



FORESTRY

Vegetative Recovery after Wildfire

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Quick Facts...

The ability of a tree to withstand fire damage is based on the thickness of the bark, rooting depth, needle length, bud size, and degree of scorch.

Conifers are cone-bearing trees that reestablish only from available seed reserves. Wind and wildlife aid in seed dispersal into the burned area.

Fire often prepares a suitable seedbed by exposing mineral soil necessary for good germination.

Aspen is unique among Colorado forest trees in its ability to sprout new stems after a fire. Many shrubs and grasses share this ability to resprout from under-ground roots undamaged by fire.

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It's difficult to see the rebirth of a forest after a devastating fire. The speed and extent of recovery depends on the severity of the fire, when it occurred, and the plant community.

Nature has equipped many plants to recover quickly from fire. The root systems of many plants run deep and are often protected from lethal temperatures. Once the above ground stem is removed, roots are stimulated to send up new shoots. The soil profile may contain many dormant seeds waiting for the right conditions to germinate and grow. Some trees are so adapted to fire that they rely upon it to regenerate new stands. Pinecones of some species will not open and release the seed until exposed to the heat of fire. Given these adaptations to fire, recovery of many plants will occur, often rapidly.



In 2000, the Hi Meadow Fire southwest of Denver caused extensive damage to the area's natural resources.

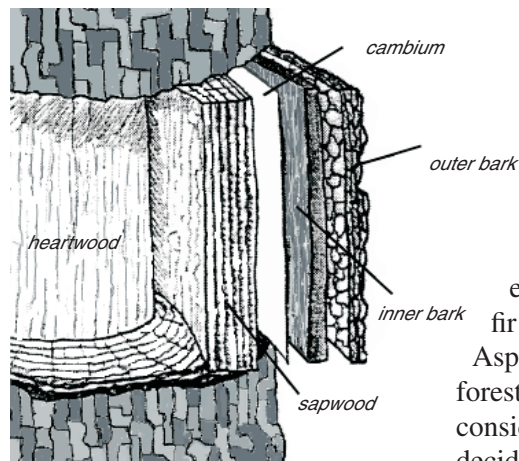


Figure 1: Outer bark, inner bark, cambium, sapwood and heartwood of a tree. Cambium must survive a fire for the tree to survive.

Trees

In Colorado the major forest types are pinon pine-juniper; ponderosa pine-Douglas-fir; lodgepole pine; spruce-fir; and aspen. Fire is more frequent in pinon-juniper, ponderosa and lodgepole pine trees. These types of trees are typically lower in elevation and dryer than the spruce-fir forest types of the subalpine zone. Aspen is Colorado's major deciduous forest type. Response to fire varies considerably among coniferous and deciduous trees. Colorado conifers are limited in their response to fire. Unlike some deciduous trees and shrubs, the root systems of conifers do not regenerate new stems or 'suckers.'

Conifer trunks

In order for a conifer (a cone-bearing tree) to survive, some of the roots, the cambium of the main trunk, and buds must survive. The cambium is the sensitive layer of growing cells that produces the vascular system that conducts water and nutrients through the tree (Figure 1). The bark insulates the cambium from the damaging intensity of a fire; the thicker the bark, the better the protection. Bark thickness varies with age and differs by species. (Table 1.)

Buds

Buds are located at the terminal end of branches in trees. Buds begin forming at the end of spring to provide tissues for next year's growth.

The foliage (needles) of a conifer provides some protection to the buds. Longer needles provide more protection than short ones. When the fire occurs can impact the development and survival of the buds. New buds may not have formed prior to an early summer fire, which reduces its survival.

The amount of scorched foliage in the tree crown can predict conifer survival to a certain degree. Even with severe scorch damage, the buds may survive and grow the following spring. Basing survival estimates on scorch alone can be misleading; foliage color after a fire can be deceptive. Buds should be carefully examined – they should be firm and the terminal stem flexible. The bud or stem should not break off easily.



Table 1: Tree characteristics important to surviving fire and overall species resistance to fire rating.

<i>Species</i>	<i>Ability to sprout after fire</i>	<i>Size when fire resistance is gained</i>	<i>Fire resistance at maturity</i>	<i>Bark thickness at base of mature tree</i>	<i>Branch density</i>	<i>Bud size</i>	<i>Needle length</i>
CONIFERS							
Pinon pine	None	None	Low	Thin	Low	Large	Short
Ponderosa pine	None	Sapling/Pole	High	Thick	Medium	Large	Long
Lodgepole pine	None	Mature	Medium	Very thin	Low	Medium	Short
Limber pine	None	Mature	Medium	Thin	Low	Large	Long
Bristlecone pine	None	Mature	Medium	Medium	Low	Medium	Long
Douglas-fir	None	Pole	High	Thick	High	Medium	Medium
Subalpine fir	None	None	Very low	Very thin	High	Medium	Medium
White fir	None	Mature	Medium	Medium	High	Medium	Medium
Juniper	None	Mature	Low/Med	Thin/Medium	Low	Small	Short
Colorado blue spruce	None	None	Low	Thin	High	Medium	Medium
Engelmann spruce	None	None	Low	Thin	High	Medium	Medium
DECIDUOUS							
Gambel Oak	Root crown, rhizomes	None	Low	Thin	High	Small	
Cottonwood	Root crown, stump sprouts	Mature	Low/Med	Medium	Medium	Large	
Alder	Root crown	None	Low	Thin	High	Small	
Birch	Root crown	None	Low	Thin	High	Small	
Aspen	Rhizomes	Mature	Low	Thin	Low	Small	

Sizes are defined as follows: saplings, 1 to 4 inch dbh; poles, 5 to 10 inch dbh; mature, > 11 inch dbh. (dbh = diameter at breast height)
 (Table adapted from *Wildland Fire in Ecosystems: Effects of Fire on Flora*, GTR RMRS-GTR-42-volume 2)



Although most of the foliage is severely scorched in these two photos, the trees may survive because sufficient healthy foliage remains to support the tree.



Roots

Damage to roots depends, in part, on the nature and overall depth of the root system in the soil profile. The amount and depth of the duff layer (needles, leaves, and other recognizable litter on the forest floor) can impact a fire's effect and damage to the root system. Fast moving fires may not destroy the duff layer and may cause little root damage. (Figure 2.)

Ponderosa pine and Douglas-fir

The degree of damage to roots, stems, and the crown determines whether trees will survive a fire. Bark thickness plays an important role in the survival of these trees. As a ponderosa pine matures, it develops a very thick bark that insulates the cambium from damaging heat. Even if the bark is considerably scorched, the cambium can remain undamaged.

Ponderosa pine roots run deep thus providing further protection. Hot slow moving fires will often destroy the duff layer and cause root damage to shallow rooted species such as Colorado blue spruce.

Trees beyond the pole stage (about the size good for fence and corral posts) are very resistant to fire damage if they are not too crowded. The crowns of larger trees are more elevated, thus protecting the buds and foliage from heat scorch.

Cambium damage can be evaluated by chipping away a small section of bark with an axe. A healthy cambium is a light tan or cream color. Dead cambium is dry, brown or gray, and has a sour fermented smell. A large amount of pitch exuding from deeply charred bark can also indicate cambium damage.

Crown scorch and bud kill is considered the principle cause of death. In healthy, well-spaced stands mortality is usually low. Ponderosa's lengthy needles can provide sufficient protection to the buds, which are large and well protected by heavy scales.

Douglas-fir shares similar bark characteristics with ponderosa pine. Both are more fire resistant than spruce and true fir. Douglas-fir needles are very short in comparison with ponderosa pine. These offer little protection to the small buds. Douglas-fir saplings are more prone to loss than ponderosa pine.

Trunks nine inches in diameter or larger can survive low to moderate intensity fires. If 25 percent of the cambium is damaged, a Douglas-fir will most likely die. In addition, Douglas-fir has shallow lateral roots that are susceptible to damage.

Currently, many ponderosa pine/Douglas-fir forests are over-crowded. This leads to higher mortality rates due to fire than in well-spaced stands.

Regeneration From Seed

Natural reestablishment of ponderosa pine and Douglas-fir can occur from seed depending on the presence of cones on the tree. Most pines do not develop cones every year. Cones of pine require two seasons to mature. Cones typically mature and release their seeds to the wind in late summer and early fall. In some cases cones may continue to mature on a top-killed tree and release a



Use an axe to reveal the cambium layer to evaluate fire damage.



Cones of ponderosa pine.

viable seed crop. While most pines have variability in cone crop production, the Douglas-fir is more regular.

In a severe fire only live trees around the perimeter of a burned area may produce viable seed. Wind dispersal of the seed is often limited to a few hundred feet from the seed-bearing tree; birds and rodents also help distribute seed.

Even with a good seed crop, moisture conditions must be optimal for seed germination and seedling survival. Fire effects on the forest floor will impact the success of seedling establishment. Most conifers require bare mineral soil for successful germination. The litter layer is often consumed in slow moving fires, which exposes the necessary mineral soil.

Aspen

Aspen can form extensive pure stands in Colorado, but are also present to a greater or lesser degree in many other forest types. As a result, the aspen component in a conifer stand can greatly increase after a fire. In addition, while conifers successfully out-compete aspen in a non-fire situation, after fires occur, aspen may regenerate in a pure stand. This is due to the extensive suckering from roots when the main trunk of the aspen is destroyed.

Thin aspen bark makes it susceptible to fire damage. Pure stands are often missed or jumped in some fires due to the low flammability of aspen. Again, the diameter of the trunk influences the trees resistance to fire. Diameters of six inches or more are often quite resistant.



Regeneration of aspen after a fire can occur from extensive root suckering.



Pinon pine destroyed by fire



Lodgepole pine regeneration 13 years after a fire.

Piñon-Juniper

Both piñon and juniper are very susceptible to fire damage and are easily top-killed. Both have thin, highly flammable bark that provides little insulation to the cambium.

Reestablishment of these trees is from seed; rodents and birds often store large amounts of seed. However, this can be a very slow process. Typically, a severely damaged stand will convert to a shrub community with gradual reintroduction of trees at 60 to 100 years.

Lodgepole Pine

Lodgepole pine forests are very adapted to a natural fire regime. Regeneration of new lodgepole seedlings can be rapid (as little as two to three years).

Lodgepole bark is thin in comparison to that of ponderosa pine. Temperatures lethal to the cambium are common.

A unique characteristic of lodgepole pine is its serotinous cones. The cone scales can remain closed for several years because of a resin coating. During an intense fire this resin melts away allowing the cone scales to open, thus releasing the seed. After a fire, a massive number of seeds are released. An intense fire also exposes mineral soil to provide a good seed bed.



Some cones of lodgepole pine are serotinous, remaining closed until intense heat from a fire forces them open.



Bare mineral soil exposed after a fire.



Wildflower regeneration after fire.



This stand of gambel oak resprouted quickly after a fire.

Spruce-Fir

Stands of spruce and true fir occupy the highest elevations of Colorado's mountains; moisture and temperature conditions here are often less favorable for development of an intense fire. Catastrophic fires are less frequent in this zone; however, when fires do occur, they can be intense.

Colorado blue spruce can be a component in lower forest types. Its thin bark and shallow roots make it very susceptible to fire damage. Branches often grow low to the ground, which allows the fire to climb into the crown and destroy the tree.

Engelmann spruce and subalpine fir forests are common in higher elevations of the state. Both trees share characteristics making them highly susceptible to fire mortality. The bark is thin and ignites easily, the roots are shallow and the branches grow near the ground.

Recovery of these trees after a fire can be difficult and slow. Both are adapted to a cool and shady environment. Seedlings may become established in small burns of 1/10 acre or less. Larger areas may not reestablish because seedlings are intolerant of the intense sunlight at this elevation. New seedlings may establish at the perimeter of a larger fire. The seedlings require the shade the larger trees provide.

Other Conifers

Limber pine and bristlecone pine are present in scattered stands throughout the state. Fire is relatively uncommon in the zone where these pines occur. Limber pine bark is thin but mature trees are more fire resistant. The large seed of limber pine is attractive to Clark's nutcracker, which can be instrumental in caching and dispersing limber pine seed.

White fir is common in southern Colorado at mid-elevations. Like subalpine fir it has a thin bark and is susceptible to top-kill in the sapling and pole stages. White firs have shallow root systems, low growing branches and foliage making it susceptible to burning.

Shrubs, Grasses and Forbs

Unlike conifers, many shrubs, forbs and grasses readily sprout from underground root structures after a fire. These root structures vary in size, shape and depth in the soil profile. Fire severity directly impacts these structures and influences which species regenerate. Slow moving fires destroy the duff layer and heat the soil to lethal temperatures. Sometimes shallow root structures are destroyed favoring those species with deeper roots. However, when a forest canopy is so dense that there is little or no understory, it may take considerably longer for grasses and shrubs to come in after a wildfire.

Dormant buds can be located in the roots. These become the new growing points for reestablishment after a fire.

Common Colorado shrubs, such as antelope bitterbrush, rabbitbrush, and mountain mahogany, can sprout from the root collar (the point where the stem and root meet). The root collar is rather shallow and may be destroyed in a slow moving fire that consumes the duff layer.

Rhizomes (horizontal underground stems – not roots) occur deeper in the soil profile. This depth protects the rhizome from lethal temperatures. Gambel oak and chokecherry are common species with rhizomes in this

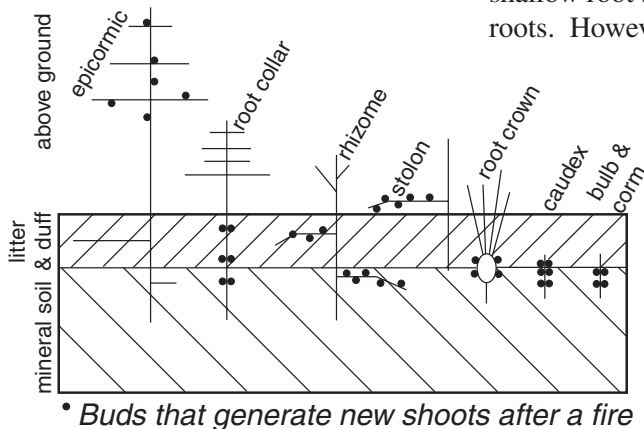


Figure 2. Various plant parts that regenerate new shoots and their location in the soils (Table adapted from *Wildland Fire in Ecosystems: Effects of Fire on Flora*, GTR RMRS-GTR-42-volume 2).



Natural recovery of forb and grass community.



FIREWISE is a multi-agency program that encourages the development of defensible space and the prevention of catastrophic wildfire.



This fact sheet was produced in cooperation with the Colorado State Forest Service.

state. Gambel oak often resprouts readily after fire. Oak rhizomes are often four to 20 inches deep in the soil profile. The density of Gambel oak often increases after fire. Many types of willow also resprout quickly.

Forbs, which include many common wildflowers, have similar root structures that resprout after fire depending on fire severity and depth of the root structure. Wildflowers, such as Indian paintbrush, lupine, and columbine resprout from an underground structure called the caudex. Some wildflowers form underground bulbs or corms develop and new sprouts.

The seeds of many shrubs and forbs can persist in the soil for years after dispersal. A fire can open an area to greater sunlight and warmth stimulating germination of some seeds.

Hard seeds with thick seed coats are ruptured by fire allowing the seed to absorb moisture and germinate. Raspberry, gooseberry, currant, plum, and chokecherry seed are stimulated in this way.

Many grass species are rhizomatous and regenerate readily after fire. Buds and grass meristems (growing points) are protected by being deeper in the soil profile.

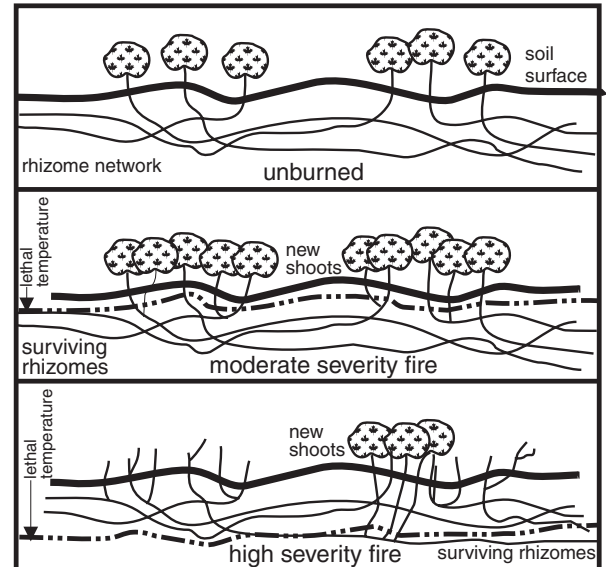


Figure 3. Effects of subsurface heating on postfire sprouting on rhizomatous shrub (adapted from Wildland Fire in Ecosystems: Effects of Fire on Flora, GTR RMRS-GTR-42-volume 2).

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- From Colorado State Forest Service, Colorado State University, Fort Collins, CO 80523-5060; (970) 491-6303; Fax (970) 491-7736; www.colostate.edu/Depts/CSFS:
- 6.302, *Creating Wildfire Defensible Zones*
 - 6.303, *Fire-Resistant Landscaping*
 - 6.304, *Forest Home Fire Safety*
 - 6.305, *FireWise Plant Materials*
 - 6.306, *Grass Seed Mixes to Reduce Wildfire Hazard*
 - 6.308, *Soil Erosion Control after Wildfire*

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