

## Commercial Thinning

1. Bailey, J.D. and J.C. Tappeiner. 1998. Effects of thinning on structural development in 40- to 100-year-old Douglas-fir stands in western Oregon. *Forest-Ecology-and-Management* 108(1/2): 99-113.

**Keywords:** thinning  
commercial thinning  
regeneration  
tree morphology

**Abstract:** The composition and structure of the understory was studied in thinned and unthinned Douglas fir/western hemlock (*Pseudotsuga menziesii*/*Tsuga heterophylla*) stands on 32 sites in western Oregon. These stands had regenerated naturally after timber was harvested between 1880 and 1940; they were thinned between 1969 and 1984. Commercially thinned stands had 8-60% of their volume removed 10-24 yr before the study (in 1993-95). Undisturbed old-growth Douglas fir stands were present for comparison on 20 of these paired sites. Conifer regeneration density and frequency were consistently greater in thinned than unthinned stands. For example, average seedling density in thinned stands (1433/ha) was significantly greater than in unthinned stands (233/ha), but very similar to that in old-growth stands (1010/ha). Seedling density and frequency were strongly related to the volume removed and to stand density index (and other measures of overstorey density) just after thinning. In thinned stands, the density of small trees (intermediate crown class overstorey trees and advanced regeneration) was 159/ha, significantly greater than in unthinned stands (90/ha), but not significantly different from that of old-growth (204/ha). The live crown ratio of these trees in thinned stands (66%) was greater than in unthinned (44%) and old-growth (48%) stands. Cover and stem density of shrubs was variable in all 3 stand types. There was significantly less tall shrub cover in unthinned stands than in either thinned or old-growth stands, which did not differ. Thinned stands had the most low shrub cover. Salal (*Gaultheria shallon*) and bracken fern (*Pteridium aquilinum*) cover was greater in thinned stands than in the other stand types, but there was no difference in sword fern (*Polystichum munitum*) and Oregon grape [*Berberis nervosa*] cover. Leaf area index in thinned stands (6.6) was not significantly different from that in unthinned (6.8) and old-growth stands (7.1); however, there was more leaf area in shrubs in the thinned stands. Thinning young Douglas-fir stands will hasten the development of multistorey stands by recruitment of conifer regeneration in the understory as well as by enabling the survival of small overstorey trees and growth of advanced understory regeneration. Thinning will also help develop the shrub layer by increasing tall shrub stem density and cover of some low shrubs.

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2. Barbour, R.J. and D.L. Parry. 2001. Log and lumber grades as indicators of wood quality in 20- to 100-year-old Douglas-fir trees from thinned and unthinned stands. Pacific-Northwest-Research-Station,- USDA-Forest-Service General-Technical-Report PNW-GTR-510. 22 p.

**Keywords:** thinning  
commercial thinning  
wood quality

**Abstract:** This report examines the differences in wood characteristics found in coastal Pacific Northwest Douglas-fir (*Pseudotsuga menziesii*) trees harvested at the age of 70 to 100 years old or at the age of 40 to 60 years from a trial involving multiple thinnings in Seattle, Washington, USA. Comparisons of differences in domestic log grades suggest that the proportion of log volume in the higher grades (Special Mill and No. 2 Sawmill) increased with both stand age and tree size. Simulation of lumber grade yields based on log characteristics suggests that yields of higher grades of lumber increased until about age 60 to 70, and then levelled off over the rest of the age range examined in this analysis. We included structural lumber products in the analysis but not higher value appearance grade products, and some evidence suggests that yields of these products might have begun to increase in the oldest trees. The analysis also showed that the younger trees had larger branches and more juvenile wood, possibly because they had been grown in stands that received a higher level of early stand management than the older trees. If these young trees were grown to the ages of 70 to 100, they likely would not produce the same log and lumber grade yields found in the older trees we examined.

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3. Bettinger, P., K.A. Bettinger and K. Boston. 1998. Correlation among spatial and non-spatial variables describing a cut-to-length thinning site in the Pacific Northwest, USA. *Forest-Ecology-and-Management* 104(1/3): 139-149.

**Keywords:** thinning  
commercial thinning  
tree/stand health

**Abstract:** Variables describing the pre- and post-logging conditions of a thinning site in 47-yr-old naturally regenerated stand of second-growth Douglas fir (*Pseudotsuga menziesii*) and western hemlock (*Tsuga heterophylla*) in western Oregon, were examined for correlation, and subsequently used to develop models to estimate residual stand damage levels. A cut-to-length harvesting system was utilized to perform the thinning operation, which used a single-grip harvester and a forwarder, and marked logging trails. Several of the variables were measured in an intensive field survey; other variables were developed using geographic information system (GIS) processes. An analysis of correlations among the site variables showed several obvious, and a few interesting, results that describe the operation. Most of the variables provided negative, or inconclusive, assistance in describing the variation in stand damage levels. Only one variable, the number of original trees/hectare, was significantly correlated with residual stand damage levels, and was represented in the models that were developed to estimate residual stand damage levels. The resulting models are of limited practical value, however, since they explain little of the variability in damage levels. Most of the variation in residual stand damage levels may well be explained by random chance, operator error, other unmeasured operational variables associated with this harvesting system, or interactions among variables. The main conclusion from the study is that although both spatial and non-spatial data were utilized in describing the logging operation and in developing models to estimate stand damage levels, the importance of using spatial data was inconclusive.

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4. Bettinger, P. and L.D. Kellogg. 1993. Residual stand damage from cut-to-length thinning of second-growth timber in the Cascade Range of western Oregon. *Forest-Products-Journal* 43(11/12): 59-64.

**Keywords:** thinning  
commercial thinning  
tree/stand health

**Abstract:** Residual stand damage was measured on 25% of an area that had been thinned with a cut-to-length logging system. Total damage (scar area) per acre was less than in any similar study in the Pacific Northwest, although 39.8% of the residual trees sustained some damage. Only 0.8% of the trees, however, sustained significant damage. Western hemlock (*Tsuga heterophylla*) was more susceptible to damage than Douglas fir (*Pseudotsuga menziesii*). Most of the damage occurred within 15 feet of a trail centreline and originated within 3 feet of the groundline. Early summer logging may have resulted in more damaged trees than might occur during other seasons. Future volume loss due to decay is likely to be minimal because a low percentage of scars were considered vulnerable to wood-decaying fungi.

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5. Brandeis, T.J., M. Newton and E.C. Cole. 2001. Underplanted conifer seedling survival and growth in thinned Douglas-fir stands. *Canadian-Journal-of-Forest-Research* 31(2): 302-312.

**Keywords:** planting operations  
thinning  
commercial thinning  
site preparation  
chemical preparation  
release treatments  
chemical release  
growth  
tree/stand health  
regeneration

**Abstract:** In a multilevel study conducted at the Oregon State University's McDonald-Dunn Research Forest, Oregon, USA, to determine limits to underplanted conifer seedling growth, Douglas-fir (*Pseudotsuga menziesii*), grand fir (*Abies grandis*), western redcedar (*Thuja plicata*) and western hemlock (*Tsuga heterophylla*) seedlings were planted in January 1993 beneath second-growth Douglas-fir stands that had been thinned in 1992 to basal areas ranging from 16 to 31 m<sup>2</sup>/ha. Understorey vegetation was treated with a broadcast herbicide (glyphosate + imazapyr) application prior to thinning, a directed release herbicide (glyphosate, plus triclopyr for tolerant woody stems) application 2 years later, or no treatment beyond harvest disturbance. Residual overstorey density was negatively correlated with percent survival for all four species. Broadcast herbicide application improved survival of grand fir and western hemlock. Western redcedar, grand fir and western hemlock stem volumes were inversely related to overstorey tree density and this effect increased over time. There was a strong indication that this was also the case for Douglas-fir. Reduction of competing understorey vegetation resulted in larger fourth-year stem volumes in grand fir and western hemlock.

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6. Curtis, R.O. 1987. Levels-of-growing-stock cooperative study in Douglas-fir: Report No. 9 - some comparisons of DFSIM estimates with growth in the levels-of-growing stock study. Pacific-Northwest-Research-Station,-USDA-Forest-Service Research-Paper PNW-RP-376. 34 p.

**Keywords:** thinning  
commercial thinning  
growth  
tree/stand health  
computer modeling

**Abstract:** Initial stand statistics for the 9 levels-of-growing-stock (LOGS) study installations in Oregon and Washington, USA, and Vancouver Island, British Columbia, Canada, were projected by the Douglas fir (*Pseudotsuga menziesii*) stand simulation program (DFSIM) over the available periods of observation. Thinnings were simulated by use of observed top height trends, actual residual basal areas, and actual ratios of cut tree diameters to stand diameter before cutting (d/D). Estimates were compared with observed gross and net volumes and basal area growth, net change in quadratic mean diameter, and change in number of trees. Although the LOGS installations included regimes quite different from those in most of the data used to construct DFSIM, overall agreement was reasonably good. Results indicated some density-related bias in the thinned stands and a need for revision in the method used to control the maximum density in the DFSIM program and in the associated mortality estimates.

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7. Curtis, R.O., G.W. Clendenen and D.J. DeMars. 1981. A new stand simulator for coast Douglas-fir: DFSIM user's guide. Pacific-Northwest-Forest-and-Range-Experiment-Station,-USDA-Forest-Service General-Technical-Report PNW-GTR-128. ii + 79 p.

**Keywords:** planting operations  
thinning  
precommercial thinning  
commercial thinning  
fertilization  
yield  
computer modeling

**Abstract:** A description of a computer program, written in FORTRAN IV, for simulating managed stands. The program has been developed from remeasured plot data contributed by many organizations in the Pacific Northwest USA. It can produce yield tables which include estimates of effects of initial spacing, precommercial and commercial thinning and addition of N fertilizer. Topics discussed include program limitation and potential for further development. Appendices include operating instructions and notes on testing. The program is available from the authors on request.

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8. Curtis, R.O. and D.D. Marshall. 1986. Levels-of-growing-stock cooperative study in Douglas-fir. Report no. 8 - The LOGS study: twenty-year results. Pacific Northwest Research Station, USDA Forest Service Research-Paper PNW-RP-356. v + 113 p.

**Keywords:** thinning  
commercial thinning  
growth

**Abstract:** A further report in a series on 9 study areas in Oregon, Washington and British Columbia. The programme aimed to determine relations between growing stock and vol., b.a. and diam. growth for 8 thinning regimes. Results presented are mainly from 5 site class II installations. Growth was strongly related to growing stock. Thinning treatments produced marked differences in volume distribution by tree sizes. There were considerable unexplained differences in productivity between installations, beyond those attributable to site quality. During the 4th treatment period (32-42 yr old in site class II sites) c.a.i. was approx. twice m.a.i. An evaluation is given of the LOGS study design.

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9. Curtis, R.O. and D.D. Marshall. 2002. Levels-of-growing-stock cooperative study in Douglas-fir: report no. 14 - Stampede Creek: 30-year results. Pacific-Northwest-Research-Station,-USDA-Forest-Service Research-Paper PNW-RP-543. xi + 77 p.

**Keywords:** thinning  
commercial thinning  
growth  
yield  
tree morphology  
tree/stand health

**Abstract:** Results of the Stampede Creek installation of the levels-of-growing-stock (LOGS) study in Douglas-fir (*Pseudotsuga menziesii*) are summarized. To age 63 (planned completion of 60 feet of height growth), volume growth on the site III natural stand has been strongly related to level of growing stock, but basal area growth-growing stock relations were considerably weaker. Marked differences in tree size distributions have resulted from thinning. Periodic annual volume increments at age 63 are two to three times greater than mean annual increment; this stand is still far from culmination. Results for this southwest Oregon installation are generally similar to those reported from other LOGS installations, although development has been slower than on the site II installations that make up the majority of the series.

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10. Curtis, R.O., D.D. Marshall and J.F. Bell. 1997. LOGS: a pioneering example of silvicultural research in coast Douglas-fir. *Journal-of-Forestry* 95(7): 19-25.

**Keywords:** thinning  
commercial thinning  
growth  
yield

**Abstract:** A regional levels-of-growing-stock (LOGS) study of young Douglas fir (*Pseudotsuga menziesii*) stands in western Oregon and western Washington, USA and Vancouver Island, British Columbia, Canada, was conducted between 1961 and 1970. The objective was to determine how the amount of growing stock retained in repeatedly thinned stands of *P. menziesii* affects cumulative wood production, tree size and growth:growing stock ratios. Nine LOGS installations were established during the study period, each consisting of 27 one-fifth acre plots, with 8 thinning treatments (and controls). All plots received initial calibration thinning. After the first 10 feet of height growth and at intervals of 10 feet thereafter, 5 subsequent thinning treatments were made. As of 1994, all installations on site class II, and most installations on site classes III and IV had completed the planned thinning sequence over 60 ft of height growth. Periodic annual increment of both basal area and volume was clearly related to basal area of growing stock and several measures of density. Thinning accelerated diameter growth, and diameter and volume distributions differed greatly among treatments. Mean annual increment and periodic annual increment showed no sign of approach to culmination in either total or merchantable cubic volume. Cumulative volume production (live stand plus thinning) of the controls exceeded all thinning treatments to date when measured in total cubic volume of all trees, although when volume was measured in merchantable cubic feet several thinning treatments exceeded net volume production of the controls. A discussion of the results includes: a comparison with other thinning studies; an analysis of application of the Langsaeter hypothesis (that the same cubic volume production could be obtained over a wide range of stand densities); growth trends and rotations; thinning gains; non-timber values; and critical analysis of the study design. The continuing value of the demonstration stands is discussed.

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11. Curtis, R.O., D.D. Marshall and D.S. DeBell. 2004. Silvicultural options for young-growth Douglas-fir forests: the Capitol Forest study - establishment and first results. Pacific Northwest-Research-Station,- USDA-Forest-Service General-Technical-Report PNW-GTR-598. xi + 110 p.

**Keywords:** thinning  
commercial thinning  
economics  
soil properties

**Abstract:** This report describes the origin, design, establishment and measurement procedures and first results of a large long term cooperative study comparing a number of widely different silvicultural regimes applied to young-growth Douglas-fir (*Pseudotsuga menziesii*) stands managed for multiple objectives. Regimes consist of (1) conventional clear felling followed by intermediate thinning; (2) retention of reserve trees to create a two-aged stand; (3) small patch cuts dispersed within a thinned matrix, repeated at approximately 15-year intervals to create a mosaic of age

classes; (4) group selection within a thinned matrix on an approximate 15-year cycle; (5) continued thinning on an extended rotation; and (6) an untreated control. Each of these regimes is on operation-size units (approximately 30 to 70 acres each). A LIDAR system was used to scan the surface of the 2 miles<sup>2</sup> that encompass the Blue Ridge study site on the Capitol State Forest, near Olympia, Washington, USA. This measurement technology emits laser pulses that are reflected by vegetation, buildings, or the ground surface. Output variables from the study to be evaluated include conventional timber growth and yield statistics, harvest costs, sale layout and administration costs, aesthetic effects and public acceptance, soil disturbance, bird populations, and economic aspects. Descriptive statistics and some initial results are presented for the first replicate, established in 1997-98.

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12. El Kassaby, Y.A. and A. Benowicz. 2000. Effects of commercial thinning on genetic, plant species and structural diversity in second growth Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) stands. *Forest-Genetics* 7(3): 193-203.

**Keywords:** thinning  
commercial thinning  
genetic relationships

**Abstract:** The impact of commercial thinning on biodiversity was studied in two Douglas-fir (*Pseudotsuga menziesii*) plantations, Weeks Lake (WL) and Fairservice Creek (FC) located on southern Vancouver Island, British Columbia, Canada. The age of the stands at thinning was 53 and 70 years for FC and WL, respectively. Other tree species were also present in both sites due to natural regeneration. Biodiversity was evaluated before and after commercial thinning with respect to tree species composition/abundance, tree species genetic diversity assessed by allozyme analysis and stand structural diversity represented by the diameter class (5-cm) distribution. In addition, understorey plant species diversity was monitored in WL and FC for 4 and 5 years following thinning, respectively. Tree species composition changed in both plantations in a similar fashion as the proportion of Douglas-fir increased at the expense of all other tree species. Stand structural diversity was simplified due to the decreased number of trees in small diameter classes. These results were expected since the commercial thinning was conducted to promote the growth of Douglas-fir. Genetic diversity parameters (average number of alleles per locus, percent polymorphic loci and expected heterozygosities) did not differ significantly before and after thinning; however, thinning resulted in a loss of 8 and 7 alleles across species for FC and WL, respectively. Most of the allelic loss occurred in the naturally regenerated species (93%). This allelic loss represents 7 and 6% of the total alleles present in FC and WL, respectively. Thus, only one allele was lost from the crop tree in the FC plantation. Understorey vegetation species richness decreased the year following commercial thinning and then consistently increased over time in both plantations. A total of 17 and 9 new species colonized FC and WL, respectively. One species was replaced in each plantation. In FC, diversity of the understorey plant community based on the Shannon diversity index (H) changed in an increasing linear trend that corresponded to the increase in species richness. On the other hand, H in WL remained stable. Species evenness (H/H<sub>max</sub>) did not change in WL and FC over the course of study except for seasonal fluctuations. Rare species diversity increased over time in both plantations.

[OSU Link](#)

13. Emmingham, W.L., P. Oester, M. Bennett, F. Kukulka, K. Conrad and A. Michel. 2002. Comparing short-term financial aspects of four management options in Oregon: implications for uneven-aged management. *Forestry-Oxford* 75(4): 489-494.

**Keywords:** thinning  
commercial thinning  
economics  
yield

**Abstract:** Private family forest owners are often more interested in comparing short-term financial outcomes of management options, as opposed to longer time horizons and classical economic analyses including net present value. Therefore, we compared projected 10-year value of timber and land for four theoretical management scenarios starting with stands ripe for thinning. The options were (1) hold for 10 years (i.e. no thinning), (2) thin for even-age, or (3) partial cut for uneven-age and (4) clearcut now. To simulate the outcomes of these scenarios, we marked and measured 2-ha plots in 10 stands typical of private forest ownerships across Oregon and projected timber yields and revenues. The financial analysis included current market values for logs, payment of taxes and typical reforestation costs and computation of net asset values (NAV) at a 7 per cent interest rate. The hold option consistently gave the highest NAV for timber and land after 10 years, and the thin option was within 2 per cent. For the eight western Oregon stands, the partial-cut option averaged about 3 per cent less, and the clearcut option ranged from 8 to 17 per cent less than holding. Pine stands of eastern Oregon showed similar trends; however, all options were within about 6 per cent of the hold option. Thus, using financial criteria typical of those used by private forestowners, we found that there was little short-term financial loss in choosing to thin toward even-age, partial cut toward uneven-age, or the hold approach in well-stocked stands.

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14. Garman, S.L., J.H. Cissel and J.H. Mayo. 2003. Accelerating development of late-successional conditions in young managed Douglas-fir stands: a simulation study. Pacific-Northwest-Research-Station,-USDA-Forest-Service General-Technical-Report PNW-GTR-557. ii + 57 p.

**Keywords:** thinning  
commercial thinning  
yield

**Abstract:** The goal of this simulation study was to provide information for defining thinning regimes for young Douglas-fir (*Pseudotsuga menziesii*) stands in the Central Cascades Adaptive Management Area, located in west-central Oregon, USA. Specifically, this study used the ZELIG.PNW (3.0) gap model to evaluate effects of experimental thinning treatments on the development of late-successional attributes and on extracted merchantable volume. Sixty-four thinning treatments were simulated for four rotation intervals (260, 180, 100, and 80 years) starting with a 40-year-old managed Douglas-fir stand. The amount of time for five late successional attributes to reach defined threshold levels, long-term developmental trends of these attributes, and amount of extracted merchantable volume were recorded for each treatment. Stand conditions of selected treatments were used in a subsequent harvest rotation in which 64 additional experimental thinning treatments were applied and evaluated. A total of 1744 thinning treatments was evaluated in this study. Results of this study confirm previous



recommendations for accelerating development of late-successional attributes in young managed stands. Additionally, results show the potential for a range of thinning treatments to attain late-successional conditions in about the same amount of time, but with different trade-offs in terms of merchantable volume and long-term stand conditions. In general, heavy thinning of existing stands at ages 40 and 60 years promoted rapid development of large boles, vertical diversity, and tree-species diversity, but provided the least amount of extracted volume and required artificial creation of dead wood. Treatments that retained more than 40% of the original overstorey and thinned to 99 trees per hectare at age 60 delayed attainment of late-successional conditions by 10 to 30 years but provided 12 to 20% more extracted volume, resulted in higher levels of most late-successional attributes at the end of a rotation, and required less artificial creation of dead wood. Treatments providing the fastest development of late-successional conditions in subsequent rotations varied with the amount of canopy cover retained at the end of the first rotation. For stands starting with  $\leq 30\%$  canopy cover, delaying the first commercial thin for 40 years promoted the most rapid development of vertical structure and shade-tolerant stems. Lower canopy-retention levels required heavy or light thins in subsequent entries, depending on the rotation interval, for rapid development of late-successional attributes.

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**15.** Greene, S.E. and W.H. Emmingham. 1986. Early lessons from commercial thinning in a 30-year-old Sitka spruce-western hemlock forest. Pacific-Northwest-Research-Station,-USDA-Forest-Service Research-Note PNW-RN-448. 14 p.

**Keywords:** thinning  
commercial thinning  
growth  
tree/stand health  
tree morphology

**Abstract:** Three commercial thinning treatments were applied to a 30-yr-old stand of *Picea sitchensis* and *Tsuga heterophylla* with *Pseudotsuga menziesii* that had been precommercially thinned at 15 yr old on the Oregon coast. Data were collected to determine the effects of thinning on diam. and ht. growth, the amount of damage and subsequent decay in remaining trees and relations between leaf area and volume production.

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**16.** Haight, R.G. 1993a. The economics of Douglas-fir and red alder management with stochastic price trends. Canadian-Journal-of-Forest-Research 23(8): 1695-1703.

**Keywords:** planting operations  
site preparation  
prescribed fire  
release treatments  
chemical release

thinning  
precommercial thinning  
commercial thinning  
tree/stand protection  
economics

**Abstract:** A financial analysis of Douglas fir (*Pseudotsuga menziesii*) and red alder (*Alnus rubra*) management was conducted using yield projections from the Stand Projection Simulator for the Pacific Northwest region of the United States. The analysis included uncertainty in the price trends and stocking levels of both species following reforestation. Results from a case study in which Douglas fir price is likely to increase faster than red alder price show that (i) on more productive sites, greater regeneration investment is justified to increase the likelihood of Douglas fir establishment, (ii) on less productive sites, low-cost regeneration options that produce mixed-species stands have expected present values close to or greater than a high-cost Douglas fir regeneration effort, (iii) optimal precommercial removal of red alder depends on mid-rotation prices and regeneration success, and in many cases growing a mixed-species stand to maturity produces the highest economic return, and (iv) commercial thinning of Douglas fir increases the expected present value of the most intensive regeneration option by up to 10%. The low-cost regeneration options have relatively high expected returns because of low initial investments and the presence of two species that may have high values in the future. The sensitivity of these results to changes in the probability distributions of regeneration success and price trends is discussed.

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17. Haight, R.G. 1993b. Technology change and the economics of silvicultural investment. Rocky-Mountain-Forest-and-Range-Experiment-Station,-USDA-Forest-Service General-Technical-Report RM-GTR-232. ii + 18 p.

**Keywords:** planting operations  
site preparation  
prescribed fire  
release treatments  
chemical release  
tree/stand protection  
thinning  
commercial thinning  
precommercial thinning  
yield  
economics

**Abstract:** Financial analyses of intensive and low-cost reforestation options are conducted for loblolly pine (*Pinus contorta*) stands with broadleaved competition in the Southern USA, and Douglas fir with red alder (*Pseudotsuga menziesii* with *Alnus rubra*) in the Pacific Northwest. Results show that the expected present values (EPVs) of low-cost options that result in mixtures of conifers and broadleaves are superior in some situations to the EPVs of the intensive options.

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18. Hunt, J.A. 1995. Commercial thinning a coastal second-growth forest with a Timberjack cut-to-length system. Forest-Engineering-Research-Institute-of-Canada FERIC TN-235. 14.

**Keywords:** thinning  
commercial thinning  
economics  
tree/stand health

**Abstract:** In the summer of 1994, after 2 years operation, FERIC monitored a thinning operation of second-growth forest dominated by Douglas fir [*Pseudotsuga menziesii*] near Cowichan Lake, Vancouver Island, to determine productivities, costs and impacts to sites and residual stands. The thinning treatment was carried out with a Timberjack 1270 harvester and a Timberjack 910 forwarder.

[Non-OSU Link](#)

19. Kellogg, L.D., G.V. Milota and M. Miller, Jr. 1996. A comparison of skyline harvesting costs for alternative commercial thinning prescriptions. Journal-of-Forest-Engineering 7(3): 7-23.

**Keywords:** thinning  
commercial thinning  
economics

**Abstract:** Harvesting production and costs were examined for three alternative silvicultural prescriptions at two sites in the Coast Range of Oregon, USA. Thirty-three-year-old Douglas fir (*Pseudotsuga menziesii*) stands were commercially thinned to residual densities of 247, 148, and 74 trees per hectare (tph). Detailed time studies were conducted on manual felling and uphill skyline yarding with small yarders. Separate regression equations were developed to predict delay-free felling cycle time and delay-free yarding cycle time. The 74 tph treatment had the highest production rate and was the least costly to harvest. Total harvesting costs of the other two treatments averaged from 6.0% (148 tph) to 12.3% (247 tph) more than the 74 tph treatment.

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20. Kellogg, L.D., G.V. Milota and B. Stringham. 1998. Logging planning and layout costs for thinning: experience from the Willamette young stand project. Forest-Research-Laboratory Research Contribution 20, Oregon-State-University, Corvallis, OR.

**Keywords:** thinning  
commercial thinning  
economics

**Abstract:** Logging planning and layout costs were examined for commercial thinning of 40- to 50-yr-old stands of Douglas-fir (*Pseudotsuga menziesii*) on the Willamette National Forest in the Cascade

Mountains of Oregon. The study consisted of four replications of threesilvicultural treatments. Thinning involved three types of logging systems: mechanized cut-to-length (a combination of single-grip harvester and forwarder), tractor, and skyline. Data for the study came from two sources: activities completed by the Forest Service in preparing sales for bid, and the layout completed by the logging contractor after a contract was awarded. Planning and layout costs showed no consistent relationship to type of silvicultural treatment. Logging contractor layout costs showed a relationship to type of logging system: the mechanized system had the lowest layout cost, followed by the tractor systems, with the skyline systems having the highest costs.

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**21.** King, J.E., D.D. Marshall and J.F. Bell. 2002. Levels-of-growing-stock cooperative study in Douglas-fir: report no. 17 - the Skykomish study, 1961-93; the Clemons study, 1963-94. Pacific-Northwest-Research-Station, USDA-Forest-Service Research-Paper PNW-RP-548. vii + 120 p.

**Keywords:** thinning  
commercial thinning  
growth  
yield  
tree/stand health

**Abstract:** A study was conducted at the Skykomish Tree Farm, and at the Clemons Tree Farm, Washington, USA, to determine how the amount of growing stock in repeatedly thinned stands of Douglas Fir (*Pseudotsuga menziesii*) affects cumulative wood production, tree size and growth-growing stock ratios. Initial stands were thinned to the same level of growing stock so that all plots would have virtually the same growth potential except the unthinned controls. The Skykomish and Clemons stands were 24 and 19 years old, respectively, when the studies were started. Stand treatments were completed at ages 42 and 36, and measurements were continued to ages 56 and 50. After 32 years at Skykomish and 31 years at Clemons, the basal area per acre in the eight regimes ranged from 119-244 ft<sup>2</sup> at Skykomish and 101-195 at Clemons. The corresponding gross yields in cubic feet per acre were 8709-13 579 at Skykomish and 6329-9072 at Clemons. Volume in thinnings were 18-53% of the gross yield. Stand treatments included four regimes with different combinations of heavy and light thinning and four regimes with constant intensities of thinning. Variable regimes were found to have consistent advantage over constant regimes. Within a given level of growing stock, the constant regimes are recommended for applications where wood production is the primary objective. A substantial increase in the yield was produced in all regimes during the post thinning holding period. Based on standing volume after the last thinning, the holding period of 4 years produced approximately 30% more volume in all regimes. Extending the period to 9 years produced approximately 70% more volume, and at 14 years, the standing volume was more than double the volume remaining after the last thinning. This extra yield enhanced by the high quality of the stands makes the length of the holding period an important factor in the scheduling of final harvest.

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**22.** Latham, P. and J. Tappeiner. 2002. Response of old-growth conifers to reduction in stand density in western Oregon forests. *Tree-Physiology* 22(2/3): 137-146.

**Keywords:** thinning  
commercial thinning  
growth

**Abstract:** The positive growth response of healthy young trees to density reduction is well known. In contrast, large old trees are usually thought to be intrinsically limited in their ability to respond to increased growing space; therefore, density reduction is seldom used in stands of old-growth trees. We tested the null hypothesis that old-growth trees are incapable of responding with increased growth following density reduction. The diameter growth response of 271 Douglas-fir (*Pseudotsuga menziesii*), ponderosa pine (*Pinus ponderosa*) and sugar pine (*Pinus lambertiana*) trees in Oregon, USA, ranging in age from 158 to 650 years was examined 20 to 50 years after density reduction. Density reduction involved either light thinning with removal of less vigorous trees, or shelterwood treatments in which overstorey trees were not removed. Ratios of basal area growth after treatment to basal area growth before treatment, and several other measures of growth, all indicated that the old trees sometimes benefited and were not harmed by density reduction. Growth increased by 10% or more for 68% of the trees in treated stands, and nearly 30% of trees increased growth by over 50%. This growth response persisted for at least 20 years. During this 20-year period, only three trees in treated stands (1.5%) exhibited a rapid decrease in growth, whereas growth decreased in 64% of trees in untreated stands. The length of time before a growth response to density reduction occurred varied from 5 to 25 years, with the greatest growth response often occurring 20 to 25 years after treatment. These results have important implications both for the basic biology of aging in woody plants as well as for silvicultural practices in forests with old-growth trees.

[OSU Link](#)

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23. LeDoux, C.B., R.D. Fight and T.L. Ortman. 1986. Stump-to-truck cable logging cost equations for young-growth Douglas-fir. *Western-Journal-of-Applied-Forestry* 1(1): 19-22.

**Keywords:** thinning  
commercial thinning  
economics

**Abstract:** Data on log sizes were generated to simulate young (age 40-120 yr) Douglas fir site III and IV in the Pacific Northwest. The data were used to develop equations for estimating the delay-free costs of: (1) felling, limbing and cross-cutting; (2) yarding; (3) loading; (4) road changing; and (5) moving in and out and initial rigging up and down. An additional equation estimates the number of logs per 1000 ft<sup>3</sup> for logs of d.b.h. 6-24 inch. The equations were developed for 2 small and 1 medium sized yarders and are applicable on slopes of 10-50%. The equations can be used to provide detailed estimates for thinning, partial or shelterwood felling and clearfelling. A BASIC computer program is available from the authors.

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24. Maguire, D.A., J.A. Kershaw, Jr. and D.W. Hann. 1991. Predicting the effects of silvicultural regime on branch size and crown wood core in Douglas-fir. *Forest-Science* 37(5): 1409-1428.

**Keywords:** thinning  
precommercial thinning  
commercial thinning  
wood quality

**Abstract:** Three major determinants of wood quality (whorl frequency, branch size and crown wood core) in Douglas fir (*Pseudotsuga menziesii*) were estimated from the dynamics of crown structure in ORGANON, an individual-tree, distance-independent growth model. Data for the model were collected from Douglas fir plots in SW Oregon. Branch whorl locations were estimated directly from the height growth predictions assuming formation of one whorl per year. Mean maximum branch diameter was predicted as crown base receded past each whorl; branch diameter estimates were based on current depth of the whorl into crown, tree diameter, stand relative density, and site index. Diameter of crown wood core was established as diameter inside bark, also as crown base receded past each branch whorl. This approach facilitated description of harvested log distribution (40-ft butt logs) by various branch size, whorl frequency and crown wood core indices. Based on projections of a 9-yr-old Douglas fir stand to final harvest at 65 years, thinning precommercially to 121 trees/acre at 9 yr old resulted in a BD4 (mean of four largest branch diameters per log) of 2.5 inches, vs. 1.5 inches for the unthinned stand (484 trees/acre). When thinned to 121 trees/acre, approximately 55% of the volume/acre in 40-ft butt logs consisted of crown wood, as opposed to 30% at 484 trees/acre. Responses to subsequent thinnings were less pronounced, but included larger branches in the largest 80 trees/acre, and larger total crown wood percentages for a given initial stand density. Thinning from below resulted in larger average BD4 values and slightly greater crown wood percentages than proportional thinning. Individual-tree growth models that contain a crown recession component can easily be modified to predict crown wood core and indices of branch size.

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**25.** Marshall, D.D. and R.O. Curtis. 2002. Levels-of-growing-stock cooperative study in Douglas-fir: report no. 15 - Hoskins: 1963-1998. Pacific-Northwest-Research-Station,-USDA-Forest-Service Research-Paper PNW-RP-537. 80 p.

**Keywords:** thinning  
commercial thinning  
growth  
yield  
tree/stand health  
tree morphology

**Abstract:** The cooperative levels-of-growing-stock (LOGS) study in Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) was begun to study the relations between growing stock, growth, cumulative wood production, and tree size in repeatedly thinned stands. This report summarizes results from the Hoskins installation through age 55. Growing stock has been allowed to accumulate for 19 years since the last treatment thinning was applied in this high site class II natural stand. Volume and diameter growth were strongly related to growing stock. Basal area growth-growing stock relations were considerably weaker. Differences in tree size and volume distribution were considerable. Culmination of mean annual increment has not occurred for any of the treatments, although the control has culminated for total stem cubic volume and is near culmination for

merchantable cubic volume. Only small differences are seen in growth percentages between thinning treatments. Results demonstrate potential flexibility in managing Douglas-fir to reach a range of objectives.

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26. Miller, M. and B. Emmingham. 2001. Can selection thinning convert even-age Douglas-fir stands to uneven-age structures? *Western-Journal-of-Applied-Forestry* 16(1): 35-43.

**Keywords:** thinning  
commercial thinning  
growth  
yield  
tree/stand health  
regeneration

**Abstract:** Uneven-age management of Douglas-fir (*Pseudotsuga menziesii*) stands can be used to address aesthetic, wildlife habitat, biodiversity and sustainability concerns, but there has been little long-term experience with this type of management. To develop timely information on converting even-age stands to uneven-age forests, we used retrospective stand reconstruction methods to document harvest frequency, intensity and stand structural development at four sites in western Oregon, USA. We studied stands managed by selection thinning and identified strategies for creating and managing uneven-age forests. Selection thinning benefited mid- and understorey trees and stimulated natural regeneration. Although stand growth was less than expected from low thinning, growth per unit of growing stock was similar to that in unmanaged stands. Douglas-fir often dominated natural regeneration and had satisfactory vigour at stocking levels about half that considered full stocking for even-age management, but good growth of regeneration may require even lower overstorey stocking. Shade-tolerant grand fir (*Abies grandis*) and western hemlock (*Tsuga heterophylla*), however, were more abundant at higher stocking levels. Selection thinning of young Douglas-fir (*Pseudotsuga menziesii*) stands can sometimes be effective in promoting viable regeneration while providing regular income and biodiversity. Because this was a retrospective study only, further, long-term testing is necessary.

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27. O'Hara, K.L. 1988. Stand structure and growing space efficiency following thinning in an even-aged Douglas-fir stand. *Canadian-Journal-of-Forest-Research* 18(7): 859-866.

**Keywords:** thinning  
commercial thinning  
growth  
tree morphology  
carbon allocation

**Abstract:** The growth of individual trees from four thinning treatments in a 64-yr-old *Pseudotsuga menziesii* stand in western Washington was analysed to determine desirable residual

stand structures after thinning. Dominant and codominant trees had the highest individual tree stem vol. growth rates over the previous 5 yr and accounted for most stand vol. growth in thinned and unthinned stands. Two measures of growing space, crown projection area and sapwood b.a. (a surrogate for leaf area), were used to measure how efficiently individual trees used their growing space. Crown classes were useful in characterizing growing space efficiency (vol. growth per unit of growing space) only in the unthinned treatment. In thinned treatments, tall trees with medium-sized crowns were most efficient, while in the unthinned treatment tall trees with relatively large crowns were most efficient. A large crown in an unthinned stand was comparable in size to a medium-sized crown in a thinned stand. Results suggest growing space is not limiting individual tree growth in thinned stands and that thinning to a particular stand structure is more appropriate than thinning to a particular stand density.

[OSU Link](#)

[Non-OSU Link](#)

28. O'-Hara, K.L. 1989. Stand growth efficiency in a Douglas fir thinning trial. *Forestry-Oxford* 62(4): 409-418.

**Keywords:** thinning  
commercial thinning  
growth  
carbon allocation  
tree morphology

**Abstract:** Stand growth efficiency (ratio of periodic stand volume growth to sapwood basal area) was measured over 5 yr (1980-84) in a long term Douglas fir (*Pseudotsuga menziesii*) thinning trial (established in 1957 at 36-yr-old, with 5 thinnings over 23 yr) in coastal Washington, USA. Sapwood basal area - as a surrogate for leaf area - and volume growth were estimated in two fifth-hectare plots from each of three thinning treatments, and from a single fifth-hectare control plot. Stand growth increased with increasing sapwood basal area. No distinct pattern of stand growth efficiency with sapwood basal area was evident. Large differences in efficiency between plots of the same treatment were found and were attributed to differences in stand structure, or the arrangement of tree sizes.

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29. O'-Hara, K.L. 1990. Twenty-eight years of thinning at several intensities in a high-site Douglas-fir stand in western Washington. *Western-Journal-of-Applied-Forestry* 5(2): 37-40.

**Keywords:** thinning  
commercial thinning  
growth  
yield

**Abstract:** Results are presented of a 28-year thinning study of a dense (182-452 tree/acre) natural, second growth Douglas fir (*Pseudotsuga menziesii*) stand at Delezenne, which compared 3 thinning treatments with an unthinned control. Treatments were: an increasing basal area treatment; a constant



basal area treatment (of approximately 140 ft<sup>2</sup>/acre); a decreasing/increasing reserve basal area treatment; and control plots, which were 35 to 37-years-old with basal area 80-203 ft<sup>2</sup>/acre in 1957 when the tests were started. Gross, net, and total recoverable periodic cubic volume increments of the control treatment (10 396, 9108 and 16 092 ft<sup>3</sup>/acre, respectively) were not significantly different from the highest yielding treatment, which was the increasing reserve basal area thinning treatment (8896, 8594 and 16 636 ft<sup>3</sup>/acre, respectively). These results, and options for thinning schedules, are discussed; it is suggested that commercial thinnings of dense or fully stocked plantations of Douglas fir may produce similar results, that is, vigorous stands with rapid growth potential.

[OSU Link](#)

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**30.** Oliver, C.D. and M.D. Murray. 1984. Stand structure, thinning prescriptions, and density indexes in a Douglas-fir thinning study, Western Washington, U.S.A. Canadian-Journal-of-Forest-Research 13(1): 126-136.

**Keywords:** thinning  
commercial thinning  
growth  
stand conditions

**Abstract:** In a stand regenerated after logging in 1930, thinnings to set b.a. values were carried out in 1959, 1962, 1966, and 1970. On each plot both large and small trees were removed since av. b.a. per tree was kept constant before and after thinning. Volume growth varied greatly between plots of the same age, initial b.a., and site because of differences in stand structure. Large trees on a plot grew more per tree and per b.a. than small trees. Stand b.a., stand vol., number of stems, or number of dominant and codominant trees were not closely related to vol. growth/ha, although density indexes giving weight to larger trees showed the closest relationship. The lack of a close relationship between stand density indexes and growth probably means the indexes do not uniquely define structures; it does not necessarily mean that thinning will not increase volume growth/ha. Volume growth/ha after thinning to a given b.a. will be greater and probably more consistent if larger trees are left and enough time is allowed for the stand to recover following thinning.

[OSU Link](#)

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**31.** Omule, S.A.Y. 1988. Growth and yield 35 years after commercially thinning 50-year-old Douglas-fir. B.C. Ministry of Forests FRDA-Report 021. vi + 15 p.

**Keywords:** thinning  
commercial thinning  
growth  
yield  
tree/stand health

**Abstract:** Remeasurement data over a period of 35 years from fourteen 0.2023-ha permanent plots were analysed to determine the growth and yield effects of commercially thinning 50-year-old Douglas fir (*Pseudotsuga menziesii*) stands on a good site on Vancouver Island, British Columbia. Compared to unthinned stands, the commercially thinned stands had: virtually the same total volume gross annual increment, top height and top height increment; 12% more potentially usable total volume yield (including thinnings); 18% less total volume at final harvest age 86 yr; virtually the same crop tree (193 largest diameter trees per hectare) average diameter, but 24% larger entire stand quadratic mean diameter; and 11% less total volume production lost to mortality. These results show that commercial thinning slightly increased total stand yield (including thinnings) and produced larger stand diameter at rotation age 86 yr, but that it also reduced usable total volume at final harvest and had virtually no effect on size of the crop trees. Data from this study are useful for validating growth models, and for constructing and comparing managed stand yield tables for various commercial thinning regimes.

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**32.** Ralston, R., J. Buongiorno and J.S. Fried. 2004. Potential yield, return, and tree diversity of managed, uneven-aged Douglas-fir stands. *Silva-Fennica* 38(1): 55-70.

**Keywords:** thinning  
commercial thinning  
economics  
yield

**Abstract:** The effects of different management regimes on uneven-aged Douglas-fir stands in the Pacific Northwest of the United States were predicted with a simulation model. Management alternatives were defined by residual stand structure and cutting cycle. The residual stand structure was set by basal area-diameter-q-ratio (BDq) distributions, diameter-limit cuts (assuming concurrent stand improvement), or the current diameter distribution. Cutting cycles of 10 or 20 years were applied for 200 years. The current diameter distribution was defined as the average of the uneven-aged Douglas-fir stands sampled in the most recent Forest Inventory and Analysis conducted in Oregon and Washington. Simulation results were compared in terms of financial returns, timber productivity, species group diversity (hardwoods vs softwoods), size class diversity, and stand structure. Other things being equal, there was little difference between 10- and 20-year cutting cycles. The highest financial returns were obtained with either a 58.4 cm diameter-limit cut, or a BDq distribution with 8.4 m<sup>2</sup> of residual basal area, a 71.1 cm maximum diameter, and a q-ratio of 1.2. Using the current stand state as the residual distribution was the best way to obtain high tree size diversity, and high species group diversity. Several uneven-aged regimes gave net present values comparable to that obtained by converting the initial, uneven-aged stand to an even-aged, commercially thinned, plantation.

[OSU Link](#)

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**33.** Sachs, D. and P. Sollins. 1986. Potential effects of management practices on nitrogen nutrition and long-term productivity of western hemlock stands. *Forest-Ecology-and-Management* 17(1): 25-36.

**Keywords:** thinning

commercial thinning  
yield  
soil properties  
computer modeling

**Abstract:** The FORCYTE-10 computer model, developed by J.P. Kimmins and K. Scoullar for Douglas-fir forests in British Columbia, was modified to simulate growth and nutrient cycling of coastal western hemlock stands in Oregon. Initial calibration indicated that predicted yield was extremely sensitive to the rate of mineralization of soil organic matter (SOM), variation in SOM C/N ratio with site quality, the soil extractable NO<sub>3</sub>-/NH<sub>4</sub><sup>+</sup> ratio, and the decomposition rate and N mineralization pattern of large and medium-size roots and woody debris. The predictions suggested that yield and SOM remain stable under a management system consisting of six successive 90-yr rotations. More intensive utilization (e.g., shorter rotations, whole-tree harvesting and commercial thinning) causes depletion of soil and forest floor nitrogen and a small decline in site productivity in later rotations.

[OSU Link](#)

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**34.** Stone, M. 1993. An economic evaluation of commercial thinning Douglas-fir in the coastal region of British Columbia. BC Ministry of Forests FRDA-Working-Paper WP-6-002. x + 146 p.

**Keywords:** thinning  
commercial thinning  
economics  
growth  
yield

**Abstract:** The economic evaluation of commercial thinning of Douglas fir [*Pseudotsuga menziesii*] in the coastal region of British Columbia, includes an estimation of the economic effects of the thinning on the final harvest. This was done by simulating the growth and yield impacts of a commercial thinning, estimating the potential costs and revenues derived from the thinning and the final harvest, and determining the net present value of the full impacts of commercial thinning.

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**35.** Williamson, R.L. 1982a. Applicability of four regional volume tables for estimating growth response to thinning in Douglas-fir. Pacific-Northwest-Forest-and-Range-Experiment-Station, USDA-Forest-Service Research-Paper PNW-RP-295. 10 p.

**Keywords:** thinning  
commercial thinning  
growth

**Abstract:** A 110-yr-old stand in Washington was given light or heavy thinning or left unthinned in 1952 and 1971. Stem sections were taken from trees removed in 1971 and analysed to show volume growth for the 19 yr before and 19 yr after the 1952 thinning. Estimates of volume growth for the same stand

were also made from 4 volume tables and the results compared. The agreement between volume table estimates and the stem analysis results was within 10%, and was unaffected by thinning severity.

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**36.** Williamson, R.L. 1982b. Response to commercial thinning in a 110-yr-old Douglas-fir stand. Pacific-Northwest-Forest-and-Range-Experiment-Station, USDA-Forest-Service Research-Paper PNW-RP-296. i + 16 p.

**Keywords:** thinning  
commercial thinning  
growth  
tree/stand health

**Abstract:** [See FA 28, 584] A stand in Washington was thinned in 1952 to 75 or 50% of normal b.a. After 19 yr the plots were remeasured and thinned again and stem analyses made for felled trees. Overall growth was similar in thinned and control plots, although mortality was 3-5x higher on control plots. The growth response relative to control trees was significantly greater for suppressed trees in the heavily thinned plots.

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**37.** Williamson, R.L. and R.O. Curtis. 1984. Levels-of-growing-stock cooperative study in Douglas-fir. Report No. 7 - Preliminary results, Stampede Creek, and some comparisons with Iron Creek and Hoskins. Pacific-Northwest-Forest-and-Range-Experiment-Station,-USDA-Forest-Service Research-Paper PNW-RP-323. v + 42 p.

**Keywords:** thinning  
commercial thinning  
growth

**Abstract:** [See FA 43, 3890, 6692] A further report in a series on 9 study areas in Canada and the USA. Results are summarized for a 43-yr-old stand in SW Oregon, which was 'calibration thinned' in 1968 (aged 33 yr) and thinned again to retain 10-70% of the b.a. increment of the untreated control plot at age 38 yr. Recommendations for desirable density are given.

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