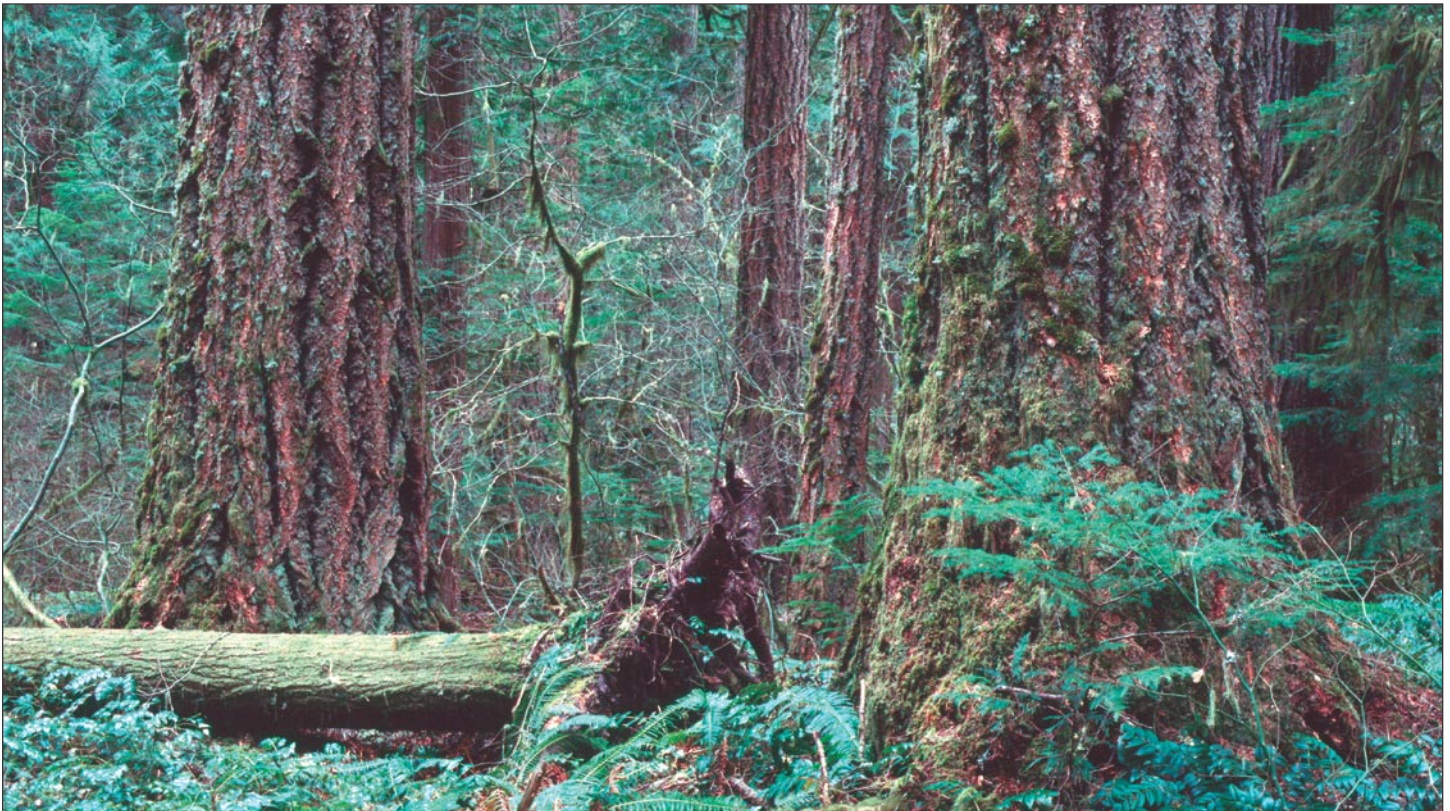




NEW FINDINGS ABOUT OLD-GROWTH FORESTS



IN SUMMARY

Not all forests with old trees are scientifically defined as old growth. Among those that are, the variations are so striking that multiple definitions of old-growth forests are needed, even when the discussion is restricted to Pacific coast old-growth forests from southwestern Oregon to southwestern British Columbia.

Scientists understand the basic structural features of old-growth forests and have learned much about habitat use of forests by spotted owls and other species. Less known, however, are the character and development of the live and dead trees and other plants. We are learning much about the structural complexity of these forests and how it leads to ecological complexity—which makes possible their famous biodiversity. For example, we are gaining new insights into canopy complexity in old-growth forests.

Old-growth forests are **not** places undisturbed by nature

for many centuries. Today's old-growth forests developed along multiple pathways with many low-severity and some high-severity disturbances along the way. And, scientists are learning, the journey matters—old-growth ecosystems contribute to ecological diversity through every stage of forest development. Heterogeneity in the pathways to old-growth forests accounts for many of the differences among old-growth forests.

Complexity does not mean chaos or a lack of pattern. Scientists from the Pacific Northwest (PNW) Research Station, along with scientists and students from universities, see some common elements and themes in the many pathways. The new findings suggest we may need to change our strategies for conserving and restoring old-growth ecosystems. As we discover greater complexity in forests than we ever imagined before, we will need to develop greater complexity in our cultural responses to forests as well.



Probably no single definition of old-growth forests and their values will ever exist.

What is an old-growth forest?

The question is not as simple as it may seem. The term “old growth” came from foresters in the early days of logging. In the 1970s research ecologists began using the term to describe forests at least 150 years old that developed a complex structure characterized by large, live and dead trees; distinctive habitats; and a diverse group of plants, fungi, and animals. Environmental groups use the term “old growth” to describe forests with large, old trees and no clearly visible human influences. Many forest scientists do not see the absence of human activity as a necessary criterion for old-growth, but there is no consensus on this in the scientific community. This publication focuses on a scientific perspective of old-growth forests; however, this viewpoint is not the only possible one.

Recently, researchers and managers from Oregon, Washington, and British Columbia held a workshop on the development of old-growth forests in the region from southwestern Oregon to southwestern British Columbia. The group looked at what scientists have learned since the first major publication on ecological characteristics of old-growth forests in 1981. They focused on coastal Douglas-fir forests, but also included closely associated types such as western hemlock and Sitka spruce forests. “Coastal” included the area from the Pacific Ocean to the crest of the Cascade Range.

By using new technologies such as canopy cranes and laser scanning, scientists are learning much about canopy complexity and development in old-growth forests.

Of many challenging topics on the 3-day agenda, the question of definitions was the first one the group discussed. Many forestry textbooks lump all old-growth forests into one stage of forest development. Most scientists now agree, though, that the term “old-growth forests” actually includes forests in many stages of development, and forests that differ widely in character with age, geographic location, and disturbance history. Even within the specified geographic area, no one definition represents the full diversity of old-growth ecosystems.

“There may never be a single, widely accepted definition of old growth—there are just too many strong opinions from different perspectives including forest ecology, wildlife ecology, recreation, spirituality, economics, sociology,” says Tom Spies, research forest ecologist for PNW Research Station.

Spies and Jerry Franklin, University of Washington professor, developed a generic definition of old-growth forests in 1989 for the Forest Service. The definition reads, in part: “Old-growth forests are ecosystems distinguished by old trees and related structural attributes...that may include tree size, accumulations of large dead woody material, number of canopy layers, species composition, and ecosystem function.” Most scientists would now include vertical and horizontal diversity in tree canopy as an important attribute.

This definition of old growth is widely accepted but too general for forest inventory or planning. Most scientists at the workshop thought that multiple definitions of old growth are needed for the diversity of forest types within the region. Also, they thought, old-growth definitions should be fine-tuned to the inherent patterns and dynamics of the forest landscape mosaic of an area. “At best, we thought it may be possible to converge on a small set of definitions for inventory or mapping purposes,” Spies says.

Even so, when these definitions are applied, some old forests might be just one large tree per acre below the required minimum or have too few large, down logs, and thus might not meet a rigid definition. “The boundaries of what defines old-growth forests are a lot fuzzier than we’d like,” Spies explains. “Some young forests have elements of old growth, and old growth often has patches of young forest. Where fire was common in the past, the dominant trees have a wide range of ages.”

In the end, he comments, “Because we deal with complex ecosystems, we have to be comfortable with flexible terms and some ambiguity.”

Purpose of PNW Science Update

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Large, old Douglas-firs develop complex crowns with broken, forked, or fan-shaped branches, and gaps where branches are missing.

What are we learning about canopy structure and development in old-growth forests?

The variations in old-growth forests are striking. Jerry Franklin summed it up this way: “Heterogeneity rules.”

The deep canopies of old-growth forests are among the more distinctive components of these forests, and perhaps the least understood because they are difficult to study. By using new technologies such as canopy cranes and laser scanning, scientists are learning much about canopy complexity and development in old-growth forests.

Douglas-fir is the dominant tree species in the old-growth forests of the lower to mid elevations of the Cascade Range and coastal mountains of the Pacific Northwest. Old-growth Douglas-fir are commonly 3 to 6 feet in diameter, and 150 to over 250 feet tall. These huge trees usually have massive, complex crowns. The crowns are deep, with branches growing from much of the tree trunk, or bole, not just from the uppermost trunk. The large, complex crowns of old-growth trees, and the processes that create these deep crowns, are important for the canopy diversity of the stand.

Scientists once speculated that the deep crowns of old-growth Douglas-firs resulted because the trees were widely spaced when young and grew characteristic fans of branches in their lower crowns. Recent studies have shown that although many old-growth Douglas-firs were open-grown when young or

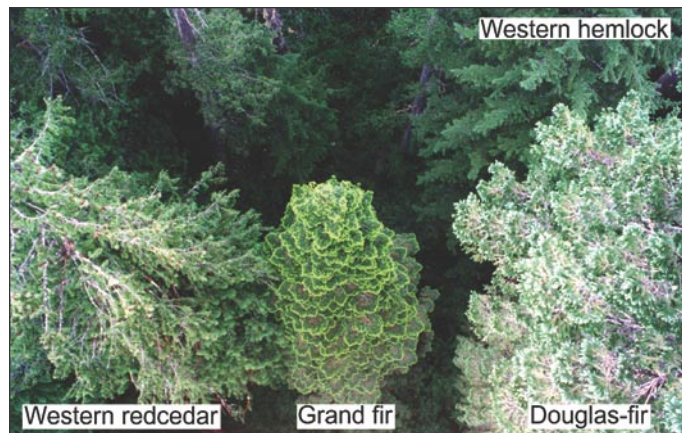
grew in closed-canopy but low-density stands, others grew in dense, closed-canopy conditions. Some kept their original branches, and others developed epicormic branches. Epicormic branches develop from dormant buds in a tree trunk in response to internal hormonal controls as the tree gets taller and primary branch systems die. Other branches do not have to be damaged or lost in order for epicormic branching to occur, as was once thought.

Douglas-fir tree crowns continue to produce new branch systems even when very old, an unusual trait for a conifer species. The trees often are able to regenerate some crown even after major damage, increasing the trees’ ability to survive for many centuries. “This is in contrast to some other tree species,” Spies explains, “whose crown growth and development stop at much earlier ages.”

Key Findings

- Pacific coastal old-growth forests are diverse regionally in both their structures and their development. The diversity is a result of regional differences in climate history, fire history, site productivity, and species composition. Although the forests share the same general definition and similar attributes such as large live and dead trees, the details differ and no one specific definition describes all Pacific coastal old-growth forests.
- In many old-growth forests, the dominant trees have a wide range of ages. This is especially true in the mixed-conifer and mixed-evergreen forests of southwestern Oregon, where low-intensity, frequent fires had an important role in forest development. Fire suppression is changing the character of these old-growth forests by changing the disturbance processes and forest structure and composition.
- Today’s old-growth forests developed along multiple pathways. Some developed under open conditions created by multiple fires, and with different levels of biological legacies such as large live and dead trees. Others developed from closed, dense stands after a single major fire or other disturbance. In very wet, cool parts of the region, some old-growth forests developed without fire; these forests are dominated by shade-tolerant tree species in a mosaic of patches. Old-growth Douglas-fir forests occur in dryer west-side areas where there is a history of fire.
- Mature and old Douglas-fir trees have immense capabilities to renew their crowns through the process of epicormic branch initiation and development. Epicormic branches will replace some primary branches as a normal process of the Douglas-fir life cycle.
- Today’s old-growth forests developed from disturbances and under the climate conditions of the last millennium. The particular composition and structure of these old-growth forests may not occur again under modern climates and disturbance regimes.

Other tree species in old-growth forests also develop complex crowns, but each species grows to different heights, has different branching structures, and so forth. Each species contributes a little differently to an old-growth forest. Scientists do not completely understand branch development in old forests. They do know, however, that although the process differs among species, western redcedar, noble fir, incense cedar, bigleaf maple, and western hemlock all can develop complex crowns, especially when the trees have been damaged and then have regenerated parts of their crowns.



E. David Ford

Different tree species have distinctive crown shapes—grand fir has a compact crown, Douglas-fir has large irregular branches, western redcedar has drooping branches, and western hemlock has long branches.

A few large, old trees do not make an old-growth forest. The larger context, or stand level, is what you're aware of when you walk through a forest. Key structural features are the large, old trees, large snags, deep and intricate canopy, and large fallen trees. The structural complexity leads to ecological complexity, creates many habitats, and affects the ways that energy and nutrients are cycled through the forest.

Old-growth canopies develop into deep, complex structures that can last for centuries, even though individual trees die. The stand-level longevity of the canopy makes it possible for epiphytes (plants that grow on other plants) to thrive in the less-shaded upper canopy layers. More than one hundred species of mosses and lichens are found in old-growth canopies.

Red tree voles build nests at a wide range of heights throughout the large branches of mature and old-growth Douglas-firs; spotted owls use the intricate canopy for cover as they hunt tree voles and flying squirrels, and escape their own predators. Many species of flies, gnats, and spiders thrive in old-growth canopies. Snags provide habitat for many insect species not found on live trees, and insect-eating birds such as the brown creeper and hairy woodpecker feed on the insects. Cavity-nesting birds such as the chestnut-backed chickadee and various woodpecker species make homes in large snags.

In Pacific coastal old-growth forests, biodiversity is expressed subtly through not-so-easily observed organisms such as fungi, lichens, mites, spiders, and bats. The amounts and distributions of live trees, snags, canopy complexity, and fallen trees create the intricate habitat niches that support these many species.

Time is another factor in the biodiversity of old forests. Some species, such as *Lobaria oregana* (a canopy lichen), certain rare mollusks, and others, spread slowly to new habitats. After a major forest fire, these species may take centuries to recolonize a forest.

Old-growth forests together with forests of different ages, structures, and sizes make up a landscape. The landscape is the result of small and large disturbances, and differences in site conditions such as soil and slope. Because disturbances shape the pattern, it should be no surprise that the pattern changes over time.

How did today's old-growth forests get started and develop?

The development of old-growth forests has often been simplified into one or a few scientific stories. In the leading textbooks on forest stand dynamics, the standard model of forest development has only a few stages. The standard model goes like this: A devastating wildfire kills all or nearly all trees in a forest. Seeds blow in from unburned forests or dying trees, and new trees establish and grow over the next decade. As trees grow and crowd together they form dense stands that shade out other organisms. Trees that don't get enough light die. The surviving trees grow larger, and when some of these large trees die from insects, disease, and wind, canopy gaps form that allow shade-tolerant trees and other plants to grow beneath the canopy. No major disturbances disrupt the forest for several hundred years and it slowly develops into old growth.

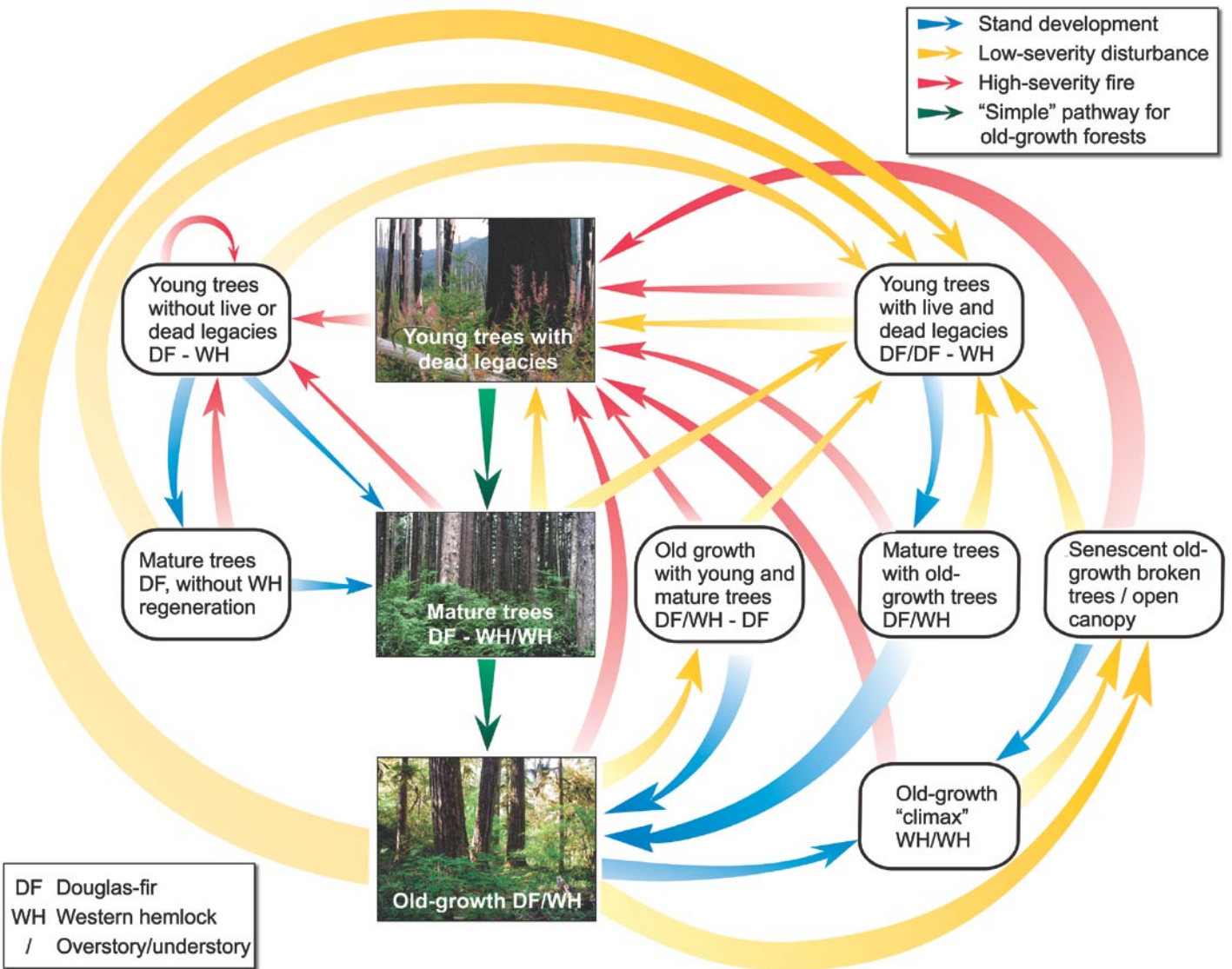
The truth is much more interesting. Simple models do not do justice to complex systems such as forests. "It's impossible to understand and manage old growth without understanding the diversity of all the stages that lead to old growth," Spies says.

Scientists have reconstructed the histories of some old-growth forests and found very different stories. The figure on the next page shows multiple pathways of development that scientists have found for old-growth forests in the western Oregon Cascade Range. This figure would not apply exactly to forests in



David Powell

The nitrogen-fixing lichen *Lobaria oregana* grows in upper canopy layers of old-growth forests and is most often seen when it falls to the ground, as shown here.



Climax — Final self-sustaining and self-reproducing stage of natural forest development if no large disturbances occur.

Legacies — Biological pieces such as live and dead trees, surviving seeds, spores, and animal species inherited from previous ecosystem on the site.

Low-severity disturbance — Small or low-intensity fires, insect and disease mortality, floods and sediment deposits; tree mortality is light to moderate.

Mature — Trees that have achieved a substantial part of their potential height growth; for Douglas-fir, about 80 years.

Senescent — Very old, with little or no growth occurring, and with decreased ability to resist or repair damage.

Stand development — Changes in forest stand structure over time, through tree growth, mortality, and regeneration.

(Some definitions from: Helms, J.A., ed. 1998. The dictionary of forestry. Bethesda, MD: Society of American Foresters.)

This figure shows some of the multiple pathways along which old-growth Douglas-fir forests developed in the central western Cascade Range. The most straightforward pathway, from young forest to old growth, is shown from top to bottom in the center. Low-severity fires, shown by yellow arrows, take a forest back to an earlier stage of forest development, although not always back to young forest. High-severity fires, shown by red arrows, take a forest back to one of two young forest types. Dense plantations without legacies are a forest type often created by forest management. Forest management, of course, could be used to modify the pathways shown.

western British Columbia or southwest Oregon. Scientists do not yet understand well how the relative frequency of these different pathways changed across the region or over the centuries.

The simple version described above is shown in the center of the figure, with photographs for each stage and green arrows showing the stages of forest development. The three-step sequence is not wrong; however, it simplifies many changes into just three classes, and it is just one of many possibilities.

Fire was a key process in most pathways, although the exact role of fire varied from south to north, and from coast to Cascade Range. Red and yellow arrows in the figure represent high-severity and low-severity fires, respectively, which in a matter of days can change forests to another stage. Fires do not necessarily take a forest all the way back to the beginning, but create mixed forests of young, mature, and old-growth trees in various proportions (and thus various ecological characteristics). These mixed-age forests may still be old growth or, depending on what happens next, may return to old-growth conditions in a few decades, or not for a long time.



Vaux's swifts.

down logs become legacies in young forests. As forests develop, small disturbances such as low-intensity fires, windstorms that drop a few trees, or insects and disease that kill pockets of trees create “character”—mosaics of young and old patches of trees, snags, damaged trees, small openings, shrubs, and herbs. These mosaics contribute to ecological diversity continuously throughout a forest’s history.

The journey matters. The multiple pathways that can lead to old-growth forests are critical for providing all the habitats found in natural Pacific Northwest forests.

“The journey matters,” agreed workshop participants. “Heterogeneity in the pathways to old growth may be as ecologically important as heterogeneity in the endpoints.” The multiple pathways shown in the figure on page 5 are critical for providing all the habitats found in natural Pacific Northwest forests.

Old-growth forests are part of a landscape of changing forests. In the controversies about old-growth conservation, other forest stages and their ecological contributions have not been fully appreciated. In many cases, young and mature forests with remnants of live or dead old-growth trees serve as good habitat for species such as the northern spotted owl or canopy lichens, which are typically associated with old forests. Small openings and patches of young trees make critical contributions to old-growth forests. In fact, “old” forests can contain almost as many young trees as “young” forests.

In one sentence, then: many young natural forests owe much of their diversity to old-forest legacies—and old forests are equally indebted to the young forests within them.

Young managed forests may have few old-forest legacies—but possibilities exist for managing forests to retain or develop legacies.

Forest development, shown by blue or green arrows, is a continuous process and leads forests toward mature or old-growth stages—until it is interrupted, which happens frequently in nature.

Many pathways can lead to old-growth forests. One trend is consistent among all of them—increasing structural complexity as a forest develops. Pieces of old-growth ecosystems survive wildfires, and these living trees, snags, and

Regional variations in old-growth forests are particularly striking, even in the geographic area considered by the workshop scientists (see page 9). Scientists are finding that although forests have common elements and themes in their development, each old-growth forest has an individual story.

How much of the landscape was old-growth forest at any one time?

No large landscape was ever all old-growth forest. “The amounts and patterns of old-growth have varied over the centuries, and one should be careful in using historical information from one date or time period as a reference for the present or the future,” Spies cautions.

Pacific Northwest forests have always been in a state of change. Looking at just the last 10,000 years, roughly since the end of the last ice age, Pacific Northwest forests have changed continually in composition and structure. People influenced forests over all, or nearly all, of that time. For just one example, Native Americans set fires in the Willamette Valley, keeping much of the valley as prairie or savannah ecosystems. These human-started fires burned into adjacent foothills and, sometimes, if conditions were right, burned extensive areas in the wetter and cooler mountain forests. Lightning fires also occurred, although lightning fires were not as prevalent west of the Cascade Range as on the east side.

Extensive fires did not occur at an even pace over that time. In western Oregon and Washington, episodes of extensive fires occurred 8,000 to 10,000 years ago, and again 1,000 years ago, and 500 years ago. Many of today’s old-growth Douglas-fir trees established after the extensive large fires that burned circa 1400 to 1650. Large fires burned also in the 1800s, in part concurrent with European-American settlement.

The periods of extensive fires were also periods of warm, dry climate. The circa 1400 to 1650 warm, dry period affected the development of current old-growth forests in possibly two ways. Not only was the climate conducive to the extensive fires, after which young forests established, but also because of the warm climate, Douglas-fir may have been able to establish and thrive at higher elevations than it does now.

For small areas, the amount of old-growth forest varied between 0 and 100 percent at any one time. Scientists have estimated historical patterns for large regions. “In the Oregon Coast Range, when old growth is defined as forest where the upper canopy is dominated by trees over 200 years old, the amount of old-growth is estimated to have ranged from about 30 to 70 percent at any one time over the last several thousand years,” Spies says. “Fires burned in a complex mosaic of patch sizes from individual trees to tens of thousands of acres.”



Hoary bat.

In the Olympic Peninsula and North Cascade Range of Washington, old-growth stands developed in very large patches of discrete age classes established after a few large, severe fires that occurred in that region over the last 700 years. In southwest Oregon, estimating the amount of old-growth forest requires a different approach because frequent, low-to-high-intensity fires resulted in a fine-grained mosaic of forests with trees of mixed ages.

Forest dynamics change from southwest Oregon to southwest British Columbia, and historical amounts of old growth and other forest stages also varied across the region.

Information is also incomplete about the processes of forest development after fire. Scientists are using the Warner Creek burn in the Oregon Cascade Range to study one pathway for natural forest development after fires (see “Fire Recycles Old-Growth Forest” on page 11).

How much of the landscape is old-growth forest now?

In the 1880s many old-growth forests were cleared by European-American settlers or were destroyed in wildfires set by settlers; the exact amount cleared in that century has never been quantified. Scientists estimate that about half of the west-side old-growth forests that existed in the Pacific Northwest at the beginning of the 20th century have since been logged. Most remaining Pacific coastal old-growth forests are on federal lands.

Science supports the idea that managed forests can be complex too.

The *Forest Ecosystem Management: An Ecological, Economic, and Social Assessment* (“FEMAT Report,” 1993, page IV-64) indicated that out of 18.4 million acres of federal lands in the range of the northern spotted owl in Oregon and Washington, about 3 million acres were multistory, medium and large conifer forests, the inventory category closest to the definition of old-growth forest. When mature forest conditions (forests about 80 to 200 years old) are included, which have some elements of old-growth character, the total area is roughly 6.5 million acres.

Estimates were derived from satellite imagery, which provided information only about the upper canopy conditions. Detailed data about snags, fallen trees, and so forth were not available.



Old growth is one component of a shifting mosaic of forest types over the landscape.

Put into percentages, these figures mean that in the range of the spotted owl in Oregon and Washington, about 16 percent of federal lands had old-growth forest in 1993 (about 35 percent had mature and old forests), which is probably close to what occurs today, as few acres of such forests have been cut on federal lands since 1993. The 3 million acres of old-growth forests are about 7 percent of the total land base in the specified area; total land base contains all state, tribal, and private lands, including agricultural and residential areas.

Management implications

Nature and Native Americans changed Pacific Northwest forests for thousands of years, frequently with spectacular results. Everything that scientists learn gives them increased respect and appreciation for the intricacy, diversity, and beauty of natural forests. Why, then, discuss management implications at all in respect to old-growth forests?

There are four main issues:

- Fire management
- Development of old-growth characteristics in forest plantations
- Landscape management and planning
- Old-growth protection policies

Fire management. The old forests within the reserves set up under the Northwest Forest Plan face two types of risk: sudden loss from high-severity fire, and slow loss of ecological complexity from suppression of patchy fires, which were important in the development of dry types of old growth. The plan assumed that some old forest habitat would be lost to fire, but there is considerable uncertainty in estimating future losses to fire.

In southwest Oregon, fires were frequent and usually low intensity, until the past century of fire suppression. Spies points out, “Without reducing understory densities in these stands

and restoring frequent surface fires, this type of old-growth forest will be lost in the coming decades to insect outbreaks, disease, and high-severity fires.” (In the summer of 2002, the Biscuit fire burned across nearly 500,000 acres in southwest Oregon. Burning severity ranged from patchy to intense across the fire area, some areas within the fire perimeter were not burned, and millions of acres in southwest Oregon did not burn at all in 2002, so forest risks described by Spies still exist.)

Old-growth forests will change even with “protection” status.

Farther north in western Oregon and Washington, fire regimes are mixed, a complex combination of surface fires and crown fires. Old-growth forests in these areas are also at risk to loss from both high-severity fire and lack of surface fires. Fires were less frequent in this area than in southwestern Oregon, however, so the last century of fire suppression probably has had little effect on forest structure and development in these areas. However, if fire suppression policies continue for another 50 to 100 years, changes will definitely occur in many of these old-growth forests as well. In the rest of western Oregon and in western Washington, where climate is wetter, fires were infrequent but often more intense. In the 1800s, before firefighting began in earnest, forest fires in the Oregon Coast Range turned skies dark at mid-day, burned down the mountain sides to the beaches, and dropped ashes on ships out at sea.

“We’re not willing to let fire back in the moist west-side forests the way it was before,” Spies comments. With towns and houses close to forests, and people and property to protect, fire managers will almost certainly continue policies to control most wildfires. Fuel levels in these forests are naturally high because the forests are highly productive, and large fires are infrequent (100- to 400-year intervals). So fire suppression over the last century has not changed fuel levels very much in these forests. Managers and communities can make choices, however, to carry out fuel reduction projects in such forests in the urban-wildland interface, depending on social needs.

Development of old-growth characteristics in forest plantations. Forest plantations already cover millions of acres in western Oregon and Washington. Spies asks, “Will these dense young stands diversify naturally?” Natural processes will undoubtedly create gaps and variability in these stands; however, if this does not happen soon enough, the risk is that these stands will not develop as much structural diversity as current old-growth stands and thus will not supply the full range of habitats provided by current old-growth forests.

What scientists learn about the development of old-growth forests may be useful to managers responsible for plantations. Science supports the idea that managed forests can be complex too. Managers may want to consider diversifying stands with variable-density thinnings, leaving some patches or even whole stands unthinned, and using other silvicultural practices designed to accelerate structural complexity in maturing forests.

If managers aim to accelerate the development of some plantations toward old-growth conditions, they might develop the stands along different pathways, so that these stands have variations in structures through the decades of development. The multiple pathways may have ecological implications we do not fully grasp yet, such as supplying habitat needs that are unrecognized. “From what I’ve seen, Forest Service silviculturists are very excited about these restoration challenges and are keen on using a diversity of approaches,” Spies remarks.

Landscape management and planning. “Sustainability of old growth requires planning and evaluation at landscape and regional scales and long timeframes,” Spies explains. Under current federal policies, mature forests, which are the source of future old growth, would decline over the long term. On a landscape of national forests and private timber lands, age classes could become bimodal—old forests on federal lands and young plantations on private and federal lands, with intermediate age classes scarce.

Only through landscape-level planning can we understand what it might take to maintain the diversity of forest conditions. Forest diversity is necessary if we are to retain or restore the full range of habitats and ecological functions in forests. Also, if some old-growth forests are lost to fires, a diversity of forest types ensures that mature forests will be available to become the next generation of old-growth forests.

The subtleties of regional variation in old-growth forests matter because these forests will change structurally in response to human influences and climate change. In some places these changes will be slow and subtle, taking perhaps a century for us to see them. In other places the changes may occur over several decades or even in a few days, in the case of a wildfire. As the structure and dynamics of forests change, so might their ecological functions including habitats and nutrient cycling.

Spies says, “The real questions here are, How much landscape diversity will nature create through fires and other events, in spite of our attempts at control? How much will forest managers use chain saws to create this diversity because firefighting reduces the number of big fires?”

The answers will differ regionally. Combinations of active management and natural disturbances may be the answers that maintain old-growth diversity across the entire region. Decisions about urgency will differ, as historical fire regimes were different from north to south in the west-side region. In general, if managers want to use historical amounts of old-growth forest as a reference, the historical range of variation for the area in question would be more useful than any single point in the past.

Old-growth protection policies. Current policies reflect our desire to maintain and restore ecological values associated with old growth. Yet old-growth forests will change even with “protection” status. Sources of change include fire occurrence, fire suppression, invasive species, wind, landslides and debris flows, insect and disease outbreaks, forest succession, climate change, pollution, and so forth.

The Stories of Four Old-Growth Forests

Every forest has its own story. The composite stories below are representative of old-growth forests along the Pacific Northwest coast but do not tell the stories of all the region's old-growth forests.



Siskiyou Mountains in southwest Oregon.

Southwest Oregon, Siskiyou Mountains

This forest developed with frequent, low-severity fires, averaging 7- to 13-year return interval. As a result, trees regenerated almost continuously. Stand age has little meaning, as old trees are widely scattered and mixed with trees of all ages. Douglas-fir, ponderosa pine, and sugar pine are the dominant overstory tree species; madrone and tanoak are common trees in the understory; manzanita and other shrubs are common also. Young trees can often grow rapidly. The low-intensity fires created brushy open areas within the matrix of old forest. Over the last century in these forests, however, fire suppression has resulted in the buildup of fuels, increased insects and disease, and reduced stand vigor and diversity.



Western Washington Cascade Range.

Western Washington Cascade Range

This forest developed slowly in a closed-forest condition with no major disturbances that opened up the stand. Some Douglas-firs grew slowly when young and faster in later years. Hemlocks and other shade-tolerant trees with a wide range of sizes and ages developed in the understory with little influence from surface fires. Canopy gaps filled with and surrounded by young hemlocks create a distinctive mosaic of overstory and understory patches.



Western Oregon Cascade Range.

Western Oregon Cascade Range

This forest developed through a mixture of intense but patchy fires, low-severity fires, and small gap disturbances such as wind, insects, and tree diseases. The mixed disturbances left many snags, and fire scars and charred bark on many surviving old-growth trees. Douglas-fir and western hemlock dominate the overstory, with components of silver fir and western redcedar; silver fir are more common at higher elevations. The hemlocks and understory trees may be less than 150 years old or no older than the last surface fire. Bigleaf maple (at lower elevations), yew, and shade-tolerant conifers grow in the understory. Vine maples, rhododendrons, ferns, and other plants flourish in the shrub layer and on the forest floor.



Northern Washington Cascade Range.

Northern Washington and Western British Columbia

Fire was rare or absent in this landscape. Shade-tolerant trees such as western hemlock regenerated and reached the canopy in small gaps created by wind and disease. In a natural landscape in this area, the small patches of old, young, and maturing trees create a nearly continuous old-growth forest with a fine-grained texture. Douglas-fir may not be very common in this forest where fire is rare; western hemlock and western redcedar are more common. Sitka spruce occurs near the coast.



Research ecologist Tom Spies. "We need to find new ways of understanding, communicating, and managing forest diversity and complexity."

For areas outside wilderness, the old-growth manager must decide: is this change compatible with the old-growth goals for the area? In the case of old-growth forests, some changes or lack of changes may not be desirable, and forest managers may want to consider some actions. In setting goals for these forests in terms of definitions and desired future conditions, two important factors are regional variability in forests and the role of fire in creating complexity at stand and landscape scales.

Beyond the Pacific Northwest and the short-term future

"We have a richness and abundance of mature and old-growth forests in the Pacific Northwest that doesn't exist elsewhere in the world's temperate forests," Spies points out. "We have a global resource for learning about old growth and how to maintain large areas of forests with high natural values in a generally human-dominated landscape."

"But," he adds, "we also need to learn what is unique to our Pacific Northwest forests and what is appropriate to extrapolate to other forests." For example, old-growth Douglas-fir forests have many general similarities with old-growth white pine forests in the eastern United States and eucalyptus forests in Australia. However, it is not clear to what degree the findings can be extrapolated to boreal forests or the deciduous forests of the Eastern United States. Details differ, but similarities are likely to exist. For example, the increase in structural complexity of forests over time is common to forests of all kinds. Thus, abundant and diverse old-growth forests in the Pacific Northwest can serve as learning resources for understanding the ecology of old-growth forests throughout the world.

The diversity of nature frequently defies our attempts to put it in nice boxes.

Some people have said that old-growth forests are irreplaceable. "The forests may be irreplaceable in ways not considered," Spies reflects. The climate of the last 500 years may have been a unique period in the eons of climate changes, and our present old-growth forests may be the unique products of the past 500 years. Future climate changes and disturbance regimes, whatever they may be, will almost certainly not be identical to the past. Climate changes can affect which tree species grow at which elevations and latitudes, how fast the trees grow, which insects and diseases affect trees, and frequencies of wildfires, ice storms, and other weather-related disturbances.

The question, then, may not be how managers could set up the right conditions for nature to create more old-growth forests just like the ones we love now. The questions might be:

What are the essential characteristics we want to encourage in developing forests? What conditions do we want to create, that will encourage natural processes to develop old-growth forests?

"If we've learned anything in the last 30 years," Spies says, "it's that our understanding of ecosystems will change, just as our understanding of old-growth forests changed during the late 20th century. We have also learned that the diversity of nature frequently defies our attempts to put it in nice boxes either with words, scientific models, or plans. Natural systems are complex and our cultural responses to them are complex as well. Given the natural and social diversity, it would seem prudent to recognize as much diversity as possible in how we understand, manage, and plan for forests of the future whether they are old or young."

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Resources on the Web

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Fire Recycles Old-Growth Forest: Witnessing the Beginning of a Possible Future Old-Growth Forest

Warner Creek is a 10-year-old case study of one pathway of natural forest development after a severe forest fire.

The Warner Creek basin is in the watershed of the Middle Fork of the Willamette River, southeast of Eugene, Oregon, in the Cascade Range. In the early 1990s, much of the area was advanced mature and early old-growth forest, with trees 20 to 35 inches in diameter at breast height. The area was protected as a spotted owl habitat reserve (later redesignated under the Northwest Forest Plan as a late-successional reserve, meaning a reserve to be managed for mature and old forest characteristics).

A large forest fire burned across thousands of acres in the basin, in the fall of 1991. Although this fire was human-



Scientists are observing natural forest development in the Warner Creek burn on the Willamette National Forest.



Ten years after the fire, young Douglas-firs and vine maples grow among mature and old-growth trees that survived the fire.

caused, its size and intensity were believed to be similar to stand-replacement fires that preceded some of today's old-growth forests. One distinctive feature of the Warner burn was a heavy Douglas-fir seed crop in the tree canopies, much of which survived and regenerated the area promptly. Across most of the area, no salvage logging or tree planting was done. The burn gives scientists a chance to observe the processes of natural forest development—and see if what actually happens matches theories.

Ten years after the fire, silver and black snags cover the mountain slopes. Among the snags, young Douglas-firs 3 to 6 feet tall have established themselves. The young trees tend to be gathered in small, dense patches, and the patches are scattered across the slopes among ceanothus, thimbleberry, and bracken fern. Where patches of the mature trees survived the fire, young Douglas-firs grow among vine maple, wild rose, Oregon grape, twisted stalk, and trailing blackberry. Little down wood is on the ground yet, but when the hundreds of snags decay enough to fall, there will be large amounts.

On a lower slope, near a riparian area, surviving trees are mixed with snags. The snags are not all Douglas-fir here; some are western redcedar and some hemlock. Some big-leaf maples, red alders, and incense cedars survived the fire in this draw. Young Douglas-firs are 3 to 12 feet tall in this moister area, and grow among vine maple, huckleberry, salal, Oregon grape, and blackberry.

The Douglas-fir regeneration is dense in most places, but it's more diverse than regeneration in plantations. Instead of even spacing, the young trees are growing in dense clumps and in microsites next to down logs, and gaps have no young trees but many native brush and forb species. Tiny yew trees grow in some open areas; they might have survived the burn and resprouted. When the standing dead trees come down, conditions in these young natural stands will be very different from plantations. The falling snags will crush some young trees and create spacing. Large amounts of down wood will offer shelter and habitats, and eventually will turn into large amounts of decaying wood.

Warner Creek offers a fascinating chance to observe the processes of natural forest development. Given what we have learned about multiple pathways in forest development, Warner Creek can be taken as a case study, not as a prototype. Other large burns may have scarcer seed sources than Warner Creek and thus may restock slowly. Also, the Warner Creek forest is only 10 years along a pathway that will probably have many twists, turns, and even reversals (if fire reoccurs) over the next centuries before an old-growth forest occupies this site again.

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