A Land Manager's Guide for Creating Fire-Resistant Forests

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Photo by Stephen Fitzgerald © Oregon State University

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NORTHWEST FIRE SCIENCE CONSORTIUM

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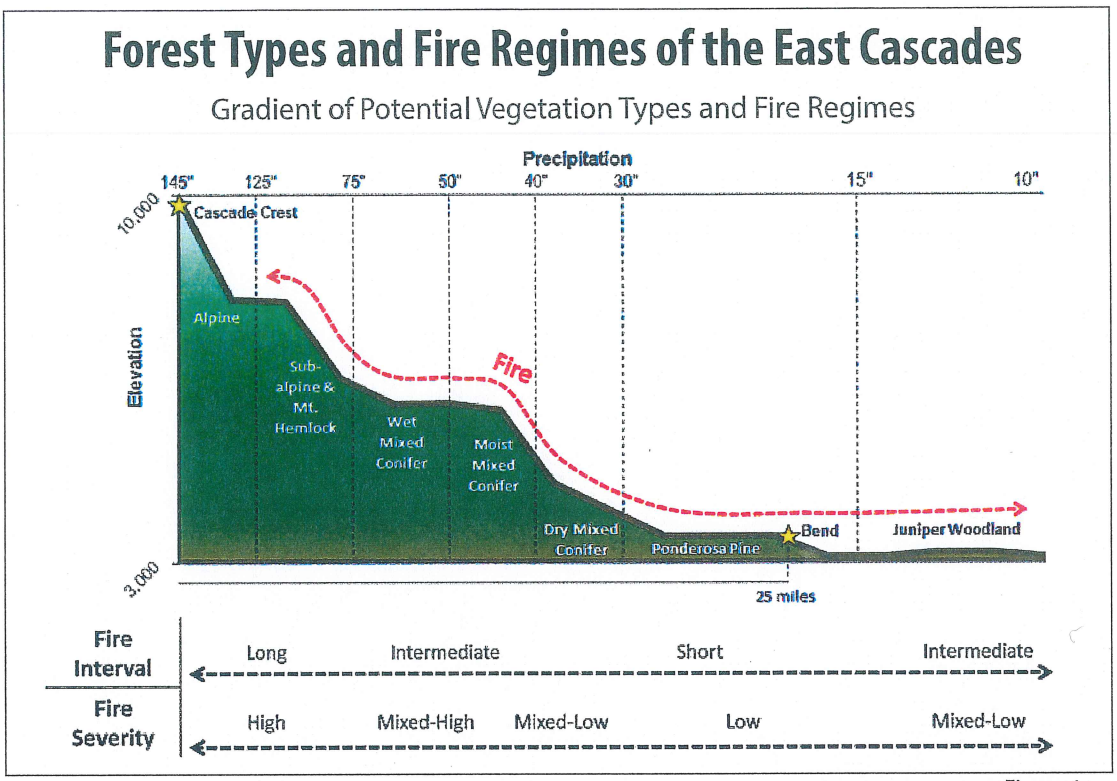

The Nature Conservancy

Figure 1

and overstory trees are more likely to survive than in untreated forests. Fire-resistant forests are not "fireproof" – under the right conditions, any forest will burn. Much of what we present here is pertinent to the drier forests of the Pacific Northwest, which have become extremely dense and fire prone.

Fire Behavior 101

The fire triangle

Three elements are needed to sustain a fire: heat or an ignition source, fuel, and oxygen (Figure 2). Take any one of these elements away and the fire doesn't start or goes out. For example, digging a fire line down to mineral soil, which is noncombustible, removes combustible material on the forest floor (surface fuel) and stops a forest fire's progress if the fire line encircles the fire.

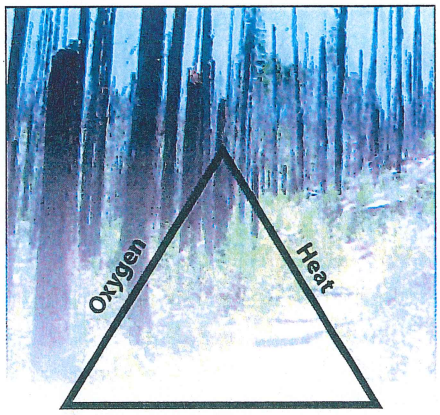

Photo by Stephen Fitzgerald, © OSU

Figure 2

The fire behavior triangle

Fire "behavior" is primarily described by its rate of spread (in feet per hour) and its intensity (i.e., how hot it burns and how long its flame is). Once a fire ignites in forest or rangeland vegetation, its behavior depends on the three factors that comprise the fire behavior triangle: the amount and arrangement of fuel, the area's topography, and weather conditions (Figure 3). A change in any one factor during a fire alters its behavior and type (i.e., whether it's a ground, surface, or crown fire). For example, if the weather becomes hot, dry and windy, the fire will burn with more intensity and move faster across the landscape. If a fire is burning in heavy fuels and then moves into an area with light or discontinuous fuels, fire intensity and spread decrease.

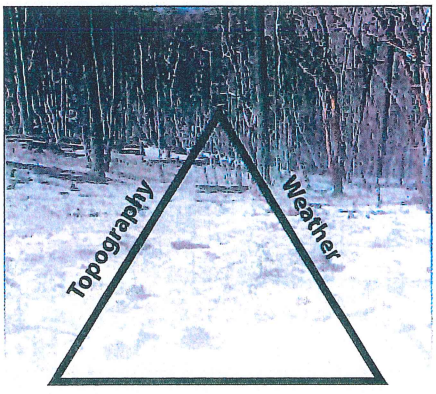

Photo by Stephen Fitzgerald, © OSU

Figure 3

Photo by BLM

Surface fires

Surface fires produce flaming fronts that consume needles, moss, lichen, herbaceous vegetation, shrubs, small trees, and saplings (Figure 5). Surface fires can ignite large woody debris and decomposing duff, which can then burn (glowing combustion) long after surface flames have moved past. Surface fire severity can be low to high.

High-severity surface fires can kill most trees (up to or more than 75 percent) as a result of crown and bole scorch, but can be highly variable, leaving scattered individual trees and patches of green trees. Surface fires with flame lengths less than 4 feet can be controlled by ground crews. Surface fires can develop into crown fires if "ladder fuels" connect surface fuels to crown fuels, fuel moisture is low, or weather conditions favor torching and crowning.

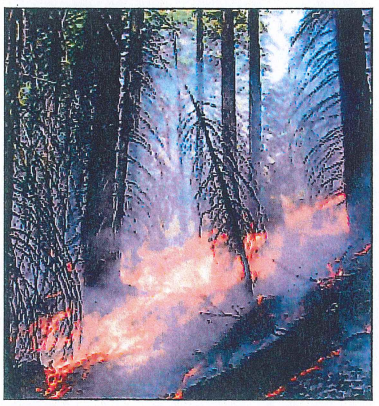

Photo by Teresa Brennan, USGS

Figure 5. Surface fires consume needles, moss, lichen, herbaceous vegetation, shrubs, small trees, and saplings.

Wildlandfire.com

Figure 7. Active crown fires are intense and stand-replacing blazes influenced by wind, topography, and crown density.

Crown fires

Crown fires are either passive or active. Passive crown fires involve the torching of individual trees or groups of trees (Figure 6). Torching is the precursor to an active crown fire. Crown fires become active when enough heat is released from combined crown and surface fuels to preheat and combust fuels above the surface, followed by active crown fire spread from tree crown to tree crown though a canopy (Figure 7). Crown fires are usually intense and stand-replacing, and are strongly influenced by wind, topography, and tree (crown) density.

Photo by Scott Isaacson, National Park Service

Figure 6. Passive crown fires involve individual trees or groups of trees.

Photo © Oregon State University

Ponderosa pine has an open crown, high moisture content in the foliage, and thick bud scales that help it survive fire.

Increase distance to base of tree crowns

When tree crowns ignite (torching), the stage is set for a crown fire. Removing ladder fuels, including surface fuels, and pruning the larger trees raises the base of the forest canopy so that a longer flame is needed to ignite the crowns. Pruning is particularly effective in young stands, when crowns may still be low to the ground. Prescribed underburning can also increase the height of the lower canopy due to scorching and killing of lower branches.

Increase spacing between tree crowns

When tree crowns are farther apart, it is harder for fire to spread from one crown to another, even when the wind is blowing. Thinning reduces crown density. Reducing the slash generated from thinning will diminish the potential for a high-intensity surface fire.

Keep large trees of more fire-resistant species

Fire kills trees by killing the cambium layer (a layer of cells just inside the tree bark that produces new wood and bark), scorching the foliage and killing the buds, and damaging and killing roots.

When thinning to improve fire resistance, leave larger trees with thicker bark that insulates the cambium. Although a fire may scorch the foliage above, the cambium is still protected. Also, large trees tend to have higher crowns, so their foliage and buds are less likely to be damaged by heat from a surface fire.

Ponderosa pine, western larch, and Douglas-fir tend to develop thick bark that insulates the cambium from heat, and their root systems are deeper and more protected. Ponderosa pine has other features that help it survive fire, including an open crown, high moisture content in the foliage, and thick bud scales. Western larch also is very fire-resistant. Lodgepole pine, the true firs, and hemlock have thin bark and shallow roots, and are more likely to be killed in a fire, even a light surface fire.

Hardwood trees are a significant component of many Pacific Northwest forests, particularly west of the Cascades. Some hardwoods, especially deciduous species such as bigleaf maple, red alder, and Oregon white oak, have higher moisture content and less volatile oils in their foliage than conifers; as a result, they burn at lower intensities. Evergreen hardwoods such as Pacific madrone, common in southwest Oregon,

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have intermediate flammability. Other than Oregon white oak, most hardwoods are readily killed by fire due to their thin bark, but they will sprout back rapidly from stumps or root crowns with few exceptions.

Promote fire-resistant forests at the landscape level

The larger an area treated, the more effective fuels treatments will be at moderating fire behavior. This includes creating gaps and openings to further reduce the potential for crown fire. Treating in strategic locations can help break up both continuous horizontal and vertical layers of fuels. For example, reducing fuels adjacent to natural features, such as meadows and rock outcroppings, and manmade features, such as roads, helps firefighters connect firelines to these locations.

Fuel Reduction Methods

There are a variety of ways to reduce or treat surface, ladder, and crown fuels to create fire-resistant forests. Table 3 lists fuel-reduction methods, their costs, and the effects of each on surface, ladder, and crown rules. Since few methods are effective on all types of fuels, they are typically used in combination. For example, a stand may be thinned and pruned, and the resulting surface fuels piled and burned.

Thinning

Common questions about thinning include: Which trees should be selected? How far apart should trees be spaced? And, when should I thin (or not thin) during the year? Below, we address these questions only with respect to creating fire-resistant stands. Making decisions about thinning will involve a variety of other considerations.

Tree selection

Remove smaller trees and retain larger, more vigorous trees (Figure 10). This approach, called "thinning-from-below," removes ladder fuels, raises the base of tree crowns, and, if enough larger trees are removed, increases the spacing between tree crowns. Large trees are more fire-resistant due to thicker bark. This approach tends to shift species composition away from shade tolerant species that are often abundant in the understory.

Thinning from below is a common approach in even-aged stands. In cases where you want to maintain or promote a multi-aged forest (a forest containing three or more age classes of trees), a modified approach can be used. Trees can be thinned across the range of diameter or age classes so that stand density and ladder fuels are reduced while maintaining a multi-aged character. Compared to an even-aged stand, such a stand will have a higher risk of crown fire because some younger understory trees (ladder fuels) would remain.

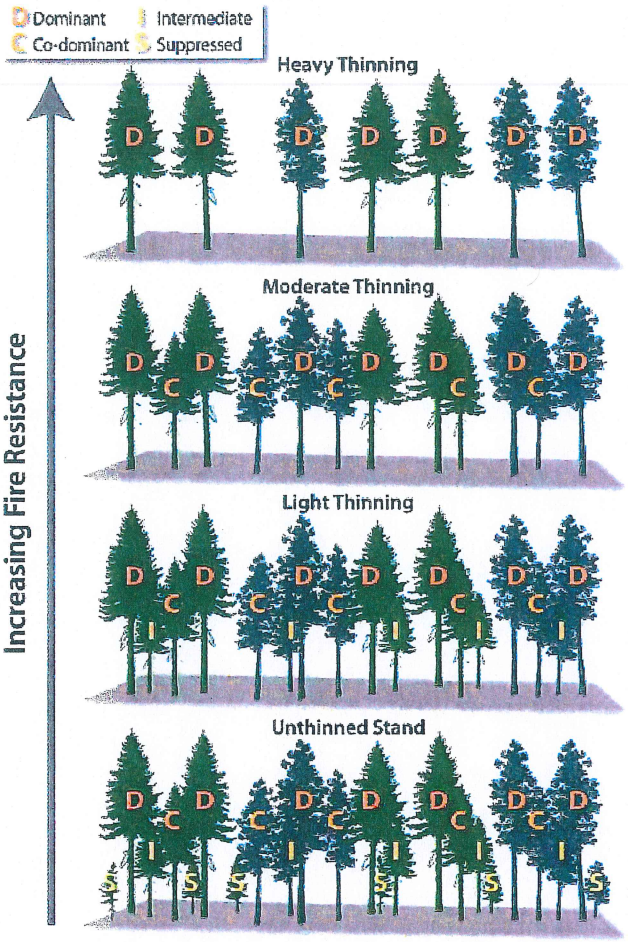

Figure 10

Tree spacing

How far apart do crowns need to be to reduce crown fire? In general, if the branches of adjacent trees are overlapping within the stand, crown density is high enough to sustain crown fire under the right weather conditions. Conversely, if trees are widely spaced, say with crowns spaced more than one dominant tree crown width apart, crown fires are much less likely to occur. Factors that tend to increase the required crown spacing include steep slopes, locations with high winds, and the presence of species like grand fir with dense, compact

PRESCRIBED BURNING

Key points to consider:

- Prescribed burning, especially underburning, is risky with high potential liability.
- A professionally developed burn plan is a must, and professional contract burners are recommended.
- Contact your state fire control agency in advance to discuss your plans to burn and obtain necessary permits.

Photo by BLM

Prior to initiating any prescribed underburn, a landowner must develop a profession burn plan. Good planning helps meet pre-determined objectives and minimize the chance of an escaped burn. Key elements of a burn plan include:

- A clear description of the stand or vegetation to be enhanced by underburning and expected outcomes for that vegetation
- Data on fuel amount, distribution, and moisture content, as well as the topography and desirable weather conditions on a potential burn day
- Predictions of fire behavior (intensity and spread) based on the above factors
- Ignition patterns and arrangements for holding (maintaining the fire within the area)
- Timing and seasonality of the burn
- Smoke management guidelines

Burn plans should include a map of the unit to be burned, the various types of equipment and other resources needed to implement the project, needed permits, back-up contingency plans in the event of an "escape," medical and communications plans, public awareness and coordination with other agencies as needed, and post-burn plans for "mop-up" and monitoring. Often the area to be burned will need some type of fuel pre-treatment in order to meet objectives. This could include tree falling and brushing of unwanted vegetation in order to carry a fire, or raking or pulling slash away from trees you want to keep (called 'leave trees') to increase their likelihood of survival during the burn. Careful and constant monitoring of weather on the burn day, constant contact with a local weather service, or both is imperative; sudden changes in weather can rapidly change fire behavior, increasing the risk of escape.

Because of its complexities and the associated liability, prescribed underburning is rarely done on private, non-industrial woodlands because the cost of an escaped burn can be considerable, as it includes not only the cost of suppression, but also the cost of reimbursing any neighbors whose properties may be damaged. On federal lands, prescribed burning is conducted regularly. Federal agencies are much more willing to accept potential liability as they have the know-how, trained personnel, and the equipment to manage a prescribed burn.

Mechanical Fuels Reduction (Mastication)

Mechanical fuels treatments utilize several different types of equipment to chop, mow, or otherwise break apart (masticate) ladder fuels, such as brush and small trees, into relatively small chunks or chips, forming a compact layer of woody material that is distributed across the site.

Mechanical fuels reduction equipment includes "slashbusters," "brush mulchers," mowers, and other devices. The "slashbuster" is a vertically mounted rotating cutting head mounted on a tracked excavator. The "brush mulcher" consists of a horizontally mounted cutting drum attached to the front of an all-terrain vehicle (ATV)

Photo by BLM

Figure 13. Examples of slash piles waiting to be burned. With pile burning, you have the option to cut, pile, and immediately burn ("swamper burning"), or cut, pile, cover, and burn later in the fall and winter months when the forest is moist and the pile is dry.

Pile and burn

Pile and burn is a common method for reducing surface fuels generated in thinning and pruning. (Figure 13).

Another option is to leave the slash over the winter to let some of the nutrients leach out, and then pile and burn later.

Guidelines for pile burning:

- Carefully evaluate locations of piles. Place at least 10 to 20 feet away from trees, stumps, brush, and logs, and 50 feet from streams. Stay well away from snags, structures, power lines, etc.
- Construct the piles so they will burn easily. Put small branches, twigs, and brush less than ½-inch diameter at the bottom of the pile to provide "kindling," then lay larger limbs and chunks of wood parallel to minimize air pockets. For hand piles, 4-by-4-foot piles are a good size; machine piles may be much larger.
- When machine piling, use a brush blade or excavator to avoid getting dirt in the pile. This helps prevent "holdover" fires that smolder for weeks, suddenly flaring up when winds and temperatures increase.
- Cover piles if they are not to be burned immediately. Cover when pile is about 80 percent complete, placing the remaining material to hold the cover in place. In Oregon, you must remove the cover prior to burning unless it is made of pure polyethylene plastic (not all plastic is pure polyethylene). Cover just enough of the pile to keep it dry in the center so it will burn easily.
- Burn when conditions are wet or rainy with little or no wind, and during daylight hours.
- Avoid piling green pine slash (more than 3 inches diameter) in the late winter through mid-August due to the risk of attracting pine beetles.
- Make sure you have a burn permit from the state forestry office, fire warden, or other local authority that regulates open burning.
- Some areas have a system utilizing 'good burn days' based on ventilation index. Make sure you are in compliance.
- Monitor the piles to make sure they are out.

Chipping

Chipping is effective but is also labor intensive and requires good access. It is probably best suited to homesites and defensible space treatments.

Many contractors, including arborists and tree service companies, have large chippers that can process relatively large-diameter material efficiently. Self-propelled, whole tree chippers have been developed and may be available for contract work in some areas. Be aware that large piles of chips are a fire hazard from spontaneous combustion. The chips can be scattered across the ground or, better yet, used as mulch for covering skid roads and trails.