Wood Quality

1. 1997. PNWTIRC Annual Report 1996-97, Pacific Northwest Tree Improvement Research Cooperative. Oregon State University, Oregon, USA. ii + 29 p.

Keywords: genetic tree improvement
tree/stand protection
tree phenology
growth
wood quality
tree physiology

Abstract: The report describes highlights for 1996-97, current research (3 projects), student project updates (3 projects), planned Douglas fir [Pseudotsuga menziesii] seed orchards for the new millennium and other planned activities of the PNWTIRC, a research cooperative operating in the Pacific Northwest area of North America (USA and Canada). Details are included of publications and finances. Details of the 3 current research projects and the 3 student projects, which all concern Douglas fir, are presented as short papers including brief results: (1) Influence of second flushing on cold hardiness; (2) Seedling drought physiology study; and (3) Quantitative trait loci influencing cold hardiness; (4) Seedling cold hardiness; (5) Growth response of saplings to drought; and (6) Measurement study follow-up: age-age correlations in forking defects.

OSU Link
Non-OSU Link

2. Abdel-Gadir, A.Y. and R.L. Krahmer. 1993. Genetic variation in the age of demarcation between juvenile and mature wood in Douglas-fir. Wood-and-Fiber-Science 25(4): 384-394.

Keywords: genetic tree improvement
wood quality

Abstract: Variation in the age of demarcation between juvenile and mature wood based on wood density was studied in 180 Douglas fir (Pseudotsuga menziesii) trees. Ring density profiles were generated from X-ray densitometry of increment cores from each of 3 randomly selected trees from each of 30 wind-pollinated families (parent trees) grown in 2 replication blocks in Washington. The families represented 10 provenances (3 families per provenance) from Washington and Oregon. Two boundary points were determined: the age at which a significant change occurred in the slope of the density-age relationship (using piecewise regression techniques), and the age at which species average density was reached. The period of juvenile wood production ranged from 11 to 37 years among the trees sampled. Most of the variation was among trees-within-plots; however, significant differences among families-within-provenances indicated that the period of juvenile wood production for this population of Douglas fir was under appreciable genetic control.

OSU Link
Non-OSU Link

3. Abdel-Gadir, A.Y., R.L. Krahmer and M.D. McKimmy. 1993. Relationships between intra-ring variables in mature Douglas-fir trees from provenance plantations. Wood-and-Fiber-Science 25(2): 182-191.

Keywords: genetic tree improvement
wood quality
genetic relationships

Abstract: Relationships among a variety of densitometric characteristics of juvenile and mature wood from 360 trees growing in two plantations of Douglas fir (Pseudotsuga menziesii) in Oregon and Washington were examined. Variables included earlywood density (EWD) and width (EWW); latewood density (LWD), width (LWW), and proportion (LWP); average ring density (RD); and total ring width (RW). The RD components (EWD and LWD) had strong phenotypic and genetic correlations with their respective RW components (EWW and LWW). However, no phenotypic correlation existed between average RD and total RW, and genotypic correlation was weak. The relation between wood density and radial growth varied by plantation and genotype. It was shown that the potential exists for improving wood density in juvenile and mature wood by selection, with only a minor effect on radial growth. Selection during the juvenile period to improve mature wood quality would be feasible for RD, EWD, LWW, and LWP. Further, selection to improve juvenile RW would not result in reduced wood density during maturity.

OSU Link
Non-OSU Link

4. Arnott, J.T. and F.T. Pendl. 1994. Field performance of several tree species and stock types planted in montane forests of coastal British Columbia. Canadian-Forest-Service, Pacific and Yukon Region Information Report BC-X-347. viii + 45 p.

Keywords: nursery operations
planting operations
growth
tree/stand health
wood quality

Abstract: Planting trials were established at sites within the Mountain Hemlock and montane Coastal Western Hemlock biogeoclimatic zones. Six test areas were chosen within each zone. Amabilis fir (Abies amabilis), noble fir (A. procera), yellow cedar (Chamaecyparisnootkatensis) and mountain hemlock (Tsuga mertensiana) were the species selected for planting in the Mountain Hemlock zone. In addition to Abies amabilis and A. procera, western white pine (Pinus monticola), western redcedar (Thuja plicata), Douglas fir (Pseudotsugamenziesii) and western hemlock (Tsuga heterophylla) were planted in the Coastal Western Hemlock zone. Plug (PSB 211), plug transplant and bareroot stock types were used for the eight species across both zones. Seedlings were planted during the autumn (September/October) and spring (May) in each of two successive years: 1978-79 and 1979-80. Survival, growth and tree form 13 years after planting were used as indicators of the reliability (a combination of tree survival and form) and productivity of the planting treatment combinations. Noble fir and amabilis fir were the most reliable species in the Mountain Hemlock zone; i.e. these species have average survival rates higher than 80% and few form defects. Yellow cedar crowns were badly broken by snow, which reduced the reliability of this species in the early years of plantation establishment. The growth, survival and form of mountain hemlock ranked between that of the true firs

and yellow cedar. Noble fir was by far the most productive species in the Mountain Hemlock zone. Within the Coastal Western Hemlock zone no single species demonstrated a superior combination of productivity or reliability. Douglas fir, western hemlock and western redcedar were good species in the lower elevations of the zone, whereas noble fir and amabilis fir were better species at the upperelevational limits of the zone. Western white pines should be avoided until rust-resistant seed sources are available. Little variation was found among the three planting stock options and even less between the two planting seasons. Plug transplant stock was more reliable thanbareroot or plug stock; productivity ranked from greatest to least in the following order within both zones: plug transplant, bareroot and plug stock. This ranking among stock types may well change as different stock types are developed. However, the relative size and design differences among stock types, no matter when they become available, will always have an effect on the ultimate reliability and productivity of planted trees. Autumn planting gave significantly lower survival in the Coastal Western Hemlock zone only.

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5. Aubry, C.A., W.T. Adams and T.D. Fahey. 1998. Determination of relative economic weights for multitrait selection in coastal Douglas-fir. Canadian-Journal-of-Forest-Research 28(8): 1164-1170.

Keywords: genetic tree improvement
yield
wood quality
economics

Abstract: Relationships between tree traits and tree value for lumber production were investigated. For the purposes of estimating relative economic weights for use in multitrait selection in coastal Douglas fir (Pseudotsuga menziesii var. menziesii), tree height, diameter at breast height, and branch diameter were measured on 164 trees (ages 36-66 yr) sampled from 11 intensively managed stands with a wide range of site attributes, growing conditions, ages and stocking histories in western Washington and Oregon. Increment cores from asubsample (92) of these trees were assayed by X-ray densitometry to determine wood density. Bole volume was derived by summing the log volumes of all logs from each tree. Value of lumber recovered from each tree was determined in a separate mill study using both visual and machine stress rated (MSR) grading rules. Multiple linear regression was used to relate tree value to the growth and wood quality traits. Stem volume and branch diameter significantly influenced tree value under visual grading, with relative economic weights of 0.06dmsuperscript 3 and -5.22 cm, respectively. Wood density significantly influenced tree value under MSR grading (relative economic weights: 0.06 dmsuperscript 3, -6.69 cm, and 0.06 kg/msuperscript 3, respectively), where lumber strength is measured more accurately. These regression coefficients can be used directly as economic weights in selection indices in the development of advanced breeding programmes for Douglas fir.

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Non-OSU Link

6. Barbour, R.J., S. Johnston, J.P. Hayes and G.F. Tucker. 1997. Simulated stand characteristics and wood product yields from Douglas-fir plantations managed for ecosystem objectives. Forest-Ecology-and-Management 91(2/3): 205-219.

Keywords: thinning
yield
wood quality

Abstract: Hundreds of thousands of hectares of Douglas fir (Pseudotsuga menziesii) plantations in coastal forests in the US Pacific Northwest have been established over the past 40 years. Density management regimes designed to increase structural and compositional diversity in these plantations are being tested and implemented on an operational scale, in order to satisfy goals of ecosystem management. These regimes are designed to promote various tree and stand characteristics, such as trees with large limbs, stands with multi-layered canopies, and dense unthinned patches. Changes in forest management policy associated with these types of regimes raise questions about whether it is possible to manage for both ecosystem values and timber production. State-of-the-art growth models were used to simulate stand development and wood product yields under several silvicultural prescriptions. The results indicated that timing and intensity of early thinnings are critical in determining both stand structure and wood quality. It is concluded that it should be possible to manage Douglas fir plantations to provide a high degree of structural diversity, and wood products with a quality similar to that grown in many industrial plantations.

OSU Link
Non-OSU Link

7. 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 mensziesii) 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.

OSU Link
Non-OSU Link

8. Bodner, J. 1984. Effect of thinning and fertilization on wood properties and intra-ring characteristics in young Douglas-fir. Holzforschung-und-Holzverwertung 36(1): 5-11.

Keywords: fertilization
thinning
wood quality

Abstract: Studies were made on samples from a total of 21 trees (felled in 1982) from 42-yr-old control and thinned/[N] fertilizer-treated stands near Sweet Home, Oregon, and a 48-yr-old thinned stand near Corvallis. Wood properties, studied between and within treatments, included ring density (analysed by X-ray densitometry), earlywood and latewood density, min. earlywood density, max. latewood density, and ring width. There was n.s.d. in av. wood density between treatments. There were significant between-treatment differences in MOE and MOR. Heavy thinning (during the juvenile wood formation phase) reduced latewood fibre length by 26.5%. Min. earlywood density and max. latewood density were the most important components of ring density.

OSU Link
Non-OSU Link

9. Briggs, D.G., F. Mecifi and W.R. Smith. 1986. Effect of sludge on wood properties: a conceptual review with results from a sixty-year-old Douglas-fir stand. *In* The forest alternative for treatment and utilization of municipal and industrial wastes. *Ed.* D.W. Cole, C.L. Henry, and W.L. Nutter. Seattle, Washington, USA: University of Washington Press. pp. 246-257.

Keywords: fertilization
wood quality

Abstract: Expected changes in wood properties due to cultural practices are reviewed. The hormone theory and published studies on the effects of thinnings and fertilizers are used to provide a basis for hypotheses describing the effects of sludge treatments on wood properties. Notes are given on the effect of municipal sludge on relative density, tracheid characteristics and strength properties of Douglas fir.

OSU Link
Non-OSU Link

10. Brix, H. 1993. Fertilization and thinning effect on a Douglas-fir ecosystem at Shawnigan Lake: a synthesis of project results. B.C. Ministry of Forests FRDA-Report 196. X + 64 p.

Keywords: fertilization
thinning
growth
tree morphology
tree/stand health
carbon allocation
wood quality
tree physiology

photosynthesis
economics

Abstract: Treatments were initiated in 1970-71 in a 24-year-old Douglas fir (Pseudotsuga menziesii) near Shawnigan Lake, Vancouver Island, British Columbia, to determine the effects of 3 intensities of thinning (removing none, one-third and two-thirds of basal area) and 3 levels of urea fertilizer (0, 224 and 448 kg N/ha) on the growth and biology of the trees. Subsidiary experiments were established during 1972-87 to examine the effects of high doses of urea (672-1344 kg N/ha), ammonium nitrate as an N source instead of urea, understoreyresponse to thinning and fertilizer, and responses to P and S fertilizer.

OSU Link
Non-OSU Link

11. Busing, R.T. and S.L. Garman. 2002. Promoting old-growth characteristics and long-term wood production in Douglas-fir forests. Forest-Ecology-and-Management 160(1/3): 161-175.

Keywords: thinning
yield
wood quality

Abstract: Trade-offs among wood production, wood quality and ecological characteristics in the management of harvested forest stands are explored through model simulation of various silvicultural regimes. Long-term production of merchantable wood, production of various types of high-quality wood, and the level of certain quantitative ecological indicators are projected for coniferous forests of Pacific Northwestern USA. The set of ecological indicators used is based on the species composition and physical structure of old, unloggedforest stands. Simulations are performed with an ecological model of forest stand dynamics that tracks the fate of live and dead trees. Short rotations (<50 years) produce the least amount of high-quality wood over the multi-century simulation period. They also fail to generate ecological attributes resembling those of old forest stands. Production of high-quality wood is moderate to high under all rotations of 80 years or more; however, most ecological indicators require longer rotations unless alternatives to clear felling are applied. Alternatives examined include retention of 15% cover of live tree canopy at each harvest in combination with artificial thinning between harvests. Thinning from below can expedite the development of large live and dead trees, and canopy height diversity without greatly diminishing wood quantity or quality. Proportional thinning retains understorey stems, thereby expediting the recruitment of shade-tolerant trees. A possible drawback to thinning, particularly proportional thinning, is the diminished production of clean-bole wood at rotations of 150 and 260 years. It is concluded that most wood quantity, wood quality and ecological objectives can be met with long rotations (approximately 260 years). Certain objectives can be met with shorter rotations (80-150 years) when treatments of thinning and canopy tree retention are applied.

OSU Link
Non-OSU Link

12. 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

13. Carter, R.E., I.M. Miller and K. Klinka. 1986. Relationships between growth form and stand density in immature Douglas-fir. Forestry-Chronicle 62(5): 440-445.

Keywords: planting operations
wood quality
tree morphology
growth

Abstract: Spacing was found to affect stem and crown characteristics and branching at whorls 6-10 in 27-yr-old Douglas fir established at 3 spacings (1.8x1.8, 3.6x3.6 and 4.6x4.6 m) near Haney, British Columbia. Ht., d.b.h. and stem diam. at the base of the live crown increased significantly with spacing, while age and ht. at the base of the live crown decreased. Increased spacing resulted in significantly greater branch diam. at whorls 6-10 and, in some whorls, an increase in branch number. Swelling of the stem at branch whorls, the number of Lammas whorls, knottiness ratio and a subjective index of stem form (where higher index indicated poorer form) increased with spacing. The selection of initial spacing is discussed and it is concluded that intensive management practices, e.g. thinning and pruning, will be necessary in all regimes if clear wood is to be produced over short rotations.

OSU Link
Non-OSU Link

14. Cole, D.W., M.L. Rinehart, D.G. Briggs, C.L. Henry and F. Mecifi. 1984. Response of Douglas fir to sludge application: volume growth and specific gravity. *In* Proceedings of the Technical Association of the Pulp and Paper Industry 1984 Research and Development Conference, Appleton, Wisconsin, September 30-October 3. pp. 77-84.

Keywords: fertilization
thinning
growth
wood quality

Abstract: In 1977 and 1980 municipal sludge was applied to a 60-yr-old lowland Douglas fir stand in Washington State. Application procedures and rates and suitable sites for treatment are described. There was a 6 yr av. diam. growth response of 93% in unthinned and 48% in thinned stands treated with 142 t/ha sludge and a vol. growth response of 53 and 42%, respectively. The accelerated rate of growth has not shown signs of decreasing since treatment. Relative density of sludge-grown wood was 10-15% less than that of untreated wood, but within the range for Douglas fir grown on higher land. This is thought to be a result of the change in forest site produced by the sludge treatment.

OSU Link
Non-OSU Link

15. 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

16. 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

17. 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

18. 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

19. Gartner, B.L., J.J. Morrell, C.M. Freitag and R. Spicer. 1999. Heartwood decay resistance by vertical and radial position in Douglas-fir trees from a young stand. Canadian-Journal-of-Forest-Research 29(12): 1993-1996.

Keywords: fertilization
thinning
wood quality

Abstract: Heartwood durability of Douglas-fir (Pseudotsuga menziesii var. menziesii) was studied as a function of vertical and radial position in boles of trees with a wide range of leaf area/sapwood area ratios. Six 34-year-old trees were harvested from each of three plots: very dense, thinned, and thinned and fertilized with N, P, K, Ca, S and Fe (51, 11, 10, 7, 4 and 0.3 kg/ha, respectively), established 14 years before at a site in the central Cascades of Oregon. Heartwood samples from three radial positions and five heights were incubated with the decay fungus Postia placenta [Oligoporus placenta]. There were no significant differences in wood mass loss (decay resistance) by vertical or radial position. One could expect that trees with high leaf area/sapwood area could have the carbon to produce heartwood that is more resistant to decay than trees with lower leaf area/sapwood area. However, no relationship was found between leaf area above node 20, sapwood area there, or their ratio, and the decay resistance of outer heartwood at that node. These results suggest that, for young Douglas-fir trees, heartwood durability does not vary with position in the bole or with environments that alter the balance of sapwood and leaf area in a tree. It is suggested that young stands may thus be robust with respect to the effect of silvicultural regimes on heartwood durability.

OSU Link
Non-OSU Link

20. 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

21. Gonzalez, J.S. and J. Richards. 1988. Early selection for wood density in young coastal Douglas-fir trees. Canadian-Journal-of-Forest-Research 18(9): 1182-1185.

Keywords: genetic tree improvement
wood quality

Abstract: Selection age for wood density in vigorous coastal Douglas-fir (Pseudotsuga menziesii) on Vancouver Island was determined by examining the strength of the correlation between total-stem wood density of 50-yr-old trees and the b.h. density when the trees were 5-30 yr old (b.h. age), and the efficiency in terms of gain per year of tree improvement effort by selecting at ages 5-30, relative to selecting at age 50. The linear regression and rank correlation between total-stem and b.h. densities improved as age increased from 5 to 15 yr, but showed no significant improvement from 15 to 30 yr. Densities of early-growth rings fluctuated considerably and their exclusion from the calculation of b.h. density enhanced the linear regression with total-stem density. Efficiency estimates in terms of gain per year showed an opt. value at age 15, but the estimates for ages 10-14 were nearly as efficient.

OSU Link
Non-OSU Link

22. Grotta, A.T., B.L. Gartner and S.R. Radosevich. 2004. Influence of species proportion and timing of establishment on stem quality in mixed red alder-Douglas-fir plantations. Canadian-Journal-of-Forest-Research 34(4): 863-873.

Keywords: planting operations
tree morphology

wood quality

Abstract: The relationships among stand structure, Douglas-fir (Pseudotsuga menziesii) branch characteristics, and red alder (Alnus rubra) stem form attributes were explored for 10- to 15-year-old trees growing in mixed Douglas-fir-red alder plantations in Oregon, USA. Treatments included a range of species proportions, and red alder was either planted simultaneously with Douglas-fir or after 5 years. Both replacement effects (total stand density held constant) and additive effects (stand density doubled) of competition were considered. When the two species were planted simultaneously and red alder proportion was low, red alder trees had low crown bases and much stem defect (lean, sweep, and multiple stems). Douglas-fir grew slowly when the two species were planted simultaneously. When red alder planting was delayed, species proportion did not affect red alder stem form, and height to the base of the Douglas-fir live crown decreased with increasing red alder proportion. Doubling Douglas-fir density increased the height to the base of the Douglas-fir live crown; however, doubling stand density by adding red alder did not affect Douglas-fir crown height. Douglas-fir lumber coming from mixed stands may be inferior because of the changes in knot characteristics associated with these different patterns of crown recession. In stands with a low proportion of red alder, red alder product recovery may be compromised because of the stem defects described above.

23. Hong, S. and J.J. Morrell. 1997. Treatability of Douglas-fir heartwood with ACZA or CCA: effect on site, silvicultural practice, and wood properties. Forest-Products-Journal 47(10): 51-55.

Keywords: planting operations
fertilization
thinning
wood quality

Abstract: The effects of site, silvicultural treatments, and wood properties on treatability of Douglas-fir (Pseudotsuga menziesii) heartwood, from Washington and Oregon, with chromated copper arsenate (CCA) or ammoniacal copper zinc arsenate (ACZA) were studied. Thinning appeared to be associated with slight improvements in treatability (penetration and retention of preservative), but combinations of thinning and fertilization had no significant effect on this property. Other factors such as site, height from which the sample was removed, and percentage of juvenile wood had inconsistent effects on treatability. Although the results indicate that silvicultural practices have minimal effects on treatability of Douglas-fir, further studies are required to clarify these effects.

24. Jozsa, L.A. and H. Brix. 1989. The effects of fertilization and thinning on wood quality of a 24-year-old Douglas fir stand. Canadian-Journal-of-Forest-Research 19(9): 1137-1145.

Keywords: fertilization
thinning
wood quality

growth

Abstract: The effect of thinning and N fertilization on growth and wood density of coastal Douglas fir (Pseudotsuga menziesii) on a poor site on Vancouver Island (British Columbia) is described for plots established at approx. 24 yr old in 1971-72. Stem cores were taken using an increment borer in Mar.-Apr. 1984. Ring-width and ring-density data were obtained from pith to bark for all trees using computerized X-ray densitometry. Fertilization reduced ring density at b.h. and 25% stem ht. by an av. of 6% for a 3- to 4-yr period after treatment, but not thereafter. Reductions in ring density resulted from decreases in the density of earlywood and latewood, as well as from decreases in latewood percentages. Effects were only pronounced in the lower half of the stem. Thinning resulted in a slight increase in ring-density in the lower bole and a reduction in the top. The combined treatments had an intermediate effect on ring density. Ring density showed an increasing trend from pith to bark at all ht. except at 75% stem ht., and a decrease with increasing ht. in the bole. Fertilization and thinning both increased diam. growth, and the beneficial effects were still evident 13 yr after treatments.

OSU Link
Non-OSU Link

25. Jozsa, L.A. and G.R. Middleton. 1994. A discussion of wood quality attributes and their practical implications. Forintek Canada Corp. 42 p.

Keywords: planting operations
wood quality
tree morphology

Abstract: Wood quality is defined as the suitability of wood for a particular end-use. Wood anatomy and tree growth are discussed in terms of macroscopic and microscopic features of a tree examined in cross section. End-use requirements are described in terms of lumber grading. The following wood quality attributes are introduced, defined and discussed in terms of their practical implications for wood processing and wood products: wood density, density variation, juvenile wood/mature wood distribution, proportion of heartwood/sapwood,fibre length, fibril angle, compression wood, knots, grain and extractives. The potential for influencing tree growth characteristics (e.g. wood density, branch size) and wood quality (structural and appearance lumber grades) through stand stocking control is discussed.

OSU Link
Non-OSU Link

26. Kennedy, R.W. 1995. Coniferous wood quality in the future: concerns and strategies. Wood Science and Technology 29: 321-338.

Keywords: planting operations
wood quality

Abstract: As the raw material base for forest products manufacturing shifts from old-growth to short-rotation plantation stock, the wood from these younger trees will contain larger proportions of juvenile wood. This in turn will influence the quality of forest products obtained. The pattern of specific gravity

variation in these trees, which varies among the five most important Pacific Northwest species groups, is reviewed, and the nature of their differences is related to growth habit. It is speculated that the shade intolerance of some species manifests itself in an early culmination of annual height increment, after which specific gravity increases rapidly to a maximum. This is contrasted to shade-tolerant species, in which specific gravity may take several decades to attain a minimum value, followed by only moderate increases thereafter. In addition, faster growth rates in widely spaced plantation trees tend to depress specific gravity and advance the age at which these trees reach their minimum value, thereby compounding the overall wood density deficit of short-rotation trees. Lower specific gravity, compounded with reduced lignin content in juvenile wood, negatively influences kraft pulp yield, but not pulp quality parameters such as sheet density, burst and tensile strength. Reduced wood density, coupled with larger fibril angles in juvenile wood, reduces average strength and stiffness of lumber from younger plantation trees. Mechanical stress rating needs to be adopted to segregate the strong, stiff material for engineered construction uses, because a large proportion of visually graded lumber from juvenile wood zones will not meet currently assigned stress values. Mechanical stress rating can ensure a continued stream of appropriate engineering grades from future tree supplies. These conclusions are drawn from data in the literature
on Pseudotsuga menziesii, Pinus contorta, Tsuga heterophylla,Picea spp., and Abies spp.

OSU Link
Non-OSU Link

27. Koshy, M.P. and D.T. Lester. 1994. Genetic variation of wood shrinkage in a progeny test of coastal Douglas-fir. Canadian-Journal-of-Forest-Research 24(8): 1734-1740.

Keywords: genetic tree improvement
wood quality
genetic relationships

Abstract: Directional (longitudinal, tangential and radial) and volumetric wood shrinkage were analysed in 413 trees belonging to 48 full-sib families (4 paternal and 12 maternal parents) from an 18-year-old coastal Douglas fir (Pseudotsuga menziesii var. menziesii) progeny test in British Columbia. Six samples per ring position (ring positions 1-5 from pith along stem radii), with two rings in each ring position, were examined in a bolt taken at breast height from the tree. Genetic effects were minimal for shrinkage, except for longitudinal shrinkage at ring positions 1 and 2. High variability was expressed among trees within plots and among samples with trees. The lack of statistically significant family variance eliminates the possibility of improving the shrinkage traits by genetic means, except for longitudinal shrinkage in the first few rings. However, the high amount of variability expressed between trees within plots and between samples within trees warrants special attention for achieving uniformity of wood. Much of this variability can be reduced by silvicultural methods.

OSU Link
Non-OSU Link

28. Koshy, M.P. and D.T. Lester. 1997. Wood shrinkage and tree growth in coastal Douglas-fir: implications of selection. Canadian-Journal-of-Forest-Research 27(1): 135-138.

Keywords: genetic tree improvement

wood quality
growth
genetic relationships

Abstract: Phenotypic and genetic correlations of height and diameter at breast height with wood shrinkage were studied in an 18-year-old Douglas fir (Pseudotsuga menziesii) progeny trial in British Columbia. Correlations between growth traits and shrinkage were minimal except for longitudinal shrinkage at rings close to the pith. In early ring positions, there was a negative correlation between height and longitudinal shrinkage, such that selection for increased height is expected to reduce longitudinal shrinkage at ring positions closer to the pith. The results support current efforts to increase wood production through genetic improvement in growth rate by showing that current programmes of selection for rapid early height growth will not result in significant increase in wood shrinkage.

OSU Link
Non-OSU Link

29. 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

30. Maguire, D.A. 1994. Branch mortality and potential litterfall from Douglas-fir trees in stands of varying density. Forest-Ecology-and-Management 70(1/3): 41-53.

Keywords: thinning
wood quality
soil properties

Abstract: Differential crown recession and crown development among stands of differing density suggest that an opportunity may exist to control the input of fine woody litter into the system by manipulating stand density. The objective of this study was to measure the rate of branch mortality among stands of differing density and to estimate the range in total per hectare necromass inputs. Although litter traps are reliable for estimating per hectare rates of litterfall, branch mortality dating on sectioned stems uniquely allows assessment of several other litterfall components: (1) individual tree contributions to total litterfall; (2) the amount of branch material released by mortality, regardless of whether the branches are shed to the forest floor; (3) the distribution of basal diameters characterizing the litterfall from a given tree and stand. Twenty-four trees were felled and sectioned on permanent plots that were part of a silvicultural study of Douglas fir (Pseudotsuga menziesii) stand density regimes, in Umpqua National Forest, near Tiller, Oregon. Whorl branches were dissected out of bole sections to determine the dates of mortality, and a branch biomass equation was applied to estimate potential rate of litterfall. Periodic annual rates were expressed in four ways: (1) number of branches per tree; (2) mass of branches per tree; (3) mass of branches per unit of crown projection area; (4) mass of branches per hectare. For the growth periods investigated, larger trees and trees growing on denser plots tended to release a greater necromass through branch mortality. Average branch basal diameter generally decreased with increasing stand density. Annual branch mortality ranged from 33 to 430 g m-2 crown projection area for individual trees, and from 236 to 1035 kg ha-1 for individual plots. These rates approached the low end of the range of previously published fine litterfall rates for Douglas fir. Rates on these plots were relatively low owing to the temporary delay in crown recession imposed by artificial thinning. A conceptual model of branch litter dynamics is presented to depict consistencies with crown development among stands managed under different density regimes.

31. 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.

OSU Link
Non-OSU Link

32. 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

33. 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

34. 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

35. Regan, R.P. and W.M. Probesting. 1989. Development of Douglas-fir clones for Christmas trees. *In* Combined Proceedings: International Plant Propagators' Society (Vol 38): 187-191.

Keywords: genetic tree improvement
growth
wood quality

Abstract: Douglas fir (Pseudotsuga menziesii var. menziesii) clones have been selected for vigour and ornamental quality in Christmas tree production in Oregon. Preliminary evaluations in commercial plots suggest that these clones have significantly higher value than seedlings.

OSU Link
Non-OSU Link

36. Schermann, N., W.T. Adams, S.N. Aitken and J.C. Bastien. 1997. Genetic parameters of stem form traits in a 9-year-old coastal Douglas-fir progeny test in Washington. Silvae-Genetica 46(2/3): 166-170.

Keywords: genetic tree improvement
growth
wood quality
genetic relationships
tree phenology

Abstract: The genetic control of stem form traits was investigated in a 9-year-old progeny test comparing 80 open-pollinated families of Pseudotsuga menziesii, located in a fertile Pacific coast site in Washington, USA. In addition to stem form traits (internode sinuosity, and number of forks and ramicorns per tree), stem volume (height and DBH), bud phenology (earliness of budburst and budset), and occurrence of second flushing on the leader shoot (9th growing season) were measured. Trees with at least one fork or ramicorn were frequent (26% and 46%, respectively), as were trees with second flushing (26%). Most of the trees exhibited sinuosity of limited magnitude. Due to strong differences among family means and at least modest family heritabilities (0.35 to 0.66), all traits were found to be amenable to genetic improvement. The estimated genetic correlation (rA) between numbers of forks and ramicorns was relatively strong (0.54), and both forking defects traits exhibited similar genetic associations with other traits. Forking defects were strongly and positively associated with frequency of second flushing, a trait which in turn is positively and moderately correlated with both DBH (0.32) and earliness of budburst (0.39). These results are consistent with previous findings. Breeding consequences for simultaneous improvement of both stem volume and form are discussed.

OSU Link
Non-OSU Link

37. Sonne, E., E. Turnblom, D. Briggs and G. Becker. 2004. Log and lumber grades and value from a Douglas-fir stand 20 years after thinning and biosolids fertilization. Western-Journal-of-Applied-Forestry 19(1): 34-41.

Keywords: fertilization
thinning
economics
yield
wood quality

Abstract: Three replications of four treatments: biosolids fertilizer application, thinning, thinning plus biosolids fertilizer application, and untreated control were established in 1977 in a dense, low site, 55-year-old Douglas-fir (Pseudotsuga menziesii) stand in western Washington, USA. In 1998, 12 trees from each treatment were harvested, bucked into logs, and sawn into visually graded lumber. Taking into account effects of treatments on stand yield and log grades, biosolid fertilizer application only, thinning only, and thinning combined with biosolids increased log value/ac by $1142 (19%), $3642 (62%), and $9969 (155%), respectively, over the untreated control. When treatment effects were viewed in terms of changes in lumber yield and quality, per acre gains over the control were $2107 (26%), $5683 (70%), and $10 708 (132%), respectively. Willingness to pay analysis indicates that if the landowner intends to manage the stand to a rotation of approximately 75 years, each of the treatments, and especially the combination of thinning and applying biosolids, appears to be financially attractive at both 5 and 9% interest rates. However, if the rotation had been set at 55 years, only the thinning/biosolids combination at 5% interest rate would entice management to delay immediate harvest.

OSU Link
Non-OSU Link

38. St-Clair, J.B. 1994a. Genetic variation in tree structure and its relation to size in Douglas-fir. I. Biomass partitioning, foliage efficiency, stem form, and wood density. Canadian-Journal-of-Forest-Research 24(6): 1226-1235.

Keywords: genetic tree improvement
genetic relationships
carbon allocation
wood quality
growth

Abstract: Genetic variation and covariation among traits of tree size (volume, basal area, diameter at breast height and height) and structure were assessed in 1991 in an 18-year-old Douglas fir (Pseudotsuga menziesii var. menziesii) genetic test in the Coast Range of Oregon. Considerable genetic variation was found in size, biomass partitioning and wood density, and genetic gains may be expected from selection and breeding of desirable genotypes. Estimates of heritability for partitioning traits, including harvest index (the proportion of fixed carbon converted to stemwood), were particularly high.

Foliage efficiency (stem increment per unit leaf area) was correlated with harvest index and may represent an alternative measure of partitioning to the stem. Estimates of foliage efficiency where leaf area was estimated based on stem diameter or sapwood area were unrelated to foliage efficiency where leaf area was measured directly. Strong negative genetic correlations were found between harvest index and stem size, and between wood density and stem size. Large trees were more tapered than small trees. It is concluded that simultaneous genetic gain in stem size and either harvest index or wood density would be difficult to achieve.

OSU Link
Non-OSU Link

39. St-Clair, J.B. 1994b. Genetic variation in tree structure and its relation to size in Douglas-fir. II. Crown form, branch characters, and foliage characters. Canadian-Journal-of-Forest-Research 24(6): 1236-1247.

Keywords: genetic tree improvement
carbon allocation
tree morphology
wood quality
genetic relationships

Abstract: Genetic variation and covariation among traits of tree size (volume, basal area, diameter at breast height and height) and structure were assessed in 1991 in an 18-year-old Douglas fir (Pseudotsuga menziesii var. menziesii) genetic test in the Coast Range of Oregon. Considerable genetic variation was found for relative crown width, stem increment per crown projection area, leaf area and branch weight relative to crown size, branch diameter and length adjusted for stem size, branch stoutness, cross-sectional area of branches per crown length and needle size. Little genetic variation was found for branch numbers per whorl, branch angle and specific leaf area. At both the phenotypic and genetic level, large trees growing in relatively small spaces had tall, narrow crowns, high leaf areas per crown projection area or branch length, greater partitioning to leaves versus branches, and stouter branches. Thus, large, efficient trees were those that invested more in the photosynthetic machinery of leaf area and the branch biomass necessary to support that leaf area, but distributed that leaf area over a greater vertical distance. Unfortunately, these traits were also associated with increased branchiness, and selection for these traits would be accompanied by reductions in harvest index and wood quality.

OSU Link
Non-OSU Link

40. Stinson, S.D. 1999. 50 years of low thinning in second growth Douglas-fir. Forestry-Chronicle 75(3): 401-405.

Keywords: thinning
growth
yield
wood quality

Abstract: Results are presented from four of the Port Blakely XT series of thinning trials, established during 1948-58 in naturally regenerated Douglas fir [Pseudotsuga menziesii] stands in

western Washington. Three trials were designed to evaluate the effects of repeated low thinning and extended rotations, while the fourth compared the effects of different levels of removal on standing volume and wood quality. Periodic and mean annual increment trends were examined in all trials. Results indicated the extension of culmination of mean annual increment in response to low thinning, combined with extended rotations. Thinned plots in 2 trials had increased stem size and total harvested volume. Extended rotations and low thinning increased the quantity of structural log grades when compared with stands harvested on shorter rotations.

OSU Link
Non-OSU Link

41. Taylor, A.M., B.L. Gartner and J.J. Morrell. 2003. Co-incident variations in growth rate and heartwood extractive concentration in Douglas-fir. Forest-Ecology-and-Management 186(1/3): 257-260.

Keywords: thinning
growth
wood quality

Abstract: Extractives can have a major impact on the properties of heartwood; however, our understanding of the process of heartwood formation and extractives production is limited and there are few data on how environment affects heartwood extractive content. This study assessed the relationship between growth ring width and extractive content of heartwood in Douglas-fir (Pseudotsuga menziesii [Mirbel] Franco) trees. The radial growth rates of the sampled trees were variable over their 53-61 years, in part, because of recent stand thinning treatment. The year that each heartwood increment was formed was estimated by assuming that the trees maintained the same number of growth rings of sapwood in the past as they had at the time of sampling. Growth ring width increased after the recent thinning and there was an associated increase in the extractive content of the heartwood estimated to have been formed at the same time. In addition, there appeared to be a rough correlation between growth ring width and extractive content in the time before the thinning. These results suggest that silvicultural treatments that affect growth rate may affect wood durability in Douglas-fir.

OSU Link
Non-OSU Link

42. Temel, F. and W.T. Adams. 2000. Persistence and age-age genetic correlations of stem defects in coastal Douglas-fir (Pseudotsuga menziesii var. menziesii (Mirb.) Franco). Forest-Genetics 7(2): 145-153.

Keywords: genetic tree improvement
genetic relationships
growth
wood quality

Abstract: Persistence of stem defects, including bole sinuosity, large branch size and the occurrence of steep-angled branches (i. e., forks and ramicorns), and the efficiency of early selection against these traits, were investigated in 90 open-pollinated families of Douglas fir
(Pseudotsuga menziesii var. menziesii) from coastal Oregon, USA. Trees originally measured for these

traits at age 12 were remeasured at age 24 in three progeny test plantations. The majority of trees scored as having ramicorn branches at age 12 (62%) still had them at age 24, but most forks (53%) had become ramicorns by the second measurement. Thus, there seems little need to score forks and ramicorns separately; simply counting the number of whorls with steep-angled branches seems sufficient for selection purposes. Branch size scores were relatively consistent between the two ages, but not scores for bole sinuosity. Because of low estimated individual and family heritability estimates (<less or =>0.13 and <less or =>0.41, respectively), predicted genetic responses in diameter at breast height (DBH) and individual stem-defect traits were only modest for this population. Nevertheless, with the exception of sinuosity, genetic correlations between comparable stem-defect traits at the two ages were strong (rA<more or => 0.82), and predicted responses in traits at age 24, from selection at age 12, were nearly as great as responses expected if selection was delayed until age 24. Branch size and occurrence of steep-angled branches were unfavourably (positively) correlated with DBH (estimated rA= 0.56 and 0.41, respectively). Thus, it is important to include these stem defect traits as selection criteria in Douglas fir breeding programmes, if stem volume growth is to be improved without sacrificing wood quality.

OSU Link

43. 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

44. Vargas-Hernandez, J. and W.T. Adams. 1991. Genetic variation of wood density components in young coastal Douglas-fir: implications for tree breeding. Canadian-Journal-of-Forest-Research 21(12): 1801-1807.

Keywords: genetic tree improvement
genetic relationships
wood quality
growth

Abstract: A study was made of the genetic control of wood density components (earlywood density, latewood density, and latewood percentage) and their relationships with overall density in coastal Douglas fir (Pseudotsuga menziesii var. menziesii) to assess the usefulness of this information in breeding for wood density. The genetic relationships of wood density with intra-ring density variation and bole volume growth were also investigated. Increment cores were taken at breast height from 15-yr-old trees of 60 open-pollinated families growing in the Coyote Creek progeny test plantation near Eugene, Oregon, during summer 1988. Averages across each core for overall wood density, its components and intra-ring density variation were determined by using X-ray densitometry. Bole volume at age 15 yr for the same trees was derived from tree height and diameter at breast height measurements taken at the end of the 1987 growing season. Although wood density components varied significantly among families and were under moderate genetic control (individual-tree heritability (hisuperscript 2) >0.24), none had a higher heritability than overall density (hisuperscript 2 = 0.59). Density components had strong genetic correlations with overall density (r <more or => 0.74), but were also strongly related among themselves (0.57 <less or => r <less or =>0.92). Thus, density components have limited value in improving the efficiency of selection for overall density. Overall density was positively correlated with intra-ring density variation (r = 0.72) and negatively correlated with bole volume (r = -0.52). However, comparison of several selection indices incorporating wood density and one or more growth traits showed that it is possible to obtain substantial gains in bole volume without loss in (or even with a modest increase in) wood density. By restricting the response in wood density, the change in intra-ring density variation can also be limited.

45. Vargas-Hernandez, J. and W.T. Adams. 1992. Age-age correlations and early selection for wood density in young coastal Douglas-fir. Forest-Science 38(2): 467-478.

Keywords: genetic tree improvement
genetic relationships
wood quality

Abstract: Age-age correlations and age-associated changes in the genetic control of wood density and its components (earlywood density, latewood density, and latewood proportion) were investigated in 15-yr-old trees of 60 open-pollinated families of coastal Douglas-fir (Pseudotsuga menziesii var. menziesii) in Oregon. The possibility of using wood density components as secondary traits to increase the efficiency of early selection for overall wood density was also explored. Heritability estimates for overall density and its components increased with age, mainly because of a decrease in the error variance as the number of rings in the core sample increased. Overall density and its components at age 15 yr had strong genetic correlations with their respective traits at all younger ages analysed. Moreover, with few exceptions, age-age genetic correlations were greater than phenotypic correlations. Early selection to improve overall density at age 15 yr was quite efficient (relative efficiency >79%), even when selection was based on core density at the youngest age (7 yr). Using wood density components as secondary traits produced a slight increase in the efficiency of early selection only at the youngest ages, presumably because age-age correlations for overall core density were already strong, limiting the potential for additional improvement.

46. Vargas-Hernandez, J. and W.T. Adams. 1994. Genetic relationships between wood density components and cambial growth rhythm in young coastal Douglas-fir. Canadian-Journal-of-Forest-Research 24(9): 1871-1876.

Keywords: genetic tree improvement
genetic relationships
wood quality
tree phenology
growth

Abstract: Genetic relationships of wood density, and its components, with cambial growth rhythm traits were examined in a 15-year-old progeny test of coastal Douglas fir (Pseudotsuga menziesii var. menziesii) in Oregon, in an attempt to better understand the genetic control of wood formation, and to assess the potential effect of selecting for increased wood density on adaptation of trees. Timing of diameter growth during the 1987 growing season was determined in an earlier study, and wood formation traits were estimated by X-ray densitometry of increment core samples. Wood formation traits were under weak genetic control (hisuperscript 2<0.20). Duration of earlywood and latewood formation were mostly determined by the timing of latewood transition. Overall core density was negatively correlated with the dates of cambial growth initiation (rA=-0.41) and latewood transition (rA=-0.62), and positively correlated with the date of cambial growth cessation (rA=0.40). As a result of these relationships, higher wood density was associated with a longer duration of cambial growth (rA=0.67) and a slower rate of wood formation (rA=-0.37). All density components showed similar relationships with cambial phenology and wood formation traits. Selection for increased wood density is expected to cause only a slight extension of the cambial growth period, but it would also cause an earlier transition to latewood formation, negatively affecting growth rate.

47. Vargas-Hernandez, J., W.T. Adams and R.L. Krahmer. 1994. Family variation in age trends of wood density traits in young coastal Douglas-fir. Wood-and-Fiber-Science 26(2): 229-236.

Keywords: genetic tree improvement
genetic relationships
wood quality

Abstract: Changes in ring density and its components with increasing distance from the pith (i.e. age trends) were examined in 15-yr-old trees from 60 open-pollinated families of coastal Douglas fir [Pseudotsuga menziesii] grown in the Coyote Creek progeny test plantation near Eugene, Oregon. Earlywood, latewood, and overall densities of each annual ring, obtained by X-ray densitometry of increment cores, were weighted by the area of the ring occupied by each trait, relative to the total stem cross-sectional area at breast height for the trait. Age trends in weighted values differed among traits but, with the exception of earlywood density, family variation was not detected. Weighted earlywood density (WED) steadily increased from pith to bark in some trees, while in other trees a plateau occurred at age 11 or later. Significant family differences were found in the proportion of trees reaching a plateau in WED by age 12. This proportion was under moderate genetic control (family hsuperscript 2=0.30) and was not genetically correlated with overall core density or stem growth

at age 15. Although there are reasons to hypothesize that the plateau in WED is an indication of transition from juvenile to mature wood formation, this hypothesis needs to be verified in older trees.

OSU Link
Non-OSU Link

48. Vargas-Hernandez, J.J., W.T. Adams and D.G. Joyce. 2003. Quantitative genetic structure of stem form and branching traits in Douglas-fir seedlings and implications for early selection. Silvae-Genetica 52(1): 36-44.

Keywords: genetic tree improvement
nursery operations
growth
genetic relationships
wood quality

Abstract: Open-pollinated (OP) and full-sib (FS) families of coastal Douglas fir (Pseudotsuga menziesii var. menziesii) were grown in two replicated nursery regimes to evaluate the magnitude and repeatability of genetic parameter estimates for stem form (stem sinuosity, forking) and branching (number, length and angle of branches) traits in 2-year-old seedlings, and the relationships of these traits with stem growth. With data from older trees of the OP families growing in the field (ages 12 and 24), genetic control of similar traits was compared at the different ages, and nursery-field correlations (rxy) were estimated. With the exception of forking, estimates of family heritability (h2f) were moderate to strong for stem form and branching traits in seedlings (0.32<less or =>h2f<less or =>0.94; mean=0.73), and similar to growth traits (0.45<less or =>h2f<less or =>0.90; mean=0.75). Family performance and estimates of genetic parameters were relatively stable across nursery regimes and family type. Genetic relationships among traits in seedlings were similar to those observed in older field-grown trees, indicating that these traits are controlled by similar sets of genes in the two age classes. Nursery-field correlations between comparable traits were consistent across nursery regimes, but rxy was strong enough to be useful for early testing purposes (i.e. | rxy | <more or =>0.30), only for number of whorls with steep-angled branches (WSAB), branch length, and branch angle in older trees. Predicted gains from early selection for these or correlated traits were at least 40-50% of those expected from selection at older ages. Because of unfavourable genetic correlations, selection for stem growth potential alone at the seedling stage is expected to produce unfavourable impacts on WSAB and stem sinuosity in older trees. To avoid such negative effects on wood quality, both stem form and branching traits should be included as selection criteria in Douglas fir breeding programmes.

OSU Link
Non-OSU Link

49. Woods, J.H., D. Kolotelo and A.D. Yanchuk. 1995. Early selection of coastal Douglas-fir in a farm-field test environment. Silvae-Genetica 44(4): 178-186.

Keywords: genetic tree improvement
planting operations
site preparation
mechanical preparation

release treatments
chemical release
manual release
genetic relationships
wood quality
growth

Abstract: Farm-field tests are progeny tests established using intensive site preparation, close spacing and nearly complete weed control. Early growth and wood density of coastal Douglas-fir (Pseudotsuga menziesii) in a farm-field environment for up to 7 years from seed were compared with stem volume and wood density from 11 field sites at age 13 (20-25 of commercial rotation). The farm-field test material comprised 70 full-sib families from six 6-tree half-diallels (some reciprocals and missing crosses) without selfs. Parent trees were from natural stand selections in the coastal area of British Columbia, Canada, and the farm-field test was conducted on southern Vancouver Island. Family heritabilities were high for almost all traits in both the farm-field and field sites. Breeding-value correlations of farm-field heights with field stem volume at age 13 increased from a low of 0.5 for farm-field age 1 and levelled off at about 0.7 by farm-field age 3. Farm-field diameter with field volume age 13 breeding-value correlations were initially lower than those for height, but increased to 0.82 by age 7. Wood density breeding value correlations between field pilodyn assessments at age 13 and farm-field stem sections at age 6 were 0.83. Maximum family-selection efficiency per year (including a 5-year breeding delay), relative to direct selection on field volume 13, reached 162% using index selection on farm-field height and diameter at age 3. Within-family selection efficiencies per year were highest at age 1 and declined quickly thereafter. All selection in the farm-field test had a higher efficiency per unit time than selection in field tests. It is concluded that correctly established farm-field tests will provide greater per year gains in stem yield and wood density traits than field sites.