San Juan County
Community Wildfire Protection Plan

Prepared for:
San Juan County, Colorado

Prepared by:
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San Juan County Emergency Manager
PO Box 184
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June 2013

Community Wildfire Protection Plan: San Juan County Colorado

Approval

The Durango District of the Colorado State Forest Service has reviewed this Community Wildfire Protection Plan and approves its content and certifies that it meets or exceeds CSFS Community Wildfire Protection Plan minimum standards.

D. Kent Grant, District Forester
Colorado State Forest Service

Date 6/12/2013

Gilbert Archuleta, Chief
Silverton & San Juan County Fire & Rescue Authority

Date 6/12/2013

Ernest Kuhlman, Chair
San Juan County Board of Commissioners

Date 6-12-2013

Kristina Maxfield
San Juan County Office of Emergency Management

Date 6/12/2013

The following entity has received a copy of this Community Wildfire Protection Plan and agree with and support its content and recommendations.

Dan Noonan, Chief
Durango Fire & Rescue Authority

Date 7/26/13

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Publications

SECTION 1

A – Introduction

Community Wildfire Protection Plans are authorized by the Healthy Forests Restoration Act (HFRA) of 2003. HFRA places renewed emphasis on local community wildfire protection and response planning by extending a variety of benefits to communities with a wildfire protection plan in place. Among the benefits are the ability to participate in establishment of fuels treatment priorities for both federal and non-federal lands surrounding communities, establishment of a local definition and boundary for the Wildland-Urban Interface (WUI), and enhanced opportunities for cost-sharing of community-based fuels treatments.

According to the guide, *preparing a Community Wildfire Protection Plan: A Handbook for Wildland-Urban Interface Communities*, “The wildland-urban interface (WUI) is commonly described as the zone where structures and other human development meet and intermingle with undeveloped wildland or vegetative fuels.”

Most of the factors and treatments that determine the survivability of a structure lie within one to two hundred yards of the structure, and usually it is located on private lands. However, many other items beyond that distance are critical to a community. These include, among others, community water supplies, effects on property and real estate values, community infrastructure, economic impacts to residents and businesses, aesthetic values, and a sense of community or why “we live here.” Because of those factors, it is important for this CWPP to define a WUI that includes all items critical to the communities.

B – Background

San Juan County is home to 699 residents with 520 residents residing in the town of Silverton which is situated in the southwest corner of Colorado approximately 50 miles north of Durango, Colorado and 60 miles south of Montrose, Colorado. The land is punctuated by high mountain passes and peaks and has the highest mean elevation of any county in the United States.

Silverton, the county seat, is the only town in the county and sits at an elevation of 9,318 feet. Most of the county’s 388 square miles is remote wilderness that can only be accessed by four-wheel drive, horseback, or on foot. US Highway 550 is the only 32 miles of paved road traversing three mountain passes. There are 190 miles of unpaved, four-wheel drive roads, which are open only in the summer months. Silverton is located on the Historic Alpine Loop and Scenic Skyway. According to the BLM, there are approximately 250,000 vehicles that drive the Alpine Loop from June through August. The Colorado Department of Transportation states approximately 3,000 vehicles travel Highway 550 on a daily basis.

The year-round population of the county is approximately 699; however, in the summer, the population rises significantly. Silverton has been designated a National Historic Landmark District and we are impacted daily in the summer by the thousands of tourists riding the Silverton-Durango Narrow Gauge Railroad, driving the highways, or exploring the backcountry.

Type of Ownership	Number of Acres
Private	28,000
San Juan National Forest	172,000
Bureau of Land Management	49,000
State of Colorado	1,880
Total	250,880

Natural and Historic Assets
Silverton has been designated a National Historic District and there are several historic sites within San Juan County that could be subjected to wildfire hazard. The San Juan County Commissioners and local residents would like to see as many of the counties' historic sites protected during a wildland fire as possible as these sites are part of the county's history and are a popular attraction for many of our visitors.

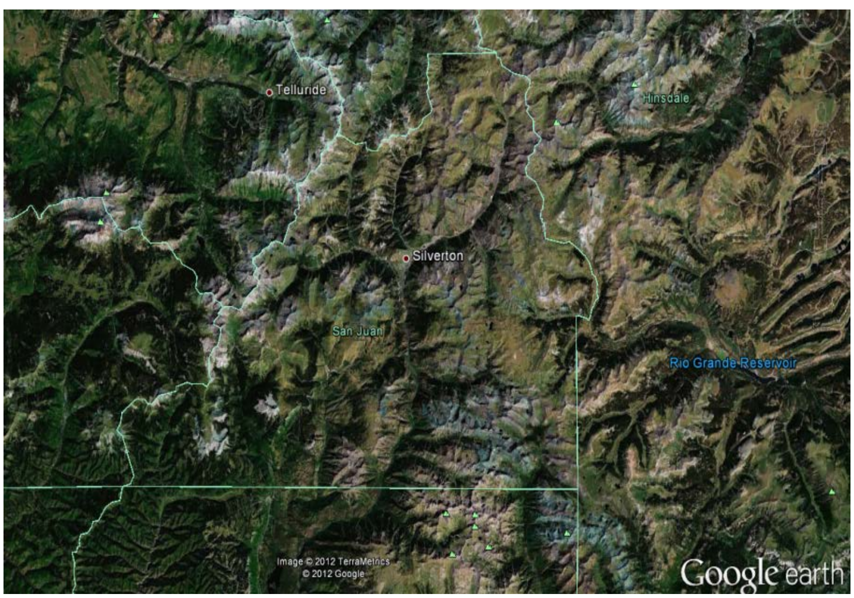
C – Location/Boundaries

This CWPP covers all of San Juan County including Cascade Village, Know Your Neighbor, Cascade Creek Summer Home Group and Mill Creek subdivisions.

D – Community/Public and Private Land Characteristics

San Juan County is characterized by topographic isolation and surrounded by vast expanses of public lands ranging in elevation from 8,000 feet to over 14,000 feet. There are areas of dense forest and areas of high altitude tundra.

In 2011, there were 179 San Juan County residents living outside of the incorporated Town of Silverton. The homes located at higher elevations (above 9,300 feet) are rustic homes and cabins surrounded by alpine forests and accessible only during the summer months or by snowmobile in the winter months. Home and cabin owners who have built above 9,300 feet are aware of the reduced services from the Silverton and San Juan County Fire and Rescue Authority due to the remote location, difficult access, and lack of water sources. All homeowners are informed of this prior to building.



Homes located at the southern end of the county are at approximately 8,000 feet in elevation. These homes are primarily vacation homes but a few have year-round residents. The homes are generally located in alpine forests. Most of the property owners belong to the Durango Fire and Rescue Authority (DFRA) Fire Protection District and have year-round fire protection.

E – Local Fire History

The largest fire in the county's history occurred in the late 1880's when a wildland fire burned thousands of acres along Lime Creek. Since that time, there have been many small fires started by lighting, the Durango and Silverton Narrow Gauge Train, and some human-caused fires; however, none of these smaller wildland fires have impacted a populated area.

San Juan County is at a much lower risk for wildland fires then the surrounding counties due to the altitude, terrain, types of vegetation and precipitation received (both snow and rain).

F – Wildfire Preparedness Activities

The Colorado State Forest Service and FireWise of Southwest Colorado both provide good written and electronic materials that can help homeowners prevent fires, prepare for wildfire and evacuation, and reduce vegetation to change fire size and behavior on private lands. At this time, San Juan County utilizes printed materials provided by these entities to hand out to and educate property owners whose property is located next to forested areas in San Juan County. Both entities are available to visit with homeowners and homeowner associations.

Other preventative measures in place are found in the San Juan County Land Use Code Chapter Four – Review and Appeal Process Section 4-110 letter "o" and are listed below:

o. The building site shall be in compliance with the following wildfire prevention standards:

1. Only fire-resistant materials which maintain a Class B rating or better shall be used for the construction of roof structures. Wooden or shake shingles are not permitted.
2. Defensible Space: the applicant shall create a plan for design of defensible space based upon the types of structures to be protected, the topography of the area, and the types and density of vegetation present in the area.
3. An annual assessment of defensible space shall be conducted by the property owner to include the following:
    a) Trees and shrubs are properly thinned and pruned within the defensible space. Slash produced from thinning and construction operations is disposed of offsite (in a location with no fire hazard), or properly mulched.
    b) Roof and gutters are clear of debris.
    c) Branches overhanging roofs and chimneys are removed.
    d) Chimney screens are in place and in good condition.
    e) Vegetation is removed from within 15 feet of chimneys.
    f) Grass and weeds are mowed to a low height.
    g) Fire extinguishers are checked and in good working condition.
    h) Driveways and access points are cleared sufficiently to allow for emergency equipment that is compatible with the County road conditions.
    i) Escape routes are posted when appropriate.
    j) Trash and debris accumulations are removed from the defensible space.
    k) Stack firewood at least fifteen (15) feet uphill from any structure.

SECTION 2

A – Fire Protection

The following agencies are involved in fire prevention and firefighting in the county including:

- Silverton San Juan Fire and Rescue Authority (SSJFRA)
- Durango Fire and Rescue Authority (DFRA)
- Bureau of Land Management (BLM)
- Colorado Division of Fire Prevention and Control (DFPC)
- United State Forest Service (USFS)
- Durango and Silverton Narrow Gauge Railroad (D&SNGRR)

Because 86% - 88% of San Juan County is public lands the policy for wildland fires located in areas where the terrain is difficult or inaccessible and no private property is threatened there may be a “let it burn” policy. There are areas where this policy would not be acceptable such as populated areas that are threatened, the Town of Silverton’s water supply is threatened, egress or ingress is threatened in populated areas, or important viewsheds along Highway 550 are threatened and would have an adverse impact on the Counties’ tourism economic base.

San Juan County has several historical designations such as the Town of Silverton, Eureka, and Animas Forks; these areas should be protected if at all possible in the event of a wildland fire.

SECTION 3

A – Federal

The San Juan County CWPP has been developed in response to the Healthy Forests Restoration Act of 2003 (HFRA). This legislation established unprecedented incentives for communities to develop comprehensive wildfire protection plans in a collaborative, inclusive process. Furthermore, this legislation directs the Departments of Interior and Agriculture to address local community priorities in fuel reduction treatments, on both federal and non-federal lands. The HFRA emphasizes the need for federal agencies to collaborate with communities in developing hazardous fuel reduction projects and places priority on treatment areas identified by communities themselves through development of a Community Wildfire Protection Plan (CWPP). Priority areas include the wildland-urban interface (WUI), municipal watersheds, areas impacted by windthrow or insect or disease epidemics, and critical wildlife habitat that would be negatively impacted by a catastrophic wildfire. In compliance with Title 1 of the HFRA, the CWPP requires agreement among local government, local fire departments, and the state agency responsible for forest management i.e., the Colorado State Forest Service. The CWPP must also be developed in consultation with interested parties and the applicable federal agency managing the land surrounding the at-risk communities.

B – San Juan County Annual Operating Plan

San Juan County, Federal land management agencies, Colorado Division of Fire Prevention and Control, Silverton and San Juan County Fire and Rescue Authority, and Durango Fire and Rescue Authority operate under the auspices of the San Juan County Annual Operating Plan (AOP) for wildfire prevention and suppression. This plan provides for mutual aid to assist with the management of wildfire incidents in San Juan County. The plan provides for significantly enhanced initial and extended attack capabilities through the rapid convening of fire protection resources for managing a wildfire. The AOP outlines standard operating procedures and the level of participation and available resources of each party under the plan.

C - USFS and BLM Land and Resource Management Plan/ Fire Management Plan

The San Juan National Forest and San Juan Resource Area Land and Resource Management Plan and associated Fire Management Plan describe the role of fire in the native ecosystems in southwest Colorado. These plans outline the strategies that the USFS and BLM will utilize to manage wildland fire and fuels on these federal lands in southwest Colorado. The San Juan National Forest and San Juan Resource Area Fire Management Plan (2007) specifically describes objectives and strategies to manage fire and fuels on federal lands near communities within the wildland-urban interface.

D – San Juan County CWPP

The San Juan County CWPP approved and adopted in 2013 is consistent with the goals and strategies persons involved in writing and reviewing this plan agree with.

SECTION 4

A - Process

There is not a Firewise committee for San Juan County; the County chose to task the San Juan County Emergency Manager with writing the CWPP instead of hiring of contractor. The Emergency Manager (EM) sought input from various County departments and developed the plan. Upon completion of that phase, the plan was given to the Colorado State Forest Service in Durango and San Juan County Fire and Rescue Authority for their comments. These comments and/or changes were incorporated into the document. Then the CWPP was presented to the San Juan County Commissioners for their comments and changes. The last step in this process was a public hearing with the San Juan County Commissioners and other interested parties. Changes to the plan were agreed upon during the public hearing and incorporated into the plan. The final CWPP was then submitted to the appropriate entities for approval and signature in June of 2013.

SECTION 5

A – Forest Health

Due to their high elevation, the forests of San Juan County typically receive greater precipitation in the form of rain and snow than those at lower elevation. This is an important component in maintaining forest health. However, longer periods of higher temperatures and lower moisture are increasingly stressing Colorado's forests, including those in San Juan County. Because of this, overcrowding of trees, and excessive stand age, several destructive forest insects have become noticeably active in the area. According to the 2012 forest insect and disease aerial detection survey, heavy spruce budworm defoliation of spruce, fir, and Douglas-fir was observed in parts of San Juan County. Subalpine fir mortality was also noted from an association of western balsam bark beetle and root disease. Although not as active in San Juan County as in the recent past, fir engraver beetle is still attacking and killing white fir. Tree mortality caused by this insect is particularly evident in the Ouray area at this time.

In addition, a major spruce beetle epidemic is ongoing in the Engelmann spruce/subalpine fir forests of Hinsdsale, Mineral, Rio Grande, and Saguache Counties, and to a lesser extent in parts of Dolores, La Plata, Montezuma, and San Juan Counties. If the epidemic continues to spread, which appears likely due to numerous stands of mature/overmature Engelmann spruce combined with anticipated extended warm and dry conditions, San Juan County could experience heavy spruce mortality.

B – Fuels and Fire Hazard

The predominant natural fuels of San Juan County include Engelmann spruce/subalpine fir, lodgepole pine (planted in portions of the Lime Creek Burn by the Garden Clubs of America), mixed conifer, aspen, riparian, mountain grassland, meadow, and alpine tundra vegetative types. Under dry, windy conditions, fires in stands of conifers can burn very aggressively and be very difficult to control. Of special concern is southern San Juan County where elevations are lower and the chance of a wildfire is generally higher on average than in other parts of the County, and along the Durango & Silverton Narrow Gauge Railroad tracks.

At a mean elevation of 11,240 feet above sea level, San Juan County is not only the highest county in Colorado, but in the nation as well. Because of this, San Juan County typically receives higher snow and rainfall than areas at lower elevation in southwest Colorado, generally reducing fire danger and the potential for significant wildfires. However, the moisture received in recent years has often been substantially less than average, increasing the possibility of wildland fires. Much of San Juan County's forests are spruce-fir, which typically have a low fire frequency and a long fire return interval. However, when burning conditions are very high to extreme, these forests have the potential to burn very actively, characterized by torching of individual trees and destructive crown fires. Crown fires are often highly resistant to control and are commonly stand replacing events. This is evidenced by the Lime Creek Fire of 1879 which burned thousands of acres of timber, the effects of which are still discernible today.

During periods of drought and low fuel moisture, stands of living, green trees can actively burn. If bark beetles infest and kill many of the spruce on the mountainsides, a fire start on a windy day, especially while the dead needles still remain attached to the twigs, could result in a significant wildfire. Over time as the beetle-killed trees fall down and build up on the forest floor, they will represent an increasingly greater surface fire hazard. Areas of beetle killed spruce can be especially hazardous to firefighters due to the danger from falling snags.

The Durango/Silverton Narrow Gauge Railroad (D&SNGRR) represents another potential wildfire hazard, especially when fuels close to the tracks are dry. Over the years the railroad has started numerous fires and in response to this, D&SNGRR has taken mechanical measures to reduce the likelihood of embers from the locomotive causing a fire, and rail cars with a water supply, firefighting tools, and firefighting personnel follow behind the trains during fire season to extinguish any fires they start. Occasionally a train-ignited fire escapes initial attack efforts, requiring the mobilization of additional firefighting resources from Silverton and San Juan County Fire and Rescue Authority, Durango Fire and Rescue Authority, and federal land management agencies (USDA Forest Service and USDI Bureau of Land Management).

C – Values at Risk

	Total Value	Imp Value	Imp Counts
Town	$118,382,269	$52,955,367	513
County	$20,789,405	$ 9,025,236	106
South County	$42,901,448	$13,718,682	189

D – Emergency Evacuation

Evacuations will be determined based on the threat to human life and property. These will be identified on a case by case basis. Evacuation details have been outlined in the San Juan County/Town of Silverton Emergency Operations Plan and will be executed by the San Juan County Sheriff's Office. See the Evacuation section of the Emergency Operation Plan for details.

SECTION 6

A - Community Wildfire Protection Plan Goals

1. Provide more public education about how to make homes and properties Firewise.
2. Protect the Town of Silverton's water supply on Bear Creek form a catastrophic wildfire.
3. Protect important viewsheds along Highway 550 and around Silverton since tourism comprises the county's economic base.
4. Work with the D&SNGRR in prevention and control of spot fires ignited from the train.
5. Protect national designated Historical Districts within San Juan County.

B – Recommendations

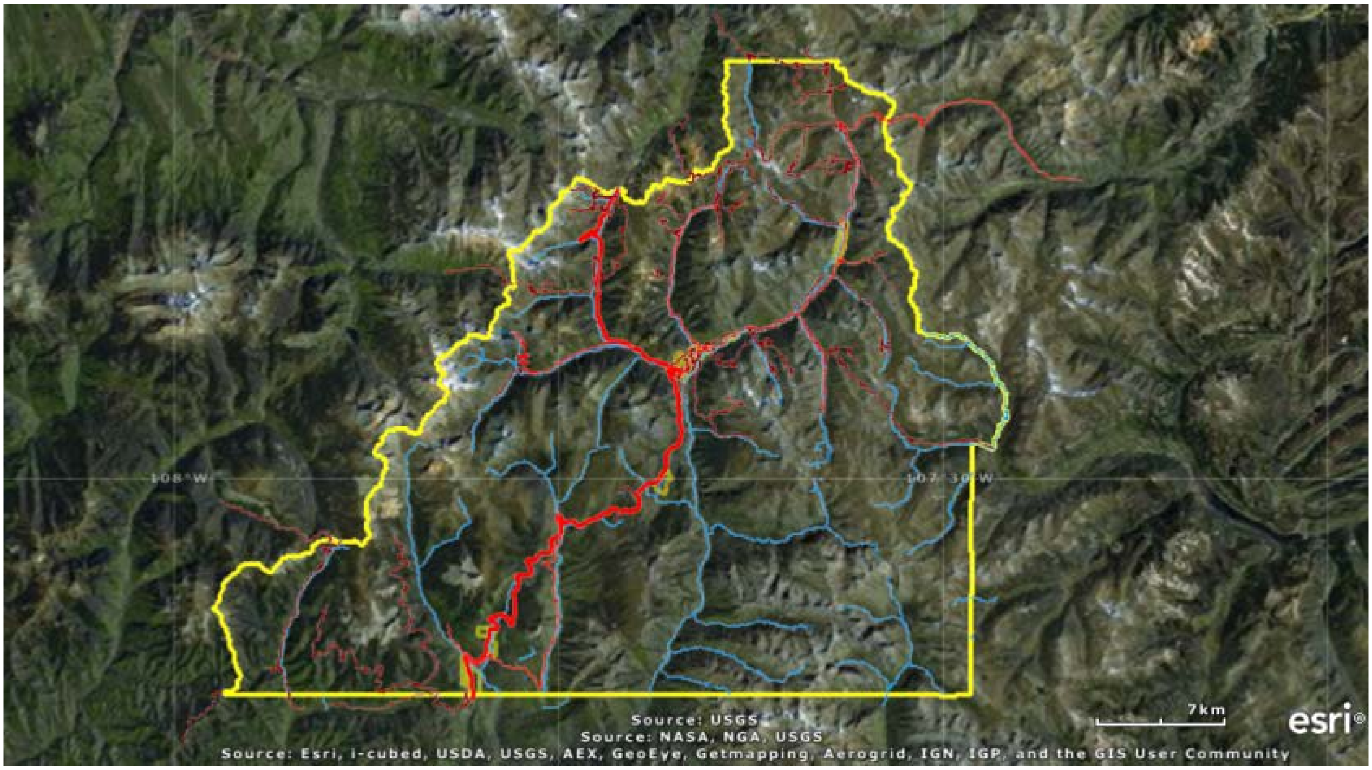
1. Work with the Colorado State Forest Service and FireWise of Southwest Colorado to conduct public education programs for county residents.
2. Make Firewise brochures and web site(s) available to property owners within San Juan County.
3. Enforce policies in the San Juan County Land Use Code, Chapter Four – Review and Appeal Process Section 4-110 letter "o."
4. Place better signage in the backcountry, and improve communication mechanisms between San Juan County personnel and federal agencies when federal fire bans are put in effect that impact the county.
5. Seek grant funding to obtain a pop car with trailer so reliable transportation is available on the train tracks south of Silverton when an emergency arises.
6. Encourage the United States Forest Service and Bureau of Land Management, in partnership with local communities, the fire departments, and Colorado State Forest Service, to consider fire prevention and mitigation projects on lands identified in the Community Wildland Fire Protection Plan including:
    - Subdivisions in the lower part of the county;
    - Projects along Cascade and Lime Creeks; and
    - Bear Creek drainage that projects Silverton's water supply.

7. Further, the following areas were identified as priorities in terms of viewsheds, community values and tourism:
    - The San Juan Skyway
    - Public lands that can be seen immediately from Silverton.

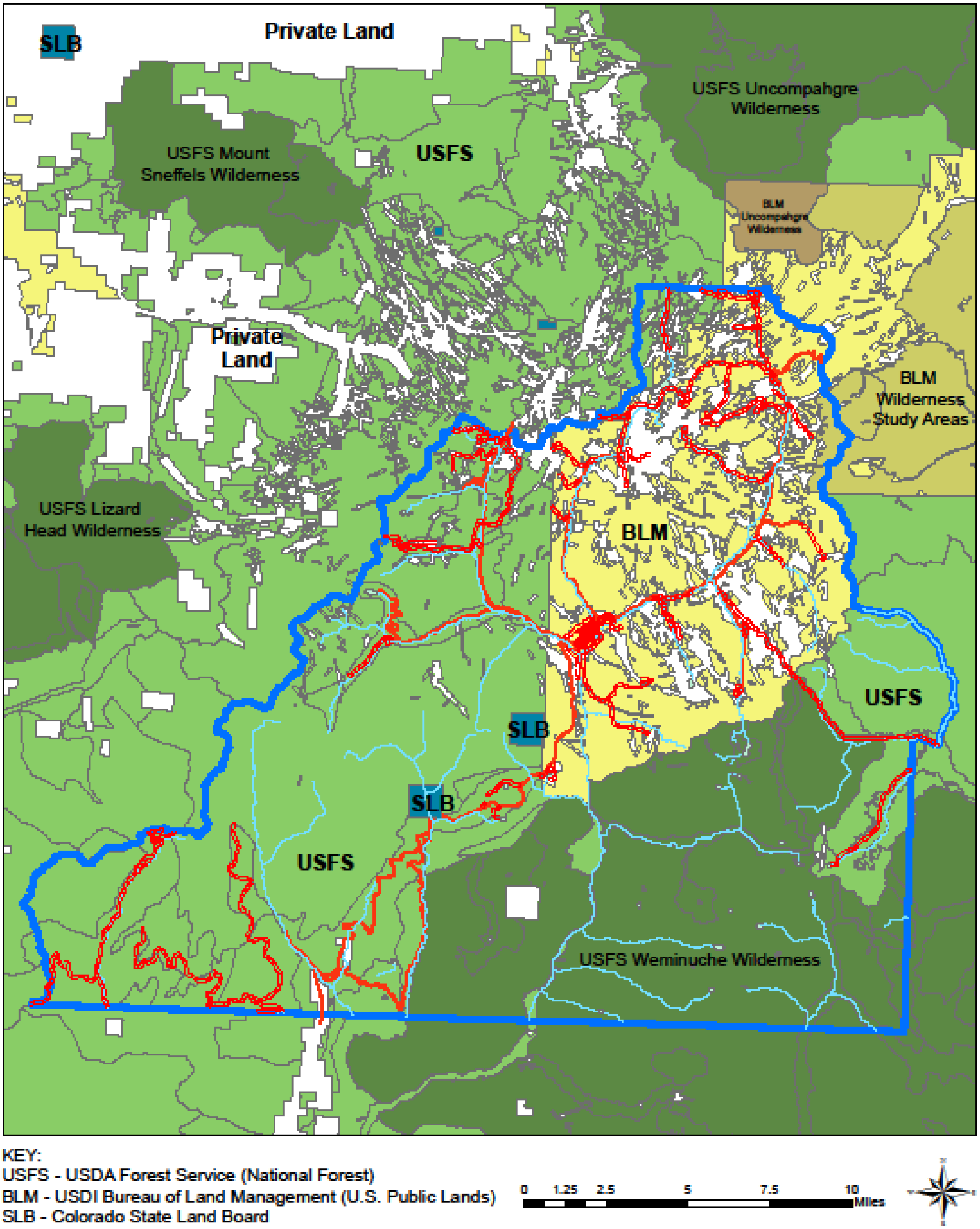
SECTION 7: Appendices

Maps

San Juan County

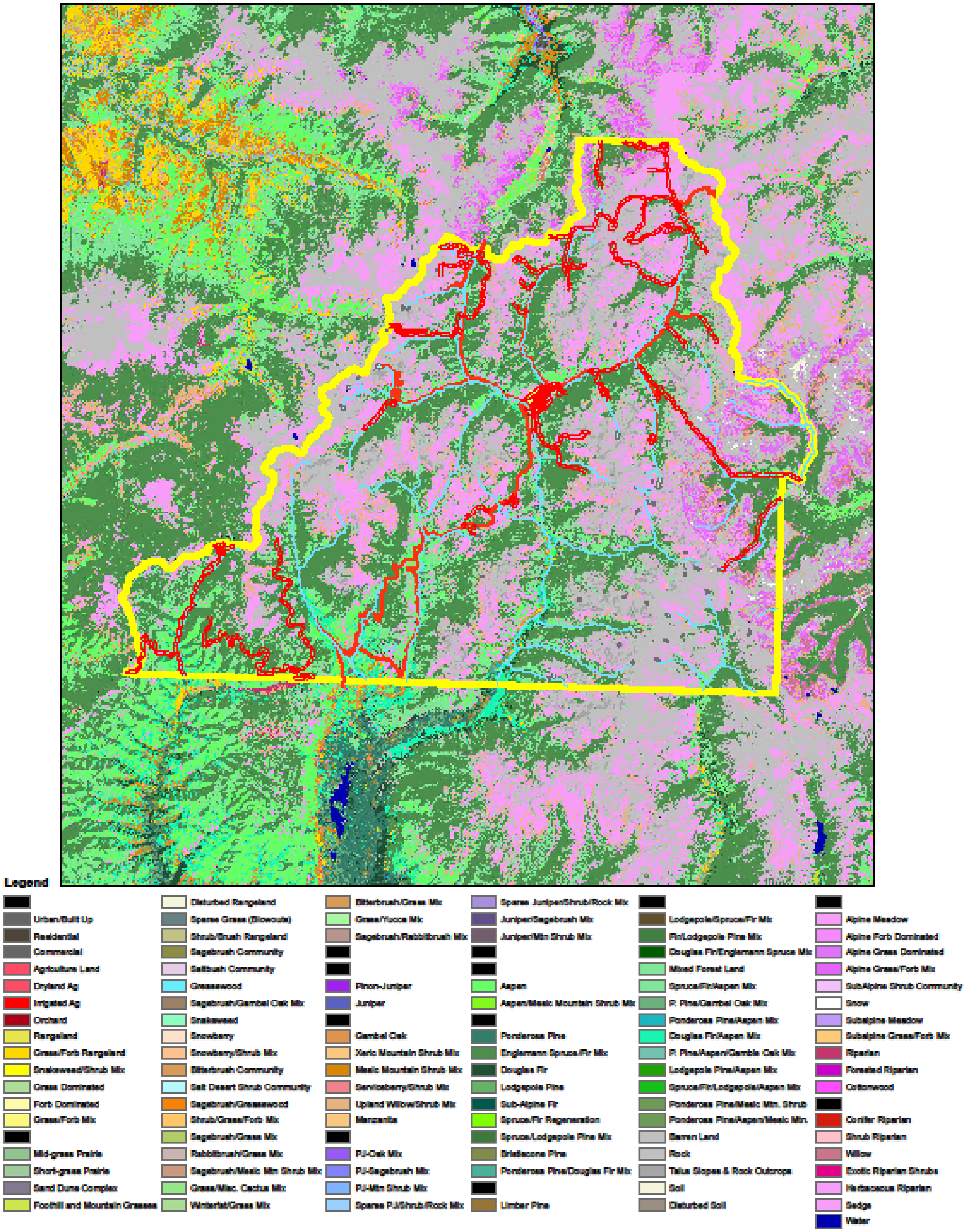


San Juan County Ownership Map



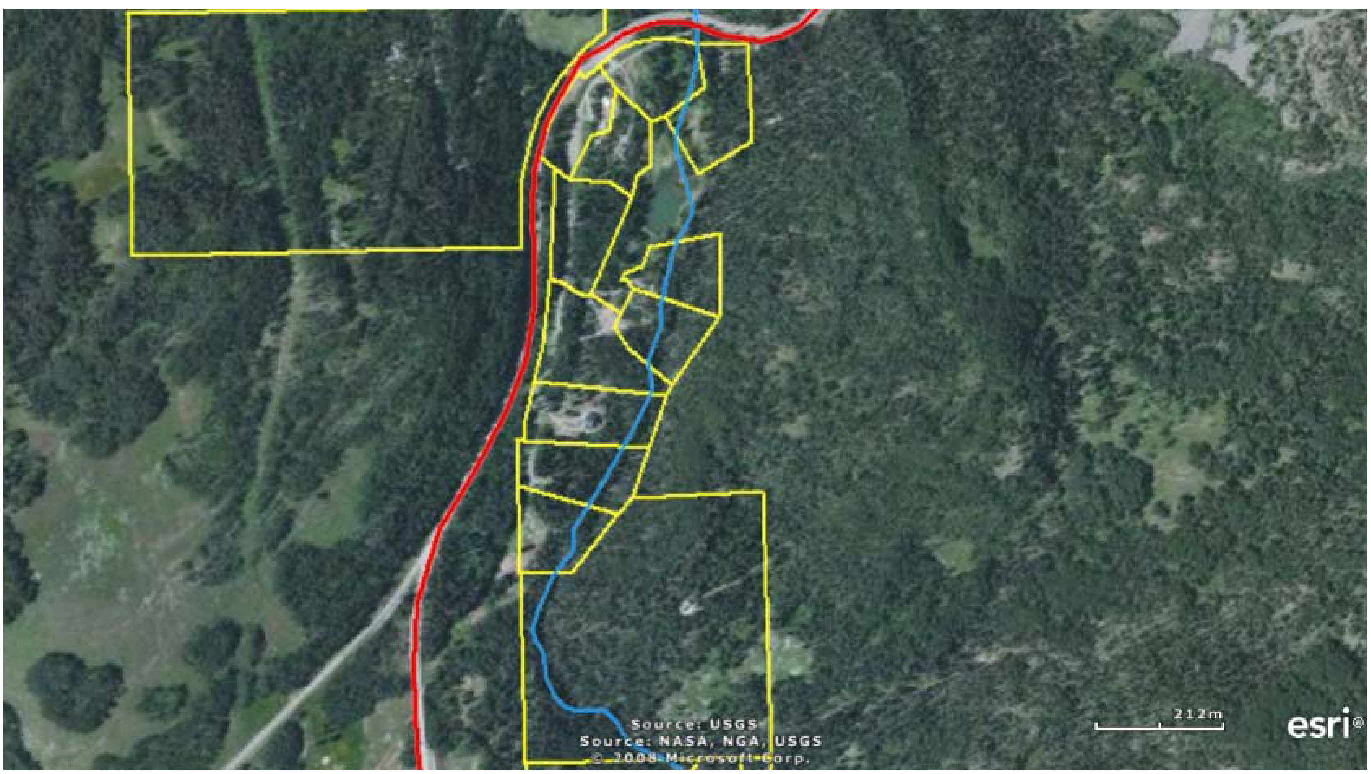
KEY:
USFS - USDA Forest Service (National Forest)
BLM - USDI Bureau of Land Management (U.S. Public Lands)
SLB - Colorado State Land Board

San Juan County Vegetative Types

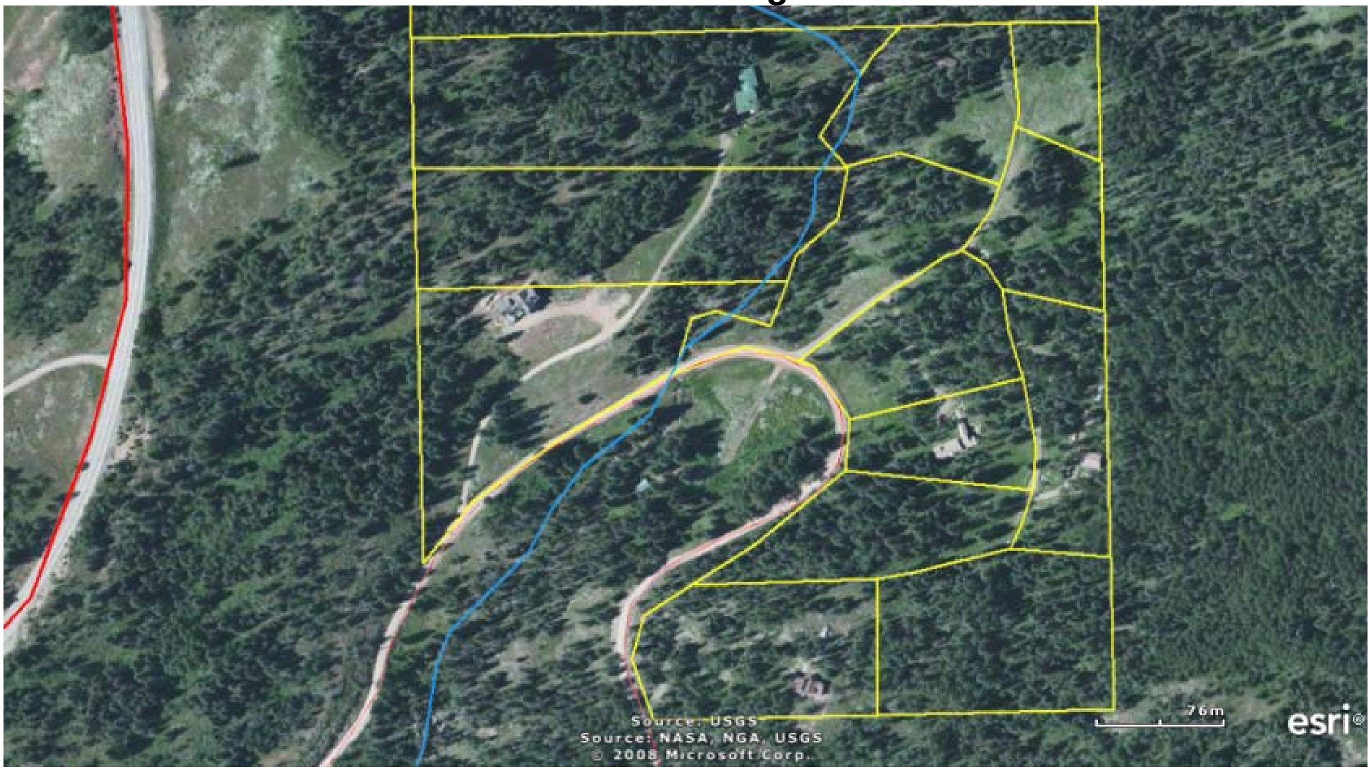


Silverton

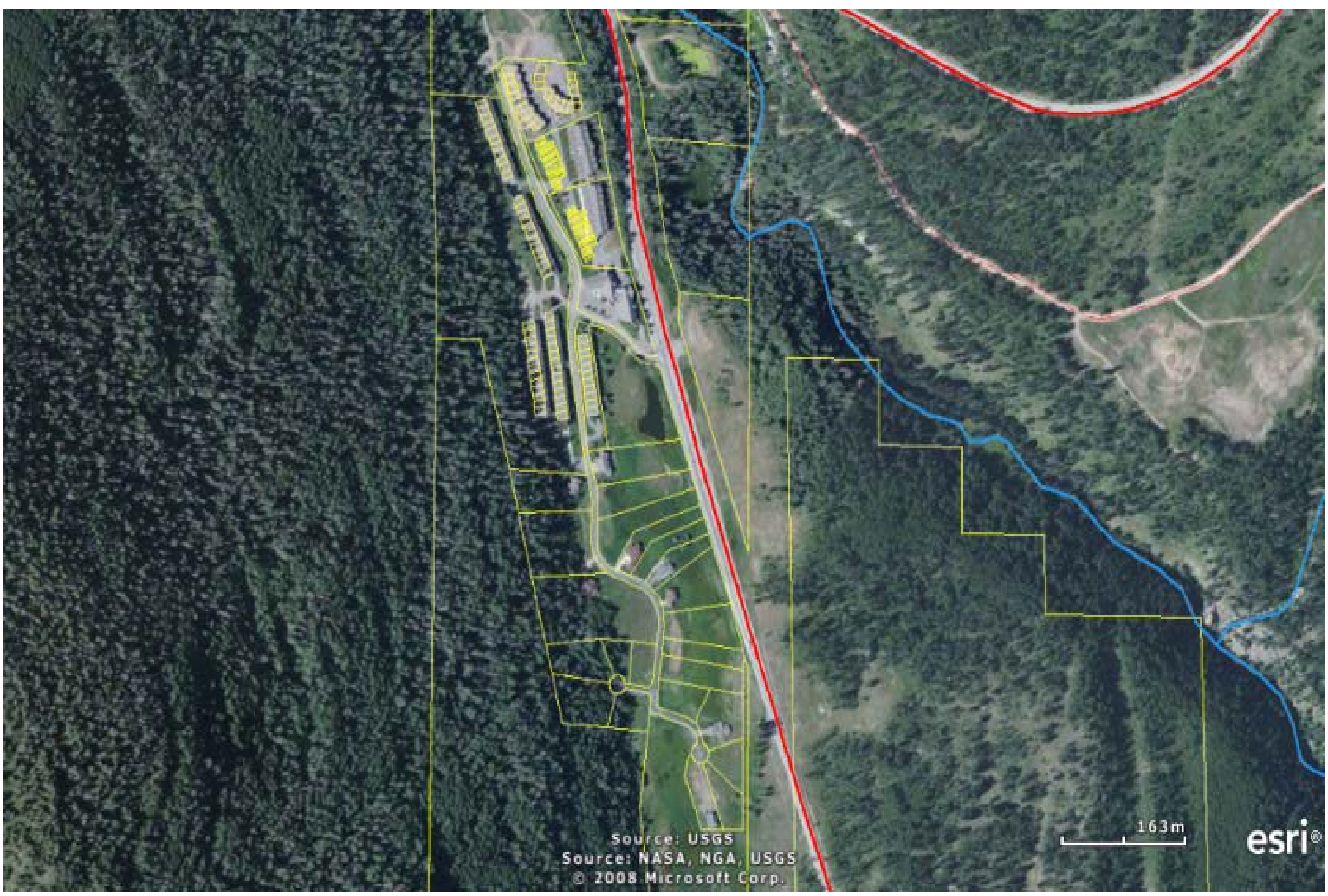
Mill Creek



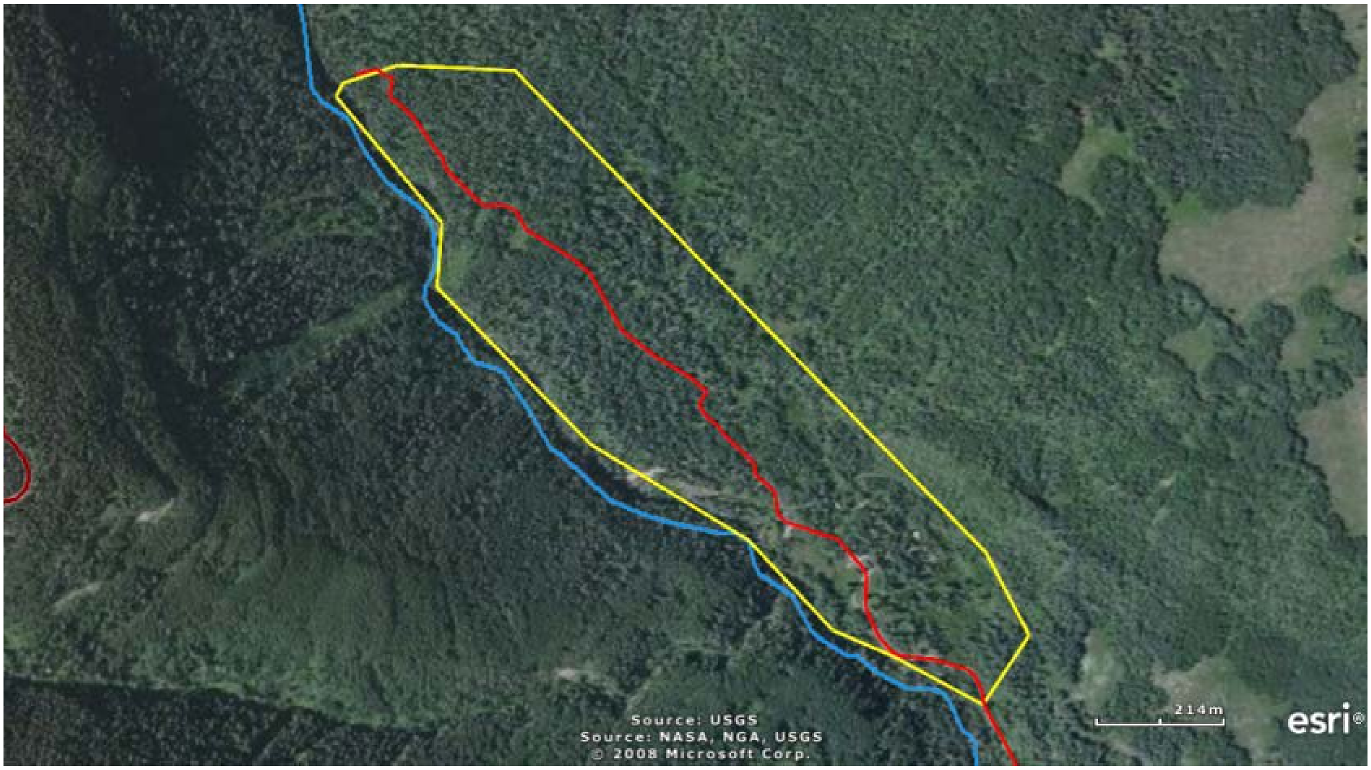
Know Your Neighbor



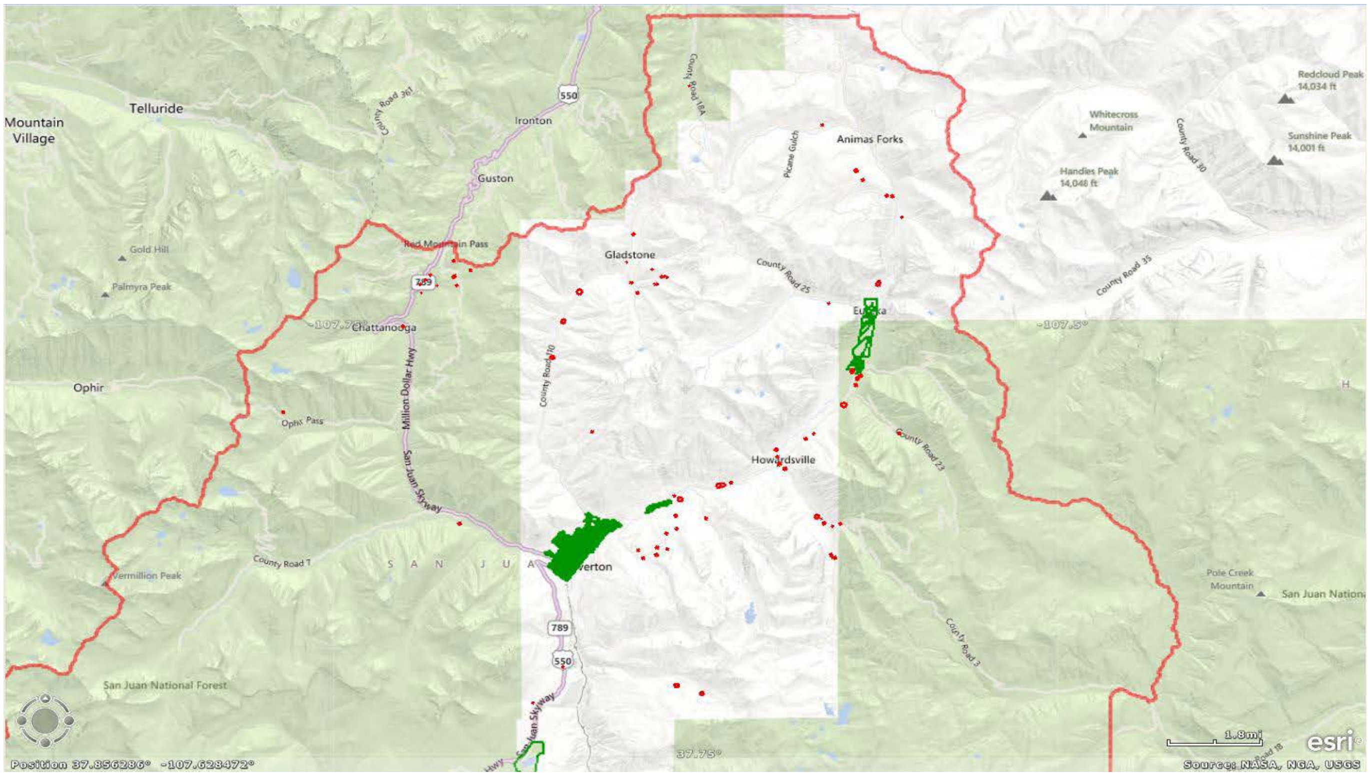
Cascade Village



Cascade Creek Summer Home Group

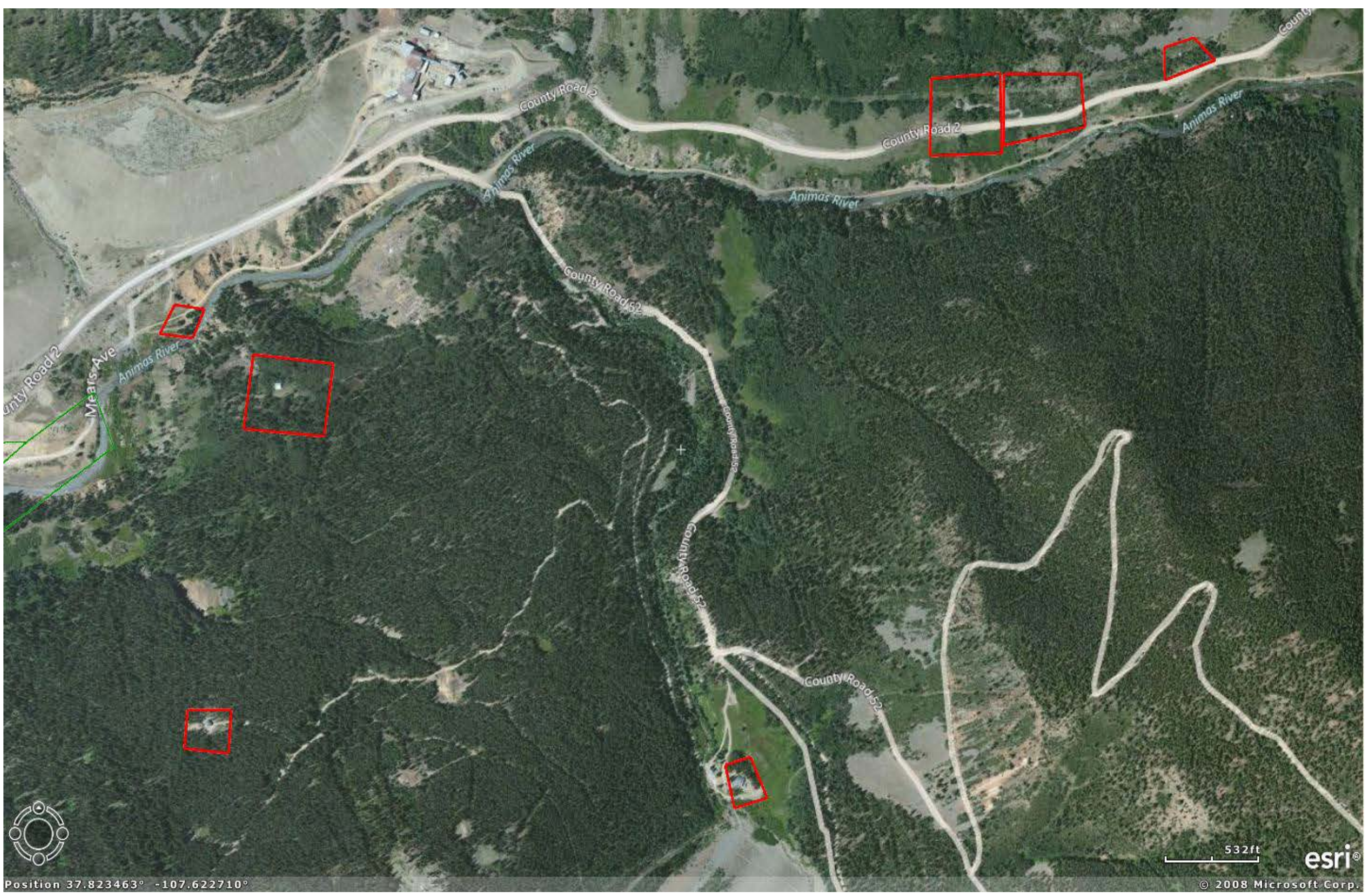


San Juan County Cabin Location Overview



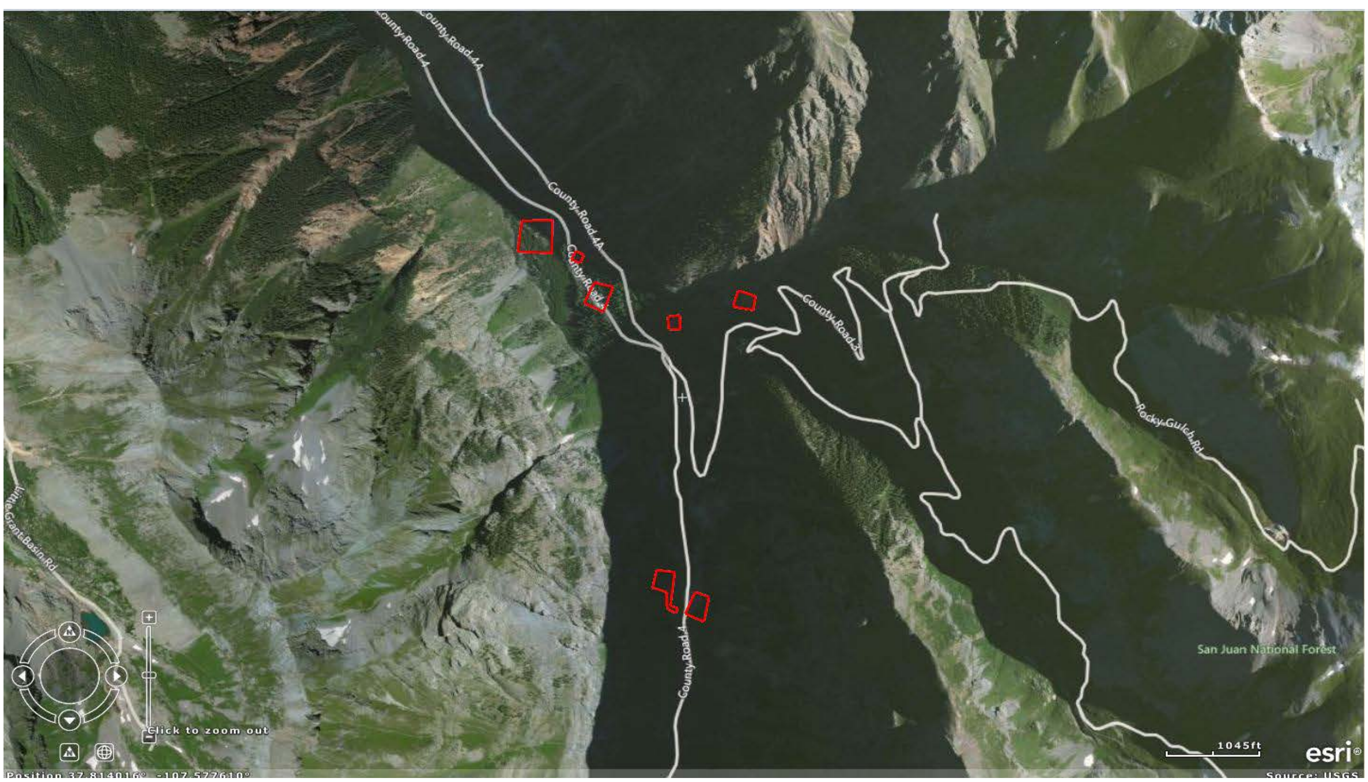
Swansea and Blair

Blair and Arastra

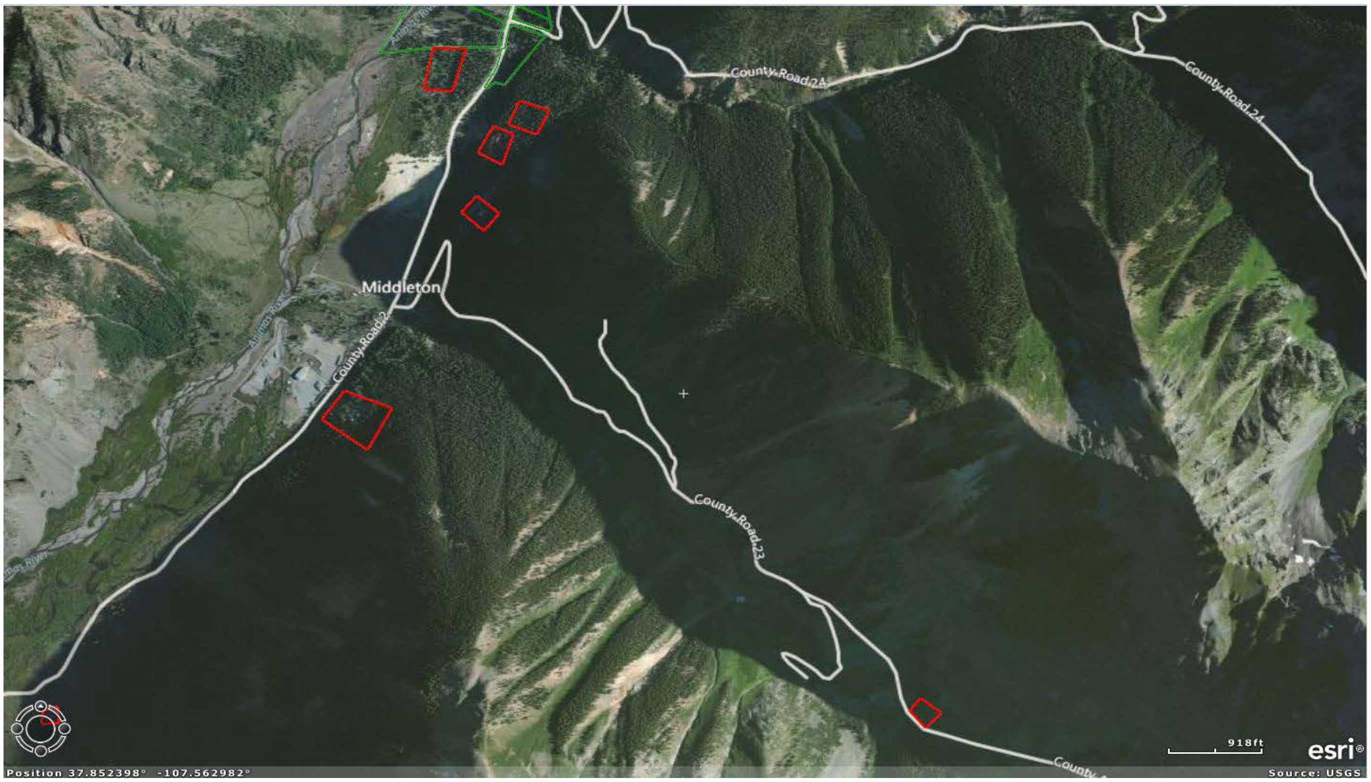


Howardsville

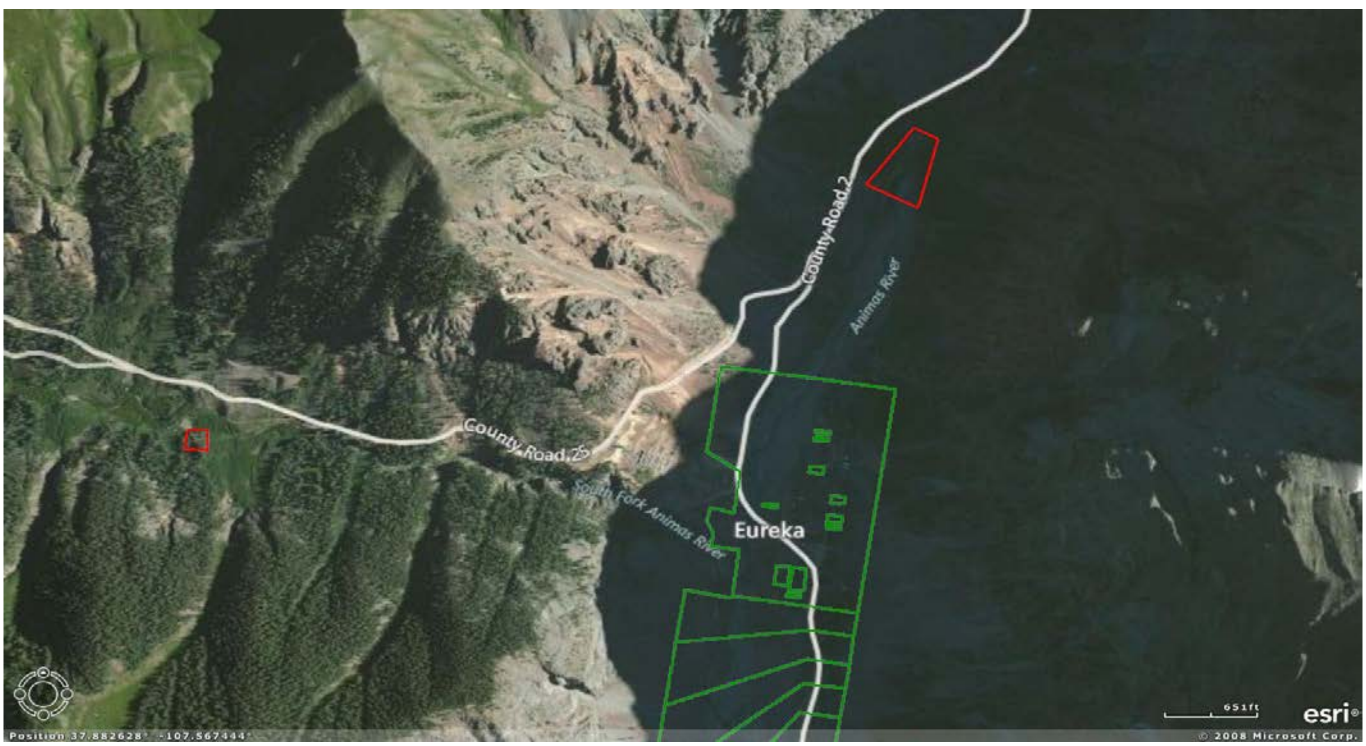
Cunningham



Middleton



Eureka

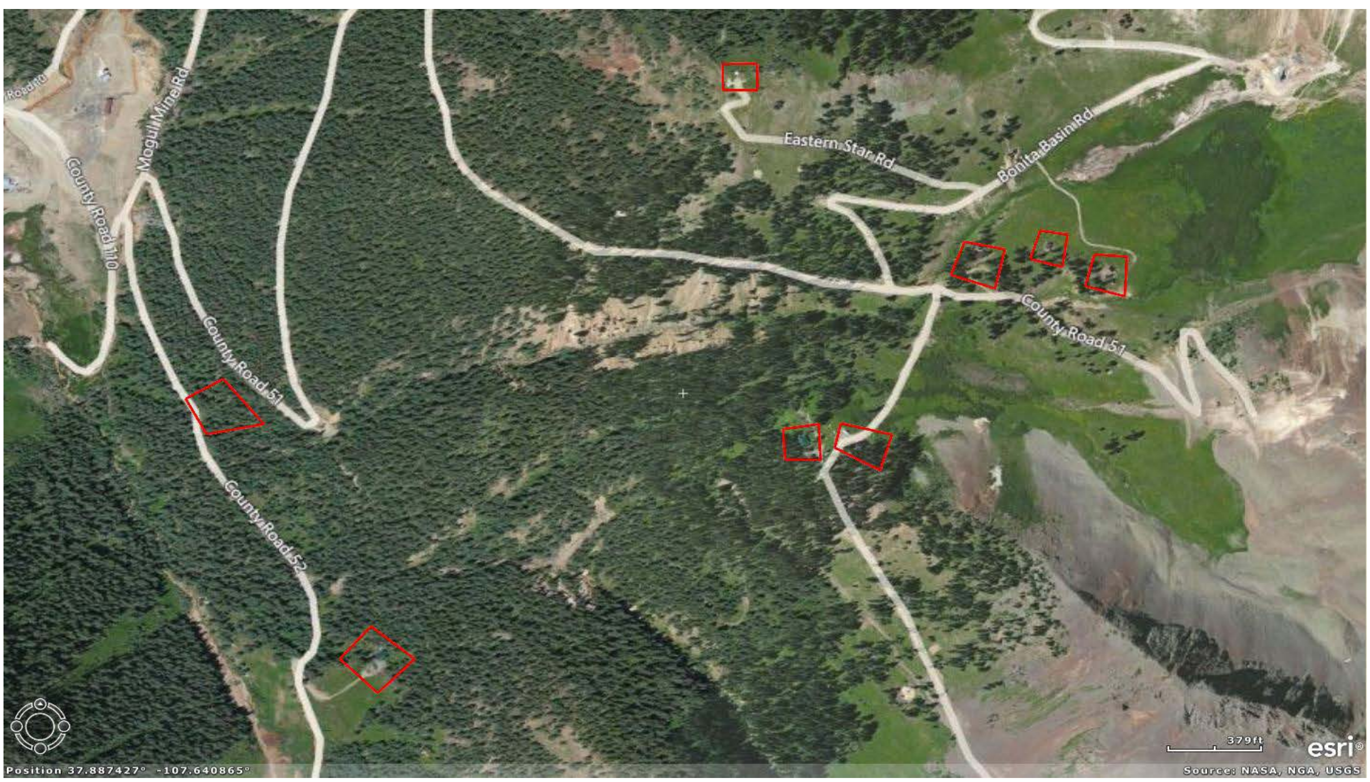


Picayune

Animas Forks

Poughkeepsie

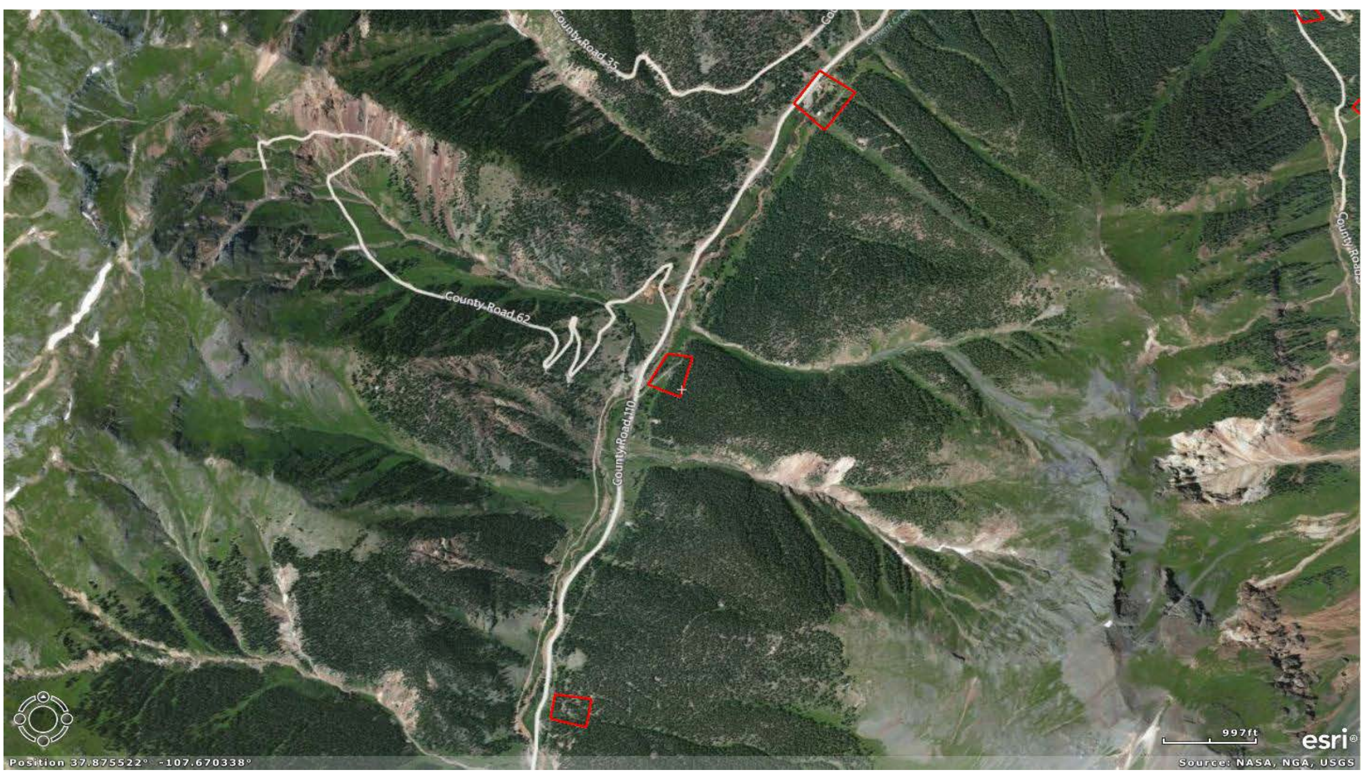
Minniehaha & Gladstone



Mogul


County Road 110
Mogul Mine Rd
445ft
esri

CR 110


County Road 35
County Road 62
County Road 110
997ft
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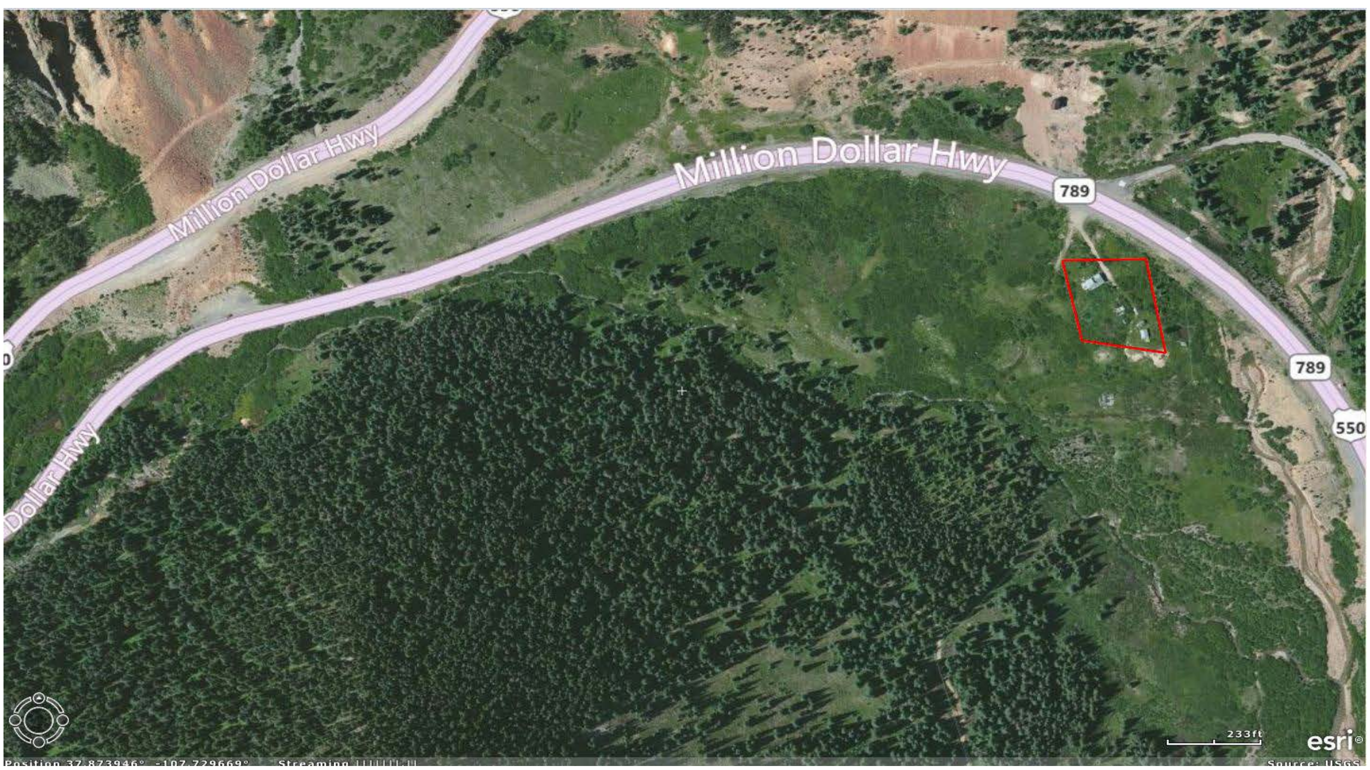
Source: NASA, NGA, USGS

Hancock Gulch

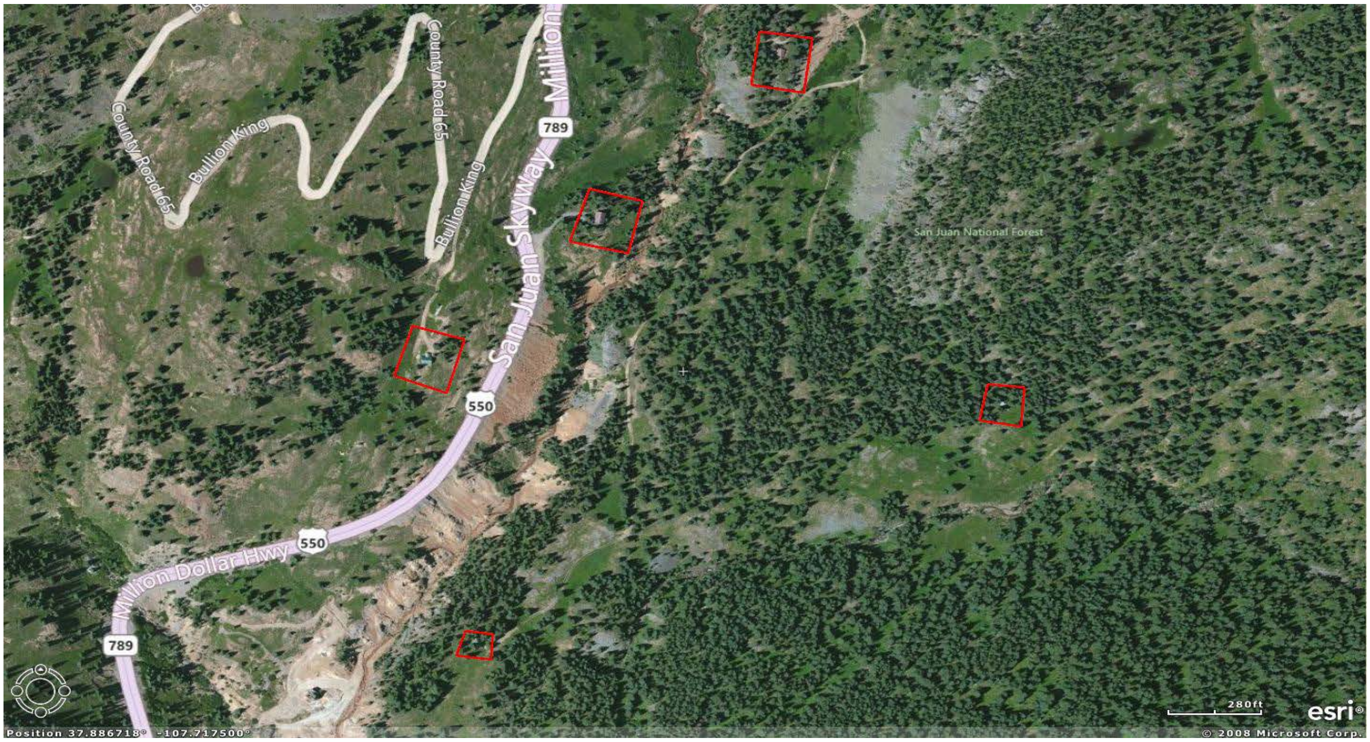
South Mineral

Ophir Pass

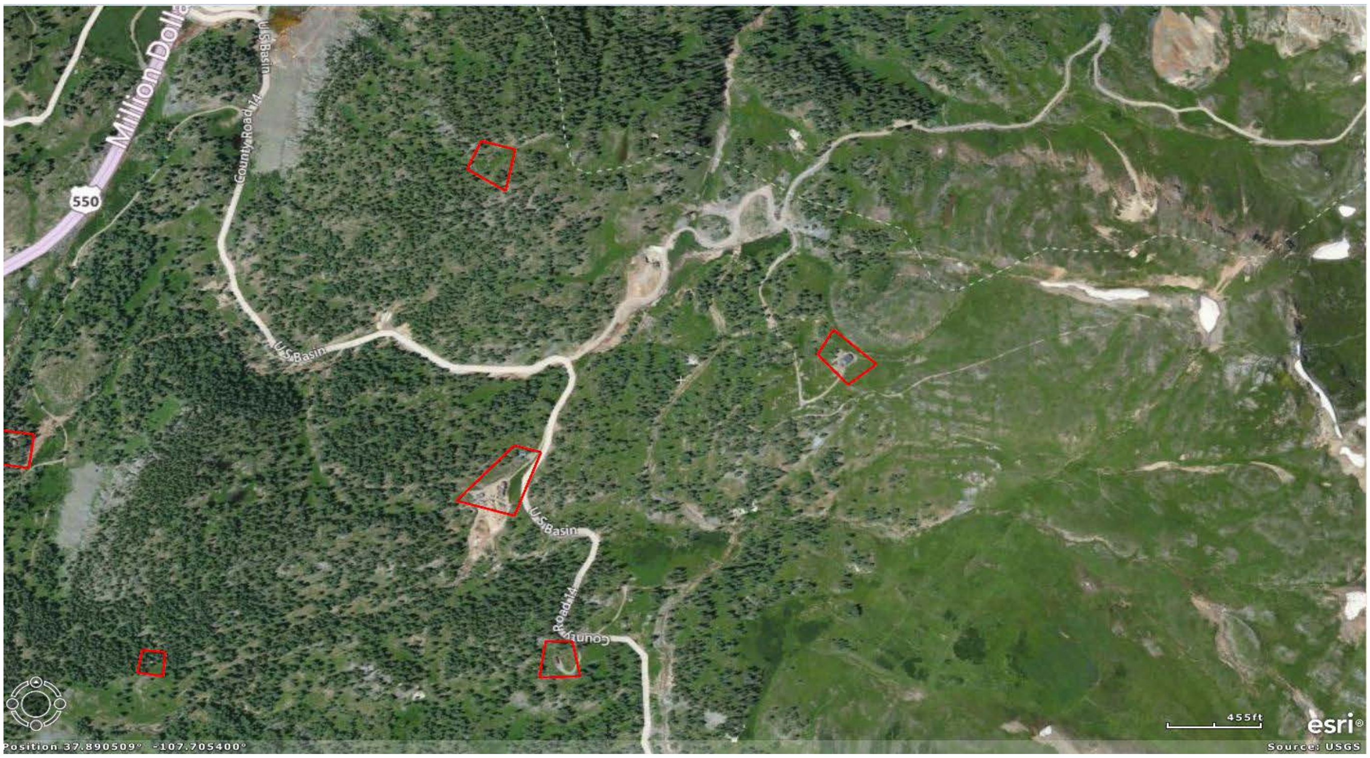
Chattanooga



Red Mountain

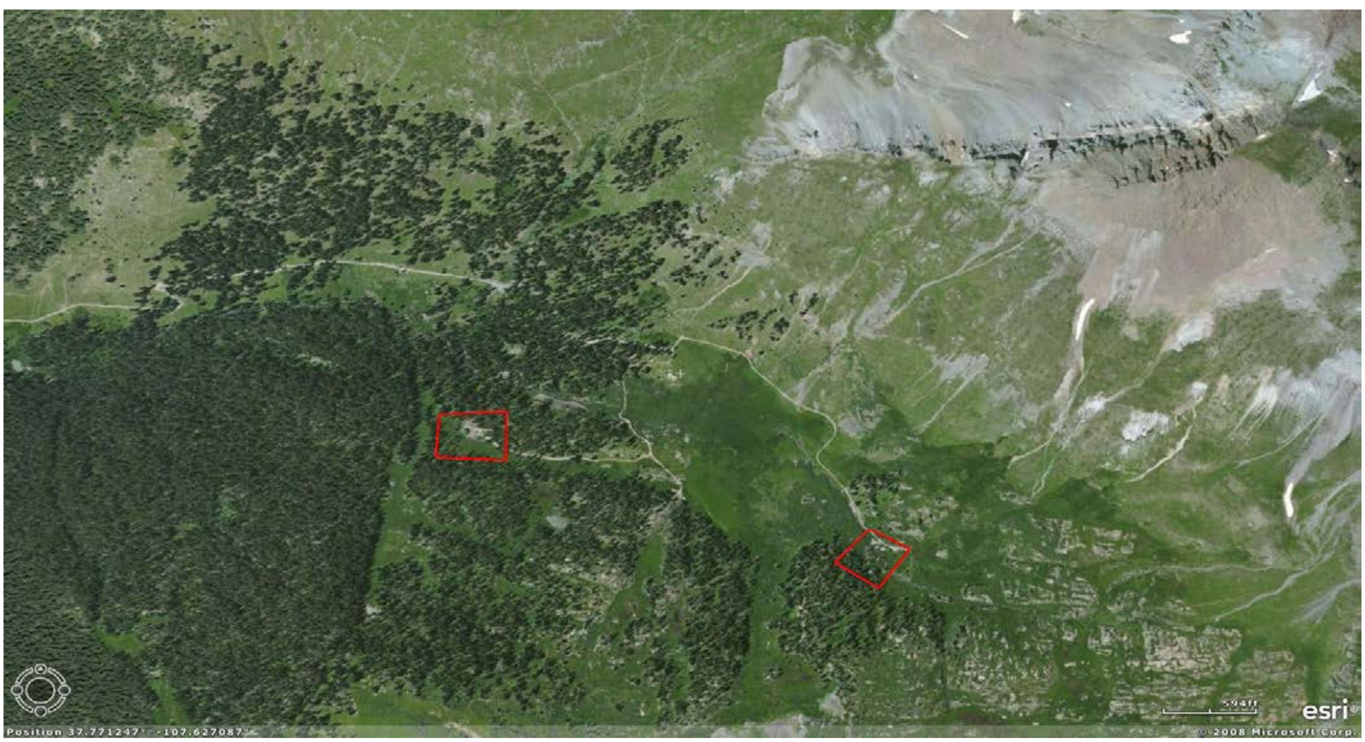


Top of Red Mountain



US 550 South of Silverton

Deer Park



QUICK GUIDE SERIES FIRE 2012-1

Protecting Your Home from Wildfire:

Creating Wildfire-Defensible Zones

Formerly CSU Extension Factsheet 6.302

If your home is located in the natural vegetation of Colorado's grasslands, shrublands, foothills or mountains, you live in the **wildland-urban interface** (WUI) and are inherently at risk from a wildfire. The WUI is any area where structures and other human developments meet or intermingle with wildland vegetative fuels. In many vegetation types, it is not a matter of ***if*** a wildfire will impact your home, but ***when***.

Figure 1: ***Firefighters will do their best to protect homes, but ultimately it is the homeowner's responsibility to plan ahead and take actions to reduce fire hazards around structures. Photo: National Interagency Fire Center***

Wildfires are a natural part of Colorado's varied forest ecosystems. Many rural communities are located in areas historically prone to frequent natural wildfires. Living in the wildland requires more self-reliance than living in urban areas. It may take longer for a fire engine to reach your area, and a small fire department can easily become overwhelmed during an escalating wildfire. Planning ahead and taking actions to reduce fire hazards can increase your safety and help protect your property. As more people choose to live in areas prone to wildfire, additional homes and lives are potentially threatened every year. Firefighters always do their best to protect rural residents, but ultimately, **it is YOUR responsibility to protect your life, family, animals and property from wildfire.**

The information contained in this document is for use by individual landowners to help reduce wildfire risk on their property. In order to effectively protect subdivisions and communities, all landowners must work together to reduce fire hazards within and adjacent to communities. This includes treating individual home sites and common areas within communities, and creating fuelbreaks within and adjoining the community where feasible. This document will focus on actions individual landowners can take to reduce wildfire hazards on their property. For additional information on broader community protection, go to www.csfs.colostate.edu.

Figure 2: *Colorado's grasslands, shrublands, foothills and mountains all have areas in the wildland-urban interface where human development meets wildland vegetative fuels. Photo: CSFS*

In this guide, you'll read about steps you can take to protect your property from wildfire. These steps focus on beginning work closest to your house and moving outward. Also, remember that keeping your home safe is not a one-time effort – it requires ongoing maintenance. It may be necessary to perform some actions, such as removing pine needles from gutters and mowing grasses and weeds several times a year, while other actions may only need to be addressed once a year. While

This quick guide was produced by the Colorado State Forest Service to promote knowledge transfer.

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www.csfs.colostate.edu

you may not be able to accomplish ALL of the actions described in this document to prepare your home for wildfire, each completed activity will increase the safety of your home, and possibly your family, during a wildfire.

Figure 3: ***Burning embers can be carried long distances by wind. Embers ignite structures when they land in gaps, crevices and other combustible places around the home. Photo: CSFS***

(Note: These guidelines are adapted for ponderosa pine, Douglas-fir and mixed-conifer ecosystems below 9,500 feet. See page 9 for guidelines adapted to other forest ecosystems.)

This guide primarily will help design your defensible space. **Defensible space** is the natural and landscaped area around a home or other structure that has been modified to reduce fire hazard. Defensible space gives your home a fighting chance against an approaching wildfire. Creating defensible space also reduces the chance of a structure fire spreading to the surrounding forest and other homes.

Three factors determine wildfire behavior: **fuels, weather** and **topography**. We cannot alter weather or topography, so we must concentrate on altering fuels. Fuels include vegetation, such as trees, brush and grass; near homes, fuels also include such things as propane tanks, wood piles, sheds and even homes themselves. Some plant species are more flammable than others, and the flammability of vegetative fuels changes depending on the season, recent weather events, and other factors such as drought. Fuel continuity and density also play an important role in wildfire.

Wildfire often creates its own weather conditions. Hot rising air and associated winds can carry embers and other burning materials into the atmosphere for long distances, where they can ignite vegetation and structures up to several miles away. Embers have caused the loss of many homes during wildfires.

As you think about protecting your home and property from wildfire, consider how you can manage fuels on your property to prevent fire from spreading to your home and other structures.

For more information on wildfire behavior, please see *FireWise Construction: Site Design and Building Materials* at www.csfs.colostate.edu.

Remember...

- ***Reducing fuels around a home will increase the chances for survival in a wildfire, but there is no guarantee.***
- ***This quick guide provides minimum guidelines. The more fuels you remove, the greater the chance your home will survive.***
- ***Working with your neighbors and community will increase the effectiveness of your home's defensible space.***

Fuel Arrangement and Types

When fuels are abundant, a fire can be uncontrollable and destructive. But when fuels are scarce, a fire cannot build momentum and intensity, which makes it much easier to control and is more likely to be beneficial to the land.

The more dense and continuous the fuels, the bigger the threat they pose to your home. The measure of fuel hazard refers to its continuity, both horizontal and vertical. Horizontal continuity refers to fuels across the ground, while vertical continuity refers to fuels extending from the ground up into the crowns of trees and shrubs. Fuels with a high degree of both vertical and horizontal continuity are the most hazardous, particularly when they occur on slopes. Mitigation of wildfire hazards focuses on breaking up the continuity of horizontal and vertical fuels.

Heavier fuels, such as brush and trees, produce a more intense fire than light fuels, such as grass. However, grass-fueled fires travel much faster than heavy-fueled fires. Some heavier surface fuels, such as logs and wood chips, are potentially hazardous heavy fuels and also should be addressed.

Vertical/Ladder Fuels

Ladder fuels are defined as smaller trees and brush that provide vertical continuity, which allows a fire to burn from the ground level up into the branches and crowns of larger trees. Lower branches on large trees also can act as ladder fuels. These fuels are potentially very hazardous, but are easy to mitigate. The hazards from ladder fuels near homes are especially important to address. Prune all tree branches from ground level up to a height of 10 feet above ground or up to 1/3 the height of the tree, whichever is less. Do not prune further up because it could jeopardize the health of the tree. Shrubs should be pruned based on specifications recommended for the species. Dead branches should be removed whenever possible.

Figure 4: *Ladder fuels are shrubs and low branches that allow a wildfire to climb from the ground into the tree canopy. Photo: CSFS*

Surface Fuels

Logs/Branches/Slash/Wood Chips

Naturally occurring woody material on the ground and debris from cutting down trees (also known as slash) may increase the intensity of fires. Increased fire intensity makes a fire harder to control and increases the likelihood of surface fires transitioning to crown fires. Dispose of any heavy accumulation of logs, branches and slash by chipping, hauling to a disposal site or piling for burning later. Always contact your county sheriff's office or local fire department first for information about burning slash piles. Another alternative is to lop and scatter slash by cutting it into very small pieces and distributing it widely over the ground. If chipping logs and/or slash, it's essential to avoid creating continuous areas of wood chips on the ground. Break up the layer of wood chips by adding nonflammable material, or allow for wide gaps (at least 3 feet) between chip accumulations. Also, avoid heavy accumulation of slash by spreading it closer to the ground to speed decomposition. If desired, two or three small, widely spaced brush piles may be left for wildlife habitat. Locate these well away from your home (NOT in Zones 1 or 2; see page 5-8 for zone descriptions).

Figure 5: *Surface fuels include logs, branches, wood chips, pine needles, duff and grasses. Photo: CSFS*

Pine Needles/Duff Layers

Due to decades of fire suppression, decomposing layers of pine needles, twigs and other organic debris–called duff – is deeper under many large trees today than it would have been a century ago. This is especially true in ponderosa pine forests where frequent and naturally occurring fires have been absent. These large trees often are lost when fires occur, because flames burning in the duff layer can pre-heat live vegetation and ignite the trees, or the tree's roots can be damaged from the intense heat of the smoldering duff, killing the tree. It is important to rake needle or duff layers deeper than 2 inches at least 3 feet away from the base of large trees. This should be done annually, and the additional duff also should be removed from the area.

Grasses

Grasses are perhaps the most pervasive and abundant surface fuel in Colorado. Mow grasses and weeds as often as needed throughout the growing season to keep them shorter than 6 inches. This applies to irrigated lawns and wild or native grasses. This is critical in the fall, when grasses dry out, and in the spring, after the snow is gone but before plants green-up.

Be especially careful when mowing in areas with rocks. Mower blades can hit rocks and create sparks, causing fires in dry grass. Consider mowing only on days with high humidity or after recent moisture to reduce the risk of starting an unwanted fire.

Figure 6: *Tree canopies offer fuel for intense crown fires. Photo: Paul Mintier*

When mowing around trees, be sure to avoid damaging the root system and tree trunk by using a higher blade setting on the mower and trimming grass that grows against the trunk only by hand.

Crown Fuels

An intense fire burning in surface fuels can transition into the upper portion of the tree canopies and become a crown fire. Crown fires are dangerous because they are very intense and can burn large areas. Crown fire hazard can be reduced by thinning trees to decrease crown fuels, reducing surface fuels under the remaining trees, and eliminating vertical fuel continuity from the surface into the crowns. Specific recommendations are provided in the Defensible Space Management Zones, pages 5-8.

Figure 7: ***Addressing both components of the Home Ignition Zone will provide the best protection for your home. Credit: CSFS***

The Home Ignition Zone

Two factors have emerged as the primary determinants of a home's ability to survive a wildfire – the quality of the defensible space and a structure's ignitability. Together, these two factors create a concept called the **Home Ignition Zone** (HIZ), which includes the structure and the space immediately surrounding the structure. To protect a home from wildfire, the primary goal is to reduce or eliminate fuels and ignition sources within the HIZ.

Structural Ignitability

The ideal time to address home ignition risk is when the structure is in the design phase. However, you can still take steps to reduce ignitability to an existing home.

The **roof** has a significant impact on a structure's ignitability because of its extensive surface area. When your roof needs significant repairs or replacement, use only fire-resistant roofing materials. Also, check with your county building department – some counties now have restrictions against using wood shingles for roof replacement or require specific classifications of roofing material. Wood and shake-shingle roofs are discouraged because they are highly flammable, and are prohibited in some areas of the state. Asphalt shingles, metal sheets and shingles, tile, clay tile, concrete and slate shingles are all recommended roofing materials.

Figure 8: ***(above) Wood shingle roofs are highly flammable and not recommended. Photo: CSFS***

Figure 9: ***(above right) Class A roofing materials including tile, clay, concrete, slate and asphalt shingles are fire-resistant options. Photo: CSFS***

The extension of the roof beyond the exterior structure wall is the eave. This architectural feature is particularly prone to ignition. As fire approaches the building, the exterior wall deflects hot air and gasses up into the eave. If the exterior wall isn't ignition-resistant, this effect is amplified.

Most **decks** are highly combustible. Their shape traps hot gasses, making them the ultimate heat traps. Conventional wooden decks are so combustible that when a wildfire approaches, the deck often ignites before the fire reaches the house.

The **exterior walls** of a home or other structure are affected most by radiant heat from the fire and, if defensible space is not adequate, by direct contact with flames from the fire.

Figure 10: ***Decks, exterior walls and windows are important areas to examine when addressing structure ignitability. Photo: CSFS***

Windows are one of the weakest parts of a building with regard to wildfire. They usually fail before the building ignites, providing a direct path for flames and airborne embers to reach the building's interior.

Burning embers are produced when trees and structures are consumed by wildfire. These embers sometimes can travel more than a mile. Flammable horizontal or nearly horizontal surfaces, such as wooden decks or shake-shingle roofs, are especially at risk for ignition from burning embers. Since airborne embers have caused the loss of many homes in the WUI, addressing structural ignitability is critical, even if the area surrounding a home is not conducive to fire spread.

This guide provides only basic information about structural ignitability. For more information on fire-resistant building designs and materials, refer to the CSFS *FireWise Construction: Site Design and Building Materials* publication at www.csfs.colostate.edu.

Defensible Space

Defensible space is the area around a home or other structure that has been modified to reduce fire hazard. In this area, natural and manmade fuels are treated, cleared or reduced to slow the spread of wildfire. Creating defensible space also works in the reverse, and reduces the chance of a structure fire spreading to neighboring homes or the surrounding forest. Defensible space gives your home a fighting chance against an approaching wildfire.

Creating an effective defensible space involves a series of management zones in which different treatment techniques are used. Develop these zones around each building on your property, including detached garages, storage buildings, barns and other structures.

Figure 11: ***Homesite before defensible space. Photo: CSFS***

The actual design and development of your defensible space depends on several factors: size and shape of building(s), construction materials, slope of the ground, surrounding topography, and sizes and types of vegetation on your property. You may want to request additional guidance from your local Colorado State Forest Service forester, fire department or a consulting forester as you plan a defensible space for your property.

Defensible space provides another important advantage during a fire: increased firefighter safety. Firefighters are trained to protect structures only when the situation is relatively safe for them to do so. They use a process called "structural triage" to determine if it is safe to defend a home from an approaching wildfire. The presence or absence of defensible space around a structure is a significant determining factor used in the structural triage process, as defensible space gives firefighters an opportunity to do their job more safely. In turn, this increases their ability to protect your home.

Figure 12: ***Homesite after creating a defensible space. Photo: CSFS***

If firefighters are unable to directly protect your home during a wildfire, having an effective defensible space will still increase your home's chance of survival. It is important to remember that with wildfire, there are no guarantees. Creating a proper defensible space does not mean that your home is guaranteed to survive a wildfire, but it does significantly improve the odds.

Defensible Space Management Zones

Three zones need to be addressed when creating defensible space:

Zone 1 is the area nearest the home and other structures. This zone requires maximum hazard reduction.

Zone 2 is a transitional area of fuels reduction between Zones 1 and 3.

Zone 3 is the area farthest from the home. It extends from the edge of Zone 2 to your property boundaries.

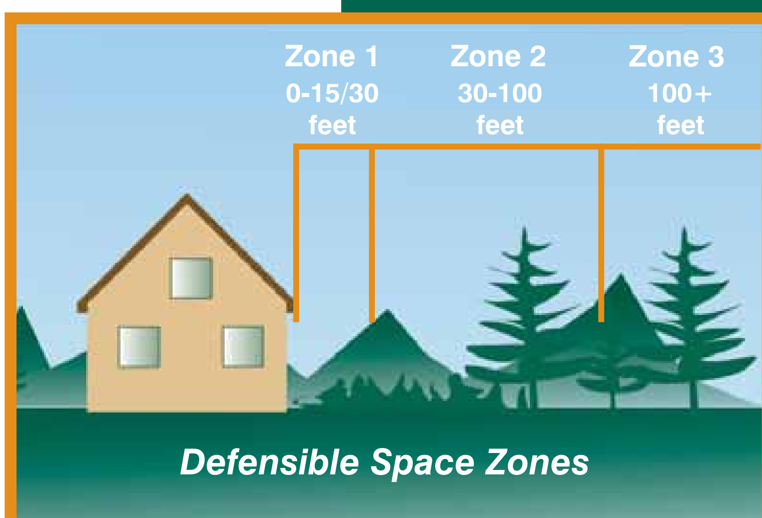

Figure 13: ***Defensible space management zones. Credit: CSFS***

Figure 14: ***This homeowner worked hard to create a defensible space around the home. Notice that all fuel has been removed within the first 5 feet of the home, which survived the Waldo Canyon Fire in the summer of 2012. Photo: Christina Randall, Colorado Springs Fire Department***

Figure 15: ***Clearing pine needles and other debris from the roof and gutters is an easy task that should be done at least once a year. Photo: CSFS***

Figure 16: ***Enclosing decks with metal screens can prevent embers from igniting a house. Photo: Marilyn Brown, La Plata County***

Zone 1

The width of Zone 1 extends a minimum distance of 15-30 feet outward from a structure, depending on property size. Most flammable vegetation is removed in this zone, with the possible exception of a few low-growing shrubs or fire-resistant plants. Avoid landscaping with common ground junipers, which are highly flammable.

Increasing the width of Zone 1 will increase the structure's survivability. This distance should be increased 5 feet or more in areas downhill from a structure. The distance should be measured from the outside edge of the home's eaves and any attached structures, such as decks. Several specific treatments are recommended within this zone:

- Install nonflammable ground cover and plant nothing within the first 5 feet of the house and deck. This critical step will help prevent flames from coming into direct contact with the structure. This is particularly important if a building is sided with wood, logs or other flammable materials. Decorative rock creates an attractive, easily maintained, nonflammable ground cover.
- If a structure has noncombustible siding (i.e., stucco, synthetic stucco, concrete, stone or brick), widely spaced foundation plantings of low-growing shrubs or other fire-resistant plant materials are acceptable. However, do not plant directly under windows or next to foundation vents, and be sure areas of continuous grass are not adjacent to plantings. Information on fire-resistant plants is available on the CSFS website at www.csfs.colostate.edu.
- Prune and maintain any plants in Zone 1 to prevent excessive growth. Also, remove all dead branches, stems and leaves within and below the plant.
- Irrigate grass and other vegetation during the growing season. Also, keep wild grasses mowed to a height of 6 inches or less.
- Do not store firewood or other combustible materials anywhere in this zone. Keep firewood at least 30 feet away from structures, and uphill if possible.
- Enclose or screen decks with $^{1}/_{8}$-inch or smaller metal mesh screening ($^{1}/_{16}$-inch mesh is preferable). Do not use areas under decks for storage.
- Ideally, remove all trees from Zone 1 to reduce fire hazards. The more trees you remove, the safer your home will be.
- If you do keep any trees in this zone, consider them part of the structure and extend the distance of the entire defensible space accordingly.
- Remove any branches that overhang or touch the roof, and remove all fuels within 10 feet of the chimney.
- Remove all pine needles and other debris from the roof, deck and gutters.
- Rake pine needles and other organic debris at least 10 feet away from all decks and structures.
- Remove slash, wood chips and other woody debris from Zone 1.

Zone 2

Zone 2 is an area of fuels reduction designed to diminish the intensity of a fire approaching your home. The width of Zone 2 depends on the slope of the ground where the structure is built. Typically, the defensible space in Zone 2 should extend at least 100 feet from all structures. If this distance stretches beyond your property lines, try to work with the adjoining property owners to complete an appropriate defensible space.

The following actions help reduce continuous fuels surrounding a structure, while enhancing home safety and the aesthetics of the property. They also will provide a safer environment for firefighters to protect your home.

Tree Thinning and Pruning

- Remove stressed, diseased, dead or dying trees and shrubs. This reduces the amount of vegetation available to burn, and makes the forest healthier.
- Remove enough trees and large shrubs to create at least 10 feet between crowns. Crown separation is measured from the outermost branch of one tree to the nearest branch on the next tree. On steep slopes, increase the distance between tree crowns even more.
- Remove all ladder fuels from under remaining trees. Prune tree branches off the trunk to a height of 10 feet from the ground or $1/3$ the height of the tree, whichever is less.

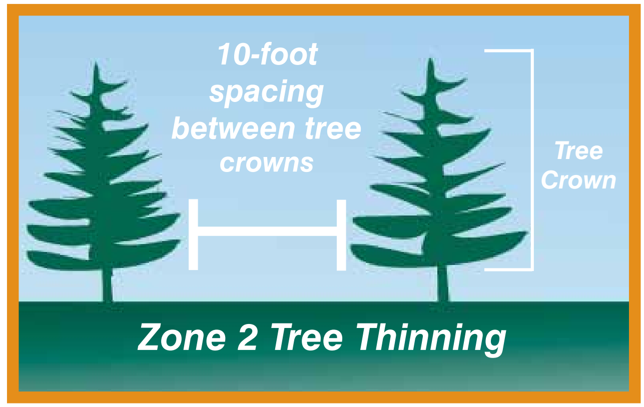

Figure 17: *In Zone 2, make sure there is at least a 10-foot spacing between tree crowns. Credit: CSFS*

- If your driveway extends more than 100 feet from your home, thin out trees within a 30 foot buffer along both sides of your driveway, all the way to the main access road. Again, thin all trees to create 10-foot spacing between tree crowns.
- Small groups of two or three trees may be left in some areas of Zone 2, but leave a minimum of 30 feet between the crowns of these clumps and surrounding trees.
- Because Zone 2 forms an aesthetic buffer and provides a transition between zones, it is necessary to blend the requirements for Zones 1 and 3. For example, if you have a tree in Zone 2 with branches extending into Zone 1, the tree can be retained if there is proper crown spacing.
- Limit the number of dead trees (snags) to one or two per acre. Be sure snags cannot fall onto the house, power lines, roads or driveways.
- As in Zone 1, the more trees and shrubs removed, the more likely your house will survive a wildfire.

Shrub Thinning/Pruning and Surface Fuels

- Isolated shrubs may be retained in Zone 2, provided they are not growing under trees.
- Keep shrubs at least 10 feet away from the edge of tree branches. This will prevent the shrubs from becoming ladder fuels.
- Minimum spacing recommendations between clumps of shrubs is $2\ 1/2$ times the mature height of the vegetation. The maximum diameter of the clumps themselves should be twice the mature height of the vegetation. As with tree-crown spacing, all measurements are made from the edge of vegetation crowns.

Figure 18: *Pruning trees will help prevent a wildfire from climbing from the ground to the tree crowns. Credit: CSFS*

- Example – For shrubs 6 feet high, spacing between shrub clumps should be 15 feet or more (measured from the edge of the crowns of vegetation clumps). The diameter of these shrub clumps should not exceed 12 feet.
- Periodically prune and maintain shrubs to prevent excessive growth, and remove dead stems from shrubs annually. Common ground junipers should be removed whenever possible because they are highly flammable and tend to hold a layer of duff beneath them.
- Mow or trim wild grasses to a maximum height of 6 inches. This is especially critical in the fall, when grasses dry out.
- Avoid accumulations of surface fuels, such as logs, branches, slash and wood chips greater than 4 inches deep.

Firewood

- Stack firewood uphill from or on the same elevation as any structures, and at least 30 feet away.
- Clear all flammable vegetation within 10 feet of woodpiles.
- Do not stack wood against your home or on/under your deck, even in the winter. Many homes have burned as a result of a woodpile that ignited first.

Figure 19: *Keep firewood, propane tanks and natural gas meters at least 30 feet away from structures. Photo: CSFS*

Propane Tanks and Natural Gas Meters

- Locate propane tanks and natural gas meters at least 30 feet from any structures, preferably on the same elevation as the house.
- The tank should not be located below your house because if it ignites, the fire would tend to burn uphill. Conversely, if the tank or meter is located above your house and it develops a leak, gas will flow downhill into your home.
- Clear all flammable vegetation within 10 feet of all tanks and meters.
- Do not visibly screen propane tanks or natural gas meters with shrubs, vegetation or flammable fencing. Instead, install 5 feet of nonflammable ground cover around the tank or meter.

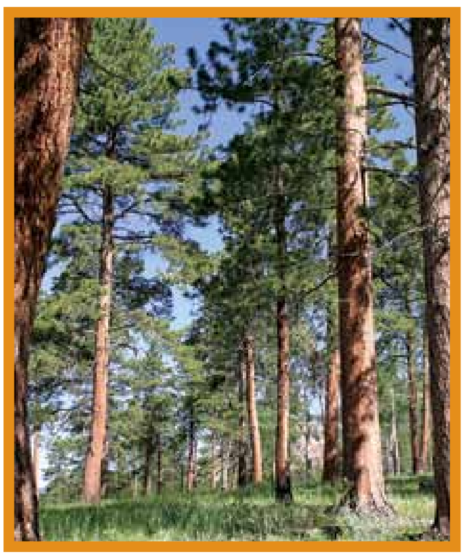

Figure 20: *This ponderosa pine forest has been thinned, which will not only help reduce the wildfire hazard, but also increase tree health and vigor. Photo: CSFS*

Zone 3

Zone 3 has no specified width. It should provide a gradual transition from Zone 2 to areas farther from the home that have other forest management objectives. Your local Colorado State Forest Service forester can help you with this zone.

This zone provides an opportunity for you to improve the health of the forest through proper management. With an assortment of stewardship options, you can proactively manage your forest to reduce wildfire intensity, protect water quality, improve wildlife habitat, boost the health and growth rate of your trees, and increase tree survivability during a wildfire.

In addition, properly managed forests can provide income, help protect trees against insects and diseases, and even increase the value of your property. Typical forest management objectives for areas surrounding home sites or subdivisions provide optimum recreational opportunities; enhance aesthetics; improve tree health and vigor; provide barriers against wind, noise, dust and visual intrusions; support production of firewood, fence posts and other forest commodities; or cultivate Christmas trees or trees for transplanting.

Consider the following when deciding forest management objectives in Zone 3:

- The healthiest forest is one that includes trees of multiple ages, sizes and species, and where adequate growing room is maintained over time.
- Remember to consider the hazards associated with ladder fuels. A forest with a higher canopy reduces the chance of a surface fire climbing into the tops of the trees, and might be a priority if this zone has steep slopes.
- A greater number of snags – two or three per acre, standing or fallen – can be retained in Zone 3 to provide wildlife habitat. These trees should have a minimum diameter of 8 inches. Make sure that snags pose no threat to power lines or firefighter access roads.
- While tree pruning generally is not necessary in Zone 3, it may be a good idea from the standpoint of personal safety to prune trees along trails and firefighter access roads. Or, if you prefer the aesthetics of a well-manicured forest, you might prune the entire area. In any case, pruning helps reduce ladder fuels within tree stands, thus reducing the risk of crown fire.
- Mowing grasses is not necessary in Zone 3.
- Any approved method of slash treatment is acceptable, including piling and burning, chipping or lop-and-scatter.

Other Recommendations

Windthrow

In Colorado, some tree species, including lodgepole pine, Engelmann spruce and Douglas-fir, are especially susceptible to damage and uprooting by high winds or windthrow. If you see evidence of this problem in or near your home, consider making adjustments to the defensible space guidelines. It is highly recommended that you contact a professional forester to help design your defensible space, especially if you have windthrow concerns.

Figure 21: ***During high winds, these lodgepole pine trees fell onto the house. Lodgepole pine is highly susceptible to windthrow. Photo: CSFS***

Water Supply

If possible, make sure that an on-site water source is readily available for firefighters to use, or that other water sources are close by. Lakes, ponds, swimming pools and hot tubs are all possible options. If there are no nearby water sources, consider installing a well-marked dry hydrant or cistern. If your primary water source operates on electricity, be sure to plan for a secondary water source. During wildfires, structures often are cut off from electricity. For more information on how to improve the accessibility of your water source, contact your local fire department.

Recommendations for Specific Forest Types

The above recommendations refer primarily to ponderosa pine, Douglas-fir and mixed-conifer ecosystems. For other forest types, please refer to the additional recommendations below:

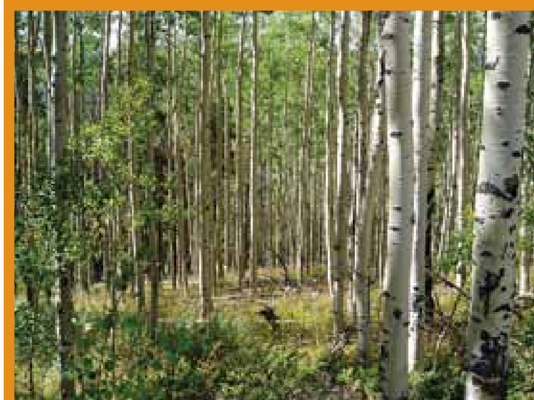

Figure 22: ***Mature aspen stands can contain many young conifers, dead trees and other organic debris. This can become a fire hazard. Photo: CSFS***

Aspen

Tree spacing and ladder fuel guidelines do not apply to mature stands of aspen trees. Generally, no thinning is recommended in aspen forests, regardless of tree size, because the thin bark is easily damaged, making the tree easily susceptible to fungal infections. However, in older stands, numerous dead trees may be on the ground and require removal. Conifer trees often start growing in older aspen stands. A buildup of these trees eventually will increase the fire hazard of the stand, so you should remove the young conifers. Brush also can increase the fire hazard and should be thinned to reduce flammability.

Lodgepole Pine

Lodgepole pine management in the WUI is much different than that for lodgepole pine forests located away from homes, communities and other developments. Normally, it is best to develop fuels management and wildfire mitigation strategies that are informed and guided by the ecology of the tree species. This is not the case with lodgepole pine.

Figure 23: ***A young lodgepole pine stand. Thinning lodgepole pines early on in their lives will help reduce the wildfire hazard in the future. Photo: CSFS***

Older lodgepole pine stands generally do not respond well to selective thinning, but instead respond better to the removal of all trees over a defined area to allow healthy forest regeneration. Selectively thinning lodgepole can open the stand to severe windthrow and stem breakage. However, if your home is located within a lodgepole pine forest, you may prefer selective thinning to the removal of all standing trees.

To ensure a positive response to thinning throughout the life of a lodgepole pine stand, trees must be thinned early in their lives – no later than 20 to 30 years after germination. Thinning lodgepole pine forests to achieve low densities can best be accomplished by beginning when trees are small saplings, and maintaining those densities through time as the trees mature.

Thinning older stands of lodgepole pine to the extent recommended for defensible space may take several thinning operations spaced over a decade or more. When thinning mature stands of lodgepole pine, do not remove more than 30 percent of the trees in each thinning operation. Extensive thinning of dense, pole-sized and larger lodgepole pine often results in windthrow of the remaining trees. Focus on removing trees that are obviously lower in height or suppressed in the forest canopy. Leaving the tallest trees will make the remaining trees less susceptible to windthrow.

The defensible space guidelines in this quick guide are predominantly for ponderosa pine and mixed-conifer forests. These guidelines will vary with other forest types.

Another option is leaving clumps of 30-50 trees. Clumps are less susceptible to windthrow than solitary trees. Allow a minimum of 30-50 feet between tree crowns on the clump perimeter and any adjacent trees or clumps of trees. Wildfire tends to travel in the crowns of lodgepole pine. By separating clumps of trees with large spaces between crowns, the fire is less likely to sustain a crown fire.

Piñon-Juniper

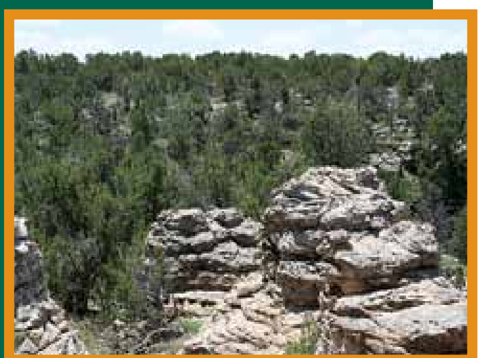

Figure 24: ***Piñon-juniper forests are often composed of continuous fuels. Creating clumps of trees with large spaces in between clumps will break up the continuity. Photo: CSFS***

Many piñon-juniper (PJ) forests are composed of continuous fuel that is highly flammable. Fire in PJ forests tend to burn intensely in the crowns of trees. Try to create a mosaic pattern when you thin these trees, with a mixture of individual trees and clumps of three to five trees. The size of each clump will depend on the size, health and location of the trees. The minimum spacing between individual trees should be 10 feet between tree crowns, with increasing space for larger trees, clumps, and stands on steeper slopes.

Tree pruning for defensible space is not as critical in PJ forests as in pine or fir forests. Instead, it is more important to space the trees so that it is difficult for the fire to move from one tree clump to the next. Trees should only be pruned to remove dead branches or branches that are touching the ground. However, if desired, live branches can be pruned to a height of 3 feet above the ground. Removing shrubs that are growing beneath PJ canopies is recommended to reduce the overall fuel load that is available to a fire.

It is NOT recommended to prune live branches or remove PJ trees between April and October, when the piñon ips beetle is active in western Colorado. Any thinning activity that creates the flow of sap in the summer months can attract these beetles to healthy trees on your property. However, it is acceptable to remove dead trees and dead branches during the summer months.

For more information, please refer to the CSFS *Piñon-Juniper Management Quick Guide* at www.csfs.colostate.edu.

Gambel Oak

Figure 25: ***Gambel oak needs to be treated in a defensible space at least every 5-7 years because of its vigorous growing habits. Photo: CSFS***

Maintaining Gambel oak forests that remain resistant to the spread of wildfire can be a challenge because of their vigorous growing habits. Gambel oak trees grow in clumps or groves, and the stems in each clump originate from the same root system. Most reproduction occurs through vegetative sprouts from this deep, extensive root system. You may need to treat Gambel oak near your home every five to seven years. Sprouts also should be mowed at least once every year in Zones 1 and 2. Herbicides can be used to supplement mowing efforts for controlling regrowth.

For more information, please refer to the CSFS *Gambel Oak Management* publication at www.csfs.colostate.edu.

Note: This publication does not address high-elevation spruce-fir forests. For information on this forest type, please contact your local CSFS district office.

Maintaining Your Defensible Space

Your home is located in a dynamic environment that is always changing. Trees, grasses and shrubs continue to grow, die or are damaged, and drop their leaves and needles each season. Just like your home, the defensible space around it requires regular, ongoing maintenance to be effective. Use the following checklists to build and maintain your defensible space.

Defensible Space: Initial Projects

Figure 26: *Keeping the forest properly thinned and pruned in a defensible space will reduce the chances of a home burning during a wildfire. Photo: CSFS*

- ☐ Properly thin and prune trees and shrubs within Zones 1 and 2.
- ☐ Dispose of slash from tree/shrub thinning.
- ☐ Screen attic, roof, eaves and foundation vents, and periodically check them to ensure that they are in good condition.
- ☐ Screen or wall-in stilt foundations and decks; screens should be 1/8-inch or smaller metal mesh (1/16-inch mesh is best).
- ☐ Post signs at the end of the driveway with your last name and house number that are noncombustible, reflective and easily visible to emergency responders.
- ☐ Make sure that the driveway is wide enough for fire trucks to enter and exit, and that trees and branches are adequately cleared for access by fire and emergency equipment. Contact your local fire department or check the CSFS website for information specific to access.
- ☐ Take pictures of your completed defensible space for comparison of forest growth over time.

Defensible Space Tasks: Annual Requirements

Figure 27: *Sharing information and working with your neighbors and community will give your home and surrounding areas a better chance of surviving a wildfire. Photo: CSFS*

- ☐ Clear roof, deck and gutters of pine needles and other debris. *
- ☐ Mow grass and weeds to a height of 6 inches or less. *
- ☐ Rake all pine needles and other flammable debris away from the foundation of your home and deck. *
- ☐ Remove trash and debris accumulations from the defensible space.*
- ☐ Check fire extinguishers to ensure that they have not expired and are in good working condition.
- ☐ Check chimney screens to make sure they are in place and in good condition.
- ☐ Remove branches that overhang the roof and chimney.
- ☐ Check regrowth of trees and shrubs by reviewing photos of your original defensible space; properly thin and prune trees and shrubs within Zones 1 and 2.
- ☐ Dispose of slash from tree/shrub thinning. *

**Address more than once per year, as needed.*

Be Prepared

- ☐ Complete a checklist of fire safety needs inside your home (these should be available at your local fire department). Examples include having an evacuation plan and maintaining smoke detectors and fire extinguishers.
- ☐ Develop your fire evacuation plan and practice family fire drills. Ensure that all family members are aware of and understand escape routes, meeting points and other emergency details.
- ☐ Contact your county sheriff's office and ensure that your home telephone number and any other important phone numbers appear in the county's Reverse 911 or other emergency notification database.
- ☐ Prepare a "grab and go" disaster supply kit that will last at least three days, containing your family's and pets' necessary items, such as cash, water, clothing, food, first aid and prescription medicines.
- ☐ Ensure that an outdoor water supply is available. If it is safe to do so, make a hose and nozzle available for responding firefighters. The hose should be long enough to reach all parts of the house.

Preparing your home and property from wildfire is a necessity if you live in the wildland-urban interface. It is important to adequately modify the fuels in your home ignition zone. Remember, every task you complete around your home and property will make your home more defensible during a wildfire.

Always remember that creating and maintaining an effective defensible space in the home ignition zone is not a one-time endeavor – it requires an ongoing, long-term commitment.

If you have questions, please contact your local CSFS district office. Contact information can be found at www.csfs.colostate.edu.

Figure 28: ***This house has a high risk of burning during an approaching wildfire. Modifying the fuels around a home is critical to reduce the risk of losing structures during a wildfire. Photo: CSFS***

List of Additional Resources

- The Colorado State Forest Service, http://www.csfs.colostate.edu
- CSFS wildfire-related publications, http://csfs.colostate.edu/pages/wf-publications.html
- Community Wildfire Protection Planning, http://csfs.colostate.edu/pages/community-wf-protection-planning.html
- Colorado's "Are You FireWise?" information, http://csfs.colostate.edu/pages/wf-protection.html
- National Fire Protection Association's Firewise Communities USA, http://www.firewise.org
- Fire Adapted Communities, http://fireadapted.org/
- Ready, Set, Go!, http://wildlandfirersg.org/

Figure 29: *This house survived the Fourmile Canyon Fire in 2010. Photo: CSFS*

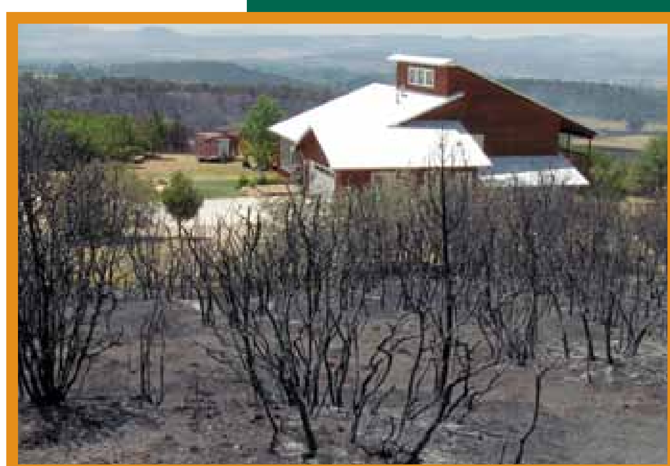

Figure 30: ***Firefighters were able to save this house during the 2012 Weber Fire because the homeowners had a good defensible space. Photo: Dan Bender, La Plata County***

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Fuelbreak Guidelines for Forested Subdivisions & Communities

By

Frank C. Dennis

Colorado State Forest Service
Knowledge to Go Places

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

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

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

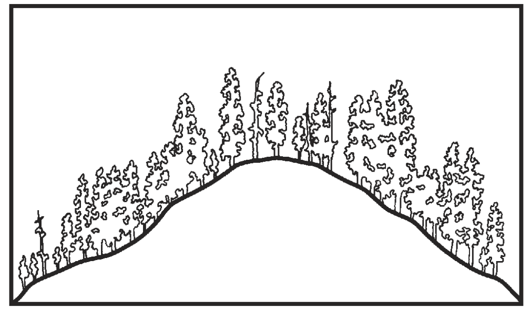
But with development inevitably comes a higher risk of wildfire as well as an ever-increasing potential for loss of life and property. Methods of fire suppression, pre-suppression needs, and homeowner and fire crew safety must all be considered in the planning and review of new developments as well as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

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

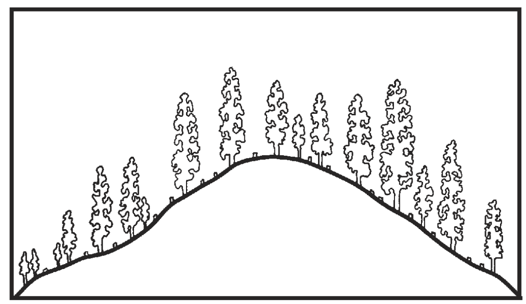
Fuelbreak vs Firebreak

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

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



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



• A fuelbreak (or shaded fuelbreak) is an easily accessible strip of land of varying width (depending on fuel and terrain), in which fuel density is reduced, thus improving fire control opportunities. The stand is thinned, and remaining trees are pruned to remove ladder fuels. Brush, heavy ground fuels, snags, and dead trees are disposed of and an open, park-like appearance is established.

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

Fuelbreak Limitations

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

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

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

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

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

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

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

The Need For A Fuelbreak

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

Potential Problem Indicator

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

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

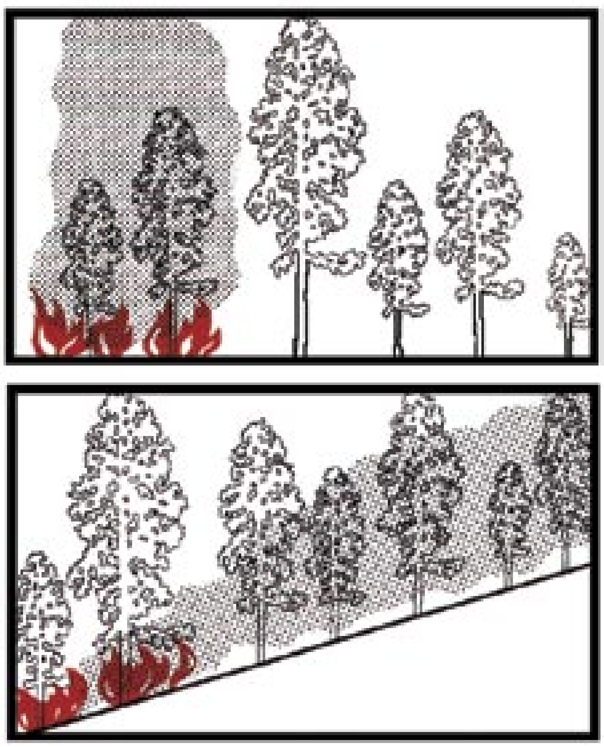
Legend: 5 – Problem may be crucial; 4 – Problem very likely; 3 – Exercise caution; 2 – Problem usually limited; 1 – No rating possible

Wildfire Hazard Maps

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

Slope

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



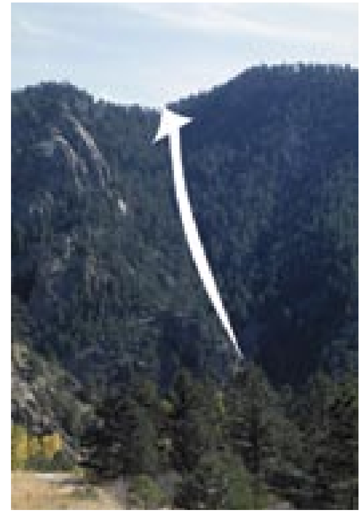
Fire effects, flat vs steep terrain. Note preheating of fuels on steep ground from passage of smoke column.

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

Topography

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

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

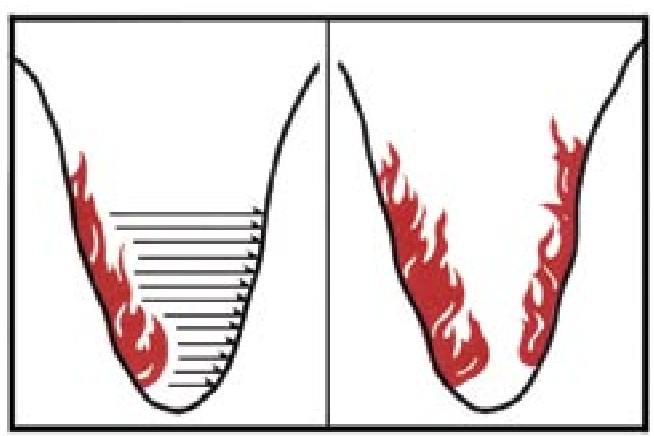


Chimney.

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

Saddle.

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



Flashover in V-shaped valley.

Crowning Potential

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

Crowning Potential Key

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

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

Ignition Sources

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

Fuelbreak Locations

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

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

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

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

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

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

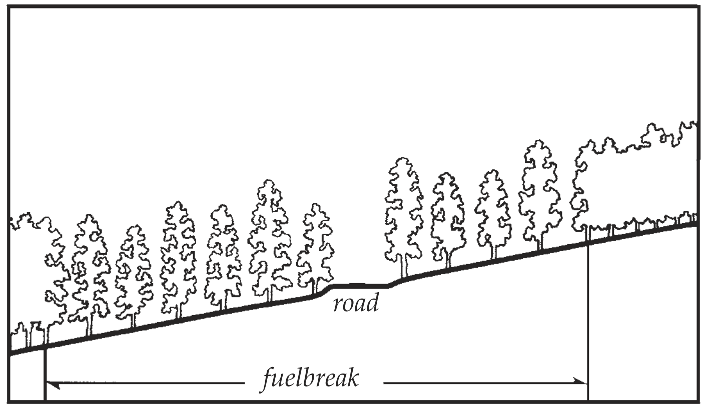
Aesthetics

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

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

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

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



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

Constructing the Fuelbreak

Fuelbreak Width and Slope Adjustments

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

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

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

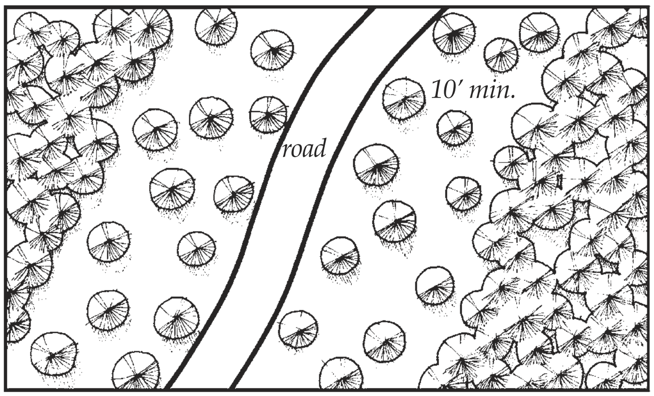
Fuelbreak Width/Slope

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

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

Stand Densities

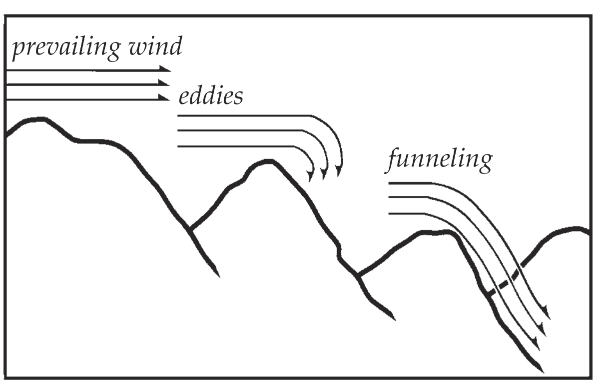
Crown separation is a more critical factor for fuelbreaks than a fixed tree density level. A *minimum* 10-foot spacing between the edges of tree crowns is recommended on level ground. As slope increases, crown spacing should also increase. However, small, isolated groups of trees may be retained for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



Plan view of fuelbreak showing minimum distance between tree crowns.

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

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



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

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

Debris Removal

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

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

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

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

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

Fuelbreak Maintenance

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

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

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

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

Conclusion

An image of well-designed communities for Colorado includes:

• Forested subdivisions where the total forest cover is well-managed through carefully planned, designed, and maintained thinnings. This contributes to reduced wildfire hazards and a much healthier forest — one that is more resistant to insects and disease.

• A system of roads and driveways with their associated fuelbreaks that break up the continuity of the forest cover and fuels. These help keep fires small, while also providing safer locations from which to mount fire suppression activities. In addition to allowing fire personnel in, they will allow residents to evacuate if necessary.

• Individual homes that all have defensible space around them, making them much easier to defend and protect from wildfire, while also protecting the surrounding forest from structure fires.

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

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

FireWise Construction:

Site Design & Building Materials

Based on the 2009 International Wildland-Urban Interface Code

Colorado State Forest Service

About the Authors

David Bueche, Ph.D., of Lakewood, Colo., works for Hoover Treated Wood Products, a major producer of fire-retardant-treated wood. He has more than 30 years of construction experience in both academia and industry. In addition to his hands-on experience as a carpenter, superintendent and project manager, he has been a research scientist at Colorado State University, taught college courses in construction and forest products, was a field representative for APA – The Engineered Wood Association and an applications engineer for the American Galvanizers Association. He is active in building code development, serves on the National Fire Protection Association (NFPA) and American Society for Testing and Materials (ASTM) committees that develop standards on the performance of materials in fire and building construction, is a member of the Society of Fire Protection Engineers, the Society of Wood Science and Technology and the Forest Products Society.

David developed sections 4 and 5 of this publication based on the 2009 International Wildland-Urban Interface Code.

Tim Foley most recently worked for the Colorado State Forest Service as the Northwest Colorado Fire Management Officer. Tim started his wildfire career with the Pike Hot Shots in 1977. He then worked for the Bureau of Land Management as a West Zone Fire Management Officer for the Upper Colorado River Interagency Fire Management Unit. Tim also serves on a wildfire Type 1 Team as a fire behavior analyst and fire investigator.

Tim was the main author of the first three sections of this publication.

Dedication

Peter Slack of Boulder, Colo., was a practicing architect for 26 years, until his untimely death in June 2000. Peter designed many homes and other buildings in the wildland-urban interface (WUI). His designs emphasized the integration of fire-resistive elements with other important design principles, such as proper site development for limited impact, low energy and water consumption, and the use of appropriate, resource-conserving materials.

Peter developed the first iteration of this publication in 1999.

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December 2012

Introduction

Two factors have emerged as the primary determinants of a home's ability to survive a wildfire – quality of the defensible space and structural ignitability. Together, these two factors create a concept called the Home Ignition Zone (HIZ), which includes the structure and the space immediately surrounding the structure. To protect a home from wildfire, the primary goal is to reduce or eliminate fuels and ignition sources within the HIZ.

This publication addresses both defensible space and structural ignitability.

Sections 1 – 3 are based on a recent publication developed by the Colorado State Forest Service, *Protecting Your Home from Wildfire: Creating Wildfire-Defensible Space.*

Sections 4 and 5 are based on the *2009 International Wildland-Urban Interface Code*.

In 2003, a growing awareness of wildfire risk led the International Code Council (ICC) to publish the first edition of the International Wildland-Urban Interface Code (IWUIC). This was the culmination of an effort initiated in 2001 by the ICC and the three statutory members of the International Code Council: Building Officials and Code Administrators International, Inc. (BOCA), International Conference of Building Officials (ICBO) and Southern Building Code Congress International (SBCCI). The intent was to draft a comprehensive set of regulations for mitigating hazards to life and property from the intrusion of fire resulting from wildland exposures and adjacent structures, and preventing structure fires from spreading to wildland fuels. Technical content of the 2000 Wildland-Urban Interface Code, published by the International Fire Code Institute, was used as the basis for development of the initial draft, followed by the publication of the 2001 final draft.

This updated publication is based on the 2009 IWUIC. It provides criteria for establishing an area's fire hazard severity as moderate, high or extreme, and spells out prescriptive measures for building within those zones. Local jurisdictions often use the IWUIC or adopt something similar for their communities. It is hoped that the information presented will help homeowners, designers and builders understand the unique issues associated with structure construction in the wildland-urban interface and encourage consistency in the application of provisions.

Table of Contents

1. Wildfire in Colorado

This publication was developed to provide homeowners, building designers/builders and landscape architects with design, building and landscaping techniques for additional protection from wildfires in the wildland-urban interface (WUI).

It is not always possible to control a wildfire. Under extreme conditions, wildfires can threaten homes and other structures, infrastructure and evacuation routes. Planning and preparation can make the difference in personal safety and home protection.

What is the wildland-urban interface?

The wildland-urban interface (WUI) is any area where structures and other human development meets or intermingles with wildland vegetative fuels.

Population growth in the WUI has increased, especially in the Western U.S. The expansion of subdivisions and other high-density developments has created conditions under which local fire departments cannot possibly protect all structures during a wildfire.

Fire suppression and increased fuels

Past fire suppression and limited forest management have produced dangerous accumulations of fuels, causing hotter and more intense fires when they burn. The arrangement of these fuels causes fire to travel to the top of the forest, rather than staying close to the ground. These crown fires are extremely threatening to soils, habitat, property and people.

In some of Colorado's forests, naturally occurring low-intensity wildfires periodically burned through stands of trees, removing fuels and thinning out excess vegetation.

As population in the WUI has increased, so too has the difficulty of protecting that population. When fires occur in the WUI, they are suppressed to prevent the destruction of homes and other values at risk. This creates a problem because historically, some forests have depended on fire to maintain good health. Fire can thin trees and brush, and eliminate dead material. By fighting wildfires to protect homes and people, this natural process has been altered and vegetation density has increased, which provides more fuel for fires. When fires occur, the dense vegetation can burn more intensely, making it more destructive and dangerous.

How can we protect our homes?

Construction in virtually every jurisdiction in the United States is regulated by building codes for the purpose of providing minimum public health and safety standards. Non-governmental model building code organizations, such as the International Code Council (ICC) and the National Fire Protection Association (NFPA), develop and maintain model building codes for use by state and local jurisdictions. A model building code is not enforceable until it is adopted by a state or local jurisdiction, with or without amendments, and becomes law. Several states, including Colorado, are "home-rule states." Under home rule, local governments have the ability to establish their own sets of codes and standards specific to their community. Because Colorado is a home-rule state and no statewide building code has been enacted as law, local jurisdictions adopt and/or adapt their own codes.

Typically, model codes allow the use of given building materials, while creating the parameters under which the material can be used. The concepts presented in this publication are based on the 2009 International Wildland-Urban Interface Code (IWUIC), the most widely adopted code addressing the WUI in the United States.

This comprehensive WUI code establishes minimum regulations for land use and the built environment in designated WUI areas, using prescriptive and performance-related provisions. It is founded on data collected through tests and fire incidents, technical reports and mitigation strategies from around the world. The IWUIC references the International Building Code (IBC), rather than the International Residential Code (IRC), the code most often adhered to by builders for home construction. This is because the IRC does not address several of the fire-resistive construction concepts that are necessary to meet the Ignition-Resistance Construction Classification. (*Ignition-resistant building materials are those that sufficiently resist ignition or sustained flaming combustion to reduce losses from WUI conflagrations under worst-case weather and fuel conditions with wildfire exposure to burning embers and small flames.*)

This publication offers a two-part approach to the problem:

1. Build more ignition-resistant structures, and

2. Reduce hazardous forest fuels.

A combination of site/landscape management techniques and appropriate construction materials are necessary to build more ignition-resistant structures in the WUI. The goal is to create structures that can either resist fire on their own, or at least make it easier for firefighters to safely protect structures. Building a noncombustible structure, as often is done in urban settings, can be prohibitively expensive; this publication discusses a combination of cost-effective strategies that increase the probability a structure will survive a wildfire.

Solutions to problems in the WUI involve a two-part approach: Make structures more ignition-resistant and reduce surrounding wildland fuels. Choosing the best combination of these two strategies for a particular site requires a basic understanding of wildfire behavior.

- If we leave the surrounding wildland in its current state, we need to build structures that are resistant to fire. Noncombustible structures are very expensive to build.
- Trying to provide a defensible space large enough for a typical wood-frame structure may not be practical or desirable.

Another goal of this publication is to give homeowners, designers and builders a better understanding of how buildings in the WUI ignite during a wildfire. With this information, it is possible to make better choices when selecting building techniques and materials. However, fire is only one of many factors to consider during construction. There is no single approach, and using alternative materials or landscape management techniques is always possible.

Awareness of the unique issues landowners face when building in the WUI will help direct them toward a more comprehensive solution during the design process. Some design elements and materials may help mitigate fire hazards; some may not. It is possible, however, to compensate for less desirable fire protection choices and still meet design goals.

Fire intensity and duration related to the fire resistance of structures

How ignition-resistant should a structure be? The answer to this question depends on fire intensity (how hot the fire burns) and fire duration (how long the fire will last at your site). If the fire hazard is low to moderate, only a few precautions may be necessary. If the fire hazard is high or extreme, most, or all, of the strategies described may be necessary.

In Colorado, almost any area surrounded by natural vegetation faces some hazard due to wildfire. In mountainous regions between elevations of 5,000 and 10,000 feet, fire hazard increases due to topography and increased vegetation density.

Ember propagation potential in relation to structures

Burning embers, have caused of the loss of many homes in the WUI. Embers in wildfires are produced when conifer trees are consumed by the fire. In WUI fires, burning structures also can be sources of burning embers. Flammable horizontal surfaces, such as wooden decks or shake roofs, are especially at risk for ignition from burning embers.

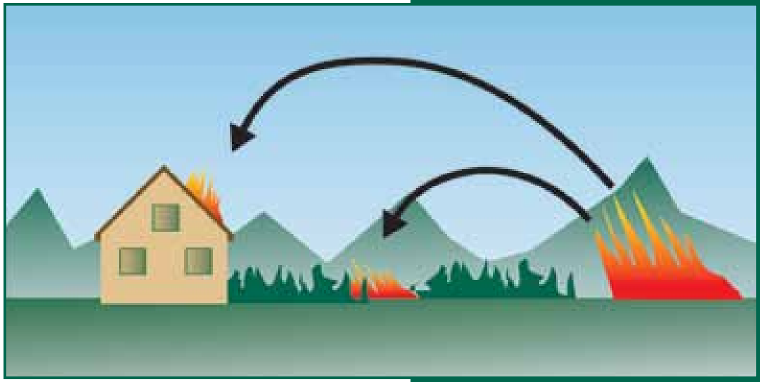

Figure 1-1: Fire brands, transported by convective lifting, create spot fires

Evaluating fire hazards

An effective way to determine the specific fire hazard severity in an area is to look at a fire hazard map or study located in the county building or land use department. Your local fire protection district also may have information. The code officially establishes the fire hazard severity of your site based on section 502.1 (Appendix C) of the IWUIC. If this information is not immediately available, use Figure 1-2 to determine the hazard level of your site.

Slope	Score
Level	0
0° - 10°	1
10° - 20°	2
20° - 30°	3
30°+	4

Vegetation	
water, rock or bare ground	0
grass, shrub, less than 2 feet with no trees	1
grass, shrub, less than 4 feet, widely scattered trees	2
dense young shrubs, no dead wood or trees	2
many trees, touching, some grass and brush	3
dense shrubs with some trees	3
thick, tall grass	3
dense evergreen trees with grass and shrubs	4
dense mature shrub with dead branches	4

After selecting the appropriate slope and vegetation scores, add them together to determine the fire hazard severity.

Scores	Fire Hazard Severity
0 - 2	low
3 - 4	moderate
5 - 6	high
7 - 8	extreme

Figure 1-2: Fire hazard severity ratings

This short evaluation is based on the Wildland Home Fire Risk Meter developed by the National Wildfire Coordinating Group.

Note: The term fire hazard severity in this publication refers to material elements used in building design and the actual design itself.

2. Fire Behavior: Fuels, Weather and Topography

Wildfires and the nature of burning structures

Wildfires can ignite structures in two ways:

1. Direct flame contact with a moving fire. The fire behavior factors that influence a structure's potential for ignition are fire intensity and duration of flame contact.
2. An ignition started by a burning ember landing on a flammable surface, such as a shake roof or wooden deck.

Understanding the potential fire behavior, especially intensity, duration and ember deposition at a building site, will help homeowners, designers and builders determine how ignition-resistant a structure needs to be.

Wildfires have been studied in great detail to help predict fire behavior. Predicting fire intensity, rate of spread, duration, direction and spot-fire production is important for firefighter safety and is the basis for tactical decisions made during the suppression of a fire.

Three factors affect wildfire behavior in the WUI:

1. **Fuels:** The type, continuity and density of surrounding vegetation and, sometimes, flammable structures, provide fuel to keep the fire burning.
2. **Weather:** Wind, relative humidity and atmospheric stability all affect potential fire behavior.
3. **Topography:** The steepness and direction of slopes, and building-site location in relation to topography are features that affect fire behavior.

Fuels are anything that burns in a fire

Wildland fuels are divided into four categories:

1. Grass
2. Brush or shrubs
3. Timber
4. Woody debris

All plants can burn under extreme conditions, such as drought; however, plants burn at different intensities and rates of consumption. The type and density of a specific plant determines how it will burn. Some vegetation rarely burns, while other vegetation burns at different times of the year; and some can burn almost anytime. The amount of moisture in the fuels is the biggest factor affecting flammability.

Grasses: Grass primarily exists in two conditions – green and cured. When grass is green, moisture content is high enough to prevent or decrease fire spread. Firefighters sometimes use green meadows and lawns as safety zones. As the year progresses, plants enter a dormant state and the residual surface vegetation dies. Cured grass has the potential to promote extreme fire rates of spread (ROS); grass fuels have the highest potential ROS of any fuels. Another hazard associated with cured grass is the potential for a rapid decrease in fuel moisture; the ability of air to circulate through standing grass allows the grass to dry rapidly and can result in sudden changes in fire behavior.

Brush: Brush fires spread slower than grass fires, but burn at a higher intensity. The most common flammable brush species in Colorado are oak brush and sagebrush. Brush is least flammable in late spring when new growth occurs.

Timber: Timber burns in two manners – as surface fires and crown fires. Surface fires consume fuels on the forest floor without burning trees, although trees may burn individually, which is called torching. Crown fires occur when entire stands of trees are totally consumed. These fires are the most intense, but tend to move less rapidly than other types of fire. Coniferous trees are more susceptible to crown fire than deciduous trees. Torching and crown fires are the major source of ember production, which can start new fires (spot-fires) in vegetation and structures downwind.

Woody debris: Dead logs, branches and sticks on the ground surface are referred to as woody debris. Debris can result from human activity, such as thinning, or from natural processes, such as wind-throw or beetle-killed trees that have fallen to the ground. Wildfires in these fuels vary greatly, but can produce high-intensity, slow-moving fires that are very difficult to control. Colorado's mountain pine beetle epidemic will result in a major increase in woody debris over large areas.

Complexes: More than one fuel component is present in most wildland areas. Areas containing these fuel complexes are more common than those represented by a single fuel component.

Structures: The effect of a burning structure can significantly impact wildfire behavior. Structures burn with extreme intensity, often launching large burning embers over long distances.

Fuels and fire duration: Fire duration refers to the length of time a wildfire will burn under certain conditions. Fuel type, quantity, temperature and moisture content determine the duration of a fire. Building structures that will resist fires for any length of time is dependent on a good understanding of local conditions that contribute to the duration of fire in a particular area. Different building materials can resist fire for different time periods.

Climate and Weather

Climate: Fire seasons in Colorado's high country and on the Western Slope tend to last from late spring until mid-autumn. Fire seasons on the Front Range and Eastern Plains tend to be split, with most large fires occurring in the spring or fall. It's important to keep in mind that these are generalizations and that large fires can occur anytime conditions are right. The most likely fire season depends on the geographical location of the building site.

Weather is a major factor that affects fire behavior and is highly variable in terms of time, intensity and location. Weather can change dramatically in a short period of time, resulting in rapid changes in fire behavior.

Wind: Surface winds are the most important element in determining fire direction and rate of spread. Wind pushes flames into adjacent fuels, facilitating rapid ignition, and tends to be the common theme in large fire events. High-velocity, warm, dry, down-slope winds, such as a Chinook, can cause fuels to dry rapidly, resulting in extreme fire behavior.

Relative Humidity (RH): RH is a measure of how much moisture is in the air compared to the maximum amount of moisture the atmosphere can hold at that temperature. RH has a major influence on the moisture content of dead fuels. The smaller the dead fuel, the faster it will react to a change in the RH. Cured grass can dry out in less than 15 minutes when a dry air mass moves into an area. Firefighters generally monitor RH on an hourly basis when fighting a fire.

Temperature: Before combustion can occur, fuels must reach ignition temperature (approximately 450° F); fuels heat up and reach ignition temperature more quickly on hot days. In addition, when fuels are preheated, fire expends less energy and will burn at a higher intensity.

Topography and Fire Behavior

Topography is the shape of the land's surface. It influences fire behavior by the effects it has on wind, temperature, moisture and the preheating of fuels.

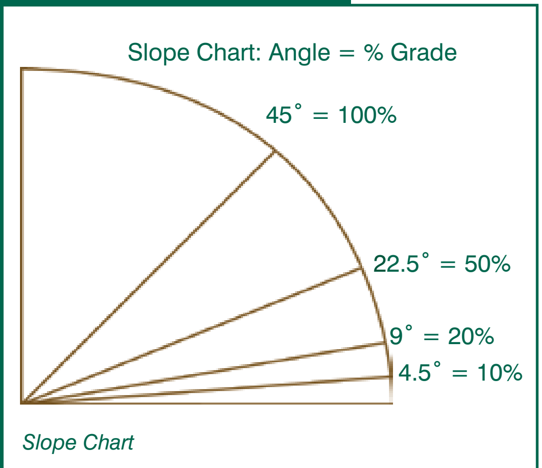

Figure 2-1: Slope chart

Slope: Defined as the angle of the ground relative to the horizon, slope commonly is measured in degrees or as a percent. On calm days, heated air, including flames, rises and preheats the fuels upslope, which causes an increase in fire spread. On gentle slopes, preheating has little effect on fire behavior, but on steep slopes, the effect can be significant. During summer months, preheating generally causes winds to blow upslope. The combined effect of slope and wind results in rapid fire spread.

Aspect: Aspect is the direction the slope faces. South and southwest aspects are warmer and drier than north and northeast aspects.

Saddles and Chimneys: A saddle is a low spot on a ridge. A chimney is a gully or drainage that goes up a slope. Both saddles and chimneys funnel winds and increase fire spread and intensity.

Structures located on steep slopes or in saddles or chimneys require more ignition-resistant components and/or larger defensible space.

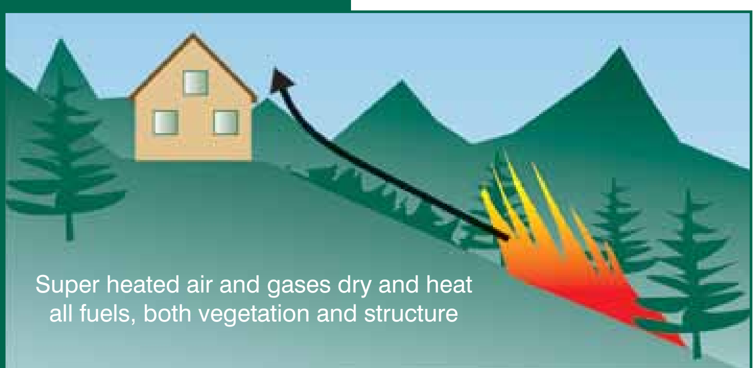

Figure 2-2: Super heated air and gases rise and heat fuels

Fire behavior and ignition of fuels: heat transfer mechanisms

As fuels burn, they release hot gas in the form of flames and smoke. These gases rise and move with the wind. Sometimes embers are carried aloft by this convective lifting. These hot gasses also heat fuels in which they come in contact, bringing those fuels closer to their ignition point. Fires also produce large amounts of radiant energy (like the sun), which heats surrounding fuels. Ignition occurs more easily once flames make contact with the vegetation. This, in turn, accelerates the rate at which the fire moves and increases in intensity.

Several heat-transfer mechanisms from a wildfire are involved in the ignition of a structure:

- Radiant heating that results in an ignition or heats a flammable surface makes structures more susceptible to ignition from another source.
- Direct flame contact with a flammable portion of the structure can cause ignition.
- Convective lifting resulting in ember deposition on a flammable surface can cause ignition.

Understanding these processes will help design structures and landscapes that reduce wildfire risk.

Indirect: radiant heating

The transfer of heat by radiant energy from fire can preheat or even ignite structures. This is the same process that occurs when sunlight heats an object. Radiant heat transfer occurs on a straight line of sight and is not affected by wind.

Vertical surfaces, such as siding, can ignite as a result of this process before fire actually reaches the structure. Curtains can ignite from radiant heat transferred through windows. Torching trees and crown fires nearby can cause high levels of radiant heat for short to moderate durations. Adjacent burning structures create intense radiant heat for long durations. And once ignited, large, heavy fuels burn at high temperatures that amplify radiant energy, creating more potential for ignition through heat transfer.

Radiant energy decreases with distance. It follows the inverse square rule shown in Figure 2-4. Doubling the distance from the heat source will reduce radiant heat by significantly more than half. A torching tree 10 feet from a structure will produce four times more radiant heat than the same tree torching 20 feet from a structure. Radiant heat energy decreases dramatically with increased distance.

Figure 2-3: Radiant heating

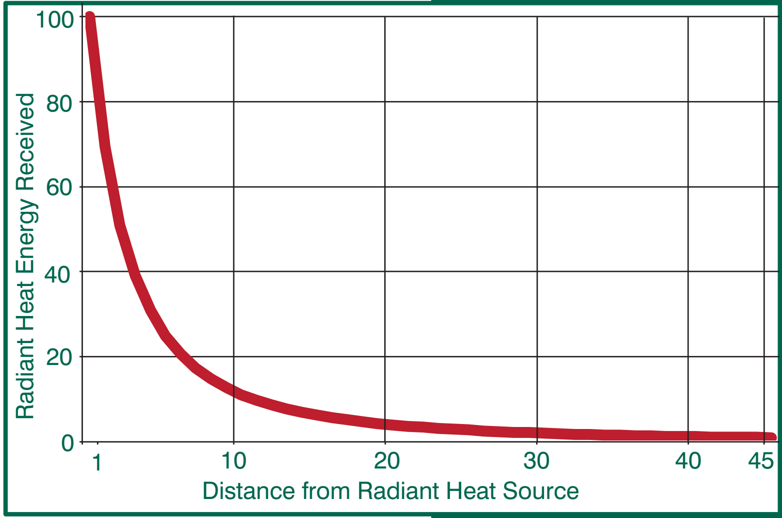

Figure 2-4: Radiant energy decreases with increased distance

Direct contact or impingement

Unmanaged vegetation adjacent to a structure provides continuous and abundant fuels, which can ignite flammable building surfaces. Creating defensible space and fuelbreaks around a structure is specifically intended to reduce this effect.

Figure 2-5: Fire directly impinging on a house

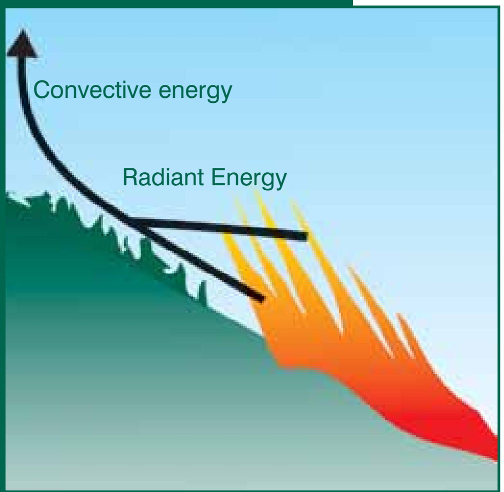

Figure 2-6: Convective and radiant energy from a fire

Convective lifting

Fire produces hot gases that rise into the atmosphere. During a wildfire, this atmospheric effect can be very strong, even causing its own wind as cooler air rushes in to replace the rising hot air.

Convective air currents also lift burning materials or embers. Winds can carry embers horizontally for long distances from the fire.

Embers can fall onto horizontal surfaces, such as combustible roofs, decks and dry vegetation around structures. When this results in a new ignition, it is called spotting and can be very widespread. Embers often travel hundreds or even thousands of feet ahead of the actual fire.

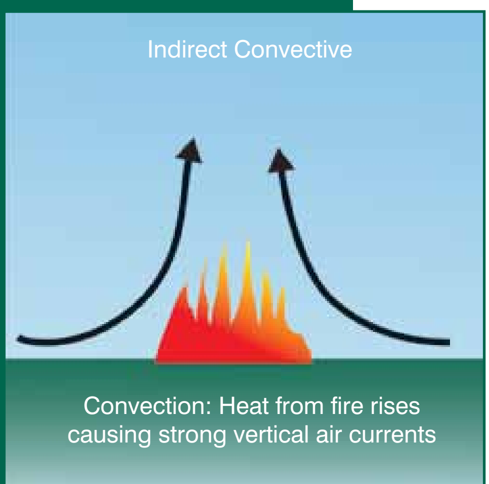

Figure 2-7: Convective lifting

Indirect: convective heating

The same hot air and gasses that dry and preheat vegetation have the same effect on structures, predisposing combustible materials to ignition as the fire gets closer.

3. Building-site Location and Landscaping

Topography and vegetation: fire behavior and intensity

Structure location influences the potential fire intensity and duration to which that structure may be exposed. The information in the fire behavior section (Section 2) discussed how to estimate fire intensity and duration. This information can be used to determine the building site that will allow the highest probability of survival in the event of a wildfire. When choosing a site or determining the level of ignition resistance a structure requires, homeowners, designers and builders should be aware of how local vegetation and topographic variations affect fire behavior.

Aspect

Aspect is the direction that the slope faces. Vegetation varies widely between the extremes of south-facing and north-facing slopes.

South and west slopes tend to have the least vegetation because they quickly dry out and have less available moisture for plants. Southwest slopes tend to have the fastest moving fires.

East aspects generally have more vegetation than southwest slopes and tend to dry out in later in the summer.

North slopes typically have the densest vegetation because there is more water available for plants. Because the moisture content of the vegetation on north slopes is higher, fires tend to burn with less intensity. However, when fires occur during times of drought, they can burn with greater intensity because of the increased amount of fuels.

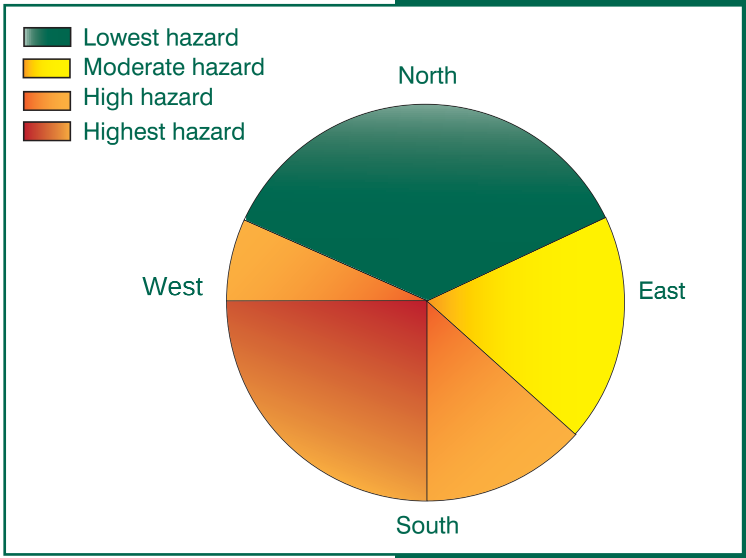

Figure 3-1: Fire hazard varies widely from aspect to aspect

Dangerous topographic features: areas of more intense fire behavior

Variations in topographic features such as valleys, ridges, canyons and saddles present hazards that further intensify or attract fires. A **valley**, as a concave form, tends to collect and concentrate winds. This means that the intensity of a wildfire can increase as it moves through a valley. In **canyons**, this effect is even more pronounced. **Ridges** experience more wind primarily because they are elevated above the surrounding land. When a fire moves up a slope toward a ridge, it gathers speed and intensity. A low point between the higher parts of a ridge is called a saddle. Like a valley, saddles will channel, intensify and increase the fire's rate of spread. These areas often are popular building sites because they offer some shelter and tend to be flat. **Saddles** are natural pathways for fire; fire often travels first and with increased intensity in saddles. As wind crosses a ridge, a leeward eddy can occur, where the wind rolls around and comes up the leeward side, exposing both sides of a structure to wind and fire. Ridges usually offer no protection from fire.

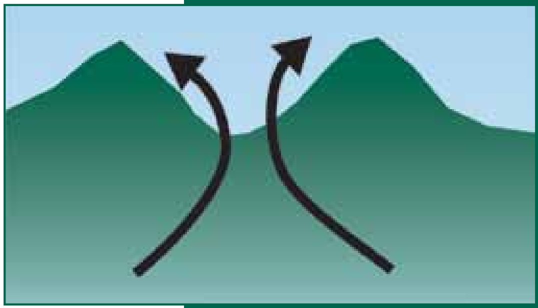

Figure 3-2: Saddle, or low area, on a ridge

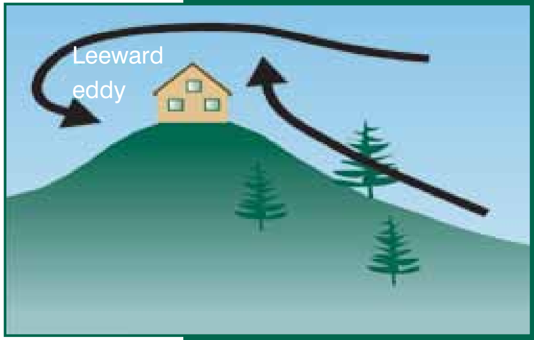

Figure 3-3: Ridge with wind exposure

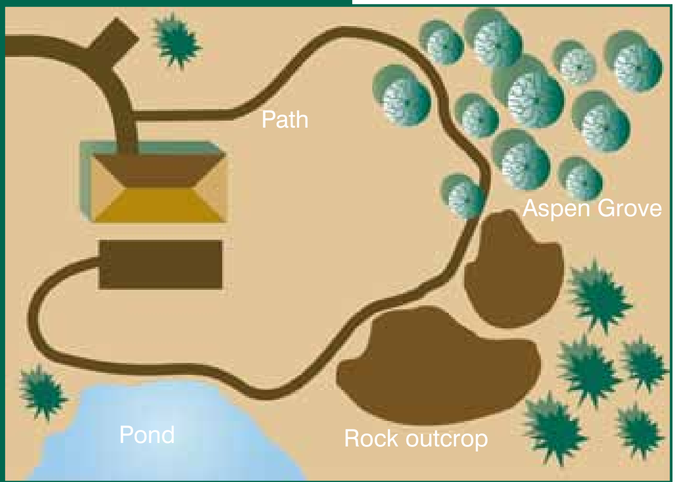

Figure 3-4 Site: House located relative to natural features that buffer against fire

Natural barriers and buffer zones

Some physical features reduce fire behavior and can be used to slow, reduce or deflect a fire. Examples include natural rock outcroppings, wetlands, streams, lakes and deciduous tree stands, (aspen, cottonwood, etc). It is advantageous to locate the structure between the natural barrier and the anticipated path of a fire. Some areas, such as meadows or lawns, can be barriers at certain times of the year, but serve as fuels after they cure.

How this affects building location and design decisions

On large parcels of land, consider the physical features previously discussed when choosing the final location of a structure. Many factors will affect decisions regarding building-site location, such as privacy, views, access and aesthetic values; fire is just one of these factors. Determining whether fire is the primary consideration will depend on the severity of the fire hazard in the area.

On smaller parcels, only one suitable building location may exist. The physical features of the site will determine the probable fire intensity and dictate what combination of site modifications and fire protection is necessary to prevent the structure from igniting.

Site Evaluation, Design, and Modifications to the Vegetation

When selecting a building site, several questions should be answered:

1. Is there adequate ingress and egress in the event of a fire?
2. Can fire engines and other emergency equipment safely access the property?
3. Can close-in fuels be modified to reduce fire potential (defensible space)?
4. What is the potential fire behavior and ember production in the fuels further out?

After evaluating the fire hazard severity of a site, develop a plan to manage the surrounding vegetation and defensible space. This is the first part of the two-part strategy to build an ignition-resistant structure. Defensible space is defined as an area where material capable of allowing a fire to spread is modified to slow the rate and intensity of an advancing wildfire, and create an area for firefighters to safely work. It also can work in reverse by helping to prevent a structure fire from spreading to surrounding vegetation.

In diagramming the features of a building site, it is apparent that the features gradually shift from man-made to natural, as the distance increases from the structure into the wildland; this area should be divided into zones. Developing a defensible space plan requires an inventory of the existing site features and their hazards. Man-made elements include landscaping features, such as masonry walls, patios, footpaths and driveways. These features create fire barriers and buffer zones. Three zones need to be addressed when creating defensible space:

Zone 1 is the area nearest the home and requires maximum hazard reduction.

Zone 2 is a transitional area of fuels reduction between Zones 1 and 3.

Zone 3 is the area farthest from the home, where traditional forest management techniques should be used. It extends from the edge of Zone 2 to the property boundaries.

Zone 1 – The width of Zone 1 extends a distance of 15 - 30 feet minimum from a structure depending on property size. Increasing the distance of Zone 1 will increase structural survivability. This distance should be increased five or more feet for fuels downhill from a structure. Remove most flammable vegetation, with the possible exception of a few low-growing shrubs or FireWise plants (plants that are comparatively fire resistant). Avoid landscaping with common ground junipers. The distance should be measured from the outside edge of the home's eaves and any attached structures, such as decks. Several specific treatments are recommended within this zone:

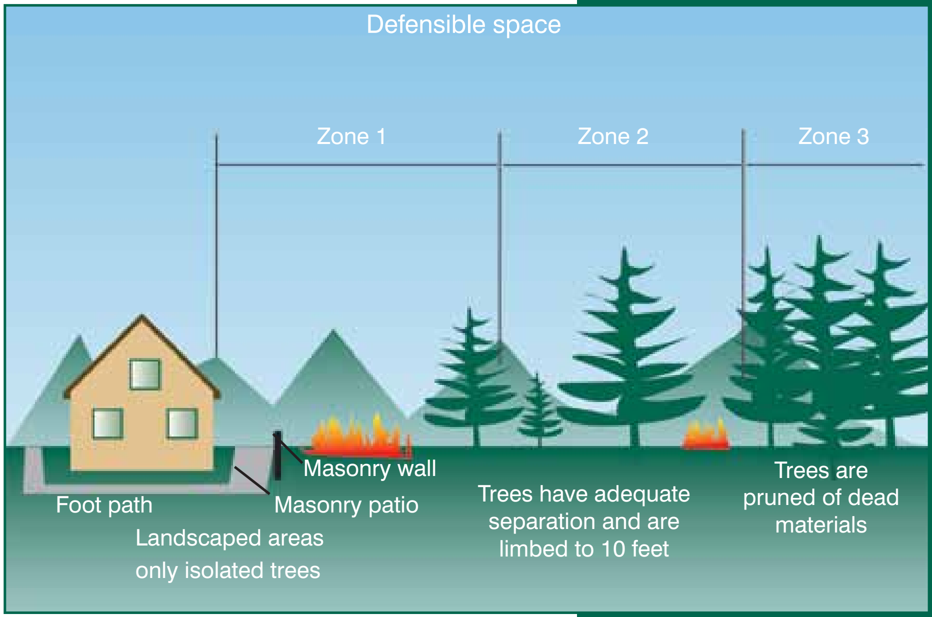

Figure 3-5: Defensible space

- Install nonflammable ground cover and plant nothing within the first 5 feet of the structure and deck.
- If a structure has noncombustible siding (i.e. stucco, synthetic stucco, concrete, stone or brick), widely spaced foundation plantings of low-growing shrubs or other FireWise plant materials are acceptable. Do not plant directly under windows or next to foundation vents.
- Prune and maintain plants and remove all dead branches, stems and leaves within and below the plant.
- Irrigate grass and other vegetation during the growing season if possible. Keep grasses mowed to a height of 6 inches or less.
- Do not store firewood or other combustible materials in this zone. Keep firewood at least 30 feet away from structures, uphill if possible.
- Enclose or screen decks with at least 1/8-inch metal screening (1/16-inch is preferable). Do not use areas under decks for storage.
- Ideally, remove all trees from Zone 1 to reduce fire hazards. The more trees you remove, the safer the home will be. If you do retain any trees, consider them part of the structure and extend the distance of the entire defensible space accordingly.
- Remove any branches that overhang or touch the roof, and remove all fuels within 10 feet of the chimney.
- Remove all needles and other debris from the roof, deck and all gutters.
- Rake needles and other debris at least 10 feet away from all decks and structures.
- Remove slash, chips other woody debris from Zone 1.

Zone 2 – Zone 2 is an area of fuels reduction designed to reduce the intensity of any fire approaching structures. The width of Zone 2 depends on the slope of the ground where the structure is built. Typically, the defensible space in Zone 2 should extend at least 100 feet from all structures. If this distance stretches beyond the property line, try to work with the adjoining property owners to complete an appropriate defensible space.

The following actions help reduce the continuous fuels surrounding a structure, while enhancing home safety and the aesthetics of the property. It also will provide a safer environment for firefighters to protect homes.

- Remove stressed, diseased, dead or dying trees and shrubs.
- Remove enough trees and large shrubs to create at least 10 feet between crowns. Crown separation is measured from the farthest branch of one tree to the nearest branch on the next tree. On steep slopes, increase the distance between tree crowns.

- Remove all ladder fuels from under remaining trees. Prune tree branches to a height of 10 feet from the ground or 1/3 the height of the tree crown, whichever is less.
- Extend tree thinning out 30-feet along both sides of your driveway all the way to the main access road, even if it is over 100 feet from your home. Thin all trees to create 10-foot spacing between tree crowns.
- Small groups of two to three trees may be left in some areas of Zone 2, but leave a minimum of 30 feet between the crowns of these clumps and surrounding trees.
- As noted in Zone 1, the more trees and shrubs removed, the more likely the structure will be spared in a wildfire.
- Isolated shrubs may remain, provided they are not under trees.
- Keep shrubs at least 10 feet away from the edge of tree branches. This will prevent the shrubs from becoming ladder fuels.
- Minimum spacing recommendations between clumps of shrubs is 2 1/2 times the mature height of the vegetation. The maximum diameter of the clumps themselves should be twice the mature height of the vegetation. As with tree-crown spacing, all measurements are made from the edge of vegetation crowns.
- Periodically prune and maintain shrubs to prevent excessive growth; remove dead stems from shrubs annually.
- Mow or trim grasses to a maximum height of 6 inches. This is critical in the fall when grasses dry out.
- Avoid accumulations greater than 4 inches deep of surface fuels such as logs, branches, slash and chips.
- Stack firewood and woodpiles uphill from or on the same elevation as any structures, and at least 30 feet away.
- Clear, mow and remove all flammable vegetation within 10 feet of woodpiles.
- Do not stack wood against your home or on/under your deck, even in winter.
- Locate propane tanks and natural gas meters at least 30 feet from any structures, preferably on the same elevation as the structure. The containers should not be located below your home because if it ignites, the fire would tend to burn uphill. Conversely, if the tank or meter is located above your structure and it develops a leak, gas will flow downhill into your home.
- Clear and remove flammable vegetation within 10 feet of all tanks and meters.
- Do not visibly screen propane tanks or natural gas meters with shrubs, vegetation or flammable fencing. Instead, install 5 feet of nonflammable ground cover around the tank or meter.

Zone 3 – Zone 3 has no specified size. It should provide a gradual transition from Zone 2 to areas farther from the home that have other forest management objectives. Your local Colorado State Forest Service forester can help you with this zone.

Forest management in Zone 3 provides an opportunity to improve the health of the forest. With an assortment of tools and alternatives, it is possible to proactively manage forest land to reduce wildfire intensity and protect water quality, increase habitat diversity for wildlife, increase the health and growth rate of trees and increase the survivability of trees in a wildfire.

For additional information about defensible space, see *Protecting Your Home from Wildfire: Creating Wildfire-Defensible Space* or visit http://csfs.colostate.edu/pages/wf-publications.html.

4. Building Design

So far, we have discussed elementary fire behavior and how to manage the wildlands surrounding a home in the interface. The second part of our approach to building ignition-resistant structures is learning about appropriate design and material choices.

Simple vs. complex forms

Simple building forms have less surface area relative to the volume of the structure. Complex building forms have much more surface area relative to volume. Simple building forms are less expensive to build, more energy efficient and easier to protect from wildfires. There is simply less exterior surface to protect.

Complex forms not only increase the surface area of the structure, but also create shapes that trap the fire's heat; these areas are called heat traps. Transitions between vertical surfaces and horizontal surfaces, inside corners between two walls or abrupt intersections of different solid planes form pockets where wind velocity drops and eddy currents form.

Parapet walls, solar collectors, intersecting roofs and walls, roof valleys and decks are examples of heat traps. These forms cannot be avoided, therefore their locations require much more attention to ignition-resistant materials. Burning embers most often fall in these locations when wind velocity decreases.

Roofs are very susceptible to embers in a wind-driven fire. A simple roof form such as a hip or straight gable is best. Complicated roofs with intersecting planes and valleys form dead air pockets and areas where currents eddy. The use of complicated forms further highlights the importance of a truly ignition-resistant roof.

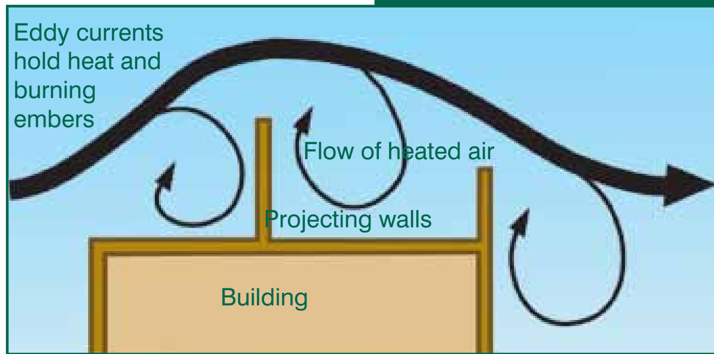

Figure 4-1: Heat traps around walls

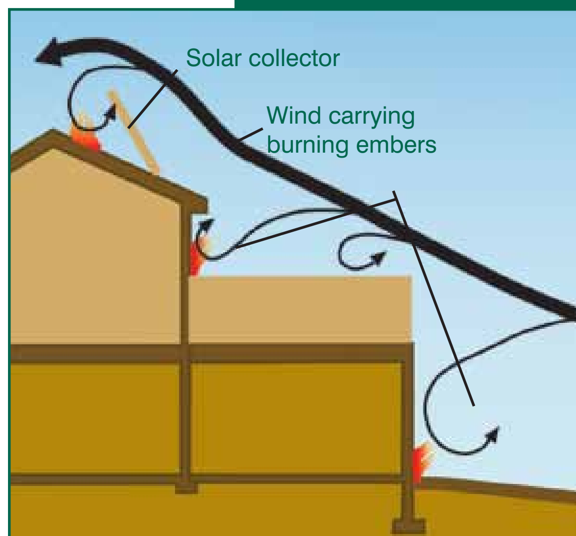

Figure 4-2: Heat traps around roofs

Some roof coverings have gaps that allow ember intrusion under the covering and can result in ember intrusion and ignition of the structure under the roof covering. The worst types of roof coverings allow combustible debris to blow or rodents and birds to build nests under the roof covering. This can occur in clay (Spanish or straight-barrel mission) tile roof covering unless eave closures or "bird stops" are used to close the convex opening created by the shape of the tile at the eave. If you can see wood through gaps in the roof covering, embers can penetrate and ignite the structure.

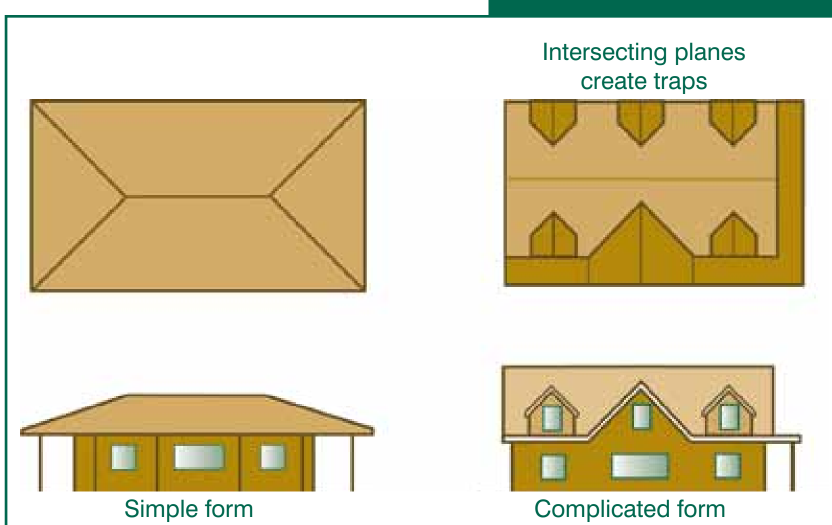

Figure 4-3: Roof forms

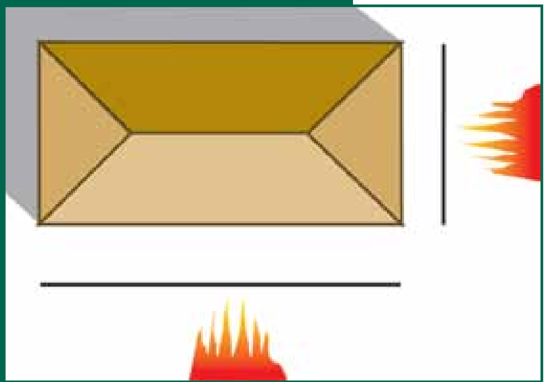

Figure 4-4: Aspect ratio is the ratio between the east-west axis and the north-south axis.

Aspect ratio

Aspect ratio is the ratio between the east-west axis and the north-south axis. In Colorado's climate, it generally is better to build a structure that is longer on the east-west axis than the north-south axis. Such a structure has a more favorable energy relationship with the climate and can benefit from passive solar heat.

With regard to wildfire, if the widest exterior of the structure faces the direction from which a fire is likely to come, it will be more vulnerable. More fire-resistive materials and components are needed on the side that faces oncoming fire. On a flat site, the direction of a fire is somewhat unpredictable, but it generally is determined by predominant winds and fuel.

The probable fire path is more easily predicted on sloping sites. Fire can be expected to approach up the slope. On east- and west-facing slopes, it is best to locate the structure on the longer east-west axis in terms of energy efficiency and fire risk, as the widest side of the structure faces the winter sun and the narrowest side faces the fire path.

When simple forms and optimum aspect ratios cannot be used, the structure will require more ignition-resistant building materials.

Vents, eaves, soffits, gutters, downspouts and decks

Building an ignition-resistant structure can be compared to building a watertight roof. One little hole in the roof allows water to leak in, and it doesn't matter how well the job was done on the rest of the roof, it failed and damage occurred. Small building elements like soffits and vents can be the weak link in a fire. An otherwise ignition-resistant structure can be damaged or destroyed because fire found a way in through these areas.

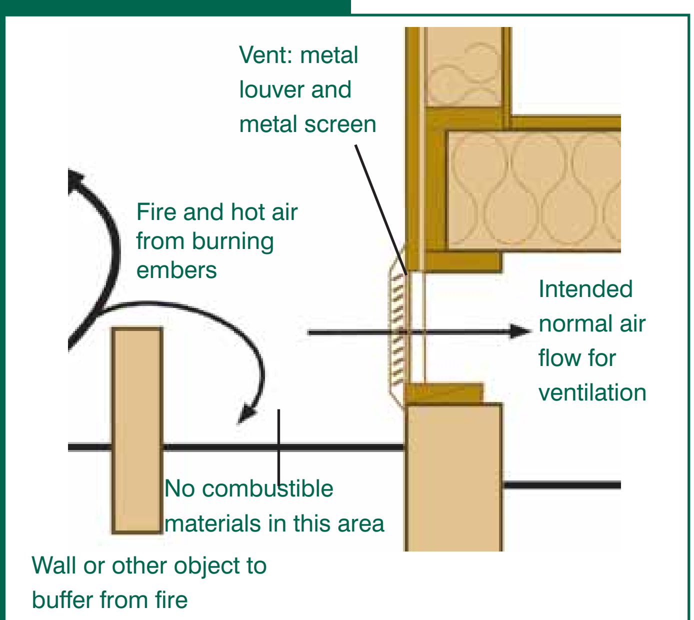

Figure 4-5: Crawl-space ventilation

Vents

The International Building Code (IBC) requires vents to prevent accumulation of water vapor in the structure. All crawl spaces under wood floors are required to have ventilation. One square foot of vent is required for every 150 square feet of floor area. Because these vents typically are located near the ground, combustible vegetation should not be located next to them.

Vents located on the downhill side of the structure should be protected by landscaping elements, such as stone patios or walls, that block the direct path of the fire. Mechanical ventilation with intakes and exhaust located away from the ground also can be used.

All attic spaces and roof cavities are required to have ventilation. One square foot of vent is required for every 300 square feet of horizontal projected roof area (see eaves and soffits). In both cases, the vents should be covered with noncombustible, corrosion-resistant mesh with openings that do not exceed ¼-inch, or be designed and approved to prevent flame or ember penetration into the structure. Roof turbine vents also should be screened to prevent embers from entering attic spaces.

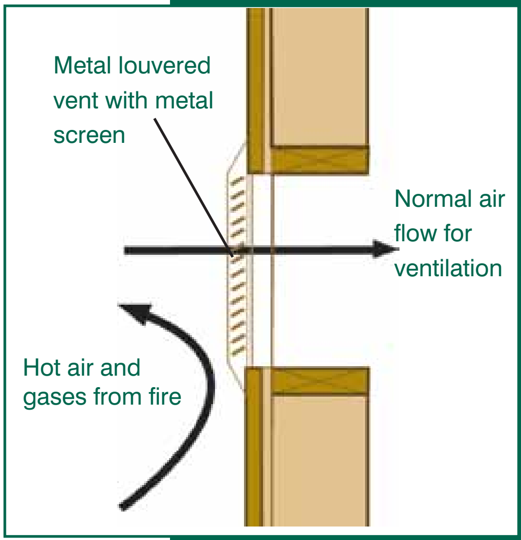

Figure 4-6: Attic vent

Eaves and soffits

The extension of the roof beyond the exterior wall is the eave. This architectural feature is particularly prone to ignition. As fire approaches the structure, the exterior wall deflects the hot air and gasses up into the eave. If the exterior wall isn't ignition resistant, this effect is amplified.

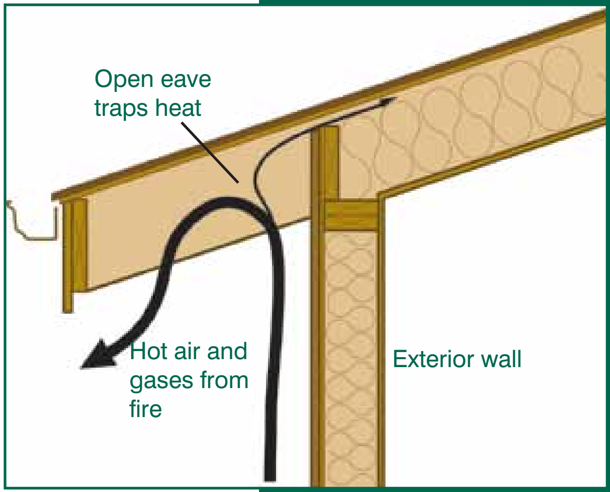

Figure 4-7: Open eave with no soffit

The eave should be covered with a soffit. If the soffit is applied directly to the rafter eave, it forms a sloping soffit, which creates a pocket that can trap fire.

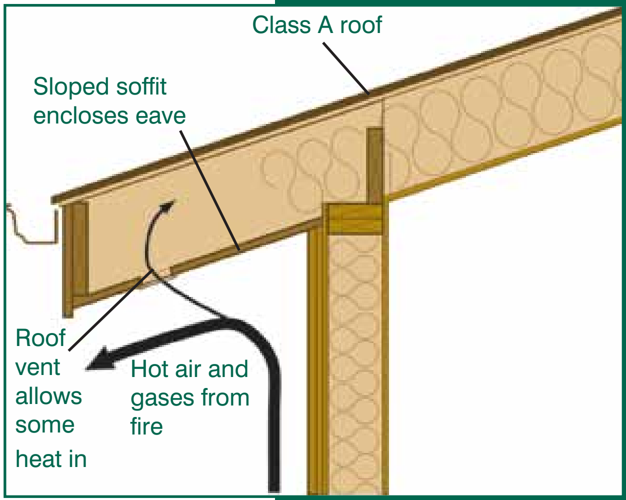

Figure 4-8: Open eave with soffit

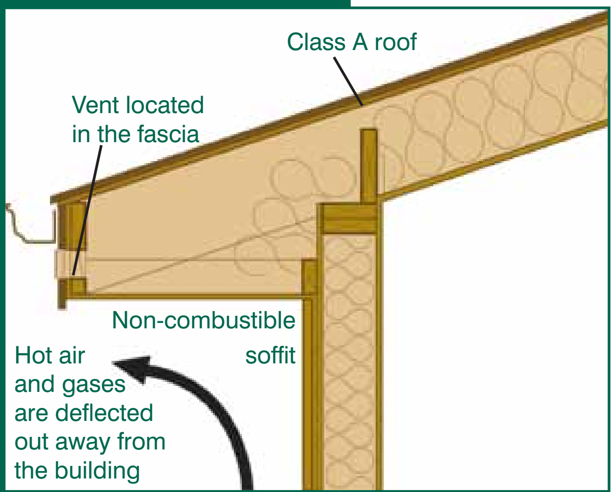

Figure 4-9: Fully enclosed soffit with isolated vent

A flat soffit allows the structure to more readily deflect fire outward.

Vents for roof ventilation often are found in the soffit. Placing vents in these locations creates a path for fire to enter the roof structure. If the vent must be placed in this location, it is better to place it farther from the wall and closer to the fascia. The vent also can be placed in the fascia or near the lower edge of the roof.

Gutters and downspouts

Gutters and downspouts collect leaves and pine needles. Gutters and eave troughs made from combustible materials (e.g., wood, vinyl) are as vulnerable to ember collection as the roof and other parts of the structure. If leaf litter is allowed to gather in gutters, embers can ignite the leaf litter, which in turn could ignite combustible eave materials or overhangs. If gutters are attached to combustible fascia boards, the fascia board should be considered a possible fuel that can be ignited by fine fuels burning in the gutters.

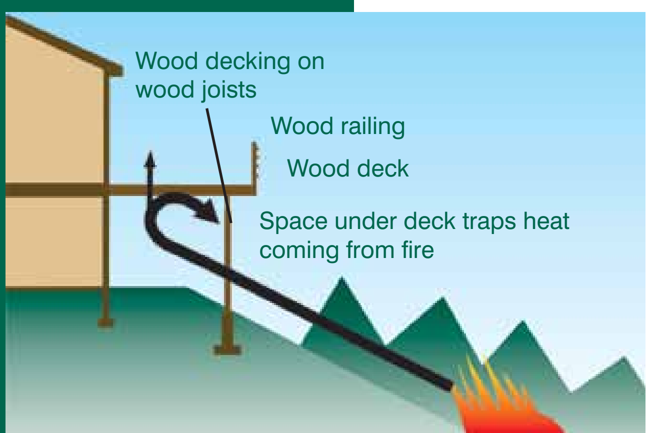

Figure 4-10: Conventional deck in a fire

Decks

Decks are a popular and well-used feature of the structure, especially in the mountains. Because they are elevated above the terrain and surrounding vegetation, they offer a better view and provide flat areas for walking on otherwise sloping terrain.

Most decks are highly combustible structures. Their shape traps hot gasses, making them the ultimate heat traps. And because they often face downhill – they allow easy access to an approaching fire, which most likely is moving up a slope.

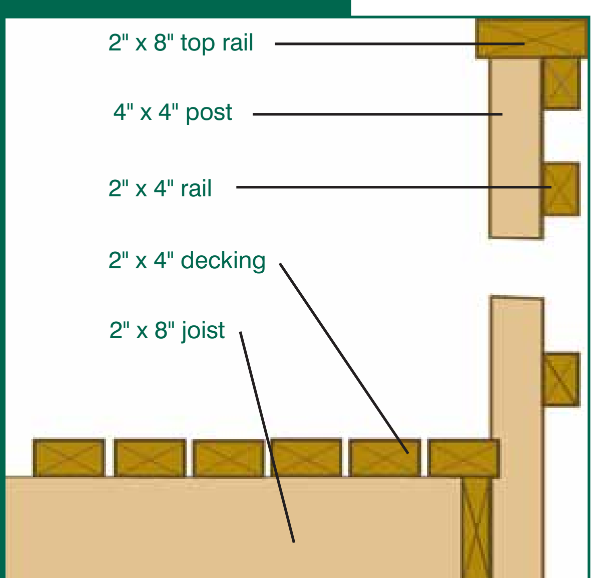

Figure 4-11: Conventional deck construction detail

Decks are built to burn almost as easily as wood stacked in a fireplace. All the components of a deck – joists, decking and railings – generally are made of wood, plastic or wood-plastic composites generally no more than 2 inches thick with high surface-to-volume ratios.

When fire approaches, deck material quickly heats up. Ignition can easily occur when the radiant energy from the fire gets hot enough or a burning ember lands on it.

Ignition of decks

Conventional decks are so combustible that when a wildfire approaches, the deck often ignites before the fire gets to the structure.

Normally, decks ignite in one of two ways. A burning brand landing on the surface of the deck is all that's required, particularly if the decking is dry or has wide gaps between the boards, which allows airflow and harbors embers. Similarly, space between the first deck board and the structure can provide airflow and catch embers, increasing the risk that the siding will ignite.

The other common cause of deck fires is direct flame from unmaintained vegetation igniting the deck from below, or a burning brand igniting debris under the deck. Again, dry or widely spaced deck boards speeds the spread of fire.

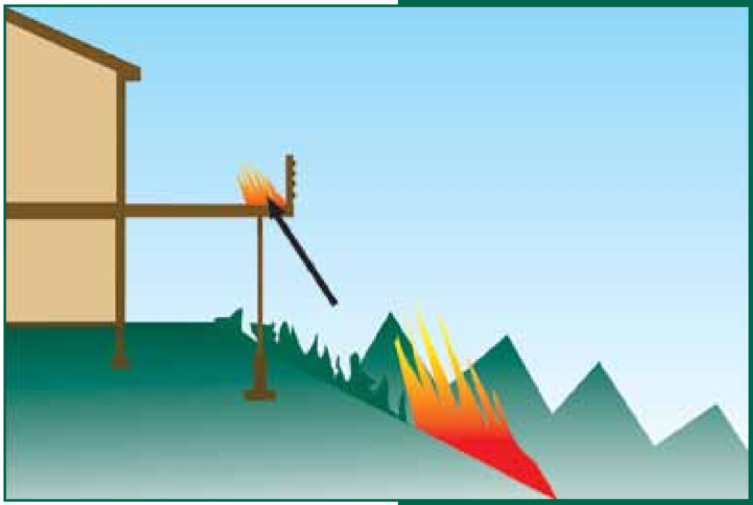

Figure 4-12: Conventional decks can easily ignite during a wildfire

Once the deck ignites, it may set the structure on fire. Heat from the deck fire, for example, may cause the glass in a sliding door to break, permitting flames to enter the interior of the structure. Or, combustible siding or soffits can ignite, carrying fire to the structure. The end result is the same. Even if the structure itself doesn't ignite, the structural integrity of the deck can be compromised and can become too hazardous to use.

Isolate the deck from wildfire with a patio and a wall

In low and moderate fire areas, it may be sufficient to isolate the deck from the fuels and fire by building a noncombustible patio and wall below it. The patio will ensure that no combustible materials are below the deck. The wall will act as a shield, deflecting both the radiant and convective energy of the fire.

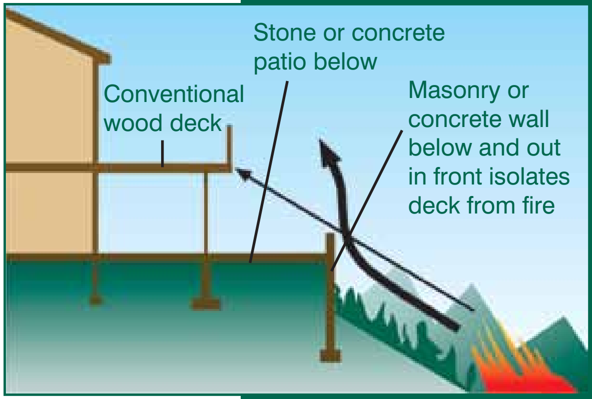

Figure 4-13: Deck with a patio and a wall below

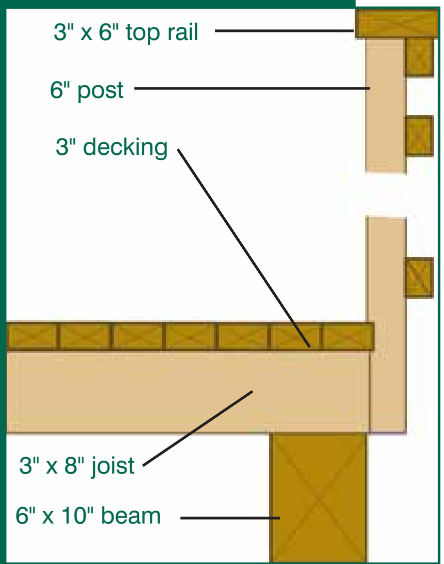

Figure 4-14: Heavy timber deck

Heavy timber construction

Like log construction, heavy timber is combustible but so thick that it burns very slowly.

Minimum thickness for a heavy timber deck is 6 inches for the posts and structural members and 3 inches for the decking and rails. This type of construction can be used with a patio below for additional protection.

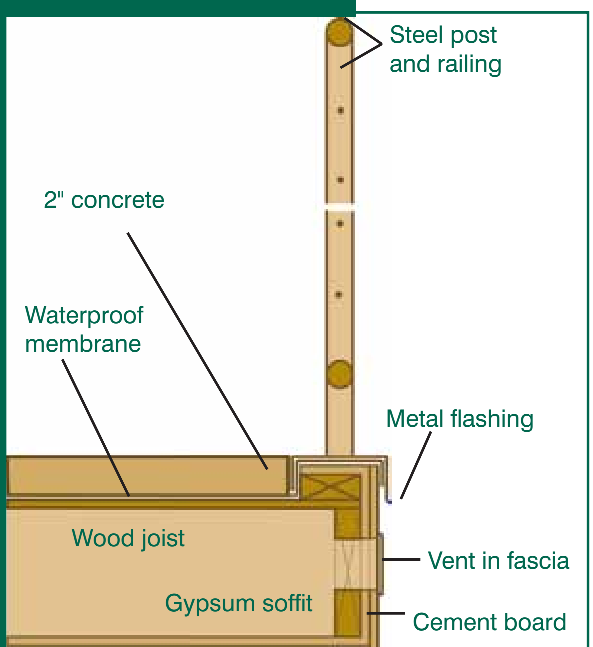

Figure 4-15: Fire-resistive deck construction detail

Fire-resistive deck construction

In the highest fire hazard areas, consider noncombustible surfaces, fire-retardant-treated wood and fire-resistive building materials for a deck. Wood frame construction is permitted, but the surface should be composed of noncombustible, fire-retardant-treated or one-hour fire-resistive materials.

To build this type of surface, place a waterproof membrane over the top of the deck. This allows the use of fire-resistive soffit materials, which cannot tolerate moisture. The most common materials are cement fiber or metal panels (noncombustible), fire-retardant-treated plywood (ignition resistant) and gypsum sheathing (noncombustible).

Cover the membrane with fire-retardant-treated lumber decking, or use 1 to 2 inches of concrete or stone. This surface is ignition resistant and protects the deck from air-borne embers, but will require that the structure be strengthened to support the additional weight.

Posts and railings can be economically built from steel. Wood posts near the ground can have stone, brick or noncombustible coverings, or be of fire-retardant-treated wood. A popular, but expensive, baluster design is steel wire. Steel pipe, usually 1 to 2 inches in diameter, is economical and easy to work with. Square steel shapes can look like traditional wood railings.

Fully enclosed decks

The best design is to convert the deck to a solid form by fully enclosing it, completely eliminating the heat trap. This form also complies with the *2009 International Wildland-Urban Interface Code*.

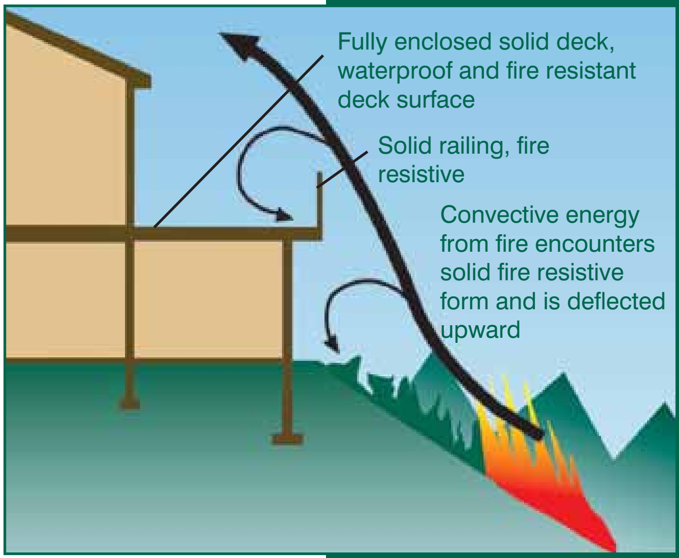

Figure 4-16: Fully enclosed solid deck

Ignition-resistant construction class

The IWUIC requires that structures constructed, modified or relocated into or within WUI areas meet the requirements of Class 1, Class 2 or Class 3 ignition-resistant construction. The requirements of these ignition-resistant construction classes are based on the fire hazard severity of the site. The greater the fire severity, the greater the fire protection provided by the class. Class 1 provides the most protection in areas of extreme fire hazard; Class 2 provides protection in areas of high fire hazard; and, Class 3 provides additional protection over the traditional construction requirement in areas of moderate fire hazard. The following table is an extract of IWUIC Sections 504, 505 and 506, which define the Class 1, Class 2 and Class 3 requirement, respectively.

Allowable Construction and Architectural Features for Various Ignition-Resistant Construction Classes

Architectural Feature	Class 1 (Extreme Severity)	Class 2 (High Severity)	Class 3 (Moderate Severity)
Roof covering	Class A Roof Assembly	Class B or noncombustible	Class C or noncombustible
Eaves and soffits	Ignition-resistant material, or 1-hour fire-resistance-rated construction, or 2-inch dimensional lumber, or 1-inch exterior fire-retardant-treated lumber, or ¾-inch exterior fire-retardant-treated plywood	Combustible eaves, facias and soffits shall be enclosed with solid materials with a minimum thickness of ¾ of an inch. No exposed rafter tails are permitted unless constructed of heavy timber.	No special requirement
Gutters and downspouts	Constructed of noncombustible materials and provided with approved means to prevent the accumulation of leaves and debris in the gutter.	Constructed of noncombustible materials and provided with approved means to prevent the accumulation of leaves and debris in the gutter.	No special requirement
Exterior walls	1-hour fire resistance from the exterior side, or Approved noncombustible materials, or Heavy timber or log wall construction, or Exterior of fire-retardant treated wood , or Exterior of ignition-resistant material	1-hour fire resistance from the exterior side, or Approved noncombustible materials, or Heavy timber or log wall construction, or Exterior of fire-retardant-treated wood , or Exterior of ignition-resistant material	No special requirement
Unenclosed underfloor protection	1-hour fire-resistance-rated construction, or Heavy timber construction, or Exterior fire-retardant-treated wood	1-hour fire resistance-rated construction, or Heavy timber construction, or Exterior fire-retardant-treated wood	1-hour fire resistance-rated construction, or Heavy timber construction
Appendages and projections, such as decks	1-hour fire resistance from the exterior side, or Heavy timber construction, or Approved noncombustible materials, or Exterior fire-retardant-treated wood, or Ignition-resistant building materials	1-hour fire resistance from the exterior side, or Heavy timber construction, or Approved noncombustible materials, or Exterior fire-retardant-treated wood, or Ignition-resistant building materials	No special requirement
Exterior glazing	Tempered glass, or Multilayered glazed panels, or Glass block, or Fire protection rating of not less than 20 minutes	Tempered glass, or Multilayered glazed panels, or Glass block, or Fire protection rating of not less than 20 minutes	No special requirement
Exterior doors	Approved noncombustible construction, or Solid core wood not less than 1¾-inch thick, or Fire protection rating of not less than 20 minutes	Approved noncombustible construction, or Solid core wood not less than 1¾-inch thick, or Fire protection rating of not less than 20 minutes	No special requirement
Vent location	Not allowed in soffits, eave overhangs, between rafters at eaves or in other overhang areas.	Not allowed in soffits, eave overhangs, between rafters at eaves or in other overhang areas.	No special requirement

Figure 4-17 ** Not all jurisdictions follow these fire-severity classifications. Consult your local building department, fire department or county planning department for local fire hazard classifications.*

*** For statewide fire hazard ratings, see the Colorado Statewide Forest Resource Assessment & Strategy (Action Plan).*

5. Building Materials and Components

When discussing building materials and components, we make frequent references to types of construction, noncombustible materials and various classes and ratings. Flame-spread classes, roofing classes and hourly ratings are confusing terms and sometimes are misused. The first is based on the Society for Testing and Materials' ASTM E-84/UL 723 "Test for Surface Burning Characteristics of Building Materials," the second is based on ASTM E-108/UL 790, "Test for Fire Performance of Roofing Materials," and the third is based on ASTM E-119, "Fire Tests of Building Materials."

Noncombustible

As applied to building materials, noncombustible means a material that, in the form in which it is used, is one of the following:

1. Material of which no part will ignite and burn when subjected to fire. Any material conforming to ASTM E-136 "Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C" is considered noncombustible. Materials such as concrete, steel and brick masonry generally are considered noncombustible.
2. Material that has a structural base of noncombustible material, as defined in Item 1 above, with a surfacing material not over 1/8-inch (3.2 mm) thick, and a flame spread index of 50 or less. The paper face on most gypsum wallboard has a flame-spread index of 15 and is considered noncombustible.

If a building material does not fall into either of the above categories, it is assumed to be combustible.

Flame-spread classification of building materials

The Uniform Building Code UBC uses the I-II-III designation, and the International Building Code (IBC) uses A-B-C. The flame-spread categories are as follows, per ASTM E-84/UL 723:

Class A or I:	Flame-spread index of 25 or less (Fire-Retardant-Treated Wood or FRTW)
Class B or II:	Flame spread index of 26 to 75 (some untreated lumber)
Class C or III:	Flame spread index of 76 to 200 (most untreated lumber and plywood)

Class A-B-C roof coverings

Class A, B or C roofing systems sometimes are confused with the Class A-B-C/I-II-III flame-spread categories as referenced above. The tendency is to assume that Class A roof systems have a Class A flame spread, and so on, but there is no correlation.

The ASTM E-108/UL 790 roof-coverings test does not produce a flame-spread rating. It is a pass-fail test under which a product either passes the criteria as a Class A, B or C roof covering system or it doesn't. It is an entirely different test from ASTM E-84/UL 723, and it includes weathering per the ASTM D-2898 "Standard Rain Test." The highest fire classification is Class A. Note that a Class C roof system is considered fire resistant, while a Class C (or III) building material (as above) is not. Non-classified roof systems have no fire rating.

Hourly fire-resistance ratings

Hourly ratings are a function of the assembly being used (wall, floor, door, ceiling, roof, etc.) and generally require use of a noncombustible membrane (e.g. gypsum, masonry). ASTM E-119 "Fire Tests of Building Construction Materials," is the test used to determine the hourly rating of an assembly. It exposes an assembly to heat and flame on one side and tests for heat transmission, burn-through, structural integrity and ability to withstand a hose stream from a fire hose.

Because of the potential for radiant heat exposure from one structure to another, either on adjoining sites or on the same site, the IBC regulates the construction of exterior walls for fire resistance. Where exterior walls have a fire-separation distance of more than 5 feet, IBC Section 705.5 allows the fire-resistance rating to be determined based only on interior fire exposure. This recognizes the reduced risk that is due to the setback from the lot line. For fire separation distances greater than 5 feet, the hazard is considered to be predominately from inside the structure. Thus, fire-resistance-rated construction whose tests are limited to interior fire exposure is considered sufficient evidence of fire resistance under these circumstances. However, at a distance of 5 feet or less, there is additional hazard of direct fire exposure from a structure on the adjacent lot and the possibility that it may lead to self-ignition at the exterior face of the exposed structure. Therefore, exterior walls located very close to any lot line must be rated for exposure to fire from both sides. The listings of various fire-resistance-rated exterior walls will indicate if they were only tested for exposure from the inside, usually by a designation of "FIRE SIDE" or similar terminology. Where so listed, their use is limited to those applications where the wall need only be rated from the interior side. For application in the WUI, the "FIRE SIDE" of the wall system must be the exterior wall surface.

The difference between a non-combustible material and a rated material or assembly is the surface resistance to ignition versus the protection afforded the structure behind it. A good example of a non-combustible material is metal roofing and siding. Metal is non-combustible, but an excellent conductor of heat. If the fire remains present long enough, the heat will be conducted through the metal and ignite the material behind it. An example of a fire-rated assembly is wood siding applied over 5/8 inch gypsum sheathing. This assembly is rated as one hour. The surface can ignite, but the structure is protected from the fire for one hour. **The importance is the difference between intensity of fire and duration of fire, as described in the fire behavior section (Section 2).**

Most ratings are for commercial structures in urban settings. That is why the IWUIC references the IBC, which is used to build both commercial and residential structures, rather than the IRC, which is used for single family and multi-family homes with up to four units.

The IBC allows both prescriptive and performance-based fire-resistant designs, although its current emphasis is clearly on the former. Section 720 of the code explicitly lists several detailed, prescriptive fire-resistant designs. However, Section 703.3 also allows the designer to choose from other alternative methods for design as long as they meet the fire exposure and criteria specified in the American Society for Testing and Materials (ASTM) fire test standard ASTM E-119.

IBC 703.3 Alternative methods for determining fire resistance:

1. Fire-resistant designs documented in recognized sources.
2. Prescriptive designs of fire resistance-rated building elements, components or assemblies, as prescribed in Section 720.
3. Calculations in accordance with Section 721.
4. Engineering analysis based on a comparison of building element, component or assemblies designs having fire-resistance ratings, as determined by the test procedures set forth in ASTM E119 or UL 263.
5. Alternative protection methods, as allowed by Section 104.11.

Fire-resistant construction assemblies (walls, floors, roofs) and elements (beams, columns), that perform satisfactorily in standard fire-resistance tests, are documented in building codes, standards, test reports and special directories of testing laboratories. Over the years, a considerable amount of accumulated test data allowed the standardization of many fire-resistant designs involving generic (non-proprietary) materials, such as wood, steel, concrete, masonry, clay tile, "Type X" gypsum wallboard and various plasters. These generalized designs and methods are documented in IBC sections 720 and 721, with detailed explanatory figures, tables, formulas and charts. Fire-resistant designs that incorporate proprietary (pertaining to specific manufacturers and/or patented) materials are documented by test laboratories in reports and special directories of both test laboratories and trade associations. The major sources of documented construction designs rated for fire resistance are described below.

Underwriters Laboratories Inc. (UL) conducts tests of various building components and fire protection materials. The assemblies are tested under recognized testing procedures, including ASTM E119 and ANSI/UL 263, all of which are essentially the same. When the assembly complies with the acceptance criteria of the fire-test standard, a detailed report is provided, including its description and performance in the test, pertinent details and specifications of materials used. A summary of the important features is produced and given a UL designation, which is then added to the UL directory.

To facilitate the design process, numerous associations publish wall-design configurations that meet various fire criteria. Examples of these publications are Fire Rated Wood Floor and Wall Assemblies (DCA-3), published by the American Wood Council; Fire Rated Systems Design/Construction Guide (W305), published by APA-The Engineered Wood Association; and Fire Resistance Design Manual (GA-600), published by the Gypsum Association.

Heavy timber and log wall construction

Heavy timber is another type of wood construction. Experience and fire tests have shown that the tendency of a wood member to ignite in a fire is affected by its cross-sectional dimensions. During a fire, large-size wood members form a protective coating of char that insulates the inner portion of the member from the fire. This type of wood construction often is referred to as slow burning.

Different minimum dimensions apply to different types of wood members, and the minimum cross-sectional dimension required in order to qualify for the heavy-timber fire rating is set forth in IBC Section 602.4. The following is a condensed version of building code sections, which is provided as a guide. Consult the IBC or your local building or fire departments to determine complete requirements.

602.4.1 Columns. Wood columns shall be not be less than 8 inches nominal in any dimension where supporting floor loads and not less than 6 inches nominal in width and not less than 8 inches nominal in depth where supporting roof and ceiling loads only.

602.4.2 Floor framing. Wood beams and girders shall be not less than 6 inches nominal in width and not less than 10 inches nominal in depth.

602.4.3 Roof framing. Framed or glued-laminated arches for roof construction, framed timber trusses and other roof framing, which do not support floor loads, shall have members not less than 4 inches nominal in width and not less than 6 inches nominal in depth.

602.4.4 Floors. Floors shall be without concealed spaces. Wood floors shall be of sawn or glued-laminated planks, splined or tongue-and-groove, of not less than 3 inches nominal in thickness. Floors shall not extend closer than 0.5 inch to walls. This space shall be covered by a molding fastened to the wall and so arranged that it will not obstruct the swelling or shrinkage movements of the floor.

602.4.5 Roofs. Roofs shall be without concealed spaces and wood roof decks shall be of sawn or glued-laminated, splined or tongue-and-groove plank, not less than 2 inches nominal in thickness, 1 1/8 inch thick plywood, or of planks not less than 3 inches nominal in width, set on edge close together and laid as required for floors. Other types of decking shall be permitted to be used if providing equivalent fire resistance and structural properties.

Fire-retardant-treated wood

Certain ingredients, when added to the wood, can insulate its surfaces so that its temperature remains below the kindling temperature for an extended period of time, no matter how hot the heat source might become. Among the ingredients used for this purpose are the acid salts of sulfates and phosphates, borates and boric acid.

All fire-retardant treatments are water-soluble, so water is used as the vehicle for carrying the treatments into the wood. The only effective method of application is the pressure treatment process. After pressure impregnation, most of the moisture is removed until the treated wood has a moisture content of no more than 19 percent for lumber and 15 percent for plywood.

Fire-retardant treatments do not necessarily prevent wood from being destroyed by fire, but they are the necessary ingredient that, when added to wood, slow decomposition to such an extent that the wood structurally outperforms most other building materials during actual fire conditions.

When temperatures reach a point slightly below the kindling point, the chemicals react with each other. Nonflammable gases and water vapor are formed and released at a slow, persistent rate that envelops the wood fibers, insulating them from temperatures that cause the wood to decompose. The inflammable gases and tars are reduced and an insulating char forms on the surface of the wood, further slowing the process of decomposition. Structural integrity of the wood is preserved for a longer time with the reduced rate of decomposition, and smoke and toxic fumes are greatly reduced. When the heat source is removed, the treated wood ceases to decompose and fire spread is eliminated.

In Section 2303.2, the IBC defines fire-retardant-treated wood as

"any wood product that, when impregnated with chemicals by a pressure process or other means during manufacture, shall have, when tested in accordance with ASTM E 84 or UL 723, a listed flame spread index of 25 or less and show no evidence of significant

progressive combustion when the test is continued for an additional 20-minute period. In addition, the flame front shall not progress more than 10.5 feet (3200 mm) beyond the centerline of the burners at any time during the test."

This is far more severe than the 10-minute ASTM E-84 test used for the flame-spread classification of building materials.

Flame-spread classification per ASTM E-84, 30-minute duration, has no relation to a 30-minute rating or any other hourly rating (which must be determined by ASTM E-119). ASTM E-119 is not a required test for FRTW, therefore FRTW has no different hourly rating than untreated wood. The advantage of FRTW over untreated wood and other combustible materials is the fact that it doesn't ignite or contribute to flame spread.

The IWUIC and IBC require FRTW to be properly labeled. Code-compliant stamps must contain the information in Figure 5-1. Product coloration is not a substitute for a building-code approved, third-party inspection agency label.

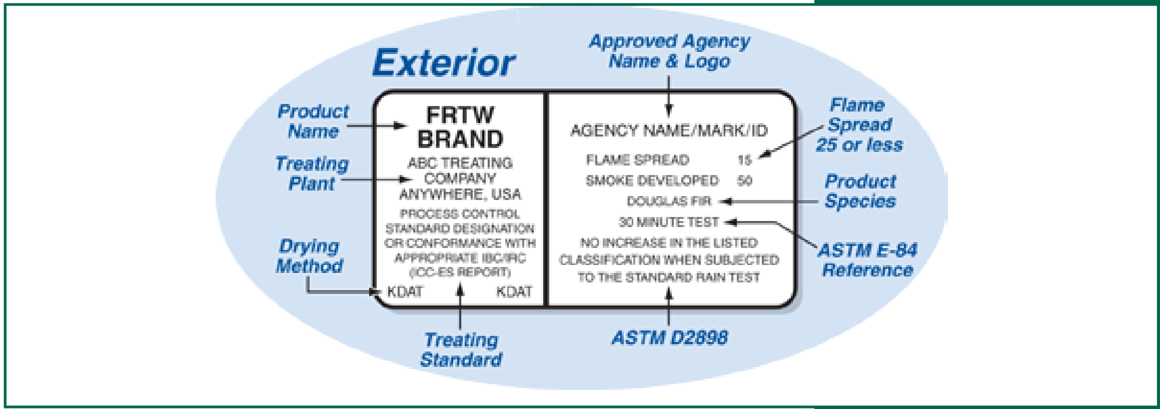

Figure 5-1: Courtesy of Western Wood Preservers Institute

Ignition-resistant building material

Ignition-resistant building materials are those that sufficiently resist ignition or sustained flaming combustion under worst-case weather and fuel conditions and with exposure to burning embers and small flames. Ignition-resistant building materials shall comply with any one of the following:

1. Extended ASTM E 84 testing. Materials that, when tested in accordance with the procedures set forth in ASTM E 84 or UL 723, for a test period of 30 minutes, comply with the following:

   1.1 Flame spread. Material shall exhibit a flame-spread index not exceeding 25 and shall show no evidence of progressive combustion following the extended 30-minute test.

   1.2 Flame front. Material shall exhibit a flame front that does not progress more than 10 1/2 feet (3200 mm) beyond the centerline of the burner at any time during the extended 30-minute test.

   1.3 Weathering. Ignition-resistant building materials shall maintain their performance in accordance with this section under conditions of use. Materials shall meet the performance requirements for weathering (including exposure to temperature, moisture and ultraviolet radiation) contained in the following standards, as applicable to the materials and conditions of use:

1.3.1 Method A "Test Method for Accelerated Weathering of Fire-Retardant-Treated Wood for Fire Testing" in ASTM D 2898, for fire-retardant-treated wood, wood-plastic composite and plastic lumber materials.

1.3.2 ASTM D 7032 for wood-plastic composite materials.

1.3.3 ASTM D 6662 for plastic lumber materials.

Identification. All materials shall bear identification showing the fire-test results.

2. Noncombustible material.
3. Fire-retardant-treated wood identified for exterior use.
4. Fire-retardant-treated wood roof coverings. Roof assemblies containing fire-retardant-treated wood shingles and shakes that comply with the requirements of Section 1505.6 of the *International Building Code* and classified as Class A roof assemblies, as required in Section 1505.2 of the *International Building Code*.

Roofing

Noncombustible roof coverings

The following are noncombustible roof coverings:

- cement shingles or sheets
- exposed concrete slab roof
- ferrous or copper shingles or sheets
- slate shingles
- clay or concrete roofing tile
- approved roof covering of noncombustible material

Roofing is one of the most important ways to protect a structure from wildfire. As shown earlier, when wildfires become more intense, the lofted embers become a significant cause of the fire spread. Because most roofing has a rough surface and numerous cracks, it can trap wind-blown embers. In many major WUI fires, burning roofs have been observed on structures thousands of feet from the fire.

Figure 5-2: Wood shakes

Wood shakes and shingles

Simply put, untreated wood shakes and shingles are almost like kindling. They are thin, 1/2- to 1-inch thick, with a very rough surface and many cracks. When an untreated wood roof burns, it also lofts burning embers, contributing to fire spread.

Cedar shakes and shingles can be modified by pressure impregnation with fire-retardants, which changes their classification to either B or C. Fire-retardant-treated cedar shakes and shingles installed over a gypsum underlayment have a Class A assembly rating.

Figure 5-2: Reinforced asphalt shingles

Asphalt shingles

Conventional mineral reinforced asphalt shingles usually have a Class C rating.

Mineral-reinforced shingles gradually have been replaced by fiberglass-reinforced asphalt shingles. These have a Class A rating. They are available in many colors and textures and can even imitate wood or slate shingles.

Metal

Metal roofing in many colors is available in sheet form, and usually has standing seams or ribs. The most common metal roof is galvanized steel with factory-applied paint.

Metal roofing also is available in patterns that imitate wood and slate shingles. This product is made by stamping a texture and shape on the metal and then applying the appropriate color. This imitation is so good that at a distance of 100 feet or more it is difficult to tell the difference between it and the material it is imitating.

While metal roofing is noncombustible, it requires a gypsum underlayment in order to have a Class A assembly rating.

In addition to galvanized steel with paint, metal roofing also is available in aluminum with paint, stainless steel and copper. These tend to be more expensive, but may last longer.

Figure 5-4: Metal roofing

Fiber–cement shingles

These shingles are made of cement and fiberglass, or cement and wood. Like the metal shingle, they are made to imitate a wood shingle's texture, shape and color. The cement in these products is altered with polymers to make it less brittle. These products may be noncombustible and may require an underlayment for a Class A assembly rating.

Membrane roofs

These materials include both rubber and hot-applied, bituminous-saturated mineral felt for flat roofs. They are marginally combustible, but most often are used with other covering systems such as concrete. They can be applied over a gypsum underlayment for a Class A assembly rating.

Concrete shingles and tile, slate shingles and clay tile

These products are noncombustible. They are 1-inch thick, heavy (10 pounds per square foot or more) and Class A rated. Concrete shingles often are manufactured to look like wood shingles.

Figure 5-5: Concrete tiles

Exterior walls: siding

The exterior walls of a structure are most affected by radiant energy from the fire and, if defensible space is not adequate, by direct impingement of the fire.

Wood panels and boards

Wood panels and boards are the most common and economical forms of siding, but they are readily combustible. This siding usually is not very thick (1/2-inch to 3/4-inch) and will burn through to the structure behind it in less than 10 minutes. A one-hour fire-resistance rating can be achieved by adding 5/8-inch Type X gypsum sheathing behind the siding.

Fire-retardant-treated lumber and plywood siding is another option. These products are traditional wood-siding materials that have been pressure impregnated with fire retardants and meet the definition of ignition-resistant materials. They can be used in all fire hazard severity zones.

Figure 5-6: Wood siding

Fiber cement panels, boards and shingles

While these products may be noncombustible, they may not have a fire-resistance rating and may need gypsum sheathing to achieve a one-hour rating. These materials are virtually permanent on a vertical surface and may need to be painted; stain can even be used on some with satisfactory results. These products are available with textures molded to imitate wood grain.

Metal

Like their counterparts in roofing, metal siding is available in either flat sheets with seams or in stamped patterns intended to imitate wood boards or shingles. They are noncombustible, but like other metal products, they need gypsum sheathing to achieve a one-hour rating.

Stucco

Real stucco, as base material, is ¾-inch to 1-inch thick cement and gypsum. The stucco is applied in two or three coats with metal mesh reinforcement. It is both a non-combustible and one-hour rated material, which makes it a very good material for high-hazard areas.

Synthetic stucco

Synthetic stucco also is referred to as EIFS (exterior insulating finish system). It consists of a 1/8-inch thick acrylic cement finish on fiberglass mesh. This is applied to the top 1 to 2 inches of expanded polystyrene insulation. The surface may be noncombustible and has no rating by itself. During a fire, it can delay ignition of the structure because it melts and falls away. It can, like other products, obtain a one-hour rating with gypsum sheathing.

Figure 5-7: Log wall construction

Log wall construction

Log wall construction has exterior walls constructed of solid wood members where the smallest horizontal dimension of each member is at least 6 inches. Although the logs are combustible, the low surface-to-volume ratio of the logs causes them to burn very slowly.

Log siding is not an acceptable substitute for log wall construction, as it is not as thick as actual log wall construction. However, log siding can achieve a one-hour fire resistance rating by adding 5/8-inch Type X gypsum sheathing behind the siding.

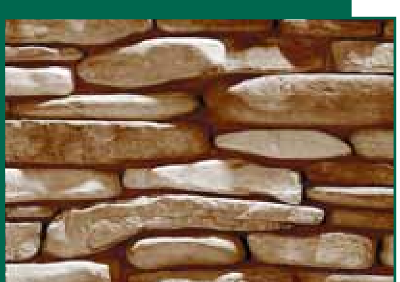

Figure 5-8: Concrete synthetic stone

Concrete synthetic stone

Concrete synthetic stone is cast concrete with integral color forming the texture and shape of the stone being imitated. The stones are modular in shape with consistent dimensions and flat backs. This synthetic stone is noncombustible and can have a fire resistance rating.

Brick, stone and block

These materials are inherently noncombustible and can have a fire-resistance rating.

Figure 5-9: Brick wall

Windows and Glass

Windows are one of the weakest parts of a structure with regard to fire. They usually fail before the structure ignites, providing a direct path for the fire to reach the structure interior.

Glass failure

Glass provides only a partial barrier to fire and only for a short time as it fractures in the presence of heat. In the case of a wildfire, this will happen in about five minutes. Glass deflects most of the convective energy, but not the radiant energy of the fire.

Convective energy contains hot air and gasses. Approximately 70 percent of the heat is deflected by window glass; roughly 20 percent is absorbed; and 10 percent is transmitted to the interior of the structure.

Radiant energy from a fire is infrared light energy, like the energy we experience from the sun. Sixty percent of the radiant energy from a fire is transmitted through the glass to the interior of the structure; approximately 20 percent is reflected; and the other 20 percent is absorbed by the window glass.

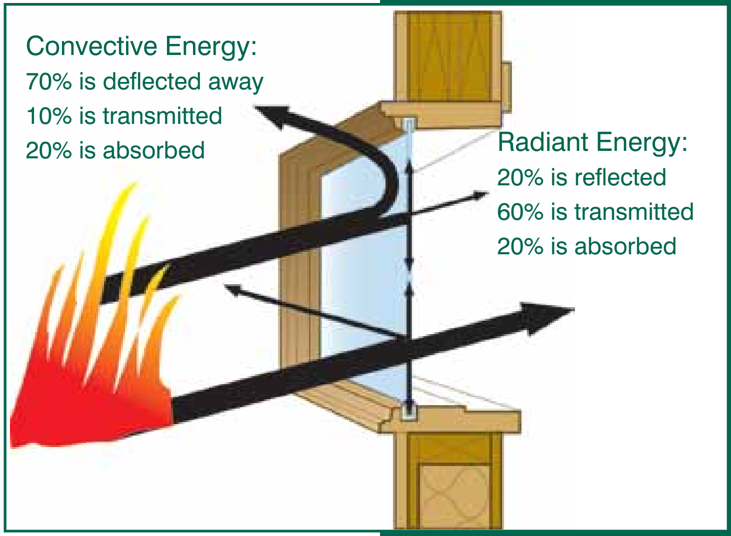

Figure 5-10: Energy transmission, conventional glass

Both radiant and convective energy heats the glass, but the perimeter of the glass is covered and protected by a sash. As a result, differential heating and stressing of the glass occurs, which causes it to crack.

Large and small windows

Even if the glass does fracture, the hot gasses (convective energy) from the fire and the fire itself cannot enter the structure if the glass stays in place. Only the radiant energy heat can pass through the glass. Eventually, even with the glass in place, combustible materials behind the window may ignite. (See Low E glass).

Small windows, less than 2 feet wide or tall on a side, will keep fractured glass in place. The size of glass held in place by the sash is relatively small and light weight.

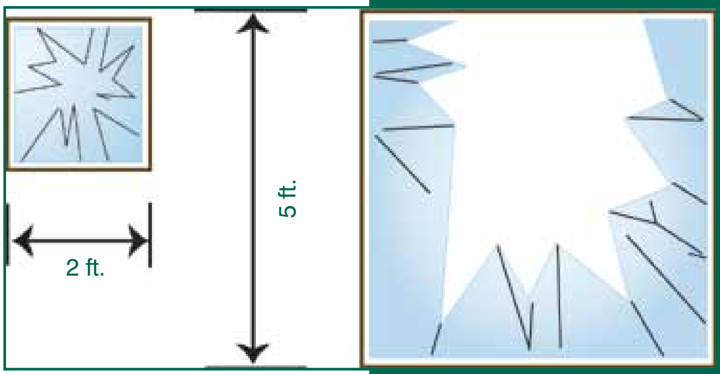

Figure 5-11: Small and large windows

Large windows (more than 2 feet wide or tall on a side) cannot keep the fractured glass in place. The size and weight of glass in relationship to the length of sash is too great.

Thermopane or double-glazed windows

Most of today's energy codes require glass to be double-glazed or Thermopane. During a fire event, double-glazed windows last approximately twice as long as a single pane, or about 10 minutes.

The same processes of convective and radiant energy affect the front pane of glass. As long as the front pane is in place, the second pane is partially protected. When the front pane fails and falls away, the process continues until the second pane fails and falls away.

As shown earlier in the fire behavior section (Section 2), the duration of a fire in an area is dependent on slope and fuels; which, in the case of a grass fire, can be as short as 5 minutes.

If the duration of the fire is any longer than 10 minutes due to preheating or significant fuel around the structure, additional protection is necessary to prevent glass failure and fire from entering the structure.

Figure 5-12: Thermopane window

Tempered glass

Tempered glass is resistant to high impact and high heat, which means it will remain in place and intact throughout a wildfire event. Building codes require tempered glass to be used in patio doors and all areas subject to human impact. Tempered glass also is used in front of fireplaces.

Tempered glass typically costs 50-percent more than regular glass. However, patio door replacement units are mass-produced and stocked by virtually every glass business. As a result, they are economical and less expensive than conventional glass. They come in six sizes, as shown in Figure 5-12, and typically can be used as a picture window unit, or combined to make a window wall or solar structure.

Using patio door replacement units provides tempered glass at a very economical price.

A few brands of windows are marketed as replacement windows in existing mid-rise urban structures where the use of tempered glass is required. As a result, the additional cost for these brands of tempered glass is only 25 percent more than standard glass. Your local window supplier can suggest appropriate manufacturers.

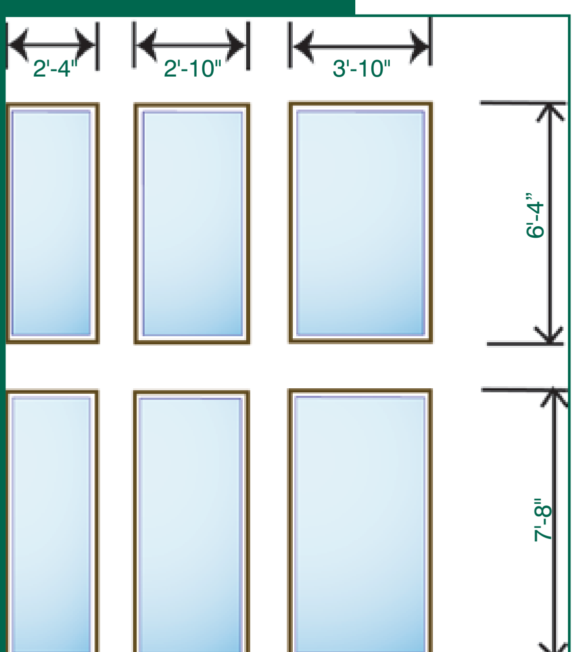

Figure 5-12: Patio door replacement unit sizes

Glass block

Glass block is the most fire-resistive glass available. It has the highest available rating of 90 minutes.

Glass block may be a good choice when only daytime lighting is needed, a view is not a factor and the window is oriented toward a very high fire hazard.

Figure 5-14: Glass block

Doors

Wood doors

Residential structures typically use wood doors with glass inserts. The same fire issues related to window glass apply to glass in doors. An unrated wood door typically is 1 1/2 to 2 inches thick, and can readily ignite and burn through in only 10 minutes, which is much faster than the rest of the structure.

Wood doors are available with a 20-minute rating. Solid-core wood doors a minimum of 1 1/2-inches thick also are acceptable.

Metal doors, steel and aluminum

Metal doors are non-combustible and available with 20-minute, 45-minute and 90-minute ratings. Glass sizes are restricted in these doors. The surfaces are available with embossing to simulate wood grain and raised panel designs.

Just as with energy conservation, a good fire-resistant door requires adequate weather stripping to prevent hot gasses or burning embers from entering the structure.

6. Summary

A major wildfire can be an overwhelming event to experience. It can be huge, blotting out the sun and creating its own winds. It can throw flames and burning embers everywhere. Wildfire is a natural part of our environment that we can either respect or fear. When we modify our homes and the surrounding environment, we can adapt to living in fire-prone areas. Every WUI resident must understand the basic characteristics of wildfire and the risks it presents to their lives and property. The actions we take by building appropriate structures and properly caring for the surrounding environment can significantly reduce wildfire hazards.

A comparison often is made between fire and water. Fire, like water, tries to find a way into our homes. It does not matter how fire-resistant some parts of a structure are if weak points allow a fire to enter. An awareness of how each building component is affected by fire will allow the owner, architect or builder to eliminate those weak points.

References and Additional Resources

2009 International Wildland-Urban Interface Code
International Code Council, Inc.
www.iccsafe.org/Store/Pages/Product.aspx?id=3850X09

NFPA 1144 Standard for Reducing Structure Ignition Hazards from Wildfire
National Fire Protection Association, (NFPA)
www.nfpa.org/catalog/product.asp?pid=114413

2009 International Building Code
International Code Council, Inc.
www.iccsafe.org/Pages/default.aspx

Fire-Retardant-Treated Lumber and Plywood
Hoover Treated Wood Products
www.FRTW.com

The following is a partial list of organizations that can provide more information on the subjects covered in this document.

Colorado State Forest Service
http://csfs.colostate.edu/
http://csfs.colostate.edu/pages/wildfire.html
http://csfs.colostate.edu/pages/wf-publications.html

Fire Adapted Communities
http://fireadapted.org/

Firewise Communities USA (National Fire Protection Association)
http://www.firewise.org/

eXtension Wildfire Information Network (eWIN)
http://www.extension.org/surviving_wildfire

Southern Rockies Fire Science Network
http://www.frames.gov/partner-sites/srfsn/home/

Federal Emergency Management Agency-Wildfire
http://www.ready.gov/wildfires

Insurance Institute for Business and Home Safety
http://www.disastersafety.org/Wildfire

USDA Forest Service, Southern Research Station,
Centers for Urban and Interface Forestry
http://www.humanandnaturalsystems.org/technology/cuif

University of Nevada Cooperative Extension, Living with Fire
http://www.livingwithfire.info/who-we-are

Acronyms

APA	American Plywood Association (now APA-The Engineered Wood Association)
ANSI	American National Standards Institute
ASTM	American Society for Testing and Materials
BOCA	Building Officials and Code Administrators International, Inc
FEMA	Federal Emergency Management Agency
FRTW	Fire-retardant-treated wood
ICBO	International Conference of Building Officials
ICC	International Code Council
IRC	International Residential Code
IWUIC	International Wildland-Urban Interface Code
NFPA	National Fire Protection Association
SBCCI	Southern Building Code Congress International
UBC	Uniform Building Code
UL	Underwriter's Laboratory
WHIMS	Wildfire Hazard Identification and Mitigation System
WUI	Wildland-Urban Interface

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