



Boulder County
Land Use Department
Publications

Fuel Models for Colorado

Land Use Department

Courthouse Annex Building
2045 13th Street
PO Box 471
Boulder, CO 80302

Wildfire Mitigation Services:

Phone: 720-564-2625
Fax: 303-441-4856
wildfiremitigation@bouldercounty.org
www.bouldercounty.org/lu

Office Hours:

Monday — Friday 8 a.m. to 4:30 p.m.
Closed Tuesdays 8-10 a.m.

Fuel Models for Colorado

A Guide for the Homeowner

Using the following guide, a homeowner can determine which of the eight standard fuel models found in Boulder County best represents the vegetative environment of their home site. They can then use that information to help make an educated assessment of how a wildfire will affect their area.

Fire Behavior

The three major factors that have the greatest influence on the behavior of wildfire are weather, topography, and fuel.

Weather is a variable we cannot control; the wind will blow, dry periods will occur, and hot days in the summer are assured. Topography can only be controlled to some extent, mainly by informed selection of a building site; avoiding steep slopes and narrow gullies for example. Fuels, on the other hand, can be easily manipulated in many ways in order to influence fire behavior.

Fuel is any material that will burn and contribute to the spread of a fire. This includes vegetation (such as trees, shrubs, and grasses) and human created fuels (firewood piles, fences, and homes for instance).

By modifying the species composition, vegetation density, fuel arrangement, and continuity around the home site, the overall fire behavior response is changed, potentially making the home site more fire-safe. This is the principle underlying the creation of defensible space.

Vegetation as Fuel

Different kinds of vegetation burn in different ways. Fires in fine fuels (such as grasses, leaf litter, and pine needles) ignite easily and burn through quickly, but with low to moderate intensity. Fires in heavy fuels (such as brush and timber), though they may not ignite as readily, burn with much greater intensity and for longer duration.

Different species also burn with varying intensity. Evergreen species (especially junipers) are highly flammable because they contain large amounts of waxes and resins. Deciduous species, by contrast, generally do not have as many of these kinds of compounds and are therefore less flammable.

Regardless of the species, areas where large amounts of dead and down woody material that have built-up will burn with greater intensity and cause the fire to spread more rapidly.

The density of the vegetation also has a large influence on wildfire. In general, the more dense the vegetation, the greater the intensity of the fire, and the greater the rate of spread.

Arrangement of the fuel is another key factor. If fuels are continuous (i.e. the vegetation extends across an area more or less uninterrupted by topography and/or different fuel types), the fire can spread relatively unchecked. Areas that have several layers of fuels generally burn with more intensity than areas with less continuity.

Compare two sites: an open pine stand vs a closed mixed conifer stand.

An open pine stand has a few widely spaced trees with little understory brush or other ladder fuels (vegetation or other combustible material that leads vertically from the surface fuels up into the crown of trees). Fires in such areas are generally low intensity and burn through the surface fuels (grasses, pine needles, and dead limbs), and can be controlled relatively quickly and easily by modest fire suppression efforts.

A closed mixed conifer stand, by contrast, often has large amounts of surface fuels with mid-level "ladder" fuels, and an upper level of tree canopies spaced very close together. A fire in these areas can be a very high intensity event. This is due to the presence of so much fuel (which allows fire to spread upwards and outwards and possibly become a "crown" fire). When all of these levels of fuels become involved in flame, a wildfire can become "extreme" with very erratic and intense fire behavior. Firefighters cannot control such fires, and often must wait until the fire reaches an area of lower density, such as a natural opening in the forest, or a cut area (referred to as a "fuel break").

Fuel Model Key

The first step in determining what fuel model best fits your area is to evaluate your site.

- ✓ Note the types of vegetation present (i.e. species and percent cover of trees, shrubs, and grasses).
- ✓ Determine the relative density and continuity of the vegetation.
- ✓ Look at the amount of dead and down materials present (needles, limbs, old stumps, standing dead trees).

After making a visual assessment of the fuel conditions, use the descriptions below to "key out" your fuel model. Then examine the corresponding fuel model description on the following pages for more detailed information to determine if that model is, in fact, the one that most represents your home site.

- I. The site is mostly open with grasses and/or widely spaced trees. Primary carrier of fire are the fine fuels.
 - A. Grass has a relatively fine structure, is generally below knee level, and is easy to walk through. Trees and shrubs may or may not be present and are widely scattered... **Fuel Model 1 (A, L & S).**
 - B. Trees are open grown. The understory is grass, forest litter, or both. There are few understory trees or shrubs... **Fuel Model 2 (C).**
- II. The site has a large amount of brush, or very dense small trees. The primary carrier of fire would be surface fuels and some aerial fuels.
 - A. The area is heavily forested with small diameter trees (6-8" or less) that are relatively short (20-15' or less). This would include areas of thick pine regeneration. There is a large amount of dead lower limbs on trees. Understory has forest litter and may contain some grasses... **Fuel Model 4 (B).**
 - B. The area is main low brush with some grass and few large trees. Shrubs are generally short (3-5'). Shrubs are generally deciduous and may or may not retain cured leaves. Grasses are usually present in the understory... **Fuel Model 5 (T).**
- III. The site is forested with trees of various sizes from small to large. Tree density ranges from partially open to dense closed stands. Primary carriers of fire are down woody materials and/or aerial fuels
 - A. The area has a closed canopy of mainly lodgepole pine. There is little understory growth, and amounts of forest litter are low... **Fuel Model 8 (H).**
 - B. The area has a closed canopy stand of pine or mixed conifer. Several size and age classes are represented. An understory is present and includes small trees, grasses and shrubs. Higher amounts of needle and woody litter may be present... **Fuel Model 9 (U).**
 - C. The area has a closed canopy of pines or mixed conifer. There is a greater density of understory vegetation, as well as higher amounts of forest litter and large dead material. Tree densities and fuel loadings are greater than in Model 9... **Fuel Model 10 (G).**
- IV. The site is generally forested, but there is a large amount of standing dead and/or down material as a result of insect or disease epidemics. Primary carrier of fire is the down woody material and/or aerial fuels.
 - A. The area is composed of large amounts of dead and down woody materials, including small limbs as well as large diameter branches and whole trees. Areas of near complete mortality may be intermixed with live trees. Understory will include grasses as well as light to moderate amounts of regeneration... **Fuel Model 11 (K).**

Fuel Model 1 (A, L & S)

Characteristics

This fuel model represents open grasslands consisting of short grasses and forbs, generally one foot tall or less. The area has very few shrubs or trees; any that are present are widely scattered. This model occurs from the plains, to mountain meadows of the lower and upper montane zones, and up to the alpine.

Common Types/Species

Vegetation is mainly prairie, montane, and alpine grasses and forbs. Some scattered shrubs (such as mountain mahogany, in lower elevations; wax currant, bitterbrush, and buckbrush in the montane; and birch and willow at higher elevations), and isolated trees (such as ponderosa pine and/or Rocky Mountain juniper at lower elevations, and limber pine and Engelmann spruce at higher elevations) may be found.



Fuel Model 1 (A, L, & S): Grasses (photo courtesy: Rich Gray)

Fire Behavior

Fire is carried by the dried grasses and fine herbaceous materials. Surface fires may be ignited easily and can burn rapidly with low to moderate intensity.

Fuel Model 2 (C)

Characteristics

This fuel model consists of open grown pine stands. Trees are widely spaced with few understory shrubs or tree regeneration. Ground cover is moderate and consists of grasses and/or needles and small woody litter. This model occurs as open-grown, mature ponderosa pine stands in the foothills to upper montane zone.



Fuel Model 2 (C): Grasses with Downed Stemwood (photo courtesy: R. Gray)

Common Types/Species

The predominant tree species is ponderosa pine. This type may include some scattered Douglas-fir, Rocky Mountain juniper, and aspen. Shrub species may include wax currant, Rocky Mountain maple, mountain mahogany, and buckbrush. Montane grasses and forbs are also included in this model.

Fire Behavior

Fire is carried predominantly by grasses and woody litter, but some individual tree "torching" can occur. Low intensity surface fires predominate, but clumping of fuel can generate somewhat higher fire intensities.

Fuel Model 4 (B)

Characteristics

This model consists of thick, closed-canopy "dog-haired" pine stands. Small to medium diameter trees predominate with continuous closed crowns and few openings. There may be high amounts of small dead limbs retained on the lower portion of the trees. There may also be high amounts of wood and needle litter associated with the stand. This model occurs as areas of thick, continuous regeneration or in dense, suppressed stands in the montane zone.

Common Types/Species



Fuel Model 4 (B): Doghair pine stands (photo courtesy: R. Gray)

Trees that commonly associated with this model are ponderosa and lodgepole pine. Shrubs such as common juniper and Oregon grape may be present. Few grasses and forbs are present due to heavy shading.

Fire Behavior

Fire is carried throughout surface and aerial fuels, predominantly by the live and dead fine fuels (pine needles, small branches) Fire spread and intensity can be high and may be enhanced by dead woody fuel on the ground.

Fuel Model 5 (T)

Characteristics

This model consists of

continuous stands of low brush. Generally, heights do not exceed six feet. The stands will have a grass understory with leaf litter. Widely scattered ponderosa pine and Rocky Mountain Juniper may be present. This model occurs along the first hogbacks of the foothills, in draws, and south slopes in the lower montane zone.

Common Types/Species

This type includes most mountain shrub communities, such as mountain mahogany, wax currant, bitterbrush, and buckbrush. Montane grasses and forbs are associated with this type.



Fuel Model 5 (T): Mixed shrubs (photo courtesy: Eric Philips)

Fire Behavior

Fire is usually carried in the surface fuels (grasses and leaf litter) and are generally low intensity. However, under the right conditions, fire can spread rapidly through the shrub canopies, burning dead stems, cured leaves and live foliage.

Fuel Model 8 (H)

Characteristics

This model is represented by closed canopy stands of mature pines with little understory growth. Amounts of needle and woody litter are also low. This type typically occurs at higher elevations of the montane zone.

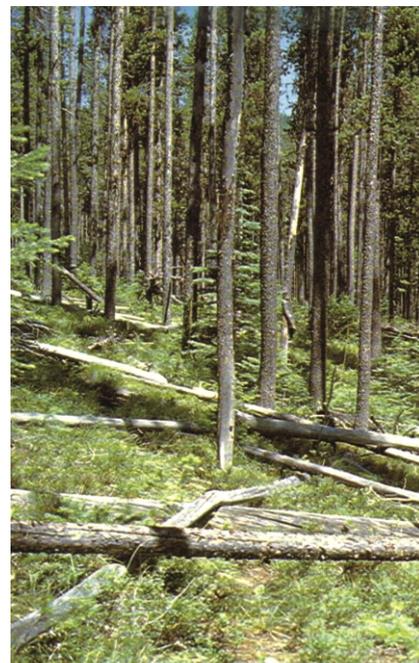
Common Types/Species

Trees that commonly associated with this model are ponderosa and lodgepole pine. Understory is mostly duff and needle litter.

Shrubs (such as common juniper, Oregon grape, or snowberry) may be present, but generally there are few or no understory plants. Some sparse bunches of shade tolerant grasses and sedges may be present.

Fire Behavior

Fires are generally be slow burning, low intensity events, mainly consuming in the surface fuels, needle cast and woody litter. Fires are dangerous mainly in scattered areas where accumulations of down woody materials can cause tree torching and spotting.



Fuel Model 8 (H): Closed canopy pine (photo courtesy: R. Gray)

Fuel Model 9 (U)

Characteristics

This type is represented by closed canopy stands of mature pine and mixed conifers. Understory may consist of small trees and shrubs, grasses, and moderate concentrations of down, dead woody litter. High amounts of needle litter may be present. This model can exist from foothills to sub-alpine.

Common Types/Species

This model can include ponderosa pine, lodgepole pine, and a mixture of Douglas-fir, Engelmann spruce and limber pine. Some mountain shrubs and grasses are present in scattered locations. Few grasses are present due to heavy shading.



Fuel Model 9 (U): Closed canopy mixed conifer. (photo courtesy: R. Gray)

Fire Behavior

Fires can either be slow burning, low intensity events (mainly in the surface fuels), or given the proper conditions, fast spreading, high intensity events. Heavier fuel loads than model 8 can cause torching and crown fire. In extreme conditions, fires have the potential to develop into stand-replacing events.

Fuel Model 10 (G)

Characteristics

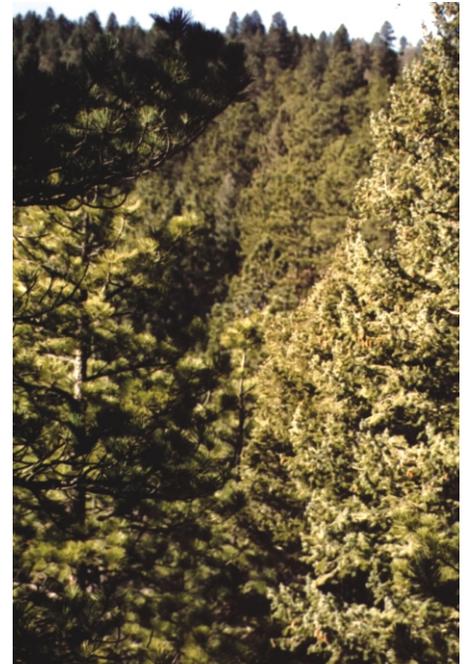
This type is represented by dense stands of over-mature ponderosa pine, lodgepole pine, mixed conifer, Engelmann spruce-subalpine fir forest, and continuous stands of Douglas-fir. In all stands, heavy down material is present. There is also a large amount of dead, down woody fuels. Reproduction may be present, acting as ladder fuel. This model can occur from the foothills to the sub-alpine zone.

Common Types/Species

Any and all of the various overstory and understory species can occur in this model. Included in this fuel type are prairie, montane, and alpine grasses, forbs and shrubs.

Fire Behavior

Fires tend to be moderate to high intensity events, in part due to the density of the tree canopy and the amounts of dead, down woody material. Torching and spotting of fires is frequent, and high intensity fires can occur and have the potential to develop into stand-replacing events.



Fuel Model 10 (G): Closed canopy pine (photo courtesy: R. Gray)



Fuel Model 11 (K): Mixed conifer with snags (photo courtesy: R. Gray)

Fuel Model 11 (K)

Characteristics

This model occurs in areas of heavy surface fuel loadings. This model best fits where a stand has high concentrations of down, woody materials. This model generally includes stands of bark beetle killed pines and budworm killed Douglas-fir. These stands have a greater build-up of fuels than does model 10, with large amounts of ladder fuels and shrubs, and heavy fuel loadings of downed trees.

Common Types/Species

Mixed conifers of all kinds, with a heavy concentration of standing and down dead trees. All the various understory species can occur in this model.

Fire Behavior

Fires tend to be high intensity events, mainly due to the large amounts of dead, down woody material. Tree torching, fire branding from dead woody materials, and spotting of fires is frequent.