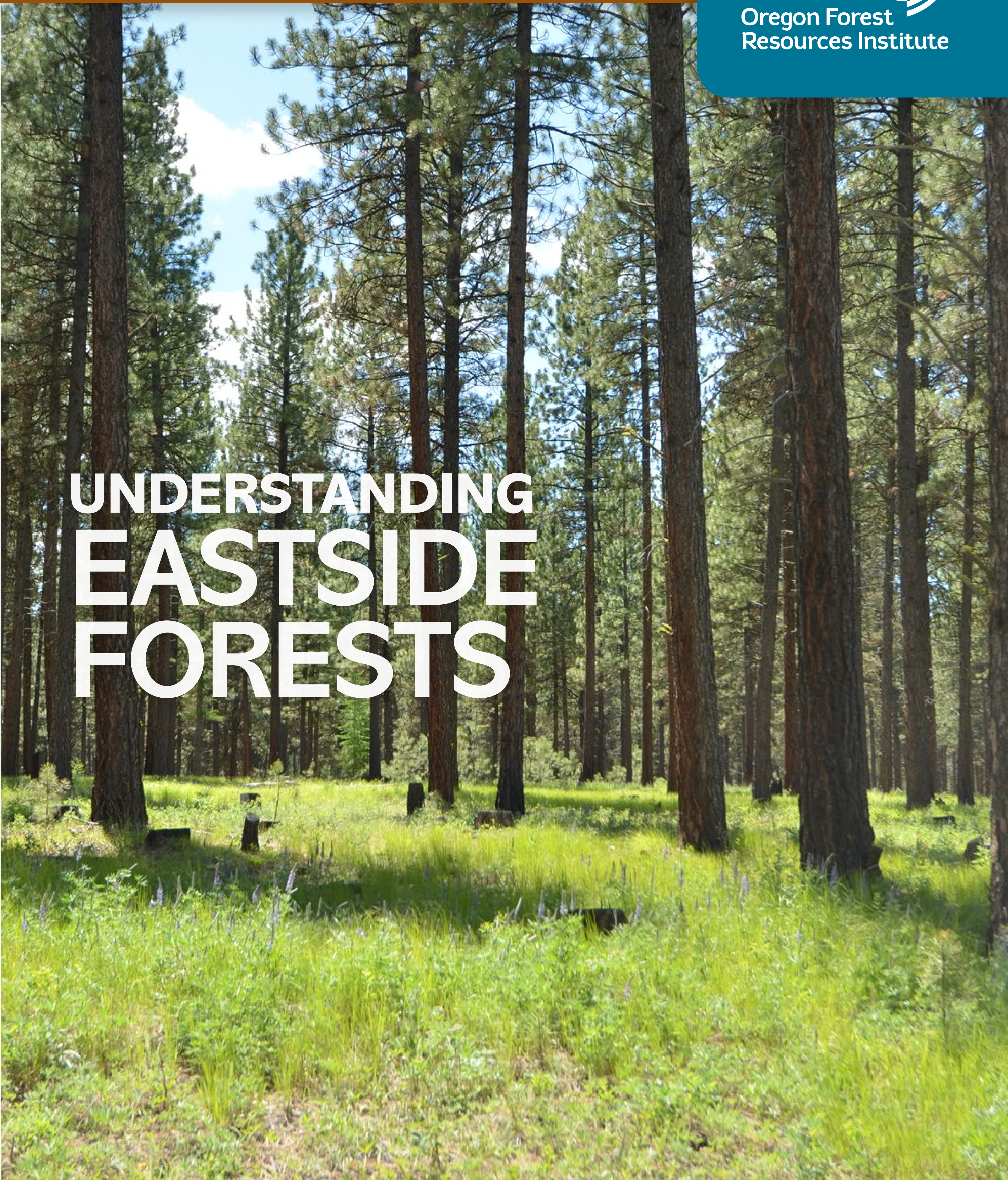
A guide for eastern Oregon landowners

Oregon Forest Resources Institute

UNDERSTANDING EASTSIDE FORESTS



Prepared for the Oregon Forest Resources Institute by Stephen A. Fitzgerald and William H. Emmingham, Oregon State University.

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A ponderosa pine stand on the eastern flank of the Cascades.

Get to know Oregon’s eastside forests

Eastern Oregon forests are well known for their scenic, recreational and wildlife habitat values, as well as for timber. But in the last couple decades, Oregon ’s eastside forests have been affected by wildfires and large insect outbreaks. Understanding the ecology and management approaches best suited to these forests is essential to increasing their health and resilience; expanding their positive contributions to wildlife, people and communities; and minimizing the expense and problems associated with them.

How do the forests of eastern Oregon work, and how can we manage them to sustainably produce a wide range of benefits? The task is formidable because of geologic and climatic complexity and a complicated management history. These forest ecosystems evolved over more than 10,000 years in a regime of frequent wildfires ignited by native people and lightning. Following Euro-American settlement, fire was excluded from eastern Oregon forests for more than a century. As a consequence, these forests became much denser, accumulated large amounts of fuel, changed structurally and are now more susceptible to drought.

The forested landscape of eastern Oregon is a complex mosaic of forest ecosystems varying from pure stands of juniper, ponderosa or lodgepole pine to mixtures of the pines with Douglas-fir, larch, and grand and subalpine fir. The forests are woven into a diverse topography with a wide variety of non-forest systems varying from open grasslands to tall sage. These forestlands can produce many outputs, including clean water, recreation, wildlife habitat, livestock range and timber. The primary commercial outputs are timber, livestock and recreation. Determining a sustainable balance of all these uses is not easy.

Current conditions of these forests vary from healthy and resilient to unhealthy and at high risk of wildfires, insects and tree diseases. Wildfires of the past few decades have burned hundreds of thousands of acres. Eastern Oregon forests are also vulnerable to a host of insects and diseases that can kill or degrade trees over large areas in a matter of a few years. Fires, insect attacks and diseases all reduce the ability of the forest to provide clean water, scenic vistas, timber and wildlife values.

Forest managers face difficulty not only in restoring burned-over landscapes, but also in managing existing dense and fire-prone forests to reduce their vulnerability to the effects of wildfire, drought, insects and disease. We understand how to manage forests to make them more resilient, but it takes skilled evaluation and planning, along with a concerted and sometimes costly effort, to accomplish the task. The challenge lies in understanding these varied and dynamic forests and taking timely management action to make them more resistant to the threats they face. This will be particularly important for the future as temperatures are predicted to increase due to climate change, placing additional stress on these dry forests.

Another complicating factor affecting private and public forestland owners is the decline in the sawmilling infrastructure in eastern Oregon. This has increased the distance private landowners and public land managers have to truck logs, and therefore their costs as well. As a result, they receive less income, if any, from harvesting timber.

The objectives of forest management in eastern Oregon vary by ownership. Federal forests are still managed for multiple objectives, with emphasis on wildlife habitat, recreational values and timber production. Most of the timber produced today on federal lands is the result of trees removed to restore health and vigor of forests, and to reduce the risk of severe, stand-replacing wildfires. Ranchers and private small woodland owners often focus on production of both timber and forage for livestock. Although limited in ownership acreage, large private timber interests in eastern Oregon focus mainly on timber production.

This publication, which examines the ecology and management of Oregon’s eastside, is a guide for eastern Oregon landowners and managers. Included are discussions on the influences of geology and climate on forest site potential, characteristics of important tree species and their tolerance to different environmental stresses, and a classification of forest types and how successful management approaches vary among the types. It concludes with guidance for sustainably managing eastern Oregon forests into the future.

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This report will help you understand the general ecology and management of eastern Oregon forests, and help you decide which forest type(s) you have on your property. We explain some basic ecological relationships and tree characteristics, define the major forest types, and discuss common management problems and techniques to keep trees healthy and to ensure your forest has the stand conditions, wildlife habitat, forest products and other values you desire.

For the purposes of this report, "eastside" and "eastern Oregon" both mean all of Oregon east of the crest of the Cascade Range. This also encompasses the region commonly known as central Oregon.

Geology and ecology of eastern Oregon forests

A basic understanding of the geology, soils and climate of eastern Oregon, and of the way the forests have developed over time, will help you determine which tree species to manage and which management strategy is likely to work best. The forests discussed here include those on the eastern slopes of the Cascade Range and in the Ochoco, Strawberry and Blue mountains (Figure 1).

The mountains of eastern Oregon originated in a variety of geological processes. They contain a rich variety of ancient to recent rock types, formed at great depths and either uplifted into mountains, extruded in lava flows or ejected aerially from volcanos. Some of these formations contain rich fossil records. Other portions were formed when lava periodically spilled across the surface of eastern Oregon, leaving basalt layers thousands of feet thick. Erosion processes such as river down-cutting and several glaciation periods subsequently shaped the mountains. In the Wallowas and Steens Mountain, glaciation during the past few ice ages left long, deeply carved valleys through layer upon layer of basalt. The east flanks of the Cascades were formed as active volcanos erupted violently and covered the surface with various forms of volcanic pumice and ash, or molten lava.

About 7,700 years ago, the violent eruption of Mount Mazama formed Crater Lake. Coarse pumice deposits covered hundreds of thousands of acres near the mountain, and fine ash layers were deposited across northeastern Oregon and beyond (Figure 2). Post-eruption winds sometimes blew fine ash from south slopes and deposited it on north slopes, or ash washed or sloughed off steep slopes and was deposited in ravines and river bottoms. All these geologic processes created variation in landforms and soils, which, combined with slope, aspect and elevation, created large differences in plant growth and forest potential on sites only short distances from one another.

Plant distribution and growth in the Pacific Northwest are most strongly influenced by temperature and drought. The eastern Oregon climate is hot and dry in summer and cold and moist in winter, when much of the annual precipitation (8 to 100 inches) comes as snow. Rainfall increases with elevation, but temperatures drop. The high Cascades form a "rain shadow." As moist air from the Pacific rises over the Cascades and the air mass cools, it is less able to hold moisture, forcing moisture from clouds in the form of rain or snow before the air mass arrives east of the mountains depleted of moisture.

Figure 1. The topography, climate and geology of eastern Oregon create a diverse mosaic of forest types.

During summer, three to five months pass with insignificant amounts of rain, creating very stressful drought conditions for trees and other plants as soil water is depleted. The severity of drought on a particular site depends on:

- annual rainfall
- elevation (which is related to temperature)
- soil moisture-holding capacity (which is related to soil type and depth)
- evaporative demand (which is related to site aspect, such as a north versus a south slope)

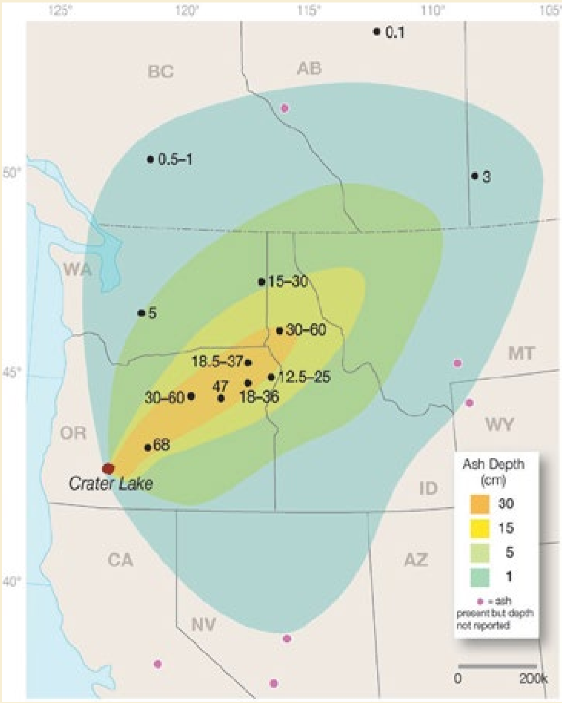

Figure 2. When Mount Mazama erupted 7,700 years ago, coarse pumice deposits covered hundreds of thousands of acres near the mountain, and fine ash layers were deposited across northeastern Oregon.

Deep, ash-filled soils at moderate elevations on north slopes can store winter precipitation and create conditions that support very productive forests. Coarse, gravelly deposits on hot, south slopes can create droughty sites with low moisture-holding capacity that are far less productive. The net effect on the landscape is a complex pattern of forest types and growing conditions. All this variation means that management actions must be tailored to the changing site and forest conditions on a small scale.

Major forest types of eastern Oregon

Most private forestland of eastern Oregon is one of four forest types: ponderosa pine, lodgepole pine, warm-dry mixed-conifer, or cool-moist mixed-conifer. A "forest type" indicates the potential for that soil and site to produce certain kinds of forest stands (see Figure 3). Before you make management decisions, it is important to know which forest type you have and, therefore, the most suitable trees species to promote or manage for. With a little practice, it is possible to determine forest type (Table 1.1).

PONDEROSA PINE FOREST TYPE

This type supports nearly pure ponderosa pine forests (Figure 3). The ponderosa pine forest type is so dry that no other commercial tree species can grow there; however, western juniper can often be found in the understory as seedlings and saplings or occasionally as a medium-sized tree in the forest canopy. Historically, fire visited this type at short intervals (every five to 25 years), keeping stocking levels low and the stands open and park-like. Ponderosa pine is the climax pine type because it is able to regenerate beneath itself. Pine regeneration is often poor or nonexistent due to long periods between cone crops, long summer droughts and low site productivity. The presence of Douglas-fir or grand fir seedlings and saplings in the understory indicates more moisture, meaning the site is a warm-dry mixed-conifer forest type.

Figure 3. A ponderosa pine forest type with pine in both overstory and understory.

LODGEPOLE PINE FOREST TYPE

This type is more than 90 percent lodgepole pine. Lodgepole pine dominates the forest on three major site types: on pumice flats, in frost pockets (slight depressions where cool air collects) and on high-elevation plateaus. A primary climate factor for the lodgepole pine type is the potential for heavy frost during spring and summer, when seedlings are actively growing. Of the common tree species, lodgepole pine is the most tolerant of frost. Its ability to tolerate frost damage allows it to germinate, survive and grow in the most frost-prone areas. Historically, a common pattern in lodgepole pine stand development was mountain pine beetle attacks that killed most of the existing stand, followed by an intense, stand-replacement fire. Lodgepole pine also is within many mixed-conifer forest types, either as part of the mixture or as the dominant pioneer species. If the latter, it might be replaced by more shade-tolerant species such as grand or subalpine firs (Figure 4).

Both lodgepole and ponderosa pine forest types are managed for those pine species because they are the only trees that do well on those sites. Both pines can, however, be managed in nearly pure stands on some mixed-conifer sites.

Figure 4. Lodgepole pine stand with a pine overstory and an understory of mostly grand fir and some subalpine fir, indicating that this is a cool-moist mixed-conifer forest type.

Figure 5. A warm-dry, mixed-conifer forest type, with a ponderosa pine overstory and an under- and mid-story of grand fir and Douglas-fir.

MIXED-CONIFER TYPES

A mixture of conifer species occupies many forest sites across eastern Oregon that are not limited by drought or spring or summer frosts. Historically, fire visited frequently on the drier end of the mixed-conifer type (similar frequency to the climax ponderosa pine type) and at longer intervals on the cool-moist end of the mixed-conifer type. Fire intensity varied from light to intense depending on fuel accumulation since the last fire. The mixed-conifer forests can be divided into two subtypes based on temperature and moisture conditions. The warm-dry mixed-conifer type occupies the warmer and drier end of the spectrum.

Typically, ponderosa pine dominates in young stands, but where soils are deep, larch may also play the role of a pioneer species. Douglas-fir and grand fir most commonly regenerate in the understory (Figure 5), but incense-cedar joins them on the east flank of the Cascades, along with sugar pine. Ponderosa pine also can regenerate vigorously beneath open stands, often in even-aged patches. Site productivity is higher than on the ponderosa pine type.

The cool-moist mixed-conifer type is indicated by the addition of more moisture-demanding and cold-tolerant species such as subalpine fir, western white pine or Engelmann spruce (Figure 4 and Figure 7). Typically, lodgepole pine or larch dominate the early successional stages and grow well, but ponderosa pine, Douglas-fir and grand fir also can be present. Engelmann spruce may be part of a mixture or be in almost pure stands at upper elevations or along streams and small rivers where cold air drainage and deep frost eliminate the other species. Western white pine and sugar pine (both five-needle pines) can also be found in the cool-moist mixed-conifer type on the eastern flank of the Cascades.

On mixed-conifer sites that have been thinned or selectively logged, a wide variety of species mixes can grow. Remember, even if you have mostly pine in the overstory, but seedlings of Douglas-fir, grand fir or incense-cedar are scattered about in the understory, the site should be classed as warm-dry mixed-conifer type. Engelmann spruce and subalpine fir are key indicators of the cool-moist mixed-conifer type. The pines, larch and Douglas-fir can be found in either type.

Exceptions to the simple rules for determining forest type occur where fire or logging and reforestation have modified species distribution and may mask the true forest type. For example, you may find mostly pine instead of a mix of pine and Douglas-fir or grand fir where a young lodgepole pine stand has seeded after an intense wildfire. The fire may have eliminated the fir species that can grow on the site. Therefore, instead of a lodgepole pine type, it should be regarded as a mixed-conifer type. It is sometimes necessary to depend on shrubs, herbs or grasses as indicators of forest type. In such cases, referring to the local plant-association guides (available from a U.S. Forest Service ecologist or silviculturist) can be very helpful.

The productive potential of the different forest types ranges from very low in lodgepole pine on pumice to quite high in warm-dry mixed-conifer. Productive potential drops again at the cold end of the cool-moist mixed-conifer type, mainly because of the short, cool growing seasons. Site index is a measure of site potential or productivity based on how fast trees grow to a certain height for a given age (100 years).

You can manage mixed-conifer types for any one of the species present – pure ponderosa or lodgepole pine, for example. Often, however, there are advantages to managing a mixture of species. In the warm-dry mixed-conifer types, it is especially desirable to keep a substantial component of ponderosa pine or western larch, because they resist defoliation by spruce budworm or Douglas-fir tussock moth. On cool-moist mixed-conifer sites, manage for ponderosa pine, western larch, Douglas-fir, grand fir (on better sites), Englemann spruce, western white pine, sugar pine and lodgepole pine.

Maintaining a diversity of species is appropriate whenever it fits the owner's objective. Just keep in mind that management options are greater for a mixture of species.

Figure 6. A cool-moist mixed-conifer forest type, as indicated by the presence of larch and grand fir, with some Douglas-fir and ponderosa pine in the mix.

TREE SPECIES PRESENT	FOREST TYPE	MANAGE FOR THESE SPECIES
Only ponderosa pine	Ponderosa pine	Ponderosa pine
Mostly lodgepole pine	Lodgepole pine	Lodgepole pine
Douglas-fir, grand fir or incense-cedar and ponderosa pine, or larch	Warm-dry mixed-conifer	Ponderosa pine, larch, Douglas-fir or species mixture
Subalpine or grand fir, lodgepole, Engelmann spruce, Douglas-fir and larch, with or without other species	Cool-moist mixed-conifer	Lodgepole pine, larch, Douglas-fir, grand fir (on best sites) or species mixture

Table 1. How to recognize eastern Oregon forest types and which species to manage.

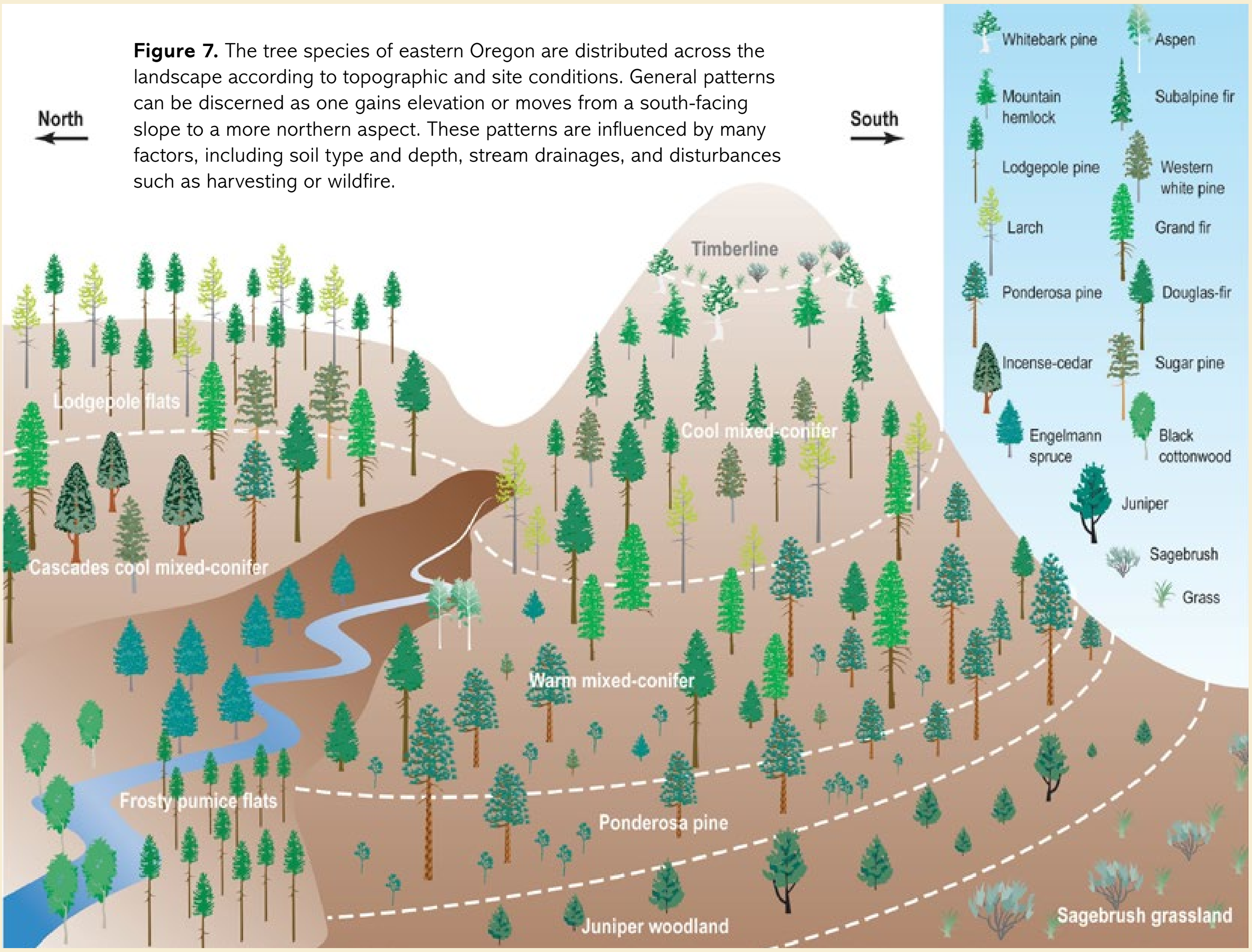

Figure 7. The tree species of eastern Oregon are distributed across the landscape according to topographic and site conditions. General patterns can be discerned as one gains elevation or moves from a south-facing slope to a more northern aspect. These patterns are influenced by many factors, including soil type and depth, stream drainages, and disturbances such as harvesting or wildfire.

Tree tolerance to environmental stresses

Each tree species has unique capabilities to tolerate stresses such as shade, drought, heat, flooding, wind, frost, fire and attack by insects or disease. Trees that can live through long summer droughts are said to be drought-tolerant. Trees that can live in shade are known as shade-tolerant. Trees with thick bark are fire-tolerant because the bark insulates the tree from heat damage. Tolerances determine where trees survive and grow, how they compete with other trees, and what we can expect them to do under management.

Figure 8 and Table 2 show relative tolerances of each tree species. The numbers in Table 2 are not exact measures, but they show how each species performs relative to the other species. The relative tolerances of different trees help explain the current condition of many forest stands and are extremely important in making management decisions. For example, the shade tolerance of Douglas-fir and grand fir have allowed them to replace less-shade-tolerant lodgepole and ponderosa pines over much of eastern Oregon during the last century. The frost tolerance of lodgepole pine explains its distribution and makes it a candidate for planting in frosty locations, but its low tolerance for bark beetle attack means that careful attention to thinning and harvest is a must. One final point to remember is that trees that are tolerant of a particular environmental stress, such as shade, don't necessarily like it and grow well in it. They are, however, able to tolerate it better than other species. For example, many trees classed as shade-tolerant prefer to grow in full sunlight.

Figure 8, right. This diagram shows where each tree species is found in relation to other tree species in a general gradient of moisture and temperature from low to high elevation. It shows the distribution of coniferous trees in eastern Oregon from lower timberline to upper timberline in order of their normal appearance. Heavier lines in the boxes around species' names show where the given species is more shade-tolerant than other species on the same site. For example, Douglas-fir growing with ponderosa pine and western larch will regenerate in the understory. (Diagram modified from Franklin and Dyrness, 1973.)

Table 2. Relative tolerances of trees to environmental stress factors in eastern Oregon.*

SPECIES	TOLERANCE TO[a]								CHARACTERISTICS		
	Shade	Drought	Flooding	Wind[b]	Frost	Fire[c]	Snow load	Pest damage[d]	Lifspan (yr)[e]	Mature ht. (ft) normal/ max.[f]	Knowledge of silvics[g]
CONIFERS											
Whitebark pine	5	5	2	1	1	3	1	4	500	40/75	little
Mountain hemlock	1	5	3	2	1	4	1	5	400	100/200	little
Subalpine fir	1	5	2	4	2	5	1	5	125	80/200	little
Engelmann spruce	1	5	1	5	1	5	1	4	225	120/165	some
Grand fir	1	3	2	3	3	4	1	5	175	120/210	broad
Sugar pine	3	3	3	2	3	3	3	4	500	180/245	some
White pine	3	3	2	3	1	3	3	4	250	170/205	broad
Western larch	5	3	2	1	2	1	2	2	250	160/190	broad
Douglas-fir	2	2	5	2	3	2	2	4	250	130/180	extensive
Incense-cedar	3	2	3	2	3	3	3	2	300	100/180	little
Lodgepole pine	4	2	1	3	1	5	3	3	100	80/120	broad
Ponderosa pine	5	1	2	1	2	1	4	3	300	165/200	extensive
Western juniper	5	1	4	1	2	4	3	1	500	40/60	little
BROADLEAFS											
Cottonwood	5	4	1	4	4	5	5	4	150	80/120	little
Quaking aspen	5	4	2	2	2	5	5	4	70	55/100	broad

* The numbers are not exact measures but instead how each species performs relative to other species.
a 1 = high tolerance, 5 = low tolerance
b Index based on bark thickness and experiencewith which species survive after fire.
c Index combines wind firmness (rooting) and trunk resistance to breakage.
d Index combines damage from insects, disease and animals.
e Typical longevity.
f First number is common height on good forest sites; second number is maximum height recorded.
g Degree to which management of the species is understood.

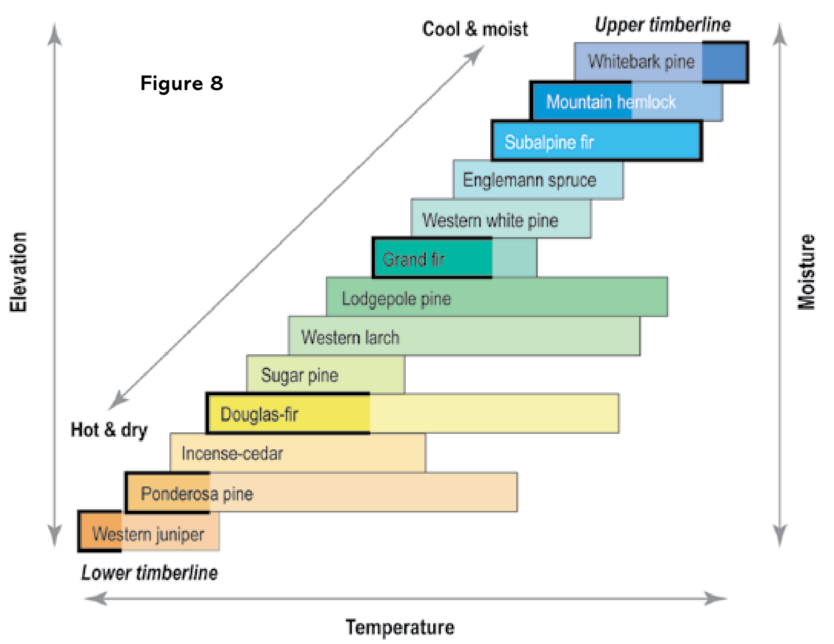

Figure 8

How to use tree tolerances in your management

You need to know the relative tolerances of the species in your forest, because you need to match each species' abilities with the role you want it to play. The key is to match the species to the site and to your objectives. What combination of tree species will do the job for you? For example, on warm-dry mixed-conifer sites you can manage for ponderosa pine, Douglas-fir and grand fir. Relative shade tolerances indicate that, for regeneration, Douglas-fir and grand fir will regenerate naturally under a pine overstory as long as a good seed source is available.

PONDEROSA PINE FOREST This older ponderosa pine stand just east of the Cascades represents a pre-settlement mature forest condition. The trees are large, widely spaced and fire-resilient. There is little undergrowth and few small trees. Lack of other trees species indicates this is a ponderosa pine forest type.

Characteristics of selected eastern Oregon trees

Let's review some of the important species for their special tolerances. In Figure 8, conifer species are listed in the general order in which they grow, from warm-dry, low-elevation sites to cool-moist, high-elevation sites. Deciduous trees are listed separately. For help with tree identification, see Trees to Know in Oregon, EC 1450, https://catalog.extension.oregonstate.edu/ec1450.

CONIFER SPECIES

Western juniper is intolerant of shade and grows in open stands called juniper woodlands. It is quite tolerant of drought and typically grows where it is too dry for any other tree species. Juniper grows slowly and has varying form, from short, wide-spreading trees with large branches to trees with good tree form on more productive sites. Western juniper has had limited commercial value as lumber, fuel for co-generation or fence posts. Over the last century, juniper has expanded its cover sixfold, often dominating many sites and causing subsequent declines in the abundance and cover of grass, herbs and shrubs important to some wildlife and grazing animals. Loss of herbaceous and shrub layers beneath juniper often leads to increased soil erosion and long-term site degradation. Juniper is resistant to pest damage but is sensitive to fire and can be killed by prescribed fire with the goal of improving rangeland values (see Biology, Ecology and Management of Western Juniper (Juniperus occidentalis), TB 152, https://catalog.extension.oregonstate.edu/tb152.

Ponderosa pine tolerates drought but not shade. It is second only to juniper in its ability to grow on the driest forested sites, where productivity is low; however, it grows better on mixed-conifer sites. It develops thick bark at a relatively young age, so it readily withstands low-intensity surface fires. It is resistant to defoliation and root disease. Ponderosa pine grows to large sizes, and its high-quality wood has made it the most valued and managed species in the dry interior West. It is susceptible to bark beetle attack when stands become overstocked, and in some areas it is badly infected by parasitic dwarf mistletoe.

Incense-cedar, where it grows on the east flank of the Cascades, is more shade-tolerant than ponderosa pine. It has low market value because of a fungus that causes pockets of rot to form in the wood. It is not favored in management except as a species for diversity. It is highly susceptible to fire due to its thin bark.

Douglas-fir is more shade-tolerant than the pines but not quite as drought-tolerant as ponderosa pine. When young it is susceptible to fire, but eventually develops a thick, fire-resistant bark that allows older trees to survive light surface fires. Because of decades of fire control, Douglas-fir is much more widespread now than it was a century ago. Its high-value wood makes it a welcome addition for those interested in timber management. It is, however, susceptible to defoliating insects, dwarf mistletoe and some root diseases, especially in dense, nearly

Ponderosa pine.

Top: Douglas-fir; left: Western larch; right: Lodgepole pine.

pure stands. It is resistant to rot from stem damage and less susceptible to bark beetle attack than associated pine species.

Sugar pine is less drought-tolerant and more shade-tolerant than lodgepole and ponderosa pines. In eastern Oregon, it is limited to the east flank of the Cascades, increasing its distribution from north to south. Although it is vulnerable to blister rust, a non-native disease, it grows well in warm and moist mixed-conifer forests and has moderate wood value.

Western larch is less drought-tolerant than the pines and Douglas-fir. It is less shade-tolerant than Douglas-fir and grand fir. Where it comes in after fire or clearcutting, it grows rapidly in height the first decade of life but can become suppressed in overstocked stands. Dwarf mistletoe can be a serious problem. Western larch resists defoliation by spruce budworm and Douglas-fir tussock moth and is resistant to root diseases, but it can be severely defoliated by needle diseases and by the larch casebearer (an insect). However, the impact of the casebearer has been greatly reduced since the introduction of natural parasites as biological controls. Because western larch is resistant to defoliation and root rots, it is advisable to promote mixed stands of pine, larch and Douglas-fir on deeper soils and north aspects. Western larch is highly resistant to fire due to its thick bark and other characteristics.

Lodgepole pine is only slightly less drought-tolerant than ponderosa pine. It is especially frost-tolerant, and it has a special ability to grow on soils composed mostly of pumice, a coarse volcanic ash. East of the Cascades, it forms pure stands over thousands of acres on deep deposits of pumice from what is now Crater Lake. It also forms pure stands in frost pockets, in or on the margins of wet meadows, and on high plateaus where summer frosts can be severe. It easily becomes suppressed in overstocked conditions and should be released by thinning.

Like ponderosa pine, at high densities it is susceptible to bark beetle attack and suffers from dwarf mistletoe. Also, it is locally heavily infected by western gall rust (a fungus), which can cause loss of volume and wood quality. Its bark is relatively thin, and therefore it is easily killed by fire, but it regenerates readily from

Left: Grand fir; middle: Engelmann spruce; right: Subalpine fir.

abundant and frequent seed crops. Lodgepole pine grows well in youth but cannot grow as tall or as big in diameter as ponderosa pine. However, its wood is valued for both lumber and paper.

Grand fir is more shade-tolerant than Douglas-fir or the pines but less drought-tolerant. It is a good grower, and in most mixtures it grows faster than any of its neighbors (pine, larch, Douglas-fir). It is, however, quite susceptible to drought, root disease and stem decay. It is killed by bark beetles and fire, and, like Douglas-fir, it is periodically defoliated. Defective trees are quite important for cavity-nesting wildlife species. Historically, its white wood was less valuable than ponderosa pine or Douglas-fir. By keeping grand fir at less than a third of the stand's potential stocking level, you can avoid many problems with insects and disease.

In Oregon forests, trees commonly referred to as "white" or "grand" fir are really hybrids between *Abies grandis* and *A. concolor*; others are more purely *A. grandis*. All are referred to as grand fir in this publication.

Western white pine's natural distribution is confined to small areas of the Wallowa and Cascade mountains. It is, however, a regular member of the cool-moist mixed-conifer forests in northern Idaho and western Montana. It may be a valuable addition to the relatively moist end of the warm-dry mixed-conifer type, because it grows fast and has high wood value. It is less drought-tolerant than Douglas-fir and moderately shade-tolerant where it grows. It is susceptible to bark beetle attack at high stocking. Although it is extremely susceptible to white pine blister rust (an introduced fungus), there has been considerable progress in finding, breeding and planting rust-resistant strains of white pine.

Engelmann spruce is a frost-tolerant species found along streams, where frost is common in summer, and at higher elevations or north slopes where moisture levels are adequate. Thus it is most common in the cool-moist mixed-conifer type. It can grow on periodically flooded or high-water-table sites; however, it is subject to windthrow in such areas. It has low susceptibility to spruce budworm, a defoliating insect. Spruce is shade-tolerant relative to the pines. Its wood is valued for its low weight, light color and strength. It is susceptible to spruce bark beetle attack in overstocked stands or near areas where spruce windfall has occurred. Engelmann spruce can be managed (thinned) to maintain tree health and vigor, but due to its shallow root system, opening up the stand can lead to blowdown.

Subalpine fir is a short-lived species (70 to 125 years) found at higher elevations in cool-moist mixed-conifer types. It is sensitive to fire. It can be attacked by balsam woolly adelgid (an insect) and can be damaged severely by root and stem decay. It grows in closed forest stands or in subalpine parklands. As a shade-tolerant species, it often seeds in under lodgepole pine or larch in the cool-moist mixed-conifer forest type. It has marginal wood value.

Mountain hemlock is found above or mixed with subalpine fir in the cool-moist mixed-conifer type or near timberline in subalpine parklands. It is quite susceptible to root disease, stem decay and dwarf mistletoe. It is found primarily along the crest of the Cascade Range and in the Wallowa Mountains, where its values for wildlife and watersheds are greater than its commercial timber value.

Whitebark pine is the conifer found at the timberline, usually in subalpine parklands. Like other five-needle pines, it is highly susceptible to white pine blister rust. Its seeds are an important source of wildlife food, including birds such as the Clark's nutcracker. Like mountain hemlock and subalpine fir, it is found mostly in national forests and has no commercial timber value.

DECIDUOUS BROADLEAF SPECIES

Black cottonwood grows in riparian areas along streams or lakes. It is important for shading streams and for diversity. The wood is soft and brittle and decays easily, but it is good for pulp and veneer. Deer, elk and cattle frequently browse its leaves and twigs.

Quaking aspen grows in a variety of locations associated with moist meadows or rocky slopes, and adds important diversity to eastern Oregon forests. It is valued for its beauty because of its white bark and bright fall foliage (Figure 9). This species forms large clonal patches through a process called suckering, where roots spreading away from the main stem send up sprouts (called suckers) that grow into trees. The patches may be small or cover tens of acres. Cattle, deer and elk readily browse the high-protein leaves and twigs. Aspen is prone to stem decay and provides high-quality cavity-nesting habitat thanks to cavities that woodpeckers excavate in decayed aspen.

Aspen stands have declined in acreage and health over the last century, and have been the focus of restoration activities in recent years. More information on the management and restoration of aspen can be found in Land Manager's Guide to Aspen Management in Oregon, EM 9005, https://catalog.extension.oregonstate.edu/em9005.

Figure 9. Deciduous species such as quaking aspen provide important diversity values, including habit for cavity-nesting birds and forage for big-game animals. They also provide a visual treat with their varied fall colors.

EASTSIDE FORESTS (Top photo) A dry mixed-conifer forest that has a mixture of ponderosa pine, Douglas-fir and grand fir. (Bottom photo) A ponderosa pine forest.

Disturbance and change in eastside forests

Forests are dynamic, changing either slowly or rapidly. We refer to most kinds of rapid change as "disturbance" because it is so noticeable, such as that caused by fire or large wind events that topple trees and forests. Gradual changes in forests occur through tree growth and competition among species. Changes in tree size and form and in stand canopy structure over a few decades are referred to as "stand development." In a longer time frame (several to many decades), changes in forest species composition, tree understory development and stand structure involve a process of change called "succession."

STAND DEVELOPMENT

Stages of stand development are (1) regeneration, (2) stand closure and (3) stem exclusion and/or stagnation. During the regeneration phase, trees become established and grow without competition among neighboring trees. During stand closure, trees grow taller and crowns expand, closing the canopy until the taller trees use most of the water, nutrients and light, leaving little for understory vegetation. During the stem-exclusion phase, less vigorous trees die while more dominant trees survive and continue to grow.

Stand stocking, a measure of how completely the trees use site resources, is important in stand development. In fully stocked stands, dominant trees receive enough resources to grow well (10 rings or fewer per inch of radial growth). In overstocked stands, all trees grow slowly (more than 15 to 20 rings per inch radial growth) and trees lack the vigor to resist bark beetle attack and some diseases.

In a condition called "stagnation," most trees remain in a slow growth mode, and a few die. This generally occurs in young stands with very high stocking. This condition is considered poor because the stand development process becomes "stuck" for long periods during which tree growth is extremely slow. A stand's tendency to stagnate depends on the tree species, stand density and site productivity. Single-species stands on low-productivity sites (e.g., lodgepole pine) are especially prone to stagnation.

Succession: In the process known as succession, tree, plant and animal species gradually change over periods of decades or even centuries, as stands grow dense and modify the microclimate within the forest. A group of early-seral species gradually is replaced by species referred to as "late successional." A common example is when Douglas-fir or grand fir seed in and grow in the understory of a ponderosa pine stand on a dry mixed-conifer site. Over several decades the firs grow up, the stand becomes overstocked and the pines decline in vigor. Eventually, beetles attack and kill the pine, leaving the forest increasingly dominated by firs. Fir-dominated stands are susceptible to severe insect defoliation and mortality, which in turn can leave stands susceptible to high-intensity fire.

Disturbance: Disturbance can result from fire, timber harvest, grazing, insect attack or disease. Since humans migrated to the Pacific Northwest more than 10,000 years ago, they have considerably influenced the disturbance pattern in the forests of eastern Oregon. The kind and frequency of disturbance in eastern Oregon forests have changed over the last century. Since about the year 2000, wildfires have increased in size and intensity in Oregon and across the West, creating rapid and great change in our forests.

From fire promotion to fire exclusion: Before European settlement, fires set by Native Americans or by lightning burned through the forests at regular intervals. The intensity and frequency of burning varied with the degree to which forests dried out, on a seasonal or climatic-cycle basis. Fire intensity also was strongly related to the amount (tons), type (size) and distribution of wood and fuel on the site. At low elevations, dry forests (i.e., those of ponderosa pine and warm-dry mixed-conifer types) had low-intensity fires at frequent intervals (five to 25 years), resulting in low stocking levels of fire-resistant ponderosa pine and/or larch. At low stocking, these trees grew well and became larger and more fire-resistant as their bark grew thicker. Most often, the low-intensity fires killed mostly smaller pine trees or thin-bark species and consumed understory shrubs and grasses. Fuel loads remained low. At upper elevations, more moist forests did not burn as frequently, thin-bark species gradually seeded in, shrubs grew large and fuels accumulated.

Typically, the longer the interval between fires, the greater the fuel load and the more intense the subsequent fire. Therefore, in the cool-moist mixed-conifer type, intense, stand-replacement fires occurred at long intervals, ranging up to 100 years or more. After fire, seral species including lodgepole pine and larch seeded in, forming pure or mixed stands that were gradually invaded by shade-tolerant subalpine fir after many decades of stand development.

Fire exclusion and suppression: Soon after European settlers arrived, they cleared land and began to suppress fire by restricting ignitions and fighting wildfire. Fires were less likely to burn across areas after grazing had removed grasses and herbs (fuel). Since about 1910, efforts to control fire have been increasingly effective. Thus, for over a century, fire exclusion has allowed stands to become dense to the point of overstocking or stagnation. Fire-sensitive, shade-tolerant species such as Douglas-fir and grand fir seeded in and spread across the landscape (Figures 10a–h).

Insects, diseases and other pathogens such as dwarf mistletoe were historically a natural part of the disturbance pattern and often interacted with wildfire to influence the distribution of successional stages across the landscape. Stands that had large numbers of trees killed by beetles or root disease became especially prone to intense, stand-replacement fires. Decades of fire exclusion have created dense stands, changed forest composition and facilitated the movement of bark beetles, defoliators and root diseases through stands and landscapes. Stands are more vulnerable, and landscapes contain higher percentages of fire-susceptible trees or stands.

Because the changes in forests due to fire exclusion were gradual, they went unnoticed until recently. Gradually, large areas became susceptible to burning at uncharacteristically high intensities. Forest stands in this unstable condition are prone to loss of both financial and wildlife values when most trees succumb to either insect attack or wildfire, although other wildlife habitat is created (snags, for example). Recent intense and widespread wildfires can be attributed to these successional trends. Such fire can severely impact watersheds, reducing their capacity to absorb and filter water during heavy rain or rapid snowmelt. Millions of acres of federal and private forests in eastern Oregon are in need of forest restoration treatments to improve forest health and increase resiliency to insects, disease and wildfire.

Grazing: As European settlers moved into the region over the Oregon Trail during the nineteenth century, cattle and sheep grazing and timber harvesting joined the list of disturbance factors. Intensive grazing by large herds of sheep and cattle spread across the landscape, often concentrating in riparian areas. Watershed conditions often were heavily impacted.

Grazing intensified as ranching became common over much of eastern Oregon. Grazing removed understory vegetation, and ranchers seeded many introduced grasses to "improve" grazing. Also, domestic grazing animals spread introduced weeds.

Overgrazing by sheep or cattle was recognized as a problem around the turn of the twentieth century, and has come under increasing regulation on federal forestland. Ranchers also have modified their forest and range management practices to improve forage production and limit damage to watersheds. Still, problems remain. For example, the spread of noxious weeds has degraded range conditions and threatens forest range values over large areas. Livestock also tend to congregate around streams and water sources where damage may occur, and thus need to be constantly managed to reduce impacts.

Timber harvesting: Timber harvest early in the last century often removed the more valuable ponderosa pine, larch and white pine in a way that was criticized as "high grading." The removal of large pine trees created openings and increased the water and light available for the more shade-tolerant Douglas- and grand firs to seed in and grow in the understory, which accelerated their development (Figures 10a–h) and oftentimes allowed them to replace the fire-tolerant pines and western larch.

Figure 10a. The stand receives its first selection cut. The original stand was dominated by ponderosa pine and had approximately 50 trees per acre. Loggers used horses to harvest about half the trees on the site. They left the other half as "reserve" timber for a second future cut and to provide seed for a new generation of trees. Most of the Douglas-firs were harvested, even though they were of lower economic value, to keep a native parasitic plant, western dwarf mistletoe (*Arceuthobium campylopodum*) from spreading through the stand.

Figure 10b. The reserve trees grew quite well for 40 years, especially during the first decade after logging and during a period of high rainfall about 30 years later. Some trees were blown down shortly after logging, but few others died. Abundant young ponderosa pine and Douglas-fir became established. These young trees grew about one inch in diameter every three to four years. The large tree in the center has been marked to be cut (see paint/blaze at stump height).

Figure 10c. To make room for the young trees to grow well, most of the undamaged Douglas-firs over 14 inches in diameter were harvested in a second selection cut in the 1950s. Loggers also cut dead-topped and lightning-damaged trees, slow-growing old trees, trees with decay near the base and trees leaning more than 20 degrees.

Figure 10d. In 1962, some large trees were cut (third selection cut) and patches of smaller trees were thinned. The most striking result captured in this photo is the proliferation of ponderosa pine seedlings. Ponderosa pine seedlings originate sporadically, in years after the trees produce abundant cones. They establish well in open spaces and on bare soil.

Figure 10e. Lots of young Douglas-fir seedlings are growing among the pines. Douglas-fir tolerates shade and dense forest conditions better than pine, so its seedlings can grow even when the site is partly occupied by taller trees and is shady.

Figure 10f. Ponderosa pine and Douglas-fir seedlings have developed into a dense understory. Tree branches are almost continuous from the ground into the tops of the tallest trees, making this stand prone to wildfire. Eighty years ago, wildfires changed the forest very little. Now they are likely to kill even the oldest, tallest trees on the site.

Figure 10g. One hundred years later. Some overstory trees were removed in a 1992 selection cut (fourth). Small trees killed by a 1993 underburning treatment have mostly fallen to the ground. Douglas-fir tree regeneration noted in 1979 continues to grow in patchy thickets.

Figure 10h. One hundred six years later. Shrub species in the understory have become more prominent. Douglas-fir regeneration is evident in foreground and background.

Adapted from "A Century of Change in a Ponderosa Pine Forest," Rocky Mt. Research Station, USDA Forest Service. Online at: https://firelab.org/project/century-change-ponderosa-pine-forest.

All these disturbances had three major effects on forest health:

1. The trend toward higher stand densities in pine and fir stands reduced the vigor of individual trees and increased the tendency for forests to be attacked by bark beetles.
2. The increased abundance of fire-sensitive species (e.g., Douglas-fir when young, and grand and subalpine firs) in mixed-conifer types led to stands with much higher susceptibility to serious insect defoliation by spruce budworm and Douglas-fir tussock moth. Overstocking and stagnation foster attack by bark beetles, root diseases and mistletoe (Figure 11). Fir species are also much more susceptible to drought.
3. The trend to higher stocking and multiple canopy layers led to stands that are prone to uncharacteristically destructive fires and, because of large fuel accumulations, fires that are extremely difficult to control. Even large pine and larch with thick bark are susceptible as the fires climb high into tree crowns on a fuel ladder of grasses, herbs, shrubs and mid-canopy trees.

HISTORIC AND CURRENT CONDITIONS

Forest condition varies according to the forest's history of management, including its history of fire, insect and disease attack, and the prevalence of mistletoe. On the negative side, many federal and private forests are overstocked and vulnerable to bark beetle attack (Figure 11). Fire suppression and lack of thinning have allowed stands to grow to high stocking levels, and in some cases to the point of stagnation. An even greater area is poorly stocked or stocked with poor-quality trees that will provide few wildlife or timber benefits in the future.

High-grade timber harvesting of the past tended to remove only the valuable, well-formed pine or larch, and it left stands dominated by Douglas-fir, grand fir or subalpine fir trees of poor form and vigor. Such species composition made these stands susceptible to defoliation by insects. In other cases, bark beetles killed many of the well-formed larger pine and left poor, understocked forests that have little timber value or opportunity for management.

On the positive side, fire or logging disturbance sometimes created soil surface conditions quite favorable for regeneration. Young stands became established and represent good opportunities for future management. In other cases, properly carried out selection management has resulted in mixed-species and mixed-age stands that have potential to grow high-quality timber and provide good wildlife habitat. Also, where naturally regenerated understories existed, logging the overstory sometimes released seedlings to grow into high-value stands. Thinning or harvest has in many cases promoted growth of valuable forage and browse for big game.

Riparian conditions also vary widely. A large proportion of streams have been negatively impacted because of the tendency of livestock to concentrate near water. Fenced-off riparian areas and distributed water tanks have been used to improve the situation; however, many areas need further attention toward managing livestock.

Your forest may have been degraded by events in the past or may have benefited from them. Either way, try to understand the current forest condition in relation to its potential, and determine what you need to do to put your forest on track to satisfy your long-term objectives.

Figure 11. Mortality of this tree may be due to bark beetles, root rots or drought. Forest stands with excessive tree mortality are susceptible to severe, stand-replacement fires due to the heavy fuel load of dead trees.

Management of eastern Oregon forests

Opportunities for beneficial management abound. Until recently, low timber values and low productivity of eastern Oregon forestlands made intensive management for timber production uncommon. Although many private forest owners have tended their stands and have healthy, productive forests, many other forest areas would benefit from more proactive management. Thinning forest stands, managing fuels and better managing riparian areas are efforts needed to correct current conditions. Such management would help prevent adverse impacts by insects, disease or fire, and would make the yield of values (e.g., wildlife habitat, timber or grazing) more predictable.

In recent decades, the loss of sawmills across central and eastern Oregon has made profitable timber management more difficult because of reduced markets and longer distances to transport logs. This has made it increasingly more difficult for landowners to economically manage stands to reduce stocking levels and promote more healthy forest conditions.

Even where stands are in good condition, normal patterns of forest development and succession ensure the forest will be different in the future. Because eastern Oregon forests are susceptible to a variety of health problems, the consequences of any management strategy, including “no touch” management approaches, must be carefully considered.

Clearly, proactive management to control species composition, stand-stocking levels and fuel loading will create stands that are more resistant to wildfire, bark beetles, defoliators, dwarf mistletoe and root disease. If commercial timber production is an important objective, these controls allow you to grow and sell timber at a time of your choosing, rather than after fire or insect damage when log values are low and management options have been lost.

Managing forest stands and landscapes often can ensure a variety of forest values, including timber, habitat for wildlife, livestock production and recreation, are available simultaneously. Each owner should decide what combination of values to promote and determine the land’s potential to produce those values.

MANAGEMENT IMPLICATIONS OF LANDSCAPE PATTERNS

Over a landscape of hundreds to thousands of acres, forest types form a varied pattern, and any one type may cover only a few to thousands of acres (Figure 13). To get the most from your land, or to simply avoid problems, you need to recognize where forest types change and what the changes mean for management.

Figure 12. Prescribed fire may be used to help control overstocking and reduce the danger that wildfire will destroy the stand.

Figure 13. Managing a landscape with many forest types and ownerships takes careful planning and good coordination to ensure safety from fire, insects and disease.

Important management benefits

Three basic management tools – stocking level control, species composition control and fuel load control – are key to growing healthy, productive forests.

STOCKING LEVEL CONTROL

Overstocking reduces tree vigor and sets up a stand for bark beetle attack. The most basic tool for keeping trees vigorous is thinning to manage the stocking level at all stages of stand development. Proper thinning has been shown to give the best protection against bark beetles to Douglas-fir, true firs and pine species. Each species has its own stocking guide, and fine-tuning each site may be necessary.

SPECIES COMPOSITION CONTROL

Keeping a mix of species and age classes is a good way to cushion stands against a variety of problems. Below are three examples of how managing for a variety of species can avoid risks from pathogens or insects.

Bark beetles and defoliators can attack mixed-species stands in mixed-conifer types. Properly thinned stands are resistant to beetle attack, but they are still susceptible to defoliator attack if the stands contain a high proportion of Douglas-fir, grand fir or subalpine fir. It is possible, however, to avoid this threat by maintaining a high proportion (more than 70 percent of the basal area) of ponderosa pine or larch, or, on more moist sites, of both pine and larch. This strategy is effective in minimizing damage even during outbreaks of Douglas-fir tussock moth and spruce budworm.

Dwarf mistletoe is a common parasite on many tree species in eastern Oregon. Dwarf mistletoe infection reduces tree vigor and growth, and can in some cases kill the tree. Dwarf mistletoe seeds are windborne, but they can infect only trees of the same species from which they grew initially. So if ponderosa pine mistletoe has become a severe problem, switching to Douglas-fir and larch as the main species will help, because ponderosa pine mistletoe cannot spread to Douglas-fir or larch. Maintaining a variety of species and a diverse stand structure, and selectively thinning to remove mistletoe-infected trees, often can help solve mistletoe problems.

Root diseases affect all tree species in eastern Oregon, slowing growth and sometimes killing the tree. However, each species has a different susceptibility to each disease. Knowing the differences between species and how to identify root diseases in the field will help you manage species composition to avoid root-disease problems.

FUEL LOAD CONTROL

Clearly, sustainable management of east-side forests requires careful planning and judicious use of available tools such as thinning, prescribed burning or other methods of fuel reduction. Thinning reduces the amount of fuel on-site and helps structure the stand to prevent spread of wildfire. Treating residual fuels by piling and burning or by prescribed broadcast burning (Figure 12) is critical in keeping the next fire on the ground and out of the forest canopy.

Figure 14, right. Well planned and executed selection management can create healthy mixed-species and mixed-age stands that have potential to grow timber as well as provide good wildlife habitat.

Many management objectives, including control of wildfires or insect outbreaks, can be achieved only by thinking at the landscape scale. Overstocking and species composition problems on many ownerships make the region susceptible to large-scale insect outbreaks or wildfires. Many wildlife species depend on having a mixture of habitats such as open grassy areas for feeding and dense young stands for shelter. Finally, the landscape perspective reminds us that planning and cooperation with neighboring landowners can help attain a more fire- and insect-resilient forest landscape and region.

It is important to keep all your forest acres in good health, because insect infestations, wildfires and even root diseases move across the landscape from one forest type to another. For example, a bark beetle infestation that starts in an overdense stand may spread into a recently thinned, adjacent stand. Stands that have been properly thinned contain healthy, vigorous trees that will resist most attacks. Likewise, a wildfire that kills all trees in a dense mixed-conifer stand where beetles have previously killed a lot of trees also might destroy a nearby thinned stand if thinning slash remains untreated. Your stands are more likely to survive fire if you've treated the thinning slash. Reducing fuels lowers fire intensity, even during a wildfire.

This information is intended only to get you started on matching or aligning your land's capabilities with your objectives.

Managing the variety of eastern Oregon forest types is a big challenge. Much of the area is dominated by the ponderosa pine forest type with one tree species, so you cannot choose which tree species to manage because only ponderosa pine will grow there. In such cases, thinning is your main tool for maintaining a healthy forest.

In mixed-conifer types, you can choose both the species and stocking level. Long experience has shown the value of managing a mixture of a few species. This provides you more management options and helps avoid wildfire, insect and disease problems. Combining control of species composition, stocking levels and fuel loading gives you the greatest opportunity to maintain healthy trees and fire-resistant stands. Passive, no-touch approaches do not protect your stands from fire or insect attack in the long run.

ABOUT OFRI

The Oregon Legislature created the Oregon Forest Resources Institute in 1991 to advance public understanding of forests, forest management and forest products, and to encourage sound forestry through landowner education. A 13-member board of directors governs OFRI. It is funded by a portion of the forest products harvest tax.

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