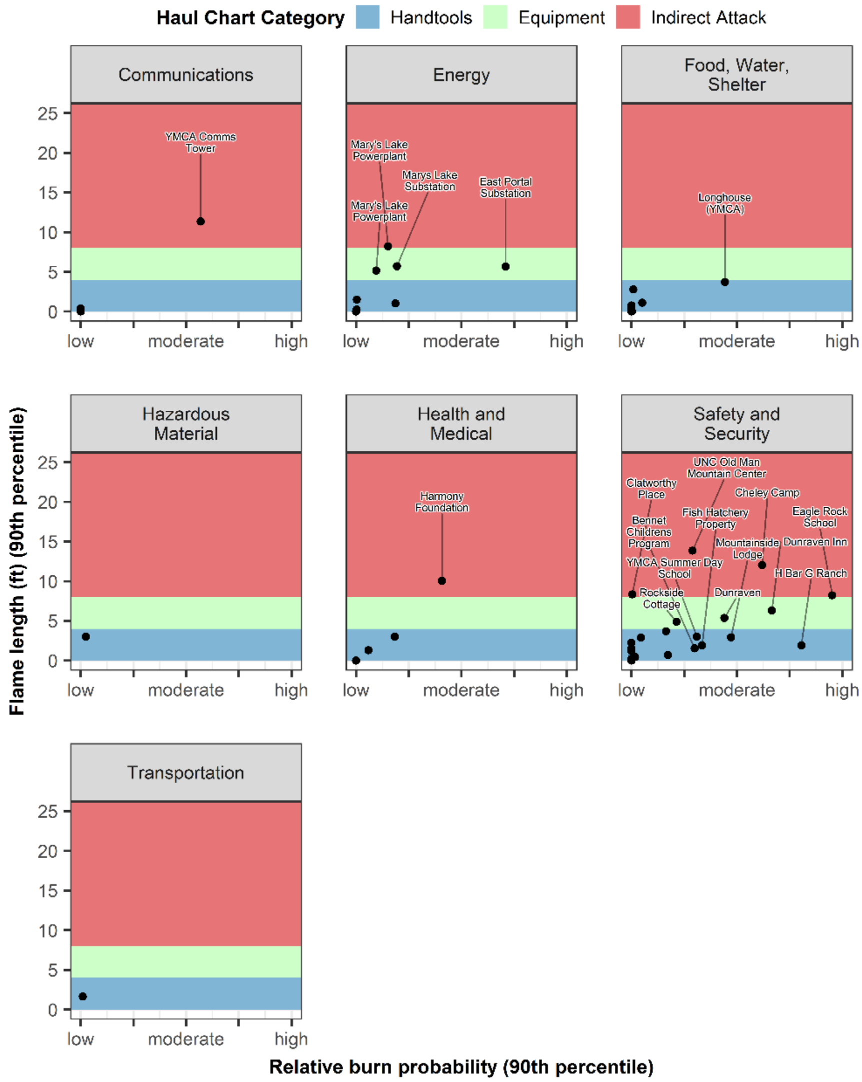

Figure 8.a.22. Quantitative risk assessment for values at risk in the Estes Valley Fire Protection District separated into FEMA community lifeline categories. Risk is assessed in terms of probability (relative burn probability) and intensity (flame length) under 90th percentile weather conditions. Values above 25 ft. flame lengths were not plotted.

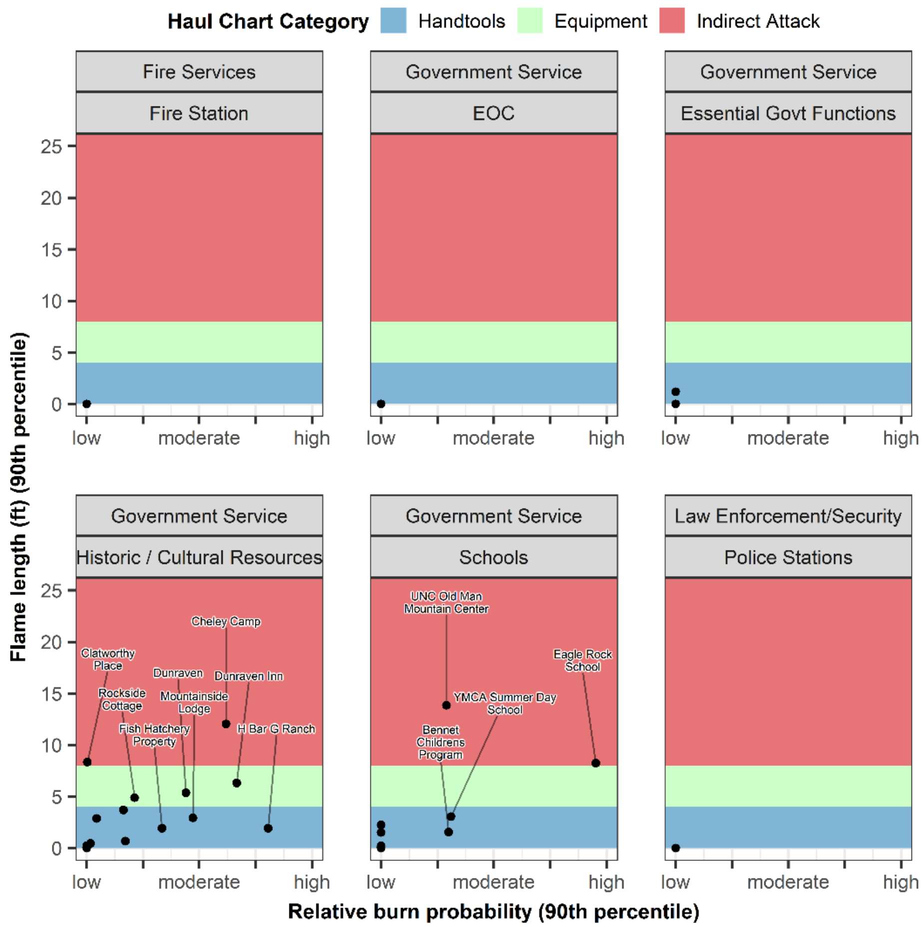

Figure 8.a.23. Quantitative risk assessment for values at risk within the "Safety and Security" community lifeline category in the Estes Valley Fire Protection District. Risk is assessed in terms of probability (relative burn probability) and intensity (flame length) under 90th percentile weather conditions. Values above 25 ft. flame length were not plotted. EOC = Emergency Operations Center.

Table 8.a.12. *Quantitative risk assessment for values at risk in the Estes Valley Fire Protection District separated into FEMA community lifeline categories. Risk is assessed in terms of Haul Chart categories (related to flame length), burn probability, and exposure to radiant heat, short-range spotting, and/or long-range spotting under 90th percentile weather conditions. Values at risk are sorted by Haul Chart categories followed by burn probability. Colors for the Haul Chart categories correspond with colors in* ***Figure 8.a.22****.*

Name	FEMA Community Lifeline Category	Haul Chart Category	Burn Probability	Exposure level[1]
Fairground - Staging Area	Safety and Security	Hand tools	Low	Low
Fuel Storage at County Facility	Energy	Hand tools	Low	Low
Mountain Top Childcare	Food, Water, Shelter	Hand tools	Low	Low
Shell Gas Station	Energy	Hand tools	Low	Low
Sinclair Gas Station	Energy	Hand tools	Low	Low
Bank of Estes Park - Hwy 7	Communications	Hand tools	Low	Low
Community Center	Safety and Security	Hand tools	Low	Low
American Legion Post 119	Food, Water, Shelter	Hand tools	Low	Moderate
Bank of Colorado	Communications	Hand tools	Low	Moderate
Bank of Estes Park - Downtown	Communications	Hand tools	Low	Moderate
Boulder Valley Credit Union	Communications	Hand tools	Low	Moderate
Estes Park EOC at the Fire Station	Safety and Security	Hand tools	Low	Moderate
Conoco Gas Station	Energy	Hand tools	Low	Moderate
Country Market	Food, Water, Shelter	Hand tools	Low	Moderate
Event Complex	Food, Water, Shelter	Hand tools	Low	Moderate
High School	Food, Water, Shelter	Hand tools	Low	Moderate
Post Office	Safety and Security	Hand tools	Low	Moderate
Local Dispatch	Safety and Security	Hand tools	Low	Moderate
Police Department	Safety and Security	Hand tools	Low	Moderate
Town Hall EOC	Safety and Security	Hand tools	Low	Moderate
EVFPD Station 1	Safety and Security	Hand tools	Low	Moderate
Famous Eastside Food Store	Food, Water, Shelter	Hand tools	Low	Moderate
Water Supply Gauge - Glen Comfort	Food, Water, Shelter	Hand tools	Low	Moderate

Name	FEMA Community Lifeline Category	Haul Chart Category	Burn Probability	Exposure level[1]
Good Samaritan	Health and Medical	Hand tools	Low	Moderate
Hangar Restaurant	Safety and Security	Hand tools	Low	Moderate
Original RMNP HQ	Safety and Security	Hand tools	Low	Moderate
KeyBank	Communications	Hand tools	Low	Moderate
Dispatch Comms Towers	Communications	Hand tools	Low	Moderate
Lifelong Learning	Food, Water, Shelter	Hand tools	Low	Moderate
Olympus Dam	Food, Water, Shelter	Hand tools	Low	Moderate
Park Place Preschool	Food, Water, Shelter	Hand tools	Low	Moderate
Plan de Salud Del Valle	Health and Medical	Hand tools	Low	Moderate
Rocky Mountain Park Inn	Food, Water, Shelter	Hand tools	Low	Moderate
Safeway Grocery Store	Food, Water, Shelter	Hand tools	Low	Moderate
Safeway Gas Station	Energy	Hand tools	Low	Moderate
Safeway Pharmacy	Health and Medical	Hand tools	Low	Moderate
Shell Gas Station	Energy	Hand tools	Low	Moderate
Sinclair Gas Station	Energy	Hand tools	Low	Moderate
UCHealth Primary Care Clinic	Health and Medical	Hand tools	Low	Moderate
Weist Lot Comms Towers	Communications	Hand tools	Low	Moderate
Water Supply Gauge - 1SSE	Food, Water, Shelter	Hand tools	Low	Moderate
Options School	Food, Water, Shelter	Hand tools	Low	Moderate
Park Theatre	Safety and Security	Hand tools	Low	Moderate
Elementary School	Food, Water, Shelter	Hand tools	Low	Moderate
Estes Park Museum	Safety and Security	Hand tools	Low	Moderate
Lake Estes Substation	Energy	Hand tools	Low	Moderate
Waste Water Treatment	Food, Water, Shelter	Hand tools	Low	Moderate
Water Supply Gauge - Estes Park	Food, Water, Shelter	Hand tools	Low	Moderate
Mountain View Bible Fellowship	Food, Water, Shelter	Hand tools	Low	Moderate
Peakview Comms Tower	Communications	Hand tools	Low	Moderate

Name	FEMA Community Lifeline Category	Haul Chart Category	Burn Probability	Exposure level[1]
Middle School	Food, Water, Shelter	Hand tools	Low	Moderate
Lake Estes Powerplant	Energy	Hand tools	Low	Moderate
Community for Kids	Food, Water, Shelter	Hand tools	Low	Moderate
Estes Park Home Health Care	Health and Medical	Hand tools	Low	High
Hospice	Health and Medical	Hand tools	Low	High
Estes Park Medical Center	Health and Medical	Hand tools	Low	High
Library	Safety and Security	Hand tools	Low	High
U.S. Bank National Association	Communications	Hand tools	Low	High
Bennet Childrens Program	Food, Water, Shelter	Hand tools	Moderately low	Low
YMCA Summer Day Camp	Food, Water, Shelter	Hand tools	Moderately low	Low
Sanitation District	Food, Water, Shelter	Hand tools	Moderately low	Moderate
Transfer Station	Hazardous Material	Hand tools	Moderately low	Moderate
Crags Lodge	Safety and Security	Hand tools	Moderately low	Moderate
Presbyterian Community Church	Food, Water, Shelter	Hand tools	Moderately low	Moderate
Urgent Care Center	Health and Medical	Hand tools	Moderately low	Moderate
Stanley Hotel District	Safety and Security	Hand tools	Moderately low	Moderate
Edgemont	Safety and Security	Hand tools	Moderately low	Moderate
Rocky Mountain Pharmacy	Health and Medical	Hand tools	Moderately low	Moderate
Fuel Storage at Estes Park School Transportation	Energy	Hand tools	Moderately low	Moderate
CDOT Facility	Transportation	Hand tools	Moderately low	High
Loveland Heights Cottages	Safety and Security	Hand tools	Moderately low	High
Fish Hatchery Property	Safety and Security	Hand tools	Moderately low	High
Longhouse (YMCA)	Food, Water, Shelter	Hand tools	Moderately high	Moderate
H Bar G Ranch	Safety and Security	Hand tools	Moderately high	Moderate

Name	FEMA Community Lifeline Category	Haul Chart Category	Burn Probability	Exposure level[1]
Mountainside Lodge	Safety and Security	Hand tools	Moderately high	Extreme
Mary's Lake Substation	Energy	Equipment	Moderately low	Moderate
Mary's Lake Substation	Energy	Equipment	Moderately low	Moderate
Rockside Cottage	Safety and Security	Equipment	Moderately low	Moderate
Dunraven	Safety and Security	Equipment	Moderately high	Moderate
Dunraven Inn	Safety and Security	Equipment	Moderately high	Moderate
East Portal Substation	Energy	Equipment	Moderately high	Moderate
Clatworthy Place	Safety and Security	Indirect	Low	Extreme
Mary's Lake Powerplant	Energy	Indirect	Moderately low	High
Harmony Foundation	Health and Medical	Indirect	Moderately high	High
Eagle Rock School	Food, Water, Shelter	Indirect	High	Moderate
UNC Old Man Mountain Center	Food, Water, Shelter	Indirect	Moderately low	High
Prospect Mtn Comms Towers	Communications	Indirect	Moderately low	Extreme
YMCA Comms Tower	Communications	Indirect	Moderately high	Moderate
Cheley Camp	Safety and Security	Indirect	Moderately high	High
Wind Ridge	Safety and Security	Indirect	High	Extreme

[1]Low exposure = potential exposure to long-range ember cast. Moderate exposure = potential exposure to long-rang ember cast and short-range ember cast. High exposure = potential exposure to long-range ember cast or short-range ember cast and radiant heat. Extreme exposure = potential exposure to long- and short-range ember cast and radiant heat.

Residential Values At Risk

Methodology

We assessed residential values to risk based on potential exposure to radiant heat, short-range ember cast, and long-range ember cast. Radiant heat can ignite structures when extreme fire behavior occurs within near proximity to structures, but embers can ignite structures even when the flaming front is far away. See Appendix **A.3. Predicted Radiant Heat and Ember Cast** for our methodology and findings.

We also determined the number of homes that could be impacted by fires traveling through different portions of the landscape. This highlighted areas where fuel treatments might protect the greatest number of homes. We determined how many homes fell within each of the 10,000 wildfire perimeters simulated for the FlamMap conditional burn probability analysis. We determined the number of fires that passed through a given area and encountered at least one home and summarized this data by fireshed. We weighted this value by the number of structures impacted by fires across all simulated fires so areas with higher values experienced more fires and exposed a greater number of homes. We normalized this value to range from 0 to 1 across the analysis area.

Key Findings

Under 90th percentile fire weather conditions, the firesheds where the most simulated wildfires impact the most structures are centralized in the northeastern part of the district (**Figure 8.a.24**). These areas, influenced by generally more open stands, flashier fuels, are at risk of fires spreading from the west and impacting the dense structures situated here. In the western and southwestern part of the district, elevated risk is present as well. These firesheds are likewise influenced by the fuels and density of structures. Due to the relative paucity of structures, outlying areas experience the least potential impacts.

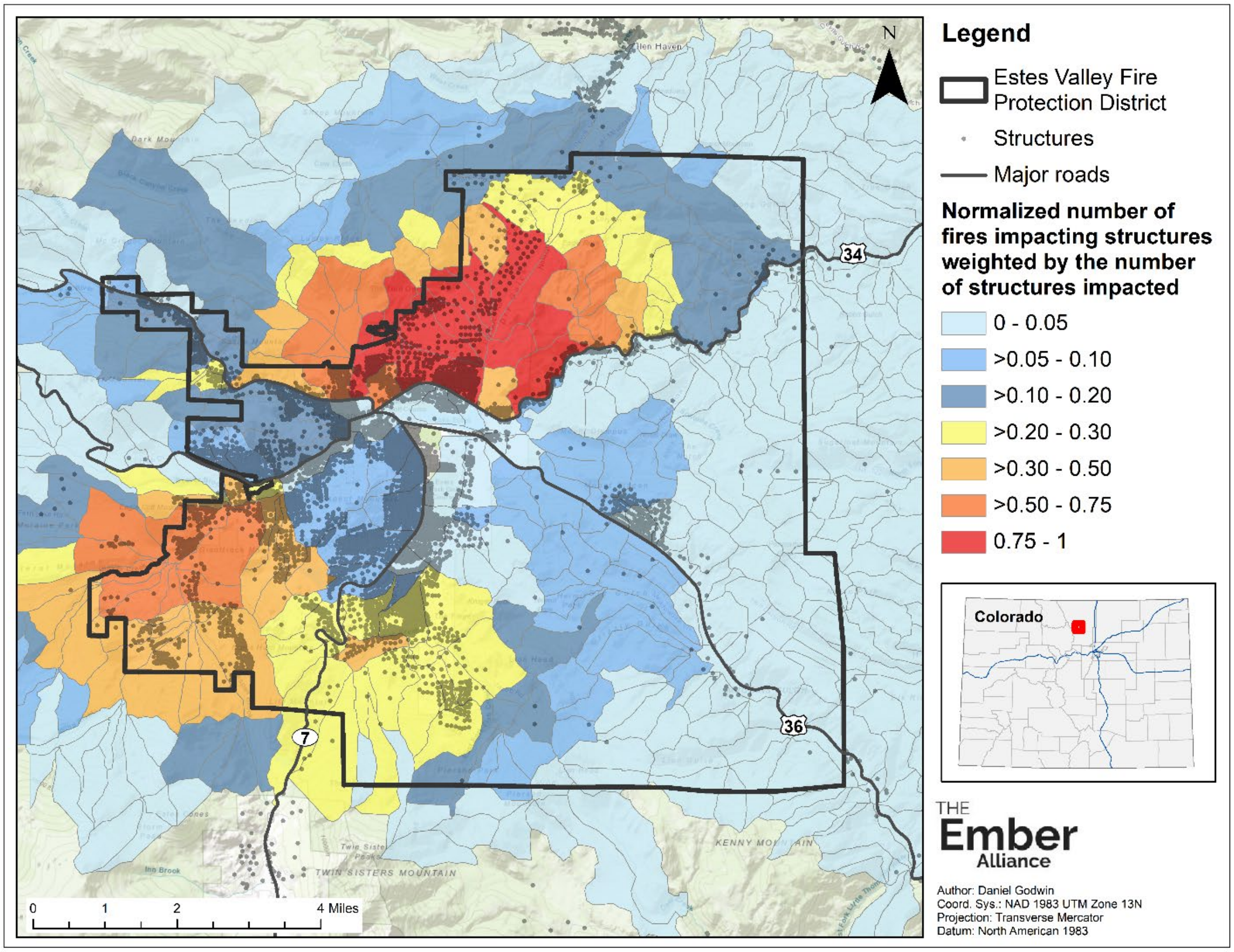

Figure 8.a.24. *We used simulated fire perimeters to determine locations more likely to experience wildfires that impact homes, with values closer to 1 indicating areas with a higher likelihood of fires that impact homes AND a higher number of homes that could be impacted.*

Appendix B. Treatment Prioritization Methodology

B.1. Plan Unit Hazard Assessment

We compared the **relative** risk that wildfires pose to life and property in 20 plan units across the Estes Valley Fire Protection District (**Figure 3.c.2**). Homes across the EVFPD have high risk from wildfire damage, but to help prioritize hazard mitigation, we 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 wildfire hazards. We assessed hazards in four categories: fire risk, fire suppression challenges (e.g., limited hydrant availability and engine access), evacuation hazards, and home ignition zone hazards. We developed the ratings of relative risk specifically for the EVFPD, so the assessment is not suitable for comparing EVFPD to other communities.

Our assessment was based on predictions of fire behavior, potential exposure to radiant heat and ember cast, roadway survivability, and evacuation time, as well as an on-the-ground assessment of each plan unit. In October of 2021, employees of The Ember Alliance drove around the EVFPD 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.

Hazard Rating Scale

A rating scale was developed specifically for the Estes Valley Fire Protection District based on the range of values observed across the community (**Table 8.b.1**). The purpose of the assessment is to compare relative hazards within the community and is not suitable for comparing the EVFPD to other communities.

***Table 8.b.1**. Relative hazard rating matrix for the Estes Valley Fire Protection District.*

	Points		Relative hazard rating		
Hazard category	Max. possible	Range of values observed in EVFPD plan units	Moderate	High	Extreme
A. Fire risk	55	7 – 53	<21	21-39	≥40
B. Fire suppression challenges	45	3 – 38	<10	10-24	≥25
C. Evacuation hazards	40	0 – 40	<16	16-20	≥21
D. Home ignition zone hazards	53	10 – 48	<20	20-29	≥30
Overall risk	193	43 – 151	<80	80-104	≥105

Relative Risk Rating Form

A. Fire Risk	Points
1. Average flame length[1]	
≤4 feet	0
>4-8 feet	6
>8 feet	12
2. Crown fire activity (percent area predicted for active crown fire)[1]	
≤0.5%	0
0.5-1%	6
>1%	12
3. Percentage of homes with exposure to radiant heat, short-range ember cast, and long-range ember cast[1]	
<2%	0
2-15%	6
>15%	12
4. Conditional burn probability[1]	
<0.06%	0
0.06-0.12%	3
>0.12%	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]Predictions from FlamMap under 60th percentile fire weather conditions for plan unit and adjacent watersheds.

B. Fire Suppression Challenges	Points
1. Average response time[2]	
<4 minutes	0
4-8 minutes	3
>8 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. General impression of evacuation challenges based on housing density and egress routes	
Low	0
Moderate	10
High	20
3. Percent of roads with non-survivable conditions under 60^{th} percentile fire weather	
<1%	0
1-20%	5
>20%	10
C. Total points possible	**40**

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
7. Average number of homes potentially exposed to short-range ember cast from other homes	
<5 homes	0
5-15 homes	3
>15 homes	6
D. Total points possible	**53**

B.2. 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 our fuel treatment prioritization, we delineated small watersheds (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.1**). We delineated hillslopes 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.

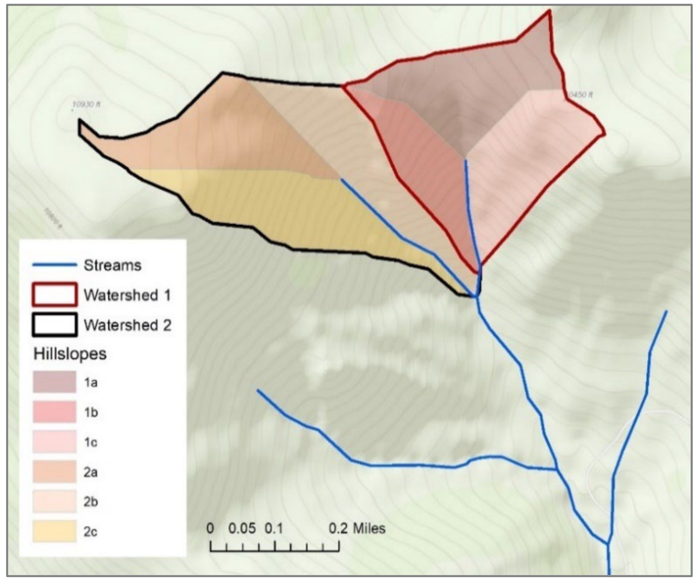

Figure 8.b.1. *Depiction of small watersheds and their subdivided hillslopes.*

We used 30 m resolution digital elevation models from the U.S. Geological Service, and delineated hillslopes with a critical source area of 60 hectares (about 150 acres) and a minimum source channel length of 330 feet (100 meters). 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.

We split hillslopes by major roads (U.S. Highway 34, U.S. Highway 36, and CO Highway 7). We merged hillslopes <10 acres with larger, adjacent hillslopes. We delineated a total of 1,036 hillslopes in and around the Estes Valley FPD, averaging 165 acres in size and ranging from 10 to 1,050 acres—reasonable sizes for forest management projects in the WUI.

We developed a prioritization scheme to weight potential treatment units based on predicted fire behavior under 60th and 90th percentile fire weather conditions, homes potentially exposed to short-range ember cast and radiant heat from the unit, potential exposure of homes to fires that could burn through a treatment unit, presence of priority roadway treatments, and percent slope within the unit (**Table 8.b.2**). Some forest stands have high risk of crown fire but are extremely steep and far from roads, and therefore inaccessible to forestry equipment. According to Hunter et al. (2007), use of mechanical equipment is generally infeasible on slopes greater than 35%. We assumed that handcrews can thin forests on slopes up to 50%. Since it is less feasible to treat steep areas, we lowered the priority of stands that had high percentages of inoperable slopes.

We prioritized roadside treatments based on non-survivable conditions (predicted flame lengths >8 feet) under 60th and 90th percentile fire weather conditions and road segments that could become evacuation pinch points. Areas with non-survivable conditions under 60th percentile fire weather are at greater risk than those with conditions that only become non-survivable under 90th percentile weather because the surrounding vegetation can produce long flame lengths even under less severe (and less uncommon) fire weather conditions. Staff from EVFPD and LCSO that manage evacuation planning and were part of the evacuation in 2020 helped identify locations that could experience the most extreme congestion. We prioritized treatments following the scheme presented in **Table 8.b.3**.

Table 8.b.2. *Prioritization scheme for ranking potential treatment units to mitigate fire hazards within and adjacent to the Estes Valley Fire Protection District.*

Prioritization category	Maximum weight		First priority	Second priority	Third priority
Number of homes exposed to short-range ember cast from crown fire in the unit and/or radiant heat from flame lengths > 8 feet (60th percentile fire weather)	30%	Cutoff	≥5 homes	1-4 homes	0 homes
		Weight	30	15	0
Contains priority roadways (non-survivable evacuation pinch point)	20%	Cutoff	At least one priority roadway		No priority roadways
		Weight	20		0
Percent active crown fire (60th percentile fire weather)	15%	Cutoff	≥5%	0.5 - <5%	<0.5%
		Weight	15	8	0
Percent area with flame lengths > 8 feet (60th percentile fire weather)	15%	Cutoff	≥75%	50 - <75%	<50%
		Weight	15	8	0
Normalized count of fires impacting structures weighted by structures impacted (90th percentile fire weather, 25 mph W winds)[1]	15%	Cutoff	≥50%	10 - <50%	<10%
		Weight	15	8	0
Percent operable (slopes <50%)	5%	Cutoff	≥75%	33 - <75%	<33%
		Weight	5	3	0
Overall priority			**First priority**	**Second priority**	**Third priority**
		Cutoff	≥61	46 – 60	31 – 45

[1]Details about this analysis are provided in the section **Residential Values At Risk** and results are displayed in **Figure 8.a.24**.

Table 8.b.3. *Prioritization scheme for ranking potential roadside treatments to mitigate fire hazards along roadways in the Estes Valley Fire Protection District.*

Prioritization category	Conditions
First	• Non-survivable conditions (flame lengths >8 feet) under 60th percentile fire weather conditions • Road segments with evacuation congestion
Second	• Non-survivable conditions (flame lengths >8 feet) under 90th percentile fire weather conditions • Road segments with evacuation congestion
Third	• Non-survivable conditions (flame lengths >8 feet) under 60th percentile fire weather conditions • Roads without excessive evacuation congestion

Appendix C. Focus Group and Survey

C.1. Methods

A focus group of community leaders from across the Estes Valley Fire Protection District was held in November 2021. Community leaders were identified by the core team and invited to participate, and all community members were invited via social media and the local newspaper to participate.

Participants filled out a short demographic survey, joined in interactive prompts regarding community values and wildfire preparedness, and participated in a discussion about community attitudes, actions, barriers, and education around wildfires.

Following the focus group, the relevant questions were transposed to an online survey format that the public could respond to in their own time. This survey was hosted by the Estes Valley Watershed Coalition. Questions were built based on feedback from the interactive prompts from the focus group as well as questions developed by the Wildfire Research group (WiRē). The survey was open to the public from mid-November 2021 to the end of January 2022.

Results from the focus group and survey were compiled together anonymously and analyzed for trends and themes.

A note on potential bias: Participants rated themselves as more knowledgeable than the average citizen about wildfires and fire mitigation and indicated that they believe many of their neighbors are less informed and less active in fire mitigation. Focus group attendees were identified as community leaders, many of whom have shown an interest in fire mitigation in the past and are in tune with their neighborhood knowledge and feelings. They were asked to both speak for themselves and to make educated guesses on their neighbors' knowledge and actions.

C.2. Results

Values at Risk

Focus group participants brainstormed all the values that residents believe are at risk from wildfire in Estes Valley. They worked together to narrow down that list to a few categories, which were then prioritized by attendees and survey respondents.

Participants ranked private property much lower than residents in other communities in Colorado. In other communities this is often the second top priority. Residents here have a high awareness of larger community problems which could indicate a willingness to invest in community-wide mitigation action, rather than an individual-centric approach. Participants are very concerned with having protected utilities and infrastructure including firefighter support and safety, and they have a notable awareness of mental health issues surrounding wildfires.

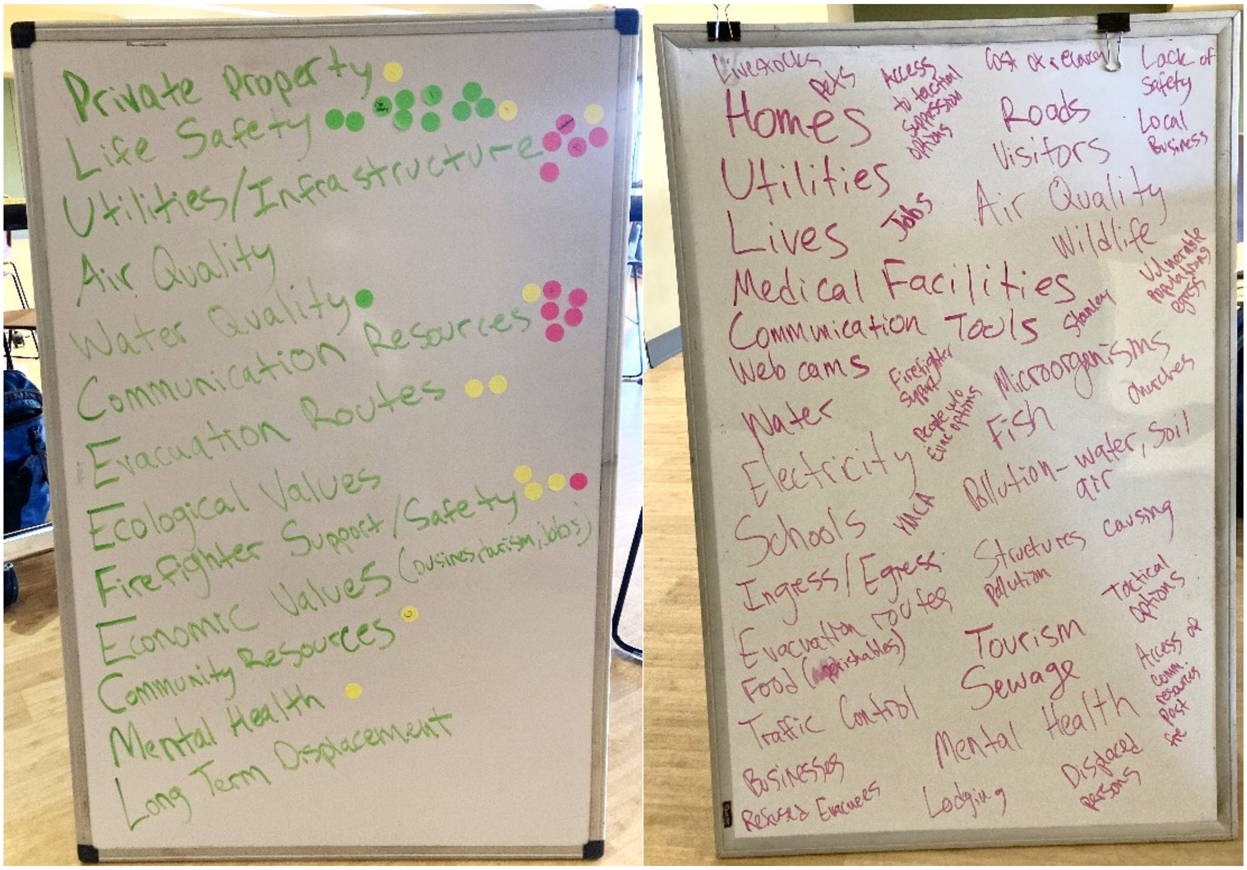

Figure 8.c.1. *Participant-identified values at risk and general value categories. Colored dots were part of the prioritization activity for the focus group.*

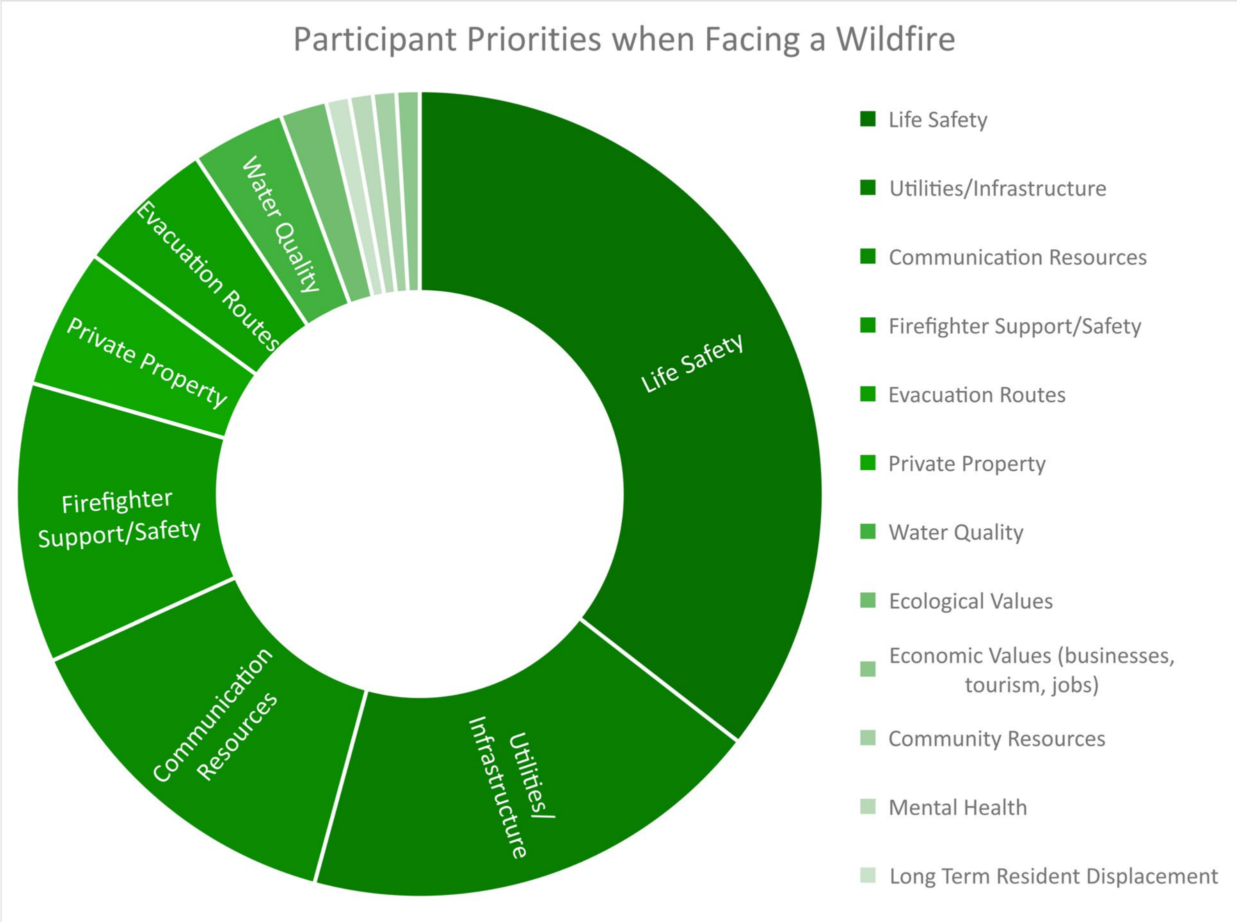

Figure 8.c.2. *Relative importance of local values at risk. Participants ranked these categories as first, second, or third priority, and these rankings were weighted (one point for each third priority, two points for each second priority, and three points for each first priority). Weighted rankings were divided by the total votes to assign a percentage of votes to each category. No one voted for "air quality" as a category.*

Mitigation Work

Participants reported starting mitigation work on their property when buying, building, or remodeling a home, when the 2020 fires were affecting the valley, and when home insurance companies required mitigation work. This indicates that working with the local realtor's association and builder or contractor associations may help deliver high-quality information when residents are most willing and ready to make changes to their properties. Most participants do annual upkeep and mitigation work in the fall, making late summer and early fall an ideal time for outreach and fire season warnings.

While most participants did not indicate that property loss was their highest concern in a wildfire event, self-serving outcomes are still useful in initiating action. Many homeowners do not want to lose home insurance and do not want to pay more for it. The FPD could encourage creating a savings plan for roof replacements so residents are financially prepared when an insurance company requires it to keep them insured. Community goals like creating a FireWise community in their neighborhood can also factor into insurance decisions.

It may be useful to build off local fires, such as the Kruger Rock Fire, to start a campaign to remind residents to mitigate their HIZs. Using specifics to detail how mitigation work did or could have changed the course of the fire may provide substantiative proof that homeowners need to begin work. Creating fear is never a sensible goal in public outreach; alleviating uncertainty with actionable knowledge is a better goal.

Community-led mitigation is a good strategy in the Estes Valley. Denser populations than many mountain towns will require shared mitigation and community action. A community ambassador program would be appropriate to help the district work more closely with each neighborhood in the valley.

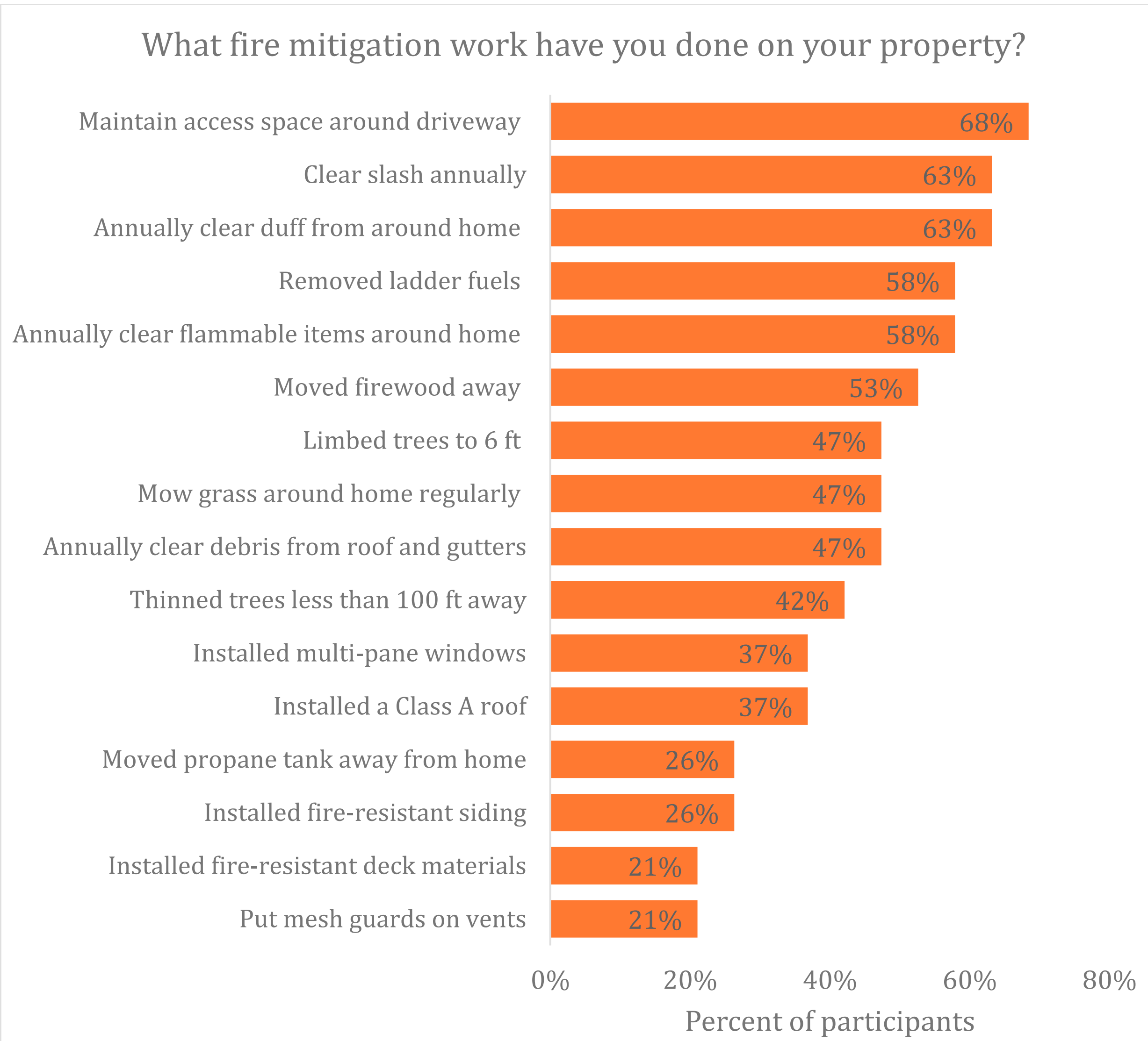

Figure 8.c.3. *Percent of participants that have completed different categories of home hardening and defensible space around their home.*

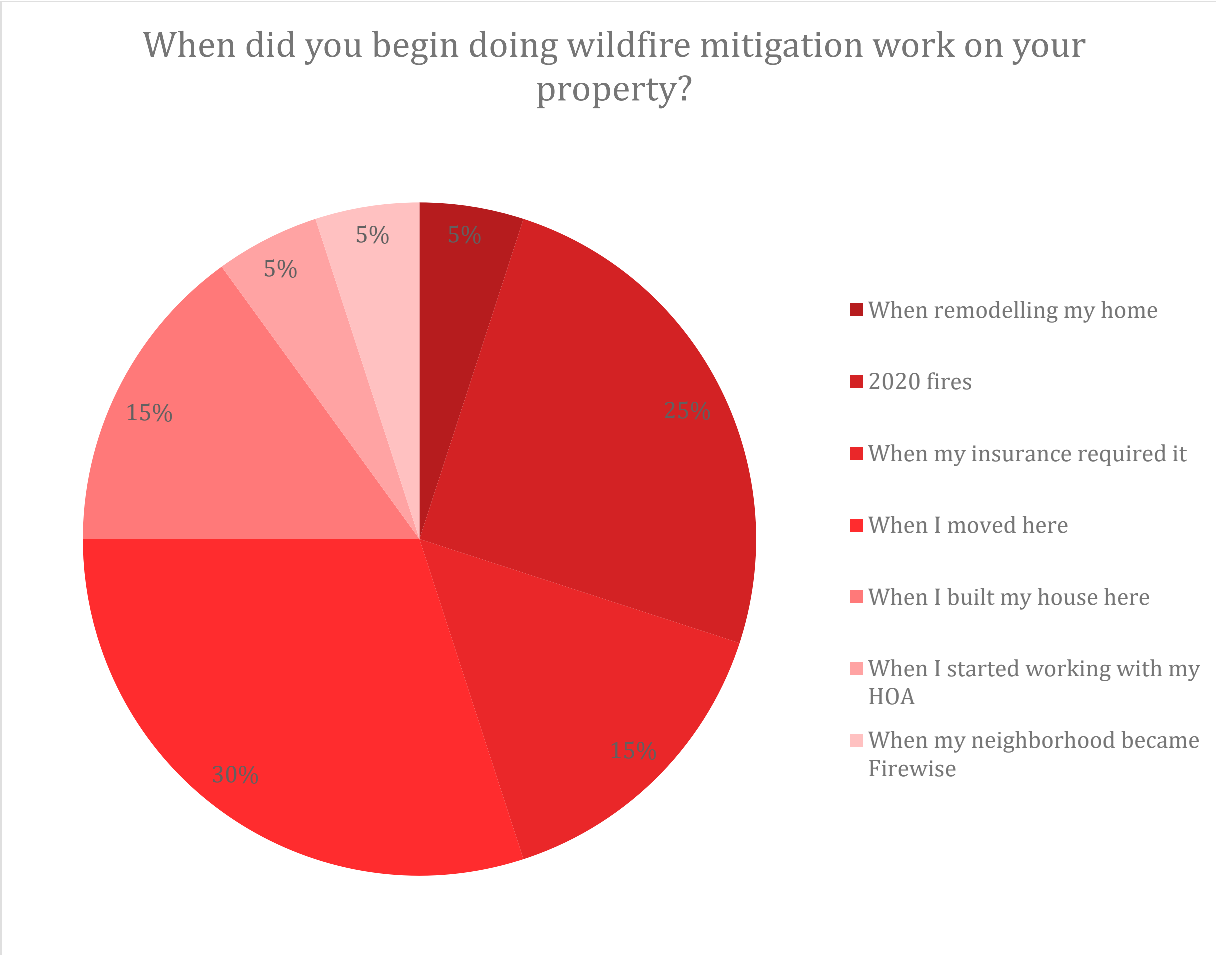

Figure 8.c.4. *Relative percent of participants that indicated what initiated their mitigation work on their property in the Estes Valley. Many events have been the catalyst for residents in Estes Park to begin wildfire mitigation on their home and property. Building off these events may help encourage others to begin the process.*

Barriers to Mitigation

Cost and time are the biggest barriers to mitigation in the community, and this is not surprising. Some mitigation tasks are inexpensive and easy (see the **Section on Defensible Space**), and others are expensive and time consuming. Estes is one of the oldest communities in the state (U.S. Census Bureau, 2020) and many retirees need assistance making big changes to their property or completing all the recommended annual maintenance tasks. A lack of contractors is a more recent issue that has been worsened due to the Covid-19 pandemic and ensuing economic issues. It is difficult for a FPD to assist with some of these barriers. However, certain financial barriers can be eased by advertising home mitigation grant opportunities or supporting a tool library with basic HIZ mitigation supplies for checkout.

Other barriers that participants identified highlight opportunities for the FPD and partners to provide assistance. Residents that do not know where to take slash can be educated about current slash disposal options, and the FPD can work toward installing a local slash yard for residents of the valley. Residents that would like help identifying specific tasks and priorities on their properties can be educated about the free home inspection program that EVFPD runs.

EVFPD can also support HOA regulations that support personal and community fire mitigation by continuing to be an active part of HOA meetings as part of their outreach.

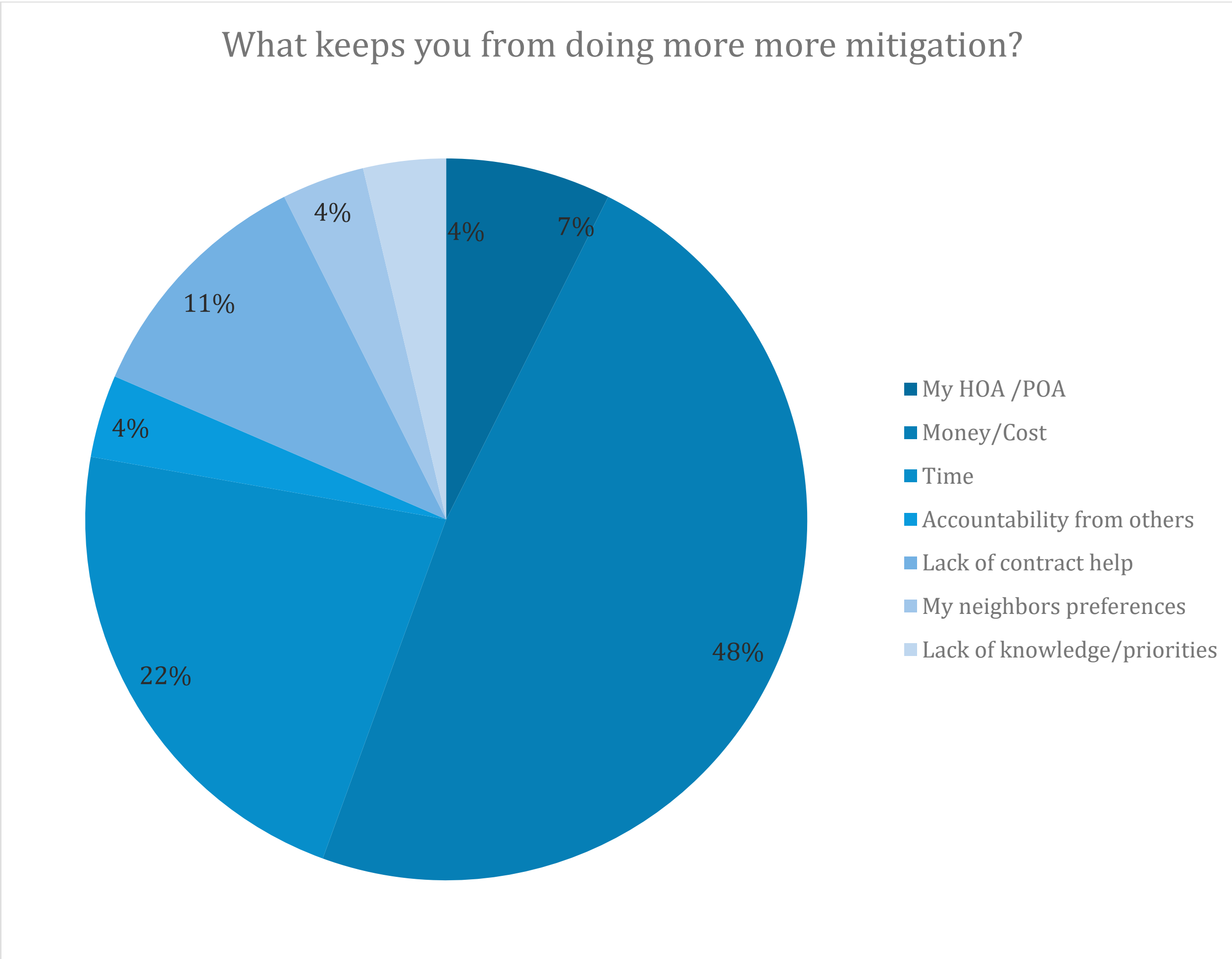

Figure 8.c.5*. Relative percent of responses that identified these barriers to mitigation.*

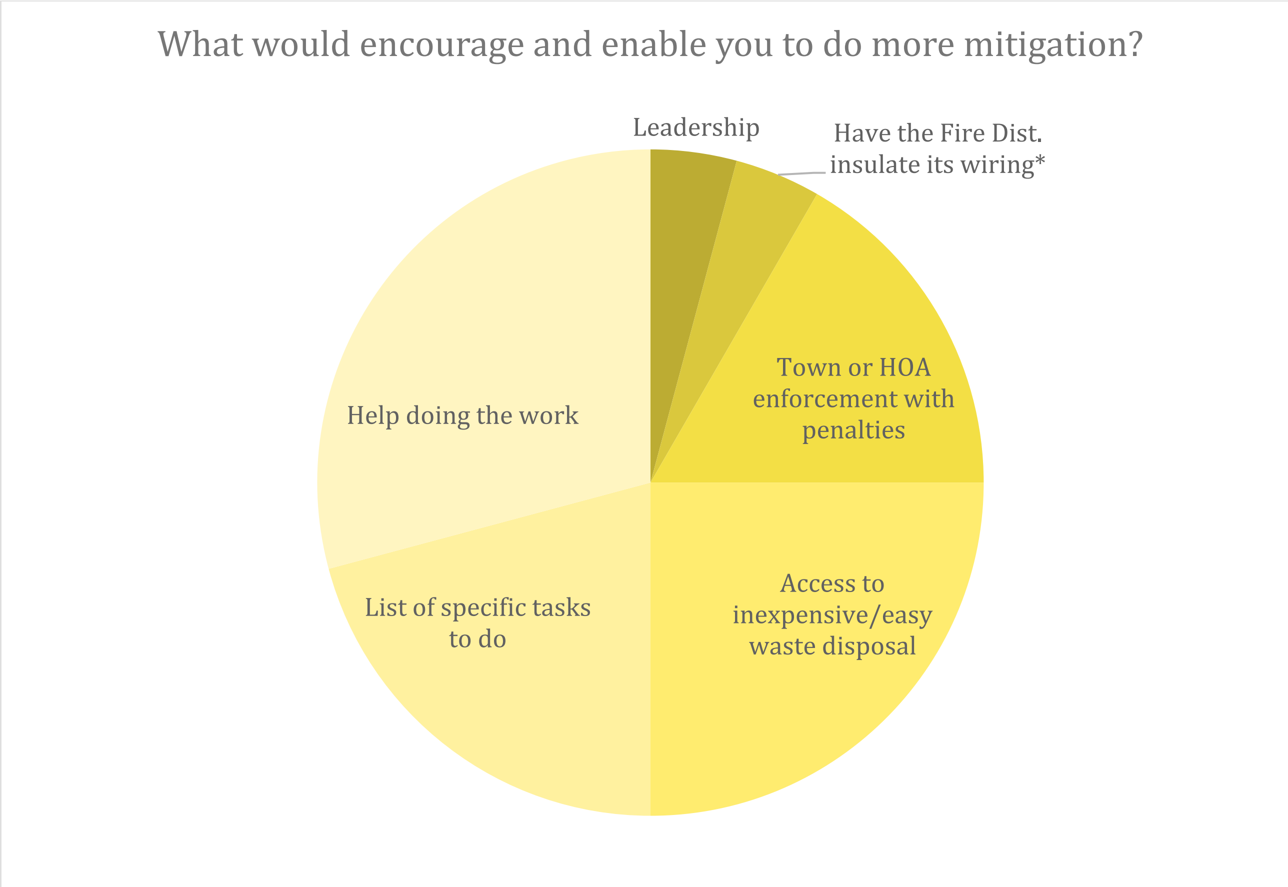

Figure 8.c.6. *Relative percent of responses that identified resident needs to enable further mitigation action. *Note that the fire district does not own any electric wiring within their district.*

Educational Content

When the fires of 2020 threatened the valley for months, many participants got their news from the live streamed video updates, InciWeb, NoCoAlerts, community Facebook pages, and the newspaper. People also found local webcams very useful once they were evacuated. This shows a trend toward residents being interested in real-time updates and information during fire events, and this is something that EVFPD can be aware of and work on continuing.

Informed participants tend to look toward the EVFPD as the local expert for fire mitigation information. This shows community trust and successful outreach by the district. Leveraging this reputation through a community ambassador program can help spread trusted, quality information. Others in the community receive information from the Colorado State Forest Service, their HOA, and their insurance agency. This CWPP document references CSFS standards for home hardening and defensible space throughout so the information coming from the EVFPD and the CSFS is coordinated. HOA leaders have asked the fire district to speak to them about fire mitigation, and these relationships can continue to develop so that residents that get their information from HOAs are receiving the same information as their neighbors.

Participants stated that they are interested to virtual events and prefer to be contacted through email, paper mail, social media, and the local newspaper. Some residents would benefit from a mitigation calendar or outreach with smaller, more achievable goals, as the HIZ checklists can be intimidating.

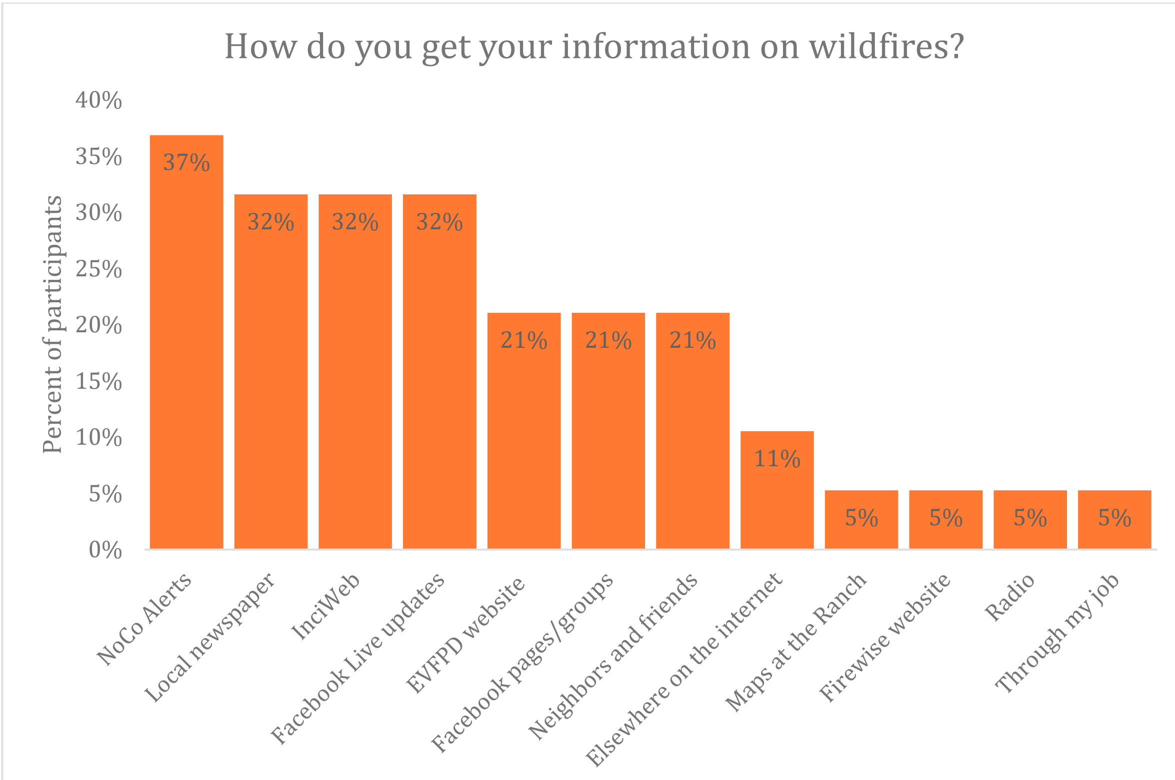

Figure 8.c.7. *Percent of participants that received information about active wildfires from each category.*

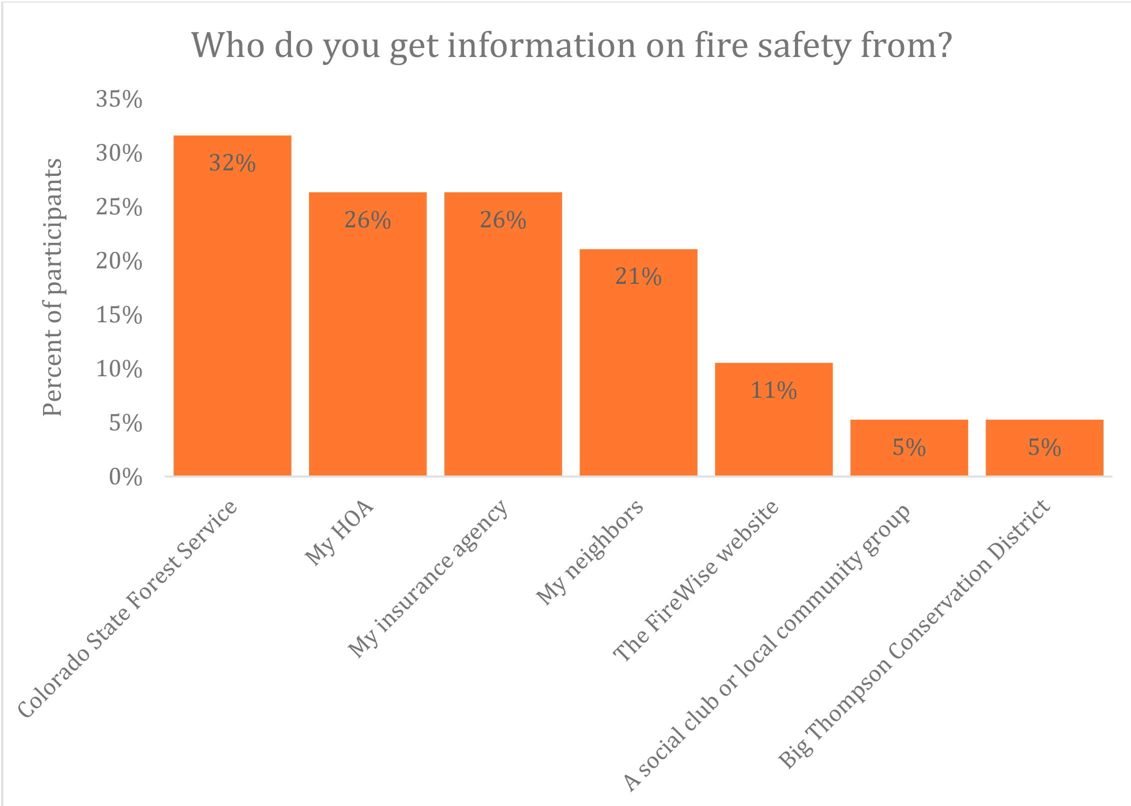

Figure 8.c.8*. Percent of participants that received information about fire safety and wildfire mitigation from each organization.*