Pruning

1. Cahill, J.M., T.A. Snellgrove and T.D. Fahey. 1988. Lumber and veneer recovery from pruned Douglas-fir. Forest-Products-Journal 38(9): 27-32.

Keywords: pruning
yield
wood quality

Abstract: Logs were selected from a 75-yr-old stand of Douglas fir (Pseudotsuga menziesii) in Washington, that had been pruned 35 yr previously, to include 146 sawlogs (97 pruned, 49 unpruned) and 151 veneer logs (100 pruned, 51 unpruned) and assessed for vol. and grade yields for sawn and peeled products. Results showed that pruned logs recovered the same vol. of products as unpruned logs but recovered more high-grade lumber or veneer. Recovery of high-grade lumber or veneer increased as the diam. of the knotty, unprunedcore decreased. Issues are listed that need consideration in order to decide whether pruning would be profitable for specific stands of young growth.

OSU Link
Non-OSU Link

2. Chen, J.M. and T.A. Black. 1992. Foliage area and architecture of plant canopies from sunfleck size distributions. Agricultural-and-Forest-Meteorology 60(3/4): 249-266.

Keywords: thinning
pruning
tree morphology

Abstract: A Poisson model is developed to describe sunfleck or gap size distributions beneath clumped plant canopies. This model is based on the assumption that foliage clumps are randomly distributed in space and foliage elements are randomly distributed within each clump. Using this model, the foliage clumping index, leaf area index (L), clump area index, element area index in each clump, and element and clump widths were successfully derived for two artificial canopies and a thinned and pruned Douglas-fir (Pseudotsuga menziesii) forest stand. It is shown that existing theories for deriving L from measurements of canopy gap fraction have limitations, and use of canopy architectural information derived from canopy gap size distribution can substantially improve the technique for indirectly measuring L of plant canopies.

OSU Link
Non-OSU Link

3. Collier, R.L. and E.C. Turnblom. 2001. Epicormic branching on pruned coastal Douglas-fir. Western-Journal-of-Applied-Forestry 16(2): 80-86.

Keywords: pruning
thinning
wood quality
tree morphology

Abstract: The Stand Management Cooperative (SMC 1998) at the University of Washington, USA, conducted live crown reduction experiments in the Pacific Northwest regions of the USA, to better understand the dynamics of the response of coastal Douglas fir (Pseudotsuga menziesii) to pruning. A detailed report on how frequently epicormic branches occur, where they occur on the bole, whether or not their occurrence is related to stand density or the amount of crown removed, and how epicormic sprouting may affect log grade, is presented. The experiments include fifty-six 0.08 ha pruning plot in 18 installations in British Columbia, Oregon and Washington. As part of the monitoring process, a subset of 38 plots in 12 installations was examined for the occurrence and size of epicormic branches 4 years after the initial pruning treatments. Results showed that epicormic branching was most severe on the south and west sides of trees. When epicormic branching was severe, sprouts occurred both at nodes (or whorls) and along internodes. Less severe or moderate sprouting tended to originate mainly in nodes. The risk of epicormic branching is minimal as long as the pruning treatment does not reduce the live crown by more than 40% and the stand has 500 or more stems/ha. The highest risk of epicormic branching was found to be when the live crown is reduced by more than 40%, and the stand carries less than 500 stems/ha.

OSU Link
Non-OSU Link

4. Fight, R.D., N.A. Bolon and J.M. Cahill. 1993. Financial analysis of pruning Douglas-fir and ponderosa pine in the Pacific Northwest. Western-Journal-of-Applied-Forestry 8(2): 58-61.

Keywords: pruning
economics
computer modeling

Abstract: Recent lumber recovery studies of pruned and unpruned Douglas fir (Pseudotsuga menziesii var. menziesii) and ponderosa pine (Pinus ponderosa var. ponderosa) were incorporated into computer software using lumber grade prices, growth and yield data, the cost of pruning, and interest rates to determine the expected financial return from pruning. Financial analyses showed that the cost of pruning at which the investment would yield an expected 4% real rate of return was positive on sites where individual tree growth is fairly high, pruning is done as early as biologically possible given limitations on crown removal, and the harvest is 30 to 70 yr after pruning. The better situations in Douglas fir showed a break-even cost of up to $21/tree and an internal rate of return exceeding 9%. The better situations in ponderosa pine showed a break-even cost of up to $11/tree and an internal rate of return of 7%.

OSU Link
Non-OSU Link

5. Fight, R.D., J.M. Cahill and T.D. Fahey. 1992. DFPRUNE users guide. Pacific-Northwest-Research-Station,-USDA-Forest-Service General-Technical-Report PNW-GTR-300. 12 p.

Keywords: pruning
economics
computer modeling

Abstract: The DFPRUNE spreadsheet program is designed to estimate the expected financial return from pruning coast Douglas fir (Pseudotsuga menziesii var. menziesii). It is a significant revision of the PRUNE-SIM program. The PRUNE-SIM program was based on the average product recovery for unpruned logs from a single stand that received frequent light thinnings. The DFPRUNE program incorporates new recovery information for unpruned young-growth Douglas fir and can be used to assess the economic potential of pruning for a wide range of management regimes. Product prices and descriptions of trees at time of pruning and at time of harvest must be supplied by the user. The DFPRUNE program was developed for the Lotus 1-2-3 spreadsheet and should work on versions 2.01 or later.

OSU Link
Non-OSU Link

6. Fight, R.D., J.M. Cahill, T.D. Fahey and T.A. Snellgrove. 1987a. Financial analysis of pruning coast Douglas-fir. Pacific-Northwest-Research-Station,-USDA-Forest-Service Research-Paper PNW-RP-390. ii + 17 p.

Keywords: pruning
fertilization
economics
wood quality
yield
computer modeling

Abstract: Unpruned stands of Douglas fir (Pseudotsuga menziesii) will yield little clear material under current management regimes in western Oregon and western Washington. Data from a recent study of grade recovery from pruned logs were analysed and a spreadsheet program was developed and used to simulate the increase in grade recovery and financial returns from pruning. Results are presented for a range of site indices, ages at time of pruning and time of harvest, product prices and interest rates, and for stands with and without nitrogen fertilizer treatment. Results showed that a 5-yr difference in the time of pruning can make a substantial difference in the financial return. An earlier age at pruning always gave a higher return. At 4 and 8% interest rates, the return was generally greatest when the harvest was 40-50 yr or 30-40 yr, respectively, after pruning. Fertilizer treatment substantially increased the return from pruning, especially on poor sites.

OSU Link
Non-OSU Link

7. Fight, R.D., J.M. Cahill, T.D. Fahey and T.A. Snellgrove. 1988. A new look at pruning coast Douglas-fir. Western-Journal-of-Applied-Forestry 3(2): 46-48.

Keywords: pruning
thinning
fertilization
economics

Abstract: A short account of an evaluation of the financial returns of pruning coast Douglas fir (Pseudotsuga menziesii), using new product-recovery information and computer software, and

assuming that: the analysis is for lumber, interest rates are 4 and 8%, stands are fertilized 2 or 3 times and thinned periodically, and that trees were pruned at age 20 yr. Results showed that higher returns from pruning could be achieved by concentrating pruning in younger stands that have a higher site index and that will be fertilized.

OSU Link
Non-OSU Link

8. Fight, R.D., J.M. Cahill, T.A. Snellgrove and T.D. Fahey. 1987b. PRUNE-SIM users guide. Pacific-Northwest-Research-Station,-USDA-Forest-Service General-Technical-Report PNW-GTR-209. 21 p.

Keywords: pruning
economics
computer modeling

Abstract: PRUNE-SIM is a spreadsheet template (program) that allows users to simulate a financial analysis of pruning coast Douglas fir (Pseudotsuga menziesii var. menziesii) in the USA. The program estimates the increase in product value resulting from pruning the butt 17-foot log. Product recovery information is based on actual mill experience with pruned and unpruned logs for both sawn and peeled products. Users must supply tree descriptions from sources of growth and yield information and product prices. The program calculates the difference in value for trees and stands with and without pruning. The present value of this difference represents the maximum amount that could be spent on pruning without reducing the rate of return on the investment below the specified rate. The LOTUS 1-2-3 spreadsheet program was used to develop PRUNE-SIM.

OSU Link
Non-OSU Link

9. Fight, R.D., J.T. Chmelik and E.A. Coulter. 2001. Analysts guide: TreeVal for Windows, Version 2.0. Pacific-Northwest-Research-Station,-USDA-Forest-Service General-Technical-Report PNW-GTR-514. 21 p.

Keywords: pruning
economics
wood quality
yield

Abstract: TreeVal for Windows provides financial information and analysis to support silvicultural decisions in coast Douglas-fir (Pseudotsuga menziesii). It integrates the effect of growth and yield, management costs, harvesting costs, product and mill type, manufacturing costs, product prices, and product grade premiums. Output files from the ORGANON growth and yield simulator can be read directly into TreeVal. All management actions, including pruning, are supported. Results, including product recovery information, net value, and financial analysis of silvicultural regimes, are available in both tabular and graphical forms to facilitate comparison of alternative regimes and sensitivity analysis with prices, costs, and other assumptions.

OSU Link
Non-OSU Link

10. Fight, R.D., S. Johnston, D.G. Briggs, T.D. Fahey, N.A. Bolon and J.M. Cahill. 1995. How much timber quality can we afford in coast Douglas-fir stands? Western-Journal-of-Applied-Forestry 10(1): 12-16.

Keywords: pruning
planting operations
wood quality
economics

Abstract: Once site and genetic stock are selected, management of stocking, rotation age, and pruning are the principal means available to foresters to affect wood quality and value in stands of coast Douglas fir (Pseudotsuga menziesii var. menziesii) in the Pacific Northwest. Financial evaluation was used to test whether or not improvements in wood quality and value by these means justify the cost of doing so. This analysis showed in general that improving quality through high levels of stocking or extending rotations were costly ways to improve wood quality while pruning was cost effective.

OSU Link
Non-OSU Link

11. Gartner, B.L., E.M. North, G.R. Johnson and R. Singleton. 2002. Effects of live crown on vertical patterns of wood density and growth in Douglas-fir. Canadian-Journal-of-Forest-Research 32(3): 439-447.

Keywords: thinning
pruning
wood quality

Abstract: It would be valuable economically to know what are the biological triggers for formation of mature wood (currently of high value) and (or) what maintains production of juvenile wood (currently of low value), to develop silvicultural regimes that control the relative production of the two types of wood. Foresters commonly assume the bole of softwoods produces juvenile wood within the crown and mature wood below. We tested that assumption by comparing growth ring areas and widths and wood density components of the outer three growth rings in disks sampled from different vertical positions of 34-year-old Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco) trees. The 18 trees were sampled from one site and had a wide range of heights to live crown. Most of the variance (63-93%) in wood characteristics (growth ring area: total, earlywood, latewood; growth ring width: total, earlywood, latewood; latewood proportion: by area, width; and ring density: total, earlywood, latewood) was due to within-tree differences (related to age of the disk). Stepwise regression analysis gave us equations to estimate wood characteristics, after which we analysed the residuals with a linear model that included whether a disk was within or below the crown (defined as the lowest node on the stem with less than three live branches). After adjusting for tree and disk position, only 2-10% of the residual variation was associated with whether the disk was in or out of the live crown. There were no statistically significant differences at p=0.05 between a given disk (by node number) in versus out of the crown for any of the factors studied. Moreover, the wood density characteristics were not statistically significant at p=0.30. This research suggests that there was no effect of the crown position on the transition from juvenile to

mature wood as judged by wood density. Therefore, we found no evidence to support the concept that tree spacing and live-branch pruning have a significant effect on the cambial age of transition from juvenile to mature wood in Douglas-fir trees of this age.

OSU Link
Non-OSU Link

12. Hermann, R.K. and D.P. Lavender. 1999. Douglas-fir planted forests. New-Forests 17(1/3): 53-70.

Keywords: genetic tree improvement
nursery operations
planting operations
site preparation
release treatments
fertilization
thinning
pruning
tree/stand protection
growth
yield

Abstract: A combination of superior wood quality and high productivity has made Douglas fir (Pseudotsuga menziesii) one of the premier timber trees in the world. As such, it is grown as a plantation species in several countries in Europe and South America, and in New Zealand and Australia, as well as throughout its extensive natural range in western North America. Decades of experience with the silviculture of young stands have demonstrated that practices such as planting, the use of genetically improved seedlings, precommercial and commercial thinning, and fertilizing may dramatically increase the yield of industrial products over that of natural forests. Further, such silviculture is compatible with the production of desired amenities. Vigorous implementation of such practices wherever Douglas fir is cultivated will increase the world's timber resources, and be an effective strategy for reducing the pressure, occasioned by the world's rapidly increasing population, to harvest the fragile tropical and boreal forests.

OSU Link
Non-OSU Link

13. Kimball, B.A., D.L. Nolte, D.L. Griffin, S.M. Dutton and S. Ferguson. 1998a. Impacts of live canopy pruning on the chemical constituents of Douglas-fir vascular tissues: implications for black bear tree selection. Forest-Ecology-and-Management 109(1/3): 51-56.

Keywords: pruning
tree/stand protection
growth
tree physiology
tree/stand health

Abstract: The impact of live canopy pruning (removal of all live and dead whorls between the ground and 5 m height, resulting in removal of ~40% of the live canopy) on the carbohydrate and terpene content of vascular tissue was investigated in the lower bole of Douglas fir (Pseudotsuga menziesii) on 4 sites in NW Oregon. Cambial zone vascular tissue samples were collected from pruned and unpruned trees in the lower bole and within the live canopy. Current year's radial growth was estimated from the mass of vascular tissue removed from the 800 cmsuperscript 2 area sampled from each tree. Chemical analyses were conducted to determine the concentration of carbohydrates and terpenes in the samples. Results indicated that 2 yr following treatment, pruning resulted in reduced growth and decreased carbohydrate content of the vascular tissue. Pruning had no effect on the terpene concentration of the vascular tissue. The impact of pruning on the foraging selection of black bears (Ursus americanus) was evaluated by surveying bear damaged trees in a 50 acre stand of pruned and unpruned timber. Odds ratios indicate that black bears were 4 times more likely to forage unpruned than pruned Douglas fir. Tree selection may be explained in part by the higher availability of carbohydrates in the unpruned tree with respect to the pruned tree.

OSU Link
Non-OSU Link

14. Kramer, H. and J.H.G. Smith. 1985. Establishment of Douglas fir stands in British Columbia. Forstarchiv 56(1): 9-13.

Keywords: planting operations
thinning
pruning
growth
yield
economics
wood quality

Abstract: Square spacing trials were established NW of Haney (180 m alt.) at 0.91, 1.83, 2.74, 3.66 and 4.57 m. Growth to age 25 yr, and simulation estimates up to 100 yr are reported. Results indicated that extra costs (incurred by thinning) of stands closer than 4 m spacing are difficult to justify in economic terms, because the market for Douglas fir timber grown in British Columbia is such that only production of large timber is economically viable. The quality of timber from trees grown at wide spacing without thinning is acceptable in relation to Canadian requirements, and could be improved if wide spacing were combined with pruning. It is recommended that close spacings be used only if availability of land is limited or demand for biomass is very strong.

OSU Link
Non-OSU Link

15. O'-Hara, K.L. 1991. A biological justification for pruning in coastal Douglas-fir stands. Western-Journal-of-Applied-Forestry 6(3): 59-63.

Keywords: pruning
growth
wood quality

Abstract: A summary, based on a review of the literature, is presented of pruning studies undertaken in Douglas fir (Pseudotsuga menziesii) plantations in the Pacific Northwest region; topics covered include tree growth responses, stem form, role of lower branches, stand dynamics and wood quality.

OSU Link
Non-OSU Link

16. Omule, S.A.Y., D.E. Paul and L.M. Darling. 1994. Cost of pruning Douglas-fir in coastal British Columbia. Forestry-Chronicle 70(1): 80-83.

Keywords: pruning
economics

Abstract: Artificial pruning can increase the quantity of high-value clear lumber harvested from Douglas fir (Pseudotsuga menziesii), but the pruning cost per tree is relatively high. To prune a young Douglas fir to 6 metres in one lift and two lifts took, respectively, 9.5 and 10.1 minutes in 14- and 18-year old stands with average spacing between trees of about 3 metres on flat or 0-30% south-facing slopes in coastal British Columbia. The associated costs were $2.09 and $2.22. This included minor travel time between trees, but excluded the cost oftravelling to the site, selecting and marking trees to be pruned, and purchasing and maintaining the pruning equipment. Differences in pruning time between one-lift pruning and two-lift pruning, in one or two passes, were small. A D-handled saw was preferred to the more strenuous snap-cut pruner with ratchet-style pinions, based on observations on a pruning time-study of 5 operators.

OSU Link
Non-OSU Link

17. Petruncio, M., D. Briggs and R.J. Barbour. 1997. Predicting pruned branch stub occlusion in young, coastal Douglas-fir. Canadian-Journal-of-Forest-Research 27(7): 1074-1082.

Keywords: pruning
tree/stand protection
tree/stand health
wood quality

Abstract: This study examined occlusion of 335 pruned branches from 38 coastal Douglas fir (Pseudotsuga menziesii) trees sampled from 13 stands (5 in British Columbia, 8 in Oregon) that were pruned between age 9 and 22 years. Regression models were developed for predicting number of years to occlude, the width of the occlusion region, and radius-over-occlusion which is the distance from the stem pith to the onset of clear wood production. Study results indicate that years to occlude is a function of stem size, stub length, stem growth rate, live or dead branch condition, and whether pruning produced smooth or nonsmooth cuts. Distance to occlude is a function of stem size, stub diameter, stem growth rate, live or dead branch condition, and whether pruning produced smooth or nonsmooth cuts. Radius-over-occlusion is a function of stem size, stub length, stub diameter, stem growth rate, and whether pruning produced smooth or nonsmooth cuts.

OSU Link
Non-OSU Link

18. Potts, S.J., B.R. Hartsough, S.E. Reutebuch and J.L. Fridley. 1997. Manual polesaw pruning of Douglas-fir. Applied-Engineering-in-Agriculture 13(3): 399-405.

Keywords: pruning
economics

Abstract: A time-and-motion study was conducted in British Columbia of second-lift (from 2.8 to 5.6 m) pole saw pruning in a 12-year-old stand of Douglas fir (Pseudotsuga menziesii), to help determine costs. Pruning quality was also assessed, using samples from random plots. Productivity relationships were derived via regression analysis. Production rates using pole saws averaged 8.2 trees per productive hour and varied according to tree and stand characteristics. Cost per tree averaged about $2.80. Both the production rates and quality were lower than for pruning with shears, indicating that pole saw pruning is less desirable in all aspects except one: the work can be done from the ground instead of on a ladder.

OSU Link
Non-OSU Link

19. Reeb, D. 1985. Influence of spacing and artificial pruning on the production of clearwood of Douglas-fir. Forestry-Abstracts 46(10): 640.

Keywords: planting operations
pruning
wood quality

OSU Link
Non-OSU Link

20. Reukema, D.L. and J.H.G. Smith. 1987. Development over 25 years of Douglas-fir, western hemlock, and western redcedar planted at various spacings on a very good site in British Columbia. Pacific-Northwest-Research-Station,-USDA-Forest-Service Research-Paper PNW-RP-381. ii + 46 p.

Keywords: planting operations
pruning
growth
yield
tree morphology

Abstract: Five spacing trials were established during 1957-67 at the University of British Columbia Research Forest, covering a range of spacings from 1 to 5 m and of experimental designs (49-tree-plot, 0.2-ha plot, rectangularity, Nelder and variable block trials). Results showed that initial spacing is among the most important factors influencing stem and crown development, and stand growth and yield for Douglas fir (Pseudotsuga menziesii), western hemlock (Tsuga heterophylla) and western redcedar (Thuja plicata). Top heights were initially taller at closer spacings, but are now similar

at all spacings. Av. ht. is now shorter at close spacing. Decreases in heights to dead and live crowns and increases in diam. of lower stem, taper and crown size occurred as spacing increased. B.a. and stand vol. increased as spacing decreased until onset of density-related mortality. It is concluded that initial wide spacings with rectangularities up to 2:1 (e.g. 6x3 m) will result in efficient production of large trees of high value and satisfactory quality. Pruning of widely spaced trees to enhance lower stem quality is strongly recommended.

OSU Link
Non-OSU Link

21. Rosso, P. and E. Hansen. 1998. Tree vigour and the susceptibility of Douglas fir to Armillaria root disease. European-Journal-of-Forest-Pathology 28(1): 43-52.

Keywords: fertilization
thinning
pruning
tree/stand protection
growth
tree/stand health
carbon allocation

Abstract: The effects of thinning, fertilization and pruning on the vigour of Douglas fir (Pseudotsuga menziesii) and its susceptibility to Armillaria root disease were investigated in Oregon, USA. Tree vigour was defined as the relative capacity for tree growth, expressed as the above-ground biomass increment per unit of photosynthetic tissue, or growth efficiency (GE). It has been hypothesized that trees with higher GE can better resist pathogen attack, and that GE can be used as a predictor of tree susceptibility to disease. In a previous study, four P. menziesii plantations were thinned, fertilized and pruned in all combinations, and the effects of these treatments on tree vigour were measured after 10 years. Root disease was not a factor in the initial study design, and mortality was ignored until 8 years after the treatments were applied. The results of an earlier study were utilized and the correlation between Armillaria root disease incidence and the effects of earlier stand treatments on tree growth was investigated. A. ostoyae [A. obscura] was the primary cause of mortality in the study area. The disease incidence of infected subplots ranged from 2 to 20%. A. obscura incidence was the highest at medium tree density (6.1%), slightly lower on the low density (5.6%) and lowest on the unthinned plots (3.8%). There were no significant correlations between disease incidence and previous tree growth. The vigour of trees that became symptomatic or died by 1993 was not significantly different from the vigour of trees that remained asymptomatic in 1983-85. On these sites, in areas of infection, A. obscura was causing mortality of the largest, fastest growing trees, as well as less vigorous trees. It is concluded that Armillaria continues to cause mortality, regardless of the growth efficiency or growth rate of the host.

OSU Link
Non-OSU Link

22. Tesch, S.D., G.M. Filip, S.A. Fitzgerald and D.D. Marshall. 1994. Silvicultural treatments for enhancing tree value, vigor, and growth in 70- to 120-year-old stands dominated by noble fir on the Warm Springs Indian Reservation: a synthesis of the literature. ForestResearch Laboratory, College of Forestry, Oregon State University. iii + 21 p.

Keywords: fertilization
thinning
pruning
tree/stand protection
growth
yield
tree/stand health

Abstract: The Warm Springs Indian Reservation, Oregon, apparently contains some 30 000 acres of naturally regenerated, largely unmanaged stands of 70- to 120-year-old mixed conifer forest dominated by noble fir (Abies procera), with Douglas-fir [Pseudotsugamenziesii], and some Pacific silver fir [Abies amabilis] and western hemlock [Tsuga heterophylla]. The synthesis focuses on growth and yield, thinning, pruning, fertilizer treatment, disease, minimizing stand damage during thinning, and insect pests.

Non-OSU Link

23. Turnblom, E.C. and R.L. Collier. 2003. Growth of residual branches on pruned coastal Douglas-fir. Western-Journal-of-Applied-Forestry 18(3): 185-188.

Keywords: pruning
wood quality

Abstract: Anecdotal evidence gathered from pruning crew observations indicates that there may be enhanced branch growth at the new crown base in young pruned coastal Douglas-fir (Pseudotsuga menziesii var. menziesii) trees compared to unpruned trees. This has the potential to reduce the quality and value of the stem above the pruned portion of the bole. An analysis of the size of branches in the remaining crown on pruned trees and matched unpruned trees of the same size at the time of pruning indicates that residual branches do not increase in diameter or length in response to light and moderate pruning. However, with a severe pruning there was a modest increase in branch length. Residual branch size in response to pruning 4 years after treatment appears to offer no real risk in degrading quality of theunpruned portion of the stem as a cost for increasing the quality of the pruned stem.

OSU Link
Non-OSU Link

24. Velazquez-Martinez, A., D.A. Perry and T.E. Bell. 1992. Response of aboveground biomass increment, growth efficiency, and foliar nutrients to thinning, fertilization, and pruning in young Douglas-fir plantations in the central Oregon Cascades. Canadian-Journal-of-Forest-Research 22(9): 1278-1289.

Keywords: fertilization
thinning
pruning
growth
carbon allocation
tree physiology

tree morphology

Abstract: The effect of thinning and silvicultural practices (multinutrient fertilization and/or pruning) on total aboveground biomass increment and growth efficiency was studied over three consecutive 2-year periods (1981-1987) in young Douglas fir (Pseudotsuga menziesii) plantations in the central Oregon Cascades. Plantations were 21-27 yr old in 1987. Plots were heavily thinned (leaving 300 trees/ha), moderately thinned (leaving 604 trees/ha) or left unthinned (leaving 3459 trees/ha) in 1981. Fertilizer (N, P, K, Ca, S and Fe) was applied with slow-release tabs. Net above-ground biomass annual increment over the 6-year period averaged 14.5, 7.8, and 5.5 t/ha for the high-, medium-, and low-density plots, respectively. Growth efficiency, after dropping sharply between leaf area indexes (LAI) of 1 and 6msuperscript 2/msuperscript 2, remained relatively constant up to the highest measured LAI of 17. Consequently, above-ground biomass increment continued to increase at LAIs well above that at which the Beer-Lambert law predicts maximum light should be absorbed. Foliage analyses indicated that thinning improved N, K and Mg nutrition and increased the translocation of K from 1-yr-old foliage to support new growth. However, fertilizer application increased foliar N and P contents only when coupled with pruning, suggesting that treesfavour total leaf area over individual needle nutrition. Indications of K and Mg limitations in this study are supported by other recent studies of Douglas fir.