USGS
science for a changing world

# Managed Forest Reserves: Preserving Diversity

## Background

As part of the Northwest Forest Plan, large areas have been designated on many federal forests in western Oregon to provide critical habitat for plants and animals that are associated with old-growth habitat. Some of the structural characteristics often considered typical of old forests include large-diameter overstory trees, large standing and fallen dead trees, and one or more understory layers (Figure 1). However, not all of these areas are currently in old-growth conditions. Many of them contain young (<40 years), uniformly dense Douglas-fir stands that regenerated after timber harvest. The original management goal for these stands was to produce high yields of timber and associated wood products. With implementation of the Northwest Forest Plan in 1994, the management objective shifted to accelerating development of old-growth characteristics by enhancing structural and biological diversity of these areas.

*Figure 1. Structural diversity is high in old-growth coniferous forests in western Oregon. Researchers are studying how these stands developed over time. Understanding the conditions under which old-growth trees grew will help provide a model for managing today's young stands.*

A major challenge today is how to promote these structural characteristics in younger stands. Researchers have been asking if lessons can be learned from the development of our current old growth and applied to management of younger stands. Dr. John Tappeiner and his university and agency research partners are helping to answer this question by examining the differences in development between old-growth and young stands in western Oregon. Understanding how the structure of these old forests developed may provide a model for management of young stands, especially when the management goal is to provide habitat for species associated with older forests.

**Understanding how the structure of old forests developed should help with decision making related to management of young forest stands. Recent science suggests that development of old-growth forests in western Oregon was quite different from that of the dense stands of today's young forests. Density management activities may enable some young stands to increase diameter growth rates and produce large crowns and stable stems in stands where the goal is to achieve old-growth forest structure.**

## Key Findings

In the Oregon Coast Range, scientists were able to infer density and development of old-growth stands during their early development by comparing the ages, sizes, and growth rates of trees in former Douglas-fir old-growth stands with those of nearby young stands. Their results suggested that old-growth forest development in the central Oregon Coast Range was quite different from that of the dense stands of today's young forests.

Examination of Douglas-fir tree rings demonstrated that the range of tree ages in old stands was quite variable as compared to young stands. Large trees in old stands ranged in age from 100-420 years. Trees in young stands were generally within 5-10 years of the same age. Old stands also demonstrated considerable spatial variation in numbers of trees, tree ages, and tree sizes. For example, Figure 2 shows the density, ages and diameters of trees in four plots in an old-growth stand and four plots in a young stand. A major conclusion from these data was that old stands exhibited considerable within-stand heterogeneity whereas young stands had much more uniform tree ages and sizes (Figure 3).

CFER Cooperative Forest Ecosystem Research

US Department of the Interior
US Geological Survey

USGS FS-034-03
April 2003

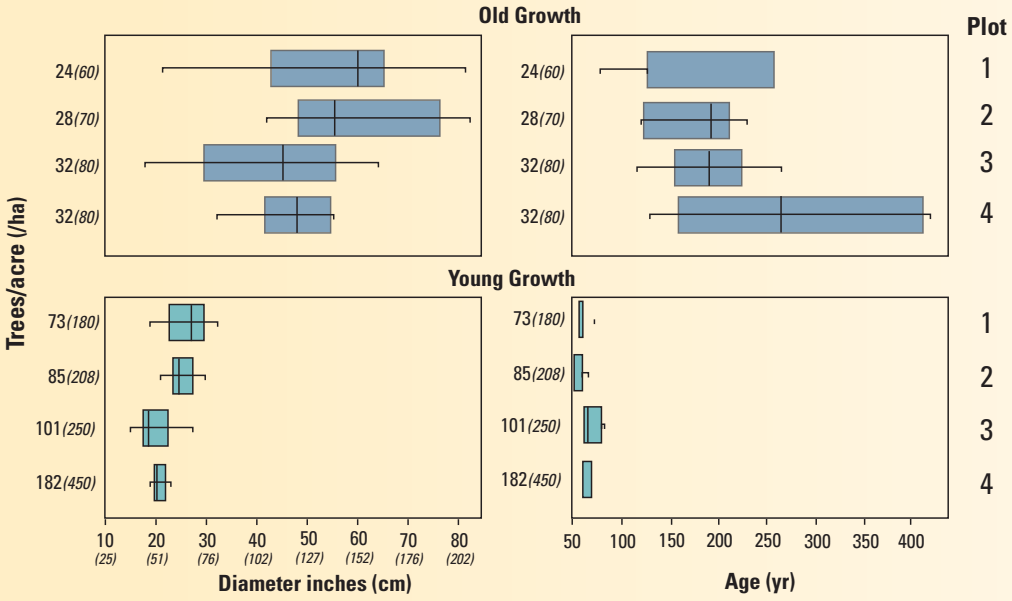


*Figure 2. Variation of tree diameter and age on four plots each in an old-growth and a young Douglas-fir stand. Boxes represent the middle 50% of observations; vertical line is the median; horizontal lines include values 1.5 times the upper or lower quartile (quartiles divide the frequency distribution into four classes with each containing one fourth of the total). Figure adapted from Tappeiner, Huffman, Marshall, Spies, and Bailey, 1997.*

The researchers also compared the early growth of trees in young-growth stands with the early growth of trees in the old-growth stands. Figure 4 displays a comparison of the diameter growth rate at 50 years of age in trees in young stands to those of contemporary old trees when they were the same age. The diameters and diameter growth rates for the first 100 years of dominant trees in the old-growth stands were found to be significantly greater than those in the young stands. The higher growth rates that were measured in the old stands were attributed to low stand densities at early ages. These growth rates were comparable with those from long-term studies of low-density young stands in which density was about 40-50 trees/acre (100-120 trees/ha). However, most young stands at present have densities well over 200 trees/acre (500 trees/ha).

*Figure 3. Young, dense stands in the age range of 40 to 60 years cover vast portions of the Pacific Northwest. Managers question whether these forests will grow to resemble the old-growth forests they replaced.*

From these studies conducted on over 50 sites, Tappeiner and colleagues (Poage 2001 and Sensenig 2002) concluded that the old-growth forests they studied developed under conditions of low tree density where little competition occurred between individual trees and stands regenerated over several decades. These conditions are in stark contrast to those of today's young stands, which are developing with high densities of trees having similar ages and exhibiting considerable self-thinning.

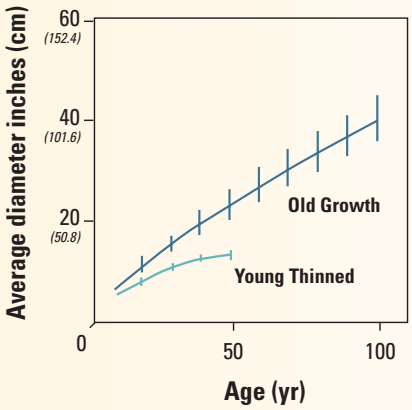


*Figure 4. Average diameter of main canopy trees from an old-growth and young stand. Error bars are standard errors. Figure adapted from Tappeiner, Huffman, Marshall, Spies, and Bailey, 1997.*

Dr. Nathan Poage expanded Tappeiner's work by examining forest development at other sites in central western Oregon. He collected diameter growth and age data from the stumps of 505 recently cut old-growth Douglas-fir trees at 28 sites in the Oregon Coast Range, Willamette Valley and western Oregon Cascades (Figure 5). He found that large-diameter old-growth trees grew rapidly when they were young. For example, trees in dense young forests averaged about 10 inches (25 cm) in diameter at 50 years of age, whereas many old-growth trees were found to have diameters twice that large at 50 years. Furthermore, the diameters of the old-growth trees at ages 100

to 300 years were strongly and positively related to their diameters at age 50 years and, more importantly, to their basal-area growth rates as young, 50-year-old trees (Figure 6). Rapid and sustained growth by age 50 years was strongly correlated with large size at older ages. Thus, the large old-growth trees generally grew rapidly when they were young.

In addition to characterizing the long-term patterns of diameter and basal-area growth of individual old-growth trees, Poage examined the stem and crown characteristics of old Douglas-fir trees and compared the structural characteristics of the old trees to those of young trees growing in different stand density treatments (low stand density, high stand density and an unthinned control). A specific characteristic, low heights to live and dead branches, supported the hypothesis that many of the old-growth trees grew at low stand densities when young. On average, live branches occurred on over 50% of the trunk. Height-to-diameter ratios of the old-growth trees also were found to be low (<50; unitless), indicating high mechanical stability. Compared to the young trees in high-density stands, the young trees in low-density stands had crowns and height-to-diameter ratios more similar to old-growth trees. From these data, it appears that specific characteristics that we attribute to old-growth trees, such as large-diameter branches low on the trunk and deep large crowns, are likely to develop much sooner at low stand densities than at high stand densities.

*Figure 5. Diameter-growth and age data were collected from the stumps of 505 recently cut old-growth Douglas-fir trees in western Oregon.*

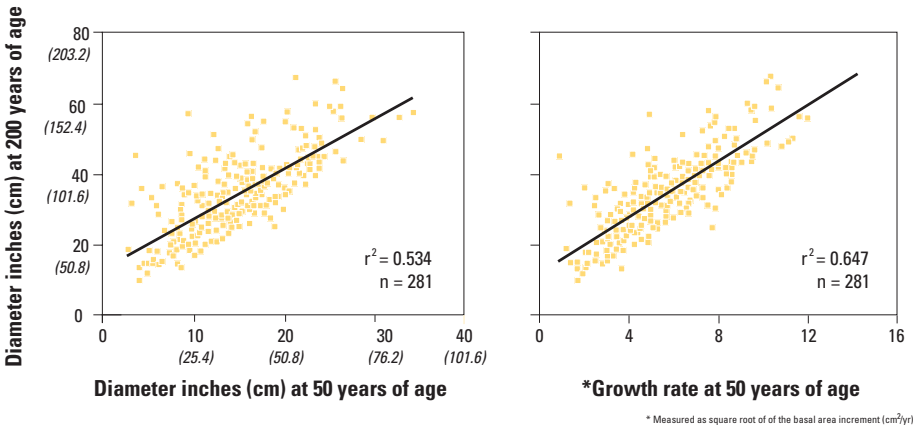


*Figure 6. The relationship of diameter of old-growth trees in the Oregon Cascades at age 200-years to their diameter and annual basal area increment at age 50-years. Figure adapted from Poage and Tappeiner (2001).*

## Conclusions

The old-growth stands examined in these studies appear to have followed similar developmental trajectories (i.e., low initial stand densities, long periods of stand initiation); however, it is likely that there are multiple developmental pathways that result in the structural complexity characteristic of old-growth forests in the Pacific Northwest. A study of structural development of a 500-year-old old-growth forest in the western Washington Cascades found that stand establishment occurred over a relatively short period of time (21 yrs) and at a relatively high density (~320 trees/acre or ~800 trees/ha at 40 yrs; Winter 2000). Thus, the development of old-growth Douglas-fir forests may have been different in the northern Cascades. Active management may be useful in accelerating the development of specific structural features. In particular, Tappeiner and Poage's work indicates that density management of these stands may be useful in increasing diameter-growth rates and producing large, deep, irregular crowns and stable stems. Evidence from related studies investigating the effects of thinning on biodiversity (e.g., Muir et al., 2002) suggests that thinning in these forests also can speed development of other old forest characteristics, including development of diverse understories of trees and shrubs and multiple canopy layers.

The results from these and other studies provide important insights for both the ecologist interested in how individual components of old-growth forests developed over time and the manager interested in incorporating aspects of natural forest development into management of young stands. Although no single silvicultural prescription is appropriate for all young stands, thinning of some stands or in some places in a stand may be an important tool to enhance habitat complexity and promote diversity more quickly in otherwise homogenous young forests. Joseph Lint, a biologist with the Bureau of Land Management states, "The thinning of young forests is a common forest management practice to increase timber yield. Now, however, our end product on some of the lands we manage is a late-successional forest, not a stand of timber for harvest. Our understanding of the role of thinning in the growing of diverse old forests will be important to the implementation of our forest management plans."

### Research Highlights from the Coast Range, Willamette Valley, and Cascades Physiographic Provinces of Western Oregon…

- Old-growth stands exhibited considerable within-stand heterogeneity whereas young stands had much more uniform tree ages and sizes.
- Diameter-growth rates for the first 100 years of trees in old-growth stands were found to be significantly greater than those in young stands. The lower diameter-growth rates in young stands were attributed to their high stand densities.
- Patterns of tree growth and stand density that an old-growth tree experienced at a young age set the stage for its ultimate size at old age.
- Specific characteristics attributed to old-growth trees, such as large-diameter branches low on the trunk and deep large crowns, develop sooner at low stand densities.
- Density management activities may be needed to enable young stands to increase diameter-growth rates and produce large crowns and stable stems in stands where the goal is to achieve old-growth forest structure.

*This factsheet is one in a series of information products produced by the Cooperative Forest Ecosystem Research (CFER) program and the USGS Forest and Rangeland Ecosystem Science Center (FRESC) on thinning to increase biodiversity in young Douglas-fir forests. The Bureau of Land Management was a particularly important contributor to this research. For additional information, please see the report "Managing for Biodiversity in Young Douglas-fir Forests in Western Oregon" and the associated video "Managing for Biodiversity in Young Forests." Requests for the report and video (available on VHS and DVD) can be directed to the CFER program office at cfer@fsl.orst.edu or 541-737-7612.*

## Glossary[1]

Basal area: The area of the cross section of a tree stem, including the bark, near its base, generally at breast height ( 4.5 feet above the ground).

Biological diversity: The variety of life forms and processes, including a complexity of species, communities, gene pools, and ecological functions.

Crown: The upper part of a tree that carries the main system of branches and foliage.

Density: An expression of the number of trees on a forest site.

Habitat: The place where a plant or animal naturally or normally lives and grows.

Northwest Forest Plan: A comprehensive strategy for lands managed by the USDA Forest Service and the USDI Bureau of Land Management to maintain and restore late-successional forests, with simultaneous recognition of their importance to regional economies. An interagency team of scientists, the Forest Ecosystem Management Assessment Team, developed and assessed a variety of forest-management alternatives, one of which was selected as the Northwest Forest Plan.

Old-growth: A forest stand usually at least 180-200 years old with moderate to high canopy closure; a multilayered, multispecies canopy dominated by large overstory trees; high incidence of large trees, some with broken tops and other indications of old and decaying wood (decadence); numerous large snags; and heavy accumulations of wood, including large logs on the ground.

Silvicultural prescription: A professional plan for controlling the establishment, composition, constitution, and growth of forests.

Stand: An aggregation of trees occupying a specific area and sufficiently uniform in composition, age, arrangement, and condition so that it is distinguishable from the forest in adjoining areas.

Young stand: Forest stands not yet mature, generally, less than 50-80 years old; typically 20-40 years old.

## Additional Information


Muir, P.S., R.L. Mattingly, J.C. Tappeiner, J.D. Bailey, W.E. Elliott, J.C. Hagar, J.C. Miller, E.B. Peterson, and E.E. Starkey. 2002. Managing for biodiversity in young Douglas-fir forests of western Oregon. U.S. Geological Survey, Biological Science Report, USGS/BRD/BSR-2002-0006.

Poage, N.J. 2001. Structure and development of old-growth Douglas-fir in central western Oregon. Ph.D. thesis. Corvallis, OR: Oregon State University.

Poage, N.J., J.C. Tappeiner. 2002. Long-term patterns of diameter and basal area growth of old-growth Douglas-fir trees in western Oregon. *Canadian Journal of Forest Research* 32:1232-1243.

Sensenig, T. 2002. Development, fire history, and current and past growth of old-growth and young growth forest stands in the Cascade, Siskiyou, and mid-Coast mountains of southwestern Oregon. Ph.D. thesis. Corvallis, OR: Oregon State University.

Tappeiner, J.C., D.W. Huffman, D. Marshall, T.A. Spies, and J.D. Bailey. 1997. Density ages and growth rates in old-growth and young-growth forests in western Oregon. *Canadian Journal of Forest Research* 27:638-648.

Winter, L.E. 2000. Five centuries of structural development in an old-growth Douglas-fir stand in the Pacific Northwest: a reconstruction from tree-ring records. Ph.D. thesis. Seattle, WA: University of Washington.


## Video


Tappeiner, J., J. Hagar, J. Miller, E. Peterson, A. Rosso, J. Lint, P. Muir, and M. Reed. 2000. Managing for biodiversity in young forests (VHS and DVD). 1155 V-T. Available from: Forest Media Center, Oregon State University. Corvallis, Oregon.


[1] Taken or adapted primarily from FEMAT (Forest Ecosystem Management Assessment Team) 1993. Forest ecosystem management: An ecological, economic, and social assessment. 1993-793-071. US Government Printing Office. Washington, DC.


**For more information contact:**

CFER
301M Richardson Hall, OSU
Corvallis, OR 97331-5752
541-737-7612
cfer@fsl.orst.edu
http://www.fsl.orst.edu/cfer
**or**

Information and Outreach
USGS Forest and Rangeland
Ecosystem Science Center
777 NW 9th St., Suite 400
Corvallis, OR 97330-6169
541-750-1047
http://fresc.usgs.gov

Authored by John Tappeiner, Nathan Poage, and Janet Erickson.
Graphics and layout by Gretchen Bracher and Don Poole.
Cooperating agencies: The Bureau of Land Management and Oregon State University.