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Economic Feasibility of Longer Management Regimes in the Douglas-Fir Region

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Abstract

The financial returns associated with extended management regimes have been the subject of recurring debate in the Pacific Northwest. Proponents argue that the amount and value of higher quality timber associated with older trees will offset the costs associated with longer management regimes. Land managers and owners express concerns about diminished financial returns depending on the expected costs of holding timber for long periods. The increase in average lumber prices for high-quality timber is insufficient, on average, to offset the costs of longer management regimes. On public land, where ownership continuity is assured and the requirement for positive rates of return is less, longer management regimes may be attractive when they involve the joint production of various public goods such as wildlife habitat and scenery.

Keywords: Forest management, economic feasibility, management regimes.

Introduction

The Pacific Northwest (PNW) is considered one of the premier regions for forest management in the United States. For almost a century, intensive forest management has supported a forest sector that has grown in both size and complexity. Various forest management regimes have evolved in response to changes in landowner objectives, the development of silvicultural information (including growth and yield information), and changes in the utilization patterns of harvested timber.

Debates about appropriate management regimes have been frequent and often contentious. Management regimes² that have longer rotations³ have been the focus of recurring debate. Proponents argue that the amount and value of higher quality

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² Most frequently these regimes are described as including planting, stocking control (often achieved by using precommercial thinning), multiple thinnings, and final harvest of a relatively higher quality mix of sawlogs associated with older trees.

³ In some applications these are referred to as extended rotations.

timber associated with older trees will offset the costs associated with longer rotations. The revealed choices by landowners and managers (discussed in the next section) suggest a steady decline in rotation lengths for private timberlands. This suggests that economic benefits associated with longer rotations have failed to materialize.

These arguments have reappeared recently as part of developing a new land management plan for the Tillamook State Forest.⁴ There the Oregon Department of Forestry is considering alternative forest management prescriptions to protect key habitats and processes in selected areas. Among the alternatives are several that involve longer rotations that provide greater timber revenues over a longer time-frame than can be obtained by the short-term high-volume harvest regime currently in operation.

This paper describes a study done for the Salmon Anchor Habitat Working Group⁵ as background to their review of alternative management strategies for the Tillamook State Forest. I review the evolution of management regimes in the Pacific Northwest and then develop three specific management regimes that encompass the types of alternatives being considered. I also review the management methods and some of the critical assumptions behind the regimes. Finally, I discuss the implications for land management and managers.

The interest in growing timber for high-quality purposes by using longer rotations is not unique to the Pacific Northwest. It has been discussed in the context of plantation management in South Africa (Craib 1948), New Zealand (Sutton 1984, Whiteside and others 1975), British Columbia (Kellogg 1989), the Pacific Northwest (Barbour and others 2003), and southeast Alaska (Barbour and others, in press). The general conclusion of this work is that the tradeoffs among rotation length, timber quality, and financial returns depend on the way in which costs are discounted and whether the computations include the value of amenities associated with longer rotations.

Evolution of Management Regimes

Speculation continues about the appropriate management regimes in the PNW, but there has been tentative consensus on the basic set of practices that compose the core of the management regimes. Some of this discussion dates from the early

⁴The Tillamook State Forest is in the northwest corner of Oregon and includes much of the area planted after a series of fires between 1930 and 1945.

⁵The Salmon Anchor Habitat Working Group was convened by the Oregon Department of Forestry at the direction of the 2003 Oregon Legislature. It was a citizen work group whose purpose was to review how forest stands with salmon habitat were being managed in the Tillamook State Forest.

1960s when the Timber Trends study (USDA FS 1963) identified three management regimes differentiated by the array of practices in each. The first regime, which we would now call custodial, represented those owners who operate expecting high rates of return⁶ on their timber investment and who prefer little active timber management. Instead, these are owners who harvest frequently and use low-cost regeneration regimes. The second management regime was called intermediate and assumed that landowners operated expecting moderate (6 percent in nominal terms) rates of return on their investments. Rotation lengths in this regime were assumed to be shorter (60 years) than with the third management regime. The intermediate regime was a plant, thin, and harvest regime differing (based on site and owner) in regeneration methods and the number of thinnings. The third management regime (which we would call intensive) assumed landowners who operated expecting lower rates of return on their investments and who would adopt longer rotations (120 years) and more thinnings and other cultural treatments. It included site preparation, planting, fertilization, precommercial thinning (PCT), commercial thinning (CT), and final harvests. In all three management regimes, final harvests were assumed to be clearcuts. As private forests in the PNW transitioned from old growth to second growth, the Timber Trends study assumed that 16, 22, and 62 percent of the private land would be assigned to each of these management regimes, respectively.

Over the last 30 years an array of studies have examined the timber supply prospects for private forest lands in the PNWW (Pacific Northwest West, western Oregon and Washington). In each case, following the lead of the Timber Trends study, efforts were made to identify the range of management practices applied to the current private forest inventory. These studies provide different perspectives of management practices (or management intentions) at three times: the early 1970s, the late 1980s, and the late 1990s. A summary of these perspectives is shown in table 1 for seven types of management regimes (see Haynes and others 2003 for more details).

In general, industrial owners' management intentions have consistently involved practices beyond simply securing regeneration, and usually some form of commercial thinning. The proportion of thinning has differed over time, with some of the more recent surveys showing a decline. Practices other than commercial thinning also appear to have gained in importance as we move from the earliest to the most recent study, including precommercial thinning, fertilization, partial cutting regimes, and use of genetically improved planting stock. There has also

⁶Landowners demand a high rate of return to capital when interest rates are high. Typically these landowners do not hold timber for long periods without financial returns.

Table 1—Summary of private timber land base allocation to management regimes from six studies of the Pacific Northwest region

	WOR	WWA	WOR	WWA	WOR	PNWW
	Early 1970s	Early 1970s	Late 1980s	Late 1980s	Late 1990s	Late 1990s
	Beuter ^a	WaFPS ^b	Sessions ^c	Adams ^d	Adams ^e	RPA ^f
Industrial management regime:						
Age (years)		50 ^{H,A}	25 ^{M,A}	45–60 ^{M,A}	50–57 ^{H,S}	43–55 ^{M,S}
		<i>Percentage of land base</i>				
Non-G ^g regenerate only	43	10	28	25	51	17
Non-G regenerate + CT ^h + other	41	80	50	21	25	17
Non-G regenerate + other (Non-CT)	0	10	13	47	14	12
Partial cut	0	0	0	0	6	2
Genetic regenerate + other	0	0	0	3	0	47
Conversion/rehabilitation	16	0	9	0	0	0
Reserved	0	0	0	4	3	6
Total ⁱ	100	100	100	100	100	100
Nonindustrial private management regime:						
Age (years)		50 ^{H,A}	45–65 ^{M,A}	45–60 ^{M,A}	43–49 ^{M,S}	40–60 ^{M,A}
		<i>Percentage of land base</i>				
Non-G regenerate only	62	95	0	98	61	83
Non-G regenerate + CT + other	3	5	0	0	1	0
Non-G regenerate + other (Non-CT)	0	0	0	1	3	7
Partial cut	0	0	0	0	33	0
Genetic regenerate + other	0	0	0	1	0	10
Conversion/rehabilitation	35	0	0	0	0	0
Reserved	0	0	0	0	3	0
Total	100	100	0	100	100	100

Note: WOR = western Oregon, WWA = western Washington, PNWW = Pacific Northwest West. Harvest (H) or minimum harvest (M); age assumed (A) or established from survey (S).

^aBeuter and others 1976.

^bWDNR 1975.

^cSessions 1991.

^dAdams and others 1992.

^eAdams and others 2002.

^fHaynes 2003.

^gNon-G = Not genetically improved planting stock.

^hCT = Commercial thinning.

ⁱTotals may not add up because of rounding.

been a decline in intentions to pursue highly complex systems such as the “intensive” regime (plant/PCT/fertilize/CT) in the Timber Trends study. These systems appear to have been replaced by simpler one- or two-treatment regimes (for example, plant/PCT or plant/PCT/fertilize).

On nonindustrial private (NIPF) lands, management is largely limited to securing regeneration with only limited use of other treatments. Earlier western Oregon

studies made it clear that NIPF lands were in relatively poor management condition (low conifer restocking after harvest) (Sessions 1991). Recent studies (Adams and others 2002) show a large fraction of the land base in some form of partial cutting or selection management.

For public lands, management regimes until the early 1990s followed a mix of the three general management regimes described earlier. The adoption of the Northwest Forest Plan altered management regimes on federal timberlands and, where timber production is allowed, changed management to mimic natural successional processes by using partial harvests accomplished through multiple entries. The state timberlands are still generally managed on longer rotations than are private timberlands and are managed for a variety of goals including the production of timber and environmental services such as habitat and water quality.

Rotation age, or age of harvest, is one of the most closely scrutinized elements of these timber management regimes. Harvest age affects the rate of return received by the owner on regeneration, tending, and landholding investments; the maximum volume attained by the stand; the characteristics of wildlife habitat afforded by the stand over its life; and the time patterns of atmospheric carbon uptake and release. Yet as important as rotation is in both management decisions and in assessing the broader social and environmental impacts of management, relatively little has been objectively measured about actual harvest age patterns on private lands in the PNW.

As shown in table 1, six of the seven timber supply studies discussed in connection with the structure of management regimes also provide information on anticipated or intended rotation ages. In most cases these are “minimum harvest ages,” the youngest age at which owners would consider harvesting a stand—not average anticipated harvest ages—and they commonly differ by site, owner, and management regime. For the most part, available estimates were developed from expert opinion rather than surveys of owners or their agents. With the exception of the Sessions (1991) study, the range of harvest ages is broadly similar for both industrial and nonindustrial ownerships, 40 to 65 years depending on site and regime. The limited information on the actual harvest age behavior of owners in the PNW (Lettman and Campbell 1997) suggests that the area-weighted average harvest age is 58 years (see Haynes and others 2003 for computation method). The range is from 20 to more than 90 years, but more than two-thirds of the private cut comes from timber whose age ranges from 40 to 70 years.

Management Regimes, Assumptions, and Methods

In the shifting discussions about land management paradigms during the late 1980s and early 1990s, longer management regimes were proposed both as a way

to produce higher quality timber (see Barbour and others 2003) and as a way to produce a broader array of ecosystem goods, services, and conditions, especially in terms of wildlife habitat. Much of this discussion is summarized by Weigand and others (1994) who described the results from the High Quality Workshop held in spring 1993. The original proposal was described by Gus Kuehne (President, Northwest Independent Forest Manufacturers) in fall 1990 as “High Quality Forestry (HQF): an alternative for management of National Forest lands.”⁷ The name HQF came from an emphasis on growing timber with old-growth-like characteristics (large diameter, relatively knot free, and a high number of rings per inch) that would produce a high proportion of Shop and Select grades of lumber. The HQF method called for extended harvest rotation of 150 to 200 years, severely reducing clearcutting and emphasizing multiple management goals. The HQF method relied on precommercial thinning, pruning, and commercial thinnings to accommodate the needs of wildlife species and to maintain and improve timber yields. The intervals between intermediate cuts ranged from 15 to 30 years, depending on site and terrain. The record of decision (UDSA and USDI 1994) implementing the Forest Ecosystem Management Assessment Team (FEMAT 1993) strategy for habitat conservation shifted discussions about public land management paradigms to approaches other than longer rotations.

Here I look at the differences between three management regimes. The first regime is currently employed on 47 percent of forest industry timberlands in PNWW (summarized from table 1). It consists of planting, PCT (at age 15 years), fertilization (usually on forest industry timberlands), and final harvest around 45 years. The second regime is one often favored by silviculturists who rely on rotation lengths set by culmination of mean annual increment, which is around 80 years for Douglas-fir (Curtis and others 1998). This regime also includes planting, PCT, and a commercial thinning at about 50 years. This thinning was designed to reduce stand volumes by one-fifth and to capture for use the expected mortality between 50 and 80 years old. A third management regime was examined that represents Kuehne’s long-rotation proposals. This regime includes planting, PCT, pruning, a series of commercial thinnings (at ages 50, 80, and 120, each designed to reduce stand volumes by one-fifth and to make use of dead trees before the next entry), and final harvest at age 160. The thinning intervals are longer than originally envisioned by Kuehne because in early analysis of his proposals, light frequent thinnings as he envisioned were not economically feasible (see Weigand 1994). A rotation length of 160 years was chosen to continue the progression of the first two regimes.

⁷His proposal is included as an appendix in Weigand and others (1994).

The analysis method consisted of calculating the soil expectation value which is the present value of all future net returns from a piece of land growing timber.⁸ Given a rate of interest, rotation length, and the value of timber (or other) products produced, the present net worth of land can be computed. In this case, we are looking at the present net worth of a stand grown under three rotation lengths each producing a different product mix (in terms of the grades of lumber that can be produced from the available logs).

This approach depends on several key assumptions. First, all prices and costs are in real terms (that is they are net of inflation). There is little expectation for real price appreciation in lumber and stumpage markets. Price projections from Haynes (2003) suggest price appreciation of 0.4 and 0.2 percent per year over the next 50 years for the lumber and stumpage markets. Second, stand volume was computed by using an empirical yield function shown in figure 1 for Douglas-fir derived from USDA Forest Inventory and Analysis data for western Oregon. This represents

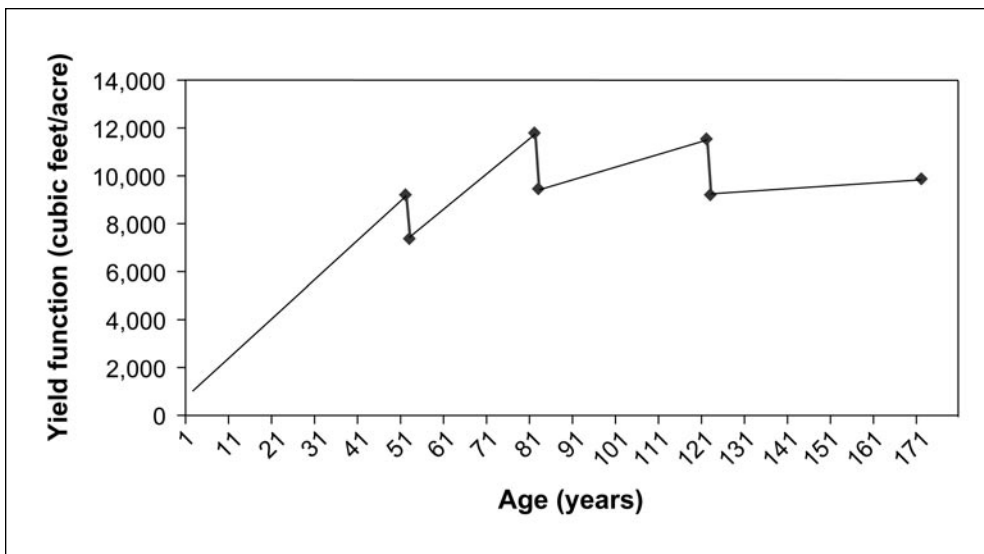


Figure 1—Empirical yield function for Douglas-fir with thinnings at 50, 80, and 120 years.

yields for relatively full stocking observed in actual stands. Actual stand stocking is between 60 and 65 percent of full stocking on the industrial and nonindustrial timberland in western Oregon suggesting that the realized yields will be less than shown in figure 1. Third, there are price premiums associated with the intermediate

⁸The present value of all future net returns, the soil expectation value or SEV, from a simple plant-and-harvest management regime can be expressed as:

$$SEV = \frac{\text{Price} \times \text{Volume at rotation} - \text{Planting cost}}{(1 + \text{Interest rate})^{\text{Rotation}} - 1} - \text{Planting cost}$$

and intensive regimes reflecting larger proportions of high-grade products resulting from larger trees with less taper and fewer branches associated with thinned stands and longer rotations. Figure 2 illustrates the actual ratios between prices for high, medium, and low Douglas-fir lumber grades (see Haynes and Fight 1992, 2004 for a discussion). Sustained high-grade prices that are three to four times low-grade lumber prices have influenced the advocates for HQF. Table 2 shows the actual proportions of Douglas-fir lumber recovery by grade groups. This table was developed from data collected in empirical wood products recovery studies (see Stevens and Barbour 2000).

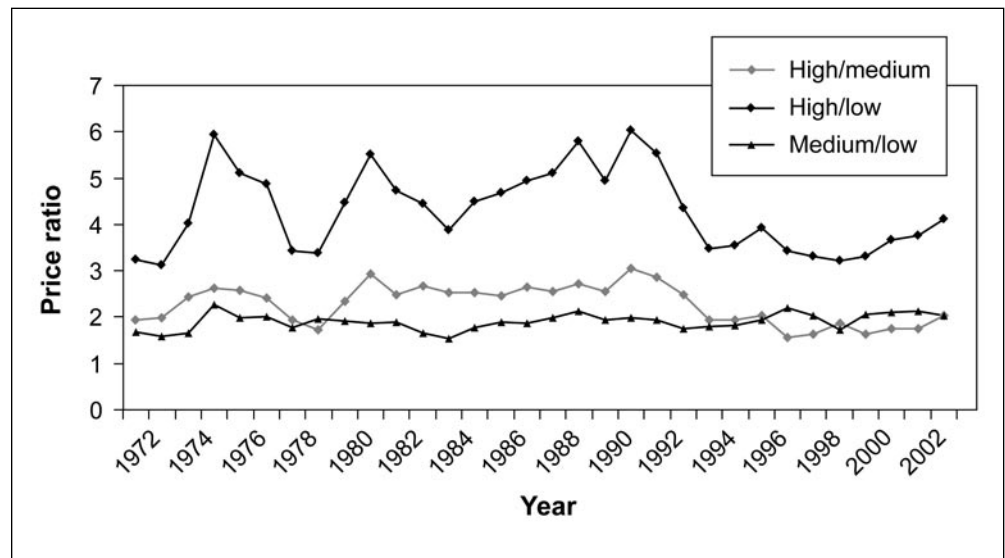


Figure 2—Douglas-fir price ratios for grade groups.

Table 2—Proportion of Douglas-fir recovery by grade groups

Age class	Factory and Selects	Select structural	No. 2 and better	Utility and Economy
<i>Years</i>			<i>Percent</i>	
40	0	21.1	70.4	8.6
80	2.3	22.3	66.8	8.6
160	7.5	24.7	59.2	8.6

A key assumption that shows differences among the three management alternatives is the price projection for mixes of stumpage coming from different stand ages. Table 3 shows the average lumber price per thousand board feet (MBF). It was developed by combining lumber price projections by grade (from Haynes and Fight 2004) and the recovery data shown in table 2. The next step converts these

Table 3—Weighted-average lumber prices by age, for all grades

Rotation length	2002	2020	2050
<i>Years</i>	<i>Dollars per thousand board feet</i>		
40	347	588	688
80	354	595	697
120	362	604	707
160	369	612	717

lumber prices to stumpage prices by using a price markup relationship describing the relation⁹ between stumpage and lumber prices. The stumpage prices used in the analysis were:

Age	Dollars per MBF
40 years	732
80 years	742
160 years	764

Another price assumption was that all thinning material was valued by using the stumpage prices for 40-year-old timber because those thinnings are assumed to be the smaller trees that would fall victim to overcrowding in the next three decades. The differences in stumpage prices (almost \$32 per MBF) among the different stand rotations are smaller than the large price differences cited by proponents of longer rotations who often look only at differences in lumber prices.

Results

The results of these regimes are summarized in figure 3 where the present value of a single rotation for the three alternative regimes are displayed. For example, a timberland owner or investor who used a 4-percent interest rate could expect to earn \$5,800 per acre for their 40-year investment or \$2,825 per acre for a 160-year investment. The present value of the 40-year rotation is about two times that of a 160-year rotation even though the total value of material eventually removed in the longer rotation is four times that of the 40-year rotation. Looking at the returns over a 160-year period, the present value of a stand managed by using a 40-year rotation (with four harvests) is about four times the value of managing a stand for a single 160-year rotation.

⁹This relation was estimated as $\text{Price stumpage} = -33.7922 + (1.1133 \times \text{Lumber price})$. The data were nominal stumpage prices in the Douglas-fir region and Douglas-fir lumber prices for 1910–2002. This relation is a type of price markup rule described in Haynes (1977) and Haynes and Fight (2004).

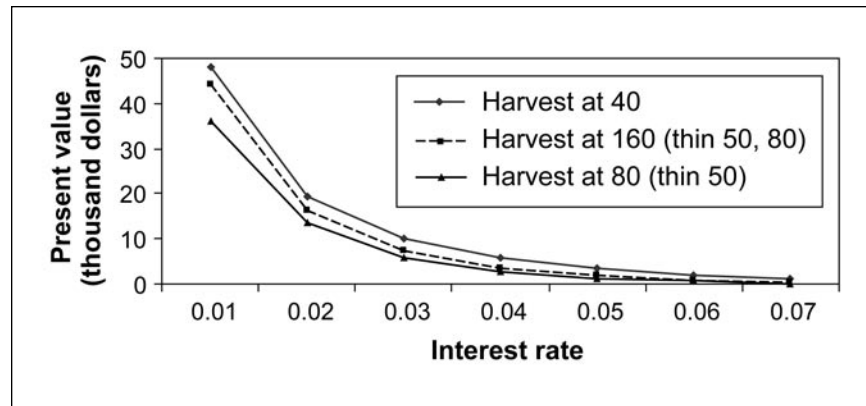


Figure 3—Present value of a single rotation for three management regimes.

If we consider the value of each management regime assuming continuous management through time (computed as a perpetual annuity), then the value of the 40-year rotation is more than 400 times that of the 160-year rotation (assuming real interest rates of 4 percent). These results demonstrate the relentless financial pressure to shorten rotation lengths and simplify management regimes. They also confirm that the higher volumes removed through thinnings and higher values for the final harvest are not sufficient to offset the preferences for earlier financial returns. Finally, these results demonstrate empirical reasons for the observed decline in rotation ages on private timberlands during the 1990s (see fig. 3 in Haynes and others 2003).

These results are subject to uncertainty in some of the key assumptions. In any economic analysis, for example, the future price assumptions are subject to considerable uncertainty. In real terms, stumpage prices in the Pacific Northwest increased at an annual rate of 8.4 percent between 1909 and 1990. Since 1990, stumpage prices have been volatile but trending downward as markets and production have adjusted to reductions in federal timber flows (see Haynes 2003). In this analysis, stumpage prices were assumed to increase 0.2 percent per year. But if rates of stumpage price appreciation were to return to something like the historical rates, then the financial returns would increase for all of the management regimes.

There is one source of uncertainty that might impact the longer rotations more than the 40-year regime: different rates of price increases for higher quality log mixes. During the 1970s and 1980s, for example, a price premium for exportable logs encouraged owners of exportable logs to both lengthen management regimes and introduce practices designed to produce a high proportion of logs that would meet export standards.

These results also reveal the advantage for some owners of maintaining flexibility of actions within a rotation as expected financial returns change. This is especially true for those owners who are motivated by financial returns and who are tending to adopt less complex and shorter rotations. These same owners, and also those interested in timberland as a form of investment, are sensitive to the variability in financial returns as well as having generally shorter time preferences for investments.

Conclusions

The analyses in this paper are set in the context of considering choice of management regime based on expected financial returns. The reality, however, is that landowners and managers make decisions considering myriad values. This is especially the case for public land managers where production of public goods and services such as habitat or recreation opportunities is part of the management goals. The record of forest management developed over successive rotations in the PNW does show a progressive trend toward simpler management regimes and a decline in rotation ages. These results have a number of management implications:

1. Increasing the time value of money leads to higher returns for shorter rotations.
2. Even in a species like Douglas-fir that experiences relatively high growth rates over a long period, longer rotations (say in excess of 50 years) are difficult to justify assuming positive interest rates, when timber revenue is the primary objective.
3. The returns from high-quality timber are not attractive to private land managers. This is especially the case when you consider that longer rotations exceed reasonable expectations for continuity of land tenure.
4. In the case of public lands where ownership continuity is assured and the need for positive rates of return is less, longer rotations may be attractive when they involve the joint production of various public goods such as habitat and scenery.
5. The increase in average lumber prices for high-quality management regimes is insufficient, in general, to offset the costs of longer rotations.

This research note also recounts the evolution of management regimes in the PNW. Considering this evolution leads to perhaps the most important lesson: the need for flexibility of management actions within a single rotation given the propensity for conditions to change. A second lesson is how management actions differ both by ownerships and by the expectations of various owners about the financial

feasibility of individual actions within a management regime. These two lessons emphasize the importance of understanding that contemporary forest management is about choices and that management regimes are evolving to include greater flexibility both in their application and their outcomes.

Metric Equivalents

When you know:	Multiply by:	To get:
Board feet, log scale	0.0045	Cubic meters, logs
Board feet, lumber scale	.0024	Cubic meters, lumber
Dollars per thousand board feet, log scale	.221	Dollars per cubic meter (logs)
Dollars per thousand board feet, lumber scale	.424	Dollars per cubic meter (full sawn lumber)
Cubic feet	.0283	Cubic meters
Acres	.405	Hectares

Literature Cited

- Adams, D.; Alig, R.; Anderson, D. [and others]. 1992.** Future prospects for western Washington's timber supply. CINTRAFOR Spec. Pap. 27. Seattle, WA: University of Washington, College of Forest Resources. 200 p.
- Adams, D.M.; Schilinger, R.R.; Latta, G.; Van Nalts, A. 2002.** Timber harvest projections for private land in western Oregon. Res. Contrib. 37. Corvallis, OR: College of Forestry, Forest Research Laboratory, Oregon State University. 44 p.
- Barbour, R.J.; Marshall, D.D.; Lowell, E.C. 2003.** Managing for wood quality. In: Monserud, R.A.; Haynes, R.W.; Johnson, A.C., eds. Compatible forest management. Dordrecht, The Netherlands: Kluwer Academic Publishers: 299–336. Chapter 11.
- Barbour, R.J.; Zaborske, R.R.; McClellan, M.H.; Christian, L.; Golnick, D. [In press].** Young-stand management options and their implications for wood quality and other values. Landscape and Urban Planning.
- Beuter, J.H.; Johnson, N.K.; Scheurman, H.L. 1976.** Timber for Oregon's tomorrow: an analysis of reasonably possible occurrences. Res. Bull. 19. Corvallis, OR: Forest Research Laboratory, Oregon State University. 119 p.
- Craib, I.J. 1948.** Silviculture and management. In: Proceedings, 5th British Empire Forest Conference, 1947: 179–182.

Curtis, R.O.; DeBell, D.S.; Harrington, C.A.; Lavender, D.P.; St. Clair, J.B.; Tappeiner, J.C.; Walstad, J.D. 1998. Silviculture for multiple objectives in the Douglas-fir region. Gen. Tech. Rep. PNW-GTR-435. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 123 p.

Forest Ecosystem Management Assessment Team [FEMAT]. 1993. Forest ecosystem management: an ecological, economic, and social assessment. Portland, OR: U.S. Department of Agriculture; U.S. Department of the Interior [and others]. [Irregular pagination].

Haynes, R.W. 1977. A derived demand approach to estimating the linkage between stumpage and lumber markets. *Forest Science*. 23(2): 281-288.

Haynes, R.W., tech. coord. 2003. An analysis of the timber situation in the United States: 1952 to 2050. Gen. Tech. Rep. PNW-GTR-560. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 254 p.

Haynes, R.W.; Adams, D.M.; Mills, J.R. 2003. Contemporary management regimes in the Pacific Northwest: balancing biophysical and economic concerns. In: Monserud, R.A.; Haynes, R.W.; Johnson, A.C., eds. *Compatible forest management*. Dordrecht, The Netherlands: Kluwer Academic Publishers: 267–296. Chapter 10.

Haynes, R.W.; Fight, R.D. 1992. Price projections for selected grades of Douglas-fir, coast hem-fir, inland hem-fir, and ponderosa pine lumber. Res. Pap. PNW-RP-447. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 20 p.

Haynes, R.W.; Fight, R.D. 2004. Reconsidering price projections for selected grades of Douglas-fir, coast hem-fir, inland hem-fir, and ponderosa pine lumber. Res. Pap. PNW-RP-561. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 31 p.

Kellogg, R.M., comp., ed. 1989. Second growth Douglas-fir: its management and conversion for value. Spec. Publ. SP-32. Vancouver, BC: Forintek Canada Corp. 173 p.

Lettman, G.; Campbell, D. 1997. Timber harvesting practices on private forest land in western Oregon. Salem, OR: Oregon Department of Forestry. 48 p.

Sessions, J., coord. 1991. Rev. Timber for Oregon's tomorrow: the 1989 update. Corvallis, OR: Forest Research Laboratory, Oregon State University. 183 p.

- Stevens, J.A; Barbour, R.J. 2000.** Managing the stands of the future based on the lessons of the past: estimating western timber species product recovery by using historical data. Res. Note PNW-RN-528. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 11 p.
- Sutton, R.J. 1984.** New Zealand experience with radiata pine. Vancouver, BC: The H.R. MacMillian Lectureship in Forestry. [Not paginated].
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1963.** Timber trends in western Oregon and western Washington. Res. Pap. PNW-5. Portland, OR: Pacific Northwest Forest and Range Experiment Station, Division of Forest Economics Research. 154 p.
- U.S. Department of Agriculture, Forest Service: U.S. Department of the Interior, Bureau of Land Management [USDA and USDI]. 1994.** Record of decision for amendments to Forest Service and Bureau of Land Management planning documents within the range of the northern spotted owl. [Place of publication unknown]. 74 p. [plus attachment A: standards and guidelines].
- Washington Department of Natural Resources [WDNR]. 1975.** Washington forest productivity study, phase 1 report. Prepared for Pacific Northwest Regional Commission. Olympia, WA: Operation Research Section, Division of Technical Services. [Pages unknown].
- Weigand, J.F. 1994.** First cuts at long-rotation forestry: projecting timber supply and value for the Olympic National Forest. In: Weigand, J.F.; Haynes, R.W.; Mikowski, J.L., comps. High quality forestry workshop: the idea of long rotations. Proceedings. CINTRAFOR SP 15. Seattle, WA: College of Forest Resources AR-10, University of Washington: 177–202.
- Weigand, J.F.; Haynes, R.W.; Mikowski, J.L., comps. 1994.** High quality forestry workshop: the idea of long rotations. Proceedings. CINTRAFOR SP 15. Seattle, WA: College of Forest Resources AR-10, University of Washington. 243 p. [plus appendix].
- Whiteside, I.D.; Wilcox, M.D.; Tustin, J.R. 1975.** New Zealand Douglas-fir timber quality in relation to silviculture. New Zealand Journal of Forestry. [Volume unknown]: 25–45.

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