

Mixed Conifer and Hardwood Forest Management in Southwest Oregon

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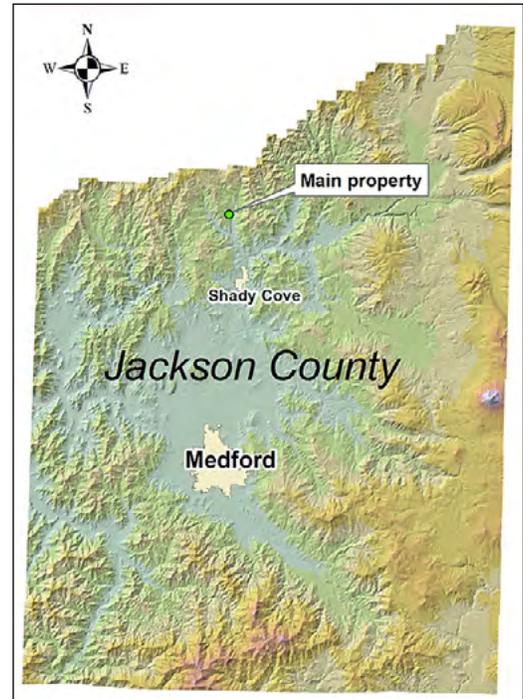
Marty Main is a consulting forester and forestry services contractor based in Medford, Oregon. Early in his career, he worked in **prescribed underburning** in the Sierra Nevada. This led to a lifelong fascination with the role of fire in forest ecosystems and ways to manage forests to emulate historical patterns resulting from fire. Marty moved to southern Oregon in the late 1970s and has been managing small woodland properties in the area ever since.

In 1989, Marty and his wife, Peggy, purchased a 122-acre forest parcel on Trail Creek, a few miles north of Shady Cove, in Jackson County (Figure 1). The Mains faced several immediate challenges upon acquiring the property:

- Many stands contained dense, noncommercial Douglas-fir and hardwoods, with 1,100 or more trees per acre. Individual tree vigor was poor, and there was a growing risk of a “crash” due to high potential for bark beetle and drought-induced mortality.
- Moderate to heavy fuel loads, especially surface and **ladder fuels**, posed a significant risk of high-severity wildfire.
- Large black oaks and Pacific madrone were being lost to overtopping by conifers, and large ponderosa and sugar pines were being lost to competition-related stress, beetle attack, and disease (white pine blister rust in sugar pine).
- There was little or no regeneration of the next age class in the developing forest. **Shade intolerant** pines and oaks, desirable both for stand diversity and wildlife and because pines showed good long-term growth potential, were particularly lacking in the uniformly dense forests, especially on south slopes.

The Mains have several management objectives for the property:

- Promote mature forest conditions.
- Maintain multiple species and age classes.
- Increase fire resistance and reduce the potential for high-intensity wildfire.
- Financially support their management practices through several income sources, including log sales and marketing of traditionally unmarketable forest by-products such as posts, small poles, and firewood.



Map by Max Bennett, © Oregon State University

Figure 1. Location of the Mains' property in Jackson County, Oregon.

prescribed underburning—

A planned and controlled burn in the forest understory that consumes small trees and brush but leaves larger, overstory trees intact.

ladder fuels—

Lower limbs of overstory trees, small to medium-size trees, and brush that can convey a surface fire into the tree canopy, resulting in a crown fire.

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Fire exclusion and **high-grade logging** were the primary management influences on the property before the Mains acquired it in 1989. Since then, the Mains have used a combination of thinning-from-below and individual tree selection. Future plans are to employ uneven-aged management, including individual tree and group selection, to maintain a multi-aged, mixed species forest.

Stand and Forest Conditions

History

A few scattered, large-branched pines and oaks make up the oldest age classes on the property, suggesting that conditions were formerly much more open. Some of the oaks are probably over 200 years old. It is likely that the property was homesteaded in the late 1800s. High-grade logging first took place in the late 1800s or early 1900s, again in the 1920s–30s, and again in the late 1940s–50s. As a result, there are three main age classes on the property: an approximately 130-year-old **cohort** of large, scattered trees; a 70- to 90-year-old cohort that resulted from logging in the 1920s and 30s; and a 35- to 50-year-old age class that developed in the 10 to 20 years immediately after the 1950s-era harvesting. The latter age class consists mostly of dense, noncommercial, and small commercial pole-sized Douglas-fir and Pacific madrone.

There have been no known wildfires on the property since the early 1900s, though fire presumably was much more common prior to 1900.

Influence of fire and fire exclusion

Historically, frequent low- to moderate-severity fires played an important role in determining stand structure, density, and species composition in southwest Oregon mixed-conifer stands. While there are no reliable records for the Main tract itself, fire history studies from similar forests in southwest Oregon suggest that until the early 1900s, a low- to moderate-severity fire occurred every 8 to 15 years on average. These studies suggest that compared to the present, stand densities in the era of more frequent fires were lower, and stands contained higher proportions of shade intolerant species (such as pines and oaks) and were “patchier” in nature.

A century of fire exclusion in southwest Oregon mixed-conifer stands has resulted in a host of ecological consequences. These include:

- Greatly increased stand densities, primarily of smaller diameter trees and shrubs
- Subsequent increases in fuel loading and the vertical and horizontal continuity of fuels, resulting in higher fire severity
- Reduced individual tree and stand level growth and vigor
- Greater susceptibility to bark beetles and pathogens

Any efforts to manage southwest Oregon mixed-conifer forests must take these ecological realities into account.

Based on analysis of the locations of large stumps on the Main property and older trees on an adjacent, unharvested, but otherwise similar BLM parcel, a recent study reconstructed the spatial arrangement of trees on the

shade intolerant—
Trees that require full sunlight for optimal growth.

fire exclusion—
Suppression of the frequent fires that historically occurred in the western U.S. Over the past 60–150 years (depending on the area), fire exclusion has resulted in a buildup of fuels and a host of ecological consequences, including increased potential for crown fire and loss of open forest habitats.

high-grade logging—
“Take the best and leave the rest.” High grading is removal of a stand’s largest and most marketable trees regardless of silvicultural considerations.

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

Main property prior to fire exclusion. The study suggests that the pre-1900 forest was:

- Significantly lower in average density than the current stand, with a larger average tree size
- **Spatially heterogeneous**, with trees distributed either randomly or in clumps with interlocking crowns, separated by fine-scale gaps of 1/20 to 1/2 acre
- Probably characterized by a multi-story structure on south slopes but with canopy strata occurring in distinct patches, while north slopes likely had a higher proportion of multi-story canopy structure
- More uneven-aged, due to more frequent, low-severity fires that resulted in a greater range in the tree age-class distribution
- Highly variable in structure, density, and composition, so there were likely many exceptions to these generalizations

Site description and productivity

Lying at 1,900 to 2,500 feet elevation, the Main tract is typical of mixed-species forests at low to mid-elevations in southwestern Oregon. Precipitation averages 35 to 40 inches a year, mostly in the form of winter rain. Summers are hot and dry, with 10 to 15 percent of the total annual rainfall occurring at this time.

Douglas-fir is the dominant tree species, mixed with varying proportions of ponderosa pine, incense cedar, sugar pine, California black oak, and Pacific madrone. Oregon white oak is found in areas with shallow or heavy clay soils. Bigleaf maple and alder are found along streams. Characteristic understory species include poisonoak, Oregon-grape, Pacific serviceberry, common snowberry, and California fescue.

Douglas-fir **site index** (50-year base) varies from 55–80 across the tract depending on aspect and soils. Slightly less than 20 acres of the tract consist of non-coniferous forest, including oak woodlands, meadows, rocky outcrops, and thin, shallow soils with associated shrublands.

Aspect and soils combine to produce significant differences in vegetation on the property. Abrupt transitions in vegetation, typically from conifer to oak woodland, are often associated with changes in soil type.

North slopes contain primarily McNull loams that are moderately deep and well-drained. These support relatively productive stands dominated by dense pole-sized and small sawtimber-sized Douglas-fir and Pacific madrone, with occasional larger trees. The **quadratic mean diameter** (QMD) is 9.2 inches, with 426 trees per acre (tpa) and 198 square feet per acre of **basal area**. Sugar pine and incense cedar are minor components of this stand, and black oak is uncommon. Douglas-fir seedlings and saplings occur in a few widely scattered openings. The light cover of understory vegetation includes Pacific dogwood, hazel, snowberry, and swordfern. Fifty-year site index for Douglas-fir is 75–80.

South-facing slopes contain a mixture of McNull and Medco soils and are lower in productivity. Medco soils have a dense clay layer, from 6 to 18 inches deep, that restricts rooting depth and the downward flow of

spatially heterogeneous—

A varied arrangement of forest structural elements, such as trees, snags, and canopy density. Spatially heterogeneous forests often have a mix of individual trees, patches of trees with overlapping crowns, and gaps or openings.

site index—

A measure of how tall dominant trees grow over a specified period (50 or 100 years). Site index reflects the combined effects of climate and soil quality on tree height growth. Trees growing on good sites (high site index) grow faster in height than trees on poor sites (low site index) over a 50- or 100-year period. The result is higher volume growth in board feet on the better site.

quadratic mean diameter (QMD)—

The average diameter of a stand, weighted by basal area. Foresters typically use QMD instead of the arithmetic diameter because it provides a more accurate representation of stand conditions.

Basal area per acre—

The cross-sectional area of all trees in square feet at breast height (4.5 feet) in an acre; a measure of forest density and stocking. The basal area of one tree is calculated with the following formula:

Basal area for a tree = (DBH in inches)² x 0.005454

water, resulting in a perched water table during winter and spring. Where these soils dominate, ponderosa pine increases in abundance and ultimately becomes the most common conifer on the site.

South slopes are also Douglas-fir dominated but include ponderosa and sugar pine, black oak, a few incense cedar, as well as the ubiquitous madrone, with a stand QMD of 8.0 inches, 479 tpa, and 168 square feet per acre of basal area. Sugar and ponderosa pines tend to be the largest and fastest-growing trees. Douglas-fir regeneration is found here and there in small openings, but it is not abundant because of excessive densities over the last 50 years. Oak regeneration is confined to stump sprouts, and pine regeneration is scarce. Understory vegetation includes poisonoak, snowberry, and grass. Fifty-year site index for Douglas-fir ranges from 55–75.

The terrain is flat to gently sloping, with steeper slopes (greater than 40 percent) confined to less than 10 percent of the area, primarily on northerly aspects. After acquiring the property, the owners created a permanent road system by upgrading fragments of roads remaining from earlier logging. Permanent skid trails have been developed throughout the property.

Insects and diseases

Large sugar pines are at risk from mountain pine beetles, pine engraver beetles, and white pine blister rust. Ponderosa pines are attacked by western pine beetle and pine engraver. Douglas-fir beetle is not common, but low-vigor Douglas-fir may be invaded by flatheaded fir borers, which act similarly to bark beetles. No major outbreaks have as yet been recorded on the property (at least in part to ongoing noncommercial thinning and resulting stand improvement over the past 20 years), but trees in overstocked stands and on marginal sites are at higher risk, especially in drought years.

Root disease problems include a few pockets of *Armillaria*, occupying less than 5 percent of the total area, and blackstain, which has killed scattered individual trees across the site. White pine blister rust is often found on sugar pine trees, which are represented in small numbers in the overstory.



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Figure 2. Plot 34 on south aspect, 1989. Note dense, pole-sized Douglas-fir. Initial stand densities in this plot exceeded 1,000 stems per acre.



Photo by Max Bennett, © Oregon State University

Figure 3. Plot 34 in 2010 after two thinnings and a light underburn. (Note: Photo position does not exactly match that in Figure 2). Note wide thinning around larger residual madrone and ponderosa pine trees. Some Douglas-fir trees in subordinate crown classes are close to marketable size; a little additional growth will convert these noncommercial logs (an expense) into commercial ones (revenue).

Stand management

Two objectives largely dictated the approach used during the first 20 years under the Mains' management:

1. Reduce stand density in very overstocked, low vigor, small diameter stands. This objective was realized through repeated light to moderate thinnings from below, with some removal of trees in larger size classes that were dead, dying, diseased, defective, or of very low vigor (Figures 2 and 3, page 4).
2. As much as possible, use or sell (or both) small-diameter material, including both small logs and other material generated from thinning that would normally be regarded as unmarketable. This objective was met through removal and processing of small, noncommercial- and commercial-sized logs that were relatively close to roads and pre-designated skid trails. This material was sold as logs, posts and small poles, and firewood.

High initial tree density resulted in poor tree vigor and unbalanced stems with high height-to-diameter ratios. The Mains felt that a series of frequent, light thinnings would improve vigor without the risk of thinning shock or tipping over of retained trees. Accordingly, they noncommercially thinned from below both the north and south slopes, once during the early 1990s and again about 10 years later. Most of the trees removed were sapling- and pole-sized Douglas-fir and hardwoods in the 40- to 50-year age class, as well as a smaller number of trees in suppressed and intermediate crown classes in the 75- to 90-year age class.

In some cases, stand density was left higher than would be optimal from a tree vigor standpoint, because residual trees were nearly of commercial size. Allowing these trees to grow into a marketable sawlog size would make the next thinning entry much more economical.

In addition to thinning from below, subsequent light commercial thinnings targeted low-vigor, dead, and dying trees, and generated a total of about 24 self-loader log-truck loads, or 67 **MBF**. These entries typically generated around 500 to 1,500 board feet per acre, although scattered individual trees were also harvested as needed. There was also wide thinning around large residual Douglas-fir, ponderosa pine, sugar pine, and hardwoods, which was intended to reduce competition and improve vigor and resistance to various pathogens. In addition, two areas were underburned.

The transition to more favorable stand densities and structure is occurring over a 25-year period. Shifting to a more desirable species composition will likely take considerably longer.



Photo by Max Bennett, © Oregon State University

Figure 4. The California black oak in the center of the photo is a remnant of an earlier stand that was likely much more open (this species is shade intolerant). Large, residual black oak trees are scattered across the property's south slopes and broad ridgetops. Their size and tendency to develop heart rot make them excellent wildlife trees.

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" × 12" × 1".

Stand Structure

Current stand structure

As noted above, there are three main age classes in the stand. The oldest age class consists of scattered, large-diameter ponderosa pine, sugar pine, and Douglas-fir (approximately 130 years old), as well as California black oaks that may be 50 to 100 years older than nearby conifers (Figure 4, page 5). These oldest trees are scattered remnants, not dense or contiguous enough to form a distinct canopy layer. The intermediate age class (70 to 90 years) consists of these same species (though with fewer pines and oaks) along with Pacific madrone. In some areas, trees in this cohort emerge above the main canopy as scattered individuals. In other areas, they are dense enough to form a distinct canopy layer. The lowest canopy layer consists primarily of dense, 1- to 8-inch DBH Douglas-fir about 35 to 50 years old.

Overall, the stand shows an uneven-aged structure and distribution of size classes (Figures 5 and 6). However, recent tree regeneration is generally sparse, except in a few patches (see “Regeneration,” page 10).

Target stand structure

General stand management goals include:

- Reduce the overall stand density to improve vigor and lower canopy fire potential.
- Create more structural heterogeneity, both vertically and horizontally, while encouraging a less wildfire-prone forest condition.
- Increase regeneration of oaks and pines. Overall, the target stand structure and composition should more closely emulate the **historic range of variability** of tree sizes, density, and structure.

Specific stand structure goals vary by aspect (Table 1, page 7). South aspects will be managed to sustain and promote multiple age classes, but in a spatially more heterogeneous pattern that includes both creating new and enhancing existing canopy gaps as well as retaining clumps of older trees, resulting in a more “patchy” arrangement that separates canopy strata horizontally (Figure 7, page 8). To reduce wildfire potential, ridgetops will be maintained as shaded fuelbreaks without a **multi-canopy structure**, with heavy emphasis on reduced surface and ladder fuel accumulations and promotion of high height-to-crown base. The more productive north slopes will be managed for a multi-aged stand structure.

DBH—
Diameter at breast height
(4.5 feet).

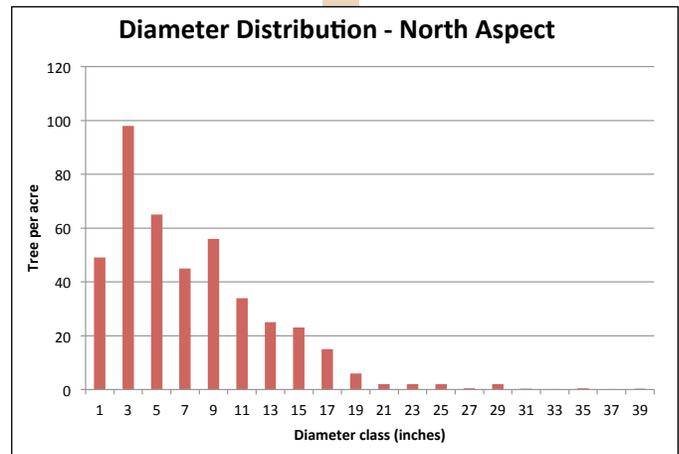


Figure 5. Diameter distribution graph (north aspect).

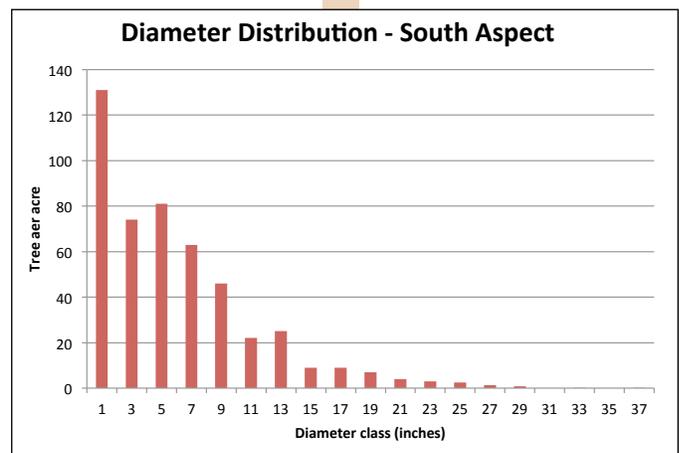


Figure 6. Diameter distribution graph (south aspect).

historic range of variability—

Forest conditions or structures found over time as a result of the interactions of disturbances (such as fire) with forest development. Implies that there was no one, fixed forest condition prior to settlement, but rather a range of conditions for any given characteristic, such as tree size or age.

multi-canopy structure—

A forest stand that has more than one main canopy.

Graph by Max Bennett, © Oregon State University

Graph by Max Bennett, © Oregon State University

Table 1. Stand conditions for south and north aspects: historic, pre-treatment (1989), post-treatment (current), and desired future.

Factor	Historic	Pre-treatment	Post-treatment (current conditions)	Desired
Stand density	<p>South aspect: Basal area 60–150 ft²/acre, 20–60 trees/acre >4" DBH</p> <p>North aspect: Basal area 80–200 ft²/acre</p>	<p>South aspect: Basal area 175–>200 ft²/acre, relative density >75%, 1,000–>1,500 stems/acre</p> <p>North aspect: Similar 800–1,200 tpa, same basal area</p>	<p>South aspect: Basal area <170 ft², relative density 60%, 480 stems/acre</p> <p>North aspect: Basal area 200 ft², relative density 70%, 420 stems/acre</p>	<p>South aspect: Basal area 60–150 ft², relative density 25%–55%</p> <p>North aspect: Basal area 80–200 ft²/acre, relative density 35%–60%</p>
Species composition	<p>South aspect: 50%–80% ponderosa pine/black oak, 20%–50% Douglas-fir/other</p> <p>North aspect: 60%–80% Douglas-fir, 20%–40% other</p>	<p>South aspect: >80% Douglas-fir</p> <p>North aspect: Same</p>	<p>South aspect: 70% Douglas-fir, 10% ponderosa pine, 20% oak/madrone</p> <p>North aspect: 80% Douglas-fir, 15% madrone, <5% other</p>	<p>South aspect: Higher proportion of ponderosa and sugar pine, black oak</p> <p>North aspect: Douglas-fir dominated, with mix of madrone, sugar pine, cedar, some black oak</p>
Stand structure	<p>South aspect: Irregular/clumped distribution of trees, significant area in openings, canopy strata spatially separated</p> <p>North aspect: Clumped to random tree distribution, fine scale openings, multi-story canopy</p>	<p>South aspect: Closed canopy, two or more canopy layers, but dominance of lower canopy layers</p> <p>North aspect: Same</p>	<p>South aspect: Closed canopy, two or more canopy layers</p> <p>North aspect: Same</p>	<p>South aspect: More open conditions, gappy-patchy-clumpy</p> <p>North aspect: Multi-age, multi-story stand</p>
Disturbance	<p>South aspect: Frequent low-severity fires, patchy canopy mortality</p> <p>North aspect: Frequent low-severity fires</p>	<p>South aspect: Decrease in disturbance frequency (fire, logging), increase in disturbance severity (fire, logging)</p> <p>North aspect: Same</p>	<p>South aspect: Increase in low-intensity disturbance (thinning and prescribed fire)</p> <p>North aspect: Same</p>	<p>South aspect: More frequent low to moderately severe disturbance (thinning and prescribed fire)</p> <p>North aspect: Same</p>
Overall vigor	<p>South aspect: Moderate to high vigor</p> <p>North aspect: Same</p>	<p>South aspect: Declining vigor, especially in larger pines and oak</p> <p>North aspect: Declining vigor</p>	<p>South aspect: Stable or improving vigor</p> <p>North aspect: Same</p>	<p>South aspect: Moderate to high vigor</p> <p>North aspect: Same</p>

Harvest, Logging, and Economics

Harvest

All trees were hand felled. In areas near roads or pre-designated skid trails, logs were yarded to the roadside or to small landings by a pickup truck, horse, or small 50-horsepower tractor equipped with a Farmi winch. The owner did all of the work, except a portion of the horse logging. Commercial logs were removed with a self-loader.

The Mains needed to use small-scale harvesting equipment because removal of scattered trees and low volumes is unattractive to conventional logging contractors. The developing stand's increasing size and suitability for commercial sale will make conventional harvesting systems more viable in the future.

Smaller, noncommercial material (that is, material that was too small to be sold to a mill as sawlogs) was converted to firewood or poles for later sale (Figure 8). Rarely, small concentrations of unused thinning slash were piled and burned. In less accessible interior stand areas where noncommercial log removal was impractical, thinned trees were cut and scattered or left to decay where they fell. This commitment to manage noncommercial portions of the stands, including aggressive utilization of noncommercial material, required a considerable up-front investment of time and energy.

Next steps

A commercial thinning is overdue but awaits better log markets. The next entry will continue to focus on removing trees in subordinate crown classes, along with removal of some larger trees to create or expand existing openings. Opening sizes will be variable, ranging from $\frac{1}{20}$ to $\frac{1}{2}$ acre, depending on topography and existing stand conditions. Wide thinning to release large, at-risk trees in the stand, particularly black oak and pine, will continue. Development of



Photo by Max Bennett, © Oregon State University

Figure 7. This stand, on an adjacent BLM parcel, has never been commercially harvested but was noncommercially thinned in the early 2000s to reduce ladder fuels. It is an example of a stand that is trending toward (but has not reached) the desired conditions for the Mains' south aspect stand. Features of desirable structural conditions include the clumpy arrangement of trees, higher proportion of pines and oaks, presence of openings, larger average tree size, and lower but still variable stand density.



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Figure 8. Traditionally unmarketable material—small trees that were thinned—were turned into small poles, posts, and firewood, and sold. Over 20 years, the Mains sold more than 7,000 posts and poles and 165 cords of firewood. Gross revenues from these sales were close to \$30,000.

greater horizontal spatial variability in general, and creation of openings in the canopy in particular, will help to:

- Promote regeneration, especially of light-demanding species such as ponderosa pine and California black oak
- Break up the continuity of fuels, thus reducing the fire hazard
- Promote structural diversity in the stand as well as understory development, favoring wildlife and biodiversity
- Restore a closer approximation of historical stand conditions (particularly of older forests) that may help to provide, on a landscape level, important habitat values for the host of species that depend on them
- Produce marketable volume and generate income to help finance ongoing forest restoration on this parcel

Economics

The Mains' chief economic objective was to offset stand improvement costs while improving long-term growth and yield. Their three main sources of revenue, cost reduction, or both were log sales, sales of small-diameter products, and cost-share funds.

Log sales totaling 67 MBF (24 loads) generated about \$37,400. Timing of sales was critical, as log values during their 20 years of ownership have ranged from \$300 to \$750 per MBF. The average delivered price they received was \$392 per MBF from 1989 through 1992, and \$651 per MBF from 1993 through 2013. Since the Mains did most of their own falling, bucking, and yarding, their major costs were for log hauling and equipment upkeep.

For slash treatment, the Mains focused primarily on utilization and to a lesser extent used prescribed underburning, **piling and burning**, and **lop and scatter**. Small-diameter thinning and utilization of traditionally unmarketable material yielded more than 7,000 posts and poles and 165 cords of firewood, which were sold for a total of about \$30,000 (worth \$40,000 at 2013 prices).

Some of this work was accomplished with the help of a professional crew, and the Mains did the rest. When a crew was employed, it was typically a break-even operation, with revenue from sales of small diameter products just covering the cost of the crew. Integral to the success of the operation was careful assessment of costs associated with product removal. Material in perhaps $\frac{1}{4}$ to $\frac{1}{3}$ of the area was too far from a road or on slopes that were too steep to make retrieval economically viable.

The Mains received cost-share funds from the Oregon Department of Forestry to cover noncommercial thinning and stand improvement activities; slash treatment was typically not covered. The cost-share rate ranged from \$100 to \$250 per acre, which generated roughly \$10,000 to \$15,000 over 20 years and multiple projects.

The 100 acres of noncommercial thinning the Mains accomplished on the property over 20 years represents a significant investment in stand growth and yield. This investment has resulted in a doubling of marketable volume

piling and burning—
Thinning slash by making small piles and burning them, either during the operation (swamper burning) or later when conditions are right.

lop and scatter—
A slash-thinning treatment in which trees or brush are lopped into several pieces and scattered on the forest floor. Reduces concentrations of hazardous fuels and promotes the breakdown of slash.

since purchase in 1989, and the current stand is well positioned for future thinnings that will be largely commercial in nature. In addition, risk to the stand from wildfire, insects, and diseases has been substantially reduced.

Regeneration

As the management priority to date has been stand density reduction in the two lower layers (the 35- to 50-year age class and, to a lesser extent, the 70- to 90-year age class), there has been no deliberate effort to secure new regeneration. **Natural regeneration** has been successful, albeit with an undesirable shift to a higher proportion of shade-tolerant species. Existing natural regeneration consists primarily of Douglas-fir seedlings with some Pacific madrone and California black oak stump sprouts and seedlings, and the occasional pine or cedar seedling. Recent regeneration is sparse and patchy, and is confined mostly to recently disturbed areas under small canopy openings. Seedling growth is slow because of overstory light competition and below-ground competition among trees in dense patches.

Securing regeneration as part of an uneven-aged management strategy is a priority for the long term. The approach used to promote regeneration will vary by aspect. On south aspects, creating new openings and enlarging existing openings will promote natural regeneration of ponderosa pine, sugar pine, and oak from existing seed sources, although Douglas-fir and incense cedar seedlings will likely be the most abundant. On north slopes, where the desired stand structure is a multi-story canopy, individual tree selection will be used, and any canopy gaps created will be relatively small. This approach will promote primarily Douglas-fir regeneration.

While natural reforestation will be the primary approach, some interplanting of tree seedlings may be necessary, and additional thinning will be needed on south aspects to promote pines and oaks over Douglas-fir and Pacific madrone. Following stand density reduction, the Mains would like to use underburning to establish a good **seedbed** and to reduce competition from grass, shrubs, or excessive sprouting of hardwoods (e.g., madrone), or all of these. After seedlings have established and grown to a size sufficient to withstand light fire, subsequent periodic underburns would be used to manage shrub and madrone competition and reduce conifer seedling density, as well as to introduce and maintain spatial variability.

However, because of liability concerns and the host of logistical challenges associated with prescribed burning, extensive use of prescribed fire on the Main property is probably unrealistic, at least in the near future. When additional vegetation management is needed, it will likely be done manually.

Creating openings and the disturbance from stand management activities increases the potential for more significant brush development, such as whiteleaf manzanita on south slopes and deerbrush on north slopes, which could hinder seedling and sapling growth and increase fire management concerns. Careful management of overstory stand densities and canopy closures will be needed to minimize the development of ladder fuels and excessive shrub competition.

natural regeneration—
Tree seedlings that germinate and grow without planting.

seedbed—
A forest floor that is conducive to the germination and growth of tree seedlings.

Lessons Learned

- **Stand management** in southwest Oregon forests is extremely complex for several reasons.
 - There is a greater diversity of tree species than in most other areas of Oregon. Mixed-conifer forests in this region include various numbers of Douglas-fir, ponderosa pine, sugar pine, incense cedar, white fir, black oak, white oak, Pacific madrone, and other species, each with distinct **silvical** requirements.
 - The environment is extremely variable and heterogeneous. Climate, soils, and topography often vary greatly over small distances and result in major changes in vegetation and site productivity. Most obvious are the typically dramatic contrasts in the composition of vegetation with slight changes in aspect. Highly variable soils and strong elevational moisture gradients also contribute to vegetative diversity.
 - Disturbance history includes a complex mix of mostly low- to moderate-severity fires, with increasing numbers of higher severity fires in the past century; various types of timber harvesting methods used in the past; and decades of fire exclusion. As a result, the current conditions and future potential of any given site are highly variable, and there is no “standard” prescription for mixed species, multi-aged management.
- **In fire-prone environments** like southern Oregon, there can be a tension between developing an uneven-aged forest structure in the long term, and the short-term need to reduce fire hazard by removing dense, early to **mid-seral vegetation** (i.e., ladder fuels). Development of an uneven-aged structure may require a multi-phase process, beginning with thinning from below in dense stands (to enhance vertical fuel discontinuity) followed by establishing or enhancing (or both) tree cohorts over time in spatially separated patches, both horizontally and vertically.

That was the case in this example, a stand that was initially very dense with low tree vigor. Large residual trees, especially pines and oaks left over from earlier logging, were at high risk of competition-, drought-, and insect-induced mortality. There was an abundance of ladder and surface fuels, increasing the risk of crown fire. These ecological conditions set the stage for the Mains’ initial management approach:

 - Multiple, relatively light entries in the lower two cohorts, designed to improve tree vigor and increase the height to the **canopy base**
 - Aggressive thinning around large, structurally valuable and **releasable** residual trees
 - Commercial utilization of marketable low-vigor, dying, and dead trees in the 70- to 90-year-old cohort, along with slash treatment
- **Management of oaks and pines** in these types of stands can be challenging given their need for light and significant growing space. In this case, wide thinning was carried out around individual large conifers (especially sugar and ponderosa pine) as well as large hardwoods (black oak in particular).

silvical—

Varying requirements of individual tree species for sunlight, soil moisture, nutrients, and growing space.

mid-seral vegetation—

Intermediate stage in stand development. Mid-seral forests are often closed-canopy forests nearing maturity.

canopy base height—

The distance from the ground to the base of the canopy or live crown. In fire management, increasing the canopy base height is often desirable, since it reduces the potential for crown fire.

releasable—

A tree that shows an increase in growth and vigor after thinning.

- **At low to mid-elevations** in southwest Oregon, Douglas-fir is more tolerant than some of its associates, notably ponderosa pine, and will regenerate in partial shade. Thus, Douglas-fir can probably be perpetuated by individual tree selection or other stand management practices that retain higher densities through time. Regeneration and maintenance of pines and oaks will require both creating sufficiently large openings initially and maintaining lower stand densities over time.
- **A more rapid conversion** to uneven-aged management might have been possible in this case, but lacking investment capital, the Mains sought to defray costs through maximizing utilization of small-diameter material produced by thinning. This operational reality, necessitated by their insistence on retaining more valuable larger conifers, resulted in repeated but lighter entries and subsequent retention of higher stand densities over a longer time than might otherwise have occurred.
- **Utilization of traditionally unmarketable by-products** (e.g., poles and conifer firewood) generated meaningful revenue for the owner, although it was very labor intensive. Costs were kept low by using “low tech” approaches and reducing move-in costs for larger equipment, such as yarding scattered small logs close to roads with a pickup truck. Intensive utilization helped reduce slash and surface fuel loads, a key consideration in this fire-prone environment, and helped offset costs that would have been incurred with other slash disposal methods, such as piling and burning.
- **The economic challenges** of converting a dense, mixed-conifer forest in southwest Oregon to a vigorous, mixed species, multi-aged stand are daunting. The initial series of entries to reduce stand density is potentially very expensive, as the material is mostly small and not marketable as sawlogs. On adjacent public lands, similar treatments involving cutting, piling, and burning often cost \$1,000 to \$1,500 per acre, a cost out of reach of most small woodland owners. Owners are often faced with four not very attractive options:
 1. Make a significant up-front investment with no immediate return.
 2. Remove only the large, commercially valuable material from the stand (i.e., high grading), which reduces the future growth and potential of the forest.
 3. Do the work themselves (the average age of small woodland owners in Oregon is 59).
 4. Do nothing.

This case study shows the potential for reducing the costs of Option 1 through aggressive utilization of thinning by-products. It should be noted that the viability of this option was improved by taking advantage of cost-share funding for stand improvement activities through various programs administered by the Oregon Department of Forestry, and by selling relatively small quantities of timber when markets were strong. Like the Mains, forest landowners should be aware of timber markets and take advantage of them when they are favorable to help boost potential income and defray management costs.

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