Two-aged to Multi-aged Stand Management in the Coast Range

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Douglas-fir forests in western Oregon are traditionally harvested and regenerated through clearcutting and replanting, but many landowners are interested in other harvest methods that retain some mature trees. Some prefer the aesthetics and ecological values of a multi-aged forest with many canopy layers. However, most private forests in western Oregon are even-aged, having originated as plantations of a single species. Transitioning these forests to multi-layered, multi-aged forests requires active management, including substantial timber harvest. This case study describes one family's experience using active management to convert a mature, even-aged stand to a multi-aged stand (Figure 1).

Photo: Stephen Fitzgerald, © Oregon State University

Figure 1. The stand in 2009, showing the residual overstory trees (background) and regenerating cohort (foreground). Note the good height growth on the young trees.

The Hayes Family and Hyla Woods

The Hayes family owns and manages about 1,000 acres of forestland at three sites in Washington County, collectively known as Hyla Woods. Peter and Pam Hayes co-manage the forests, which for the most part were bought by Peter's father, Ned Hayes, in the 1980s. The family summarizes their management philosophy as creating "ecologically complex, economically viable, responsibly operated forests." Managing multi-aged, multilayered, multispecies forests is a key part of their approach, with the assumption that these diverse forests will be more resilient to known and unknown stressors in the long term.

Hyla Woods is also recognized for leading local efforts to connect the public with the sources of the wood they consume, and has set an example in this regard. The Hayes family participates in the Build Local Alliance; manufacture many wood products, from kiln-dried lumber to cutting boards; and strive to sell logs and wood products directly to end users whenever possible. Consequently, they have found premium markets for

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the high-quality wood they produce. All of these strategies are central to maintaining economically viable forests that also foster the high level of biological diversity, complexity, and wildlife habitat that Hyla Woods is known for. The Hayes family also hopes to someday realize economic returns from **ecosystem services** such as carbon sequestration, creation of wildlife habitat, provision of quality water, or other societal benefits associated with their operations.

The Hayes family, along with community partners, researchers, and volunteers, regularly monitors their forests to determine whether their efforts to increase structural and species diversity are leading to their intended outcomes. Ongoing bird, amphibian, mammal, and stream surveys are a part of this effort.

ecosystem services—The benefits that individuals and societies gain from our environment, including clean air and water, climate regulation, pollution control, flood regulation, recreation, food, and spiritual values.

Stand and Forest Conditions

The stand described in this case study is within a 160-acre parcel near the town of Timber, in the Northern Oregon Coast Range at about 1,000 feet in elevation. Precipitation averages about 60 to 65 inches per year, with most falling between October and March as rain with occasional snow. Soils are well-drained, Melby silt loam with a 50-year site index of 110 to 115 for Douglas-fir. The property is surrounded on all sides by other forestlands including industrial, state, and other small woodland owners.

The property was logged by railroad in the 1920s. Ensuing natural regeneration resulted in a forest dominated by Douglas-fir with a minor (approximately 2 percent) grand fir component. In the 1970s and '80s, the previous owner conducted selective harvests throughout the site. Little is known about the volume harvested during this time. By 1997, the site was supporting approximately 60 trees per acre, with the dominant trees measuring about 30 inches **DBH**. Total volume in 1997 was about 22,000 board feet (22 **MBF**) per acre. Over time, perhaps as a result of the selective harvests and natural disturbances, new trees regenerated in the understory, resulting in a forest that is largely even-aged but with a minor component of younger, smaller trees.

DBH—Diameter at breast height (4.5 feet)

MBF—Thousand board feet. A board foot is used to measure or express the amount of wood in a tree. The dimensions of a board foot are 12 inches × 12 inches × 1 inch.

The forest is generally free of insect and disease problems, aside from pockets of laminated root rot, which are found scattered across the site. These areas tend to be dominated by salal and bitter cherry. Other common understory species include vine maple, Oregon grape, as well as bracken and sword fern.

Harvest Goals and Implementation

In 1997, Ned Hayes and consulting forester Mike Barnes implemented a modified **shelterwood harvest** in a 9-acre stand on a flat hilltop. Before the harvest, the stand had patchy **stocking** with significant gaps filled with vine maple. Though most of the trees dated back to the 1920s, some smaller, younger trees had grown in the intervening years.

shelterwood harvest—In this system, most trees are cut while a small percentage are left dispersed throughout the site to supply sufficient shade and seed to produce a new age class of trees beneath. The "shelter" trees can be harvested later or, if they're retained, the stand can be managed as a two-aged system.

stocking—A description of the number of trees per acre, wood volume per acre, or basal area in a stand compared with a desirable level for best growth and management. Stocking is often used as a relative term, such as partially stocked, well-stocked, or overstocked.

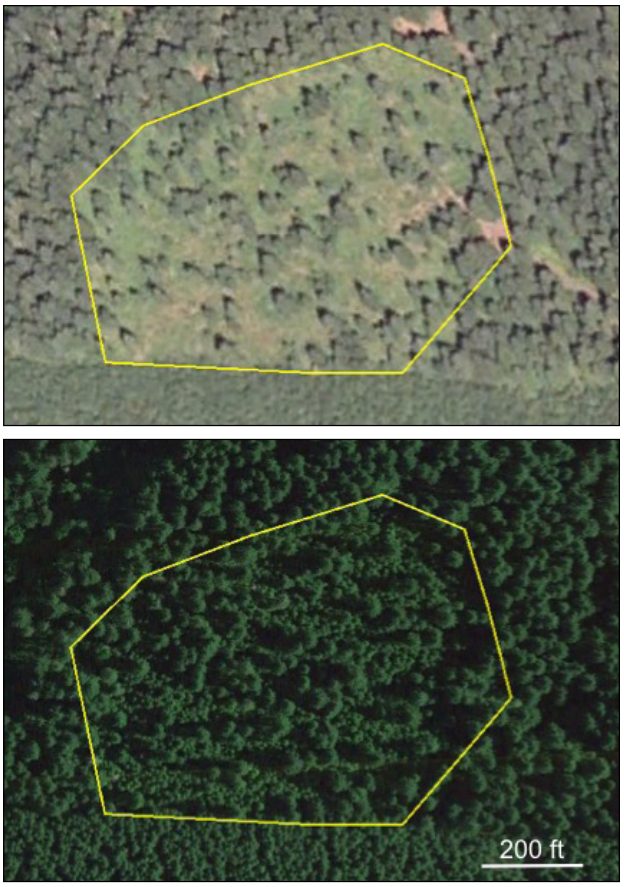
Shelterwood harvests in western Oregon are uncommon because they can be challenging to implement. Competition from the residual overstory trees can overwhelm the younger understory trees' demand for light, water,

and growing space. There is always the chance of damage from windthrow, and if the residual overstory trees are harvested later, damage to the understory trees is hard to avoid.

Despite these potential drawbacks, they chose a shelterwood harvest designed to achieve multiple goals. The first was to set the stage for growing a new age class of trees, so the canopy needed to be opened up and the site prepared for planting. Second, the family wanted to develop a more complex stand structure in the long term, with a greater diversity of tree ages, species, and canopy layers.

This second objective influenced many of the decisions about which trees to cut and which to leave. The largest dominant trees were retained. Other trees were retained to create a varied overstory pattern with a mix of heights, and individual trees and clumps of trees dispersed across the site (Figure 2). To increase the overall species diversity of the stand, grand fir and other minor species were left. As a result, the residual stand makeup shifted to about 6 percent grand fir (compared to 2 percent throughout the property as a whole).

This harvest yielded 116 MBF (roughly 13 MBF per acre). Around 75 percent of the trees were removed; but because the largest trees were retained, only about 60 percent of the stand volume was removed. After the harvest, about 35 trees per acre of varying sizes remained on the site. Logs were moved by crawler tractor and shovel to a designated skid trail that runs through the middle of the stand. Slash was piled in some areas and scattered in others, but neither burning nor chemical site preparation was used.



Source: Google Earth

Figure 2. Aerial photos taken in 2005 (top) and 2017 (bottom) show the stand (outlined in yellow) where the shelterwood harvest was implemented. Note the varied spatial distribution and size of the residual trees throughout the unit, and the varied canopy structure 20 years post-harvest. The property line is directly to the south of the stand.

Regeneration

A mix of Douglas-fir (75 percent), grand fir (15 percent), and western redcedar (10 percent) was planted the year following the harvest, with some hemlock planted a few years later. Seedlings were **released** manually as needed in the years following planting, mainly to control Scotch broom. Redcedar survival was poor due to browse damage, although both big game repellent and mesh tubes were used to try to control the damage.

In addition to the planted seedlings, natural regeneration was abundant. As a result, by 2006, about 380 trees per acre had reached **"free-to-grow"** height and were surviving in the understory with many smaller seedlings (Figure 1, page 1). It is not known how many of the seedlings regenerated naturally compared to what was planted. This young **cohort** is approximately 75 percent Douglas-fir and 25 percent grand fir.

release—A treatment that reduces competing vegetation around seedlings to ensure their survival and continued growth. Methods include manual cutting, grubbing, or the use of herbicides.

free-to-grow—A seedling or small tree that is free from direct competition from other trees, shrubs, grasses, or herbaceous plants

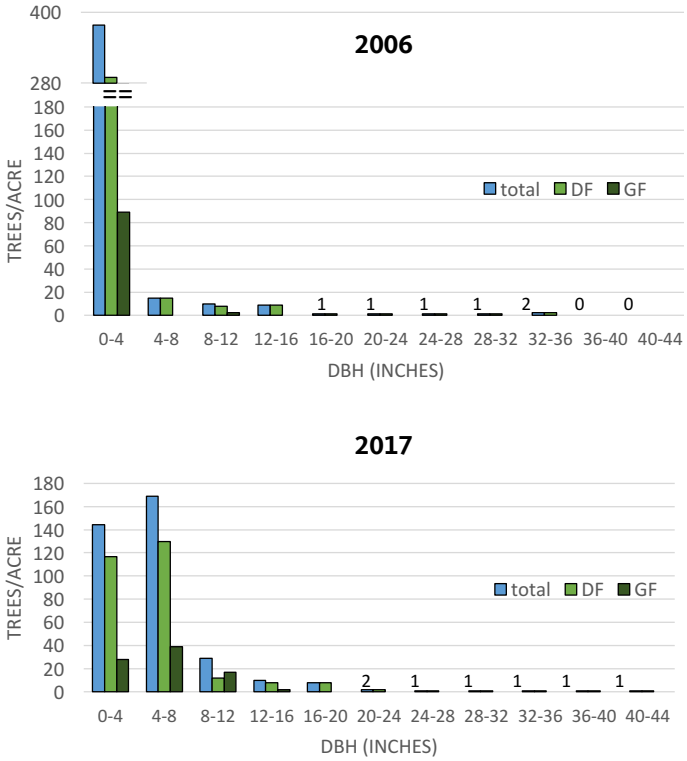
cohort—A group of trees of similar age that have developed after a disturbance such as a fire or timber harvest

Current Stand Structure

Other than some limited pre-commercial thinning, there was very little additional management in the stand through 2017. While the dense stocking of the understory has led to some competition-induced mortality, many of the trees are now large sapling size. Heavy snows and strong winds in the winter of 2017 brought down more understory trees; however, none of the overstory trees blew down.

In 2006, researchers from Oregon State University College of Forestry installed a permanent inventory plot in the stand, as part of a larger study of two-aged stand performance in western Oregon. All overstory trees were measured in a 1-acre plot, and understory trees were measured in 1/50-acre subplots. The plots were measured again in 2011 and 2017 to track stand development.

In 2017, the stand had over 360 trees per acre. Around 70 percent of these trees were less than 6 inches DBH. However, over the last 10 years, the stand diameter distribution has begun to differentiate, as shown in Figure 3.



Graph: Amy Grotta, © Oregon State University

Figure 3. Diameter distribution in 2006 and 2017 for Douglas-fir (DF) and Grand fir (GF).

Understory growth

The 2006 inventory, conducted when the young trees were 7 to 8 years old, indicated that most of the seedlings were growing less than 12 inches per year in height. Over time, height growth has improved as the trees have grown above the shrub layer; from 2006 to 2017, the understory trees grew an average of 2 feet in height per year. Average annual diameter growth has been about 0.3 inches per year, or about 6 to 7 rings per inch. Compared to 20-year-old trees growing in typical even-aged conditions, the trees in this stand are generally much smaller.

However, growth varies widely based on spacing and species of the trees. (Table 1). Among Douglas-fir, the young trees in larger openings are growing best, while those that are close to overstory trees are growing very

Table 1. Growth of understory trees 2001–2017

	Douglas-fir			Grand fir		
	Average annual height growth (ft) average (range)	Annual diameter growth (inches) average (range)	Mortality	Average annual height growth (ft) average (range)	Annual diameter growth (inches) average (range)	Mortality
2001–2006	0.8	Not measured		0.9	Not measured	
2006–2010	1.5	0.3 (0.0–0.7)	6%	2.4	0.4 (0.3–0.6)	0%
2011–2017	1.9 (0.4–3.6)*	0.2 (0.0–0.5)	10%	2.7 (2.0–3.4)*	0.4 (0.2–0.9)	0%

*Does not count trees with broken tops in 2017

slowly and showing signs of suppression. In 2017, average diameter of the understory Douglas-fir was 3.9 inches, with a range from 1 to 8 inches. The grand fir understory trees are growing faster in height and diameter; from 2011 to 2016, all grand fir grew at least 2 feet in height per year and 0.2 inches in diameter per year. Average grand fir diameter in 2017 was 5.4 inches, with a range from 1 to 10 inches. There was some Douglas-fir competition-induced mortality, but no grand fir mortality. Because grand fir trees are more shade tolerant than Douglas-fir, they appear to be less affected by shading from overstory trees. Douglas-fir trees also were more vulnerable than grand fir to blowdown in the 2017 windstorm, likely because the Douglas-fir trees were weaker, with smaller diameters for their height (Figure 4).

Photo: Amy Grotta, © Oregon State University
Figure 4: Winter snow and wind damaged this understory Douglas-fir. Trees that are spindly like this one are more vulnerable to becoming bent or blown over.

Overstory growth

With their wide spacing relative to one another and deep crowns, the overstory trees continue to grow robustly. In fact, although the overstory trees make up less than 10 percent of the total number of trees in the stand, they accounted for 35 percent of the **basal area** growth between 2011 and 2017. These large trees are growing an average of 0.5 inches in diameter per year, which translates to about 4 rings per inch. Trees in the overstory now average 17 inches DBH, with the largest trees over 40 inches DBH (Figure 5, page 6).

Future Stand Management

Peter and Pam Hayes' long-term goal is to create an **uneven-aged stand** structure on this site. Uneven-aged stands typically have many small trees and increasingly fewer large-diameter trees. Creating a two-storied stand with the 1997 harvest was a first step towards this desired outcome. Although it is technically still a two-storied stand, it is approaching the "inverse-J" diameter distribution characteristic of an uneven-aged stand structure (Figure 3, page 4; and Figure 6, page 6). This is due to the variable growth of trees in the understory.

To create and sustain a successful uneven-aged system, the following challenges will need to be taken into consideration:

Overstory management

Management of the overstory will be critical to achieve a resilient uneven-aged stand. Although the large trees were intentionally retained to diversify the stand structure (habitat), especially for birds, removing some large trees to establish another age class (or release the existing understory age class) may still provide adequate habitat while moving this stand toward an uneven-aged structure. The key to success will be in striking this balance.

There is some concern that the overstory trees may grow too large for traditional log markets. However, since the Hayes family has a small sawmill, they can potentially turn these large trees into custom and high-value products. Alternatively, the largest trees could be retained permanently, and any overstory harvesting could target trees under 36 inches DBH. In that case, it would make sense to identify the large trees to be kept indefinitely and avoid planting around them.

basal area—The cross-sectional area of a tree, or all the trees in a given area, measured in square feet at breast height (4.5 feet). The basal area of one tree is calculated with the following formula: Basal area for a tree = (DBH in inches)^2 × 0.005454.

uneven-aged stand—A stand with trees of three or more distinct age classes, either intermixed or in small groups

Harvesting any of the large trees will almost certainly cause some damage to understory trees. Solutions could include careful directional felling into the skid road and other open areas, or cutting small patches by taking out the smaller trees first and then felling the big trees into the openings created. Alternatively, given the family's habitat goals, some of the larger trees could be retained for **snags**. This would help release the understory with less disturbance, while increasing biological diversity by creating habitat for many different species.

snag—A standing dead tree

Understory tree vigor

Currently, the residual overstory trees are controlling (suppressing) some understory tree growth and development, causing the younger trees to grow at different rates. Some of the trees are growing relatively well, but many are suppressed or have grown spindly due to the overstory shade. There is some self-thinning (mortality) of the understory trees from both competition-induced mortality and storm damage. This self-thinning is likely to continue. Some additional, pre-commercial thinning of this lower canopy layer could favor the most vigorous trees. However, thinning alone without any reduction of the overstory will not substantially increase growth rates—many understory trees would likely remain below merchantable size for some time, while growth is concentrated in the overstory trees and the understory trees that are less affected by competition (i.e., growing in openings).

Photo: Amy Grotta, © Oregon State University
Figure 5. This Hyla Woods stand, pictured in 2017, shows understory trees of varying sizes and some retained overstory trees in the background. Pictured are Pam and Ben Hayes.

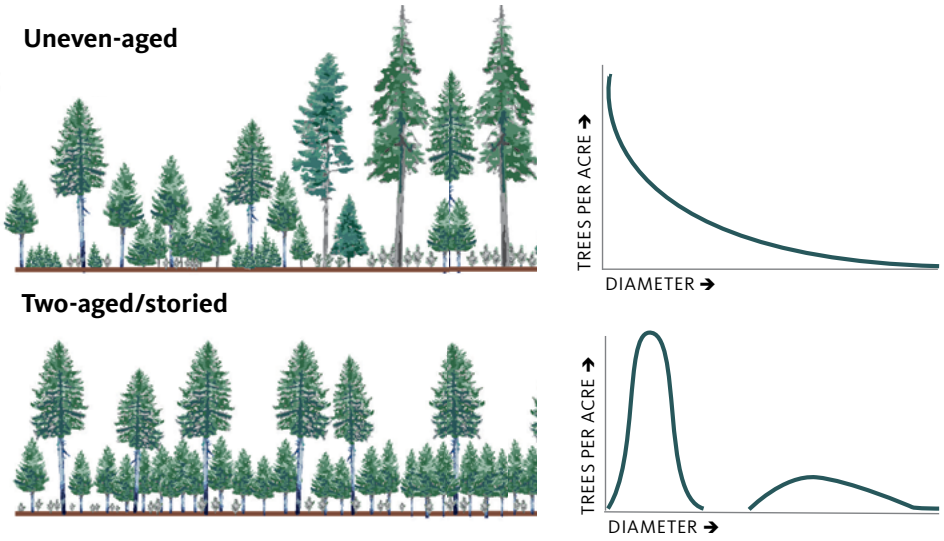


Illustration: Gretchen Bracher, © Oregon State University
Figure 6. Diameter distribution of uneven-aged stand and two-aged stand.

Regeneration

Further management will be needed to cultivate more age classes over time, although this is not critical right now. As the current understory continues to grow, natural regeneration will be unlikely unless new space is created. Harvesting small gaps (taking out trees of all age classes in the gap) will allow for some regeneration of shade-tolerant species. This could be natural grand fir reseeding, or planting western redcedar or another shade tolerant species.

Lessons Learned

- Because of the previous history of selective harvesting and patchy stocking at the time of the 1997 harvest, the overstory trees had developed long crowns and good windfirmness, so there was little risk of windthrow after the shelterwood harvest. The residual trees were vigorous, leading to good seed production. If this type of harvest had been implemented in a stand with higher initial density, the results might not have been as successful.
- Natural regeneration was highly successful in this stand. In retrospect, the owners didn't need to plant trees to achieve adequate stocking, which would have been a cost savings. A positive outcome of the experiment included testing an approach that leads to regeneration without the need to replant or use herbicides.
- Given climate predictions of hotter and drier summers, the overstory protection provided by a shelterwood system might have benefits for seedling survival. On the other hand, the large trees left behind would consume large amount of soil moisture, competing directly with seedlings and understory trees.
- The growth performance of the young cohort is variable and controlled by the overstory. In areas within the stand where there are fewer overstory trees, young trees are vigorous and growing at about the rate one would expect in an even-aged stand. Seedlings that have germinated closer to overstory trees are growing slower. Over time, this will create further variation in canopy layers and increased stand complexity, which is in line with the owners' objectives.
- There are many management options available to the landowners going forward. To move toward the uneven-aged stand that they desire, the Hayes family will have to manage stand density carefully to avoid stagnation of the understory cohort. Some additional overstory removal is likely necessary to regenerate additional cohorts.
- The owners' choice to use a shelterwood harvest was based on the assumption that retaining some large trees would create a more functional forest ecosystem by increasing complexity. The Hayes family is monitoring wildlife to learn whether their management actions have an impact. For example, they conduct ongoing bird surveys focused on several indicator species that rely on large trees. Their annual bird counts show at least as many or more birds, and more birds of at-risk species, in the shelterwood stand compared to an unmanaged mature stand nearby. However, the relationships between the number of large trees retained on

a site and desired ecological benefits (such as nesting success) are still not well understood.

- The shelterwood harvest generated a burst of income at the beginning of this project, although with the partial harvest and slightly higher management costs, the profit was not as large as it would have been from conducting a clearcut on the same site. Future revenue from this stand remains to be seen. The relatively flat terrain and good road access will facilitate repeated entries with a variety of logging equipment.

For Further Information

Please visit:

- www.hylawoods.com
- www.buildlocalalliance.org

Read another case study on managing for older forest structure in western Oregon:

- *Group Selection Cutting in Mature Douglas-fir Forests* (EM 9106) https://catalog.extension.oregonstate.edu/em9106

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