2. Fire Behavior: Fuels, Topography, and Weather

Wildland fires and the nature of burning structures

Wildland fires have been studied in great detail to help predict fire behavior. Anticipating the intensity, duration and movement of a wildland fire is very important for both fire fighter safety, and as the basis for tactical decisions made during the suppression of a fire.

Understanding fire behavior, especially how hot a fire will be and how long it will be at a building site, will help homeowners and builders decide how fire resistive a house needs to be.

Three factors affect wildland fire behavior:

1. **The fuel for the fire.** The type and density of the surrounding vegetation provides the fuel to keep the fire burning.

2. **The topography of the site.** The fire is affected by the steepness of slopes and other land features.

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3. **The weather.** Wind and humidity affect each fire.

Vegetation is the fuel for wildland fires

The type and density of a plant determines how it will burn. Not all plants burn the same way. Some plants almost never burn, some burn at different times of the year, and others can burn almost anytime.

Deciduous trees and bushes: Trees such as aspen, cottonwood, and mountain ash; bushes such as mahogany, mountain maple, and dwarf lilac usually burn only during severe droughts.

Bushes, such as the Gambel oak serviceberry and sage, can burn in the fall when leaves have changed or dropped, or when there is an extended dry period.

Evergreen trees with resinous sap: Pines, spruce, and firs can burn any time of year, but usually during extended dry weather, or during high wind events.

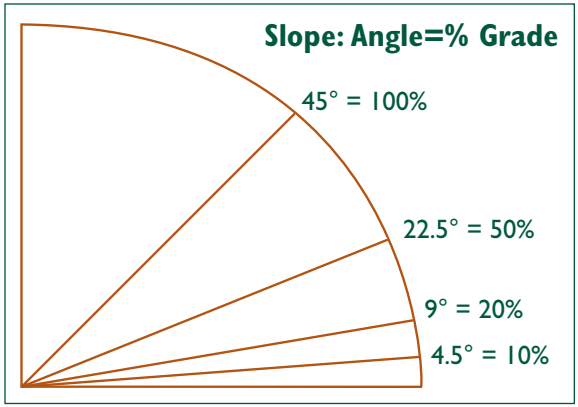
Evergreen bushes: Cedar and juniper can also burn any time of year when conditions are dry.

Grasses. Grasses can burn any time of year and only need a short dry period to ignite. It is fire resistive only when it is very green or when there is a good snow cover.

Fire duration and fuel

Fire duration is how long a fire will burn at a particular site. The type of fuel and its density determines a fire's duration. For example, grass is a light fuel, it will burn in less than 5 minutes and produce relatively less heat. Medium fuels, such as brush, burn 5 to 10 minutes with more heat. Large trees are considered heavy fuels because they burn from 10 minutes to over an hour with the most heat.

Understanding this is very important in determining how long a



Slope Chart.

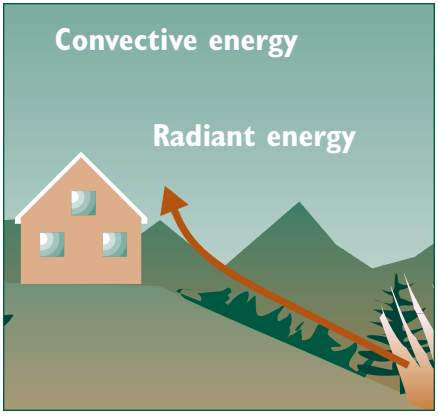
house must resist a fire. Different building materials can resist fire for different time periods.

Fire behavior and slope

A slope is the angle of the ground relative to the horizon and is commonly measured in either degrees or as a percent. Slope topography shows the steepness of the slope and the shape of the land.

The steeper the slope, the more quickly a fire moves and the hotter it burns. For example, ***a fire will spread twice as fast on a 30% slope than it will on level ground.***

This means that houses located on steep slopes need more fire resistance.



Convective and radiant energy from a fire.

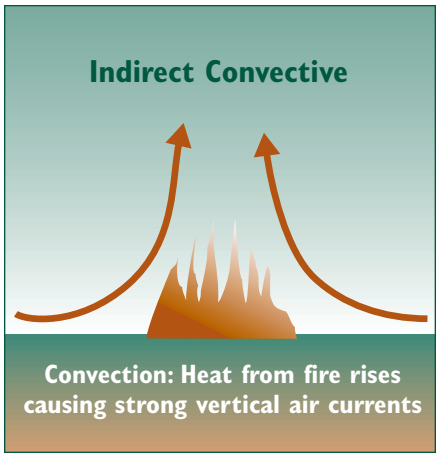
Fire behavior, ignition of fuels: mechanisms of heat transfer

As a fire burns, hot gas and air are released from the combustion of burning vegetation or buildings. These gases move up the slope drying and preheating any vegetation in the path of the fire. The fire also releases large amounts of radiant energy, like the sun, which also heats and dries the fuels. When flames make contact with these plants they are more easily ignited, which in turn speeds up the rate at which the fire moves and its intensity. Let's look more closely at the mechanisms of fire and how fire ignites a building by studying three categories of heat transfer:

1. indirect convective heating and lifting
2. indirect radiant, and
3. direct contact or impingement.

Convective lifting

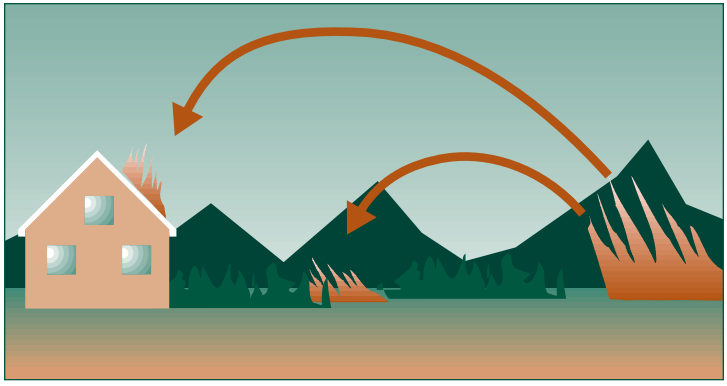
Fire produces hot gases that rise and carry partially burned substances and smoke into the atmosphere. During a wildland fire this atmospheric effect can be very strong, even causing its own wind as air rushes in to replace the rising air.



Convective lifting.

Convective vertical air currents can also lift burning materials or embers, called firebrands, and carry them horizontally for long distances from the fire.

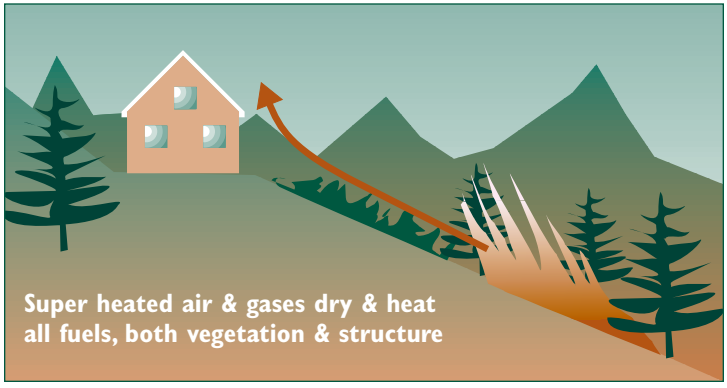
Once out of the rising air currents firebrands fall back to the ground and onto horizontal surfaces such as combustible roofs, decks and dry vegetation around a house. This effect, called spotting, can be very wide spread. Firebrands often travel hundreds or even thousands of feet in front of the actual fire.

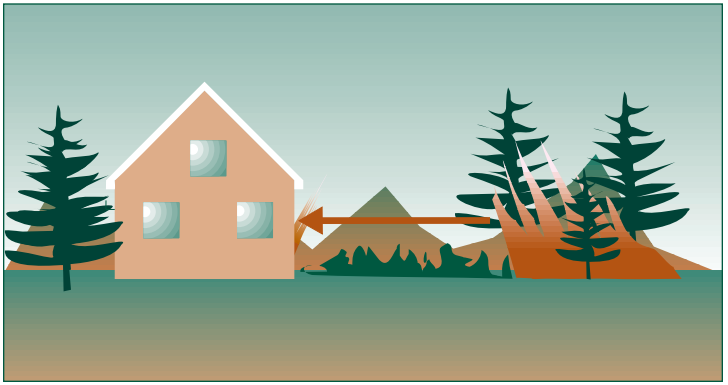


Firebrands, transported by convective lifting, create spot fires.

Indirect: Convective Heating

The same hot air and gasses that dry and preheat vegetation do the same thing to a building, making any combustible materials ready to ignite when the fire gets closer.



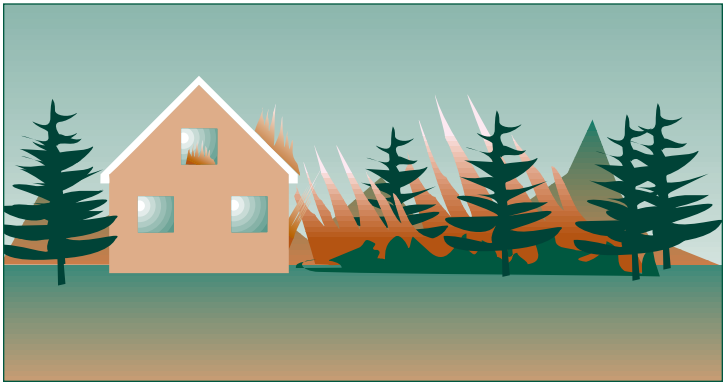


Radiant Heating

Indirect: radiant heating

Buildings can be preheated, even ignite and burn, from the transfer of heat by radiant energy from the fire. This is similar to sunlight heating objects, but fire heats only in the infrared portion of the light spectrum. Radiant heat transfers on a straight line of sight and can be reduced by barriers.

Vertical surfaces, such as siding, can ignite from this affect well before fire actually reaches the building. Large heavy fuels, once ignited, burn with high temperatures that amplify radiant energy, creating more potential for ignition through heat transfer.



Fire directly impinging on a house.

Direct contact or impingement

Continuous and abundant fuels like those found in unmanaged vegetation areas provide a direct path for a fire to contact a building. Creating defensible space and fuel breaks around a building is specifically intended to reduce this effect.

Weather

Weather is a major factor affecting fire behavior and is, of course, highly variable in terms of time and location. When there are extended periods of low moisture the possibility of wildfire increases. Weather can also increase and intensify fire behavior when there is low humidity and high winds.

Colorado's fire season is highly variable. Typically, winter and spring have few wildfires and summer and fall have more wildfires. Although the period between winter and spring, when the snow is gone but the vegetation has not yet greened up, is often a period of high fire occurrence.

In Colorado we typically have 50 to 100 days a year when severe wildfires are possible. More "fire days" occur at lower elevations while fewer "fire days" occur at higher elevations.

3. Building Site Location

Topography and vegetation: fire behavior and intensity

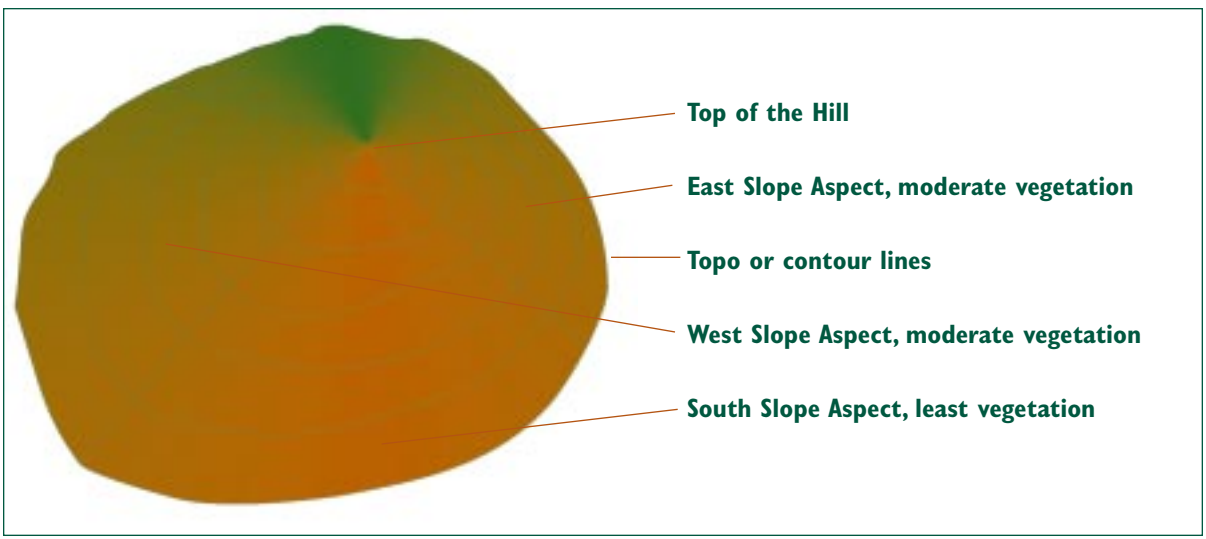
The location of a structure will determine the intensity and duration of the fire it experiences. As shown in the fire behavior section, we know at any location how intense a fire will be, how long it will be there, and how fast it will travel based on the surrounding topography and vegetation.

In choosing a location or determining the level of fire resistance a building requires, the builder or homeowner should be aware of how the local vegetation and topographic variations affect fire behavior.

Aspect

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

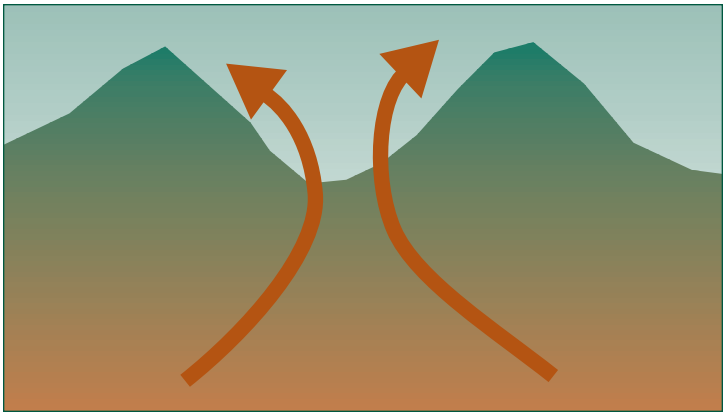
South slopes tend to have the least vegetation in an area because they dry out fast and have less available moisture for plants. Since there is less fuel on south facing slopes, fire burns there with less intensity than other slopes with more fuel. East and west slopes generally have more vegetation than south slopes. They are more prone to drying out in the summer when the sun is high in the sky so the fire potential increases on these slopes during the summer season. North slopes typically have the densest vegetation because there is more water available for plants. The higher moisture content of the vegetation on north slopes means that fires occur there less frequently, but when fires do pccur they burn with more intensity because there is so much more fuel.



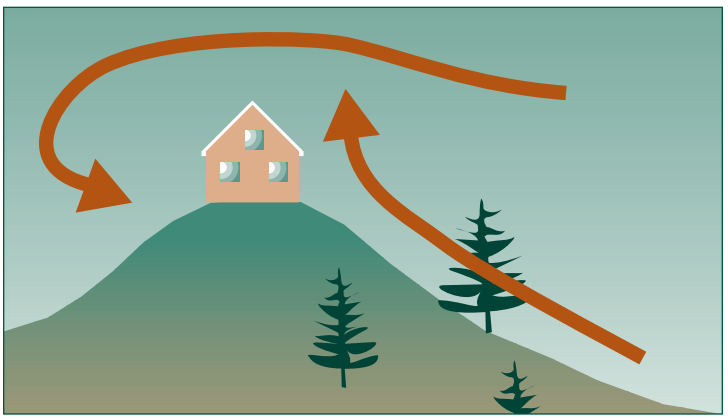
Aspect of slope

Dangerous topographic features: areas of higher fire behavior

The variations of topographic features such as valleys, ridges, canyons and saddles can be dangerous areas that further intensify or attract a fire.



Saddle, low area on a ridge.



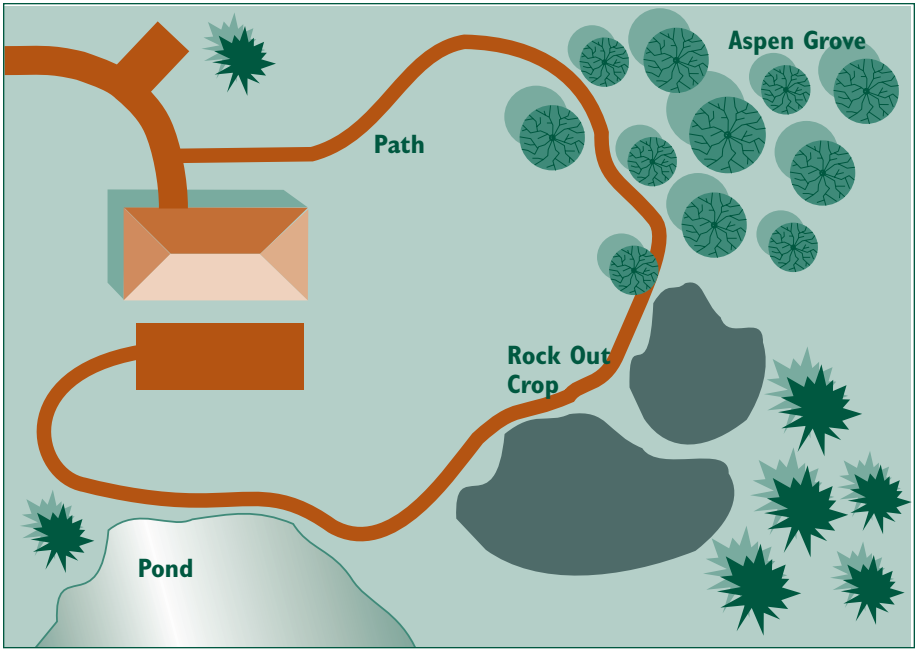
Ridge with wind exposure.

A **valley**, as a concave form tends to collect and concentrate winds. This means that as a wildland fire moves through such an area, its intensity increases. If the valley is narrow with steep sides, such as a **canyon**, this effect is even more pronounced.

When a valley crosses a ridge it creates a **saddle** between the higher parts of that ridge. Like a valley, saddles will channel, intensify and speed up a fire. These areas tend to be built upon because they offer some shelter and flat areas. It is important to recognize that saddles are natural fire paths where fire will travel first, and with more intensity.

Ridges experience more wind primarily because they are elevated above the surrounding land. When a fire moves up a slope towards a ridge it gathers speed and intensity.

As the wind crosses a ridge it usually has a leeward eddy where the wind rolls around and comes up the leeward side, exposing both sides of the structure to wind and fire. There are usually no flat or protected areas on ridges to provide some protection from the fire.



Site: House located relative to natural features that buffer against fire.

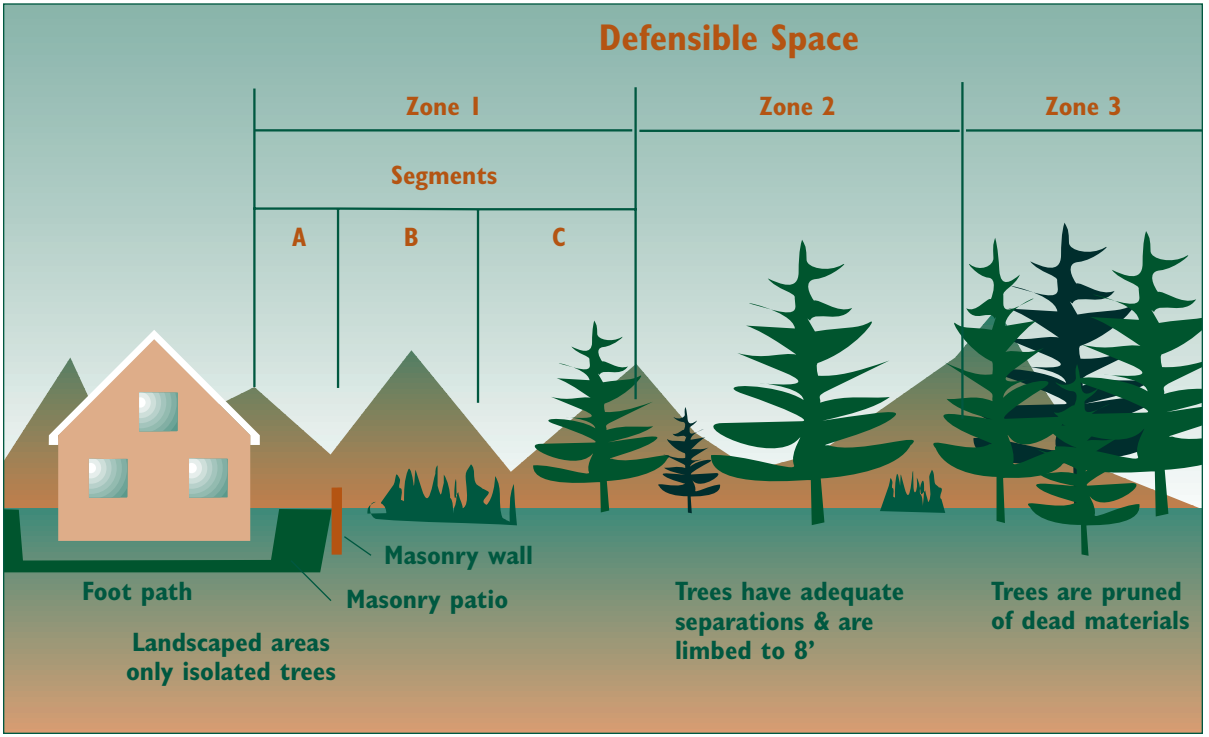
Natural barriers and buffer zones

Some physical features will actually reduce fire behavior, and can be used to slow, reduce, or deflect a fire. Some examples of these beneficial barriers are natural rock outcroppings, wetlands, streams, lakes, and aspen stands. Take advantage of these features by siting your building so that the natural barrier is between the building and the anticipated path of a fire.

How this affects building location and design decisions

On large parcels of land these physical features should be considered in choosing the final location of your building. Of course many other factors such as privacy, views, access, and aesthetic values will effect your decision. Fire is just one of these factors. Whether fire is your primary consideration or not, will depend on how high the fire hazard is in the area, the values of both the individual homeowners and the community, and how your building design and materials can compensate for the anticipated fire hazard.

On smaller parcels there may be only one suitable building location. The site's physical features will determine the probable fire intensity and dictate what combination of site modifications and fire resistance is necessary to prevent the building from igniting.



Defensible space.

Site design and modifications to the forest: developing a defensible space

Once you have evaluated the fire hazard rating of your site you need to develop a plan to manage the surrounding forest or create your defensible space. This is the first part of our two part stategy to build a fire resistive structure. **Defensible space** is the area around a building that has been significantly modified so that a wildfire's intensity will be reduced enough to prevent the fire from igniting the house and allow fire fighters to safely defend the house.

If you were to diagram all the features at a building site you would notice that as you move away from the building, out into the wildland, the features gradually shift from man-made to more natural elements. We divide this gradation into zones that form donut shapes around the building. As you develop your defensible space plan you need to inventory the existing site features and analyze how hazardous they are. Man-made elements are landscaping features such as masonry walls, patios, footpaths and driveways. These features create barriers and buffer zones.

The area right next to the building (Zone 1-A) should have primarily noncombustible surfaces in it. If there is to be planting at all in this zone it should be only deciduous, well-trimmed plants that are irrigated if possible. Ground covers should be flowerbeds and cut grass.

Moving away from the building, the next area (Zone 1-B) can have more landscaping and less man made surfaces. Vegetation should still be

deciduous, trees or bushes and grass can be native, but cut several times a year to less than 6 inches tall.

Moving further away from the building to (Zone 1-C) the landscaping should change from introduced deciduous plants to natural evergreens. These trees or bushes should be far apart and well maintained by trimming.

In Zone 2 the landscape is entirely natural vegetation but it is intensely managed or modified. The natural evergreens closest to the house need to be trimmed of dead material, limbed to 10 feet above the ground, and thinned so that a minimum of 10 feet separates the tree crowns.

Moving even further away from the house into Zone 3, the forest management gradually becomes less intensive and subtler. Limbing needs to be only 4 to 5 feet above the ground and tree crowns can be closer together.

Remember, the more modifications you make in your defensible space, the less you need to use fire resistive materials and design for your building. Conversely, the less you modify the surrounding wildland the more you need to use fire resistive materials and design for your building. The combination of these two strategies work together to achieve the goal of building a structure that does not burn when wildfire occurs.