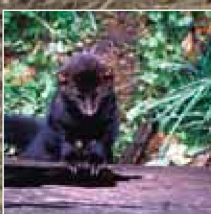

Managing Organic Debris for Forest Health

Reconciling fire hazard, bark beetles, wildlife, and forest nutrition needs

Chris Schnepf, Russell T. Graham, Sandy Kegley, and Theresa B. Jain

PNW 609 A Pacific Northwest Extension Publication
University of Idaho   Oregon State University   Washington State University

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COVER PHOTO

Forest organic debris is important for soil health. The main photo shows a log in the process of decomposing and adding structure to the soil. Thumbnail photos show organisms that will thrive in an area with healthy forest soil and coarse woody debris: chanterelle mushroom, pileated woodpecker, and fisher.

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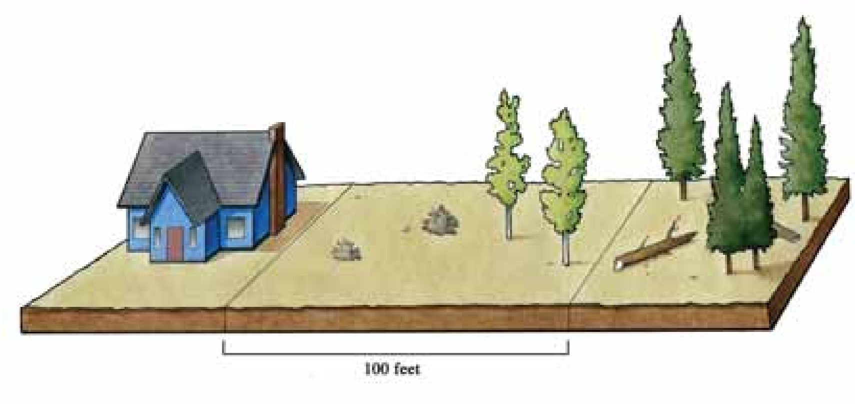

Figure 1. Removing organic debris is critical within 100 feet of homes and structures.

Figure 2. Poor soil means poor trees.

INTRODUCTION

Forest organic debris includes tree limbs, boles (trunks), needles, leaves, snags, and other dead organic materials. It ranges in amount and composition depending on a forest's history, tree species, condition, and age. In the Inland Northwest (Idaho, western Montana, eastern Oregon, and eastern Washington) there is a lot of discussion and concern about removing organic debris from forests.

Common reasons for removing organic debris include reducing bark beetle hazard, preparing a site for tree planting, harvesting forest biomass for energy, and reducing fire risk. For example, it is critical to remove organic debris within 100 feet around homes and structures to reduce fire risk (fig. 1). And some people simply like the aesthetics of a forest with less organic debris -- loggers often speak with pride or admiration of "a good clean logging job."

All these issues are important. But leaves, needles, and woody debris left in a forest are not necessarily wasted. A growing body of research supports leaving some organic debris in forests (fig. 2). Organic debris left distributed across the forest floor acts much like mulch in a garden. It protects soil from excessive moisture loss, recycles nutrients for trees and other forest plants, adds structure and organic matter to the soil, reduces soil erosion, and provides food and habitat for a wide variety of wildlife.

Many landowners are unclear on how to reconcile the potentially conflicting objectives related to forest organic debris. As a result, some landowners tend to remove all organic debris while others may treat as little as possible, to save money and time.

This publication outlines the role of forest organic debris in Inland Northwest forests and provides general management recommendations to maintain forest soil productivity and improve wildlife habitat, while simultaneously reducing wildfire and insect hazards.

Many people refer to all branches and tops accumulated from logging or a storm as "slash." But different types of organic debris have different functions and different management challenges. To that end, this publication differentiates between two broad categories of forest organic debris: fine organic debris (FOD - material smaller than 3 inches in diameter) and coarse woody debris (CWD - material 3 inches in diameter and larger).

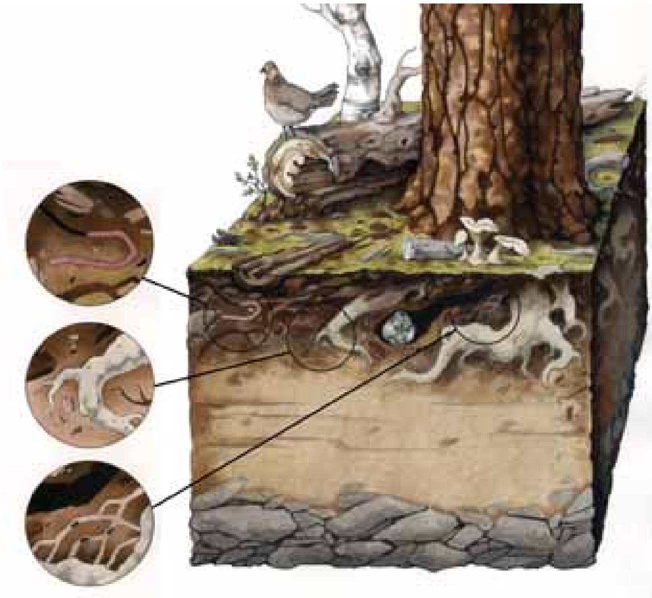

Figure 3. Forest soils are a living growth medium for trees and other organisms.

Figure 4. Surface organic layers can commonly be 1-2 inches deep on moist or cold forests.

Figure 5. In frequently burned forests, organic layers can be thin.

INLAND NORTHWEST FOREST SOILS

Soils are the foundation of forest growth and health. They provide structural support, nutrients, and water storage for trees and other forest plants and fungi. Soil quality, rainfall and temperatures determine how a forest regenerates, develops, and functions. Over thousands of years, climate and vegetation break down or "weather" parent materials (the bedrock and/or sediments underlying a forest soil) into a unique mineral soil for a given forest site.

Many Inland Northwest forest soils have also been significantly influenced by wind-blown deposits of soil and volcanic ash. In addition to mineral contents, a large portion of a soil's volume is made up of pore space, which helps a soil retain and store moisture and allows for oxygen and carbon dioxide exchange around roots.

Organic materials from plants, animals, and fungi are also integral parts of a forest soil. These living and dead organic components influence critical forest soil functions such as water holding, nutrient storage and release, aeration, nitrogen fixation, bacterial and fungal habitat, and protection from compaction and erosion (fig. 3). The contribution of organic debris to forests is as variable as the forests where it occurs. Inland Northwest forests range from moist cedar-hemlock forests to cold lodgepole pine-subalpine forests to dry ponderosa pine forests.

The most noticeable organic component of forest soils are the surface organic layers. These "duff" layers usually consist of freshly fallen twigs, leaves, and needles. In the middle of the surface layers, there is usually a layer where plant and tree materials are being decomposed by insects, worms, fungi, bacteria, and other organisms. Below this, plant parts have decomposed to where they are not distinguishable.

These surface organic layers are highly visible in a soil profile of moist forests and cold forests—often one or two inches deep (fig. 4). In dry forests and other frequently burned forests, these layers can be very thin or even nonexistent (fig. 5). However, where fire has been excluded from dry forests, large amounts of organic materials can accumulate due to very slow decomposition. This is most apparent around the bases of mature ponderosa pines that continually slough off bark and shed heavy amounts of needles.

Varying amounts of wood from decaying tree limbs and stems (also called boles, trunks, or logs) are often mixed in the surface organic layers of forest soils (fig. 6). Rotten wood (often brown and cubical) is the most noticeable and longest-lived organic material in forest soils, lasting up to centuries. Rotting

Figure 6. Wood is often found mixed in organic layers.

Figure 7. Rotting wood can also be found deeper in the soil profile.

Figure 8. Stand replacing fires often left a great deal of coarse woody debris.

Figure 9. Roughly half of a conifer's above-ground nutrients are stored in the needles and branches.

wood can also be found deeper in the soil. It can be created by decaying tree roots or by logs buried under sediment by soil erosion after wildfires, or other soil movement processes. In some cold and moist forests, up to 40% of the top 12 inches of a forest soil can be composed of this buried rotten wood (fig. 7).

Influence of fire on organic debris

Historically, wildfire helped determine the amount of fine and coarse woody debris in forests. Wildfires can be separated into two broad classes. *Stand replacing fires* killed nearly all of the trees. *Surface fires* killed small trees and vegetation in the understory but left overstory trees alive. Many individual fire events were a mixture of these two types of fire (sometimes called *mixed severity fires*).

Stand replacing fires did not usually completely consume all wood on the site, particularly if intervening surface fires reduced understory vegetation and fine fuels. Stand replacing fires typically moved through a site fairly quickly, burning up the needles and fine branches and leaving a charred sea of standing and fallen dead trees in their wake (fig. 8). Even where these sites burned again, some coarse woody debris remained.

Dry forests had frequent surface fires (every 7 to 30 years), and tended to have less large wood. Each fire would consume woody debris, but it would also kill some trees, which would create snags that would fall to the ground and replenish some of the wood consumed in previous fires.

In addition to fire, forest soil organic material can also come from trees killed or damaged by insects, disease, or winter snow and ice storms, and from residues of forest management activities such as thinning.

Organic debris & nutrients

Roughly half of a conifer's above-ground nutrients, such as nitrogen and potassium, are stored in the needles, twigs, and small branches of the tree (fig. 9). Needles, limbs, and branches cycle organic materials to the forest floor. Deciduous trees and shrubs also cycle large amounts of nutrients each year.

Moisture is the most limiting factor to tree growth in most Inland Northwest forests. But inadequate nutrients limit growth as well. Adding nutrients through fertilization increases tree growth on most Inland Northwest forests. Fertilizers containing nitrogen, potassium, sulfur and boron especially promote tree growth, though the size of the response from different fertilizer mixes varies considerably by site.

Repeatedly removing nutrients from forests in the form of trees and green slash could theoretically reduce tree growth through nutrient deficiencies. How much of a nutri-

Table 1. Biomass and selected critical above-ground nutrients in trees (lbs/acre) in standing mixed conifer forest before harvest

Nutrient	Total Crown	Merchantable Bark	Merchantable Wood
Biomass	22,205.8	20,062.7	57,462.6
Nitrogen	121.521	54.593	24.448
Potassium	101.183	56.766	79.378
Sulfur	9.365	4.964	6.169
Boron	0.383	0.179	0.263

ent reduction has not been studied thoroughly, and would likely vary by site, intensity and frequency of removals, and the time frame being considered.[1] But one way of looking at it is to study the nutrient content of slash.

A recent case study by the Intermountain Forest Tree Nutrition Cooperative estimated the nutrient content of trees in a fully stocked 80-year-old mixed conifer stand in northeastern Oregon, with basalt parent material (table 1). In the green crowns of this stand, there were an estimated 122 pounds of nitrogen per acre and 101 pounds of potassium per acre. A harvest of all the merchantable logs would remove an additional 79 pounds of nitrogen per acre and 136 pounds of potassium per acre.

Most harvests and thinnings do not currently remove or immediately burn all this material. A lot of nitrogen and other nutrients are also stored in the surface organic layers. The amount of nutrients contained there varies with climate and amount of disturbance. But since most of our forests respond positively to correctly balanced mixes of fertilizers, carefully considering possible nutrient implications of forest activities and adjusting them where possible could benefit forest growth and health.

Nitrogen naturally re-accumulates in forests from atmospheric deposition and from nitrogen-fixing plants and microbes, but this occurs slowly. A recent study on a western red cedar site in northern Idaho found that nitrogen re-accumulated at a rate of roughly 4 pounds per acre per year.

Potassium and other nutrients also re-accumulate, but even more slowly, mostly from parent material weathering and in miniscule amounts from atmospheric precipitation. The same study found potassium re-accumulating at roughly 2.5 pounds per acre per year. The amounts vary by site, but potassium and other nutrient losses would be even more important on soils with parent materials that were lower in these nutrients and slower to decompose.

Allowing rain and snow-melt water to leach water-soluble nutrients from fresh slash down into the soil retains more of those nutrients for forest growth and health. The amount and rate of nutrient leaching depends on the tree species and the climate. Warmer, wetter climates promote faster leaching. The amount of those leached nutrients a site can capture and retain depends on the soil texture and organic matter.

Even though fine organic debris contains and recycles the majority of a tree’s nutrients, coarse woody debris (CWD) also provides some nitrogen, since some of the organ-

[1] One set of studies (see Powers et al., 2005) found no growth reductions for the first ten years after forest biomass removals, but the researchers cautioned that their findings did not necessarily forecast long-term trends.

Figure 10. Decayed logs serve as moisture reservoirs where conifers multiply roots.

Figure 11. The angular texture of some organic debris decay products helps improve soil structure.

Figure 12. Most of a tree's small feeding roots are concentrated in the soil's upper layers.

Figure 13. Ground fires can be lethal to trees with many feeder roots grown into excessively thick duff accumulations.

isms that break it down fix nitrogen from the air. Depending on forest type, bacteria in coarse woody debris (CWD) can fix nearly 1/2 pound of nitrogen per acre every year. This amount, though relatively small, can be important, especially when the site has few nitrogen fixing plants such as ceanothus or alder. Organic debris also helps soils retain nutrients so they will later be available for forest plants.

Organic debris and soil moisture

Organic matter, as any experienced gardener can attest, helps retain soil moisture longer into the growing season by shading soils and storing moisture. As organic debris decays and is incorporated into the soil (fig. 10), conifers, grasses, forbs, and shrubs multiply their roots in these zones to take advantage of that moisture. These moist soil zones help keep forests resilient in the face of warmer, drier summers. Moist, decaying logs often persist after wildfires.

Organic debris and soil structure

Soil structure is the physical combination or arrangement of soil particles into larger particles or clumps, and the spaces between them. Organic debris improves soil structure as it is incorporated into the soil. Leaves, stems and other small plant material are important sources of organic materials in all soils, but large woody debris can be a particularly significant and unique contributor of organic matter for forest soils. As organic material decays and is integrated into the soil over hundreds of years, it helps soils maintain aeration (spaces between particles), resist compaction, buffer against erosion, and improve water filtration (fig. 11).

Organic debris, roots, and mycorrhizal fungi

Where are the roots?

Regardless of species, most of the small roots and root hairs a tree uses to take up nutrients and water are concentrated near the soil surface and surface organic layers of the soil (fig. 12). In surface organic layers made deep by fire exclusion, trees often grow more roots up into this material, to take advantage of the nutrients and moisture there (fig. 13). When these layers and the roots within them are destroyed mechanically or through fire, even the largest tree can be stressed and made more susceptible to death by bark beetles or disease.

Forest soil flora and fauna

In addition to roots, forest soils are alive with a variety of fungi, bacteria, worms, insects, and burrowing mammals such as pocket gophers. Different fungi use different combinations of dead and living organic matter for their survival. Many forest owners are aware of root diseases, stem decays, and other fungi that can kill trees or reduce the value of their wood. But

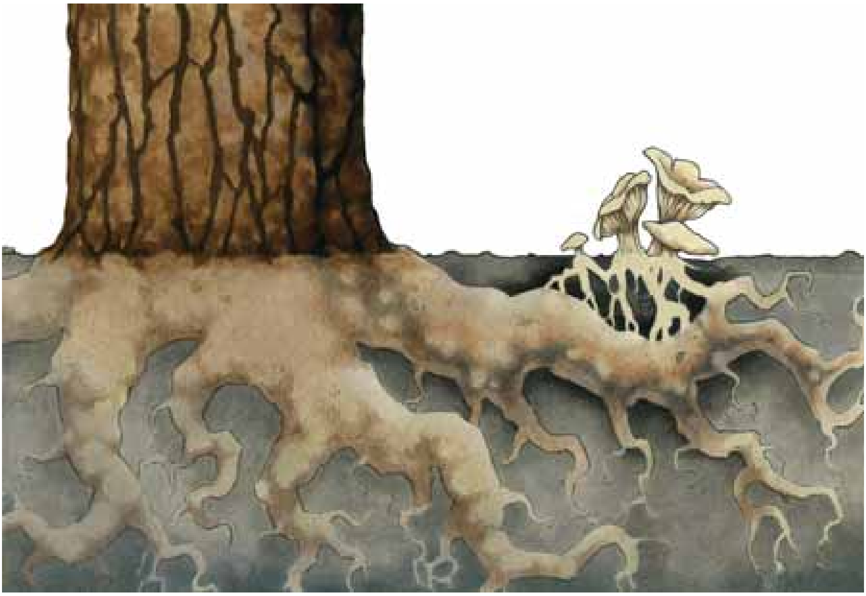

Figure 14. Mycorrhizal fungi form a mutually beneficial relationship with trees.

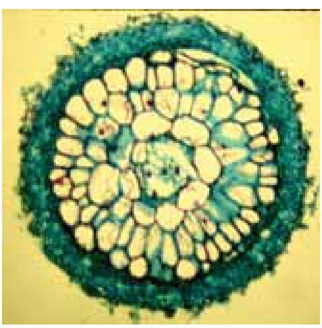

Figure 15. Ectomycorrhizae cover the outsides of rootlets, just penetrating their outer cells.

Figure 16. The tree seedling on the left was innoculated with mycorrhizal fungi.

most forest fungi do not kill trees. There are hundreds if not thousands of lesser-known microbes and fungi species that help forests function by recycling forest nutrients, decomposing slash, and improving soil physical properties. Even native tree-killing fungi may be performing a positive role by removing trees that are poorly adapted to a forest site.

Mycorrhiza = "fungus root"

One of the groups of fungi that most directly benefit tree growth is called mycorrhizal fungi. "Mycorrhiza" is translated from Latin as "fungus root." These fungi infect the roots of trees and other plants and form a symbiotic relationship (a relationship in which both the plant and the fungi benefit). Mycorrhizal fungi get photosynthate (the product of photosynthesis - carbon) from trees; and the trees get a larger effective root surface to absorb more nutrients and moisture from the hyphae (the fungus equivalent of roots) and mycelia (matted hyphae) of mycorrhizal fungi (fig. 14). In addition to improving rooting surface area and absorption, mycorrhizae can also:

- capture and retain nutrients that might otherwise be leached from the soil;
- physically block pathogenic fungi access to tree roots;
- exude antibiotic substances that deter root pathogens;
- help "unlock" soil nutrients (convert them into forms that can be used by plants);
- exude or decay into substances that act as "organic glues," helping to aggregate soil particles and improve soil structure;
- move nutrients and even photosynthate (carbon) between trees -- even between different species of trees and shrubs; and
- provide food for "fungivores" -- insects, birds, squirrels, deer and many other organisms that feed on forest fungi.

Mycorrhizae are essential for good growth of many tree species, particularly on nutrient-poor or droughty sites.

Identifying mycorrhizae

Mycorrhizal fungi form relationships with over 95% of the plants on earth, and there are many different species. Over 2,000 fungi have been reported to form mycorrhizal relationships with Douglas-fir alone. If you dig up seedlings in the forest, you may notice that the root hairs look a little thicker than others you have seen. That is because they are covered by mycorrhizal fungi (figs. 15 and 16).

Mycorrhizal fungi produce many different kinds of fruiting bodies. Some are above-ground mushrooms, such as golden chanterelles (*Cantharellus cibarius*) (fig. 17). Other fruiting bodies are underground, such as truffles.

Figure 17. Chanterelles, a popular edible forest mushroom, are the fruiting body of a mycorrhizal fungus.

Helping mycorrhizae

Mycorrhizae presence and development on tree roots depends on organic matter. For example, in one study of a Douglas-fir forest, 77% of the mycorrhizal root tips were found in the surface organic layers. Coarse woody debris, as it is integrated into the soil, eventually benefits mycorrhizae, because coarse woody debris helps soils retain moisture as it decays. Minimizing compaction of the mineral soil and minimizing excessive soil disturbance also benefit mycorrhizae.

There is usually no need to add mycorrhizae to well-established forests. As with most fungi, mycorrhizae spores are abundant in native forests. However, trees planted in non-forested areas such as agricultural fields, or dramatically altered sites such as a reclaimed mining area, may benefit from mycorrhizal inoculation.

Figure 18. Fine organic debris is smaller than 3 inches in diameter.

Figure 19. Coarse woody debris is larger than 3 inches in diameter.

Figure 20. Past harvests left a lot of coarse woody debris.

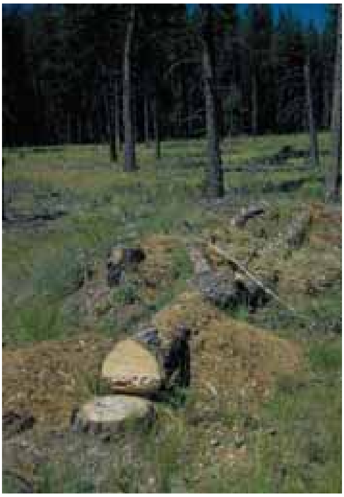

Figure 21. In some cases, CWD needs can be met by not hauling cull logs to a landing.

MANAGEMENT OBJECTIVES FOR ORGANIC DEBRIS

Organic materials play a large role in forest soils and forest health. The quantity and quality of forest organic materials is directly and indirectly impacted by our forest management activities. Fine organic debris (materials less than 3 inches in diameter) and coarse woody debris (materials 3 inches in diameter and greater) have different functions in a forest, different issues associated with them relative to fire and bark beetles, and different management objectives and strategies.

Fine organic debris (FOD)

Fine organic debris consists of small branches, limbs, treetops and similar materials less than 3 inches in diameter (fig. 18). FOD is quickly incorporated into the forest floor, its nutrients are readily leached, and it is relatively short-lived – less than 20 years depending on the forest type. FOD can be a large fire hazard if it is not carefully managed because it can quickly combust and carry a fire.

Leaving FOD distributed across the forest floor over winter and longer if possible encourages its decomposition and nutrient leaching. The objective in managing fine organic debris is to recycle the most nutrients from it while minimizing the fire hazard.

Coarse woody debris (CWD)

In general, coarse woody debris (logs and other woody pieces 3 inches in diameter and larger) is more durable than fine organic debris (fig. 19). Depending on the forest type and its inherent disturbances, 25% to 50% of the organic material found in and on a forest soil can be attributed to CWD. Coarse woody debris's contribution to forest soils is not immediate but long-term – from decades to centuries depending on size, decay rate, and the forest's fire frequency.

Historical timber harvests tended to leave more coarse woody debris (fig. 20). Much of the old growth timber had a lot of decay, and mills didn't take material below 8 inches in diameter. Young forests tend to have much less CWD than older forests or those that have experienced insect, disease, fire, or weather damage.

Many second growth stands do not have as much malformed wood, due to management activities that thinned poorly formed trees out. Trees are also harvested at younger ages, before stem decays develop as fully. Mills now take logs down to smaller top diameters (for example, down to a 4-inch top rather than an 8-inch top). All these factors mean less coarse woody debris is left on site after logging jobs now than in past timber harvests.

Table 2. Coarse woody debris recommendations for maintaining long-term forest growth

	Climax species[1] for site	Target tons per acre of coarse woody debris
Warmer Drier	Ponderosa pine	3 -13 tons/acre
Forests	Douglas-fir	7-14 tons/acre
↕	Grand fir	7-14 tons/acre
	Western Red Cedar	16-33 tons/acre
Cooler Moister Forests	Subalpine fir, western hemlock, spruce	16-33 tons/acre

Note: These are approximate recommendations. For specific recommendations for individual habitat types, see Graham et al. (1994) in the reference section.

[1]*Climax species* are the tree species that would dominate a site after a long period of forest succession (100-400 years) with little or no disturbance. On most forested sites, the climax species will be the most shade-tolerant conifer you can find growing in the understory at a rate of 10 or more trees per acre.

Figure 22. Wood decay from "white rot" (top) vs. "brown rot" (bottom).

Figure 23. Removing logs with stem decay will not reduce future stem decay on that site.

Researchers from the USFS Rocky Mountain Research Station used mycorrhizae as a “bio-indicator” to determine how much coarse woody debris was optimal for Rocky Mountain forest soils. They looked at many forest sites and found points of diminishing returns for coarse woody debris, where mycorrhizal activity leveled out above certain amounts of CWD. Above the upper limit (table 2), additional CWD did not increase mycorrhizal levels.

For the Inland Northwest, that research recommended leaving amounts of CWD ranging from three tons per acre in drier ponderosa pine forests to 33 tons per acre in more moist western hemlock forests. These CWD recommendations assume stumps are not removed.

At a minimum, pay closer attention to leaving low value (“cull”) pieces of stem wood in the forest rather than hauling them all to a central location, including them in slash piles, or worse yet, hauling them to a mill that won’t pay for them (fig. 21). Measuring how much CWD there is on site before a logging job will provide some guide to how much additional CWD should be left. See Appendix for information on measuring coarse woody debris tonnage.

Leaving larger logs (24 inches in diameter and larger) is often preferable because they decay slowly, are more likely to survive repeated fires, and can provide habitat to a wider variety of wildlife species than smaller material. Ideally, the material should be distributed across a site.

Douglas-fir, larch, western red cedar, and pine CWD decay into “red” or “brown” rotted material which provides the longest lasting benefit (hundreds of years). By contrast, CWD from grand fir, hemlock, and hardwood species is more short-lived because it is decayed by “white rots” (fig. 22). You may find stem decay in logs left after a harvest, but removing those logs will not reduce future stem decay in the stand (fig. 23).

Figure 24. Fire risk from CWD, while minimal, may be reduced by cutting the branches from logs so they lay flat on the ground.

STRATEGIES FOR MANAGING FIRE AND ORGANIC DEBRIS

Fire hazard

Fine organic debris poses the greatest fire hazard because it dries rapidly, ignites readily, and burns quickly and intensely, making fires running through it hard to control. Fire risk assessment is based primarily on the amount, arrangement, and depth of fine organic debris created by a timber harvest or thinning.

Coarse woody debris is not as much of a fire risk and in some areas, you can legally leave as much of it as you like. However, very heavy coarse woody debris loads (more than 40 tons/acre) may impede fire suppression. Fire risk from CWD may be further reduced by cutting logs' branches so they lay flat on the ground, where they can soak up more moisture and decompose more easily (fig. 24).

Most western states have fire or slash rules that require a landowner or operator to modify or reduce slash to an acceptable level. Landowners who have more slash than is acceptable may be liable for any forest fires that start on or move through the property. These rules vary from state to state and are often structured differently for slash from logging versus slash from pre-commercial thinning or other activities. Check with your local state forestry office for more information on these rules.

The ultimate goal of slash treatment is not to remove all slash, but to reduce fire hazard. Therefore, the first step in planning slash treatments is to determine the degree of slash hazard. The most common measure of fire hazard is tons of slash per acre, but slash hazard is more than weight. Other factors that determine fire hazard from slash include:

- *number, size and species of trees to be cut and resulting slash load in tons per acre* (a few large pieces present a smaller hazard than many small pieces even if the tons/acre are the same);
- *depth of the slash* (deeper slash has more fire hazard);
- *size of unit* (smaller treatment units have less fire hazard);
- *slope and aspect* (steep south or southwest facing slopes are more hazardous because they dry out sooner and fires on slopes burn with greater intensity);
- *forest structure* (for example, the distance from the ground to the base of the tree crowns);
- *condition of the unit and adjoining areas prior to activity*;
- *location of the unit relative to other slash accumulations or other fuels*;
- *accessibility of the unit* -- whether there are campgrounds

Figure 25. Limiting access is one of many ways to reduce fire risk.

Figure 26. Your local state forest fire officials can help you evaluate fire hazard and how to reduce it while retaining nutrients.

Figure 27. Fire hazard can be reduced by lopping slash into smaller pieces – making it less than 24 inches deep.

Figure 28. Heavy winter snows may compress slash considerably.

or roads close to the site that allow more opportunities for human ignition (fig. 25);
- *proximity to structures such as homes*;
- *presence of snags and cull trees* (snags ignite easily and can cast sparks and fire brands that help fire spread);
- *deterioration rate of slash* (slash close to the soil's surface decomposes more easily and loses its needles or leaves more quickly, making it less of a fire hazard than loosely compacted fine fuels with lots of brown needles); and
- *time of year activity takes place*. Fine fuels generated in the late winter and early spring create a greater fire hazard than slash created in the late summer, fall, or early winter. Late winter and spring fuels can dry and be highly combustible in the summer and early fall when the fire danger is highest.

Before deciding on a slash reduction strategy, contact your local state forest fire official to determine how much of a fire hazard you have, or are likely to have, from a harvest or thinning (fig. 26). If there is or will be enough slash to warrant further treatment, there are many methods to reduce slash to acceptable levels. The following methods may be used alone or in combination.

Methods to reduce fire hazard

Lop and scatter

Relatively small amounts of slash can be cut into smaller pieces (2 to 8 feet in length depending on their diameter and limbiness) and scattered so they lay flatter to the ground, have more contact with the forest floor, are less than 24 inches deep, and are discontinuous so they would be less likely to carry a surface fire (fig. 27).

This method, commonly referred to as "lop and scatter," is fairly standard with pre-commercial thinning slash, but it can also be used for logging slash. Its effectiveness in reducing fire hazard is very site- and slash-specific, depending on tree species, amount, location, and piece size.

For the first few months to years after the treatment, there is some elevated fire risk, depending on the forest type, amount of fuels, and the intensity of the treatment. It may not be too visually appealing to some landowners either. But after one winter's snow, the material is often compressed, needles fall off, and it is more out of sight (fig. 28). Lopped and scattered slash decomposes more quickly on moist sites than on dry sites.

Pile and burn

For heavier slash loads, lop and scatter is usually inadequate by itself. The most common approach

Figure 29. Piling and burning is the most common approach to reduce slash on family forests.

Figure 30. Dirty piles such as this are difficult to burn.

Figure 31. Leave CWD out of slash pile if possible.

Figure 32. Excavators can separate fine from coarse woody debris more easily.

Figure 33. Trees can be injured if piles are burned too close to them.

Figure 34. A piece of plastic or roofing paper placed on top of a pile keeps a portion of it dry for easier ignition.

to reduce slash hazard on Inland Northwest forests is to pile it and burn it (fig. 29). Piles can be created by hand or by using a dozer or other machinery. Hand piling is very appropriate for small areas around homes and other buildings; where slash loads are light; where machines would have difficulty working because of residual tree density or steepness of slope; or where risk of soil compaction and/or displacement is high.

Slash can be piled with dozers or tractors with rakes (brush blades), but if they are not used carefully, these machines can displace large amounts of topsoil and forest floor material, and leave a lot of soil in slash piles. Piles with a lot of soil in them (fig. 30) are difficult to burn and can smolder for days and even months after they are ignited. They may even provide an ignition source into the next fire season. Dozers also have difficulty separating fine organic debris from coarse woody debris. Tree limbs and boles may have to be cut into pieces to facilitate hand or dozer piling.

Slash can also be piled using excavators and other machines with a grapple. Because these machines can select individual pieces of slash to lift, separate, and pile, they can divide CWD from FOD (fig. 31). Because these machines lift material, piles have less soil, so they burn more completely and there is less risk of “hold-over fires” (fig. 32).

Pile location is critical so burning piles do not scorch or damage adjacent homes, buildings, or valued trees (fig. 33). Covering a portion of slash piles with plastic sheeting, roofing paper, or other waterproof material will ensure some dry material for easier ignition (fig. 34). Some states have laws regarding the types of plastic that can be used for this purpose and whether it can be burned. Check with your local state forestry office for applicable regulations. Piles are usually burned during the winter or after fall rains, to lessen the chance of fires escaping the piles.

Piling and burning reduces fire hazard, but it does have some downsides. First, it costs time and money (especially hand piling), though these costs are usually figured into a logging job that removes sawlogs. Second, there is some risk associated with burning piles, both to trees on the site and to surrounding forests and buildings, if they are not burned carefully.

Also, depending on the soil type and its moisture content and pile size, the soil under the pile can be severely damaged by heat from the fire. These severely burned areas are often invaded by noxious weeds such as thistles or spotted knapweed. However, a very small percentage of the site is usually damaged by pile burning, especially if old burning sites are re-used.

Finally, immediately piling fresh slash concentrates nutrients in a few piles. Burning those piles

Figure 35. Letting slash sit one winter before treating it retains more nutrients on the site.

Figure 36. Chipping reduces slash risk but can be expensive.

typically removes much of those nutrients and organic matter benefits from the site in the form of smoke.

One way to reduce nutrient loss is to let the slash sit one winter before piling and burning, to allow more nutrients to leach to the soil (fig. 35). Most states allow some leeway or extensions in which to treat slash before a landowner is held liable for any fire that moves from or through the property. In some cases, you may also be able to get an extension of this time period from your state forestry office. Be sure to ask them about it before logging is completed. There will be some extra expense, compared to piling immediately after logging, if you have to move equipment back to the site to pile slash.

Chipping

Chipping involves placing forest debris by hand or by a mechanical arm into a chute leading to spinning knives that reduce material to pieces 2 square inches or smaller. Chippers are most often pulled behind a truck or tractor (fig. 36).

Chipping has rarely been used for slash treatment because it is labor intensive and costly. However, there has been renewed interest in chipping, grinding and similar technologies as a way of creating biomass fuel, mulch, or feedstock for petroleum alternatives.

Chip specifications for these markets can be very stringent as to chip size, cleanliness, and species. Be sure to check with buyers regarding their specifications before chipping. Factors such as the quantity and quality of the chips, transportation costs to the site that uses the chips, and alternative fuel prices also play into whether removing the chips is economically viable. As with burning, there is also potential for some nutrient loss, if chipped fresh fine organic debris, including green needles, is immediately removed from the site.

Even if you do not sell the chips, you may still prefer to chip your slash and leave it on site. Many people like the way chipping looks. Local air quality ordinances also sometimes forbid burning, and chipping on site may be cheaper than hauling slash to a dump.

Wood chips such as those created by a chipper do not normally occur in nature. Wood chips dry and wet easily, making it more difficult for fungi and other organisms to decompose them. When chips are piled or layered, they may retain moisture and decompose poorly because of poor air circulation. These conditions are very familiar to ranchers if they bale or stack wet hay and it molds or develops heat (spontaneous combustion), or when someone finds mold under their wet carpet. Fires moving through a layer of chips can produce large amounts of heat, potentially damaging the soil and any residual vegetation.

Figure 37. Keep chipped slash less than 1 inch deep.

Figure 38. Leave chips in a mosaic, so there are areas with no chips. This reduces potential soil impact.

Figure 39. Mechanical slash reduction typically involves some type of attachment to an excavator, a bobcat, caterpillar, or similar machine.

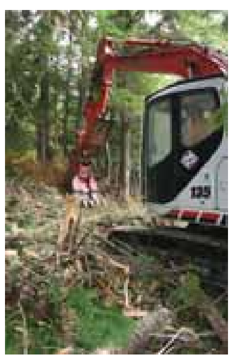

Figure 40. Fine organic debris can be treated mechanically, but coarse woody debris should be left alone if possible.

Layers of chips can also insulate the forest floor and mineral soil, disrupting heating and cooling cycles, water infiltration, and decomposition. Avoid burying or mixing the chips in with the soil, because fungi and other organisms compete for and tie up nitrogen directly from the soil as they decompose fresh buried chips.

Because chips can act as a mulch and be a poor seedbed, they can be used to suppress unwanted vegetation such as noxious weeds and unwanted shrubs and grasses, or to favor valued vegetation, such as tree seedlings, deer and elk browse, or bird habitat. However, their effect is short lived (from a few months to a couple of years). Chips can also be used on paths and trails. Chips are not appropriate within 100 feet of buildings due to fire risk.

If slash is chipped and left on site, try to keep chips less than 1 inch deep and distribute them discontinuously across the site, leaving some areas with no chips, to decrease potential impacts (figs. 37 and 38). Avoid chipping coarse woody debris. The fire risk from CWD is relatively low, and chips do not provide the same value to forest soils and wildlife as CWD.

Busting/crushing/shredding/mulching/masticating/grinding/chunking

Many terms are used to describe different practices that use machines to reduce the size and stature of slash, small trees, and brush so they lay flatter on the ground in contact with the soil. Most of the machines used for this have a rotary or drum power head attached to an excavator, a bobcat, dozer, backhoe, skid-steer tractor, or similar machine (fig. 39). The condition of the material after treatment depends on the type of head used, skill of the operator, and the amount of time spent in an area or on a piece of slash.

All of these machines vary in their maneuverability in tight stands (some can be used on sites with trees spaced as close as 12-15 feet), ability to work on slopes, degree of soil compaction, and the amount of soil they displace. Small machines and those with the cutting head on the end of a boom can work close to buildings and in and among closely spaced trees.

Most forest owners will hire a contractor to do this work, but some may be interested in purchasing a machine, particularly machines that can do multiple tasks, such as move snow, skid logs, and dig ditches. For more information, see “Small Area Forestry Equipment” in the reference section.

These machines can increase the amount of slash less than 3 inches in diameter, but fire hazard will be reduced if the material is distributed in a patchy pattern across the forest floor and in direct contact with soil. Avoid breaking up CWD (fig. 40), since this may turn it from low to high fire hazard material. If you

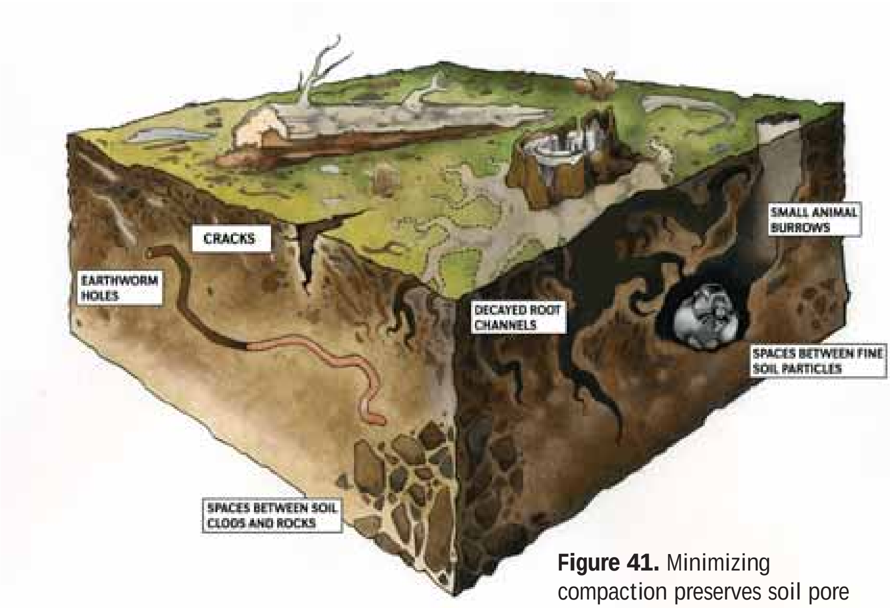

Figure 41. Minimizing compaction preserves soil pore space and ultimately forest growth.

Figure 42. Using smaller equipment is one way to reduce soil compaction.

Figure 43. Limit soil displacement when treating slash.

must break up CWD, attempt to leave it in softball- to football-sized chunks. Also focus on slash that was created in the most recent entry. Older slash is not counted in some state slash inspectors' assessments, but if breaking up old slash makes it countable as new slash, the site may not pass slash treatment standards.

Soil compaction and displacement

One of the most important qualities of healthy forest soil is adequate pore space -- the part of the soil occupied by air and water. Pore space is necessary for tree root growth and feeding, and for beneficial fungi and other soil organisms (fig. 41). Pore space is reduced when soil is compacted. Piling and burning, slash busting, or chipping may require moving heavy equipment across the site. Covering a lot of ground with repeated trips by heavy equipment risks more soil compaction.

Potential soil compaction varies by the type of soil and other factors. Ash-cap soils are very susceptible to compaction, whereas gravelly or sandy soils can be less vulnerable to compaction. Soils with extra moisture may compact more easily. The type of equipment, and the carefulness of the operator using the equipment, can also affect compaction. Compaction can be reduced by:

- using equipment with lower ground pressure, such as smaller dozers, and tracks instead of tires (fig. 42);
- working during drier seasons or on snow or frozen ground;
- limiting traffic by cabling or carrying slash to the machine;
- using machines mounted on an excavator arm; and
- operating equipment over slash mats (layers of slash laid down specifically to drive on).

For more information, see "Soil Compaction on Woodland Properties," listed in the reference section.

Soil displacement is also a potential issue with machines, particularly on very thin soils or soils with a unique layer, such as volcanic ash, that is critical to soil functioning. Soil displacement occurs most often when machines turn and/or twist, pushing the forest floor and surface mineral layers into furrows and/or mounds with their tires or tracks (fig. 43).

Blades, rakes, plows, or other implements attached to tractors used for logging and/or slash treatments can also displace soils. The more extensive the soil displacement, the greater the potential forest productivity loss. Limit soil displacement by minimizing blade or rake use, and operating logging and slash treatment machines carefully, especially on steep slopes.

Figure 44. Broadcast burn

Figure 45. Underburn

Figure 46. Burning when the lower duff layers are moist helps retain nutrients.

Figure 47. Charred CWD will still decompose and help soil.

Prescribed fire

Fires that are ignited purposely to treat the forest floor, logging slash, and even standing trees are termed “prescribed fires.” They are ignited under “prescribed” fuel and weather conditions to produce desired outcomes. There are many types of prescribed fires. For example, after a clearcut, slash is typically broadcast burned (fig. 44) to consume finer fuels and char coarse woody debris, reduce the fire hazard, kill unwanted vegetation, create sites for seed germination and/or tree planting, and improve tree planter access.

A prescribed underburn takes place under a canopy of trees and burns up needles, limbs, and other materials on the forest floor without killing overstory trees. This reduces fuels or creates bare mineral soil for conifer seed germination (fig. 45). These kinds of low intensity prescribed fires mimic the effects of surface fires that historically kept fire risk lower and recycled some nutrients.

Prescribed burning always balances between choosing conditions that allow safe burning (such as time of the year, fuel moisture, air temperature, wind speed, humidity, expected rain and/or snow) versus conditions that are dry enough to get a burn that meets management objectives. Air quality and atmospheric conditions favorable for smoke dispersal also determine burn timing.

The science and application of prescribed fire have dramatically improved. Ideally, prescribed fires burn in a way that protects the nutrient-rich forest floor, leaves the desired amount of CWD, and minimizes the risk of escape.

“Cool” burns—prescribed burns where the temperature is high enough to reduce slash but not hot enough to volatilize all the nutrients—are desirable. When the moisture content of the surface organic layers is high, fires do not usually consume these layers entirely and temperatures there don’t exceed 400°C (fig. 46). Above that temperature, nitrogen and other nutrients are volatilized.

These forest floor and fine slash moisture levels can occur throughout the year, but they are most likely during spring and shortly after fall rains. CWD is not usually consumed under these moist conditions. It may be charred, but charred logs have plenty of cracks, checks, and other openings, allowing decaying organisms to colonize the wood (fig. 47).

Prescribed fire can effectively reduce wildfire hazard, but it can also damage residual trees and coarse woody debris. It can also damage the forest floor’s nutritional and biological values, and even mineral soil, if it is not used carefully. This is particularly the case in

Figure 48. Prescribed burning should be implemented by trained professionals.

forests that have been without fire for many decades, and deep layers of duff have often developed, especially around the bases of large, old trees. Before raking these layers away from a tree or burning under it, dig into the duff to see if roots are present. If they are, be careful with fire and other treatments, as trees could be damaged.

Obviously, prescribed burning has large risks. If a fire escapes, a landowner can be held legally responsible for damage to others' properties and the cost of suppressing the escaped fire. Forest owners who are considering prescribed fire on their forests should consult with professional foresters and fire managers who are trained and experienced in assessing the risks associated with prescribed fire and implementing appropriate safeguards (fig. 48).

Other methods to help reduce fire risk

All of the fire risk reduction strategies referred to thus far are ways of directly reducing or modifying fuels. Other ways to reduce fire risk that can be used together with these methods include:

- making water available;
- limiting access by gating or closing roads to reduce the chance of human ignitions;
- creating fuel breaks, fire trails, or fire lines to limit and isolate slash and pre-existing organic debris into smaller subunits and break up the fuel continuity; and
- creating fuel break buffers along travel routes (removing all slash within 66 feet of roads).

No strategy will eliminate fire risk completely, especially when fire danger is extreme. But healthy trees and forests are more resistant and resilient to fire, insects, and disease. Evaluate a combination of different actions and develop a strategy that best fits your site and your objectives, to balance between reducing fire risk and meeting other objectives such as care of forest soils and wildlife habitat. For on-site help in devising a strategy to reduce fire hazards from slash, check with your local state forest fire official.

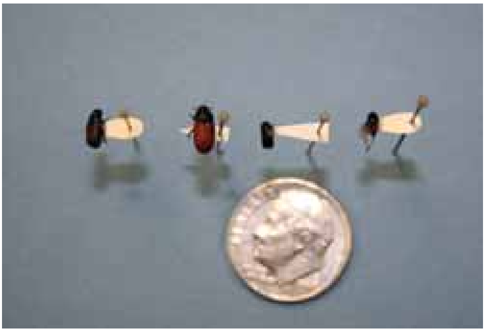

Figure 49. Bark beetles from left to right: Douglas-fir beetle, spruce beetle, pine engraver beetle, and fir engraver beetle.

Figure 50. Pine engravers attack ponderosa & lodgepole pines.

Figure 51. Pine engraver beetles leave piles of orange boring dust in green boles of ponderosa or lodgepole pine on the ground.

Figure 52. “Y”or “H” shaped galleries in the cambium confirm the presence of pine engraver beetles.

STRATEGIES FOR MANAGING BARK BEETLES AND ORGANIC DEBRIS

Some landowners believe they should remove all organic debris to reduce problems with bark beetles. Such a preventative mindset is commendable, but there are many species of bark beetles and only a handful of them kill trees (fig. 49). Of the tree killers, only a few species breed in fresh slash or downed trees. Forest owners should consider:

- *species of trees* on the site, and whether a bark beetle that breeds in the coarse woody debris can attack the standing green trees;
- the *size* of the coarse woody debris and whether bark beetles can breed in it, successfully complete their development, emerge, and attack standing trees; and
- whether the slash is *fresh* when the bark beetles are looking for habitat in which to breed.

Pine engraver beetle

Pine engraver beetle (*Ips pini*) (also referred to by its genus name "*Ips*") is the most common culprit when insects emerge from downed trees or larger diameter slash to attack and kill standing green trees in the Inland Northwest. Pine engraver beetles and their larvae feed on lodgepole and ponderosa pines (fig. 50). They usually focus on sapling to pole sized trees (3- to-8-inch stem diameter) or tops of larger trees. In the Inland Northwest, they can produce 2 or more generations per year.

Pine engravers usually attack and kill trees within a ½ mile of where slash with green stemwood has been created from logging or winter storms. When green pine tops larger than 3 inches in diameter are created and left on site between November and June, *Ips* beetles will attack that material in the spring and breed there. Their progeny emerge later in the summer to attack standing green pines. Piles of orange-red boring dust on the boles on the ground (fig. 51) indicate their presence. Peeling away the bark will reveal "Y" or "H" shaped galleries from *Ips* feeding in the cambium (fig. 52).

To minimize risk from *Ips* beetles, avoid creating and leaving fresh pine tops or bole wood from November through June. One option is to log on those sites from July to October. Usually slash created during this time dries out sufficiently to be unsuitable for beetle development the following spring, or is colonized by secondary (non-tree-killing) beetles during the summer.

If you create green slash larger than 3 inches in diameter from November to June, debark it to

Figure 53. Debarking green logs will prevent bark beetles from successfully reproducing in them.

Figure 54. Douglas-fir beetle is most commonly a problem from large diameter Douglas-fir trees fallen in winter storms.

Figure 55. Galleries 8-10 inches long, parallel to wood grain, with eggs laid alternately, confirm Douglas-fir beetles.

remove beetles' food (fig. 53), burn it, or remove it from the site. Green stemwood created during winter and spring is often difficult to burn, but to reduce bark beetle hazard, the bark and underlying tissue only need to be scorched to make it unsuitable for beetle development.

Ips prefers slash to standing trees. If you will be logging on a site through the summer, and providing fresh tops through July, the beetles will move from slash to slash, and eventually overwinter in the slash or forest floor, without getting to standing trees. This is called leaving a "green chain" for the beetles. The following spring they will disperse to search out additional fresh downed material and do not usually concentrate attacks in standing green trees unless those trees are especially stressed.

You may see evidence of *Ips* or other bark beetles in material that is smaller than 3 inches in diameter. This material usually dries out too soon for any *Ips* brood to mature to adulthood, so it is not a bark beetle hazard for the standing trees.

Douglas-fir beetle

As the name implies, the Douglas-fir beetle (*Dendroctonus pseudotsugae*) is a bark beetle that feeds predominantly on Douglas-fir (it rarely attacks larch). Douglas-fir beetles attack large diameter standing trees (larger than 12 inches), and green debris larger than 8 inches, so they are usually less of a problem in timber harvests, since trees this size are usually taken to a mill shortly after they are cut.

Douglas-fir beetle is most commonly a problem from trees that have fallen in winter storms (fig. 54). Beetles will attack these trees the following spring, and their progeny will emerge a year later to attack standing green trees, most often groups of trees. During epidemic years, larger groups of trees are attacked. The beetles produce one generation per year. Standing green trees do not usually turn color until one year after attack.

If you have recently fallen Douglas-fir trees larger than 8 inches in diameter that have been on the ground less than 1 year, remove, burn, or debark them. You can also monitor them for beetle attack. If you see trees on the ground this size, with red-orange boring dust in bark crevices, and upon cutting away the bark find galleries 8-10 inches long parallel to the wood grain, with larval mines perpendicular to the main gallery in alternate patches (fig. 55), they have been attacked and should be removed, burned, or debarked.

Spruce beetle

Spruce beetle (*Dendroctonus rufipennis*) feeds on all species of spruce. Like Douglas-fir beetle, it is mainly a problem in standing trees and green debris that is larger than

Figure 56. Spruce beetle galleries run parallel to the wood grain but are generally shorter and wider than Douglas-fir beetle galleries.

Figure 57. Fir engraver galleries are 2-4 inches long and perpendicular to wood grain, with smaller larval galleries emanating from them parallel to the grain.

Figure 58. Wood borers such as flat-headed borers (top) and longhorned borers are often found in CWD but rarely move on to kill green trees.

12 inches in diameter. Problems commonly begin when there is a large amount of wind-thrown green spruce. Beetles attack the downed trees and their brood emerge from this material 1 or 2 years later to attack standing trees.

Fallen spruce trees larger than 12 inches in diameter should be removed, burned, or debarked to destroy beetle habitat. Beetle-attacked spruce trees have reddish-brown boring dust accumulating in bark crevices and on the ground underneath infested logs. Spruce beetle galleries are similar to Douglas-fir beetle galleries, but shorter (fig. 56).

Fir engraver beetle

The primary host for fir engraver beetle (*Scolytus ventralis*) is grand fir. While this beetle is not commonly as much of a problem with downed trees as other beetles described here, fir engraver beetle sometimes breeds in wind-thrown grand fir and in the tops of grand fir (over 4 inches in diameter) left over from logging. Fir engraver beetles produce one generation per year, which attack trees from June to September, most often during periods of drought.

Not all of the attacks of standing trees are lethal. More commonly, fir engraver beetles simply kill patches of tree tissue, or kill tops. Outbreaks have never occurred due to population build-up in wind-thrown trees or logging slash. Outbreaks normally occur during periods of drought or following outbreaks of defoliating insects that stress and predispose trees to fir engraver attacks. However, populations may increase enough in downed trees to kill patches of tree tissue or treetops. Outbreaks can also occur among root-diseased trees.

During droughty periods, if you have green grand fir larger than 4 inches in diameter on the ground, check under the bark for beetle galleries. If you find main galleries scoring the wood perpendicular to the grain, and larvae galleries emanating from them parallel to the grain (fig. 57), remove or debark the stems to eliminate beetle habitat.

Generalizations about bark beetles and organic debris

A few rules of thumb can be drawn from the biology of the bark beetles that breed in green coarse woody debris:

Trees dead longer than one year are not a bark beetle hazard. Even if those trees were at one time infested with bark beetles, their brood has already left. You will often find insects in them that are superficially similar to bark beetles, but they are not usually insects that kill trees. The same goes with large larvae of wood boring insects commonly found working in dead trees or firewood (fig. 58). These insects rarely kill trees. In fact, they are beneficial to forests, because they hasten the process of decomposing

Figure 59. Cutting green stemwood into firewood-sized pieces does *not* eliminate it as bark beetle habitat.

Table 3. Tree species, and recommended slash or downed tree treatments to prevent bark beetle problems

Tree Species	Bark beetle	Material that must be treated, and how	Material that may be left for forest soils and wildlife
Ponderosa pine (*Pinus ponderosa*) and Lodgepole pine (*Pinus contorta*)	Pine engraver (*Ips pini*)	Do not leave green pine slash larger than 3 inches in diameter from November to June. Otherwise burn, chip, or dozer-trample the slash.	Pine slash that is smaller than 3 inches in diameter, created July to October, or that is more than 1 year old.
Douglas-fir (*Pseudotsuga menziesii*)	Douglas-fir beetle (*Dendroctonus pseudotsugae*)	Remove or burn green Douglas-fir slash or downed trees larger than 8 inches in diameter within 1 year of creation. Those downed from May to July should be taken out before the following April.	Douglas-fir stems less than 8 inches in diameter or more than 1 year old.
Engelman spruce (*Picea engelmannii*)	Spruce beetle (*Dendroctonus rufipennis*)	Remove, burn, or debark green spruce larger than 12 inches in diameter within 1 year of creation	Spruce stems less than 12 inches in diameter or more than 1 year old.
Grand fir (*Abies grandis*)	Fir engraver (*Scolytus ventralis*)	Remove or burn green grand-fir slash or blown-down trees larger than 3 inches in diameter.	Grand fir stems less than 3 inches in diameter or more than 1 year old.

the dead trees. They also provide food for a variety of wildlife species.

Organic debris less than three inches in diameter is never a bark beetle hazard. Occasionally *Ips* will attack smaller diameter materials, but the material usually dries out, starving the larvae before they develop fully.

CWD from some species is never a bark beetle hazard. For example, there are bark beetles that breed in woody debris from cedar, hemlock, and larch, but they do not emerge to attack standing trees.

Beyond these types of CWD, hazard from bark beetles depends on the species, the condition of the material left on the ground, and the size and species of the trees in the immediate area that might be attacked (table 3). For example, Douglas-fir organic debris may be of appropriate size and freshness in the understory, but if the standing green trees left in the immediate area are all too small or of a different species (say, ponderosa pine), you do not have a potential bark beetle problem.

A final note: sometimes landowners see a green tree that has fallen in their forest and decide to cut it into firewood-sized pieces and stack it up in the woods to cure. Cutting green stem wood into firewood-sized pieces has little effect on its suitability as bark beetle habitat. Bark beetles that breed in downed stem wood will still do this successfully in firewood-sized pieces (fig. 59). If downed stem wood is a large enough diameter and green enough to be a bark beetle hazard, remove it or debark it.

For more information on bark beetles and other forest insects, see the publications cited at the end of this booklet. For technical assistance regarding whether you are likely to have bark beetle problems as a result of fallen or broken trees, contact your local state forestry office or a consulting forester.

Figure 60. Pileated woodpeckers and fishers are among the many species that use coarse woody debris.

STRATEGIES FOR MANAGING WILDLIFE AND ORGANIC DEBRIS

Plants, animals, insects, and fungi have evolved to take advantage of forest organic debris for food and habitat. People value these species for their own sake. But even where the primary focus is on growing wood fiber, some of the organisms that benefit from woody debris are important for good tree health. Rodents transport mushrooms and spores of mycorrhizal fungi. Birds of prey make their homes in snags, and then hunt pocket gophers that might otherwise kill planted trees.

Slash ultimately helps wildlife to the extent it enriches forest soils, which in turn feed the plants, trees, and fungi that wildlife depend on. But for the most part, wildlife biologists looking at organic debris focus on coarse woody debris, since it is often limited in many forests. In addition, many species of wildlife rely heavily on CWD for different phases of their life cycles (fig. 60). For example:

- both birds and mammals use CWD as a place to forage for insects or fungi;
- martens, fishers, bobcats, and black bears use CWD for dens and shelter;
- many small mammals use CWD for hiding cover and protection;
- small mammals and amphibians use logs as protected runways;
- many amphibians benefit from CWD because it provides a cooler, moister habitat with more stable temperatures for breeding and other activities;
- birds use CWD for lookout posts and reproductive displays; and
- small-bodied carnivores such as martens and weasels hunt for small mammals that overwinter under CWD.

Managing CWD for wildlife can be complicated. The size, distribution and orientation of logs are more important than sheer quantity. Also, different wildlife species have different habitat needs, some of which may conflict. For example, heavy log concentrations may be good for small mammals but may limit elk movement.

Since many if not most wildlife species of interest cross property boundaries, you also have to factor in what needs are being met, or not being met, on adjacent forests. More research is needed, but three general strategies related to managing CWD for wildlife are often discussed: snags, log sizes and characteristics, and arrangement.

Snags

Green trees are sometimes blown down by the wind and immediately provide CWD, but more commonly, dead trees remain standing for decades, depending on their species, size, cause of death, and their local environment. Dead standing trees are called snags.

Figure 61. Trees heavily affected by insects and disease are good snag candidates.

Figure 62. Leaving snags in clumps of trees reduces their safety risk.

Figures 63. A single- or double-grip harvester can be used to create a snag and still harvest wood higher in the tree.

Figure 64. Hollow logs are particularly useful to many wildlife species.

Figure 65. Snags and coarse woody debris provide the widest variety of habitat if the bark is attached.

Snags are valuable for a whole host of wildlife species, and their quality and quantity are often the first things that biologists look for when evaluating forest wildlife habitat quality.

A hard snag has intact bark and firm wood. A soft snag has some bark remaining, and wood that is beginning to decay and soften. Green trees with stem decay also provide habitat for many of the same cavity-nesting species that use snags. Leave some hard snags, soft snags, and green trees that will be “future snags” (generally the bigger the better), distributed over the unit. If possible, leave snags from a diversity of tree species.

Many landowners and loggers prefer to leave the least valuable trees as snags, especially if they already show signs of animal use, such as woodpecker activity or cavities. Trees that are already affected by certain insects and disease are good candidates for snags (fig. 61), especially if they are of little value for wood and will not harm adjacent trees.

Snags can be a safety issue for loggers and others who work, play, or otherwise spend time in the woods, so it is important to be flexible to allow loggers to leave snags in locations that do not threaten safety. One way of safely leaving snags is to leave them in clumps of trees (fig. 62). Another technique, if a site is logged with a single- or double-grip harvester, is to clip some trees 10-20 feet above the ground (fig. 63). This creates snag habitat while reducing loggers’ safety risk. If a tree has stem decay, the worst decay is usually in the bottom of the stem. Clipping the top of such a tree may allow the harvest of one or more viable logs from the top part of the tree.

Coarse woody debris size and characteristics

Larger pieces of organic debris benefit a wider range of wildlife species. For example, a black bear can den in the hollow stump of a large, wind-thrown tree. The larger the log, the longer it will persist, providing habitat for a longer period. However, small logs still benefit other species. For example, smaller logs often provide foraging opportunities for many wildlife species, including bears.

Longer pieces of CWD are also preferred because they provide a wider range of diameters, in turn benefiting a wider range of wildlife species. Hollow logs, created by decay from Indian paint fungus, red ring rot, and other stem decays, are particularly useful to many wildlife species, such as the pine marten (fig. 64).

Snags and downed logs provide the widest variety of habitat if the bark is attached, since some wildlife species will live in the space between the wood and the bark (fig. 65). Take care not to roughen

Figure 66. Log piles provide a complex of snow-free spaces and runways for wildlife protection and foraging.

Figure 67. Logs lying parallel to slope contours may be used more by wildlife. Such logs will also trap eroding soil on the uphill side.

up snags and CWD during logging operations any more than necessary.

Coarse woody debris arrangement

The arrangement of fallen logs is an issue for some species, particularly small mammals and their predators. For example, martens and fishers like logs that are "jack-strawed" or loosely piled up across the forest floor. When log piles are covered by snow, they create a complex of snow-free spaces and runways that provide habitat for rodents and foraging opportunities for predators (fig. 66).

Log orientation matters too. Logs lying parallel to slope contours may be used more by wildlife than logs oriented up- and downhill, especially on steep slopes (fig. 67). Arranging logs this way also allows soil and fine organic matter to accumulate on the uphill side, which traps moisture, hastens decay, and reduces fire risk.

How much coarse woody debris for wildlife?

The amount of CWD to leave depends on your overall forest management objectives, but wildlife biologists rarely talk about a site having too much CWD. Some researchers have suggested that 5-7 tons of CWD per acre for ponderosa pine forests and 10-15 tons per acre of CWD in mixed conifer and spruce/fir forests will help a wide variety of wildlife species. Other experts recommend leaving three to five logs 12 inches in diameter and at least 8 feet long per acre. The best strategy may be to leave a variety of species in various decay stages to benefit a broad range of species. The publications listed in the reference section of this publication provide more details on managing snags and coarse woody debris for different wildlife species.

CONCLUSION

Fine and coarse organic debris are important parts of a healthy forest. Forest and site conditions vary widely across the Inland Northwest. Forest owner values and goals also vary widely. Therefore, the application of the information within this booklet must be customized for each unique site and landowner.

For some sites, implementing the strategies described here may require only slight, inexpensive adjustments to forest practices. For example, coarse woody debris objectives on some sites can be met by simply leaving larger diameter slash pieces and cull log pieces scattered across the site rather than hauling them all to a slash pile.

On other sites and for other objectives, decisions about treating organic debris are less straightforward, particularly as related to fire risk and fine organic debris. Landowners should balance carefully between their acceptable risk, costs, and potential benefits to plan the best treatment strategy for each site.

The information in this publication should provide a starting point to help forest owners and those who work with them ask the right questions to make decisions towards keeping forests and wildlife more healthy and sustainable, while keeping risk from fire and insects within acceptable limits. For more information on the topics discussed in this publication, see the references listed on pages 58-59.

A harvester leaving a snag and removing the merchantable part of the tree.

APPENDIX: ORGANIC DEBRIS ESTIMATES

State forest fire officials and foresters commonly talk about the amount of slash or coarse woody debris in terms of "tons" or "tons per acre." Many forest owners are not sure what a ton of slash or coarse woody debris looks like. Learning how to measure organic debris can give you a feel for different debris amounts. Once you measure it a few times, you may not need to measure as much in the future, especially for CWD, where a fairly wide range of material is targeted. There are two common ways of measuring organic debris: photo series estimation and transect sampling.

Photo series

State forest fire officials and others who inspect woody debris and slash loading commonly use photo series to guide their estimates. These are photographs of a variety of sites with differing amounts, configurations, and compositions of slash, which are then measured for their fine organic debris and coarse woody debris amounts. With this method, you simply find the photo that most closely matches what you see on your site and estimate accordingly. Some series also rate the fire potential of the material shown in each photo (such as rate of spread, intensity, torching, crowning, and resistance to control) (fig. 68). These photo series may be available through state forestry departments.

Measuring organic debris

If you would prefer to measure coarse woody debris or fine organic debris directly, you can use the planar intersect technique (fig. 69). For coarse woody debris, that involves counting sound and rotten pieces of wood (above ground) that intersect 50 or 100 foot transects.

- Logs are rotten if they can be kicked apart. Rotten logs are counted, but for fewer points because they weigh less.
- The transect must intersect the central axis of the log to count that log — the transect can't just catch the log's corner (fig. 70).
- Splintered logs are mentally molded together to estimate diameter (fig. 71).
- If the same piece crosses the transect more than once it is counted each time (fig. 72).
- Look above your head for suspended CWD (fig. 73).
- Snags and stumps are not counted.

Different weights per acre are then assigned to each piece of wood according to its diameter and soundness or rottenness, and depending on whether you do 100

DATA SHEET

Plot No. 13

FOREST COVER TYPE: SAF NO. 228, Western Redcedar

IDAHO HABITAT TYPE: NO. 531, western redcedar/queencup beadlily-queencup beadlily phase THPL/CLUN-CLUN

DOWN & DEAD WOODY FUEL LOADINGS

Size Class (inches)	Weight (tons/ac) Slash Only	Total Debris
0 - 0.25	1.0	1.1
0.25 - 1.0	1.6	3.2
1.0 - 3.0	5.7	10.7
SUBTOTAL	8.3	15.0
SUBTOTAL 3+	66.0	67.2
TOTAL	74.3	82.2

NFDRS FUEL MODEL	NFFL FUEL MODEL
I	12

Photo Taken: 6/14/88

By: Goodson/Boyles

OTHER FUEL DATA & SITE DATA

Slope: 10 Percent

Aspect: Northeast

Elevation: 2700

Remarks:

Age of Slash: 3 months - 1 year

Type of Logging: Cat

Harvest Prescription: Partial Cut

Ground Fuel Composition: Cedar - 35 Percent
DF - 25 Percent
WWP - 20 Percent
Larch - 20 Percent

FIRE POTENTIAL RATING

Rate of Spread: Medium

Intensity: High

Torching: High

Crowning: High

Resistance to Control: Medium

Overall Fire Potential: High

STAND LOCATION

Location: Twin Lakes above Inland Empire Paper Company land

Ownership: State

Forest Protective District: Mica

Figure 68. Photo series are commonly used to estimate slash loads.

Figure 69. CWD can be measured using transects.

Figures 70. The tape must cross the whole log (left), not just a corner (right) to be counted in a transect.

foot or 50 foot transects. Adding those weights together estimates the tons of coarse woody debris per acre for that transect. Anywhere from 1-3 randomly placed transects per acre are then averaged together to estimate tons of debris per acre for the site. Tables 4 and 5 are blank, so you can photcopy and use them for your estimates. Figure 74 shows an example of 3 transects. These log diameters are entered on table 6.

To be precise, these numbers must also include a slope correction, but as long as the slope isn't more than 50%, it won't increase the estimate by more than 12%. A high degree of precision isn't usually necessary for general management purposes, because we are typically looking at a fairly broad range of targeted tons per acre of coarse woody debris.

This method does not count snags. If your tons per acre seem low, but you have a lot of snags on the site, you may be fine, since snags will eventually fall and add coarse woody debris to the site.

Fine organic debris can also be measured along these transects, but the method is tedious. Pieces are counted in three diameter classes (less than .25 inch, .25 to 1 inch, & 1 inch to 3 inches) in the first 6 feet of the transect, and added in a similar manner to the large pieces, to estimate tons of slash per acre.

The planar transect method for slash is used primarily in research. In day-to-day forest practice, photos are most often used to estimate slash.

Figures 71. Splintered logs are mentally molded together to estimate diameter – this piece would be roughly 5 inches.

Figure 72. If the same piece crosses the transect more than once it is counted each time.

Figure 73. CWD that is suspended is also counted in planar intersects.

Table 4. Coarse Woody Debris Estimation – **100' Transects**.		Transect #1		Transect #2		Transect #3	
Diameter and soundness/rottenness	Tons per acre per piece[a]	# Pieces	Tons per acre	# Pieces	Tons per acre	# Pieces	Tons per acre
3" sound	.4						
3" rotten	.3						
4" sound	.7						
4" rotten	.6						
5" sound	1.2						
5" rotten	.9						
6" sound	1.7						
6" rotten	1.3						
7" sound	2.3						
7" rotten	1.7						
8" sound	3						
8" rotten	2.2						
9" sound	3.8						
9" rotten	2.8						
10" sound	4.7						
10" rotten	3.5						
12" sound	6.7						
12" rotten	5						
14" sound	9.1						
14" rotten	6.8						
16" sound	11.9						
16" rotten	8.9						
18" sound	15.1						
18" rotten	11.3						
20" sound	18.6						
20" rotten	14						
22" sound	22.5						
22" rotten	16.9						
24" sound	26.8						
24" rotten	20.1						
26" sound	31.5						
26" rotten	23.6						
		Total tons per acre:		Total tons per acre:		Total tons per acre:	
				Average tons per acre:			

[a] Values derived from Brown, 1974. Values are for tons/acre on a 0% slope.

Table 5. Coarse Woody Debris Estimation – **50' Transects**.		Transect #1		Transect #2		Transect #3	
Diameter and soundness/rottenness	Tons per acre per piece[a]	# Pieces	Tons per acre	# Pieces	Tons per acre	# Pieces	Tons per acre
3" sound	.8						
3" rotten	.6						
4" sound	1.5						
4" rotten	1.1						
5" sound	2.3						
5" rotten	1.7						
6" sound	3.4						
6" rotten	2.5						
7" sound	4.6						
7" rotten	3.4						
8" sound	6						
8" rotten	4.5						
9" sound	7.5						
9" rotten	5.7						
10" sound	9.3						
10" rotten	7						
12" sound	13.4						
12" rotten	10.1						
14" sound	18.3						
14" rotten	13.7						
16" sound	23.8						
16" rotten	17.9						
18" sound	30.2						
18" rotten	22.6						
20" sound	37.2						
20" rotten	27.9						
22" sound	45.1						
22" rotten	33.8						
24" sound	53.6						
24" rotten	40.2						
26" sound	62.9						
26" rotten	47.2						
		Total tons per acre:		Total tons per acre:		Total tons per acre:	
				Average tons per acre:			

[a]Values derived from Brown, 1974. Values are for tons/acre on a 0% slope.

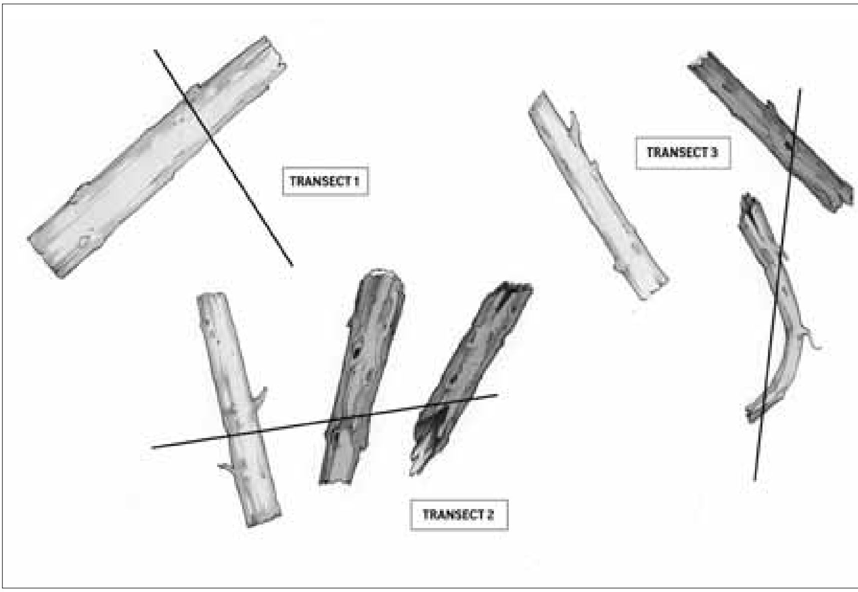

Figure 74. Three 100-foot transects.

Table 6. Coarse Woody Debris Estimation – **100' Transects**.		Transect #1		Transect #2		Transect #3	
Diameter and soundness/rottenness	Tons per acre per piece[a]	# Pieces	Tons per acre	# Pieces	Tons per acre	# Pieces	Tons per acre
3" sound	.4					1	.4
3" rotten	.3						
4" sound	.7					1	.7
4" rotten	.6						
5" sound	1.2						
5" rotten	.9						
6" sound	1.7						
6" rotten	1.3						
7" sound	2.3					1	2.3
7" rotten	1.7						
8" sound	3			2	6.0		
8" rotten	2.2			1	2.2		
9" sound	3.8						
9" rotten	2.8						
10" sound	4.7	1	4.7				
10" rotten	3.5						
12" sound	6.7						
12" rotten	5						
14" sound	9.1						
14" rotten	6.8						
16" sound	11.9						
16" rotten	8.9						
18" sound	15.1						
18" rotten	11.3						
20" sound	18.6						
20" rotten	14						
22" sound	22.5						
22" rotten	16.9						
24" sound	26.8						
24" rotten	20.1						
26" sound	31.5						
26" rotten	23.6						
		Total tons per acre: 4.7		Total tons per acre: 8.2		Total tons per acre: 3.4	
				Average tons per acre:		**5.4 tons/acre**	

[a]Values derived from Brown, 1974. Values are for tons/acre on a 0% slope.

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Managing Organic Debris for Forest Health

Reconciling fire hazard, bark beetles, wildlife, and forest nutrition needs

Forest organic debris includes tree limbs, boles (trunks), needles, leaves, snags, and other dead organic materials. Common reasons for removing organic debris include reducing fire risk, harvesting forest biomass for energy, reducing bark beetle hazard, preparing a site for tree planting, and aesthetics.

All these issues are important. But forest organic debris left on-site is not necessarily wasted. Organic debris protects soil from excessive moisture loss, recycles nutrients for trees and other forest plants, adds structure and organic matter to the soil, reduces soil erosion, and provides food and habitat for a wide variety of wildlife.

Forest and site conditions vary widely across the Inland Northwest. Forest owner values and goals also vary widely. Many forest owners are unclear on how to reconcile the potentially conflicting objectives related to forest organic debris.

This publication outlines the role of forest organic debris in Inland Northwest forests and provides general management strategies. It will help forest owners and those who work with them ask better questions to plan the best treatment strategy for each site in order to keep forests and wildlife more healthy and sustainable, while keeping risk from fire and insects within acceptable limits.

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