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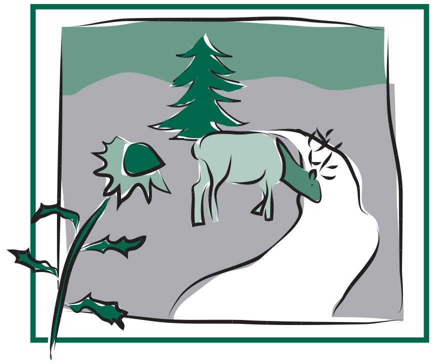

Soil Erosion Control after Wildfire

Fact Sheet No. **6.308** Natural Resources Series | **Forestry**

by R. Moench and J. Fusaro*

After a severe fire, soil erosion can cause adverse effects on many ecosystems.

The potential for severe soil erosion is a consequence of wildfire because as a fire burns it destroys plant material and the litter layer. Shrubs, forbs, grasses, trees, and the litter layer break up the intensity of severe rainstorms. Plant roots stabilize the soil, and stems and leaves slow the water to give it time to percolate into the soil profile. Fire can destroy this soil protection. There are several steps to take to reduce the amount of soil erosion. A landowner, using common household tools and materials, can accomplish most of these methods in the aftermath of a wildfire.

Hydrophobic Soils

In severe, slow-moving fires, the combustion of vegetative materials creates a gas that penetrates the soil profile. As the soil cools, this gas condenses and forms a waxy coating. This causes the soil to repel water – a phenomena called hydrophobicity. This hydrophobic condition increases the rate of water runoff. Percolation of water into the soil profile is reduced, making it difficult for seeds to germinate and for the roots of surviving plants to obtain moisture.

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Hydrophobic soils do not form in every instance. Factors contributing to their formation are: a thick layer of litter before the fire; a severe slow-moving surface and crown fire; and coarse textured soils such as sand or decomposed granite. (Finely textured soils such as clay are less prone to hydrophobicity.)

The hydrophobic layer can vary in thickness. There is a simple test to determine if this water repellant layer is present:

1. Place a drop of water on the exposed soil surface and wait a few moments. If the water beads up and does not penetrate the soil than it's hydrophobic.
2. Repeat this test several times, but each time remove a one-inch thick layer of the soil profile. Breaking this water repellant layer is essential for successful reestablishment of plants.

In addition, freezing and thawing, and animal activity will help break up the hydrophobic layer.

Erosion Control Techniques

The first step after a wildfire is reseeding grass in the severely burned areas. Remember many plants can recover after fire depending on the severity of the burn. It is important to leave existing vegetation if the plants do not threaten personal safety or property (hazardous trees in danger of falling should be identified first).

A simple test can determine whether a water repellent layer is present.

Quick Facts

- The most immediate consequence of fire is the potential for soil erosion.
- Intense heat from fire can make the soil repel water, a condition called hydrophobicity.
- Landowners should take quick action to minimize erosion once it's safe to return to the property:
  - fell damaged trees to slow water runoff after rainfall;
  - create check dams in drainages using straw bales;
  - spread straw to protect the soil and reseeding efforts;
  - use water bars to reduce soil erosion on roads.

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A positive initial step after a wildfire is to reseed grass in the affected area.

A “cyclone” seeder works well to broadcast grass seed.

Seed can be purchased throughout Colorado. It’s a good idea to obtain certified (blue tag) seed – this guarantees the variety, that it was tested under field conditions, and that it is recommended for the state.

Varieties recommended (this is not an all inclusive list) include mountain bromegrass, slender wheat-grass, bluebunch wheatgrass, western wheatgrass, Arizona fescue, streambank wheatgrass, Idaho fescue (western slope), thickspike wheatgrass, steambank wheatgrass, and blue gramma. Species selection will vary from one site to another. Species selection is based on soils, elevation, aspect, and location in the state. You may plant a nurse crop with the grass mix to provide a quick cover (oats or a sterile hybrid such as Regreen™ or QuickGuard™) until the native grasses germinate.

Seeding tips for hand planting

1. Roughen the soil surface to provide a better seedbed by breaking through the hydrophobic layer. A steel rake works well for this, or, depending on the slope, a small tractor drawn harrow could be used.

2. Broadcast the seed (a “Cyclone” seeder works well). Seeding rate depends upon the variety of seed sown. A good estimate is 10 to 20 pounds per acre of grass seed with another 10 to 15 pounds per acre of the nurse crop.

3. Rake or harrow in 1/4 inch to 3/4 inch deep.

4. If the area is small enough, roll or tamp the seed down to ensure good soil/seed contact.

5. Spread certified, weed-free hay straw. If the area is small, crimp the hay in with a shovel. (This will help keep soil, seed, and mulch in place during wind and rain.)

6. Control weeds as needed by cutting off the flower heads before they can produce seed.

7. Do not use herbicides for broadleaf weed control until after the grass has germinated and developed five leaves.

Weed Control

Weeds are among the first plants to recolonize after a fire. In many instances they are not a problem. However, if the weeds are listed as noxious, they must be controlled. Noxious weeds displace native plants and decrease wildlife habitat, plant productivity, and diversity. They can spread downstream or into agricultural areas, resulting in high control costs. Control of noxious weeds is best accomplished through an integrated pest management system that includes chemical, biological, mechanical, and cultural controls. (See fact sheet 3.106, *Weed management for small rural acreage owners*.)

Mulching

Straw provides a protective cover over seeded areas to reduce erosion and create a suitable environment for revegetation and seed germination. If possible, the straw should be crimped into the soil, covered with plastic netting or sprayed with a tacking agent. If you can only broadcast the straw, do so; it’s better to have some coverage than none at all. The straw should cover the entire reseeded section and extend into the undamaged area to prevent wind and water damage. Use only certified weed-free hay straw to avoid spreading noxious weeds. (Contact the State Department of Agriculture for a listing of Certified Weed Free Hay growers.)

Straw should be applied to a uniform depth of two to three inches. When applied at the proper density, 20 to 40 percent of the soil surface is visible. One typical square bale will cover about 800 square feet. (Figure 1.) For small areas a product call StrawNet™ (a pelletized, weed-free, straw fiber with binding agents) can be broadcast over the seeded area.

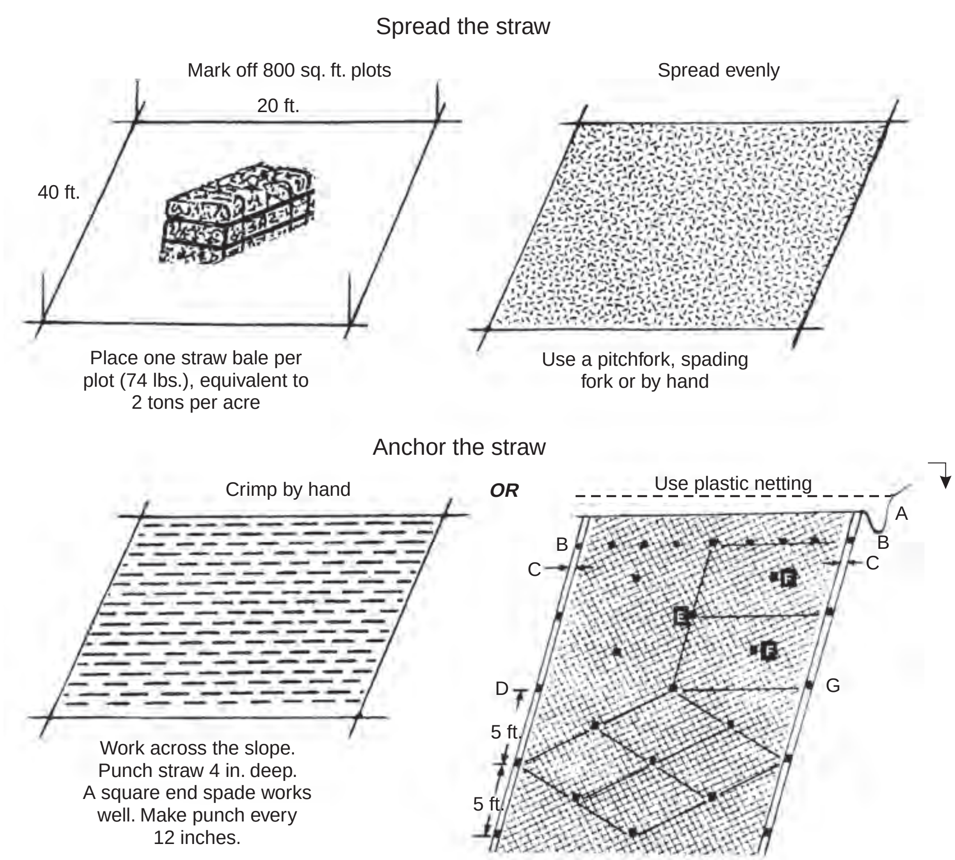


Figure 1: Application of straw to prevent erosion control (graphic courtesy of Natural Resources Conservation Service.)

Figure 2: Contour Log Terrace. These barriers are an effective, first-year treatment for hydrophobic soils, low ground cover density, and severely burned areas (graphic courtesy of Natural Resources Conservation Service).

Contour log terraces

Log terraces provide a barrier to runoff from heavy rainstorms. Dead trees are felled, limbed, and placed on the contour perpendicular to the direction of the slope. Logs are placed in an alternating fashion (Figure 2.) so the runoff no longer has a straight downslope path to follow. The water is forced to meander back and forth between logs, reducing the velocity of the runoff, and giving water time to percolate into the soil.

Logs should be 6 to 8 inches in diameter (smaller logs can be used) and 10 to 30 feet long. The logs should be bedded into the soil for the entire log length and backfilled with soil so water cannot run underneath; backfill should be tamped down. Secure the logs from rolling by driving stakes on the downhill side. It is best to begin work at the top of the slope and work down. (It is easier to see how the water might flow by looking down on an area to better visualize the alternating spacing of the logs.)

Straw wattles

Straw wattles are long tubes of plastic netting packed with excelsior, straw, or other material. Wattles are used in a similar fashion to log terraces. The wattle is flexible enough to bend to the contour of the slope. Wattles must be purchased from an erosion control material supplier.

Silt fences

Silt fences are made of woven wire and a fabric filter cloth. The cloth traps sediment from runoff. These should be used in areas where runoff is more dispersed over a broad flat area. Silt fences are not suitable for concentrated flows occurring in small rills or gullies. Silt fences are made from materials available at hardware stores, lumberyards, and nurseries. (Figure 3.)

Straw bale check dam

Straw bales placed in small drainages act as a dam – collecting sediments from upslope and slowing the velocity of water traveling down slope. Bales are carefully placed in rows with overlapping joints, much as one might build a brick wall. Some

Spread straw over seeded areas to prevent erosion.

Contour log terraces (above and below).

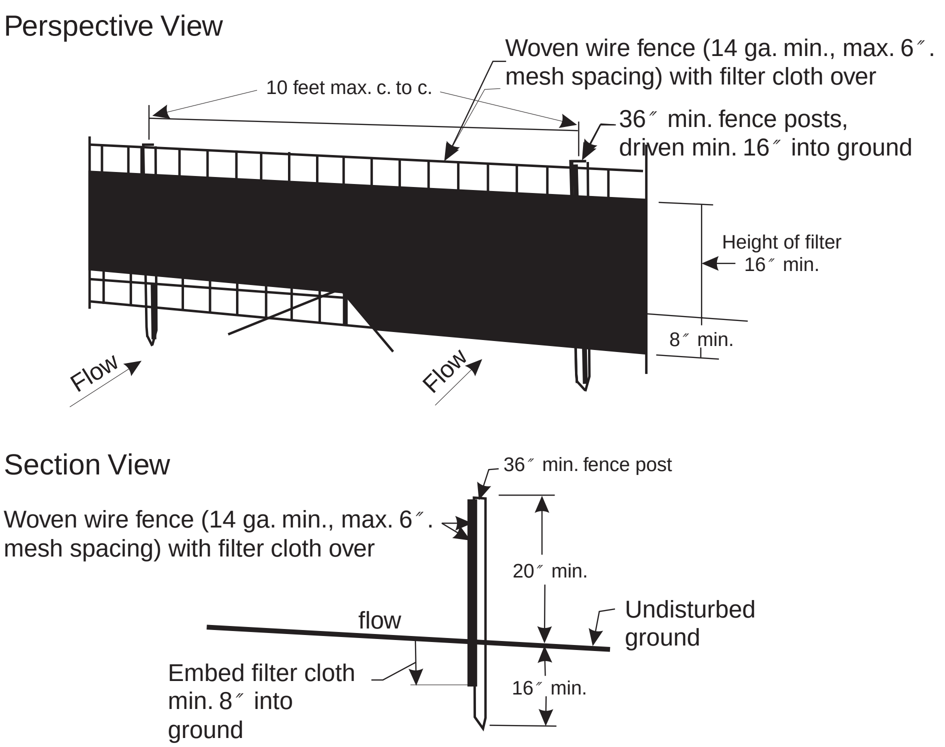


Figure 3: Silt fences are suitable for areas where runoff is in the form of "sheet flow" (graphic courtesy of Natural Resources Conservation Service).

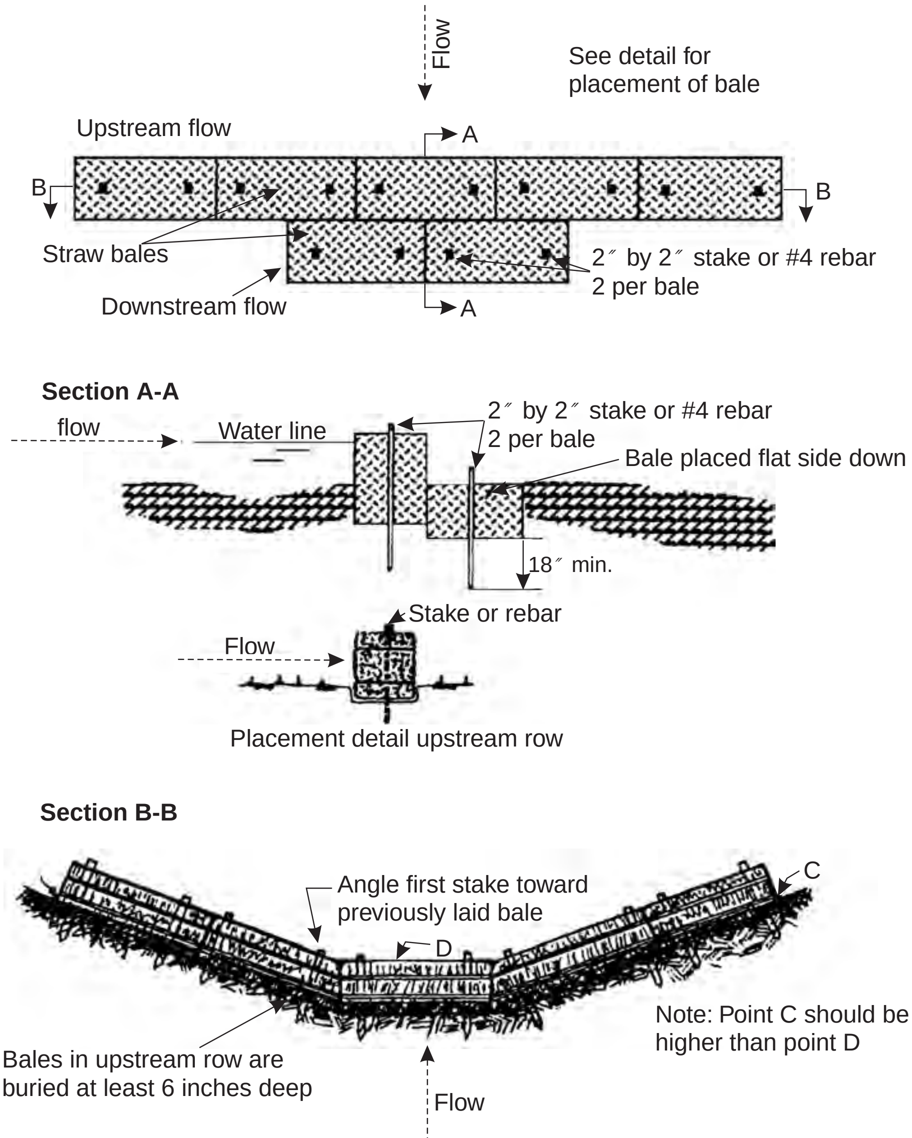


Figure 4: Typical Straw Bale Check Dam

excavation is necessary to ensure bales butt up tightly against one another forming a good seal. Two rows (or walls) of bales are necessary and should be imbedded below the ground line at least six inches. (Figure 4.)

Water bars and culverts

Bare ground and hydrophobic soils left after a fire increase water runoff. This requires intervention to channel water off of the burned area and release it to the streams below. The two most common structures to do this are culverts and water bars. Determining the type of drainage practice to use depends on the soil, type of road use, slope, speed of vehicles, season of use, and amount of use.

Culverts

A professional engineer is able to determine the size of the drainage area and the amount of runoff for rainfall events of varying intensity that needs carried by culverts. Once sized, the culverts must be installed properly at the correct locations. Installing more culverts than previously existed before the fire may be required. The inlet sides must be regularly maintained to prevent sediment and trash from plugging the pipe. It is common practice to armor the ground at the outlet end with rock rip rap in order to dissipate the energy of the discharged water and to spread it over the slope below. The inlet side can have a drop inlet so as to allow sediment to settle out before water enters the pipe. Armoring the inlet side with rock will also prevent water from scouring under and around the pipe and flowing under the road.

Straw wattles are used in a similar fashion to log terraces.

To be effective, culverts must be installed properly and at proper locations.

Water bars

Water bars are berms of soil or bedded logs that channel water off roads and trails to avoid the creation of gullies. Water bars are angled downslope to the outlet side. These bars can divert water to a vegetated slope below or redirect it to a channel that will take it to a culvert. On-site soils and the road grade will dictate spacing. (Figure 5.)

References

USDA Natural Resources Conservation Service, New Mexico State Office, 6200 Jefferson NE, Albuquerque, NM 87109; (800) 410-2067; www.nm.nrcs.usda.gov

USDA NRCS Fact Sheet, Vegetation Establishment for Soil Protection

USDA NRCS Fact Sheet, Temporary Erosion Control Around the Home Following a Fire

USDA NRCS Fact Sheet, *Straw Mulching*

USDA NRCS Fact Sheet, *Contour Log Terraces*

USDA NRCS Fact Sheet, *Straw Bale Check Dam*

USDA NRCS Fact Sheet, *Silt Fence*

USDA NRCS Fact Sheet, *Drainage Tips*

From Colorado State Forest Service, Colorado State University-Foothills, 5060 Campus Delivery, 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*

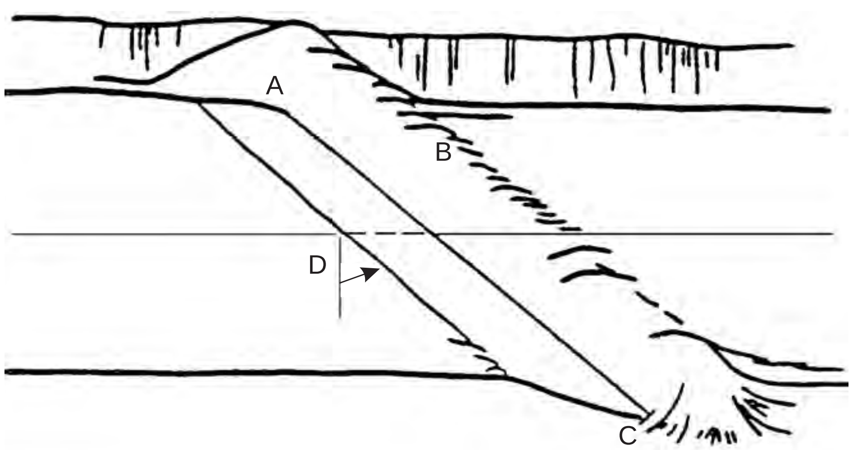
6.304, *Forest Home Fire Safety*

6.305, *FireWise Plant Materials*

6.307, Vegetative Recovery after Wildfire.

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

Waterbar –
Top view



Waterbar –
Cross-section

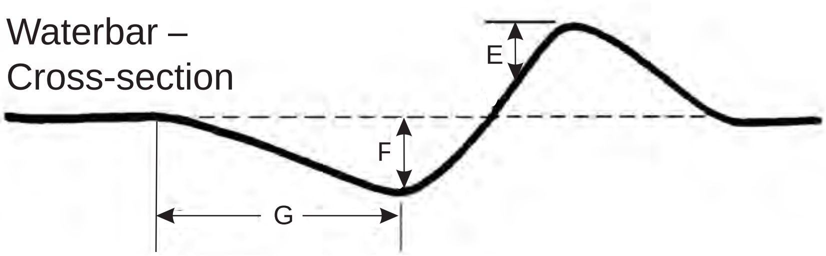


Figure 5: Waterbar construction for forest or ranch roads with little or no traffic. Specifications are average and may be adjusted to conditions.
A. Bank tie-in point; cut 6 inches to 1 foot into the roadbed.
B. Cross drain berm height 1 to 2 feet above the roadbed.
C. Drain outlet cut 8 inches to 16 inches into the roadbed**.**
D. Angle drain 30 to 45 degrees downgrade with road centerline.
E. Up to 2 feet in height.
F. Depth to 18 inches.
G. 3 to 4 feet.

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

FORESTRY

Vegetative Recovery after Wildfire no. 6.307

by R. Moench[1]

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.

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.

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

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.

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.'

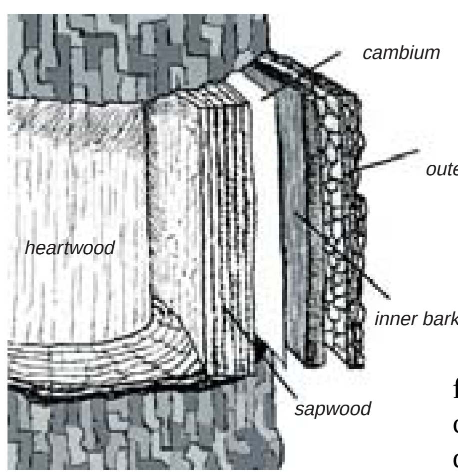


Figure 1: Outer bark, inner bark, cambium, sapwood and heartwood of a tree. Cambium must survive a fire for the tree to survive.

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.

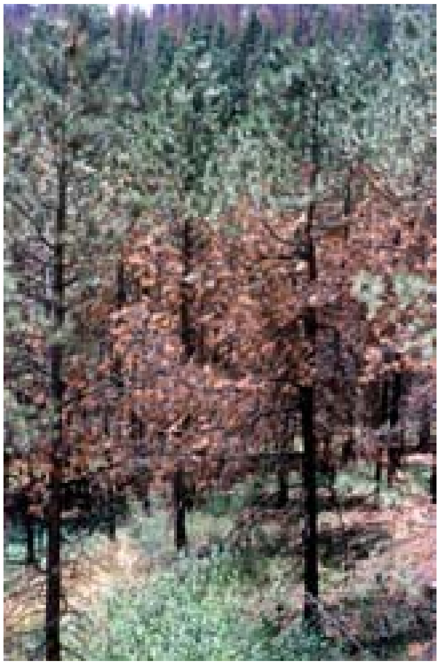
The amount of scorched foliage in the tree crown can predict conifer survival to a certain degree. Even with severe scorch damage, the buds may survive and grow the following spring. Basing survival estimates on scorch alone can be misleading; foliage color after a fire can be deceptive. Buds should 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.

Species	Ability to sprout after fire	Size when fire resistance is gained	Fire resistance at maturity	Bark thickness at base of mature tree	Branch density	Bud size	Needle length
			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.

The use of an axe can reveal the cambium layer sufficiently to evaluate fire 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.


Cones of ponderosa pine.

In some cases cones may continue to mature on a top-killed tree and release a 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.


Pinon pine destroyed by fire

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 suckerting.

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.

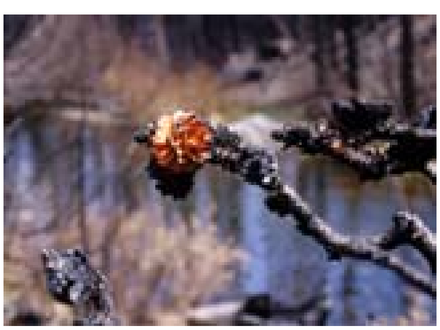

Lodgepole pine regeneration 13 years after a fire.

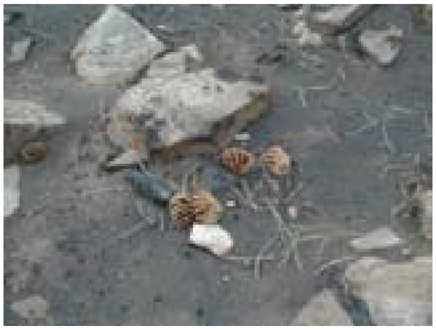
Lodgepole Pine

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.

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.

Wildflower regeneration after fire.

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.

This stand of gambel oak resprouted quickly after a fire.

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 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.

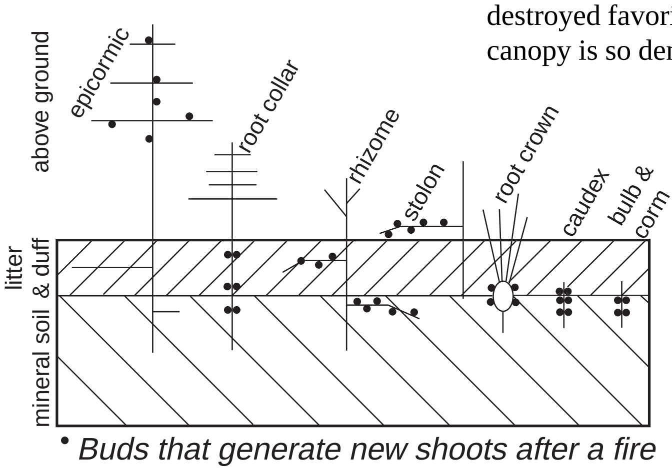
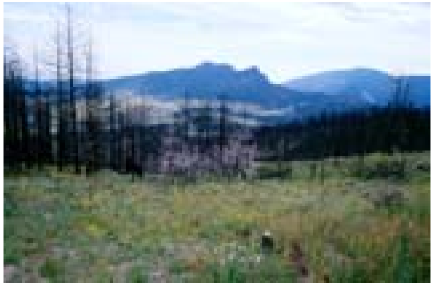


Figure 2. Various plant parts that regenerate new shoots and their location in the soils (Table adapted from *Wildland Fire in Ecosystems: Effects of Fire on Flora,* GTR RMRS-GTR-42-volume 2).



Natural recovery of forb and grass community.

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.

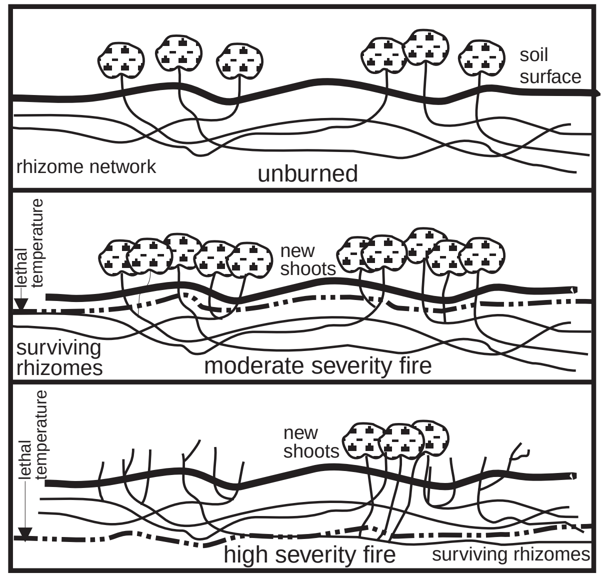


Figure 3. Effects of subsurface heating on postfire sprouting on rhizomatous shrub (adapted from Wildland Fire in Ecosystems: Effects of Fire on Flora, *GTR RMRS-GTR-42-volume 2).*

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.

References

USDA Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (2001, May). Fire Effects Information System, [Online]. Available: http://www.fs.fed.us/database/feis/ [June 22, 2001].

Brown, J.K.; Smith, J.K. eds. 2000. Wildland fire in ecosystems: effects of fire on flora. Gen. Tech. Rep. RMRS-GTR-42-vol.2 Odgen, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, 257 p.

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*

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

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