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DO LARGE TREES ALWAYS HAVE HIGHER WOOD PRODUCT VALUE?

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ABSTRACT

When the Northwest Forest Plan for the Recovery of the Northern Spotted Owl (NWFP) and associated species was established in 1994, it shifted federal land management emphasis toward noncommodity outputs. Since then, forest practices on state land in Oregon and Washington were also modified to emphasize resources other than timber. At the same time, commercial forest owners have moved to shorter rotations and most of the region's sawmills have been retooled to process smaller (< 24 inch, 61 cm) logs. Management plans for public land allow a variety of management activities, some of which may remove trees that are 50 to 120 years old and 20 or more inches (51 cm) in diameter at breast height (dbh). It is likely that these trees are larger and older than those removed from private land but because of their relatively young age, they might not necessarily yield higher value wood products. Some of the logs cut from these trees might also be too large to process in the region's sawmills making them less attractive to potential buyers. We used empirical wood product recovery data to conduct an analysis to contrast the economic value of 20 to 30 inch (51 to 76 cm) dbh trees in the 50 to 80 year and 100 to 150 year age classes. The purpose of this analysis was to illustrate the importance of age in controlling economic value in trees of the same size. The older trees had dollar values of as much as 55% higher per board foot than the younger trees. This analysis suggests that some of proposed treatments on public land will result in trees that could be difficult to market to the region's wood processors and, therefore, might not provide the economic returns anticipated under the Northwest Forest Plan or by state forestry plans in Oregon and Washington.

KEY WORDS: Wood quality, silviculture, wood products, lumber, western Oregon and Washington.

INTRODUCTION

Forest management practices on public and private land in western Oregon and Washington are diverging. This could potentially create a dichotomy in the wood characteristics of the resource which might influence the economic value and marketability of timber harvested by various owners. Federal land is now mainly managed to emphasize non-commodity outputs with recognition that removal of some commodities is important to local communities (USDA and USDI 1994). State lands in both Washington (Belcher 2001) and Oregon (Paul and Kendy 1999) still carry a mandate to produce revenues for public programs, such as education, but management practices now place more emphasis on a range of outputs in addition to financial returns. Private industrial landowners want to maintain as much freedom to manage their lands as possible but they also recognize the importance of public opinion in shaping forest practices laws. As a result, they constantly search for management options that justify their investment while also protecting the non-economic outputs that the public identifies as important for good land stewardship on private land.

These differences in broad management objectives could result in removal of timber with noticeably different characteristics from each land ownership category. Private industrial landowners will generally produce smaller, younger timber with rotation ages usually between 40 and 60 years (Briggs and Trobaugh 2001). Trees from these lands will typically have maximum breast-height diameters of 20 inches (51 cm) or less. Much of the timber produced from federal and state land over the next two decades will come from thinnings applied in young plantations. This timber will readily blend with the timber from private lands. At some point in the future, federal and state land managers could begin to implement treatments in some stands that

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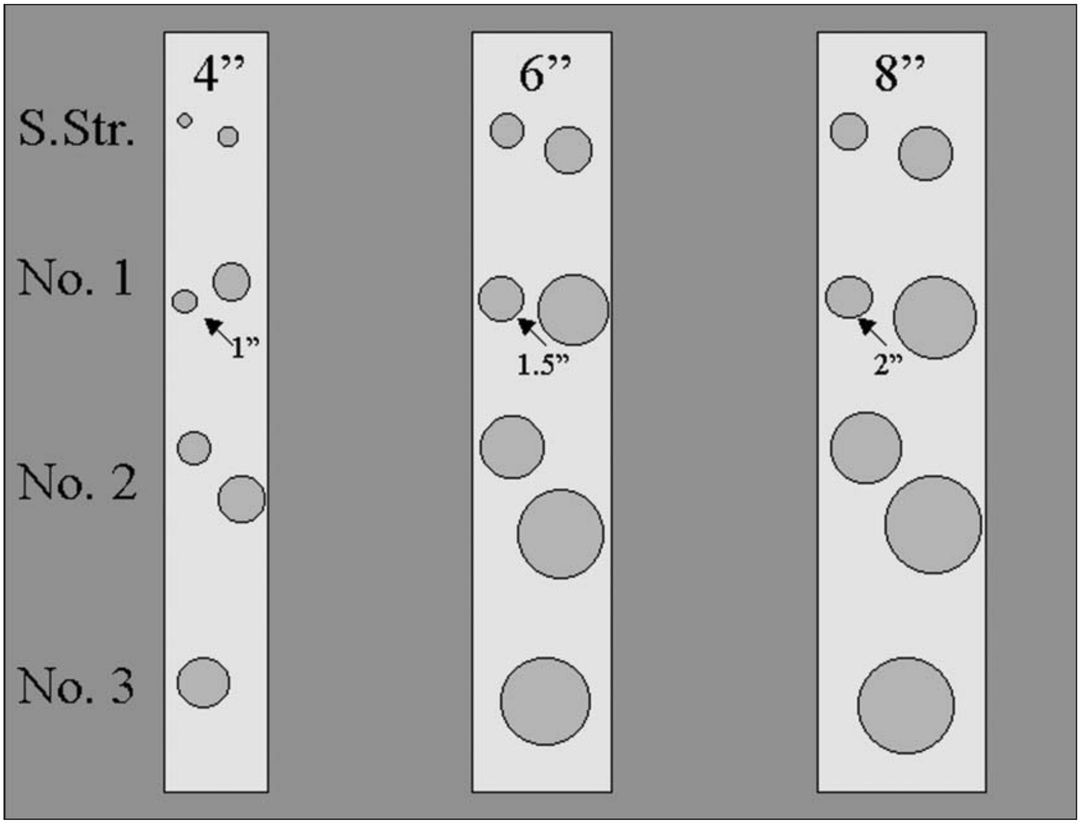

Figure 1—Influence of lumber width on acceptable knot size measurements based on the American Lumber Standards (Western Wood Products Association 1998).

remove older larger trees. These treatments will probably be designed to enhance or maintain habitat for late successionally associated species. Various management scenarios accomplish this through combinations of group selections, uniform thinnings, variable density thinnings, and extended rotations (Curtis et al. 1998; Emmingham 1996; Carey et al. 1996). Although many forest managers feel that given the current political climate, cutting treatments will never be applied in these older stands, we feel it is prudent to examine scenarios where cutting does occur to test some of the basic assumptions of the Northwest Forest Plan (USDA and USDI 1994) or state management plans and to inform future policy debates. Our full analysis will consider the actions of all landowner classes and the likely outcomes in terms of wood characteristics, wood product potential, and volume. The analysis presented here covers only Douglas-fir (*Pseudotsuga mensziesii* (Mirb.)Franco) trees in the 20 to 30 inch (51 to 76 cm) diameter class. Combining this analysis with information on anticipated volumes from different landowner classes will allow evaluation of how the structure of the wood products industry might change through time.

When developing management alternatives for the NWFP, a key assumption was that the larger older timber removed would have a higher economic value than the young trees grown on state and private land and that eventually the sale of these larger trees would enable non-timber related management activities. Presumably these large trees might come from sources such as: group selections in 80 to 120 year old stands in matrix land[5], final thinnings in 50 to 80 year-old stands in late successional reserves[6], regeneration harvests on state and private lands, hazard tree removal, clearing for development on all ownerships, etc.

The stand ages where these types of treatments are anticipated coincide with an important transition in Douglas-fir wood characteristics. Trees from unmanaged Douglas-

[5] The “matrix” as defined under the Northwest Forest Plan is the land between the other land allocations and it is where most timber management is expected.
[6] Late Successional Reserves (LSRs) are areas designated under the NWFP to support species associated with late successional forests.

fir stands younger than about 80 years old are generally suitable for manufacture of structural wood products but do not usually yield significant volumes of high value appearance products. This is because Douglas-fir trees from unmanaged stands do not typically shed the branches on their lower stems until at least age 80 (Kachin 1940). When stand density is managed from a young age, slower crown recession can further delay the loss of lower stem branches. Three recent studies suggest that young stand management could postpone the transition in wood product potential until stands are more than 100 years old depending on intensity of treatments and whether branches are pruned (Briggs and Fight 1992; Christensen 1997; Barbour and Parry 2001).

It is also likely that some of the logs manufactured from trees over 60 years old that were grown on high site class land will be too large to process in most of the region's sawmills (Christensen 1997; Barbour and Parry 2001). An effective maximum large end diameter of 24 inches (61 cm) is becoming common, although there are still a few mills that can handle 30 inch logs and at least two that can process logs up to 50 inches. Given the types of raw material available from private land, it seems unlikely that these mills will retain the capability to process larger logs for long.

In addition to retooling sawmills to efficiently process smaller logs, the forest products industry is rapidly turning to engineered wood products, like glue laminated beams and wood I-beams, to replace wider widths of solid lumber (i.e., >8 inches; 20 cm). For example, in recent years, wood I-beams captured much of the market once held by solid sawn floor joists (Fleishman et al. 2000). Substitution of engineered wood products into structural lumber markets, where wide lumber is currently used, erodes a class of moderately high valued products for large trees with good structural characteristics but not suited for appearance products. Such trees tend to have larger and more numerous knots. These are often tolerated in wide lumber but not narrow lumber. Figure 1 illustrates the interaction of knot size and lumber width in determining structural lumber grades. This relation helps to explain why markets for wide lumber widths are necessary to produce structural lumber grades from large logs with large branches.

Log size, together with the number and size of knots, is therefore important for determining the mix of products manufactured from a given resource. The way public and private landowners choose to manage stand density will influence both stem size and the number and size of knots (Briggs and Fight 1992). In this analysis, we compare differences in lumber grades that are potentially expected from large trees with different ages and management histories. Specifically, we use data from empirical wood product recovery studies to illustrate the product options that are possible from large trees grown under different management scenarios. Subsequent analyses should examine the volumes of logs in different size and quality classes to provide information about the potential structure of the region's future industry.

METHODS

We summarized results from two empirical wood product recovery studies for Douglas-fir that were conducted by the USDA, Forest Service, Pacific Northwest Research Station. The data selected from these studies included trees varying in age but approximately the same size. The first data set came from a variety of natural stands located from west of Salem and south to Medford, in Oregon's coast range. They were harvested and processed in 1981 (Willits and Fahey 1988). Trees in these stands ranged from about 100 years old to more than 350 years old. The trees in the 20 to 30 inch (51 to 76 cm) diameter range selected for this analysis varied in age from about 100 to about 150 years old. This data set is referred to as T100 to signify that most of the trees were 100 years old or older. The second data set used 20 to 30 inch trees that came from a variety of stands located throughout western Oregon and Washington with ages ranging from about 35 to about 80 years old. Their selection followed an exhaustive search for stands that represented characteristics expected from managed stands. They were harvested and processed in 1987 (Fahey et al. 1991). This data set is referred to as T50 to indicate that the average age of the trees was about 50 years old. While the selected trees represent what is expected from young managed stands, they are somewhat conservative in their representation of more intensively managed plantations that include wider initial spacings and early control of competing vegetation.

Data from the two wood product recovery studies included a log-by-log accounting of the volume and grade of each piece of lumber recovered from every tree. Lumber recovery data were summarized by five-inch breast height diameter classes and reported as percent of lumber volume in each grade group. The sawmills used in each of the wood product recovery studies cut a different set of lumber sizes and grades making it impossible to compare results directly. It is, however, reasonable to combine the lumber grades into logical grade groups and compare the percent yield of

Table 1—Average stump ring counts by tree breast height diameter for trees included in this analysis

Tree breast height diameter class	Average stump ring count	
	T100	T50
20 in (50 cm)	95	51
25 in (64 cm)	119	52
30 in (76 cm)	154	56

appearance, structural, and low quality lumber. Appearance quality lumber was defined as lumber that is used for appearance purposes. This included grades such as Selects and Finish (pieces with no or few knots), upper grades of Factory lumber (No. 3 and Better Shop), and Moulding. Structural quality lumber was defined as lumber that is used for structural or other general construction purposes and included grades such as Select Structural, No. 2 and Better dimension lumber, and No. 4 and Better Commons. Low quality lumber was defined as lumber that does not meet the criteria for the other two groups. It included categories such as shop out[7] and grades such as No. 5 Common, Utility, and Economy. For detailed descriptions of these grades see the Western Wood Products Association (1998) grading rules.

A third set of data was taken from a wood product recovery study designed to illustrate the effect of sawing lumber of various widths from logs with different diameters. These data come from a collaborative study between the USDA, Forest Service, Pacific Northwest Research Station and the New Zealand Forest Research institute that examined 50 year-old plantation-grown Douglas-fir from New Zealand (Kimberley et al. 1995; McConchie et al. 1995).

RESULTS AND DISCUSSION

Influence of Age

The age of the older T100 trees increased substantially over the target diameter range (Table 1). Although there is no documented stand level information for the T100 trees, based on their age and when the study was conducted it is likely that they came from mature and old-growth stands that developed without management. The relation between tree age and diameter for the trees in the study from which the T100 trees were selected (Figure 2) is similar to that found in old-growth stands in the Oregon coast range by Tappeiner et al. (1997). Tappeiner et al. (1997) showed that old-growth stands can have a wide range of tree ages, diameters and growth rates, but in most cases the growth rates of the main canopy trees were greater than the understory trees. The trees selected for this analysis presumably came from the younger cohorts and therefore probably had slower growth rates than the main canopy trees.

In contrast, the average age of the younger T50 trees remained fairly constant across the range of diameters (Table 1). The similarity in diameters across the age range represented in the data set is likely the result of differences in site productivity or initial stand density and from precommercial or commercial thinning treatments. All of these trees were, however, fairly rapidly grown as compared to the T100 trees.

Influence of Knots

The wood quality characteristics of interest in Douglas-fir trees less than 200 years old are usually related to the initial growth rate (juvenile wood proportion), stem form, and presence or absence of branches and the condition of branch stubs. All of the trees selected for both studies were straight and generally free from obvious external defects (Willits and Fahey 1988; Fahey et al. 1991). This means that the size and number of knots is the main quality concern in these types of trees. The change in quality over time associated with branches can be thought of as a step function where knot free straight-grained (clear) wood is the best quality and wood containing dead loose (black) knots or holes is considered the worst quality (i.e., clear wood > live knots > tight dead knots > loose black knots or knot holes). This step function is firmly ingrained in the logic used in developing lumber grading rules (for rules see Western Wood Products Association 1998). At young ages (less than 200 or 300 years), time improves quality in Douglas-fir. In slowly growing trees, there is plenty of time for dead branches to fall before stem diameter growth overgrows dead branches. This reduces the amount of wood with knotholes or black knots. Rapidly growing young trees will, however, tend to overgrow more length of branches before they are shed. This simplified explanation does not account for the interactions among branch stub length and condition (i.e., smooth or rough), branch diameter, stem diameter, and growth rate documented for pruned Douglas-fir (Petruncio et al. 1997) and other species (Gosnell 1987). Nonetheless, the wide age range in the T100 trees is expected to have a positive influence on quality, as measured by

[7] Lumber manufactured to thickness appropriate for Factory lumber but not meeting the requirements for the No. 3 Shop grade.

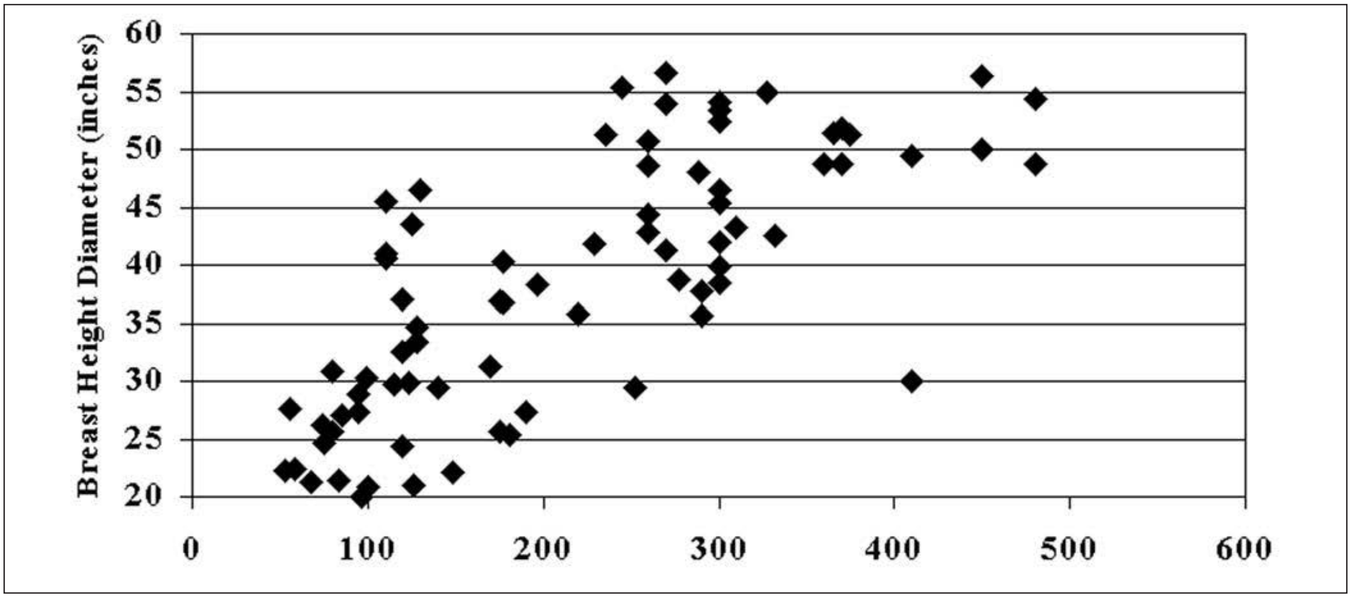

Figure 2—Breast height diameter in inches versus stump ring count for all trees with ages from the T100 data set (Willits and Fahey 1987). These trees display a diameter to age relation similar to that described for old-growth stands in Oregon's Coast Range by Tappeiner et al. (1997).

Table 2—Average percent lumber grade yield by broad grade groups and study

Tree diameter class (inches)	Study T100			Study T50		
	Appearance	Structural	Low quality	Appearance	Structural	Low quality
20	10.4	75.1	13.7	0.4	68.6	30.7
25	9.6	79.0	11.4	0.1	59.3	40.3
30	14.2	71.1	14.2	0.0	40.1	59.7

knots and their condition, while the young ages and narrow age range of the T50 trees would tend to amplify the negative influence of branches.

We did not include juvenile wood in the analysis because no information on initial growth rate was available for the T100 trees. However, the T100 trees might have less juvenile wood as a proportion of their volume than the T50 trees. They came from the youngest age cohort in the sample (Figure 2) and probably occupied less dominant canopy positions. This suggests that they grew more slowly making their juvenile cores smaller than the rapidly grown T50 trees.

Lumber Grade Yields

Age is apparently an important factor in determining the visual lumber grade yield for trees of the same size (Table 2). The older T100 trees yielded far more appearance grade lumber, more structural lumber, and much less low quality lumber than the younger T50 trees. There is a weak (r^2 0.35) but highly significant ($p < 0.0001$) linear relation between proportion of appearance grade lumber and age for the T100 trees. This suggests that quality improves over time perhaps because of the occlusion of knots. On the other hand, the amount of low quality lumber increased with increasing diameter in the younger T50 trees (Table 2). This suggests that the branch size increased with diameter in these trees.

It is likely that the way the T50 trees were sawn overstates the amount of low quality lumber but it is unlikely that it greatly reduced the amount of appearance grade lumber. This is because six-inch lumber was the widest width lumber sawn from any log, regardless of its diameter

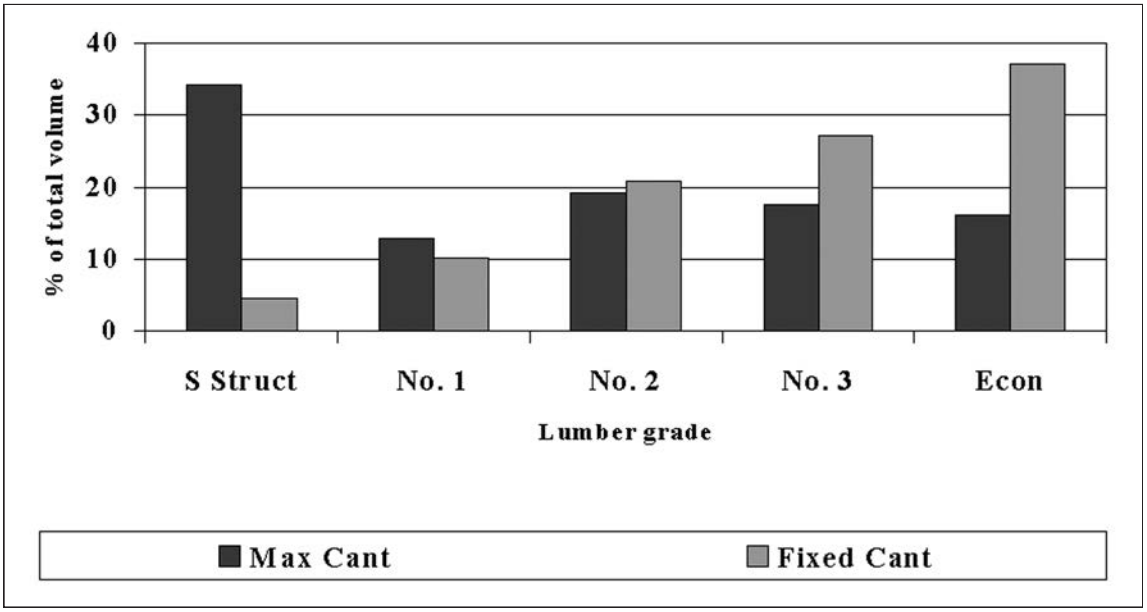

Figure 3—Effect sawing pattern on lumber grade from plantation-grown Douglas-fir logs greater than 20 inches in diameter when they are sawn to a fixed 4 and 6 inch cant widths or to the maximum cant that would fit into the log up to 12 inches (data from McConchhie et al. 1995, Kimberley et al. 1995).

(Fahey et al. 1991). This sawing strategy over emphasizes the importance of knots in structural lumber grades but tends to produce more pieces with few or no knots because of the narrow widths. It also gives a better estimate of the suitability of the material for engineered wood products because six inches is the widest width commonly used in many of these products.

The importance of lumber width is illustrated in Figure 3. This figure represents results where one set of logs was sawn to a fixed lumber width of four or six inches regardless of log diameter. Another set of logs was sawn to remove the widest lumber possible, up to 12 inches, from each log (Kimberley et al. 1995; McConchie et al. 1995). The results clearly demonstrate the negative affect of sawing narrow lumber from large logs, especially those with large branches. They suggest that such logs are not well suited for use in engineered wood products that require high quality four and six-inch dimension lumber.

The results illustrate the point that large young trees grown in ways that maintain fast growth rates might not yield much in the way of high value wood products. These results, however, are not definitive because there were numerous differences in the design and implementation of the empirical studies, the groups of trees were not paired, and the target products from each mill was different. The results do suggest that alternatives to the NWFP that result in harvest of older trees grown under relatively conservative regimes (Carey et al. 1996; Cissel et al. 1999) could result in timber with a wider range of product potential and, therefore, greater economic value, than those grown under the current Northwest Forest Plan.

Financial Implications

The financial implications of large knots and other factors associated with fast growth in young stands are illustrated in Figures 4 and 5. Figure 4 contains average lumber grade yields, while gross product values for lumber from the T50 and T100 trees plus a third scenario (50MAX) are presented in Figure 5. The 50MAX scenario uses the appearance grade results from the T50 scenario but reduces the low quality lumber to 10%. The 50MAX scenario represents a rule of thumb commonly applied in the sawmilling industry that an average mill should produce at least 90% Standard and Better or Number 2 and Better lumber. This scenario reflects the minimum grade yields expected from a mill that was free to maximize grade yield by changing lumber width, edging, and trimming. The T50 result could be thought of as a worst-case scenario where the market for wide lumber has disappeared because of continuation of the shift to engineered wood products.

The T100 trees receive a 54% premium when compared to the less optimistic T50 scenario and a 16% premium in comparison the more optimistic 50MAX scenario (Table 2). These results highlight the importance of appearance grade lumber in influencing gross product value per thousand

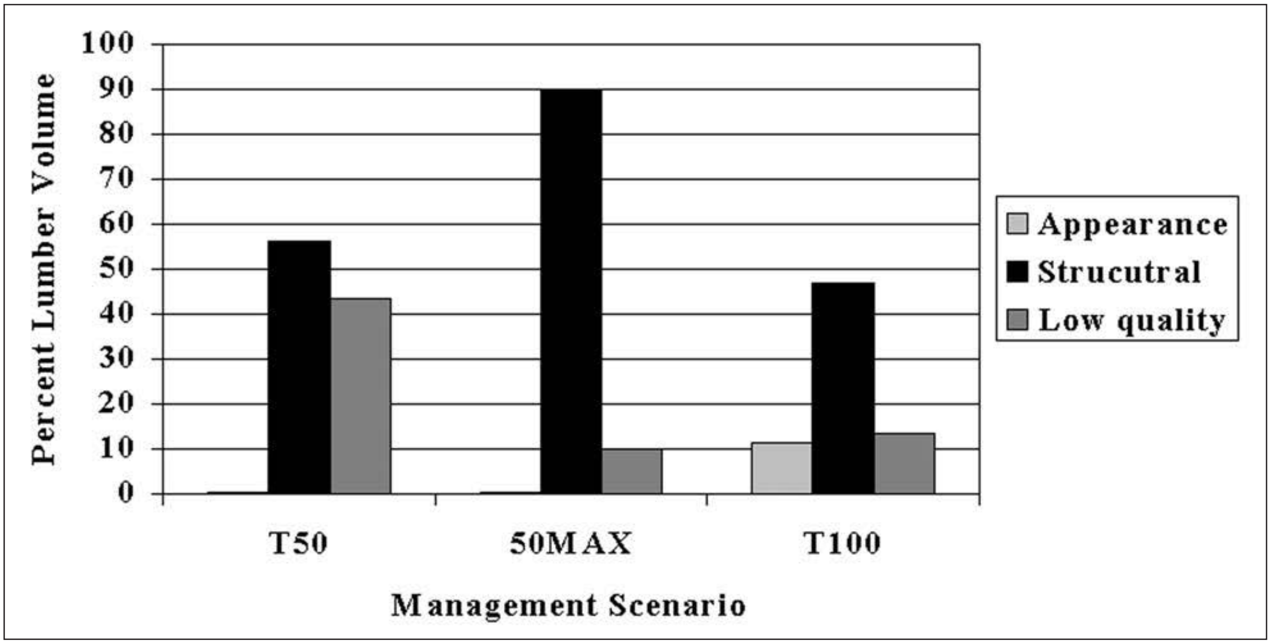

Figure 4—Percent lumber volume for each of three management scenarios used to demonstrate the financial implications of high and low quality lumber (see Figure 3). The T50 represents actual data for large 50 year-old trees sawn into 4 and 6 inch dimension lumber, 50MAX represents the likely yield if the mill had sawn to wider widths and maximized grade with edging and trimming.

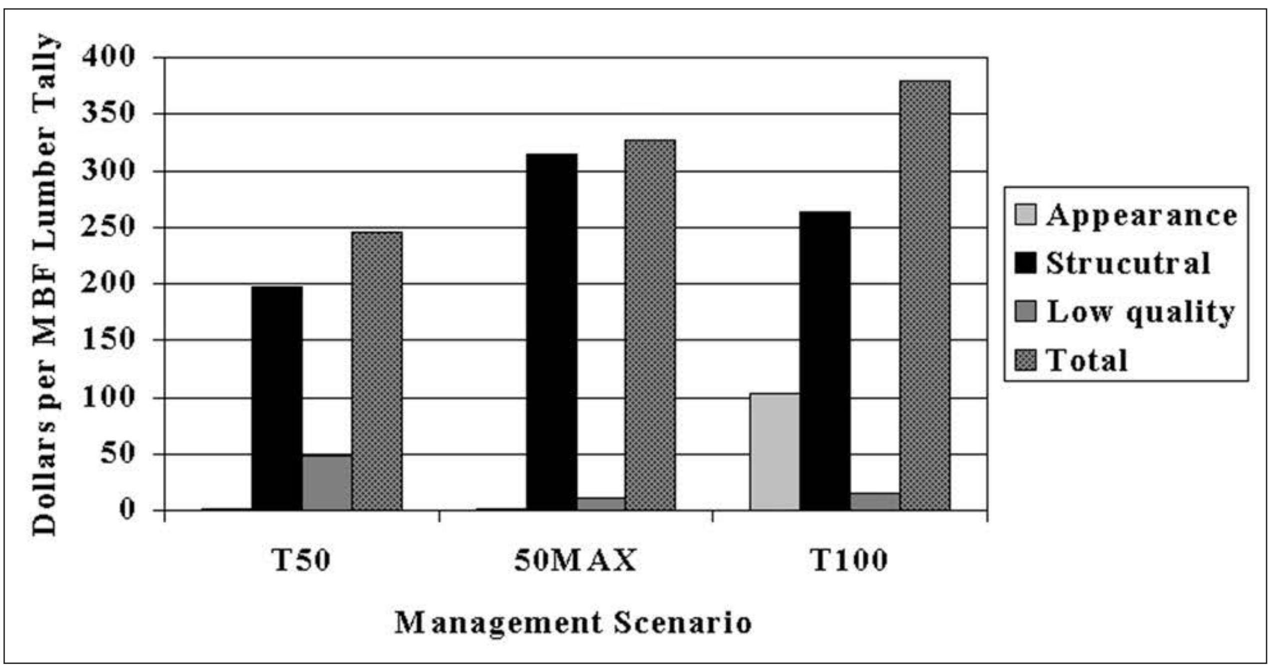

Figure 5—Gross product value for lumber recovered under three management scenarios. The T50 and T100 scenarios represent the gross product value for the corresponding data sets described in the text. The 50MAX scenario represents the T50 scenario where low quality lumber volume was reduced to 10% to represent a mill with discretion on lumber width, trimming, and edging decisions.

board feet (MBF) of lumber. This example does not consider any costs or revenues from chips, sawdust, or bark. It does, however, help to show how tree characteristics, particularly branchiness, might influence economic value by demonstrating broad product classes to which trees grown under different conditions are suited.

The results seen here support conclusions from analyses conducted by Briggs and Fight (1992); Barbour et al. (1997); and Barbour and Parry (2001). Empirical results for log grades from long term thinning trials in 80 to 100 year old stands considered by Barbour and Parry (2001) also suggest that it is possible to maintain good growth rates, produce large trees, and maintain relatively high quality if thinnings are implemented after crowns have receded above the first 40 ft log. Barbour and Parry (2001) examined trees from two trials, one received a series of light to moderate basal area removals the other involved more aggressive thinning that began at an earlier age (Curtis 1995). The yield of high quality logs from the less aggressively thinned trial was better than from the more aggressively thinned trial. Trees from both of those trials, however, had much smaller branches and slower growth rates than those projected by Barbour et al. (1997) for the very early heavy thinning trials (initial entries at ages 15 and 30 to 30 and 60 trees per acre) that were implemented by the Coastal Oregon Productivity Enhancement (COPE) program (Emmingham 1996). These earlier, heavier, thinnings were designed to rapidly develop old stand structures in young uniformly spaced plantations on National Forests in Oregon's Coast Range (Emmingham 1996).

When all of the available information is considered, it seems likely that the characteristics of trees harvested from 80 to 100 year old stands on federal and state land will be suitable for structural products but will probably only yield small volumes of appearance grade products. As a result, these trees will probably have a similar per unit volume gross product value to the 40 to 60 year old trees that are harvested from industrial land. In addition, if current trends in mill design continue, future price discounts for large logs are likely. This will further reduce the economic value of large trees with characteristics that make them suitable for structural products but not for appearance products.

On the other hand, if attention is paid to product potential and a high proportion of the volume from large trees was in logs, such as those from the later lighter thinning trials described by Barbour and Parry (2001), their processing might not be a problem. Sufficient supply of larger, higher value logs might spur wood processors to find innovative manufacturing options to recover the high value material from the older more slowly grown trees. Alternatives to the existing Standards and Guidelines in the Record of Decision for the NWFP (USDA and USDI 1994) such as those suggested by Cissel et al. (1999) or Carey et al. (1996) might yield large trees with these more desirable characteristics and also meet the other objectives of the NWFP.

CONCLUSIONS

Early stand tending (before age 40) is important in determining if larger (>24 inches; 61 cm dbh) Douglas-fir trees harvested at ages 50 and up will have characteristics that make them suitable for higher value appearance grades of lumber and veneer or whether they will only be suited for structural wood products. This analysis suggests that trees from stands where long crowns were maintained either by wide initial spacing or early thinning will not be suited for production of appearance products. The trend toward more efficient sawmills that process logs with maximum large end diameters of less than 24 inches, the decline of the veneer industry, and the trend toward engineered wood products all suggest that such trees will not be in demand by the wood products industry. The validity of this conclusion and its importance to landowners who grow large trees depends on the volume of these trees that is available on an annual basis and their distributions across the landscape. This analysis did not provide estimates of the expected volumes of large logs in the region and this information will be necessary before wood processors can determine if investing in manufacturing facilities that can handle them is justified.

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