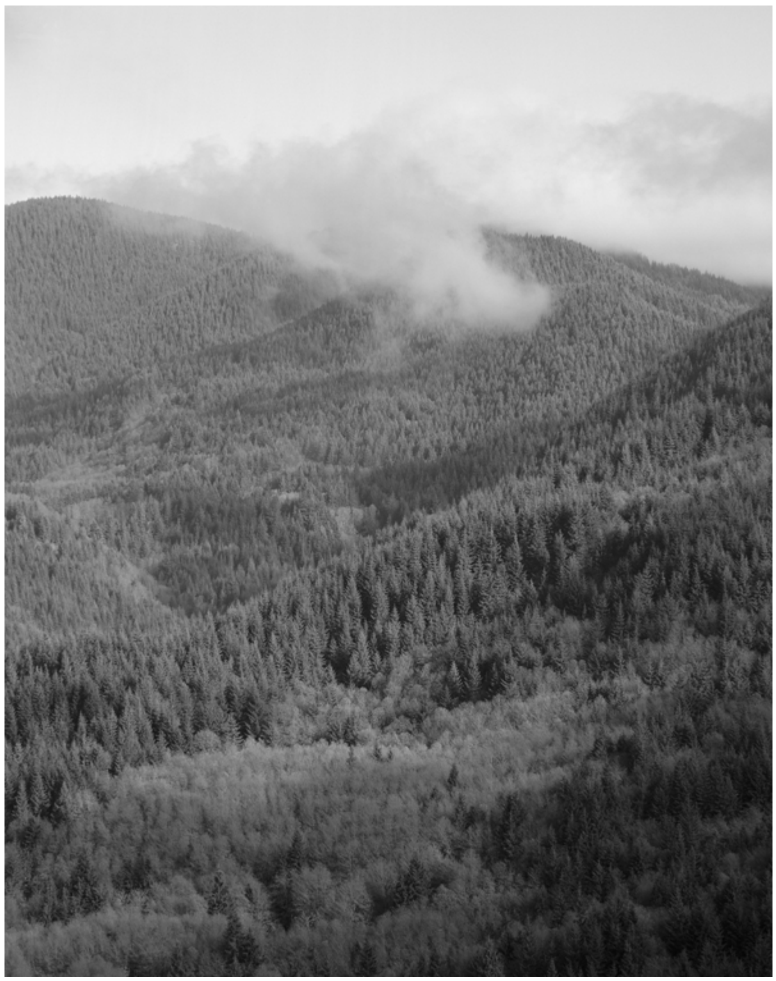
HARVEST AND REGENERATION

IN OREGON'S COMMERCIAL FORESTS



SILVICULTURAL OPTIONS
AND OUTCOMES
IN FORESTS MANAGED
FOR WOOD PRODUCTION

A BACKGROUND PAPER
COMMISSIONED
BY THE
OREGON FOREST RESOURCES INSTITUTE

CREDITS AND ACKNOWLEDGMENTS

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The cover photo, taken by Steve Terrill, illustrates second-growth Douglas-fir mixed with some red alder on Georgia-Pacific land at Diamond Peak in Lincoln County.

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ABSTRACT OF KEY POINTS

- Oregon has abundant and growing forests, which can meet a variety of values and objectives.
- Federal forest lands — which account for more than half of all forest lands in Oregon — have been dedicated increasingly to noncommercial uses.
- Oregon's privately owned timberlands, along with some other nonfederal ownerships, are now the state's primary providers of raw material for wood products manufacturing.
- The choice of silvicultural method for a particular site is as much about forest regeneration and structure as it is about harvesting.
- West of the Cascades, commercial forests are typically managed through a form of silviculture called even-aged management, using clearcutting as the harvest method prior to regeneration. Where timber production is a landowner's primary objective, many commercially valuable conifers, particularly Douglas-fir, are suited to even-aged management because they fare poorly in shade.
- Uneven-aged silviculture appears to be well suited for certain species and climates, in particular seasonally warm, dry regions. Oregon's forests east of the Cascades are often harvested by selective cutting of individual trees or groups of trees.
- It isn't known if selective harvesting can be applied successfully in western Oregon on a commercial scale to achieve regeneration of Douglas-fir forests.
- Selection silviculture and alternative forms of even-aged management may satisfy noncommercial objectives for some westside owners.
- Timber producers can balance environmental and economic considerations, whether they use even-aged or uneven-aged management.
- Use of uneven-aged versus even-aged silviculture strategies, along with stand age, have direct implications for wildlife. Some species fare better, some worse, depending on the particular silviculture system and harvest method.
- The worst possible approach to forest management in Oregon would be to manage every acre the same way. Foresters need access to a broad range of silvicultural options to achieve the most desirable economic and environmental results.

EXECUTIVE SUMMARY

Oregon's wood products output and economy now depend primarily on privately owned forests and other nonfederal lands.

Over the last two decades public controversy about forest use and policies has challenged Oregonians to think more and know more about forestry than ever before. In 1998 voters were asked to decide forest policy on a ballot measure that would have banned clearcutting and herbicide use had it passed.

These issues raise questions that interest Oregonians. Do we have enough forests for the future? Are we conserving old growth? How well are Oregon's forests being managed, both for wood production and environmental values? Is clearcutting a good forest practice? What are the alternatives? Are they appropriate?

Some of these questions can be answered with data. Oregon has as much forestland as ever, and we are harvesting less of our forests than we are growing. A large amount of old growth has been set aside and federal lands are being managed to nurture even more old growth. Harvests on federal lands have fallen to historic lows, and federal forestlands, more than half of Oregon's total, are increasingly unavailable for wood production. Oregon's forests are managed for a variety of economic, social, and environmental benefits. For example, many private landowners and other nonfederal forest managers may emphasize wildlife, recreation, or other noncommercial objectives, but still harvest timber. Nevertheless, the job of producing wood products, and sustaining their contribution to the Oregon economy, now lies primarily with 13,000 square miles of private forestlands as well as other ownerships managed primarily for wood production. These are now Oregon's commercial forests, and the balance of the questions above deals mostly with silviculture on these lands – how trees are grown, harvested, and regenerated, and what the trade-offs are. The discussion includes clearcutting, but it is bigger than that.

Silviculture might be defined as the science and art of cultivating forests, either for wood production or other values. The public discussion of silviculture in Oregon has often been focused on clearcutting, which is a method of harvesting. However, silviculture for wood production is about more than the point at which trees are harvested. It is also about regeneration and forest structure. And harvesting itself is about more than a choice between clearcutting and alternatives such as selective cutting. In fact, various harvest and regeneration systems are being applied interchangeably to meet multiple forest management objectives. Still, clearcutting is a useful starting point for an expanded discussion of silviculture in Oregon's commercial forests.

Historically, most forests in western Oregon have been harvested by clearcutting, just prior to regeneration. Hence the term regeneration harvest. Many westside landowners also harvest some trees over the life cycle of a stand through thinning, both to generate cash flow from log sales and to improve growing conditions for the remaining trees. Most forests in eastern Oregon are selectively or partially cut. Clearcutting is one form of what forest scientists call even-aged silviculture, or even-aged management. Selective cutting, *Western Oregon's commercially valuable conifers are suited to even-aged management because most fare poorly in shade.*

the harvesting of market-ready trees individually or in clusters, is often associated with uneven-aged silviculture.

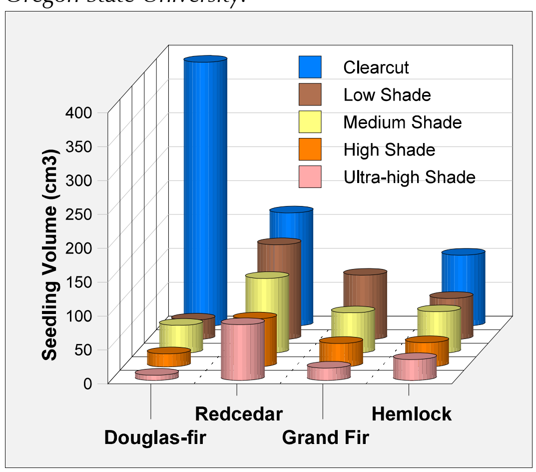
Uneven-aged silviculture appears to be well suited for certain species and climates, particularly seasonally warm, dry regions.

These are convenient, common categories for grouping silvicultural practices, but, in fact, silviculture is practiced with a great number of variations. Circumstances and objectives differ among forest owners, and they can change over time. Climate, landscape, soils, and competing vegetation combine in dozens or even hundreds of ways to shape what will and will not work in growing various species of trees. Owners of commercial forests need and use a range of silvicultural approaches to deal with multiple objectives and the distinct circumstances of their forests.

Even-Aged Silviculture

Even-aged silviculture is a well tested, reliable way to grow wood. In the commercial forests of western Oregon, which is part of the Douglas-fir region, it is the system of choice. There, commercially valuable conifers, particularly Douglas-fir, are suited to even-aged management because they fare poorly in shade. They thrive on direct sunlight, so they survive and grow much better in open clearings, which are usually created by clearcut harvests. Experiments show that these shade intolerant trees can survive if planted in a mature forest stand that has been thinned to admit some sunlight. However, the shaded seedlings grow more slowly, and many die.

Fourth-year data combined from two experiments showing how western Oregon conifers grow under various light conditions. (Growth is in cubic centimeters per tree.) *Source: Mike Newton, Oregon State University.*



As traditionally practiced, even-aged silviculture is a method of cultivating a stand of trees by seeding or planting them at the same time and cultivating them as a single-age group through final harvest. Although some trees in a stand are harvested by intermediate thinning, the most important harvest is the regeneration harvest. In a regeneration harvest, nearly all the trees in a stand are harvested in one or two cuttings that result in a clearcut. After this harvest, a new stand of trees is seeded or planted almost immediately for cultivation and future harvest. A forest landscape (thousands of acres) may consist of a mosaic of even-aged stands at different stages of development.

At the replanting stage, herbicides are often applied to grass, shrubs, and other vegetation that compete with conifers for light, water, and nutrients (inhibiting their growth or causing them to die). Where soils are deficient in nitrogen, it is common practice to add fertilizers such as urea to conifer stands once or twice over a decades-long management cycle.

In even-aged silviculture, the life cycle, or rotation, of a stand of trees begins and ends with a clearcut harvest, often 40 to 60 acres. Following harvest, owners typically plant about 400 trees per acre. Over the years, an owner must grow conifers above competing vegetation and then may thin them one or more times. The final stage in the rotation is harvest. At this stage, trees are often 40 to 80 years old and 12 to 30 inches in diameter. Under forest practice rules, buffers of live trees are left near streams, and snags, downed logs, and other features of mature forests are left in clearcuts larger than 25 acres to provide transitional wildlife habitat.

There are several forms of even-aged silviculture, and forest scientists have suggested a number of others that might be used to achieve management objectives in addition to wood production. For example, longer rotations of perhaps 80 to 120 years can grow significant wood volumes and can provide certain critical types of habitat later in the cycle. Partial or small patches of clearcutting can mitigate the visual effect of clearcutting, and leave more forest cover. These approaches would come close to group selection in uneven-aged management.

Uneven-aged Silviculture

Uneven-aged or selective silviculture has been discussed as a possible alternative to even-aged silviculture in western Oregon forests. As its name implies, uneven-aged silviculture involves the cultivation of trees of various ages in a stand and the periodic harvest of selected trees. Uneven-aged stands often contain mixed species as well. Trees are harvested either singly or in groups as they reach maturity. The small gaps created by harvesting leave room for natural seeding or transplanting of nursery seedlings. In systematic uneven-aged silviculture, owners manage the composition and spacing of trees in a stand to assure optimum growth, to regenerate the stand from time to time, and to achieve a range of age classes that allow periodic selective harvesting.

Uneven-aged silviculture offers several potential benefits. It can be a useful form of silviculture where an owner wants to produce a steady and predictable flow of logs while maintaining forest complexity and aesthetic appearance. Other possible benefits include lower and more evenly spread regeneration costs, the opportunity to cultivate larger trees and higher quality wood, and improved habitat for some wildlife species.

Forests are dynamic systems, the product of periodic and sometimes catastrophic disturbances.

Uneven-aged silviculture appears to be well suited for certain species and climates, particularly seasonally warm, dry regions. The continuous forest cover left by single or group harvest of market-ready trees protects seedlings and young trees from frost and high temperatures. While clearcutting on the westside provides young trees with light they need, selective cutting on the eastside provides young trees with shade that they need. This may explain why selective harvesting is more prevalent in eastern Oregon. While selective harvesting is widely practiced in eastern Oregon, some forestry scientists doubt that systematic uneven-aged silviculture is widely practiced on the eastside. However, several private forest owners and the U.S. Forest Service have had success in eastern Oregon with a well developed system of uneven-aged management. One private owner, for example, grows ponderosa pine and white fir in stands of several age classes using individual tree selection.

It is difficult to say whether uneven-aged silviculture might result in fewer or smaller forest landslides.

It isn't known whether uneven-aged or selective silviculture can be economically productive in western Oregon on a large commercial scale. Forestry experts have substantial reservations. While a number of forest scientists are exploring the potential benefits of uneven-aged silviculture for western Oregon, they also caution against embracing it uncritically. It is untried on the westside, is more appropriate in some circumstances than others, and requires more intensive management and expertise.

It also poses some risks. Over time in an uneven-aged system, shade intolerant species such as Douglas-fir might be replaced by other species. Harvesting in small groups and intensively managing mixed-age stands may be too costly. Yields may be lower. Harvesting on steep westside terrain would be more difficult with uneven-aged management. Younger trees may be harmed by the removal of older trees. There may be environmental damage from greater road densities and more frequent stand entries. Because of these risks, a good deal more needs to be learned about uneven-aged management in actual use, particularly in Douglas-fir forests.

The trade-offs of higher costs and lower productivity may be acceptable for some landowners who want a continuous forest cover for aesthetic or other reasons. For many small landowners, uneven-aged silviculture might be attractive as a way to obtain periodic income on a relatively small land base. Owners for whom timber production and financial return are secondary considerations might also find appeal in alternative forms of even-aged management, such as longer rotations or small patch clearcuts.

Forestry researcher James Guldin found that industrial-scale uneven-aged production of southern pine over a 36-year period was competitive, under some circumstances, with even-aged silviculture pine production. Whether similar results could be achieved in the Douglas-fir region is uncertain, given differences in climate, topography, and species.

Environmental Issues

Wood production, by definition, involves periodically disturbing forests. However, it would be a fallacy to assume that the natural condition of forests is static and undisturbed. Forests are dynamic systems, the product of periodic and sometimes catastrophic disturbances. Fires, floods, windstorms, insect and disease infestations, landslides, and even volcanic eruptions wipe out pieces or whole tracts of forest. Natural disturbances alter resources needed by plants and animals, benefitting some and depriving others. Consequently, some species in a given area flourish in the aftermath of a disturbance. Others falter for a time or temporarily disappear from the area.

Forests have an intricate relationship with water. They encompass the headwaters of most drainage systems. They consume water, retain it in snowpack, and filter it. Portions of forests can be swept away by erosion and landslides. Slides filled with broken trees can scour stream channels or fill them with debris that enriches habitat for fish. Trees shade streams, cooling water for fish and other aquatic life. When they fall into stream beds, they add structural complexity to streams and nutrients to the food chain.

Forest managers once paid little attention to these issues, but that has changed. Managers are more concerned than ever about the long-term health of the forest environment and noncommodity values such as watershed health and wildlife habitat. Ecosystem protections, in fact, are woven by law into forestry practice on private and nonfederal timberlands through the Oregon Forest Practices Act. Federal agencies have agreed to meet or exceed such standards. The OFPA governs nearly ever aspect of forest management – harvesting, regeneration, road building, protection of environmentally sensitive areas, use of chemicals, and so forth.

Despite this heightened environmental awareness among forest owners and managers, public concern persists about the extent to which forest operations and silviculture affect surrounding forest ecosystems. Do forest operations contribute to landslides? How do they affect steams and water quality? Do they accommodate or harm wildlife? Do forest practices affect declining salmon populations? What is being done by forest owners to stem these declines?

Forest Management and Landslides

Unusually heavy storms in February and November 1996 triggered what authorities estimated to be "tens of thousands" of landslides in western Oregon, along with extensive flooding. Slides blocked some roads, contaminated several municipal water supplies with sediment, and in the November storm killed five people.

In a comprehensive study of these slides in several western Oregon forests, the Oregon Department of Forestry found that the factor associated most closely with slides during heavy storms is steep terrain. Most of the landslides in 1996 were found in what ODF researchers called "red zones," areas hit hardest by rains (in some cases, 20 inches in five days) and usually on very steep slopes. In the red zones, almost 80 percent of the landslides that entered streams occurred on steep slopes.

Timber harvesting appears to have a temporary effect on some local streams but not the larger watershed.

Landslides occurred in forests of all ages but were more common in recently clearcut areas. In the ODF study, for example, recently clearcut areas were two to four times more slide prone in three out of four sites. Still, many clearcut areas were untouched by slides and thousands of landslides occurred in mature forests (those more than 100 years old). The lowest incidence of slides, in fact, occurred in second growth forests between 10 and 100 years old. The study also found that forest roads built under newer forest practice rules resulted in smaller and fewer slides than was the case with older roads.

A panel of Oregon State University scientists, who reviewed the ODF study, concluded that it is difficult to say whether uneven-aged silviculture might result in fewer or smaller forest landslides. Given the comparative data of the ODF study on slides across stand age classes, it might be argued that uneven-aged stands on steep slopes would be less susceptible to slides than plantation stands up to nine years old. However, they would still be highly susceptible during heavy or prolonged rains, where slope steepness and water volume are the principal controlling factors. Noting that road-related landslide rates can be expected to be greater than in-unit, clearcut-associated landslide rates , the panel also speculated that the more extensive road system required by uneven-aged silviculture might create as many slide problems in steep areas as uneven-aged silviculture is able to mitigate within a stand.

Forest Management and Stream Systems

Most streams in Oregon originate in or pass through forestland, particularly in the western portion of the state. So, forest use and management are often linked to water issues.

In a 1994 research review commissioned by the Oregon Forest Resources Institute, Paul Adams and Jeanette O. Ringer of Oregon State University found that the removal of trees through logging can result in measurable localized stream flow increases. This occurs because trees are no longer there to take up water. However, such effects are negligible at a larger watershed scale, and even at the localized level, they return to normal over time as a new forest becomes established. The review reached much the same conclusion about the effects of forest roads. In studies in which the effects of forest roads were evaluated separately from timber harvesting effects, roads had no impact on streamflows in some areas and only localized effects in others.

The review also found no evidence in the research that timber harvesting causes downstream flooding, although peak flows may increase during the rain or snowmelt season in small watersheds where logging has occurred. Flooding simply occurs when extended heavy rains deliver too much water for soils and streams to hold, regardless of land use.

Under earlier logging practices, the review found, stream temperatures increased where trees were cut to the water's edge, a practice no longer allowed. Timber harvesting appears to have had little or no effect on water chemistry or dissolved nutrients. Studies show that forest roads can contribute sediment runoff to streams. But where improved road location and design have been used, less erosion has been reported.

Where diverse habitat for wildlife is an objective, the method of harvesting trees is less important than what is left behind.

Forest Management and Wildlife

The most current science indicates that commercial forest operations in Oregon do not pose an immediate threat to any terrestrial wildlife species. This is the view of Dr. Fred Bunnell, a conservation biologist, in a peer-reviewed study for the Oregon Forest Resources Institute. This conclusion assumes that federal forests will continue to provide a significant amount of mature forest habitat.

In fact, from a landscape point of view, Oregon's forests offer substantial diversity to wildlife. Federal forests are increasingly being managed to satisfy environmental objectives and create additional old growth characteristics while private forests are being managed more intensively for wood production. This results in a mosaic of forest stand ages across the landscape. Bunnell believes these landscape-level variations are a plus for forest-dwelling species. "Because vertebrates have diverse life styles," he writes,"the worst possible approach to maintain vertebrate diversity would be to manage every acre the same way, or to have a large forest of a single age class."

Where diverse habitat for wildlife is an objective, Bunnell believes the method of harvesting trees is less important than what is left behind. During harvesting, whether clearcutting or selective cutting, owners can enrich habitat in a variety of ways. They can create or retain snags, leave live trees, and make sure that both the harvested area and nearby streams contain a significant amount of downed logs and other woody debris.

Still, in regard to silviculture practices, he suggests additional research is needed on the amounts, sizes, types, and distribution of trees that should be retained during clearcutting and partial cutting. In particular, he is concerned that trees being left are too few and small to produce enough large snags and downed wood in the future, and that this poses a potential threat to some species.

Bunnell found little evidence that fragmentation of forest cover in western American forests poses problems for vertebrate species comparable to those observed in conjunction with changes in forestland uses in the Midwest. Availability of habitat appears to be more important to wildlife than its distribution.

Forest Management and Salmon

Wild salmon stocks are in serious decline. Several populations are extinct and in some coastal Oregon streams stocks are at 10 percent or less of their historic abundance. The causes are complex, rooted in more than a century of human settlement, population growth, and economic activity. The main problems have been degradation of spawning and rearing habitat and dangers to fish on their migratory path. This path extends hundreds, even thousands of miles, from the spawning beds out into the ocean and then back upstream, where fish spawn the next generation.

Forest streams now contain some of the best remaining spawning habitat in the state.

Forestry practices that are no longer permitted once damaged spawning and rearing streambeds in a variety of ways. Although many streams have recovered, others still bear the marks of these earlier practices. In particular, some streams lack the complex structure of fallen logs, islands, side channels, deep pools, and overhanging banks that afford protection for juvenile fish and keep them from being prematurely swept downstream during high winter runoff.

Forest streams now contain some of the best remaining spawning and rearing habitat in the state. A combination of factors has degraded or destroyed a large share of other historic spawning and rearing waters. Dams have blocked fish access to streams. Urban development has removed or damaged stream habitat. Farming and livestock raising have damaged and continue to damage stream habitat in various ways. Hatchery fish, which make up the majority of fish runs, have also damaged native populations.

Beyond these problems, salmon have to contend with hydroelectric dams, freshwater and ocean fishing, and ocean conditions which determine how much food is available for survival and growth. From 2,500 eggs, only 25 to 125 juvenile fish may survive in their spawning habitat to reach the ocean, and only one to four fish may survive the trip back to spawn.

Forest owners are participating in efforts to improve these odds. They have provided a major share of funding for the Oregon Plan, the Governor's salmon restoration initiative, and they are also participating in numerous fish habitat restoration projects on their own property.

Conclusions

Four broad conclusions can be drawn from the information presented here. First, our forest resources are abundant, and they are adequate to meet a variety of objectives. Second, even-aged silviculture seems to be an appropriate system for western Oregon. Uneven-aged silviculture would be a problematic substitute for commercial forests in western Oregon but is well suited to many sites in eastern Oregon. Third, timber producers can balance environmental and economic considerations, whether they use even-aged or uneven-aged management. Fourth, the most desirable environmental and economic outcomes in our managed forests require access to a broad range of silvicultural options appropriate to the circumstances of the forests under management.

1. WHAT THIS PAPER IS ABOUT

People want to know whether Oregon has enough forests for the future, and whether they are being well managed.

Public concern about forestry in Oregon has shifted significantly. Earlier this decade it was focused on the use of federal forests, and whether the management objectives for these vast public resources should include the harvest of trees for wood products. A succession of federal environmental laws, court cases, and administrative rulings has answered that question for the time being. Most federal timberland will now be managed to nurture old growth forests, to protect roadless wilderness, wildlife habitat, and riparian zones, and to meet recreation and scenic values. This dedicates nearly 20,000 square miles of federal timberland, about half of Oregon's total, to uses other than wood production.

Lately, the public conversation about forestry has turned to Oregon's 13,000 square miles of privately owned timberlands, as well as other ownerships still managed primarily for wood production. These are now Oregon's principal commercial forests, and the main source of raw material for Oregon's wood products industry. These are resilient, productive lands for growing softwood, particularly from the west slopes of the Cascades to the Oregon Coast. This is part of the "Douglas-fir region" that extends from southern Oregon to British Columbia.

Forestry in the Public Mind

Two issues in particular have challenged Oregonians to think more and know more than ever before about management of private forests. Measure 64, defeated on the 1998 ballot, asked voters to approve a ban on clearcutting and other silvicultural practices which are common on private timberlands in western Oregon. The plight of Oregon's wild salmon runs and subsequent plans to save the salmon have also turned additional attention to private forestlands. Most of Oregon's coastal spawning streams flow out of private forests.

Given such issues, Oregonians are increasingly interested in the adequacy of our forest resources and their stewardship. They want to know whether Oregon has enough forests for the future, whether it has enough old growth, and whether our forests are being well managed. They want to know if forest owners are looking out for the ecosystems that their lands include. They have questions about whether clearcutting is good forest practice, what the alternatives might be, and whether and when the alternatives are appropriate.

This paper was commissioned by the Oregon Forest Resources Institute to explore these questions. In particular, it looks at the principal ways that commercial forests in Oregon — mostly privately owned timberlands that produce wood products — are grown and harvested. It discusses what is known about the trade-offs of different approaches, and it describes what is known about how these methods affect surrounding ecosystems, especially land, water, wildlife, and fish.

Forest owners in western Oregon favor even-aged management because trees there thrive on sunlight and fare poorly in shade.

Silvicultural Options — More than Clearcutting

Silviculture might be described as the science and art of cultivating forests, either for wood production or other values, such as watershed protection, scenic appeal, and wildlife habitat. The motive for choosing a given silviculture system or adapting it in different ways is often driven by the forest owner's circumstances and objectives, by what nature provides in the way of landscape and climate, and by what works for different species of trees. This is particularly true today in even-aged silviculture as both forest scientists and owners explore ways of achieving wood production while satisfying other values and objectives. In Oregon, the public discussion about silviculture for wood production has often focused on clearcutting, which is a method of harvesting. However, silviculture is about more than the point at which trees are harvested. Because it covers the gamut of stages involved in forest cultivation, silviculture is about regeneration as much as harvesting. And harvesting itself is about more than a choice between clearcutting and alternatives such as selective cutting. Still, clearcutting is a useful starting point for an expanded discussion of silviculture.

Clearcutting is one aspect — albeit the most prevalent aspect — of what forest scientists call even-aged silviculture, or even-aged management. Selective cutting, the harvesting of market-ready trees individually or in clusters, is often associated with uneven-aged silviculture.

Even-aged silviculture, as its name implies, involves cultivating and harvesting stands of trees that are all the same age. In this form of silviculture all the trees in a stand eventually reach a point of maturity where they are ready for harvest prior to the establishment of a new stand of trees. This is called regeneration harvest. It is accomplished in a short time period in one or two cuttings that result in a clearcut. After this harvest, the site is prepared for planting and a new stand of trees is planted almost immediately for cultivation and future harvest. Prior to regeneration harvest, a stand may be commercially thinned through partial cutting one or more times to generate income from log sales and to improve growing conditions for the remaining trees in the stand.

Uneven-aged silviculture involves growing trees of different ages and sometimes different species in a stand. Owners harvest portions of these stands from time to time by selecting and cutting single trees or clusters of trees. For this reason, uneven-aged silviculture is sometimes called selection cutting or selective harvest silviculture.

Virtually all commercial forests in western Oregon are managed under the even-aged silvicultural system. As shown later in this paper, many of Oregon's most commercially valuable conifers, particularly Douglas-fir, are suited to even-aged management because they fare poorly in shade. They thrive on direct sunlight, so they survive and grow much better in open clearings. The purpose of clearcutting is to create a clearing for regeneration as much as it is to harvest a crop of trees. Field research shows that these shade intolerant trees can survive if planted in a forest stand that has been thinned to allow some light through the canopy. However, shaded seedlings appear to exhibit slower growth rates and higher mortality with increasing degrees of shade.

__An ecosystem can be as small as a rotten log or as extensive as an entire drainage basin.__

Most trees in eastern Oregon are harvested by selective cutting. Selective cutting is integral to uneven-aged silviculture. However, uneven-aged management, as long practiced in Europe and elsewhere, is distinguished by maintenance of several distinct size and age classes of trees, by careful thinnings to promote the growth and health of the entire stand of trees, and by reforestation of gaps created by the harvest of mature trees. Only a few government and industrial owners practice uneven-aged management with such discipline in eastern Oregon.

Even within the broad categories of even-aged and uneven-aged management, no two forest owners grow and harvest trees exactly the same way. Under an even-aged approach, for example, one owner might harvest trees 70 years old while another owner at another location might harvest trees 50 years old — and the 50-year-old trees might be as large as those that are 70. Silviculture choices that work well in one place may or may not work well in another. And within a given area of silviculture management, there are a great many variations in forest scale, pattern, and composition. There is also substantial complexity in the decades-long process of managing forests.

Because they often must deal with multiple objectives and the circumstances of each forest, owners need and use a variety of silvicultural options. It is convenient to divide these options into even-aged and uneven-aged management, but this requires a caution. As the reader will see in this report, these two categories of silviculture are actually part of a continuum of forest management approaches.

Ecosystem Science in the Mix

Silviculture management is further complicated by the overlay of ecosystem science. An ecosystem encompasses the biotic organisms in a defined area and the way they interact with one another and their environment. An ecosystem can be as small as a rotten log (to the interrelated organisms that live there) and as extensive as an entire drainage basin. Now, besides managing the growth and harvest of trees, forest owners are expected to consider the interdependence and sustainability of forest organisms and their total environment. This includes wildlife habitat, water systems, soils, microclimates, and other factors. In forests used to grow trees for wood products manufacturing (mostly private forests in Oregon), ecosystem science deals mainly with forest legacy, the thread of continuity that binds together succeeding generations of organisms and their habitat. The idea of legacy is to harvest and regenerate the forest while leaving enough elements of the forest intact to hold and filter water, to provide habitat for wildlife and fish, and to encourage species diversity.

As a result of such considerations, ecosystem science and its applications are becoming a more integral part of forest management in general and silviculture in particular. Ecosystem considerations, in fact, are woven by law into forestry practice on both State of Oregon and private timberlands through the Oregon Forest Practices Act. The OFPA governs nearly every aspect of forest management – harvesting, regeneration, road building, protection of environmentally sensitive areas, use of chemicals, and so forth.

Silvicultural Perspectives

From a policy perspective, readers of this paper should discover three useful, and perhaps surprising, things about the silvicultural options discussed here. First, a great number of forest management objectives other than wood production can be achieved under many forms of silviculture, including even-aged management. Second, uneven-aged silviculture is a useful option deserving more scientific investigation, but it is not a magic bullet. It allows foresters to achieve some noncommercial objectives not possible with even-aged management (such as maintenance of continuous forest cover). Selective harvesting is appropriate for some sites and circumstances, but it has some economic and environmental drawbacks, and it is subject to abuses that can endanger forest health and economic value. Third, knowledgeable owners, within the boundaries of Oregon's forest practice rules, are in the best position to select the silvicultural systems they deem most appropriate for their forests and their objectives.

This paper will not settle controversies and unknowns about the interplay of wood production and other forest values. People with differing priorities disagree on some of these issues. Moreover, a great deal has yet to be researched. For the average interested reader, however, this report should clarify what is known about the tradeoffs and effects of commercial silviculture, and it may suggest issues that merit further study. At a minimum, it should put some matters in perspective.

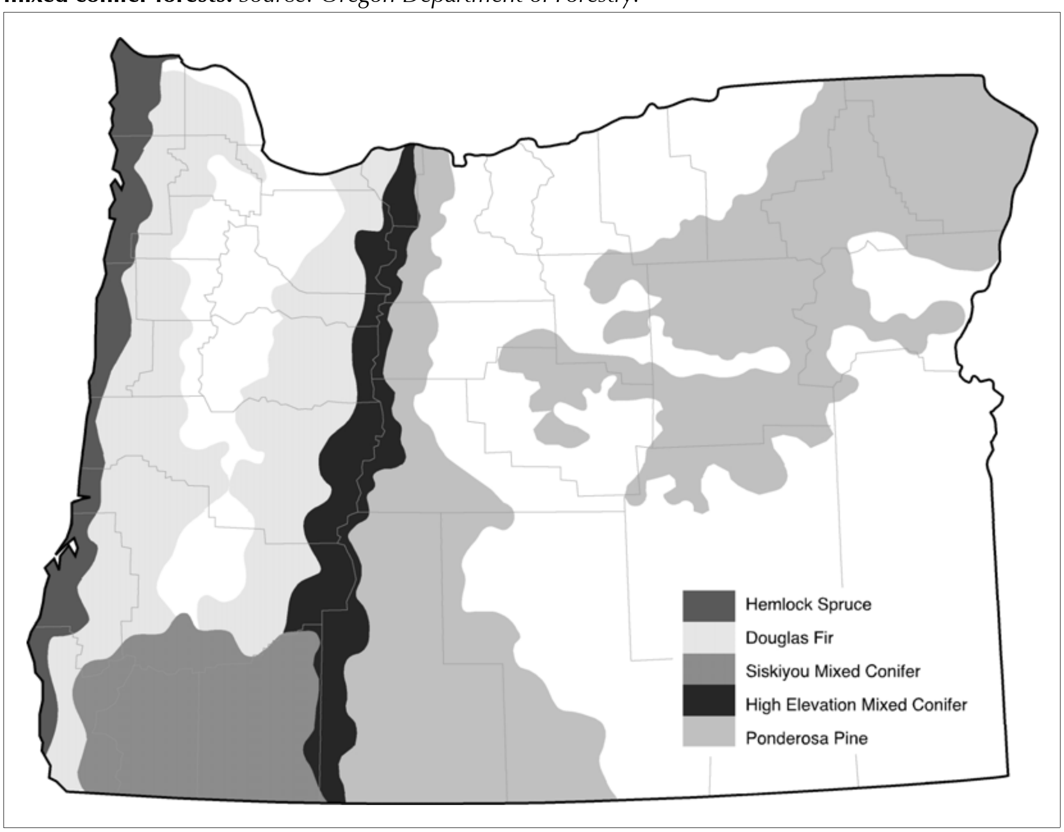
2. OREGON'S FORESTS

About half of Oregon's land area, or nearly 28 million acres, is classified as forestland. This is land that can grow trees for harvest or land that is stocked at least 10 percent with trees of any kind. To put this in perspective, this is 43,000 square miles, an expanse of land bigger than 18 U.S. states combined. Oregon's federally owned forestlands alone are twice the size of Vermont. According to sources cited in the *Oregon Forest Fact Book* for 1997, this expanse of forests represents 91 percent of the forestland that existed in Oregon in the 1600s. Therefore, despite a century and a half of population growth and development, Oregon has lost very little of its forest base.

Oregon's forests are highly productive, growing 147 cubic feet per acre per year west of the Cascades.

Nearly 23 million acres of Oregon forestland are classified as timberland. Timberland is defined as land that is able to grow 20 or more cubic feet of wood per acre per year. This merely denotes a physical and biological capability. Not all timberland in Oregon is in wood production. Oregon's commercial forests – those which are in wood production – are far more productive than the 20-cubic-foot standard. U.S. Forest Service studies show that commercial forestlands west of the Cascades are growing 147 cubic feet of timber per acre per year. By contrast, according to the *Oregon Forest Fact Book*, such lands in the Southeast United States average 58 cubic feet per acre per year.

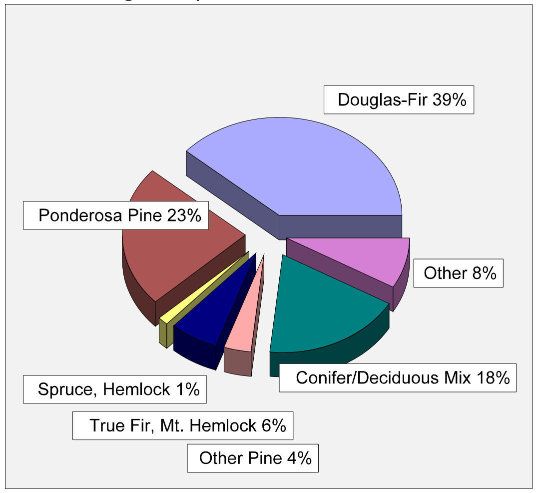
Figure 1. This map shows the location of major commercial conifer forests in Oregon. The ponderosa pine forests shown here for eastern Oregon are interspersed with lodgepole pine or mixed conifer forests. *Source: Oregon Department of Forestry.*



There are about 4.9 million acres of old growth forests in Oregon.

Oregon's forests are overwhelmingly composed of conifers, more than 30 species altogether. The state's forests are divided into westside and eastside regions, separated by the crest of the Cascade Mountains. Oregon's westside forests are often referred to as part of the "Douglas-fir region," an area which extends from south of the Oregon border to British Columbia. This encompasses western Washington and western Oregon where forests are dominated by Douglas-fir and western hemlock. Forests in the Douglas-fir region of Oregon also contain western redcedar; Sitka spruce along the coast; incense cedar, white fir, and sugar pine in the southwest corner of the state; and Pacific silver fir and noble fir in the Cascade Mountains and Coast Range.

Figure 2. Oregon Forest Types by Percentage.
Source: Oregon Department of Fish and Wildlife.



The most prominent eastside species are ponderosa and lodgepole pine, with several species of true fir and larch. The Siskiyou area, which covers Josephine and Jackson counties, and parts of Curry and Douglas counties, contains mixed conifer stands characteristic of both western and eastern Oregon. This is sometimes regarded as a distinct southwestern region. There are also forests of mixed conifers in the high elevations of the Cascade range.

Age Classes

Oregon's conifer forests range from stands of giant Douglas-firs that predate the American Revolution to seedlings just getting established. As Figures 3 and 4 illustrate, most of the older forest age classes in Oregon are on federal lands and the preponderance of younger age classes are on nonfederal — mostly private — lands. There is a rough correlation of tree age to size. For example, a 60-year-old Douglas-fir on a highly productive western Oregon site (that is, one with ideal growing conditions) could be 16 inches in diameter in a stand that hasn't been thinned, 20 inches in a stand that has been thinned. Ponderosa pine grows more slowly, particularly in the eastern side of the state. A 60-year-old tree could reach 8 inches in an unthinned stand, 12 inches in a thinned stand.

Reforestation programs have been widely in place among all owner groups about four decades. Since 1972 they have been strictly mandated by law. The most recent data for reforestation shows that 95 percent of harvested acreage is being reforested within two years as required by state law, usually by hand planting of seedlings.

Figure 3. Distribution of Forest Age Classes on Federal Lands in Oregon. *Source: 1997 Resources Planning Act National Timber Database representing inventories from 1996 to 1997, USDA Forest Service.*

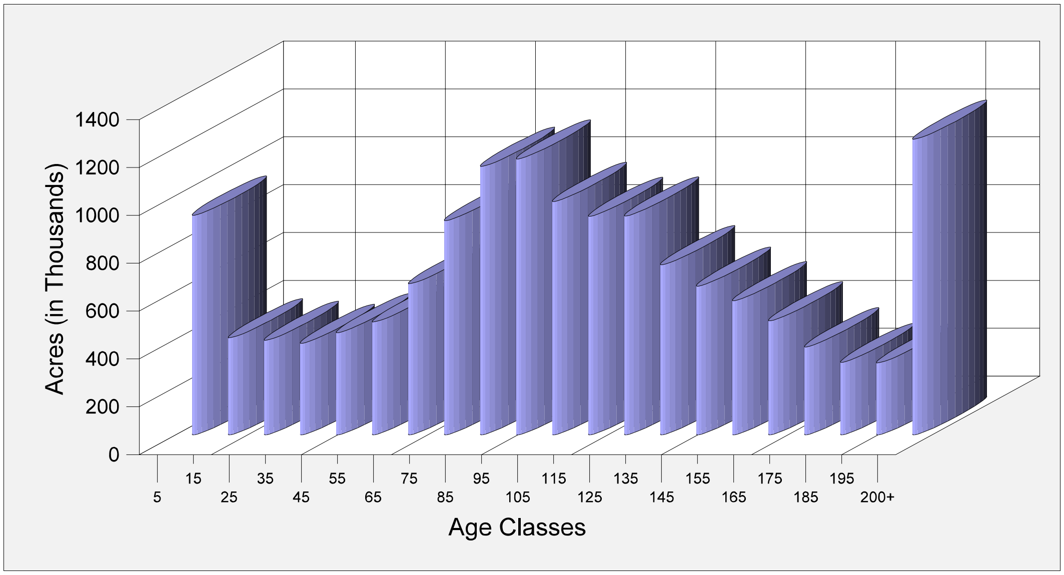
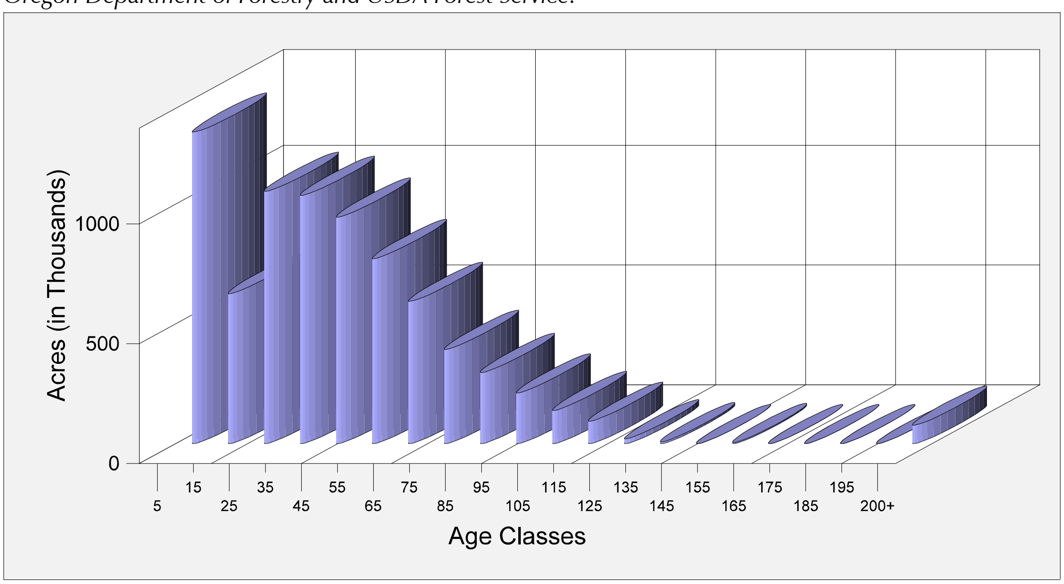


Figure 4. Distribution of Forest Age Classes on Nonfederal Lands in Oregon. *Source: Compiled from 1995 data for western Oregon and 1993 data for eastern Oregon published by the Oregon Department of Forestry and USDA Forest Service.*



Old Growth

Oregon's old growth forests have been at the center of the debate about multiple uses and habitat for several endangered species. Court cases, administrative actions, and resulting news stories have given rise to public uncertainty about old growth, particularly what it is and whether Oregon has enough of it.

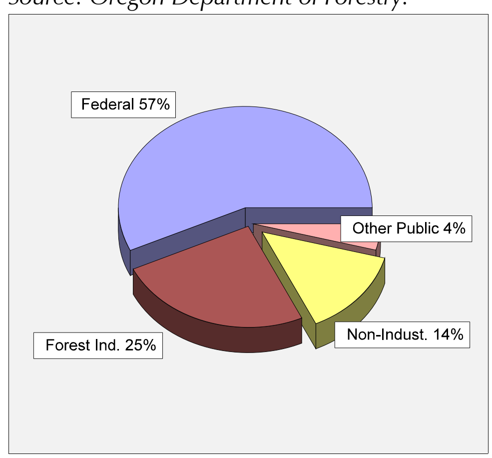
Past discussions of old growth have sometimes been confusing because definitions of old growth have varied by both age and structural characteristics of trees. Although age is no longer the most important factor in defining old growth, there is a correlation between age and structure. Douglas-fir stands may begin to exhibit old growth characteristics at about 200 years, while lodgepole pine stands would do so at 100 years. Old growth stands In the Douglas-fir region are characterized by different species and age classes in which the largest, oldest trees tower over everything else. These large old trees dominate the forest. Some of them have broken tops and show other signs of decline, including decaying wood. The forest also contains snags (dead trees still standing) and heavy accumulations of wood on the ground, including large decaying logs.

About 4.9 million acres of forestland in Oregon is classified as old growth, according to data published by the Forest Service in 1993.[1] The vast majority of old growth is on federal lands. In western Oregon, most of it is in the western Cascades. There is relatively little old growth in the Coast Range. Given the trend toward reduced harvest of federal timber, and given federal policies intended to augment old growth forests, it is probably safe to predict that Oregon's old growth inventory will increase in the years ahead.

Forest Ownership

About 61 percent of Oregon timberlands are under public ownership, while 39 percent are privately held. The federal government, primarily through the U.S. Forest Service and the Bureau of Land Management, owns 57 percent of Oregon's timberland while the State of Oregon and other government jurisdictions own 4 percent. The forest products industry owns 25 percent, while non-industrial private interests, typically individuals or families, own 14 percent. The Oregon Department of Forestry defines forest industry owners as those with their own wood processing operations, or those without such operations but with 5,000 acres or more of timberland. Other private owners are classified as nonindustrial owners.

Figure 5. Oregon Timberland Ownership.
Source: Oregon Department of Forestry.



Private lands now produce most of Oregon's output of commercial forest products.

It is important to note that nearly all of Oregon's privately owned forests are second- or third-growth forests – that is, they were cleared either by harvest or fire from the beginning of the 20th century through the present. Some of the stands in these forests are, therefore, as much as 100 years old. As explained earlier, a significant share of Oregon's federally owned timberland consists of much older trees.

[1] This estimate was based largely on data classified between 1980 and 1992 for national forest plans.

Owner Values and Uses

Until European settlement, Oregon's timberlands were not owned or managed in the sense that they are today. The primary influences on the state's forests were soil, climate, and natural disturbances such as lightening fires, windstorms, floods, diseases, and insect infestations. Pioneer journals indicate that Native Americans sometimes set fires to clear forested areas, but that was the extent of human influence. Since then, forests have come under extensive public and private ownership. Over the years, both owners and what they want from Oregon forests have changed with markets, government policies, and evolving public values.

Different Values and Uses in Private and Federal Forest

Most privately owned timberlands represent an investment. The owners, whether wood products manufacturers or individuals, typically expect to earn a return on their investment by harvesting and manufacturing or harvesting and selling timber. This is not meant to imply that such owners don't also manage their lands for other values, such as sustained forest and ecosystem health. But the primary objective, especially of large private owners, is timber production. Their investment is long term, and they typically intend to keep their forestland dedicated to some level of timber production.

Federally owned forests have a long history of mixed uses, including timber production, but those uses have been redefined dramatically in the past two decades by environmental legislation, court cases, and changing public views, culminating in the Northwest Forest Plan (sometimes called the Clinton Forest Plan) in 1993. Under these influences, harvests on federal lands have fallen to modern lows. At the same time, these lands have been managed increasingly for species diversity, wildlife habitat, watershed health, stream quality and fish habitat, scenic values, and recreation.

The amount of federal land not available for harvest illustrates the extent of this shift. Of the 15.6 million acres of Oregon forestland owned by the federal government, about 9 million acres are now unavailable for harvest. This includes 2.8 million acres of forestland incapable of producing commercial timber crops due to sterile soils, high elevation, rockiness, and other factors. It also includes 6.2 million acres of timberland falling under a variety of classifications. Some of these acres are reserved as wilderness, riparian areas, and scenic and recreational areas. Under the Northwest Forest Plan, about a third of Oregon's national forestlands in western Oregon, 3,162,000 acres, have been set aside specifically for cultivation of old growth characteristics. More than half of this acreage is covered with old-growth trees, and the rest is expected to achieve similar maturity and the structural characteristics of very old forests.

The net effect of these different values for federal and nonfederal forestlands in Oregon has been to divide federal and private forests into two very different uses. Federal forests have been committed primarily to a mix of nonindustrial uses. Private lands now produce most of Oregon's output of commercial forest products. In managing their forests, private owners must adhere to a substantial body of state forestry laws. These laws are designed to insure continued forest productivity and health, to protect watershed systems and water quality, and to avoid damage to environmentally sensitive areas and threatened or endangered species.

3. HOW FORESTS GROW IN OREGON

Fire suppression and lower harvesting levels have reduced patterns of disturbance which favor continued dominance of Douglas-fir and ponderosa pine.

Western Oregon forests make up a large portion of what is known as the "Douglas-fir region." For several millennia Douglas-fir has dominated millions of acres because it regenerates well following wildfire and has a life span of hundreds of years. In fact, according to University of Washington forestry professor Jim Agee, "almost all of the old growth Douglas-fir forests were a product of fire." Prior to modern fire controls in western Oregon, the interval between wildfires ranged from a few decades to a few centuries. Forests were a mosaic of stands of different ages. Old growth occupied a significant amount of the area, but younger forests and recently disturbed areas were part of the landscape, too.

Ponderosa pine has historically dominated the forests of eastern Oregon because it is suited to the area's dry climate and shorter intervals between wildfires, which historically varied from a few years to a few decades prior to fire suppression. Repeated fires on the eastside kept the fire-resistant ponderosa pine, and to a lesser degree western larch, in a dominant position, and eliminated much of the Douglas-fir and grand fir shortly after it sprouted from natural seeding.

After settlement and well into the 1950s, many forests were regenerated after logging by natural seeding. But because this method wasn't always reliable, owners began to use replanting as the preferred method of regenerating stands. By the 1960s replanting was the common method of regeneration, especially in western Oregon. Because westside Douglas-fir and eastside ponderosa pine are so well suited for their environment and are commercially valuable species, owners favored them over other species in replanting. Thus, they remain the dominant species among Oregon's commercial forests. In the past few years, however, both federal and nonfederal owners have begun to regenerate a more diverse mix of species.

Fire suppression programs and lower harvesting levels have reduced the patterns of disturbance which favor continued dominance of Douglas-fir and ponderosa pine. Western hemlock, a species which tends to succeed Douglas-fir in the absence of disturbance, eventually may, over decades or centuries, come to dominate certain westside forests, such as national forests, where fire is suppressed and harvesting is curtailed. In eastern Oregon, suppression of natural fire intervals has already given rise to more grand fir and Douglas-fir beneath ponderosa pine. These species are not only in a position to succeed ponderosa pine, they also form deadly "fuel ladders," which enable fires to reach the crowns of ponderosa pine. For centuries relatively wide spaced ponderosa pine have been largely impervious to frequent ground fires that suppress competing species. Ironically, fire suppression has made some ponderosa pine stands vulnerable to bigger, hotter fires that can kill them.

In old growth, only 20 to 50 of the original trees remain per acre.

How Stands Develop

In *Forest Stand Dynamics*,[2] Chadwick D. Oliver and Bruce C. Larson, describe a stand as a "continuous group of trees and associated vegetation having similar stuctures and growing under similar soil and climatic conditions." This is a biological definition. Because Oregon law restricts a harvest unit to 120 acres (with certain permitted exceptions), a stand is sometimes thought of as 120 or fewer acres. Oliver and Larson have categorized four broad phases of forest stand development: 1) *stand initiation*, 2) *stem exclusion*, 3) *understory reinitiation*, and 4) *old growth*.

Stand initiation follows a disturbance, typically fire or logging, that kills or clears an older stand. In this phase, new conifers from planting, natural seeding, or both appear and begin to grow, along with other tree species and vegetation. These include hardwoods, grasses, herbs, and shrubs. During this phase new competitors may continue to enter the stand. Stand initiation concludes as conifer seedlings mature into young trees, grow above most of their competitors, and begin to close at their crowns, forming a canopy. At this point, the total amount of space they occupy, measured in basal area per acre,[3] is small.

Stem exclusion is the phase in which new trees and other vegetation (stems) are excluded from entering the stand and some existing trees stop growing and die. As the trees in the stand grow larger, generally after 30 years in western Oregon, some of them fail to compete successfully for available moisture, nutrients, and light, and they begin to die. So, as the basal area of the stand increases, the number of trees diminish. The stem exclusion phase can continue for many decades.

If stands are left to develop naturally, they often reach the understory reinitiation phase. In this phase, trees dying in the overstory leave gaps large enough for understory trees to become established and grow. As understory reinitiation occurs, the basal area remains high (300 square feet per acre), but the number of trees declines to less than 50 per acre as each becomes larger.

In the old growth phase the stand achieves a complex mix of overstory trees and understory trees as well as gaps left by disturbance and the natural death of some older trees. Only 20 to 50 of the original overstory trees remain per acre. These large trees continue to use most of the site's resources.

During the old growth phase in westside forests, tree species such as western hemlock or true firs that tolerate more shade than Douglas-fir often become established in the

[2] Oliver, Chadwick D., and Bruce C. Larson. *Forest Stand Dynamics*, Update Edition. John Wiley & Sons, Inc., New York, NY, 1996.

[3] Basal area is the cross sectional area of a tree trunk at breast height (about 4.5 feet). A tree 13.5 inches in diameter, for example, has about 1 square foot of basal area. Basal area is used as a measure of stand density or stocking.

understory. If decades or centuries pass without disturbance, these more shade tolerant species remain to dominate the site as the older Douglas-fir trees die.

In eastside forests, if fire is excluded and no other disturbance occurs, dominant pines would give way to Douglas-fir and grand fir as these species become established in the understory and then take over as the pines reach old age and die. (Douglas-fir, which is shade intolerant in western Oregon, is genetically somewhat different in eastern Oregon, so it grows better under the ponderosa pine canopy, which is relatively open compared to conifer stands in western Oregon.) Pines in eastern Oregon do not regenerate and grow well in shade. In fact, they require more light than most other conifers to successfully regenerate and prosper. Without periodic disturbance, the shade tolerant species eventually replace the shade intolerant species.

Some forest scientists have begun to question whether today's restocked forests, if left alone, would develop the characteristics of present old growth forests. This may be a moot issue on privately owned forests because they are usually harvested at the late stem exclusion phase. But it may be a concern on publicly owned timberlands managed for multiple use.

In a recent U.S. Forest Service publication on silviculture for multiple objectives,[4] Robert O. Curtis and his co-authors summarize research on factors that may repress the development of old growth forests, or lead to old growth forests different than those today. Today's stands are stocked more densely and uniformly, animal browsing is heavier during the stand initiation phase, climatic conditions and weather patterns are different, shrub understories are denser, and some vegetation competes more effectively than ever before with seedlings. The authors say that deliberate management initiatives may be required to mitigate these factors where owners want to achieve the characteristics associated with old growth forests.

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[4] Curtis, Robert O., Dean S. DeBell, Constance A. Harrington, Denis P. Lavender, J. Bradley St. Clair, John C. Tappeiner, and John D. Walstad. *Silviculture for Multiple Objectices in the Douglas-Fir Region*, USDA Forest Service General Technical Report PNW-GTR-435, Portland, OR, 1998.

4. HARVEST LEVELS AND HISTORY

About 4.1 billion board feet of timber were harvested from Oregon's public and private forests in 1997, according to the Oregon Department of Forestry. This is consistent with a general decline in harvest levels from previous decades, particularly from federal forests, where harvesting has dropped to levels not seen since the midst of the Depression. More than 84 percent of the recent harvest is coming from nonfederal lands, primarily privately owned forests, where harvest levels have been relatively stable but declining steadily since the 1960s toward 3 billion board feet in annual cut. As discussed later, these harvest levels are far below the growth rate of Oregon's forests, so the state's forest inventory is not only abundant but also increasing.

Acreage clearcut in 1997 represented less than half of 1 percent of Oregon timberland.

Current Harvest Profile, 1997

Owners of Oregon forests harvested trees on nearly 642,000 acres in 1997, according to harvest data compiled by the Oregon Department of Forestry.[5] As shown in Table 1, just over 101,000 of these acres, or 15.7 percent of the total, were clearcut[6], mostly west of the Cascades and mostly by industrial and non-industrial private owners. On the other nearly 541,000 acres harvested, trees were removed by partial cutting[7]. The 1997 acreage on which some harvesting occurred represented less than 3 percent of Oregon's timberland. The acreage clearcut represented less than half of 1 percent of Oregon timberland.

Table 1. Harvested Acres by Ownership, 1997. *Source: Oregon Department of Forestry.*

Ownership Groups	Clearcut Acres		Partial Cut Acres		Totals
	West	East	West	East	
US Forest Service	1,239	3,310	22,475	58,934	85,958
Bureau of Land Management	2,388	151	7,370	3,566	13,475
Oregon Dept. of Forestry	987	0	7,878	642	9,507
Local Government	441	40	7,709	8	8,198
Private Industry	58,192	6,072	121,687	173,938	359,889
Non-Industrial	13,981	1,971	95,489	77,784	189,225
Indian Lands	114	6,983	20	4,365	11,482
Totals	77,342	18,527	262,628	319,237	677,734

Data is not available for the percentage of board feet clearcut or partially cut in Oregon,

[5] *1997 Annual Reports*. Oregon Department of Forestry, Salem, OR.

[6] The Oregon Department of Forestry defines clearcutting as the removal of all or nearly all trees in a stand in a single cutting. Partial cutting is defined as the removal of only some of the trees.

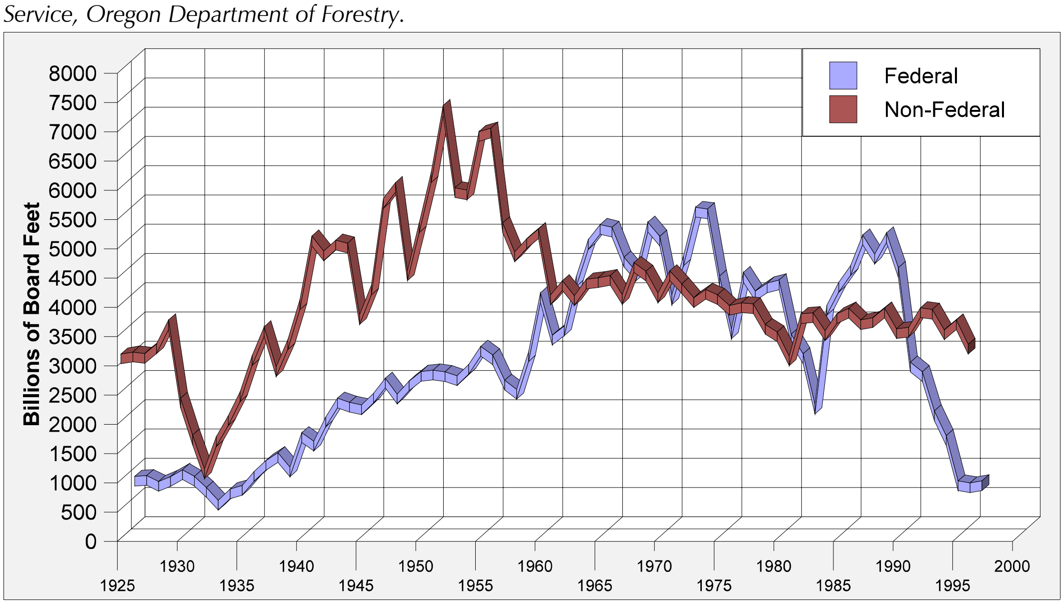
[7] Partial cutting classifications include shelterwood, seed tree, selective, preparation, intermediate improvement, and salvage harvest. It is worth noting that partial-cut harvest does not necessarily equate with uneven-aged management. Partial cutting, such as commercial thinning or intermediate cutting may take place in an even-aged management system that culminates in a clearcut harvest prior to replanting for another cycle of even-aged stand management.

but there seems to be a consensus in the forestry community that clearcutting is the predominant harvest method in western Oregon, and partial and salvage removal are the predominant methods of harvesting in eastern Oregon. Even though clearcutting is the principal regeneration harvest method in western Oregon, Table 1 shows more partial cutting than clearcutting on the westside. There are three reasons for this. First, commercial thinning is becoming a more prominent form of intermediate harvest, sometimes involving several thinning entries over the life cycle of a stand. Second, such entries are counted by the Department of Forestry as partial cutting. Third, the data for both clearcutting and partial cutting are recorded in acreage rather than board feet. If board foot harvest data were available, the prevalence of clearcutting in western Oregon would be more apparent.

Oregon's History of Forest Harvest

Since 1925 the majority of Oregon's annual timber harvest has occurred in western Oregon. Through 1960 most of the harvest came from nonfederal lands. As shown in Figure 6a, the nonfederal harvest peaked at 7.3 billion board feet in 1952, but then began to decline with depletion of mature timber. Consulting forester John Beuter has described the 1952 harvest as the juncture that marked "the end of the easy old growth,"

Figure 6. Federal and Nonfederal Timber Harvests in Oregon, 1925-1996. *Source: USDA Forest Service, Oregon Department of Forestry.*

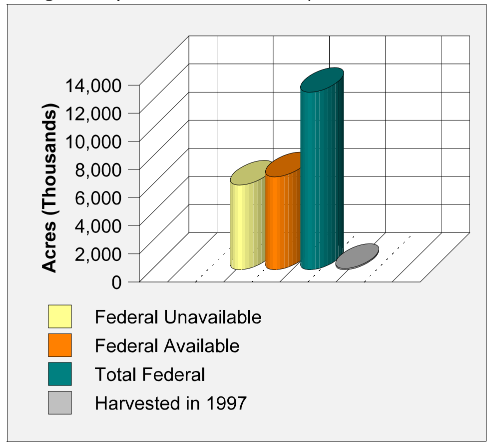


stands of timber in place since before Oregon's settlement.

Federal harvests began to increase in the latter half of the 1950s with the decline in private harvesting. Harvesting on federal lands reached its highest levels in the 1960s and '70s, but then ebbed with a swift succession of new laws mandating multiple uses and stronger attention to environmental issues in federal forest planning and management. Federal harvesting fell dramatically in the recession of the early 1980s but then increased with Oregon's economic recovery through the rest of the '80s. Since then, a succession of court cases and administrative appeals has reduced federal harvests to their lowest level in the past six decades in both western and eastern Oregon.

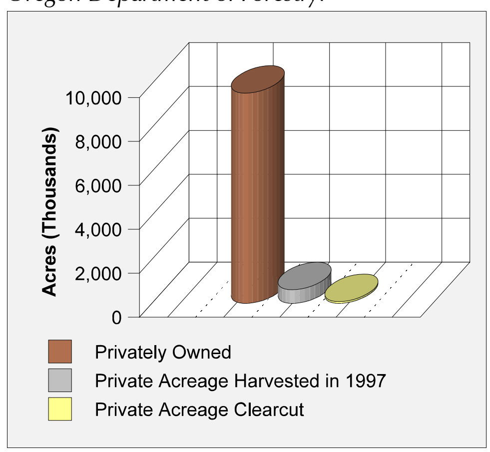
Harvests on federal lands have been reduced to their lowest level in the past six decades.

Figure 7. Share of Federally Owned Timberland Harvested in 1997. *Source Data: Oregon Department of Forestry.*



Although the federal government owns 12.8 million acres of timberland in Oregon, nearly half of that is off limits to harvesting for a variety of reasons.[8] The balance is available for harvest, but just under 100,000 acres of that (or 1.4 percent) were thinned or harvested in 1997. Of that harvest, just over 7,000 acres (or about one-tenth of a percent) were clearcut. This would be equivalent on a city block 240 by 600 feet to a patch of ground 12 by 12 feet. Figure 7 illustrates how little of the total federal ownership was harvested. Figure 8 illustrates the share of privately owned timberlands harvested in 1996.

Figure 8. Share of Privately Owned Timberland Harvested in 1997. *Source Data: Oregon Department of Forestry.*



Other Harvesting Trends

In a 1995 report to the Oregon Legislature,[9] the Oregon Department of Forestry identified several other trends in timber harvesting on private lands.

- ***The dominance of clearcutting***. "Clearcutting, the harvest of all commercial-sized trees in a stand, remains the dominant type of harvest on private timberland in western Oregon," the report noted. Clearcut harvesting in eastern Oregon, the report said, has increased in recent years "but is not widespread and has not returned to the levels reported in the late 1970s and early 1980s."
- ***More clearcutting***. The report shows that from the late 1970s through 1993,

[8] Under the Northwest Forest Plan, just over 6 million acres of federal land are off limits to timber harvest. This includes wilderness, scenic areas, campgrounds or botanical areas, acreage reserved to develop late successional or old-growth stands, research areas, and riparian reserves along streams, wetlands, or other bodies of water.

[9] Lettman, Gary J. *Timber Management Practices and Land Use Trends on Private Forest Land in Oregon*. Oregon Department of Forestry, 1995.

clearcutting in western Oregon increased on timberlands owned by both the forest products industry and nonindustrial private owners. Industry clearcutting, for example, rose from just over 50,000 acres in 1977 to about 80,000 acres in 1993.

The biggest advantage of engineered wood products is that they do more with less.

- ***Declining age of trees harvested***. "The transition from old-growth to young-growth stands is complete on private land in western Oregon," the report noted, adding "the ages of private harvests in western Oregon continue to decline." In 1980, only 16 percent of the private timber harvest in western Oregon came from stands younger than 60 years. By 1993 stands of less than 60 years made up 62 percent of the harvest by volume.

- ***Declining volume of trees harvested***. Younger trees are smaller trees, and they yield fewer board feet per cubic feet of tree than do older, larger trees. As the age of harvested stands has gone down, so has the volume recovered per acre.

The Impact of Product Technology on Forest Practices

However, there is another important reason that younger stands have been harvested, particularly by industrial timberland owners. The shorter rotations and smaller size of trees harvested on private lands reflect evolving technologies and products in the forest products industry. While a good many forest products continue to be manufactured in the form of solid, sawn pieces, particularly dimensional lumber, more and more products are engineered from smaller pieces of wood and fiber that are glued together and formed under heat, pressure, and controlled humidity. These products, which include I-beams, laminated veneer lumber, laminated beams, and finger-jointed studs, are typically stronger, more uniform, more reliable, and often lighter and cheaper than anything comparable cut whole from trees. Because it is made from chips, oriented strand board can be made from smaller trees than those required for plywood. Another advantage of engineered products is that they can be designed as integrated parts of larger building systems, which gives them added value to architects, builders, and consumers.

From the standpoint of raw material, however, the biggest advantage of engineered wood products is that they do more with less. By some estimates, engineered wood products require half the fiber from a tree that is consumed in comparable solid, sawn products. Thus, they can be made from younger, smaller trees grown in shorter rotations.[10]

[10] Information on engineered wood products was gleaned from the websites of Boise Cascade Corporation, Louisiana-Pacific Corporation, and the Engineered Wood Association, and from interviews with managers in the forest products industry.

5. SUSTAINABILITY OF HARVEST LEVELS

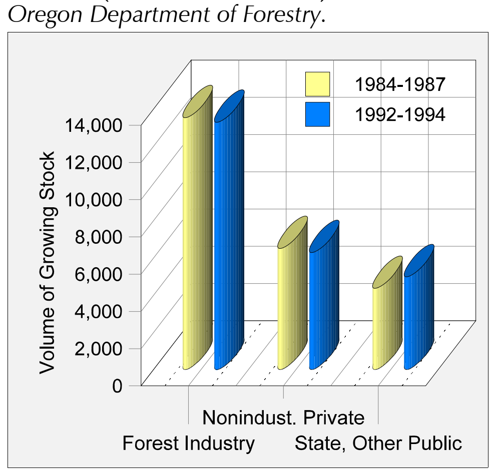
Are harvest levels of the recent past sustainable? The answer appears to be yes, for both federal and nonfederal lands.

Oregon's current timber yield appears to be sustainable.

On federally owned timberlands, harvest levels have declined dramatically since the mid to late 1980s, due primarily to changing land use allocations. Timber growth currently exceeds harvest by a wide margin. According to a 1989 OSU study, sustainable harvest levels on federal lands in Oregon are 3.8 billion board feet per year. Compared to this benchmark, just under 660 million board feet were actually harvested from federal lands in 1997. This represents a precipitous drop over the decade in which federal forestland use underwent a fundamental change. It should be noted, also, that a decrease in the land base available for harvest changes the benchmark for sustainability. The sustainable harvest level is much lower today because more federal timberland is off limits to harvest.

On nonfederal lands, according to the 1989 OSU study, the long-term sustainable harvest level is 3.7 billion board feet per year. In 1997, approximately 3.4 billion board feet were harvested on nonfederal lands in Oregon. The 1987-96 average harvest on these lands was 3.6 billion board feet.

Figure 9. Volume of Growing Stock on Nonfederal Timberland in 1984-87 and 1992-94 (in million cubic feet). *Source: Oregon Department of Forestry.*



In Oregon, private and other nonfederal forestlands were inventoried from 1984 to 1987 by the U.S. Forest Service's Pacific Northwest Research Station, and then again from 1992 to 1994. The volume of timber in the 1992-94 inventories was virtually identical to that in the 1984-87 inventories, suggesting that overall growth rates were about equal to harvest rates.

The main declines in timber volume (or growing stock) were on private timberland in eastern Oregon and nonindustrial private land in western Oregon. These declines were offset by gains in volume on state lands in northwestern Oregon. A comparison of growing stock estimates from private land in eastern Oregon from 1987 to 1992 shows a net reduction of 9 percent. A comparison of state and other public growing stock in western Oregon from 1984-86 through 1994 shows an increase of 18 percent. Volumes on industrial lands in western Oregon remained about the same between 1987 and 1992.

Sustainability Under Various Scenarios

Consulting forester John Beuter offered another perspective on sustainability in *Legacy and Promise*, a status report on the Oregon timber industry that he wrote in 1994 and updated in 1998.[11] In his view, Oregon will not run out of timber under any of the possible scenarios growing out of the policy debate on the uses of federal forests.

As Beuter noted in his report, a 1989 baseline study by Oregon State University (which updated an earlier OSU study) estimated that Oregon has the long-term capacity to sustain annual harvests of 7.5 billion board feet. As shown in Table 2 from Beuter's report, this is much higher than actual harvest levels from 1987 to 1996, and far greater than harvest levels under several alternative scenarios.

Table 2. Future Timber Harvest Possibilities in Oregon by Owner Class and Region. (In billions of board feet per year). *Source: John Beuter.*

Comparisons With Long-Term Sustainable Baseline	Western Oregon	Eastern Oregon	Oregon Total
Recent Past – 1987-96 Average*			
Federal	1.6	0.9	2.5
Nonfederal	2.9	0.7	3.6
All Owners	4.5	1.6	6.1
OSU Study – Long-Term Sustainable Baseline			
Federal	2.6	1.2	3.8
Nonfederal	3.2	0.5	3.7
All Owners	5.8	1.7	7.5
1. Northwest Forest Plan + ICB** Plan Implementation			
Federal	0.7	0.6	1.3
Nonfederal	3.2	0.5	3.7
All Owners	3.9	1.1	5.0
2. Northwest Forest Plan + ICB Implementation + Westside Reductions			
Federal	0.7	0.6	1.3
Nonfederal	2.0	0.5	2.5
All Owners	2.7	1.1	3.8
3. Total Ban on Federal Timber Sales + Westside Nonfederal Harvest Reductions			
Federal	0.0	0.0	0.0
Nonfederal	2.0	0.5	2.5
All Owners	2.0	0.5	2.5

*The actual harvest in 1997 for Oregon as a whole dropped to 4.1 billion board feet. The federal share was 660 million board feet, the lowest since 1934, and half of what was projected for the Northwest Forest and ICB plans.
** Interior Columbia Basin Plan, eastern Oregon's counterpart to the Northwest Forest Plan for western Oregon.
These are the assumptions for each of the three scenarios in Table 2:
1. *Full implementation of the Northwest Forest plan for western federal forests and the Interior Columbia Basin Plan for eastern federal forests*. Compared to the Oregon State University projections, federal harvests would drop by 73 percent on the westside, 50 percent on the eastside.
2. *Northwest Forest Plan and ICB plan for federal harvest reductions plus nonfederal harvest reductions in western Oregon*. A ban on clearcutting and herbicides, if enacted, would reduce the OSU harvest projections for nonfederal lands in western Oregon by 38 percent, in addition to the federal land reductions of Scenario 1.
3. A total ban on federal timber sales plus nonfederal harvest reductions in western Oregon. This assumes no timber sales from federal lands, eastside or westside, plus harvest reductions on nonfederal lands from Scenario 2.

It is most likely, according to Beuter, "that harvest volumes in the near future will lie

[11] Beuter, John H. *Legacy and Promise*, revised and updated. Oregon Business Council and Oregon Forest Resources Institute, Portland, OR, 1998.

somewhere in the range between scenario 1 and 2, perhaps around 3.5 billion board feet on the westside, and 1 billion on the eastside, yielding a statewide total not likely to be in excess of 4.5 billion board feet. This would be 40 percent below the OSU sustainability projection and 32 percent below the 1987-96 average harvest." The total harvest in 1997 was just under 4.1 billion board feet.

6. FOREST HARVEST AND REGENERATION REGULATIONS

Oregon was one of the first states in the nation to recognize that sound forest practices sustain not only timber production and the wood products economy, but also other forest resources, particularly water, soil, and fish and wildlife habitat. Oregon adopted its first comprehensive forest practices standards in 1971 with the passage of the Oregon Forest Practices Act. This law now governs the stewardship of approximately 11 million acres of state and private timberland, and it influences the management of Oregon's federal forestlands, whose governing agencies voluntarily abide by the state standards.

Over the years, Oregon has amended and strengthened its forest practices rules.

Over the years the state has amended and strengthened its forest practices rules to assure prudent logging practices, require prompt regeneration of harvested timberlands, control runoff and erosion, protect riparian zones, and maintain wildlife habitat. The rules regulate not only timber harvesting and regeneration, but also such activities as road construction and maintenance, application of chemicals, design of drainage systems, and precautions that forest owners must take to protect threatened or endangered species. Over the years, the state has made a substantial effort to educate and work with landowners to develop cooperative compliance with the forest practices rules. However, the state also has substantial enforcement power to assure compliance, including citations, fines, latitude to compel damage restoration, and even criminal prosecution.

These are some of the major provisions of the Forest Practices Act:

- *Reforestation*. After a harvest, a landowner has 12 months to start reforestation tasks such as site preparation and ordering seedlings, 24 months to complete planting, and 6 years to establish an adequately-stocked, free-to-grow stand. A stand is free to grow when it exceeds the height of surrounding brush and other vegetation and appears to have a high probability of thriving. The reforestation rule has been extremely successful. In 1995, for example, state inspection of post-harvest stands showed 99.6 percent compliance with reforestation.

- *Harvest size limit*. Within a single ownership, a clearcut may not exceed 120 acres in size. No stand within a single ownership may be clearcut within 300 feet of an existing clearcut on the same ownership until that clearcut meets all reforestation requirements, including a free-to-grow stage of development.

- *Logging operations*. All harvesting operations must be detailed in notification forms and maps submitted to the Oregon Department of Forestry. Precautions must be taken to minimize soil disruption from yarding out logs. Landings, skid trails, and fire trails must be located on stable ground and designed to keep runoff water from destabilizing soils or draining into streams and other waters. Owners who want to

The intent of water protection rules is to produce streamside conditions typical of a more mature forest.

harvest on or near steep, unstable slopes or near fish-bearing streams must submit more specific, detailed plans for approval by the Oregon Department of Forestry.

Why Leave Standing Trees and Downed Logs?

In their Extension Service publication *Forest Ecosystem Stewardship*, Robert Logan and Richard Fletcher advance the reasons for leaving some trees and downed logs following a harvest.

Large standing green trees, they note, provide immediate structural complexity in the new forest and hasten the return of mature forest characteristics. They carry a gene pool into the next forest and help link adjacent parts of the forest landscape. Ultimately they become a source for coarse woody debris and in-stream log structures that harbor many organisms.

Dead standing trees provide habitat for cavity nesting birds, mammals, and decomposing organisms. On forest floors, logs accumulate moisture during the rainy season and become water reservoirs through dry summer months. They accumulate nitrogen, which is crucial to succeeding generations of tree growth, and they attract insects, fungi, amphibians, and other organisms important to forest health. They form what the authors call a biological legacy, a means of carrying over organisms from the preceding forest to the succeeding forest. They provide this transition for decades while a new forest grows.

- *Wildlife trees and downed logs*. In harvest units larger than 25 acres, where a harvest reduces tree stocking below specific limits (typically a clearcut), an owner must leave two snags or green trees plus two downed logs per acre to provide habitat to birds and ground-dwelling animals. The snags or green trees must be at least 30 feet tall and 11 inches in diameter. Each downed log must be at least six feet long and contain a gross volume of at least 10 cubic feet.

- *Use of chemicals*. Herbicides, insecticides, and fertilizers are recognized as appropriate tools in protecting and promoting productive forests, but precautions are required to prevent spills and leaks, to keep chemicals away from streams and water bodies, to dispose of chemical containers safely, and to keep accurate records of chemical use. Applicators of chemicals and the foresters who supervise them must be licensed by the Oregon Department of Agriculture.

- *Roads*. Forest roads must be designed to minimize erosion and they must be located to avoid steep, unstable terrain and marshes, meadows, drainage channels, and riparian areas. On some steep terrain, roads are allowed only on ridge tops rather than the sides of slopes. If they must be built on slopes, road beds must rest fully on a cut into the hillside rather than on fill pushed to the side from a cut. Roads must avoid crossing streams as much as possible. Where roads do cross streams, culverts and bridges must not block fish passage. Roads and adjacent ditches and culverts must be maintained to avoid erosion and improper runoff. In fact, new roads and drainage structures must be designed to withstand a 50-year flood event.

- *Protection of riparian areas*. To protect water bodies, particularly where fish and domestic water supplies are involved, harvesting may not be conducted within a certain distance from banks, and additional streamside restrictions apply, depending on the size and nature of the water body. This is meant to leave a buffer of trees and vegetation to provide shade in and near streams, to filter sediment from runoff water entering streams, and to provide additional wildlife habitat. In some cases where harvest occurs adjacent to fish bearing streams, owners are encouraged to add logs and other woody debris to stream beds to enhance them as habitat for fish. The intent of water protection rules, particularly where fish are involved, is to produce and maintain over time streamside conditions typical of a more mature forest.

- *Sensitive wildlife habitat*. Harvesting and other forest practices must be modified or avoided in or near sensitive bird nesting, roosting, or watering sites, particularly when these sites are used by osprey, great blue herons, bald eagles, or northern spotted owls. Before the Department of Forestry issues approval for harvesting operations on or near sensitive sites, it must consult with other state agencies, particularly if there is uncertainty about how to protect a site.

- *Scenic highways*. Where timber is harvested near certain federal and state highways, the owner must maintain a "visual corridor" of standing trees adjacent to the highway.

There are some variations to these rules, depending on local conditions, the kind of silviculture practiced, and the region of the state in which a stand of trees is located. For the most part, however, these rules apply to virtually all forest owners.

Provisions That Govern Selective Harvesting

Prior to 1995, Oregon's forest practice rules were focused primarily on even-aged silviculture, particularly following clearcutting and similar harvesting operations. The most recent modifications to the reforestation rules now recognize both even-aged and selective harvesting systems, as well as both natural and artificial reforestation methods. Where free-to-grow trees do not remain in sufficient number after selective cutting, an owner must provide additional stocking within specific time limits.

7. BALANCING OBJECTIVES AND CONSTRAINTS

In deciding how to manage forests today, owners and forest managers must take into account a wide array of objectives, requirements, and constraints. Many of these complement one another, but others compete or conflict, calling for an awareness of trade-offs in making management decisions.

Hundreds of factors shape what will and will not work in choosing and growing various species of trees.

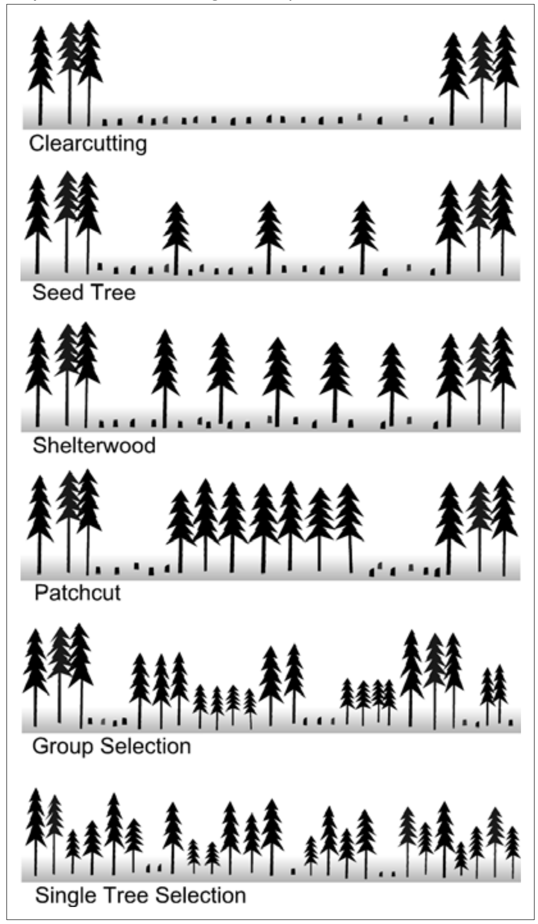
As noted earlier, legislative mandates, court cases, appeals, and the Northwest Forest Plan have, as a practical matter, resolved the near-term future of federal forests. They will be managed primarily to maintain biodiversity and wildlife habitat and to provide scenic and recreational value. Toward this end, much of Oregon's federally owned forestland is expected to maintain and increase older forest characteristics.

Most private forest owners – both large timber producers and many small landowners – have a different set of imperatives. They need to realize a return on their investment and meet market demand for wood products. So they must manage their lands primarily for commercial productivity, through cycles of harvest and regeneration. In doing this, they must work with the advantages and natural constraints their land gives them. Climate, soil, elevation, slope, exposure, drainage, and competing vegetation combine in dozens or even hundreds of ways over a landscape to shape what will and will not work in choosing and growing various species of trees. Even within the same landscape, species or silviculture methods appropriate for one site may be inappropriate for another. Species that thrive on coastal hillsides may struggle in central Oregon. Methods that work near Lakeview may falter near Lincoln City.

Superimposed on these objectives and constraints are others. Many private owners, despite their commercial aims, also value the contributions that their forests make to such broader ecological functions as filtering water, maintaining biodiversity, and providing wildlife habitat. In this vein, they work within, or even go beyond, the regulatory rules intended to regenerate forests and protect the forest environment. Nearly all private owners comply with the rules described earlier. By doing so, they protect fish bearing streams and sensitive areas from harvesting damage while providing transitional habitat in harvested areas for wildlife. While owners must avoid damaging wildlife through forest operations, they must also limit the damage that wildlife can do to trees. For example, in many areas, owners must keep pocket gophers from eating seedling roots and they must find ways to protect seedlings from foraging by deer and elk, which eat tender new foliage.

Forest owners and managers today also have more reason to think in terms of whole landscapes. Owners of large tracts of land have the advantage and the challenge of designing forest landscapes to maintain different stand rotations and structures. Where they practice even-aged silviculture and clearcutting to harvest trees, owners can plan at the landscape level for different stages of stand growth, a variety of species, and thinning and harvesting patterns that provide a mix of habitat for wildlife. In western Oregon's commercial forests, for example, many landscapes are a mosaic of stands in various stages of growth, from recently planted clearcuts to 60-year-old second growth. Species in these landscapes typically include a mix of conifers. Douglas-fir is the most commonly planted species. Other species, such as grand fir, western hemlock, and red alder, often naturally reseed themselves in harvested areas. Increasingly, owners are planting other species, especially near the coast and in streamside areas.

Figure 10. Continuum of Silvicultural Choices as depicted in *Balancing Act*, by Hamish Kimmins.



In summary, silviculture and forest landscape management involve a complex array of natural circumstances, species characteristics, owner objectives, environmental considerations, and regulatory rules. Silviculture choices and their trade-offs, the subject of this paper, should be considered in this larger context. Within this context, silviculture does not break down neatly into either-or choices. The range of silviculture options, from even-aged clearcutting to single-tree selection, exist on a continuum of the kind described by Hammish Kimmins (Figure 10) in his book *Balancing Act: Environmental Issues in Forestry*.[12] In looking at each choice on that continuum, it is important to consider what works and what doesn't in meeting private objectives and public policy requirements.

[12] Kimmins, Hamish. *Balancing Act: Environmental Issues in Forestry*. University of British Columbia Press, Vancouver, BC, 1992.

8. EVEN-AGED SILVICULTURE

Even-aged silviculture is the most predominant forest management system for wood production around the world. It is the system of preference in the westside forests of the Pacific Northwest, including western Oregon. It is particularly prevalent on industrial timberlands where managed stands have replaced original forest stands cleared off by harvest or forest fire.

Douglas-fir is capable of growing in an uneven-aged system, but because it is shaded, much of it will not survive and it will grow more slowly.

There seems to be agreement among most forestry professionals that even-aged silviculture is the best system for efficiently regenerating Douglas-fir on a commercial scale in western Oregon. Even-aged silviculture is well suited to Douglas-fir and a number of other species because they depend on direct sunlight for regeneration and growth. Douglas-fir *is* capable of growing in an uneven-aged system, where seedlings and young trees are shaded in whole or part by an overstory of taller trees. But Professor Mike Newton, who has researched the matter with colleagues at Oregon State University, says, "A lot of it won't survive in the shade. What survives will grow more slowly."

What It Is

As traditionally practiced, even-aged silviculture is a method of cultivating a stand of trees by seeding or planting them at the same time, cultivating them as a group, and harvesting a portion or all of them of the same age. In this form of silviculture nearly all the trees in a stand are harvested in one or two cuttings that result in a clearcut. The purpose of clearcutting is to create a clearing for regeneration as much as it is to harvest a crop of trees. After harvest, the site is prepared for regeneration and a new stand of trees is seeded or planted almost immediately for cultivation and future harvest. A forest landscape (thousands of acres) may consist of a patchwork of even-aged stands at different stages of development, ranging from newly planted areas recently clearcut to trees more than half a century old and over 100 feet tall.

Genetic quality, competition control, and nutrient management all play important roles in successful even-aged silviculture.

Substantial improvements in tree nursery stock have been made the past few decades through genetic research. Since the 1960s forest managers have also been careful to start new forests from seed sources that originate in the zone where planting takes place. Research showed that seedlings were more successful, apparently due to genetic adaptation, if they were planted in the zones where their seeds originated. Consequently, forest zones have been carefully mapped to match seed collection and planting.

The use of herbicides is often integral to even-aged silviculture because of the need to control grass, shrubs, and other vegetation that inhibit conifer seedlings or cause them

The term clearcutting is often used in reference to even-aged forestry, but it is only one event in the life cycle of a managed forest.

to die. Herbicides are often applied to areas scheduled for replanting to suppress such vegetation. Herbicides keep surrounding plants from competing with seedlings for light, soil moisture, and nutrients. By suppressing competition and helping to keep seedlings healthy, they also improve the survivability of seedlings subject to animal browsing or other natural damage. In a recent position paper, the Oregon Society of American Foresters wrote, "The chemicals used in the forest are the same as those that are used by the household gardener. Foresters, however, apply chemicals to an area much less often, such as once or twice every 30 to 50 years."

Where soils are deficient in nitrogen, it isn't unusual to add fertilizers such as urea to conifer stands. Nutrients are typically applied when stands are getting established, or later in conjunction with thinning.

Thinning Is One of the Forester's Main Management Tools

Thinning is practically a discipline by itself in forest management. As David Smith and his co-authors write in *The Practice of Silviculture*,[8] "Thinning represents the primary means by which the yield of stands can be increased beyond the best that might be achieved under purely natural conditions."

Thinning involves the removal of some trees, usually as a means of shaping the structure and growth of the remaining trees in the stand. Smith describes a wide variety of methods for doing this.

In recent decades, thinning has been used to increase growth and yield of the most promising trees. Thinning once produced little or no immediate commercial benefit in the Douglas-fir region. In the past two decades, however, as markets have evolved for smaller logs, commercial thinnings have produced revenue for forest owners. Thinning, for quick, maximum revenue can be an abusive practice. In some cases in the past, thinning degenerated into high-grading when used to remove only the highest grade trees for immediate sale.

In recent years, foresters have become interested in thinning as a method of achieving objectives other than higher wood production. Thinning is one of the tools that forest owners can use to convert existing even-aged stands into uneven-aged structures. It can also be used to improve understory wildlife habitat and scenic and recreational values.

The term clearcutting is sometimes used synonymously with even-aged management. However, clearcutting is only one event in a decades-long series of cultivation and harvesting events in the life cycle of a managed forest. As discussed above, clearcutting in Oregon is regulated by the Oregon Forest Practices Act. Clearcutting also takes a variety of forms, as discussed below.

The life cycle of a managed stand of trees is called a *rotation*. In even-aged silviculture this begins with site preparation soon after a clearcut harvest. The size of such a harvest typically ranges from 40 to 60 acres on industrial lands. Site preparation usually includes some cleanup of logging debris, or slash, following a clearcut, and it often involves herbicide application to control vegetation. It may also include tilling soil compacted by logging to give seedlings a better chance to grow. Some forms of even-aged silviculture rely on growing trees from seed which is either applied to the landscape artificially or allowed to fall from adult seed trees left standing after a partial cut. In most industry-owned forests and many nonindustrial forests, stands are regenerated by transplanting nursery-grown seedlings. This allows greater control over genetic quality and gives a new stand a more predictable start. Owners typically plant 400 or more seedlings per acre.

Buffers of live trees are left near streams, and snags, downed logs, and other features of mature forests are left to provide transitional wildlife habitat.

After seedlings are in place, or in the stand initiation phase, the forester's initial task is to grow them above grass and brush. Attainment of this height is described as a *free-to-grow* stage. The stand initiation phase concludes when crowns begin to close and form a canopy. Before crown closure, seedlings must survive against any competing vegetation not eliminated by herbicides, and they must often survive browsing by deer and elk who find tender new foliage attractive forage.

After 10 to 20 years, depending on tree growth, owners may perform a precommercial thinning. During this process trees falling behind, too crowded together, or poorly formed are thinned from the stand, leaving 250 to 300 trees per acre. This thinning process leaves the healthiest trees more room to grow and a greater share of light, water, and soil nutrients.

At 20 to 30 years, an owner may conduct the first commercial thinning, a harvest in which trees now 8 or more inches in diameter can be sold for conversion into studs and chips. Some owners continue to perform these commercial thinnings as frequently as every five years until trees are sufficiently mature to harvest in a clearcut. In commercial forestry practice today in Oregon, trees at the clearcut stage of harvest are usually at least 40 to 80 years old and 12 to 30 inches in diameter.

The harvest of these trees brings a rotation full cycle in even-aged silviculture, and it sets the stage for regeneration to follow. The rotation age is determined by biological and economic factors. A key biological factor is the growth rate of trees in a stand. In most Douglas-fir forests, the average annual growth rate increases up to about age 70, reaches a plateau between ages 70 and 90-, and then declines slowly thereafter. Harvesting the stand when this growth rate peaks produces the highest timber yields. However, most commercial forest owners must take into a account a great many financial considerations, including log prices, cash needs, and return on investment criteria.

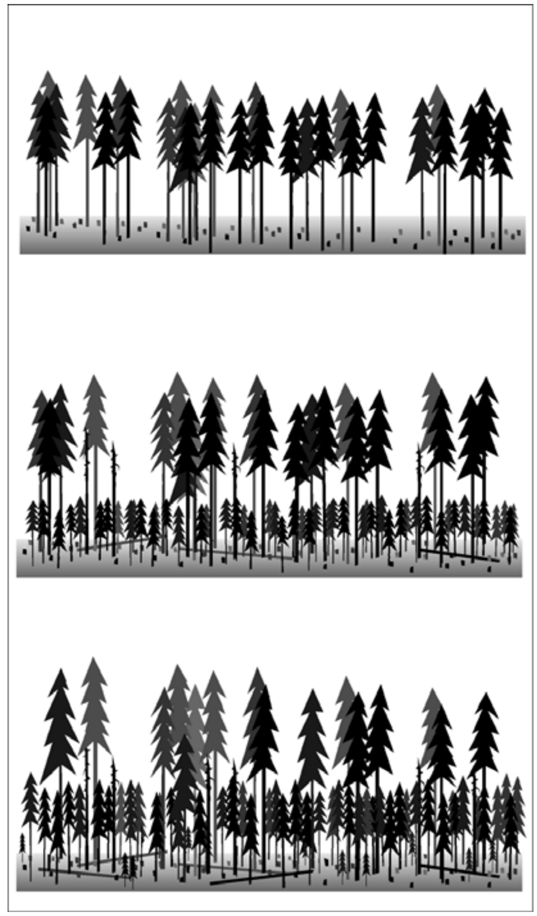
In traditional even-aged silviculture, clearcutting is the most common form of harvest. Under forest practice rules, as noted earlier, buffers of live trees are left in place along riparian zones, and snags, downed logs, and other features of mature forests are left to provide transitional wildlife habitat while the harvested section of forest regenerates. Adjacent forestland is not harvested until the recently logged unit is reforested.

Variations of Even-Aged Management

There are variations to the kind of traditional even-aged management that concludes with a standard clearcut harvest. Two in particular, *seedtree* and *shelterwood* silviculture, are used occasionally to aid in forest regeneration following a clearcut.

The seedtree approach leaves a select few trees with the best genetic qualities either scattered or clumped together to seed the surrounding harvested area. After the seed trees have naturally regenerated the surrounding acreage, and after the new stand is well established, the seed trees may be harvested. Because planting is a more certain method of regenerating stands, the seedtree method is seldom used any longer. Although forest practice rules require retention of some green trees along with snags and downed debris, the retained live trees are not the same as seed trees because the objective of retaining them is not to regenerate the stand but to provide some habitat for wildlife while a newly planted stand is growing up.

Figure 11. This is how Curtis and his co-authors see a two-aged reserve shelterwood approach at three intervals: initial cut, 30 years, and 75 years.



In shelterwood silviculture a large portion of a stand is harvested but enough of the stand is left to protect (and sometimes naturally regenerate) the surrounding areas where trees have been removed. As its name implies, the shelterwood method helps shelter seedlings from excessive exposure and temperatures. Shelter trees can be grouped or spread evenly, as conditions warrant. After the new stand is established, they can be removed in stages or in one cut.

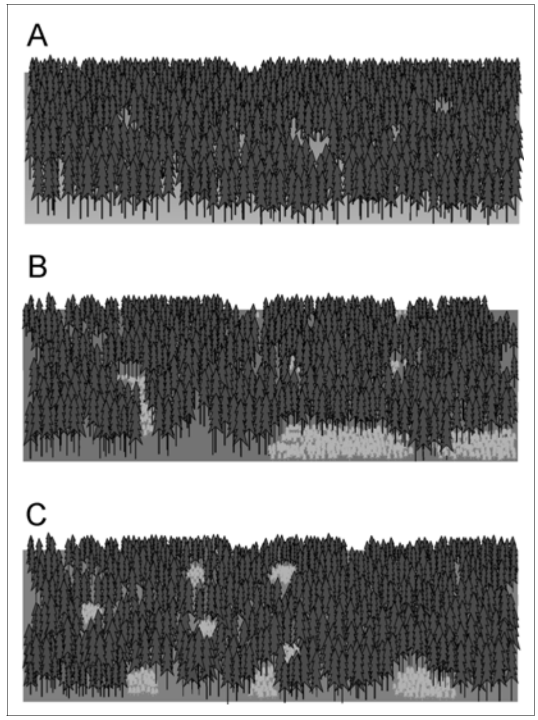
In describing silviculture for multiple objectives, Curtis and his co-authors describe how shelter trees can be left in place as *reserve shelterwood* (Figure 11) to establish layered and two-aged stands, as contemplated earlier by John D. Matthews and R.D. Nyland. According to Curtis and his colleagues, "Both two-aged and layered but essentially even-aged stands often arise naturally because of differences in species tolerance and growth rates, and often are thought favorable to wildlife and biodiversity values."

In one potential management scenario, Curtis and his co-authors describe another variation of even-aged silviculture that moves very close to the group selection form of uneven-aged silviculture. In this approach, called *patch-wise even-aged management* (Figure 12), small patch clearcuts of 1.5 to 5 acres would be regenerated primarily in Douglas-fir either by natural seeding or planting and then tended with conventional even-aged techniques. Over time, they note, such stands "can be converted to an uneven-aged mosaic of such even-aged patches that would be predominantly Douglas-fir (with lesser proportions of western hemlock and western redcedar)."

Options in Rotation Length

Increasing rotation length, the time between stand regeneration and harvest, is another way that foresters can adapt even-aged silviculture to objectives that complement increased wood yield. As noted earlier, rotations on most private timberlands in western Oregon are edging below 60 years. Few extend beyond 80 years.

Figure 12. Curtis and his co-authors project that patchwise even-aged management would look like this at 1 year (A), 30 years (B), and 75 years (C).



In their paper on silviculture for multiple objectives, Curtis and his co-authors cite the following potential advantages for extended rotations:

- Reduction in visual impact
- Reduction in frequency of major site disturbance
- Less need for herbicides and slash disposal
- Lower costs through reduced frequency in regeneration and respacing
- Larger trees and higher wood value
- The opportunity to develop age balance across the landscape as well as multistory stand structures
- Enhanced biodiversity; improved habitat for many wildlife species.

The principal attraction of even-aged silviculture is faster, more efficient regeneration of harvested timberland.

However, longer rotations may impose substantial financial penalties on private owners, in particular since the value gained from growing larger, older trees often isn't sufficient to offset the slower growth rates of older timber. For this reason, longer rotations are most likely to be adopted by owners for whom non-timber objectives are primary and financial returns are secondary.

Where Even-Aged Management Is Preferred, and Why

As noted earlier, even-aged silviculture is widely practiced and preferred in westside and coastal forests of the Pacific Northwest where conifers, especially Douglas-fir, are cultivated for production of wood products. The principal attraction of even-aged silviculture is faster, more efficient regeneration of harvested timberland. Planting Douglas-fir and other species on a clearcut space, especially where competing vegetation is suppressed, gives them ample light, moisture, and soil nutrients to grow successfully.

This is especially important for Douglas-fir because it is shade intolerant and regenerates best in open space. Even-aged management is also favored because clearcut harvesting, as opposed to single-tree and group cutting, is more cost efficient.

Other arguments have been advanced for even-aged silviculture. For example, some foresters contend that compared to uneven-aged silviculture, harvesting in even-aged stands allows forest managers to 1) better control disease outbreaks, 2) reduce the potential of harvesting injury to forest workers, 3) avoid more frequent environmental disruption, 4) avoid damaging healthy young trees, and 5) build a smaller road network to remove logs. This paper will later summarize some differences between the two forms of silviculture.

The Shade Issue

Light is a vital resource for trees, and conifers are no exception. Westside forest owners believe from experience that Douglas-fir and other commercially valuable conifers regenerate most successfully when not in the shade. Hence they favor even-aged silviculture, which treats young trees to full sunlight as soon as they grow free of surrounding brush.

Most forest scientists agree, and studies confirm, that shade has this inhibiting effect, especially with Douglas-fir, which is shade intolerant. (By contrast, western hemlock seems especially well adapted to shade, which is the principal reason that hemlock may succeed Douglas-fir, over time, in unmanaged forests.) However, research also suggests that the *degree* of overhead shade makes a difference in the vigor of young trees that are nominally shade intolerant. Some data indicate that they can survive lower shade densities achieved through thinning or uneven stand structuring. (However, because thinned stands continue to grow vigorously, they would continue to threaten the survival of Douglas-fir unless thinned repeatedly.)

This raises two related questions. To what extent does overstory shade, in various degrees, inhibit understory conifer growth? And, what is the point at which acceptable levels of understory growth can still be achieved in stands that have been structured to meet objectives that include more than wood production?

Two soon-to-be-published studies by forest scientists at Oregon State University address these questions. In a study conceived in 1987 and begun in 1992, Michael Newton, Elizabeth Cole, John Tappeiner, and others set out to determine growth and survival of planted seedlings in differing light conditions.[13] Douglas-fir, western redcedar, and western hemlock seedlings were planted under 55- to 65-year old Douglas-fir stands thinned to various densities (ranging from 80 to 40 trees per acre) in both uniform and

[13] Brandeis, Thomas J. *Underplanting and Competition in Thinned Douglas-fir*, PhD thesis. Oregon State University, College of Forestry, 1999.

patchy distributions.

As shown in Figure 13, fourth year data on seedling volume, measured in cubic centimeter per tree, suggest that shade from denser overstory significantly impairs the survival and growth of seedlings. The results with Douglas-fir are particularly striking. Douglas-fir seedlings growing under heavy shade measured just below 8 cm^3. Even in low shade, Douglas-fir growth was just under 30 cm^3. The other species also experienced lower growth with higher shade levels.

For comparison, the researchers sampled the four-year growth of Douglas-fir, redcedar, and hemlock seedlings in a clearcut at a site similar in soil, elevation, and latitude 20 miles from the study site. Although the growth of seedlings in the clearcut was not part of the shade study, it illustrates dramatically the difference that full light makes on conifer growth. As shown in Figure 13a, Douglas-fir growing in the clearcut attained average stem volume of 390 cm^3.

Figure 13. Fourth-year data on average seedling stem volume per tree, in cubic centimeters, shows much stronger growth under favorable light conditions. *Source: Mike Newton, School of Forestry, Oregon State University.*

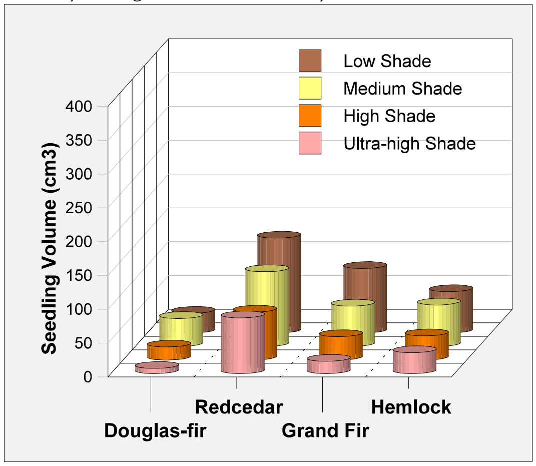
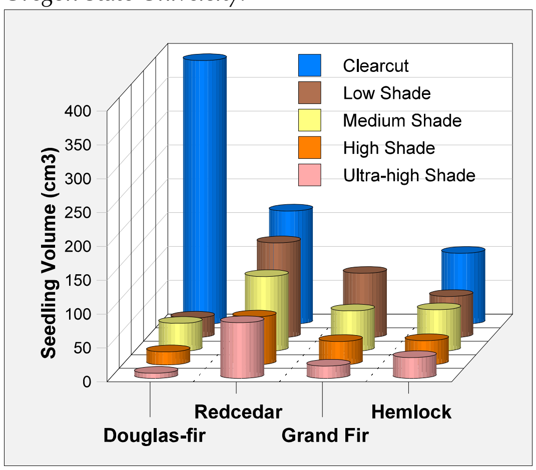


Figure 13a. Comparative fourth-year data showing how Douglas-fir, redcedar, and hemlock seedlings, not part of the study depicted in Figure 13, fare in stem volume growth in an open clearcut. *Source: Mike Newton, School of Forestry, Oregon State University.*



In another shade study begun by Bill Emmingham and Kathleen Maas-Hebner in 1994,[14] a combination of hardwood and conifer seedlings were planted in three 30-year-old Douglas-fir plantations in the Coast Range. The stands ranged from 220 trees per acre to stands thinned to 100 trees per acre (normal thinning), 60 trees per acre (wide thinning), and 30 trees per acre (very wide thinning). Results were measured at the end of each year the past four years.

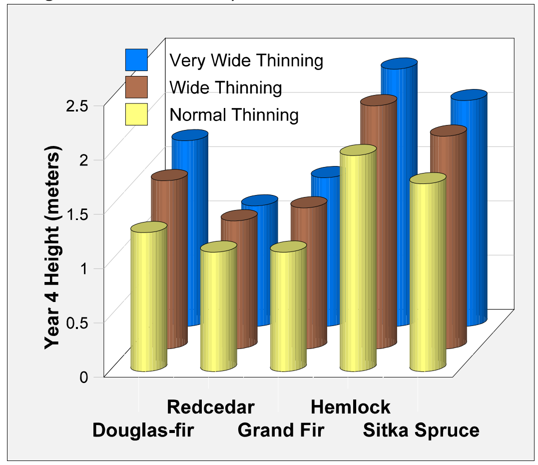
As illustrated in Figure 14, seedlings fared better with lower stand densities. They were significantly taller among an overstory of 30 trees per acre than 100 trees per acre. Seedlings under 60 trees per acre were not significantly different than under 30 or 100

[14] Emmingham, William H., and Kathleen Maas-Hebner. *Coastal Oregon Productivity Enhancement Program (COPE) 1997 Annual Report*. Oregon State University, Forest Research Laboratory, Corvallis, OR.

trees per acre. The survival rate for all species was high (95 to 97 percent) with stands thinned very widely. Douglas-fir and western redcedar survival dropped to 84 percent and 83 percent, respectively, under thinning to 100 trees per acre.

The Maas-Hebner and Emmingham data suggest that thinning to lower stand densities for other management objectives can still leave room for production of second generation stands under a thinned overstory. The trade-off is lower stocking levels (and wood volume) in the overstory, and slower growth among the new generation of trees.

Figure 14. Fourth-year data on seedling stem height in meters, shows growth under all thinning conditions, but much stronger growth under stands of 30 trees per acre. *Source: Kathleen Maas-Hebner and Bill Emmingham, School of Forestry, Oregon State University.*



Of course, results from these shade studies only suggest the silvicultural possibilities. Because study sites have their own particular combination of elevation, exposure, climate, soils, underbrush, and a variety of other factors, results in one case may not be a reliable predictor of what will happen in another case.

9. UNEVEN-AGED SILVICULTURE

As discussed below, systematic uneven-aged silviculture is not widely practiced in Oregon. Yet in recent years, it has become a subject of increasing interest in forestry conferences, classes, papers, publications, and field studies. As both the public and forest owners have become more interested in managing forests for multiple objectives, forest scientists have begun to explore the potential of uneven-aged silviculture as a tool that might be useful in this pursuit. While a number of scientists are exploring the potential benefits of uneven-aged silviculture, they also caution against embracing it uncritically. It is unproven in western Oregon, is more appropriate in some circumstances than others, and requires more intensive management. A good deal more needs to be learned about it in actual use, particularly in the Douglas-fir region.

Uneven-aged silviculture involves the cultivation of trees of various ages in a stand and the harvest of selected trees on an ongoing basis.

What It Is

As its name implies, uneven-aged or selection silviculture[15] involves the cultivation of trees of various ages in a stand and the harvest of selected trees on an ongoing basis. Uneven-aged stands often contain mixed species as well. Trees are harvested on a regular cutting cycle that ranges from five to 20 years. They are harvested either singly or in groups as they reach maturity. The small gaps created by harvesting leave room for natural seeding or transplanting of nursery seedlings. In systematic uneven-aged silviculture, owners manage the composition and spacing of trees in a stand to assure optimum growth, to constantly regenerate the stand, and to achieve a range of age classes that allow a continuous schedule of selective harvesting.

Uneven-aged silviculture is neither new nor unique. Although it is not used in industrial forestry as widely as even-aged silviculture, it is practiced in a few places in Oregon and other states, and it is used routinely in some countries. In Europe it goes back several hundred years. The system has long been used in Germany, the birthplace of modern forestry, where shade-tolerant species such as Norway spruce, silver fir, and beech are cultivated in mixed-age stands and continuously removed over a system of roads designed for frequent forest entry. However, not all European countries use the system. Uneven-aged forestry was abandoned at the beginning of the 20th century in Sweden after it degenerated into high grading, a practice in which owners cut only the most commercially valuable trees and failed to pay enough attention to other aspects of forest health and continuity. Sweden, in response, adopted policies mandating even-aged silviculture.

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[15] Uneven-aged silviculture goes by roughly a dozen different names, including selection or selective silviculture, selection or selective harvest, and multi-aged silviculture. The names often reflect a particular focus or objective. *Uneven-aged* is used here because it shows up frequently in the literature and it seems reasonably generic.

If selective or partial cutting is accepted as a definition of uneven-aged management, then the practice can be said to prevail in eastern Oregon.

Uneven-Aged Management on the Spectrum of Silviculture Choices

Uneven-aged management is divided into group or single-tree selection, with harvest intervals that can range from five to 30 years.

Group selection. On the continuum of silviculture systems discussed so far, uneven-aged group selection is the next logical step from small patch clearcutting that can be used to maintain a mix of age classes in even-aged clusters at the landscape level. (This is what Curtis and his co-authors call patchwise even-aged management in their paper on silviculture for multiple objectives.)

Bill Emmingham, in a paper on designing uneven-aged systems, describes groups ranging from a few trees to a few acres. These can be managed, he writes, as "mini-even-aged stands." The key to group size, he continues, "is that the small trees in the created opening should be shaded or sheltered by the adjacent stand." He further notes that the desired size of a group cut also depends on the height of surrounding trees, the shape and orientation of the opening, and the shade tolerance of the trees being regenerated. More shade-tolerant species such as hemlock, western redcedar, or grand fir can regenerate in a quarter- to half-acre opening. Less shade tolerant trees such as Douglas-fir and ponderosa pine would require a one- to three-acre opening.

Individual selection. A system of single tree selection is useful in developing stands with multiple age classes and sizes in a multiple-canopy, diverse structure. "In order for this to succeed, writes Emmingham, understory trees must be tended and maintained in vigorous growing condition. This requires thinning and control of stocking levels[16] in both overstories and understories. In highly productive sites, such as the Coast Range, it will also require aggressive control of competing vegetation.

Uneven-Aged Silviculture in Oregon

Partial harvesting is widely practiced in the forests of eastern Oregon, and, to some degree, in southwest Oregon. However, there is disagreement in forestry circles about the extent to which such harvesting constitutes uneven-aged silviculture. The disagreement turns on definitions and the fact that uneven-aged silviculture is sometimes used synonymously with selection harvesting, which involves individual or group selection of trees for harvest. In the view of some forestry experts, uneven-aged silviculture involves a good deal more than selective cutting.

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[16] Stocking level refers to the natural or manipulated extent that trees fill a site and compete with one another for resources. At full natural stocking levels, some trees are denied sufficient resources and die. By controlling stocking levels, foresters can keep all trees growing vigorously, including smaller trees.

Table 3. Summary Comparison of Silviculture Systems. *Source: interview with Bill Emmingham in which he shared drafts of a workbook in development for woodland owners, comparing the characteristics of even-aged and uneven-aged systems.*

Characteristic	Even-aged	Uneven-aged
Tree age and size	close in age, not necessarily size	many ages and sizes
Stand character	single story, low diversity within stand	multiple story, high diversity within stand
Stand longevity	50 to 100 years	indefinite
Harvest pattern	thinnings at 10- to 20-year intervals; final harvest at maturity	partial cutting on a 5- to 20-year cutting cycle, no final harvest
Harvest cost	clearcutting is efficient; thinning costs 5 to 10% more	partial harvest 5-35% higher than clearcutting
Regeneration	usually planting	facilitates natural regeneration, planting is common
Management intensity	May be intense or extensive	relatively intense
Management skills	low to high, available	high level needed, less available
Management risks	low to moderate	moderate to high

If selective harvest of market-ready trees is accepted as a definition of uneven-aged management, then the practice can be said to prevail in eastern Oregon and to be practiced in southwest Oregon. Selective harvest works better on seasonally warm, dry sites where continuous forest cover left by selective tree removal protects seedlings and young trees from frost and high temperatures. In fact, while clearcutting on the westside provides young trees with light they need, selective cutting on the eastside provides young trees with shade that they need.

All uneven-aged silviculture involves selection harvest, but whether selection harvest by itself is, in fact, uneven-aged silviculture, remains open to debate. Emmingham believes that too many important ingredients are missing to regard most selective harvesting in Oregon as a form of uneven-aged silviculture. First, he notes, there has been no intention to establish and maintain a stand with three or more age classes. Second, there is no plan for the treatment of smaller trees, for example, whether they should be precommercially thinned to promote better stand growth and forest health. Finally, not enough attention has been paid to regenerating parts of a stand as overstory trees are removed.

Emmingham attributes the absence of systematic uneven-aged silviculture in Oregon to several causes. There is no widespread tradition or understanding of how forests might be managed this way. Historically, there have been no good models or demonstrations of uneven-aged silviculture adapted to Oregon forests. And the kinds of planting and tending now so common in westside even-aged silviculture, such as periodic thinning, have not been commonly practiced in eastern Oregon forests except by a few industrial owners (see box, next page) and the U.S. Forest Service.

Apart from some small-scale trials, there is no uneven-aged silviculture being practiced in the fast-growing forests of western Oregon. Some selection harvesting was tried with Douglas-fir stands in the early 1940s, but without great success. Forestry historians still debate whether these early efforts were provided sufficient time and expertise to succeed.

Uneven-Aged Management Works for the Collins Companies

Since 1941 the Collins Companies have demonstrated that uneven-aged management can be a successful way to practice forestry. They do it on nearly 170,000 acres in Oregon and California (though not in Pennsylvania, where the company harvests hardwood stands by clearcutting).

On its 78,000-acre holdings near Lakeview, Oregon, Collins Products grooms stand structures in four categories: 100-foot-tall ponderosa pine up to 200 years old, 60-foot ponderosa pine and white fir, and an understory of white fir and ponderosa pine ranging from seedling size to 40 feet tall. These are on sites that average about 16 inches of precipitation a year.

According to Lee Fledderjohann, Collins Products resource manager, the company manages its stands for long-term productivity. Its landscapes, viewed from the ground, appear to be a continuous canopy of mixed age classes. Although ecosystem maintenance is an important value in Collins management, the company's lands are productive within the constraints of lower soil fertility and scant rainfall. In 1997 Collins cut nearly 8 million board feet from its Oregon property.

Collins uses individual tree selection carried out by contract loggers. Crews re-enter stands every 15 to 20 years for both thinning and harvesting. Thinned trees are converted to chips. Pine trees are milled into window and door frames; white fir goes into plywood.

Potential for Uneven-aged Management in Western Oregon

Douglas-fir regenerates relatively better in the uneven-aged mixed conifer forests east of the Cascades than it does in western Oregon. Eastside Douglas-fir is genetically adapted to the harsher environment. Because of soil and climatic conditions, ground vegetation does not compete as vigorously with Douglas-fir seedlings as is the case on the west side. Overstory trees on the eastside, such as ponderosa pine, have less leaf density than westside overstory trees, such as mature Douglas-fir and western hemlock. So eastside Douglas-fir and other shade intolerant trees receive more light through the canopy above. Still, even though Douglas-fir regenerates more successfully on the eastside, it also grows more slowly there, as do all species relative to the more productive westside.

Plant ecologist Jerry Franklin was one of the early professionals to weigh in on the potential for successful use of uneven-aged silviculture in the Pacific Northwest. In a paper he presented more than 20 years ago,[17] Franklin addressed three principal concerns: 1) whether uneven-aged management could be used without causing a shift in the species composition of conifer stands, 2) what constraints on uneven-aged management might be dictated by site conditions, and 3) whether uneven-aged

[17] Franklin, Jerry F."Effects of Uneven-Aged Management on Species Composition," reproduced in 1977 from a paper presented at a workshop October 19-21, 1976, on Uneven-Aged Silviculture and Management in the Western United States, USDA Forest Service.

silviculture was feasible from a management point of view.

Based primarily on what was then known about the shade tolerance of various species, and assuming uneven-aged management would increase shade on understory species, Franklin predicted that uneven-aged management of all shade tolerant species would be unlikely to change the species composition of a forest. Likewise, Franklin saw no likely change in species composition arising from uneven-aged management of all shade intolerant species. However, he predicted, in forests “where [shade] intolerant species are dominant and preferred, and where there are prolific shade-tolerant associates,” uneven-aged management would give a strong competitive advantage to the shade-tolerant species in eventually out competing and succeeding the shade-intolerant species. To illustrate that point, he added,

> Our classic illustration is the coastal Douglas-fir type where the preferred Douglas-fir is typically subject to continuing successional pressure from species such as western hemlock, western redcedar, and Pacific silver fir. On most of these sites limited experience and logic and intuition (which go to make up our conventional wisdom) indicate that Douglas-fir will not hold its own under single tree or group selection.

Franklin cited habitat conditions as a significant factor in the potential success of silviculture systems. “On hot, dry forest sites,” he wrote, “light is not a major limiting factor – moisture and temperature are the factors which ‘sort out’ species relationships. Shade tolerance has little relevance since stands often lack a closed forest canopy.” Thus, he went on, “On this broadly defined set of sites (hot, dry) uneven-aged management is often the safest, most dependable system for perpetuating forest cover. Indeed, on severe sites it is clearcutting that is likely to result in undesirable compositional shifts.”

Conversely, on moist, productive sites such as the Coast Range, Franklin said he feared not only shade-tolerant conifers, but also shrubs and herbs, winning out over shade-intolerant species in uneven-aged silviculture. There is, he wrote, “clearly a class of sites where shrub and herb competition can make regeneration of any tree species difficult thus limiting potential for uneven-aged management.”

Selection cutting is an excellent harvesting method for hot and dry forests.

Intensive management might overcome these constraints, Franklin argued, but practitioners of uneven-aged silviculture would also have to confront such practical problems as:

- the costs of harvesting in small groups
- the costs of silvicultural treatments to maintain the Douglas-fir component of mixed stands
- the damage done to residual trees in felling and yarding out large trees selected for harvest
- soil and watershed damage associated with greater densities in roads and more frequent stand entries
- possible reductions in yields.

To underscore this series of points, Franklin said, "We know that it is technically possible to regenerate and grow Douglas-fir in patch cuts of 1/4 to 1 acre in size. Economically and environmentally the costs are too high on ordinary forest lands, however."

Hamish Kimmins, a Canadian forester, echoes some of Franklin's observations:

> Selection cutting is an excellent harvesting method for hot and dry forests, and may be the most appropriate system for some snow-dominated subalpine forests where regeneration in clearcuts is difficult and advance regeneration is the appropriate system of forest renewal. Selection harvesting works best where trees are not too large and the forest already has an appropriate range of tree sizes and ages.

Potential Benefits and Trade-offs

As Emmingham points out, uneven-aged silviculture can be a useful form of silviculture on gentle slopes where an owner wants to produce a steady and predictable flow of logs while maintaining forest complexity and aesthetic appearance. Other benefits that he cites include lower and more evenly spread regeneration costs, the opportunity to cultivate larger trees and higher quality wood, and improved habitat for some wildlife species.

As we can see from the citations above, it does not necessarily make sense to substitute uneven-aged silviculture for even-aged silviculture in most commercial forests in western Oregon. Moreover, it would be a mistake to assume that uneven-aged silviculture is more friendly to a forest ecosystem than even-aged management. In a paper on the role of uneven-aged silviculture in ecosystem management,[18] James Guldin reminds us,

> Some fundamental distinctions between nature and operational silviculture will

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[18] Guldin, James M. "The Role of Uneven-Aged Silviculture in the Context of Ecosystem Management." *Western Journal of Applied Forestry*, January 1996.

> always exist, and these limit the ability of the silviculturist to imitate certain natural conditions. The basic practical distinction is that silviculture typically results in trees being cut, hauled from the woods, and sawed into boards. Harvesting trees is just as important to the traditional practice of uneven-aged silviculture as it is to even-aged silviculture. In addition, foresters typically retain more or less regular intervals of stand entry to improve the spatial and temporal growth patterns of stands. Frequent entries are just as important, if not more so, in uneven-aged silviculture than in even-aged silviculture. Since stand entry often has untoward ecological side effects such as road construction, erosion, and soil compaction, uneven-aged silviculture is certainly not free of negative impacts and cumulative effects that require amelioration.

The literature also suggests that uneven-aged silviculture is not easy. In fact, it requires more forestry skill and attention, and more frequent forest intervention than even-aged silviculture. An owner is often harvesting trees, either individually or in small groups, and must always be attentive to regeneration where trees are removed, either through natural seeding or transplanting. Periodic harvesting is required not only to remove market-ready trees, but also to maintain desired spacing and mix of tree sizes and age classes.

If confused with conscientious uneven-aged silviculture, selective cutting also harbors the potential to abuse the long-term health of a forest. This can happen when an owner, usually for short-term economic gain, practices high grading. Cutting only the largest and most valuable trees leaves inferior, smaller trees behind.

Growth and Yield

It isn't known whether uneven-aged or selective silviculture can be economically productive in western Oregon on a large commercial scale. Even-aged management has been so productive that uneven-aged commercial forests are virtually nonexistent in the region. In the paper cited above, Guldin found that uneven-aged production of southern pine over a 36-year period, was competitive, under some circumstances, with even-aged silviculture pine production. Study stands of loblolly-shortleaf pine grown under an uneven-aged approach, produced only about two-thirds the merchantable cubic volume typical of even-aged plantations. However, the data show that sawtimber cubic volume and board foot yields from uneven-aged stands compare favorably with even-aged sawtimber yields. Whether similar results could be achieved in the Douglas-fir region is uncertain, given differences in climate, topography, and species.

Guldin notes that uneven-aged silviculture in the south can be financially more viable than even-aged silviculture, depending on a variety of factors, such as stand stocking levels and the cost of capital. He observes, for example, that the forest products industry owns 4.4 million acres of timberland in Arkansas and manages 750,000 acres, or 17 percent, using uneven-aged silviculture. "This would not be the case," he argues, "if the method were not able to achieve industrial timber objectives in an economically robust manner."

10. ENVIRONMENTAL ISSUES

Forests represent a significant and complex component of our natural environment. They are composed not only of trees, but of shrubs, herbs, grasses, fungi, and thousands of micro-organisms, insects, other invertebrates, and vertebrates that all interconnect in countless ways in both physical space and span of time. Trees dominate the forest and define the landscape. They create habitat for wildlife. They consume carbon dioxide, store energy, and release oxygen. Over long spans of time their composition changes as species struggle to survive, come to dominate, grow old, die, and are succeeded by similar or other species.

Forests are dynamic systems, the product of periodic and sometimes catastrophic disturbances.

Even left alone, forests are anything but static. Forests are dynamic systems, the product of periodic and sometimes catastrophic disturbances. Fires, floods, windstorms, insect and disease infestations, landslides, and even volcanic eruptions wipe out pieces or whole tracts of forest. Natural disturbances alter resources needed by plants and animals, benefitting some and depriving others. Consequently, some species in a given area flourish in the aftermath of a disturbance. Others falter for a time or temporarily disappear from the area.

Forests have an intricate relationship with water. They encompass the headwaters of most drainage systems. They consume water, retain it in snowpack, and filter it. Portions of forests can be swept away by erosion and landslides. Slides filled with broken trees can scour stream channels or fill them with debris that enriches habitat for fish. Trees shade streams, cooling water for fish and other aquatic life. If they die and topple in, they add structural complexity to stream beds, as well as nutrients to the food chain.

This would all occur if humans were not around and silviculture did not exist.

The Human Factor

Humans add another dimension to forest life, and a great deal of this is in the form of commercial forest management. Human intervention is manifested in fire prevention, in road building, and in growing, thinning, and harvesting trees. Before modern times in Oregon, before silviculture as now practiced, timber operations included running railroad lines into the woods to extract timber, building splash dams to flood logs downstream, clearcutting entire drainage basins, often burning those same landscapes deliberately, and leaving regeneration entirely to nature.

Such exploitation is only a dim memory today. Ecosystem values have become a more integral part of forest management in general and silviculture in particular. Forest managers are more concerned than ever about not only the sustainability of commercial timber, but also the long-term health of the forest environment and noncommodity values. Oregon forest owners are more aware of the need to maintain *forest legacy*. This is the thread of continuity that binds together succeeding generations of organisms and their habitat. In providing forest legacy as they harvest and regenerate forests, owners are increasingly taking care to leave enough forest elements intact to hold and filter water, to provide habitat for wildlife and fish, and to encourage species diversity. Such ecosystem values are woven by law into forestry practice on private timberlands through the Oregon Forest Practices Act. As discussed earlier, the OFPA governs nearly ever aspect of forest management – harvesting, regeneration, road building, protection of environmentally sensitive areas, use of chemicals, and so forth.

Despite increased environmental awareness among forest owners and managers, there is still some public concern about the extent to which forest operations and silviculture affect surrounding forest ecosystems. Do forest operations contribute to landslides? How do they affect steams and water quality? Do they accommodate or harm wildlife? Do forest practices affect declining salmon populations? What is being done by forest owners to stem these declines?

The following sections attempt to answer these and related questions. In some cases, there are answers, and in others, only more questions. A great deal has been learned about the components of forest ecosystems and their relationship to forest practices. But because these systems are so complex, there is still much we don't know and much that we need to probe further.

11. FOREST MANAGEMENT AND LANDSLIDES

The factor associated most closely with slides during storms is steep terrain.

Landslides in mountainous terrain are part of a natural geologic process. Thousands occur every year in Oregon forests, particularly during the wet winter season. Most of them take place on remote slopes unnoticed and undocumented, but they happen more frequently and massively during heavy or prolonged storms, especially on steep or unstable terrain.

Occasionally, as happened in 1996, landslides destroy homes and take lives, vaulting them to the forefront of discussions about public safety. Human activities can and frequently do accelerate the incidence of landslides. Because destructive landslides sometimes occur on managed forestlands, questions inevitably arise about the role that forest practices might have in destabilizing slopes. Most of this discussion has centered on clearcutting and forest road building.

Unusually heavy storms in February and November of 1996 triggered what authorities estimated to be "tens of thousands" of landslides in western Oregon, along with extensive flooding. Slides that entered swollen streams contributed to fast moving flows of water, mud, rocks, and broken trees that choked stream beds with debris in some places and scoured new or altered channels in others. Some roads were blocked and several municipal water supplies were contaminated by sediment. In the November storm five people were killed in landslides in Douglas County.

The destruction prompted the Oregon Department of Forestry early in 1997 to launch the largest ground-based site study ever undertaken to determine the relationship of landslides to forest practices.[19] This was also the first study to examine landslides in managed forests of various ages. ODF staff inspected 52 square miles of forestland, 136 miles of stream channels, and 170 miles of roads. In the process, it documented roughly 600 landslides. Because the ODF study was prompted chiefly by concerns about landslides and public safety, it focused on landslides. However, it also touched on erosion and flooding as other issues connected to the interaction of forest practices and heavy rainstorms. In the absence of longitudinal studies, the ODF study provides the best perspective available to date on landslides in western Oregon forests. Its findings, however, must be viewed with caution because they focus on the results of unusually severe storms in a short time period rather than more typical winter rains.

As the ODF study was getting under way, Gov. Kitzhaber commissioned a task force of forest scientists from Oregon State University to examine pertinent literature on

[19] Robison, E. George, Keith A. Mills, Jim Paul, Liz Dent, and Arne Skaugset. *Storm Impacts and Landslides of 1996, Final Report*. Oregon Department of Forestry, Salem, OR 1999.

"It appears that clearcut silviculture usually results in an increased short-term occurrence of landslides relative to similar forested areas."

landslides and forest practices and to present a separate perspective on the issue.[20] This inquiry included a review of the ODF study and its preliminary findings.

The ODF study suggests that the factor associated most closely with slides during heavy storms is steep terrain. Most of the landslides in 1996 were found in what the research team called "red zones," areas hit hardest by rains (in some cases, 20 inches in five days) and usually on very steep slopes. In the red zones, almost 80 percent of the landslides that entered streams occurred on slopes greater than 70 percent. A slope of 70 percent drops (or rises) 70 feet for every 100 feet of lateral distance away from a point along a fall line. No landslides entered streams from slopes under 40 percent.

Harvesting and Slides

While slope steepness was the most significant factor in landslides, the ODF study found high correlations between recent harvesting and slides, and between forest roads and slides. Landslides occurred more often in clearcut areas, in fact, slide frequency increased by a factor of two to four in three out of four red zones where clearcutting had occurred within nine years. Still, many clearcut areas were untouched by slides and thousands of landslides occurred in mature forests (those more than 100 years old). The lowest incidence of slides, in fact, occurred in second growth forests between 10 and 100 years old.

One of the most significant findings of the study lay in its own methodology. As a ground-based study, it found a much higher incidence of landslides in mature forests than has been reported in previous studies that relied on aerial photography. Forest canopy, viewed from the air, can hide landslides in mature forests.

In regard to silviculture, the OSU task force concluded in its preliminary report,

> ...it appears that clearcut silviculture usually results in an increased short-term occurrence of landslides relative to similar forested areas. This increased landslide density occurs on the most landslide-prone terrain – that terrain most prone to landslide activity even in the absence of timber harvesting – and the increase is manifested primarily during large, landslide-producing storms during the first decade after harvesting.

Forest Roads and Landslides

The OSU panel observed that forest roads have long been a significant contributor to landslides, and that they "undoubtedly remain a significant source of landslides in steep terrain." However, they also noted that forest roads built under newer forest practices rules resulted in smaller and fewer slides than indicated by previous studies. Newer roads

[20] Pyles, Marvin R., Paul W. Adams, Robert L. Beschta, and Arne E. Skaugset. *Forest Practices and Landslides*. Forest Engineering Department, Oregon State University, Corvallis, OR, 1998.

are built, when possible, along ridge lines rather than mid-slope locations, and when they are built on slopes, the road bed is cut from the hillside in a full bench rather than built on fill pushed to the side away from the cut in the slope. Newer roads are also built with drainage systems better designed to channel surface water and minimize erosion.

Roads built under newer forest practice rules resulted in fewer and smaller slides.

The OSU team cited several problems typically associated with forest roads.

> When roads are built into steep, marginally stable hillslopes, the effective steepness of the local slope is increased, resulting in a less stable condition than the natural hillslope. In addition, roads locally intercept and reroute groundwater flow, surface flow, and precipitation, which can result in local instability of portions of road fills and the hillslope below the road. Finally, even well-designed and well-maintained road drainage components (e.g., roadside ditches, cross-drain culverts, rolling dips, etc.) will experience some failures between maintenance cycles that can cause water to flow toward marginally stable hillslope areas.

A 1987 study in the Siuslaw National Forest suggested that improved road location, design, and construction practices resulted in lower landslide frequency and size than older road-building practices, but that study did not have an opportunity to compare newer and older roads in similar settings. The 1996 storm gave the OSU panel that opportunity. Although the panel did not have a quantitative survey of road performance relative to landslides in the 1996 storms, it did gather substantial anecdotal information. "Discussions with researchers studying this subject and with road maintenance personnel on both state and private forestland indicate that contemporary roads fared better than the older standard roads during the February 1996 storm," the panel reported. That conclusion has since been buttressed by road survey data.

It is important to emphasize that both the ODF study and the OSU review of landslides and forest practices were still works in progress at the end of 1998. Both were scheduled for peer review about that time, so neither had been published in final form. Although both investigations are very comprehensive, both caution that more field research is needed.

In a joint presentation that they made in January 1998 on the progress of their efforts, the ODF study team and the OSU panel noted that the state forester would exercise authority granted by legislation to prohibit harvesting and road construction on high-risk sites above residences and well traveled public roads. The common characteristic of all such sites is steep terrain with marginally stable soil.

Silviculture Implications

No comparative analysis of silviculture systems and landslides can be made from either the ODF study or the OSU review because virtually all of the silviculture in western Oregon is even-aged. Both research reports noted that a silviculture treatment called a "headwall leave area" employed in a 1997 study in the Mapleton area did not clearly demonstrate its effectiveness in containing slides on steep slopes. In this study, under the auspices of Oregon State University, slide frequency was compared on headwalls (steep slopes) where stands were left in place, were clearcut, or were clearcut with leave areas (that is, areas with significant groupings of trees left standing). There was apparently no statistical difference in landslide occurrence between mature forests, leave areas, and clearcuts. The OSU panel commented, "this study compared different time periods between treatments, but adjustment for this bias cannot result in a conclusion that the headwall leave area treatment, intended to maintain the forest condition and presumably the forest landslide rate, was successful."

It is difficult to say whether uneven-aged silviculture might result in fewer or smaller forest landslides. Given the comparative data of the ODF study on slides across stand age classes, it might be argued that uneven-aged stands on steep slopes would be less susceptible to slides than plantation stands up to nine years old. However, they would still be highly susceptible during heavy or prolonged rains, where slope steepness and water volume are the principal controlling factors.

The OSU panel also speculated that the more extensive road system required by uneven-aged silviculture might create as many slide problems as uneven-aged silviculture is able to mitigate within a stand. "Since road-related landslide rates can be expected to be greater than in-unit, clearcut-associated landslide rates" the OSU panel noted, "the potential increase in road-related landslides from partial cutting could diminish any overall benefit from a decrease in in-unit landslides."

12. FOREST MANAGEMENT AND STREAM SYSTEMS

At a watershed level, stream flow increases from logging are negligible.

Oregon is a maze of contiguous and often interrelated watersheds. These form a massive drainage system both above and under ground in which water from rain and snow falls onto terrain and plants, soaks into the soil, and runs off into a network of streams that grow larger as they flow downhill and merge. A portion of this water runs back to the ocean. A portion of it is taken up by plants, which release it back to the atmosphere through transpiration from foliage surfaces. Some of it evaporates directly from soil, streams, and still water. A small fraction is consumed by wildlife and people.

Because forests cover so much of Oregon's land, most streams originate in or pass through forestland, particularly in the western portion of the state. So, forest use and management are often linked to water issues. Debates over such matters as domestic water supply, erosion, flooding, water quality, and fish habitat invariably touch on forest practices.

The relationship of forest practices to fish habitat will be taken up in a later section. This section deals with forest management and its relationship to stream flows, erosion, flooding, and water quality.

Because of public interest in these matters, OFRI in 1993 commissioned an extensive review of research on the effects of logging and forest roads on water quantity and quality in the Pacific Northwest. These studies, relevant to Oregon, were reviewed and summarized by Paul Adams and Jeanette Ringer.[21] What they found in nearly 100 research reports forms the bulk of what is summarized here. Findings from others are included where pertinent.

Forest Practices and Stream Flows

As context to the Adams and Ringer summary, it is useful to note that the quantity of water that drains through a watershed is determined primarily by seasonal levels of rain and snow. However, trees and other vegetation do have an influence on water levels in soils and streams because their canopies intercept some precipitation and they require a good deal of water to live. Generally, they take up the least amount of water in the winter, their dormant season, when rain and snow are most plentiful, and they take up the most in the growing season, when precipitation is much lower. During the winter, little precipitation intercepted by foliage is lost to the atmosphere due to cool temperatures and high humidity.

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[21] Adams, Paul W., and Jeanette O. Ringer. *The Effects of Timber Harvesting & Forest Roads on Water Quantity & Quality in the Pacific Northwest: Summary & Annotated Bibliography*. Forest Engineering Department, Oregon State University, Corvallis, OR, 1994.

As the research shows, the removal of trees through logging can result in measurable localized stream flow increases. But Adams and Ringer point out that such effects are negligible at a larger watershed scale. "Usually no obvious flow change is expected [from logging]," they note, "because only a small portion of a watershed is harvested during individual logging operations. This is especially true for the larger stream and river basins where water supply may be a concern."

Under contemporary forest practice rules, major portions of watersheds may not be harvested at one time. However, where large sections were harvested in the past and stream flows were studied, the results were sometimes (though not always) pronounced. In their summary, Adams and Ringer observe,

> When a sizable area of a watershed is logged (e.g., more than 15 or 20 percent of the forest canopy removed), streamflow typically increases. Water losses through uptake and evaporation by forest cover generally is greater than with any other type of plant cover or land use, so when logging removes the forest canopy more water is available to add to streamflow. Because this relationship was generally understood many decades ago, many of the original forest watershed studies in the U.S. actually were designed to evaluate possible opportunities for increasing water supplies through timber harvesting practices.

While such harvesting has an obvious local effect, it is temporary. Adams and Ringer note,

> Streamflow increases after logging generally become smaller with time, eventually disappearing when the canopy of the replanted forest begins losing as much water to the atmosphere as the original forest. This may take about 20-30 years in western Oregon, and perhaps 40-60 years in eastern Oregon. Most of the increase in streamflow after logging seems to occur during the rain or snowmelt seasons, so reservoir or other storage generally is needed to benefit water supply.

Adams and Ringer explain that there is one particular but rare circumstance where logging of an area can decrease stream flow. That is the case where forests in foggy microclimates intercept fog and drip moisture to the ground. In instances where fog-drip stands are removed, stream flows decrease with the absence of the forest to capture fog moisture. In a study of a small basin in the Bull Run Watershed, where this decrease occurred after harvesting, stream flows returned to previous levels within a few years as vegetation regrew in the logged area and the fog-drip process resumed.

Forest Practices and Flooding

Adams and Ringer found no evidence in the research that logging causes downstream flooding, although peak flows may increase in the rain or snowmelt season in small, upland watersheds where logging has occurred. “Large floods that cause serious property damage and other problems normally occur simply when an extended period of very heavy rains adds too much water for soils and streams to absorb,” they write, “regardless of land use.”

They reached much the same conclusion about the impact of forest roads.

> Only a few studies have evaluated the effects of forest roads on streamflow separately from timber harvesting effects. Some studies have shown no effects of roads, while others found that forest road construction increased peak flows in small, upland watersheds. In these locations, streamflow effects appear to be directly related to the total area within the watershed of roads and other heavily compacted surfaces that are relatively impermeable to water. In larger watersheds, little or no effect on streamflows is expected because forest roads and other impermeable areas on forestlands typically represent a relatively small area.

Several studies have been published since the Adams and Ringer review in 1994, including some that have fueled new scientific debate about forest practices and streamflows. However, a body of research has yet to emerge that supports a significant departure from the 1994 findings.

Forest Practices and Water Quality

Stream water quality is defined by a variety of physical, chemical, and biological characteristics. Physical characteristics include temperature, clarity, and sediment levels. Water chemistry is defined by such factors as dissolved oxygen, nutrients, and the levels of manufactured chemicals that may be present. Biological factors include levels of bacteria, algae, and insect life. Water quality standards differ for such uses as domestic water supply, fish habitat, and irrigation. The highest standards apply to water used for drinking.

Adams and Ringer found that research on the effects of timber harvesting and water quality has focused primarily on physical and chemical characteristics. For example, under earlier practices no longer allowed, where logging removed streamside trees and other shady vegetation in entire basins, stream temperatures increased with direct exposure to sunlight. Earlier logging methods and removal of streamside trees also contributed to higher sediment levels. Timber harvesting appears to have had little or no effect on water chemistry, even with historical logging practices no longer permitted. Studies reviewed by Adams and Ringer showed no changes or relatively small increases in dissolved nutrients and other constituents, and they did not adversely affect water quality. Nutrient increases that did occur generally declined after vegetation returned.

Forest Roads and Water Quality

Adams and Ringer note that studies of forest roads and water quality in the Pacific Northwest have typically focused on stream sediment from erosion. The studies show that sediment from erosion tends to occur in streams during major storms shortly after road construction. Most of the studies, they explain, pertained to roads built in the 1960s and '70s, prior to the mandates of the Oregon Forest Practice Rules. Where improved road location and design have been used, they observe, less erosion has been reported. Similarly, they add, a significant number of forest roads that were constructed to support older logging systems would not be needed with newer harvesting technologies. Today, improved location, engineering, drainage systems, landscaping, and maintenance eliminate or mitigate erosion problems that were common decades ago due to forest roads.

13. FOREST MANAGEMENT AND WILDLIFE

Commercial forest operations, including silviculture practices, affect wildlife habitat. But the most current science indicates that commercial forest operations in Oregon do not pose a serious threat to any terrestrial wildlife species.

"The worst possible approach to maintain vertebrate diversity would be to manage every acre the same way, or to have a large forest of a single age class."

In a peer-reviewed study[22] commissioned by the Oregon Forest Resources Institute, Dr. Fred Bunnell, a respected conservation biologist, examined the impact of forest practices on wildlife in Oregon, particularly on private timberlands. He concludes,

> There is no evidence that current forest practices immediately threaten any terrestrial vertebrate species in Oregon; current conservation measures appear adequate for species known to be vulnerable to forest practices (e.g., northern spotted owl, marbled murrelets). Many species designated "at risk" in Oregon are at risk primarily because of agricultural practices and consequent urbanization.

This conclusion assumes that federal forests will continue to provide a significant amount of mature forest habitat.

While Bunnell sees no immediate threat, he cautions that there are reasons to be concerned and vigilant about future conditions. This paper will return to those concerns presently. First, it looks at the broad influence of forest practices on wildlife habitat.

Both Natural and Human Events Affect Wildlife Habitat

More than 300 species of terrestrial vertebrates – birds, mammals, reptiles, and amphibians – inhabit Oregon's forests during their breeding season. All of them depend on forests in various ways for shelter and food. Because changes in the structure and composition of forests affect the survival requirements of various creatures, natural disturbances, such as floods and windstorms, impact forest habitat. So do forest management activities, ranging from fire suppression to harvesting to replanting. Even without disturbances, the natural cycles of growth, death, and regeneration in a forest create conditions favorable to some wildlife species and unfavorable to others.

Silviculture practices principally affect the structure and composition of vegetation that provides food and shelter to wildlife. Any alteration in a stand of trees, whether thinning of young trees, partial harvesting of mature trees, or clearcutting, will affect wildlife in a variety of ways. At the stand level, what improves habitat for one species may alter or remove habitat for another. However, because wildlife is established over entire forest

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[22] Bunnell, Fred L., Laurie L. Kremsater, and Ralph W. Wells. *Likely Consequences of Forest Management on Terrestrial, Forest-Dwelling Vertebrates in Oregon*. Centre for Applied Conservation Biology, University of British Columbia, Vancouver, BC, 1997.

landscapes, it makes sense to look at forest practices and their impact on wildlife from a landscape perspective.

From a landscape point of view, Oregon's forests offer substantial diversity to wildlife. On the westside, extensive tracts of federal forest consist of very old trees and associated structures such as snags and decaying logs on the forest floor, as well as second growth in various age classes. Private forests, which are managed more intensively, form a mosaic of even-aged stands and different species, ranging from newly replanted clearcuts to 70-year-old second growth. Variation in stand structure is attained by thinning, pruning, and retention of wildlife trees and downed logs. On the eastside, where partial cutting is the dominant harvest method, forests tend to have a variable structure, or a mixture of species and age classes.

Bunnell believes these landscape-level variations are a plus for forest-dwelling species. "Because vertebrates have diverse life styles," he writes,"the worst possible approach to maintain vertebrate diversity would be to manage every acre the same way, or to have a large forest of a single age class."

Bunnell goes on to note that some species thrive in recently cut over stands while others do well in more mature stands. Still others may require both. "Many species are generalists and do well in stands spanning a wide range of ages or structures," he writes. "In fact, stand age alone is a poor indicator of habitat for vertebrates."

How Silviculture Alters Habitat

James A. Rochelle, a forestry wildlife consultant, has described in time-lapse narrative how the development of a forest after a stand-clearing disturbance alters habitat for wildlife in western Oregon. This is a general description. The way that a mature stand is removed, say by clearcutting or wildfire, will result in specific habitat variations.

Loss of a mature stand removes habitat for species such as the ruby-crowned kinglet and the sharp-shinned hawk, and for small mammals such as the red tree vole and flying squirrel that nest or feed in the forest canopy.

In the resulting opening, while seedlings are getting established, the stand goes through a *grass-forb*, or weedy, stage that supports species such as deer and elk and seed-eating birds. Typical birds include ground nesters such as blue grouse, the dark-eyed junco, and several species of sparrow.

This stage gives way to the *shrub-sapling* stage, which is also attractive to deer and elk, small mammals such as shrews and voles, and shrub-nesting birds. These include the spotted towhee, several species of wrens and warblers, and the American goldfinch.

As conifers begin to dominate the site and as the canopy closes, diversity in vegetation declines, and, with it, diversity in wildlife. This *sapling*, or *sapling-pole* stage, lasts as long as several decades. Associated wildlife species include the snowshoe hare, bobcat, chipmunk, Stellar's jay, and several species of salamander and warbler.

As the stand develops, individual tree mortality and the loss of lower limbs results in a more open canopy and the return of some shrubs. Thinning can accelerate this process. Shrubs and the snags left by dead trees provide habitat for an increasingly diverse wildlife community. This *mature* stage of stand development is associated with several species of wrens, warblers, owls, hawks, band-tailed pigeons, salamanders, and mammals such as the Douglas and flying squirrel and several species of vole.

Further development of the stand leads to *old-growth* conditions – large trees, a high volume of snags and downed wood, frequent canopy openings, and well-developed shrub and mid-story vegetation. This results in high habitat diversity and more diverse wildlife. Large limbs, large tree cavities, and broken tops provide nesting sites for sensitive species such as the northern spotted owl and the marbled murrelet.

In western Oregon where even-aged silviculture is common, stages of stand growth correspond closely with some species of wildlife and generally with others. Table 4 describes this in more detail.

Table 4. Wildlife Species Associated With Stages of Conifer Growth. *Source:* Forestry and Wildlife, *special report by Oregon Forest Resources Institute, 1999.*

Young Open Stands	Middle Age Stands	Older Stands
These stands have recently been disturbed by wind, fire, or clearcutting. They are in the early stages of regenerating and are characterized by tree seedlings or saplings, along with a variety of herbs and shrubs.	At this point, trees have grown to the point where thinning or natural crowding have eliminated smaller, weaker trees, the canopy has opened up in places, and ground vegetation and an understory have begun to be established	These stands are characterized by larger trees, a more varied and complex canopy, and a more highly developed understory with large amounts od downed wood and snags.
Animals Closely Associated: striped skunk badger common nighthawk mountain bluebird American goldfinch creeping vole chipping sparrow northern pocket gopher mountain beaver deer mouse dusky flycatcher western jumping mouse MacGillivray's warbler fox sparrow Lazulli bunting spotted towhee	**Animals Generally Associated:** snowshoe hare ruffed grouse sharp-shinned hawk Townsend warbler band-tailed pigeon black-throated gray warbler bushy-tailed woodrat Swainson's thrush gray jay Douglas squirrel Cooper's hawk long-tailed weasel marten black-tailed deer chestnut-backed chickadee Pacific-slope flycatcher red-breasted nuthatch hermit warbler Wilson's warbler Ensatina salamander common garter snake rubber boa Pacific tree frog winter wren Roosevelt elk coyote raccoon cougar bobcat northern alligator lizard long-toed salamander	**Animals Closely Associated:** marbled murrelet varied thrush pileated woodpecker pygmy nuthatch Vaux's swift spotted owl red tree vole northern goshawk northern flying squirrel Oregon slender salamander Cooper's hawk pine siskin hoary bat
Animals Generally Associated: black bear red fox black-tailed deer song sparrow dark-eyed junco American robin Ensatina salamander long-eared bat common garter snake rubber boa Roosevelt elk coyote raccoon cougar bobcat northern alligator lizard		**Animals Generally Associated:** fisher marten black bear spotted skunk brown creeper Myotis bats Douglas squirrel red-breasted nuthatch chestnut-backed chickadee Ensatina salamander Pacific-slope flycatcher hermit warbler rubber boa Pacific tree frog Roosevelt elk coyote raccoon cougar bobcat northwestern garter snake winter wren black-tailed deer black-backed woodpecker

Managing for Wildlife Goals

Because the composition and structure of a forest is more important to wildlife habitat than the age of a forest, timberland owners have the means to incorporate wildlife goals in their silviculture practices. At the landscape level, whether practicing even-aged or uneven-aged management, they can be sure to maintain a mix of stand sizes and

The method of harvesting trees is less important than what is left behind.

structures. With scheduled thinning they can create canopy openings that accommodate more diverse understory vegetation, which, in turn, supports a greater variety of wildlife species. During harvesting, whether clearcutting or selective cutting, they can enrich habitat in a variety of ways. They can create or retain snags, leave live trees, and make sure that both the harvested area and nearby streams have a significant amount of downed logs and other woody debris.

In other words, Bunnell believes, the method of harvesting trees is less important than what is left behind. Still, in regard to silviculture practices, he suggests additional research is needed on the amounts, sizes, types, and distribution of trees that should be retained during clearcutting and partial cutting. In particular, he is concerned that trees being left are too small to produce enough large snags and downed wood in the future, which may pose a threat to some species.

Habitat Fragmentation

Forest fragmentation is the reduction and separation of patch sizes of forests. There are widely held views that fragmentation of forests, absent connecting corridors of trees, is a threat to species diversity and abundance. These assumptions are derived from more general views among scientists about habitat fragmentation and from studies conducted in the East and Midwest where forestland was fragmented by the conversion of surrounding land into permanent urban and agricultural use. Pacific Northwest forests are not fragmented in this sense because they remain dedicated to forest use, and because they are always in some stage of forest growth. In regard to western forests, the conversation about fragmentation has treated stands of mature trees as fragments isolated by clearcuts.

Bunnell said there is little evidence in western American forests that fragmentation, as described above, has been a problem for wildlife. In western forests, research has found that for some bird species, the amount of available habitat is more important than its distribution. Neither does there appear to be evidence that forest fragmentation, as defined above, has seriously affected mammals. "The effect of fragmentation appears largely dependent on the intervening land use," he wrote. ""Where that use is growing forests the effect is much less evident."

In November 1998, Bunnell and other wildlife scientists participated in a conference co-sponsored by a diverse range of organizations to look more closely at forest fragmentation and its implications for wildlife and forest management in the Pacific Northwest. More than 300 people with different affiliations attended. The paper that summarized the findings of the conference found,

> Leaving relatively small amounts of residual structure (e.g., shrubs, snags and decaying wood), after harvest apparently makes the area between habitat patches (the "matrix") more hospitable, so that movement and dispersal can

continue. Finally, there is general agreement that the total amount of habitat is of greater significance to vertebrate survival and reproduction than its configuration, and that habitat loss should be a higher conservation priority.

14. FOREST MANAGEMENT AND SALMON

Wild Pacific Northwest salmon are in trouble. Millions of the migrating fish once teemed in Oregon's coastal and Columbia Basin streams. Despite the remarkable resilience of salmon, many of these ancient runs are extinct, and most of those left are in decline.[23] In 1998 Oregon coho salmon were declared threatened under the Endangered Species Act.

Salmon decline stems from both natural and human causes, but seems to have intensified over the past century and a half of human influence.

According to the National Research Council, "Pacific salmon have disappeared from about 40 percent of their historical breeding ranges in Washington, Oregon, Idaho, and California over the last century, and many remaining populations are severely reduced. Most runs that appear plentiful today are largely composed of fish produced in hatcheries."[24] A task force of the Oregon Business Council summarized the problem in different but equally grim terms: "The natural productivity of Pacific salmon in the northwest has declined by about 80 percent. Several populations have gone extinct, and in Oregon some coastal stocks are at 10 percent or less of their historic abundance."[25]

Dimensions of the Problem

There are six species of migrating salmon present in Oregon waters: chinook, coho, sockeye, chum, and steelhead and sea run cutthroat trout. They are all anadromous, which means they can live in both fresh and salt water. They hatch as fry in fresh water streams, live in their spawning waters up to a year, migrate to the ocean, grow there six months to seven years, and then return as adults by a homing capability to their point of origin to reproduce by spawning. In spawning, females lay eggs in gravel beds which males then fertilize. Steelhead and sea run cutthroat trout can do this more than once, but chinook, coho, chum, and sockeye die shortly after spawning.

Upland forests are now one of the last good sources of habitat for wild fish stocks.

Salmon decline is complex. It stems from both natural and human causes, but seems to have intensified over a century and a half of settlement, population growth, and human economic activity. That activity has blocked, destroyed, or damaged spawning beds and rearing habitat, or it has reduced fish populations on their migratory path. Since this path is so extensive, sometimes beginning hundreds of miles inland and then extending hundreds or even thousands of miles more out to sea, salmon run a gauntlet of perils. In a 1995 report on the condition and prospects of Pacific salmon, a team led by Daniel B. Botkin noted, "Salmon depend heavily on the biological and physical conditions in their

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[23] A *run* or *stock* of salmon is a term that applies to a specific species that migrates in a particular season within a particular watershed or group of related watersheds. Several runs of a species may be extinct, while others are depleted and yet others might be stable or increasing.

[24] *Upstream: Salmon and Society in the Pacific Northwest*. Committee on Protection and Management of Pacific Northwest Anadromous Salmonids, National Research Council. National Academy Press, Washington, DC., 1996.

[25] *A New Vision for Pacific Salmon*. Oregon Business Council, Portland, OR, 1996.

spawning and migratory streams and must survive a virtual 'mine field' of human and environmental threats to complete their life cycles."[26] Past the human phase of this gauntlet, salmon face formidable threats in the open ocean. A sustained period of warmer-than-usual ocean currents, for example, can interrupt the natural food chain upon which salmon depend for ocean survival. The Botkin team notes that the variability in species and behavior of salmon also adds to the difficulty of pinpointing the causes of their decline: "The great complexity of the lives of salmon, the many habitats they use, and the different way each species uses these habitats would suggest that it is unlikely that the same, single factor will be the cause of all declines." For example, they say, chum spawning seems unrelated to forest practices, but might be affected by other practices in lower rivers and estuaries where chum spawn and rear, including gravel removal, agricultural pollution, flood control measures, channel modification, or over fishing.

The effects of both earlier and current human activity persist to imperil salmon populations, primarily in the form of degraded or altered stream habitat and adjacent landscapes. As shown in Table 5, the list of hazards to salmon survival is long. There are hundreds of dams, for example. These range from giant hydroelectric plants to small irrigation projects. Most of the big dams are on the Columbia-Snake river system. Some of these dams, which are impassable to fish, have blocked off thousands of miles of spawning habitat. Others that are passable raise the mortality of juvenile fish on their way to the ocean, or they impede the return of adults. Urban development has removed or damaged spawning and rearing habitat. So have farming and livestock raising in a variety of ways.

Forestry once damaged spawning habitat and riparian structures with such practices as splash damming and logging to the edge of stream banks, but those practices ended decades ago. Even state agencies damaged stream spawning and rearing habitat in the 1960s and '70s with the well-intentioned but misguided assumption that stream channels should be cleared of downed trees other woody debris. Although hundreds of streams were made less habitable to fish by such practices, at least for a time, upland forests are now one of the last good sources of habitat for wild fish stocks. Urban development, agriculture, and dams have eliminated, destroyed, or impaired major spawning areas on or adjacent to lower flood plains and valleys.

Propagation of hatchery salmon to replace depleted natural populations also appears to be a part of the problem. Oregon has an extensive system of hatcheries, and hatchery fish make up a major proportion of state fish populations. However, the National Research Council reports that hatchery fish have "reduced genetic diversity within and

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[26] Botkin, Daniel B., Kenneth Cummins, Thomas Dunne, Henry Reigier, Matthew Sobel, and Lee M. Talbot. *Status and Future of Salmon of Western Oregon and Northern California: Overview of Findings and Options*. The Center for the Study of the Environment, Santa Barbara, CA, 1993.

between salmon populations, increased the effects of mixed-population fisheries on depleted natural populations, altered behavior of fish, caused ecological problems by eliminating the nutritive contributions of carcasses of spawning salmon from streams, and probably displaced the remnants of wild runs."

Table 5. Factors That Have Diminished Salmon Populations. This is not an exhaustive list, but it does suggest the complexities of the issue.

Cause	Primary Effects
Loss or Degradation of Spawning and Rearing Habitat	
Dams	• Inaccessible spawning areas (5,000 lineal miles in the Columbia Basin alone)
Urban development	• Spawning beds lost in streams diverted, straightened, or buried • Faster rain runoff, high sediment levels, sewage system overflows • Infill and loss of some riparian areas • Sediment runoffs from construction sites during winter
Farming	• Pollution of streams with soil sediment, fertilizers, and pesticides • Lower water levels, habitat degradation from irrigation drawdowns • Spawning habitat lost in streams straightened or banked with riprap
Dairy farms and livestock raising	• Water temperature increases from shade plants lost to animal foraging • Destruction of gravel beds and banks by large animals in streams • Pollution from animal waste
Mining	• Pollution from refuse • Altered stream structure and higher sediment levels
Dredging	• Altered stream structure and higher sediment levels
Forestry	• Increased runoff from rain on roads or compacted soils • Fish access blocked by lack of culverts or culverts improperly installed • Sediment runoff or landslides in steep areas
Natural disturbances	• Habitat damage or loss from fires, landslides, floods, and mud flows (in some cases, these events add woody material to streams -- such as log jams -- that improve stream structure for habitat)
In-Stream Perils	
Dams	• Juvenile mortality from going through hydroelectric turbines • Disruption in water temperature, flow velocities, and chemistry from hydro operations
Farming	• Mortality from fish entering irrigation waterways that dry up • Alteration in water temperature, flows, and chemistry from irrigation
Sports, Indian fishing	• Loss of returning fish
Ocean Perils	
Current fluctuations	• Interruption of food chain and thus food sources by warm currents (by the same token, upwelling of cold currents can enrich the food chain)
Commercial fishing	• Loss of Oregon salmon off Alaska and Canadian coastal waters
Marine predators	• Mortality from seals, sea lions
Flawed Policies	
Hatcheries	• Overloading of in-stream and ocean resources needed by native salmon • Displacement of remnant native stocks • Reduced genetic diversity in native fish populations • Loss of stream nutrients from spawned out adults
Stream cleanup	• Loss of gravel beds and sheltering pools, and high-water washout of juvenile fish, caused by removal of downed trees and other woody debris

Forestry and Salmon

Although the forest practices most damaging to fish habitat have ended, the relationship of forestry to fish habitat has not. Timberland owners are providing a major share of funding for the Oregon Plan, the Governor's salmon restoration initiative, and they are also participating in numerous fish habitat restoration projects on their own property. In addition, researchers continue to examine some of the subtle and complex correlations between forest landscape management and the health of fish populations. For example, the Botkin team, using satellite mapping, found significant correlations between forest cover fragmentation, clearings, and areas of grass and shrub vegetation "with local extinction of spring and fall chinook, sockeye, and winter and summer steelhead." The Botkin report did not infer from this correlation that the absence of forest cover *causes* natural fish declines, but the correlation invites further study. A variety of proposals are currently in circulation to modify forest practices to afford even more protection to salmon habitat on forestlands.

Other Resource Users and Salmon

Although it may ultimately do even more to protect salmon habitat, the forest products industry, in both law and practice, has already done more than any other land- and water-use group in Oregon to halt or reverse damage to fish habitat. The degree to which commercial forest owners have improved their protection of salmon habitat was described by V. W. Kaczynski and J. F. Palmisano in a 1993 report for the Oregon Forest Industries Council.[27] "On balance," they wrote, "significant protective measures are in place today for forestry to protect water quality and salmonid habitat, more so than for water uses or any other land use."

Among land uses that threaten fish, urban development and agriculture raise far more concern today. In regard to habitat loss in Northwest urban areas, Oregon State University ecologist Stan Gregory observed recently, "The proportion of the streams within the urban areas that are degraded is greater than the proportion of highly altered streams on agricultural, range or forested lands. Though the total urban areas may be small, cities and towns are located at biologically critical positions on major rivers, tributary junctions, and estuaries."[28]

Agriculture, according to Kaczynski and Palmisano, is more responsible than forestry "for the lack of recovery of Oregon's wild anadromous salmonid stocks." Hazards to salmon posed by agriculture include stream flow reductions, stream habitat alterations, irrigation diversions that strand fry, riparian degradation and higher stream temperatures, high

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[27] Kaczynski, V.W., and J.F. Palmisano. *Oregon's Wild Salmon and Steelhead Trout: A Review of the Impact of Management and Environmental Factors*. Oregon Forest Industries Council, Salem, OR, 1993.

[28] "A Snapshot of Salmon in Oregon," tabloid publication by the Oregon State University Extension Service, 1998.

runoff of sediment, pesticides, and fertilizers into streams near farmland. These effects are magnified, they show, because close to 100 percent of agricultural lands are in operation annually (compared to a fraction in forestry), and because flood plain river habitat has been historically more productive for salmon than upland forest streams.

Reduction of rough stream structure and off-channel pools in coastal streams accounts for the greatest loss of winter rearing habitat .

In its status report on Northwest salmon, the Botkin team recommends that authorities "Establish riparian protection rules for agricultural and urban areas similar to those now in use for Oregon forestland. These should include restoration as well as maintenance and monitoring." The City of Portland is now coming to grips with such issues as it faces federal pressure to protect steelhead.

The Numbers Game in Fish Survival

Successful natural production of salmon is a difficult challenge because the odds are stacked against salmon in surviving the minefield of hazards described by Botkin. The survival of salmon is, in fact, something of a numbers game, according to an Oregon Forest Resources Institute report.[29] A pair of returning adults lays about 2,500 eggs, yet only 125 juvenile fish from those eggs, or 5 percent, are likely to make it to the ocean under the best stream conditions.

Most experts seem to agree that the best stream conditions are characterized by complex structures that include downed trees, logs, and root wads that make streams more habitable to juvenile fish. Large woody material blunts or diverts the energy of currents, scouring out pools, creating gravel beds, forming islands and side channels, and protecting stream banks from erosion. Woody material improves habitat for insects, waterfowl, other birds, and small mammals, as well as fish. "Perhaps no other structural component of the environment is as important to salmon habitat as is large woody debris, particularly in coastal watersheds," says the National Research Council report on Northwest salmon. According to Logan Norris, who heads the multidisciplined science panel advising the Oregon Plan, reduction of rough stream structure and off-channel pools in coastal streams accounts for the greatest loss of winter rearing habitat.

The poorer the spawning and rearing habitat, the lower the survival rate of eggs and young salmon. Eggs can be smothered by sediment or swept away. After hatching, fry are vulnerable to being washed downstream by strong currents, to high water temperatures caused by lack of streamside shade, and to predators who can reach them easier where there are fewer complex stream structures to afford hiding places. If fish begin life in poor habitat, only 25 from 2,500 eggs, or 1 percent, may live to enter the ocean.

Whether 5 percent or 1 percent of young fish survive to reach the ocean, only 1 to 10 percent of that number will survive to enter fresh water again. If an average of 3 percent

[29] *Saving the Salmon*. Oregon Forest Resources Institute report, 1998. Technical advice on salmon habitat and survival provided by Tom Nickelson, Oregon Department of Fish and Wildlife.

survives, this means only four fish at best and one fish at worst return to fresh water. And some of these will be taken by sport and commercial fishermen. These attrition scenarios underscore the importance of healthy spawning and rearing habitat.

Stream Protection and Enhancement Measures by Forest Owners

Forest owners can do a number of things on behalf of stream quality, and virtually all of them are. These include minimizing erosion and sediment entering streams and leaving in place forest buffers and structure that enhance riparian areas. These precautions are required by Oregon's forest practice rules. In fact, harvesting near streams that bear fish or provide drinking water requires approval of a written plan by the Oregon Department of Forestry.

Apart from preventing new damage to streams, there is also a need to repair past damage, particularly loss of large woody material. Stream enhancement isn't required by forest practice rules, but it is encouraged, and more and more forest owners are adding woody structure to streams on their property. Retention of streamside conifers required in the forest rules will eventually result in more conifers falling into streams. Riparian conifers are more desirable for a number of reasons. They provide year-round shade, and when they fall into steams, as some do, they decompose more slowly, creating longer lasting stream structure. Scientists also recommend two other riparian measures. The first is to convert some streamside hardwood stands to conifers by removing or thinning hardwood trees and then planting conifers. The second is to "release" established but suppressed conifers among hardwood stands by removing hardwoods.

Forest Owner Stream Enhancement

Although Oregon has had only a few years to organize stream habitat and enhancement efforts under the Oregon Plan, a large number of projects have already been put in place. The Governor's Watershed Enhancement Board reported in 1998 that 1,234 restoration projects were reported by forestland owners and managers for 1996 and 1997, nearly all of them west of the Cascades.[30] These included 458 projects involving in-stream restructuring, typically placing logs, boulders, and other materials in streams, and also creating side channels and off-channel ponds. Other projects involved stream bank stabilization and road improvement to reduce sediment runoff and reduce barriers to fish passage.

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[30] *The Oregon Plan for Salmon and Watersheds: Watershed Restoration Inventory.* Governor's Watershed Enhancement Board, Salem, OR, 1998.

Salmon and Silviculture

The discussion above makes it clear that riparian management involves particular silviculture treatments and practices. However, there appears to be little in the literature that directly links silviculture *systems* with salmon habitat. Scientists cite only forest conditions associated with stream habitat health that might be advanced by silviculture systems. For example, Botkin's correlations between degree of forest cover and salmon survival suggest further research might be useful. Even-aged silviculture produces one kind of cover, uneven-aged silviculture another. Long-range studies might determine how each silviculture system contributes to stream health.

15. CONCLUSION: WHAT THESE FINDINGS SUGGEST

What conclusions can be drawn from the information presented in this paper? The answers sort into several categories. First, our forest resources are abundant, and they are adequate to meet a variety of objectives. Second, even-aged silviculture seems to be an appropriate system of silviculture for western Oregon. Uneven-aged silviculture would be a problematic substitute for commercial forests in western Oregon but is well suited to many sites in eastern Oregon. Third, timber producers can balance environmental and economic considerations, whether they use even-aged or uneven-aged management. Fourth, the most desirable environmental and economic outcomes in our managed forests require access to a broad range of silvicultural options appropriate to the circumstances of the forests under management.

Oregon Has Sufficient Forest Resources To Meet a Variety of Objectives

Oregon has a vast reservoir of forestland available to meet noncommodity objectives. The federal government, which owns more than half of the timberland in the state (nearly 20,000 square miles), is increasingly managing its lands for such objectives as species diversity, wildlife and fish habitat, riparian zone protection, scenic values, and recreation. Half of all federal timberland in Oregon is unavailable for harvest, and harvesting has continued to plummet on the half that is nominally available. A third of what the federal government owns is old growth, nearly 7 percent of Oregon's land area. Current federal policies are designed to preserve that old growth and manage other federal timberlands lands to grow more.

The job of producing wood in Oregon now falls primarily to 13,000 square miles of privately owned forests, the majority of this in the highly productive Douglas-fir region west of the Cascades. Oregon's private forests are being managed for long-term production of timber, but they also are being managed to meet other objectives such as fish and wildlife habitat and watershed health. Although disturbance is a natural part of forest life, Oregon's privately owned forests are free of human disturbance most of the time. Only 6 percent of these timberlands experienced some level of harvesting in 1997; only 1 percent were harvested by clearcutting. Recent clearcuts are not aesthetically pleasing, but they are regenerated quickly and form a closed canopy within a few years.

While harvests decline, the state's forests continue to grow. Oregon can expect to have an ample inventory of timber indefinitely.

Different Silvicultural Methods Are Appropriate for Different Sites

In the commercial forests of western Oregon, even-aged silviculture makes sense because it is well suited to the species under cultivation, and it works. Uneven-aged management appears to be well suited to forests in seasonally warm, dry regions, such as eastern Oregon, where its systematic practice could be adopted more widely.

Uneven-aged silviculture offers some potential benefits on the westside, such as a steady flow of logs, continuous forest complexity, and aesthetic appearance. It is easier to apply on gentle slopes where logging or road construction costs are lower and where owners are willing to bear additional management costs. However, it also poses significant drawbacks. Shade intolerant westside conifers could be regenerated in an uneven-aged system, but they would grow more slowly and many would die. Harvesting costs would be higher and yields may be smaller. If uneven-aged management were widely practiced over time, shade intolerant species such as Douglas-fir might be out competed by shade tolerant species and by brush, leading to their demise and replacement by other species. Westside uneven-aged management would be more intensive and expensive than uneven-aged management. There also may be undesirable environmental trade-offs caused by more frequent stand entries, a more frequent schedule of harvesting, and a larger network of forest roads that could contribute to soil compaction, as well as runoff and erosion on steep slopes.

Some westside land owners who want to maintain continuous forest cover or a steady revenue stream from periodic cutting might find the trade-offs of uneven-aged management acceptable. Owners for whom timber production and financial return are secondary considerations might also find appeal in alternative forms of even-aged management, such as longer rotations or small patch clearcuts.

Timber Production Can Accommodate Environmental Values, Regardless of Silvicultural Method

Obviously, the state's federal lands are now being managed primarily to meet environmental objectives. But environmental values are also important in Oregon's commercial forests, even though their primary purpose is wood production. Private forest owners, and the Department of Forestry on state-owned lands, conform to a comprehensive set of forest practice rules that limit harvest acreage, assure reforestation, protect streams and environmentally sensitive areas, minimize erosion from roads and operations, and leave downed logs, snags, and other structures after harvest to create transitional wildlife habitat. At the forest landscape level, the mosaic of structures formed by even-aged stands at various stages of maturity create diverse habitat for wildlife. This is complemented by mature forests on federal land and by other ownerships managed for noncommodity values.

Oregon Should Maintain a Range of Silvicultural Options

There is broad consensus among forestry professionals that it is important to adapt silviculture approaches to site conditions —to the species, landscape, soils, climate, and other variables that the forest owner has to work with (and that work well with one another) to achieve particular management objectives. A forest outside Coos Bay should not necessarily be managed the same way as a forest in Germany, Arkansas, or eastern Oregon, even for noncommodity purposes.

Diverse silvicultural systems can also yield environmental benefits. For example, with modern controls on fire, uniform reliance on uneven-aged silviculture would reduce wildlife diversity since the openings needed by some vertebrates would grow into closed canopy forests and new openings would not be created. A reduction in the area of openings would increase the abundance of shade-tolerant tree species and decrease the abundance of species that require sunlight. There would be increased potential for soil compaction and sedimentation due to higher road densities and more frequent entries associated with selective harvesting.

Employing even-aged silviculture using clearcutting as the only harvest and regeneration method would have adverse consequences as well. Regeneration on some seasonally warm, dry or subalpine sites would be difficult to achieve. In addition, landscape and habitat diversity would be reduced, especially for species dependent on mature forest characteristics.

Perhaps the worst thing that could happen to Oregon's commercial forests would be to hamstring their management with rigid prescriptions and limitations, or to require that every acre of forestland look the same. Oregon's forest practice rules guard the public's interest in reforestation and protection of environmental values, and they continue to be refined as scientists make new discoveries. Dictation of silvicultural methods beyond those safeguards would have adverse consequences for forest productivity, forest health, wildlife, and Oregon's rural and statewide economy.

SOURCE DOCUMENTS

Adams, Paul W., and Jeanette O. Ringer. *The Effects of Timber Harvesting & Forest Roads on Water Quantity & Quality in the Pacific Northwest: Summary & Annotated Bibliography*. Forest Engineering Department, Oregon State University, Corvallis, OR, 1994.

Arno, Stephen F., and Ramona P. Hammerly. *Northwest Trees*. The Mountaineers, Seattle, WA, 1997.

Beuter, John H. *Legacy and Promise*, revised and updated. Oregon Business Council and Oregon Forest Resources Institute, Portland, OR, 1998.

Botkin, Daniel B., Kenneth Cummins, Thomas Dunne, Henry Reigier, Matthew Sobel, and Lee M. Talbot. *Status and Future of Salmon of Western Oregon and Northern California: Overview of Findings and Options*. The Center for the Study of the Environment, Santa Barbara, CA, 1993.

Brandeis, Thomas J. *Underplanting and Competition in Thinned Douglas-fir*, PhD thesis. Oregon State University, College of Forestry, 1999.

Bunnell, Fred L., Laurie L. Kremsater, and Ralph W. Wells. *Likely Consequences of Forest Management on Terrestrial, Forest-Dwelling Vertebrates in Oregon*. Centre for Applied Conservation Biology, University of British Columbia, Vancouver, BC, 1997.

Conway, Steve. *Logging Practices: Principles of Timber Harvesting Systems*, Revised Edition. Miller Freeman Publications, Inc., San Francisco, CA, 1982.

Curtis, Robert O., Dean S. DeBell, Constance A. Harrington, Denis P. Lavender, J. Bradley St. Clair, John C. Tappeiner, and John D. Walstad. *Silviculture for Multiple Objectices in the Douglas-Fir Region*, USDA Forest Service General Technical Report PNW-GTR-435, Portland, OR, 1998.

Emmingham, William H., and Kathleen Maas-Hebner. *Coastal Oregon Productivity Enhancement Program (COPE) 1997 Annual Report*. Oregon State University, Forest Research Laboratory, Corvallis, OR.

Forestry and Wildlife, special report by Oregon Forest Resources Institute, 1999.

Franklin, Jerry F."Effects of Uneven-Aged Management on Species Composition," reproduced in 1977 from a paper presented at a workshop October 19-21, 1976, on Uneven-Aged Silviculture and Management in the Western United States, USDA Forest Service.

Guldin, James M. "The Role of Uneven-Aged Silviculture in the Context of Ecosystem Management." *Western Journal of Applied Forestry*, January 1996.

Hobbs, Stephen D., Steven D. Tesch, Peyton W. Owston, Ronald E. Stewart, John C. Tappeiner II, and Gail E. Wells, editors. *Reforestation Practices in Southwestern Oregon and Northern California*. Forest Research Laboratory, Oregon State University, Corvallis, OR, 1992.

Kaczynski, V.W., and J.F. Palmisano. *Oregon's Wild Salmon and Steelhead Trout: A Review of the Impact of Management and Environmental Factors*. Oregon Forest Industries Council, Salem, OR, 1993.

Kimmins, Hamish. *Balancing Act: Environmental Issues in Forestry*. University of British Columbia Press, Vancouver, BC, 1992.

Kohm, Kathryn A., and Jerry F. Franklin. *Creating a Forestry for the 21st Century: The Science of Ecosystem Management*. Island Press, Washington, DC, 1997.

Lettman, Gary J. *Timber Management Practices and Land Use Trends on Private Forest Land in Oregon*. Oregon Department of Forestry, 1995.

Logan, Robert S., and Richard A. Fletcher. *Forest Ecosystem Stewardship*. Montana State University Extension Service, Bozeman, MT, 1997.

A New Vision for Pacific Salmon. Oregon Business Council, Portland, OR,1996.

Oliver, Chadwick D., and Bruce C. Larson. *Forest Stand Dynamics*, Updated Edition. John Wiley & Sons, Inc., New York, NY, 1996.

Oregon Forest Fact Book. Evergreen Foundation and Oregon Forest Resources Institute, Portland, OR, 1997

The Oregon Plan for Salmon and Watersheds: Watershed Restoration Inventory. Governor's Watershed Enhancement Board, Salem, OR, 1998.

Pyles, Marvin R., Paul W. Adams, Robert L. Beschta, and Arne E. Skaugset. *Forest Practices and Landslides*. Forest Engineering Department, Oregon State University, Corvallis, OR, 1998.

Robison, E. George, Keith A. Mills, Jim Paul, Liz Dent, and Arne Skaugset. *Storm Impacts and Landslides of 1996, Final Report*. Oregon Department of Forestry, Salem, OR 1999.

Saving the Salmon. Oregon Forest Resources Institute report, 1998. Technical advice on salmon habitat and survival provided by Tom Nickelson, Oregon Department of Fish and Wildlife.

Smith, David M., Bruce C. Larson, Matthew J. Kelty, and P. Mark S. Ashton. *The Practice of Silviculture: Applied Forest Ecology*, Ninth Edition. John Wiley & Sons, Inc, New York, NY, 1997.

"A Snapshot of Salmon in Oregon," tabloid publication by the Oregon State University Extension Service, 1998.

Tuchmann, E. Thomas, Kent P. Connaughton, Lisa E. Freedman, and Clarence B. Moriwaki. *The Northwest Forest Plan*. USDA Forest Service, Portland, OR, 1996.

Upstream: Salmon and Society in the Pacific Northwest. Committee on Protection and Management of Pacific Northwest Anadromous Salmonids, National Research Council. National Academy Press, Washington, DC, 1996.

1997 Annual Reports. Oregon Department of Forestry, Salem, OR.