Growth

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. Adams, T., T. Anekonda and C. Lomas. 1999. Annual Report 1998-99, Pacific Northwest Tree Improvement Research Cooperative. 33 p.

Keywords: genetic tree improvement
tree/stand protection
tree/stand health
growth
tree physiology

Abstract: Summaries are given of research projects on improvement of Douglas fir [Pseudotsuga menziesii] in the Pacific Northwest: seedling drought physiology; genetics of dark respiration and its relationship with drought hardiness; response of saplings to drought, as measured by growth ring variables; use of microsatellite marker loci to identify pollen contamination in seed orchards; and evaluation of miniaturized seed orchard designs.

OSU Link
Non-OSU Link

3. Adams, W.T., S.N. Aitken, D.G. Joyce, G.T. Howe and J. Vargas-Hernandez. 2001. Evaluating efficacy of early testing for stem growth in coastal Douglas-fir. Silvae-Genetica 50(3/4): 167-175.

Keywords: genetic tree improvement

nursery operations
growth
genetic relationships

Abstract: In a test to evaluate the ability to predict stem growth of families in the field from nursery performance (i.e., early testing), 67 open-pollinated families and 66 full-sib families of coastal Douglas-fir (Pseudotsuga menziesii var. menziesii) were sown in two nursery conditions, each replicated as separate experiments: two bareroot nursery trials established in successive years in the same nursery, and two container-sown greenhouse trials sown in different greenhouses in the same year. First year heights in the seedling trials were compared to mean stem volumes of the same open-pollinated families in eight 15-year-old field progeny tests and the same full-sib families in eleven 12-year-old tests. Family mean nursery-field correlations (rxy) were similar for all four seedling trials for both open-pollinated (OP) and full-sib (FS) families, and generally ranged between 0.30 and 0.40. Although low, it is shown that nursery-field correlations of this magnitude can be quite useful in tree improvement programmes. For example, based on the data in this study, it is estimated that a single stage of family selection for first year seedling height would be about 50% as effective in improving 15-year volume as direct selection for this trait in field tests. Early testing, however, is probably of more practical significance as a tool for culling families prior to out-planting field tests in two-stage selection schemes. It is estimated that 25% of the OP families in this study could have been culled in an early test (first stage selection), with gain in 15-year volume after subsequent field testing and selection of the remaining families (second stage selection) being nearly the same as if all families had been field tested. Thus, early testing is an effective tool for reducing the size and cost of field progeny tests without sacrificing genetic gain.

OSU Link
Non-OSU Link

4. Adams, W.T. and D.G. Joyce. 1990. Comparison of selection methods for improving volume growth in young coastal Douglas-fir. Silvae-Genetica 39(5-6): 219-226.

Keywords: genetic tree improvement
growth

Abstract: Data from a Douglas fir (Pseudotsuga menziesii) open-pollinated progeny test in Oregon were used for evaluating methods of selection for bole volume. Tree height and bole diameter at breast height (DBH) were measured on 12 to 13-year-old individuals from 90 families at each of 3 plantations in the central Oregon coast range, and bole-volume estimates were derived with a quadratic volume equation. Four methods were compared for both parental and progeny selection: (1) indirect selection based on height, (2) indirect selection based on DBH, (3) direct selection based on volume, and (4) selection based on an index that included all 3 traits. Two-stage selection was also explored, where test trees are culled on the basis of DBH in the first stage; height is measured only on the remaining trees, so that final selections (the second stage) are based on volume. Estimated genetic gains in volume from progeny selection were 8-11% greater than those from parental selection. The relative efficiencies of the various selection methods, however, were similar for parental and progeny selection. The greatest estimated gains in single-stage selection, which were achieved with the multitrait index, were only 1% better than those from selections based on volume alone. Indirect selection based on DBH produced about 90% of the gain achieved by direct selection for volume, and indirect selection based on height was about 92-94% as efficient as direct selection. With 2-stage selection, up to two-thirds of the trees

could be culled in stage 1 without significantly lower gains in bole volume than those expected if the height of all trees had been measured.

OSU Link
Non-OSU Link

5. Alvarez, I.F. and J.M. Trappe. 1983a. Dusting roots of Abies concolor and other conifers with Pisolithus tinctorius spores at outplanting time proves ineffective. Canadian-Journal-of-Forest-Research 13(5): 1021-1023.

Keywords: planting operations
site preparation
mechanical preparation
growth
tree/stand health
mycorrhizal response

Abstract: Dusting roots of Abies concolor, Abies magnifica var. shastensis, Pseudotsuga menziesii and Pinus ponderosa with Pisolithus tinctorius (Pt) spores when planted out produced no Pt mycorrhizae at the end of the first growing season. In the 3rd yr occasional Pt mycorrhizae had formed on A. concolor. Inoculations reduced seedling survival in some cases. High rates of spore application may have desiccated roots of the true firs and spore amounts applied need careful attention. Soil scarification and ripping significantly promoted growth of A. concolor seedlings compared with scarification alone.

OSU Link
Non-OSU Link

6. Alvarez, I.F. and J.M. Trappe. 1983b. Effects of application rate and cold soaking pretreatment of Pisolithus spores on effectiveness as nursery inoculum on western conifers. Canadian-Journal-of-Forest-Research 13(3): 533-537.

Keywords: nursery operations
growth
mycorrhizal response

Abstract: Ponderosa pine, Douglas fir, Shasta red (Abies magnifica var. shastensis), and white fir (Abies concolor) seedlings were inoculated in a bare root nursery with basidiospores of Pisolithus tinctorius. The spores were applied at 3 rates with or without cold/wet pretreatment of 7 or 21 days. Pretreatment did not affect spore efficiency as inoculum. Only ponderosa pine increased growth in response to inoculation. Inoculations in the greenhouse with a wider range of spore application rates revealed that a higher concn. of spores was needed to induce an increase in growth and mycorrhiza formation of Douglas fir than ponderosa pine. These levels were much higher than those used in nursery inoculations.

OSU Link
Non-OSU Link

7. Amaranthus, M.P. and D.A. Perry. 1987. Effect of soil transfer on ectomycorrhiza formation and the survival and growth of conifer seedlings on old, nonreforested clear-cuts. Canadian-Journal-of-Forest-Research 17(8): 944-950.

Keywords: planting operations
tree/stand health
growth
mycorrhizal response

Abstract: Small amounts (150 ml) of soil from established conifer plantations and mature forest were transferred to planting holes on 3 sites in the Klamath Mts., S. Oregon and N. California. The sites had been clear felled and burned 8-27 yr earlier and unsuccessfully reforested. At Cedar Camp, a high alt. (1720 m) southerly slope with sandy soil, transfer of soil from a Douglas fir plantation increased first-yr survival of Douglas fir seedlings by 50%, mycorrhizal formation and b.a. growth. Soil from mature forest did not enhance survival and growth. Soil transfer was less effective on 2 sites at lower alt. with clayey soils. Douglas fir seedlings at Crazy Peak showed similar, but less well defined, patterns to those at Cedar Camp. All Pinus lambertiana seedlings at Wood Creek survived well and were generally unaffected by soil transfer. Results suggest that adequate mycorrhizal formation is critical to seedling growth and survival on cold, droughty sites. Transfer of soil from a suitable source may offset the decline in native mycorrhizal fungi if reforestation is delayed.

OSU Link
Non-OSU Link

8. Amaranthus, M.P. and D.A. Perry. 1989a. Interaction effects of vegetation type and Pacific madrone soil inocula on survival, growth and mycorrhiza formation of Douglas-fir. Canadian-Journal-of-Forest-Research 19(5): 550-556.

Keywords: planting operations
growth
tree/stand health
mycorrhizal response

Abstract: One-yr-old non-mycorrhizal Douglas fir (Pseudotsuga menziesii) seedlings were planted in 1985 in cleared blocks within 3 adjacent vegetation types in SW Oregon, viz., whiteleaf manzanita (Arctostaphylos viscida), annual grass meadow, and an open stand of Oregon white oak (Quercus garryana). Within subplots in each block, either pasteurized or unpasteurized soil from a nearby Pacific madrone (Arbutus menziesii) stand was transferred to the planting holes of the seedlings; control seedlings received no madrone soil. Second-year survival averaged 92, 43 and 12% for seedlings planted on the manzanita, meadow and oak sites, respectively. Growth differences generally paralleled survival differences. Added madrone soil, whether pasteurized or unpasteurized, did not influence survival. Unpasteurized madrone soil substantially increased the growth of seedlings on the manzanita site, but not in the meadow or oak stand. Pasteurized madrone soil did not affect growth in any of the vegetation types. Unpasteurized madrone soil nearly tripled the number of mycorrhizal root tips forming on seedlings and resulted in formation of a new mycorrhiza type on the manzanita site, although it had little or no effect on the meadow or oak sites. These results suggest that manzanita and madrone impose a biological pattern on soils that stimulates Douglas fir growth and survival, and support results

of other studies indicating that root symbionts and rhizosphere organisms mediate interactions among plant species.

OSU Link
Non-OSU Link

9. Anekonda, T.S., M.C. Lomas, W.T. Adams, K.L. Kavanagh and S.N. Aitken. 2002. Genetic variation in drought hardiness of coastal Douglas-fir seedlings from British Columbia. Canadian-Journal-of-Forest-Research 32(10): 1701-1716.

Keywords: genetic tree improvement
tree/stand protection
growth
tree/stand health
genetic relationships
tree physiology

Abstract: Genetic variation in drought hardiness traits and their genetic correlations with growth potential and recovery traits were investigated in 39 full-sib families of coastal Douglas-fir (Pseudotsuga menziesii var. menziesii) from southwestern British Columbia, Canada. Seedlings of these families were grown in raised nursery beds and subjected to three moisture regimes each in the second (well-watered or control, mild, and moderate drought) and third (control, severe drought, and recovery from second-year moderate drought) seasons. Traits assessed included drought hardiness (foliage damage, cavitation of xylem tracheids, xylem hydraulic conductivity, and height and diameter growth increment) in the drought treatments, growth potential (total height and diameter) in the control treatment, and height and diameter growth increments in the recovery treatment. Xylem cavitation in the growth ring produced in a particular year was nearly three times greater under the moderate drought and four times greater under the severe drought than in the control treatment. Xylem hydraulic conductivity of seedlings in the severe drought treatment was 40% lower than conductivity of seedlings under the control treatment. Mean foliage damage in seedlings subjected to severe drought (third season) was much greater (33%) than in seedlings subjected to mild or moderate drought (second season). Families differed significantly in most drought hardiness traits, with individual tree heritabilities averaging 0.19. Thus, much potential exists for identifying drought-hardy families at the seedling stage and using this information for deployment or breeding purposes. In addition, most hardiness traits were strongly intercorrelated (genetic correlations often exceeded |0.80|) indicating that these traits are controlled largely by the same set of genes and that selection for hardiness based on one trait will increase hardiness as reflected in the other traits as well. Genetic correlations were only moderate (0.49) between hardiness traits measured in different years, perhaps due to the large difference in severity of the drought applied in the two seasons. Although injury to seedlings, as reflected in foliage damage and xylem cavitation, was relatively low under the moderate drought of the second season, it did result in reduced growth increment the following (recovery) year. Growth potential under favourable moisture regimes was nearly uncorrelated with drought hardiness, suggesting that drought hardiness could be improved in this southwestern British Columbia breeding population without negatively impacting growth potential in favourable moisture conditions.

OSU Link
Non-OSU Link

10. Arnott, J.T. and D. Beddows. 1982. Influence of Styroblock container size on field performance of Douglas-fir, western hemlock, and Sitka spruce. Tree Planters' Notes 33(3): 31-34.

Keywords: nursery operations
growth
tree/stand health

Abstract: Pseudotsuga menziesii, Tsuga heterophylla and Picea sitchensis seeds were sown in April 1971 in BC/CFS Styroblocks sizes 2 and 8 with volumes of 40 and 125 cmsuperscript 3 respectively. The seedlings in the larger containers were kept in a heated greenhouse for 2-3 months to stimulate growth to fill the containers, before joining those in the smaller containers in an outdoor shadehouse nursery. Seedlings were planted out in British Columbia in March 1972. A second trial was started in April 1972 and seedlings planted out in April 1973. Survival and ht. growth were recorded for 5 growing seasons. The larger containers produced larger seedlings at planting. There were n.s.d. in survival of seedlings grown in the different sized containers for all 3 species. The seedlings grown in the larger containers were significantly taller after the first growing season in the field, a difference which persisted for the 5 seasons. Growing seedlings in the larger containers was more expensive and the seedlings took longer to plant than those grown in the smaller containers.

OSU Link
Non-OSU Link

11. 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 (Chamaecyparis nootkatensis) 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 (Pseudotsuga menziesii) 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 upper elevational 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 than bareroot 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.

OSU Link
Non-OSU Link

12. Axelrood, P.E., M. Neumann, D. Trotter, R. Radley, G. Shrimpton and J. Dennis. 1995. Seedborne Fusarium on Douglas-fir: pathogenicity and seed stratification method to decrease Fusarium contamination. New-Forests 9(1): 35-51.

Keywords: nursery operations
tree/stand protection
tree/stand health
growth

Abstract: Twelve Douglas-fir (Pseudotsuga menziesii) seedlots from coastal British Columbia were assayed for seedborne Fusarium; all of the seedlots were contaminated. The percentage of non-stratified seeds from individual seedlots harbouring Fusarium ranged from 0.3 to 95.4. Sixty-seven percent of the seedlots had Fusarium on less than 2% of the seeds. Post-stratification seedborne Fusarium levels were significantly less for running water imbibition compared with standing water imbibition. However, seedling growth at a container nursery was not consistently different for stratified seed imbibed initially in standing or running water. Fusarium disease symptoms were not observed in the nursery environment. The species of Fusarium isolated from seed were F. acuminatum [Gibberella acuminata], F. avenaceum [G. avenacea], F. lateritium [G. baccata], F. moniliforme [G. fujikuroi], F. oxysporum, F. poae and F. sambucinum [G. pulicaris]. Twelve Fusarium isolates, comprising 6 species, were assessed for pathogenicity. Disease symptoms were observed after 4 weeks incubation and Fusarium isolates ranged in virulence from low to high. Fusarium oxysporum isolates were the most pathogenic.

OSU Link
Non-OSU Link

13. Ballard, T.M. 1984. A simple model for predicting stand volume growth response to fertilizer application. Canadian-Journal-of-Forest-Research 14(5): 661-665.

Keywords: fertilization
growth

Abstract: The equation R=KTACZQ is used to predict cumulative stand volume growth response (R) to fertilizer application, where K is a constant and the last 5 (dimensionless) multipliers represent functions of time, amount of fertilizer applied, stand composition, stocking, and site quality, respectively. Site-specific input data requirements are stand composition expressed as percent responding species, stocking expressed as a percentage of normal stocking, and site index. The model was calibrated for Douglas-fir response to nitrogen using data from Washington and Oregon. A preliminary test of the model and its calibration compared predicted responses with estimates of actual response derived from some fertilizer trials on Vancouver Island. Soil drainage class and foliar analysis data may help in qualitatively inferring whether the model's site quality function leads to overestimation of response. Future development of the model may include development and calibration of a predictively better site quality function which quantitatively uses site water regime and stand nutrient data.

OSU Link
Non-OSU Link

14. Ballard, T.M. and N. Majid. 1985. Use of pretreatment increment data in evaluating tree growth response to fertilization. Canadian-Journal-of-Forest-Research 15(1): 18-22.

Keywords: fertilization
growth

Abstract: The use of pretreatment increment can lead to improved estimates of individual and average tree growth response to fertilizing, by helping to adjust for site as well as stand structure differences between fertilized and control areas. It has applications in research using either single-tree or plot fertilizing, and also in estimating responses to operational fertilizing. Equations for analysing increment response to fertilizing are presented and discussed and 2 particularly useful ones were evaluated by examining branch length increment data from foliar spray application of iron and copper to Pinus contorta and of nitrogen and iron to Pseudotsuga menziesii, in field trials in British Columbia.

OSU Link
Non-OSU Link

15. Barclay, H., H. Brix and C.R. Layton. 1982. Fertilization and thinning effects on a Douglas-fir ecosystem at Shawnigan Lake: 9 year growth response. Pacific-Forestry-Centre, Canadian-Forest-Service Information-Report BC-X-238. 35 p.

Keywords: fertilization
thinning
growth

Abstract: Further results are given for a trial established in 1970 in a 24-yr-old stand in British Columbia, last measured 6 yr after treatment. Volume increments over 9 yr for heavy thinning alone, heavy fertilizer (urea) treatment alone, or both together, were 46%, 75% and 120%, respectively.

OSU Link
Non-OSU Link

16. Barclay, H.J. and H. Brix. 1984. Effects of urea and ammonium nitrate fertilizer on growth of a young thinned and unthinned Douglas-fir stand. Canadian-Journal-of-Forest-Research 14(6): 952-955.

Keywords: fertilization
thinning
growth
tree physiology
tree/stand health

Abstract: The effects were studied of 2 sources of nitrogen fertilizer applied at rates of 224 and 448 kg/ha N on growth of thinned and unthinned plots established in 1970 in a 24-yr-old stand on southern Vancouver Is., British Columbia. Ammonium nitrate yielded higher growth of diam. and vol. than urea over a 9-yr period, particularly with thinning. Ht. growth was not affected by nitrogen source. The efficiency of nitrogen fertilizing in terms of stem vol. response per kilogram of nitrogen applied was greatest with ammonium nitrate in thinned plots. Tree mortality increased substantially with fertilizing for both sources, and decreased markedly with thinning.

OSU Link
Non-OSU Link

17. Barclay, H.J. and H. Brix. 1985a. Effects of high levels of fertilization with urea on growth of thinned and unthinned Douglas-fir stands. Canadian-Journal-of-Forest-Research 15(4): 730-733.

Keywords: fertilization
thinning
growth
tree physiology
tree/stand health

Abstract: Diameter height and volume growth were documented for 9 yr after thinning and fertilizing in a 24-yr-old stand on a poor site on southern Vancouver Is. The treatments involved 3 thinning treatments (0, 1/3, and 2/3 b.a. removed) and 6 fertilizer treatments (0-1344 kg/ha N) with urea. Increments for both diameter and gross volume increased with the rate of fertilizer application and responses were still apparent 9 yr after treatment. For unthinned plots, the 9-yr volume growth responses were 30, 50, and 80% with fertilizer rates of 224, 448, and 896 kg/ha N, respectively. The efficiency of fertilizer use, measured as stem volume response per unit of nitrogen applied, decreased with rate of fertilizer application, but this result may change over a longer response period. There was a positive interaction between fertilizing and thinning such that high amounts of both mutually enhanced growth. Mortality increased with fertilizing, but only noticeably in unthinned plots.

OSU Link
Non-OSU Link

18. Barclay, H.J. and H. Brix. 1985b. Fertilization and thinning effects on a Douglas-fir ecosystem at Shawnigan Lake: 12-year growth response. Pacific-Forestry-Centre, Canadian-Forest-Service Information-Report BC-X-271. 34 p.

Keywords: fertilization
thinning
growth

Abstract: [See FA 45, 2316] Further results are given from the study established in 1970 in a 24-yr-old stand in British Columbia. Fertilizers (urea) and thinning both increased vol. increments over 12 yr. Refertilization 9 yr after initial treatment has produced substantial increases in vol. increment.

OSU Link
Non-OSU Link

19. Barclay, H.J. and Y.A. El-Kassaby. 1988. Selection for cone production in Douglas-fir adversely affects growth. *In* Proceedings: 10th North American Forest Biology Workshop: 'Physiology and genetics of reforestation', University of British Columbia, Vancouver,British Columbia, July 10-22, 1988. Eds. J. Worrall, J. Loo-Dinkins and D.P. Lester. pp. 149-151.

Keywords: genetic tree improvement
genetic relationships
growth
reproduction

Abstract: Cone production and radial growth increment were studied for 8 years in a Douglas fir (Pseudotsuga menziesii) seed orchard on Vancouver Island, British Columbia, in 365 trees representing 29 open-pollinated (half-sib) families. Genetic correlations for the two traits were compared for each of the 8 years. Six of the correlations were significantly negative, while the remaining two were significantly positive. The predominantly negative correlation between cone production and growth indicates that selection for one of these two characters will effectively select against the other. The practice of selecting for high cone-producing trees in seed orchards may also be expected to yield slower-growing trees.

Non-OSU Link

20. Barclay, H.J. and C.R. Layton. 1990. Growth and mortality in managed Douglas fir: relation to a competition index. Forest-Ecology-and-Management 36(2-4): 187-204.

Keywords: fertilization
thinning
growth
tree/stand health

Abstract: Twelve-year increments of diameter at breast height (DBH), height, and volume in thinned and fertilized 45-year-old Douglas fir (Pseudotsuga menziesii) stands on Vancouver Island, Canada, were related (by regression) to degree of thinning, amount of fertilizer (3x3 factorial), initial DBH, and a competitive stress index (CSI). The ability of the CSI to predict growth after treatment was examined. Causes of tree death, and CSI data, are presented, and the relationship between them discussed. The CSI was found to be only moderately good at predicting Douglas fir growth and mortality: initial DBH provided a better predictor. Most mortality in unthinned plots resulted from suppression, and

correlated reasonably well with CSI; mortality in thinned plots was not correlated with CSI, and resulted principally from snow damage. Tree height variability generally became less over the 12 years following treatment, which is more consistent with two-sided than one-sided competition predictions, a result which is contrasted to that of many other species.

OSU Link
Non-OSU Link

21. Beddows, D. 2002. Levels-of-growing-stock cooperative study in Douglas-fir: Report No. 16 - Sayward Forest and Shawnigan Lake. Pacific-Forestry-Centre, Canadian-Forest-Service Information-Report BC-X-393. viii + 67 p.

Keywords: thinning
growth
tree morphology

Abstract: Results from the two levels-of-growing-stock installations at Sayward Forest and Shawnigan Lake on Vancouver Island, British Columbia, Canada, are summarized. Volume growth at both the site-III Sayward Forest installation to age 51 and the site-IV Shawnigan Lake installation to age 52 has been strongly related to level of growing stock. Basal area growth followed a similar, though weaker, trend. Thinning has affected stand development through tree size distribution and live crown development. Periodic annual increments in volume at both installations are still two to three times the mean annual increment, indicating the potential for productivity gains as the treated stands age. Results to date from both installations are similar to results from other cooperative installations, generally differing from the more productive sites only in the rate and degree of response associated with a lower site quality.

OSU Link
Non-OSU Link

22. Berch, S.M. and A.L. Roth. 1993. Ectomycorrhizae and growth of Douglas-fir seedlings preinoculated with Rhizopogon vinicolor and outplanted on eastern Vancouver Island. Canadian-Journal-of-Forest-Research 23(8): 1711-1715.

Keywords: nursery operations
mycorrhizal response
growth

Abstract: Ectomycorrhizal colonization of container-grown Douglas fir (Pseudotsuga menziesii) inoculated with Rhizopogon vinicolor was determined after cold storage and one growing season after outplanting (in March 1988) on a clear felled area on eastern Vancouver Island, British Columbia. Inoculated Douglas fir seedlings were taller than noninoculated controls when outplanted, but perhaps because of browse damage, no growth differences were found after one growing season in the field. R. vinicolor colonized all of the inoculated but none of the control seedlings examined after cold storage. Volunteer Thelephora terrestris colonized almost half of the control and 10% of the inoculated seedlings before outplanting. After one field season, inoculated and control seedlings were colonized by 15 ectomycorrhizal fungi each, only eight of which were found on both. R. vinicolor persisted on the roots

of inoculated plants, but was also present in the field soil since the control seedlings also bore these mycorrhizas after one growing season. The relative abundance of T. terrestris decreased from the nursery to the field. The other common ectomycorrhizas in the field included Mycelium radicis atrovirens, Cenococcum geophilum and types resembling Tuber and Endogone.

OSU Link
Non-OSU Link

23. Binkley, D. 1984. Importance of size-density relationships in mixed stands of Douglas-fir and red alder. Forest-Ecology-and-Management 9(2): 81-85.

Keywords: thinning
growth
tree/stand health

Abstract: Pairs of Douglas-fir, and Douglas-fir and red alder (Alnus rubra) stands were examined at four locations (in Oregon, Washington and British Columbia) for patterns in average tree size as a function of stand density. On fertile sites, the mixed stands experienced higher mortality than the pure conifer stands. On infertile sites, the pure conifer stands were well below the maximum tree size and density relationship compared to fertile sites or mixed stands, suggesting under-utilized site resources were available for nitrogen-fixing alder.

OSU Link
Non-OSU Link

24. Binkley, D. and P. Reid. 1984. Long-term responses of stem growth and leaf area to thinning and fertilization in a Douglas-fir plantation. Canadian-Journal-of-Forest-Research 14(5): 656-660.

Keywords: fertilization
thinning
tree morphology
carbon allocation
growth

Abstract: Replicated thinning and nitrogen fertilization plots in a 53-year-old plantation in Washington State were examined for repsonses in stem growth, leaf area, and stem growth per unit leaf area. Although measurements occurred 20-30 yr after plot installation, substantial effects from the various treatments were still present. Thinning reduced leaf area of the stands but increased stem growth per unit leaf area, resulting in little difference in stem growth per ha over the 5-yr measurement period (1977-81). Fertilization increased both stand leaf area and stem growth per unit leaf area, and more than doubled 5-yr stem growth per ha. Consideration of the role of leaf area and stem growth per unit leaf area in determining stand treatment responses may account for much of the variation found among replicates of treatments or between studies on different sites.

OSU Link
Non-OSU Link

25. Binkley, D. and P. Reid. 1985. Long-term increase of nitrogen availability from fertilization of Douglas-fir. Canadian-Journal-of-Forest-Research 15(4): 723-724.

Keywords: fertilization
growth
tree physiology
soil properties

Abstract: [See FA 44, 4708; 46, 1837] Most Douglas-fir stands respond to nitrogen fertilizing by increasing stem growth for less than 8 yr, but one plantation at the United States Forest Service Wind River Experimental Forest in Washington State has responded for over 15 yr. In this study nitrogen concn. of foliage and fresh litter were shown to be higher in the fertilized plots (470 kg/ha N) 18 yr after fertilizing. Retranslocation of N from senescent needles was not affected and stem growth per unit N in the canopy was similar between unfertilized and fertilized plots. An index of soil N availability in the fertilized plots was twice that of unfertilized plots. The higher stem growth, leaf area, and stem growth per unit leaf area demonstrated in an earlier study appeared to be related to a sustained increase in soil N availability rather than increased N-use efficiency. An examination of soil N transformation processes is needed to complete the explanation of the unusually prolonged fertilizer response in these plots.

OSU Link
Non-OSU Link

26. Birchler, T.M., R. Rose and D.L. Haase. 2001. Fall fertilization with N and K: effects on Douglas-fir seedling quality and performance. Western-Journal-of-Applied-Forestry 16(2): 71-79.

Keywords: nursery operations
nursery fertilization
growth
tree physiology
tree morphology
tree/stand health

Abstract: Coastal Douglas fir (Pseudotsuga menziesii) 1+1 seedlings from coastal Oregon, USA, were applied with two fertilizers (NH4NO3+K2SO4 and (NH4)2SO4+KCl) at four rates (0, 80, 160, 320 kg N and K/ha) split over three application dates (September 19, October 13, November 1, 1996). Fertilizer type did not affect total Kjeldahl nitrogen (TKN) levels on any of the sampling dates. By January 10, TKN concentrations had increased 16, 30 and 34%, and chloride concentrations had increased 57, 77 and 112% relative to the seedlings without fertilizer, for 80, 160 and 320 kg N+K/ha treatments, respectively. Nitrate levels increased briefly after the first application of NH4NO3+K2SO4. Potassium levels remained relatively unchanged. Levels of most other nutrients, as well as foliar dry weight, increased between September 16 and January 10, but these increases were generally unrelated to the fertilizer treatments. Root growth potential and cold hardiness did not differ among treatments. Seedlings that received 160 or 320 kg N/ha broke bud an average of 3 days earlier than the seedlings without fertilizer. Chlorophyll fluorescence (Fv/Fm) of seedlings with fertilizer was consistently higher than that of seedlings without fertilizer on November 13 and December 30. These treatment differences were not reflected in seedling outplanting performance after one growing season.

OSU Link
Non-OSU Link

27. Birot, Y. and C. Christophe. 1983. Genetic structures and expected genetic gains from multitrait selection in wild populations of Douglas fir and Sitka spruce. I. Genetic variation between and within populations. Silvae-Genetica 32(5/6): 141-151.

Keywords: genetic tree improvement
genetic relationships
growth
tree phenology
tree morphology

Abstract: For Douglas fir, 371 open-pollinated progenies from 26 provenances ranging from N. to S. along the western foothills of the Cascade Mts., Washington, were tested. For Sitka spruce, 292 open-pollinated progenies from 21 provenances ranging from S. British Columbia to middle-Oregon were tested. Observations were made on growth, phenology and form from the nursery stage up to age 12. Classical patterns of geographic variation were observed for both species. Heritability and genetic correlations varied from one provenance to another, especially for Douglas fir, and also changed over time. Sitka spruce showed high additive effects, offering good prospects of future genetic gains. It was concluded that preliminary investigations on genetic parameters were necessary before setting up a breeding strategy.

OSU Link
Non-OSU Link

28. Black, C.H. 1988. Interaction of phosphorus fertilizer form and soil medium on Douglas-fir seedling phosphorus content, growth and photosynthesis. Plant-and-Soil 106(2): 191-199.

Keywords: nursery operations
nursery fertilization
growth
tree physiology
photosynthesis

Abstract: Douglas-fir seedlings were grown in containers in peat-vermiculite or mineral soil each amended with different levels of concentrated superphosphate (CSP) or a granulated North Carolina phosphate rock (RP). Dilute acid-fluoride extractable phosphorus (DAP), seedling photosynthesis, weights, and tissue P concentrations were measured at 65 + 3 and 105 + 3 days.DAP was highly correlated with soluble fertilizer P (but not total P) added at the beginning of the experiment. Considerable soluble P was lost from peat-vermiculite but not from the mineral soil. Seedling total P content was proportional to the amount of soluble P per container at both harvests, but was greater for a given level of soluble P in the organic versus the mineral medium. Added soluble P increased foliar P concentrations, plant P content, and dry weight. Net carbon uptake was highly correlated with added levels of soluble P, foliar P concentrations, and with total P content. The internal efficiency of P from the RP source was less than P from CSP with respect to P content versus growth, net CO2 uptake, and net photosynthesis rates. At the end of the experiment, seedling P content plus DAP remaining in the media

for the higher fertilizer rates accounted for 75% of the originally added soluble P in the mineral soils, but for only 15% in the organic media.

OSU Link
Non-OSU Link

29. Blake, J., S.R. Webster and S.P. Gessel. 1988a. Soil sulfate-sulfur and growth responses of nitrogen-fertilized Douglas-fir to sulfur. Soil-Science-Society-of-America-Journal 52(4): 1141-1147.

Keywords: fertilization
soil properties
growth

Abstract: Two studies were conducted to determine the growth response of N-fertilized Douglas fir [Pseudotsuga menziesii (Mirb.) Franco] to S supplements. The relationship between response and soil SO4-S extracted with Morgan's solution, 1.22 M NaOAc + 0.53 M HOAc (pH 4.8), was used to establish critical levels for S. Douglas fir seedlings were grown in the greenhouse in the surface mineral layer (0 to 0.15 m) of 20 forest soils from western Washington and Oregon. On the average, significant increases in total dry weight (17.5%), stem diameter (10.1%), and height (6.9%) occurred when soils were fertilized with N and S in comparison to N alone. Using the Cate-Nelson procedure, growth responses to N and S were most likely to occur when soil SO4-S was below 14 mg S kg-1. Twenty eight installations were established in the field containing five treatments, three rates of N as urea, and one plot of 336 kg N ha-1 with P, K, Ca, and S. Differences in percent basal area growth between N alone and N with P, K, Ca, and S were significantly related to soil SO4-S. Over the initial 5-yr period, response over N alone was improved by 74% when soil SO4-S was <20 mg S kg-1. When the N with P, K, Ca, and S plots were retreated with only N and S, response over the next 3 yr was more than doubled compared with N alone. Identification of S responsive stands was improved by the inclusion of stand age weighted subsoil SO4-S concentrations.

OSU Link
Non-OSU Link

30. Blake, J.I., H.N. Chappell, W.S. Bennett, S.R. Webster and S.P. Gessel. 1990. Douglas fir growth and foliar nutrient responses to nitrogen and sulfur fertilization. Soil-Science-Society-of-America-Journal 54(1): 257-262.

Keywords: fertilization
tree physiology
growth

Abstract: Nitrogen-fertilizer response in conifer stands of the Pacific Northwest has been related to soil and foliar S, and growth has sometimes been enhanced by the addition of S. Five stands of Douglas fir (Pseudotsuga menziesii) in Washington or Oregon, with low to moderate quantities of sulfate in the mineral soil horizon, were treated with N (urea) alone or with S (as ammonium sulfate). The results indicated that levels of soil sulfate did not provide local or site-specific predictions of the magnitude of the gain from applying N with S. The observed treatment effects were highly variable. Foliar N concentrations in the N plus S treatment were generally higher than in the N treatment. Little change in

foliar S content occurred in the N plus S plot. Periodic annual growth response to N over the study period was inversely related to site index and directly related to foliar N content.

OSU Link
Non-OSU Link

31. Bledsoe, C.S. and R.J. Zasoski. 1983. Effects of ammonium and nitrate on growth and nitrogen uptake by mycorrhizal Douglas-fir seedlings. *In* Tree root systems and their mycorrhizas. *Ed.* D. Atkinson. pp. 445-454.

Keywords: nursery operations
nursery fertilization
growth
tree physiology
tree morphology
tree/stand health

Abstract: In a greenhouse pot study, 1-yr-old mycorrhizal (inoculated with Hebeloma crustuliniforme) and non-mycorrhizal Douglas fir seedlings were grown in sandy forest soil amended with 10% of clay minerals (bentonite and/or kaolinite) and ammonium or nitrate fertilizer. Ht. growth, root and shoot DM and accumulation of nitrogen and P were greater in mycorrhizal than non-mycorrhizal seedlings, especially in the nitrate treatment. Ammonium interacted with kaolinite to reduce survival which again was poorer in the absence of mycorrhiza.

OSU Link
Non-OSU Link

32. Brand, D.G. 1986a. A competition index for predicting the vigour of planted Douglas-fir in southwestern British Columbia. Canadian-Journal-of-Forest-Research 16(1): 23-29.

Keywords: planting operations
tree/stand health
growth

Abstract: As a method of quantifying brush competition, data from 124 planted Douglas firs, age 1-5 yr, were used to derive a competition index to predict changes in tree vigour measured as a relative production rate. The index, which includes measures of brush proximity, relative ht. and % ground cover, appears to act as a measure of light interception around the tree crown. Tree vigour was found to be largely a function of the age of the tree from planting and the competition index. Foliage-based measures of growth vigour were related more strongly to the index than measures of b.a. or ht. The index has potential for assessing interspecific competition problems on suitable sites. Caution must be used in extrapolating results outside Douglas fir plantations on moist rich sites in coastal BC.

OSU Link
Non-OSU Link

33. Brand, D.G. 1986b. Competition-induced changes in developmental features of planted Douglas-fir in southwestern British Columbia. Canadian-Journal-of-Forest-Research 16(2): 191-196.

Keywords: planting operations
tree morphology
tree physiology
growth

Abstract: From measurements in 1- to 5-yr-old plantations, developmental characteristics of Douglas fir were tested against a competition index based on measures of the brush canopy surrounding individual trees. The most promising characteristics for assessing competition were specific leaf area, the allometric relationship of ht. to b.a. and bud production on nodal shoots. Measures of foliar N and leaf internode length were less well correlated with the competition index. Comparing these results with those of laboratory studies indicated that, on the study sites, brush competition effects on planted trees are expressed through adaptation to reduced light intensity. Developmental variables relating to moisture and nutritional status were not as strongly related to the competition index. This may reflect reduced tree demand or secondary brush canopy effects.

OSU Link
Non-OSU Link

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

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

Abstract: In a multilevel study conducted at the Oregon State University's McDonald-Dunn Research Forest, Oregon, USA, to determine limits to underplanted conifer seedling growth, Douglas-fir (Pseudotsuga menziesii), grand fir (Abies grandis), western redcedar (Thuja plicata) and western hemlock (Tsuga heterophylla) seedlings were planted in January 1993 beneath second-growth Douglas-fir stands that had been thinned in 1992 to basal areas ranging from 16 to 31 m2/ha. Understorey vegetation was treated with a broadcast herbicide (glyphosate + imazapyr) application prior to thinning, a directed release herbicide (glyphosate, plus triclopyr for tolerant woody stems) application 2 years later, or no treatment beyond harvest disturbance. Residual overstorey density was negatively correlated with percent survival for all four species. Broadcast herbicide application improved survival of grand fir and western hemlock. Western redcedar, grand fir and western hemlock stem volumes were inversely related to overstorey tree density and this effect increased over time. There was a strong indication that this was also the case for Douglas-fir. Reduction of competing understorey vegetation resulted in larger fourth-year stem volumes in grand fir and western hemlock.

OSU Link
Non-OSU Link

35. Brandeis, T.J., M. Newton and E.C. Cole. 2002. Biotic injuries on conifer seedlings planted in forest understory environments. New Forests 24:1-14.

Keywords: planting operations
site preparation
chemical preparation
release treatments
chemical release
thinning
tree/stand protection
growth
tree/stand health

Abstract: The effects of partial overstorey retention, understorey vegetation management, and protective Vexar(R) tubing on the frequency and severity of biotic injuries in a two-storied stand underplanted with western redcedar (Thuja plicata), Douglas-fir (Pseudotsuga menziesii), grand fir (Abies grandis), and western hemlock (Tsuga heterophylla) were investigated. The most prevalent source of damage was browsing by black-tailed deer (Odocoileus hemionis columbiana); deer browsed over 74% of Douglas-fir and over 36% of western redcedar seedlings one or more times over the four years of this study. Neither the spatial pattern of thinning (even or uneven) nor the density of residual overstorey affected browsing frequency. Spraying subplots may have slightly increased browsing frequency, but the resulting reduction of the adjacent understorey vegetation increased the volume of all seedlings by 13%, whether or not they were browsed. Vexar(R) tubing did not substantially affect seedling survival, browsing damage frequency, or fourth-year volume. Greater levels of overstorey retention reduced frequency of second flushing. Chafing by deer and girdling by rodents and other small mammals began once seedlings surpassed 1 m in height. Essentially all grand fir seedlings exhibited a foliar fungus infection.

OSU Link
Non-OSU Link

36. Brix, H. 1984. Effects of thinning and nitrogen fertilization on growth of Douglas-fir: relative contribution of foliage quantity and efficiency. Canadian-Journal-of-Forest-Research 13(1): 167-175.

Keywords: fertilization
thinning
growth
carbon allocation
tree morphology

Abstract: [See FA 43, 1948, 3839] On Vancouver Island, aboveground biomass and annual production over 7 yr was studied in relation to thinning and nitrogen fertilization at 24 yr old. Biomass yield of both treatments increased during the first 3-4 yr then decreased for fertilization but not with thinning. Treatments doubled biomass production of individual trees over the study period when applied

separately and quadrupled it when combined. Annual biomass production per unit of foliage (E) increased during the first 3-4 yr, but was at or below control level after 7 yr. E accounted for 20, 37, and 27% of the stemwood dry matter response to thinning, fertilization and the combined treatments, respectively; the remainder was attributed to an increase in foliage biomass. Thinning, but not fertilization, influenced distribution of radial growth along the stem, increasing growth only below the top one-third of the stem. This pattern was related to crown development.

OSU Link
Non-OSU Link

37. 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, understorey response to thinning and fertilizer, and responses to P and S fertilizer.

OSU Link
Non-OSU Link

38. Busse, M.D., G.O. Fiddler and A.W. Ratcliff. 2004. Ectomycorrhizal formation in herbicide-treated soils of differing clay and organic matter content. Water, Air, and Soil Pollution 152:23-34.

Keywords: release treatments
chemical release
growth
tree morphology
tree/stand health
soil properties
mycorrhizal response

Abstract: Herbicides are commonly used on private timberlands in the western United States for site preparation and control of competing vegetation. How non-target soil biota respond to herbicide

applications, however, is not thoroughly understood. We tested the effects of triclorpyr, imazapyr, and sulfometuron methyl on ectomycorrhizal formation in a greenhouse study. Ponderosa pine, Douglas-fir, and white fir seedlings were grown in four forest soils ranging in clay content from 9 to 33% and organic matter content from 3 to 17%, and treated with commercial formulations of each herbicide at 0, 1.0, and 2.0 times the recommended field rate. Many of the possible herbicide-soil combinations resulted in reduced seedling growth. Root development was particularly sensitive to the three herbicides, with an average of 51% fewer root tips compared to the control treatment. The ability of mycorrhizal fungi to infect the remaining root tips, however, was uninhibited. Mycorrhizal formation was high, averaging 91% of all root tips, regardless of herbicide, application rate, soil type, or conifer species. In agreement, soil microbial biomass and respiratory activity were unaffected by the herbicide treatments. The results show that these herbicides do not alter the capability of mycorrhizal fungi to infect roots, even at concentrations detrimental to seedling growth.

OSU Link
Non-OSU Link

39. Cameron, I.R. 1988. An evaluation of the density management diagram for coastal Douglas-fir. BC Ministry of Forests FRDA-Report 024. vi + 17 p.

Keywords: planting operations
growth
yield

Abstract: Yield predictions based on Drew and Flewelling's (1979) density management diagram for coastal Douglas fir (Pseudotsuga menziesii) were compared with remeasured plot data from British Columbia. The diagram overestimated standing volume by 64% and mean diameter by 24% on average. Volumes predicted for plantations established at initial densities between 300 and 3000 trees per hectare exceeded nearly all the plots in the database. Because of the unattainable production targets set by the diagram, strategic plans based on its predictions would be seriously in error. Consequently, the diagram cannot be used in its current form as a silvicultural planning tool in stands of Douglas fir on the coast of British Columbia.

OSU Link
Non-OSU Link

40. Carr, W.W. 1987. Restoring productivity on degraded forest soils: two case studies. B.C. Ministry of Forests FRDA-Report 002. vi + 21 p.

Keywords: site preparation
fertilization
tree physiology
growth
soil properties

Abstract: The use of green fallowing was studied at 2 sites, viz. (a) a coastal site at Koksilah, 15 km NW of Shawnigan Lake, British Columbia, where extensive subsoil exposure had resulted from roading operations in a highly productive Douglas fir (Pseudotsuga menziesii) and western hemlock (Tsuga

heterophylla) stand, and (b) an inland site 30 km S. of Vanderhook including several landings and skid roads which had been deep-ripped to a depth of 50 cm, reducing soil density to 1350 kg/msuperscript 3. Plots at (a) were seeded in 1976 at 100 kg/ha with a grass/legume mixture including 3 spp. of Trifolium and Lotus corniculatus, and received NPK (10:30:10) at 450 kg/ha. Site nutrient levels improved substantially over 5 yr with N showing the greatest gains, and Douglas fir seedlings (1+2) planted in 1977 responded with increased foliar N and K contents and 300% greater ht. growth. Plots at (b) were seeded in 1981 at 40 kg/ha with a legume mixture of 3 spp. of Trifolium, Medicago sativa and L. corniculatus, and received NPK (19:19:19) at 300 kg/ha. Nutrient gains were found after 2 yr for P, K and especially N, and although foliar nutrient contents and growth of lodgepole pine (Pinus contorta) seedlings showed no increase, the enhancement of site nutrient capital is considered to be a gain likely to benefit commercial forestry production.

OSU Link
Non-OSU Link

41. Carter, R. and K. Klinka. 1992. Use of ecological site classification in the prediction of forest productivity and response to fertilisation. South-African-Forestry-Journal (160): 19-23.

Keywords: fertilization
growth
soil properties

Abstract: The results are presented of two related studies in southern coastal British Columbia. A total of 149 study plots in even-aged immature Douglas fir (Pseudotsuga menziesii) stands were categorized into 6 ecologically similar site associations (indicated best by climax plant communities) and into 15 soil moisture and soil nutrient combinations, for the prediction of site index. Fifty-one of these plots were used to predict basal area growth response to nitrogen fertilizer (225 kg N/ha as urea). Regression models indicated strong correlations between Douglas fir site index (m (height)/50 yr) and both indirect and direct measures of soil moisture and nutrient regimes (Rsuperscript 2 >0.72; p <0.01). Third-year basal area response to N fertilizer varied significantly among site associations (Rsuperscript 2 = 0.60; p <0.01). Site index also showed a significant relation with third-year basal area response (Rsuperscript 2 = 0.52; p <0.01), while the best predictive model included site associations and pretreatment foliar N and sulfate-S (Rsuperscript 2 = 0.64; p <0.01). It is suggested that the approach and methods of the study are applicable to predicting site-specific growth performance and response to fertilization of other tree species, including eucalypts.

OSU Link
Non-OSU Link

42. Carter, R. and R. Scagel. 1989. The effects of stand density and fertilization on stand development in immature coastal Douglas-fir. B.C. Ministry of Forests FRDA-Report 094. i + 15 p.

Keywords: fertilization
thinning
growth
tree morphology

Abstract: The effects of urea fertilizer were studied in Pseudotsuga menziesii stands spaced to 500, 750 and 1000 stems/ha in coastal British Columbia.

OSU Link
Non-OSU Link

43. Carter, R.E. and R.P. Brockley. 1990. Boron deficiencies in British Columbia: diagnosis and treatment evaluation. Forest-Ecology-and-Management 37(1-3): 83-94.

Keywords: fertilization
growth
tree/stand health

Abstract: Two case-studies are presented, outlining methods of diagnosis and treatment evaluation of boron deficiencies in a Douglas fir (Pseudotsuga menziesii) stand in coastal southern British Columbia and a lodgepole pine (Pinus contorta) stand near Burns Lake, in the interior of the province. Site conditions commonly associated with B deficiency are outlined, and relations between dormant-season foliar B concentration and growing-season precipitation and moisture stress are suggested. Diagnostic methods used in the study include examination of deficiency symptoms, and foliar-analysis techniques; evaluation of response for corrective fertilizer treatments is based on changes in frequency and severity of deficiency symptoms and growth responses, measured by graphical-analysis and changes in shoot length between treatments. Boron deficiencies and response to B fertilizers are difficult to confirm. Results of graphical-analysis and examination of frequency and severity of deficiency symptoms were inconclusive, while changes in shoot length identified a measurable response in the Burns Lake fertilizer trial with lodgepole pine. Deficiencies appear to be acute rather than chronic, and may not occur in untreated control trees for several years after establishment of fertilizer trials. Alternative causes for deficiency symptoms are also common, further complicating diagnosis and evaluation of response to treatment. It is concluded that all future trials should include nitrogen and/or other limiting nutrients with and without B to aid in identification of acute B deficiencies and deficiencies induced by increasing growth.

OSU Link
Non-OSU Link

44. Carter, R.E., E.R.G. McWilliams and K. Klinka. 1998. Predicting response of coastal Douglas-fir to fertilizer treatments. Forest-Ecology-and-Management 107(1/3): 275-289.

Keywords: fertilization
growth
soil properties

Abstract: A broadly-based, intensive Douglas-fir (Pseudotsuga menziesii) fertilizer experiment throughout southern coastal British Columbia (48 sites) was used to examine 3- and 6-yr crop tree growth responses to prescribed fertilizer applications (N alone, and N + additional nutrients identified as potentially deficient by foliar analysis). Absolute and relative basal area responses were evaluated in relation to site associations of the provincial ecosystem classification system, site index (SI), and a large number of site and stand chemical and physical properties. Few of the site and stand variables examined

as possible response prediction criteria appeared to have any real utility. The strongest relationships found were between relative basal area response and (1) site index (Rsuperscript 2 0.46 for both 3- and 6-yr responses), (2) mineral soil mineralizable-N (Rsuperscript 2 0.50 and 0.46 for yr 3 and 6 responses, respectively), and (3) total mineralizable-N (Rsuperscript 2 0.47 and 0.50 for yr 3 and 6 responses, respectively). In all cases average relative response declined with increasing site quality. However, there were highly productive sites (SI50 <more or =>35 m) characterized by an absence of growing-season water deficits and relatively low foliar N concentrations (12-13 g/kg) which showed significant fertilizer responses. These sites are where the greatest financial returns from fertilizing may be realized. Relationships identified between site and stand variables and basal area responses were, in many cases, different from those found by other researchers for coastal Douglas fir. This brings the portability of identified relationships into question.

OSU Link
Non-OSU Link

45. 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

46. Castellano, M.A. and J.M. Trappe. 1985. Ectomycorrhizal formation and plantation performance of Douglas-fir nursery stock inoculated with Rhizopogon spores. Canadian-Journal-of-Forest-Research 15(4): 613-617.

Keywords: nursery operations
growth
mycorrhizal response

Abstract: Basidiospores (0, 106, 107 or 108) of 7 species of hypogeous, ectomycorrhizal fungi were applied to 1-msuperscript 2 plots sown with 4 conifer species (Pseudotsuga menziesii, Pinus lambertiana, Abies concolor and Tsuga heterophylla) in a bare-root nursery inOregon. Inoculation with

either Rhizopogon vinicolor or R. colossus succeeded with 2 provenances of Douglas-fir only. For R. vinicolor, the high spore-application rate produced the most mycorrhizae on the greatest number of seedlings. For R. colossus, the high spore-application rate produced the most mycorrhizae on the greatest number of seedlings of one seed source, while the medium rate did better with the other. Stem height and root collar diameter of seedlings did not differ significantly between treatments and controls. Douglas-fir seedlings inoculated or not inoculated with spores of R. vinicolor were outplanted at 2 yr old in southwestern Oregon. After 2 yr, inoculated seedlings had significantly greater survival, stem height, root collar diameter, and biomass than noninoculated seedlings. Although new feeder roots of both noninoculated and inoculated seedlings were colonized by indigenous fungi, R. vinicolor persisted on the old root systems of inoculated seedings and colonized new feeder roots.

OSU Link
Non-OSU Link

47. Castellano, M.A. and J.M. Trappe. 1991. Pisolithus tinctorius fails to improve plantation performance of inoculated conifers in southwestern Oregon. New-Forests 5(4): 349-358.

Keywords: nursery operations
growth
mycorrhizal response

Abstract: Bare root seedlings of Douglas fir (Pseudotsuga menziesii), lodgepole pine (Pinus contorta), white fir (Abies concolor), and grand fir (Abies grandis) were inoculated with Pisolithus tinctorius and subjected to standard nursery and cold storage practices. At age 2 years, seedlings were assessed for mycorrhizal status, and were planted out on a variety of sites in SW Oregon. After 1, 2 and 3 growing seasons root collar diameter and current year's shoot growth were measured (or a lateral branch if browsing had damaged main shoot). Results showed that inoculated seedlings performed no better than those which had not been intentionally inoculated but which had formed mycorrhizae with indigenous, nursery fungi (e.g. Thelephora terrestris, and possibly Inocybe spp.). Climate, planting sites and nursery practices in the Pacific Northwest differ drastically from those in the southeastern United States, where P. tinctorius has increased plantation survival and growth. It is concluded that further research is necessary on P. tinctorius and nursery inoculation of tree seedlings in thePacific Northwest.

OSU Link
Non-OSU Link

48. Chanway, C.P. 1997. Inoculation of tree roots with plant growth promoting soil bacteria: an emerging technology for reforestation. Forest-Science 43(1): 99-112.

Keywords: nursery operations
tree/stand protection
growth
tree/stand health
mycorrhizal response

Abstract: Results from studies performed with beneficial asymbiotic tree root associated bacteria are reviewed in this article in relation to the possible uses of such microorganisms for artificial forest

regeneration. The review includes sections on plant growth promoting bacteria for pine (Pinus spp.), spruce (Picea spp.), Douglas fir (Pseudotsuga menziesii) and hemlock (Tsuga heterophylla). Seedling root systems are colonized heavily by asymbiotic soil bacteria, many of which have the potential to influence plant growth significantly. A heterogeneous group of these microorganisms is well known for their ability to colonize roots and stimulate growth of agricultural plant species, sometimes doubling seedling biomass accumulation only a few weeks after inoculation, but more usually resulting in less spectacular biomass gains (e.g., 15%-30% greater than uninoculated controls within a growing season). Plant growth promoting soil bacteria may exert such effects through a variety of mechanisms, and include microorganisms that stimulate seedling emergence or infection by symbiotic fungi and bacteria. Other plant beneficial soil bacteria possess biological control activity or are capable of transforming plants genetically. Inoculation of tree seedlings with such bacterial before outplanting would be an inexpensive, environmentally benign, and easily applied nursery treatment, but comparatively little work has been performed with these microorganisms in forestry. Recent results with various tree species, however, indicate that seedling performance can be significantly enhanced through bacterial inoculation of root systems: pine and spruce biomass increased 32%-49% 1 yr after inoculation and outplanting at a reforestation site. In addition, infection by desired species of ectomycorrhizal fungi can also be enhanced by inoculation with certain strains of root colonizing bacteria.

OSU Link
Non-OSU Link

49. Chanway, C.P., R.A. Radley and F.B. Holl. 1991. Inoculation of conifer seed with plant growth promoting Bacillus strains causes increased seedling emergence and biomass. Soil-Biology-and-Biochemistry 23(6): 575-580.

Keywords: nursery operations
growth
tree morphology

Abstract: Seeds of lodgepole pine (Pinus contorta), Douglas fir (Pseudotsuga menziesii) and white spruce (Picea glauca) were collected from 3 sites in British Columbia. Inoculation with Bacillus strains L5 and L6 significantly increased the rate of seedling emergence of spruce but did not affect subsequent seedling growth. Pine root growth was promoted by strain L5 in sterilized, but not non-sterile, growth medium. Strain L6 promoted pine root growth in sterilized medium, but also caused significant increases in seedling emergence, shoot weight and height, root weight and surface area, and root collar diameter when tested in non-sterile peat-vermiculite medium. The positive effects due to a single inoculation of pine with strain L6 at sowing were not detectable after 12 weeks growth. However, root growth was stimulated after 16 weeks growth if seedlings were re-inoculated with strain L6 mid-way through the experiment. Shoot-growth promotion was also detected when 1-yr-old pine seedlings were planted in pots and inoculated with strain L6. Douglas fir seedlings grown from seed inoculated with strain L5 had increased root collar diameters, whereas those inoculated with strain L6 exhibited increased root surface area.

OSU Link
Non-OSU Link

50. Chapman, R.J. 1984. Growth, nitrogen content and water relations of sludge-treated Douglas-fir seedlings. Forestry-Abstracts 45(7): 385-386.

Keywords: fertilization
growth
tree physiology

OSU Link
Non-OSU Link

51. Cochran, P.H., W. Lopushinsky and P.D. McColley. 1986. Effect of operational fertilization on foliar nutrient content and growth of young Douglas-fir and Pacific silver fir. Pacific-Northwest-Research-Station,-USDA-Forest-Service Research-Note PNW-RN-445. 10 p.

Keywords: fertilization
tree physiology
growth

Abstract: During 1979-80, sulfated urea (pelletted) was applied to conifer stands in the Wenatchee National Forest, west of Cle Elum, Washington. Nitrogen concn. in current needles of Pacific silver fir (Abies amabilis) showed a significant 1.9-fold increase after fertilizer treatment compared with a non-significant 1.3-fold increase in Douglas fir (Pseudotsuga menziesii). A significant 2.5-fold increase in foliar N also occurred in bracken (Pteridium aquilinum). Analysis of foliage from untreated trees indicated N deficiency in A. amabilis, but N concn. in Douglas fir was above threshold values. Fertilizer treatment did not affect foliar S in either species, but increased needle surface area for A. amabilis. Tree diam. growth, stand b.a. growth and vol. growth were all increased by fertilizer treatment.

OSU Link
Non-OSU Link

52. 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

53. Cole, E.C. and M. Newton. 1987. Fifth-year response of Douglas-fir to crowding and nonconiferous competition. Canadian-Journal-of-Forest-Research 17(2): 181-186.

Keywords: release treatments
chemical release
growth
tree morphology

Abstract: Measurements were made in autumn 1982 in 5-yr-old plantations with trees spaced 17-123 cm apart, alone or with grass or red alder (Alnus rubra) on 3 site types in the Oregon Coast Range. Crowding and competition from both grass and alder reduced aboveground dry wt. per tree. Dry wt./ha was higher at higher tree densities, but this is expected to change with time as the larger trees at low densities form fully stocked stands. Grass showed the greatest effect on growth at the driest site. Although red alder decreased growth on all sites, the effect was most significant at the coastal site where light is most limiting and moisture least limiting. For the production of max. individual tree size, low stocking with control of competing vegetation is recommended.

OSU Link
Non-OSU Link

54. Cole, E.C. and M. Newton. 1989a. Height growth response in Christmas trees to sulfometuron and other herbicides. Proceedings-of-the-Western-Society-of-Weed-Science (Vol. 42): 129-135.

Keywords: release treatments
chemical release
growth
tree/stand health
stand conditions

Abstract: Abies procera, A. grandis and Pseudotsuga menziesii cv. Menziesii were evaluated for tolerance to sulfometuron (0.05-0.21 kg/ha), atrazine (4.5 kg/ha) and hexazinone (2.2 kg/ha). Herbicides were applied pre-budbreak and sulfometuron was also applied post-budbreak. Weeds were suppressed equally effectively by all rates and herbicides pre-em. Low rates of sulfometuron were less effective post-em. There was no significant damage to A. procera seedlings, although the highest rate of sulfometuron slowed growth significantly. A. grandis was not affected by any treatment. All treatments caused injury to 1-year-old P. menziesii, primarily needle chlorosis and slight stunting. Growth was best in atrazine-treated plots. For 3-year-old P. menziesii, injury was not significant but high rates of sulfometuron caused cosmetic damage. Best growth was observed with hexazinone and worst with sulfometuron. Post-budbreak applications and high rates of sulfometuron reduced growth more than pre-budbreak application and low rates.

OSU Link
Non-OSU Link

55. Coleman, M., J. Dunlap, D. Dutton and C. Bledsoe. 1987. Nursery and field evaluation of compost-grown conifer seedlings. Tree-Planters' Notes 38(2): 22-27.

Keywords: nursery operations
nursery fertilization
growth
tree physiology
tree/stand health

Abstract: Seedlings of Douglas fir (Pseudotsuga menziesii), noble fir (Abies procera) and ponderosa pine (Pinus ponderosa) were raised in beds that had been treated with 0, 2, 4 or 6 inches of compost (fir/hemlock sawdust and municipal sewage sludge, 3:1) at a nursery in Carson, Washington. In autumn 1983, the 2+0 stock was lifted, stored until spring 1984 and then planted out on Mt. St. Helens, Washington (Douglas fir), near Estacada, Oregon (noble fir) or E. of the Cascade crest near Leavenworth, Washington (ponderosa pine). Data are given on the ht., biomass and concn. of N, P, Zn, Cu, Pb, Ni and Cd after 1 yr in the nursery beds and on the ht. and survival for 2 yr after planting. The responses of the seedlings to the compost, the immobilization of nutrients and the accumulation of heavy metals are discussed.

OSU Link
Non-OSU Link

56. Colinas, C., D. Perry, R. Molina and M. Amaranthus. 1994b. Survival and growth of Pseudotsuga menziesii seedlings inoculated with biocide-treated soils at planting in a degraded clearcut. Canadian-Journal-of-Forest-Research 24(8): 1741-1749.

Keywords: planting operations
fertilization
growth
tree/stand health
tree morphology

Abstract: To determine the factors of transfer soils responsible for increased seedling survival and growth, planting holes, at a site in SW Oregon, were inoculated with forest, plantation, and clear-cut soils subjected to one of 8 treatments: (i) treated with fertilizer to test for effects of nutrients; treated with biocides to test for effects of (ii) grazers (microarthropods or nematodes), (iii) protozoa, (iv) fungi, or (v) bacteria; (vi) pasteurized; (vii) Tyndallized; or (viii) untreated. Douglas fir (Pseudotsuga menziesii) seedlings were planted in June 1990 and seedling growth and survival was assessed in December 1990. Survival was increased by inoculation with untreated plantation soils, but not if they were fertilized or treated with dimethoate + carbofuran (grazercide), fumagillin (protozoacide), or oxytetracycline + penicillin (bactericide). Addition of untreated forest soil did not increase survival. For all soils, survival was increased by captan (fungicide), pasteurization and Tyndallization. Untreated plantation and forest soil transfers increased dry weights whereas neither did when treated with dimethoate + carbofuran. Dry weights of seedlings given clear-cut soil were increased by fertilization, pasteurization and Tyndallization of the soil; the latter two treatments also increased the number of short roots. It is hypothesized that stimulation of seedling growth by soil transfers was related to an increased rate of nutrient mineralization due to microbivorous soil animals contained within the transfer soils. Soil transfers may have enhanced seedling survival by at least two mechanisms: (i) by providing a safe site

for beneficial rhizosphere organisms to proliferate, free from competing organisms that have proliferated in the clear-cut soil; and (ii) through volatile organic compounds, especially ethylene, that stimulated seedling root growth.

OSU Link
Non-OSU Link

57. Copes, D.L. 1980. Effect of root stock vigor on leader elongation, branch growth, and plagiotropism in 4- and 8-year-old Douglas-fir grafts. Tree-Planters' Notes 31(1): 11-14.

Keywords: genetic tree improvement
tree grafting
growth
tree morphology

Abstract: In treatment (a) 2-yr-old seedling rootstocks were planted in containers in 1969 and scions from Oregon and Washington plantations grafted on in April 1970. The grafted trees were moved to transplant beds in Nov. 1970 and finally to field positions in Oregon in Dec. 1979. In treatment (b), rootstocks of the same age were bare-root planted in Nov. 1970 and scions grafted in April 1974. Graft growth was examined in May 1978. Field-grafted trees (b) showed upright tree form, significantly greater leader growth p.a. and longer branches in the 1976 whorl. Some 61% of container-grafted trees (a) showed a noticeable lean from vertical compared with none of the field grafted trees.

OSU Link
Non-OSU Link

58. Copes, D.L. 1983. Failure of grafted Douglas-fir planted at Monterey, Calif. Tree-Planters' Notes 34(3): 9-10.

Keywords: genetic tree improvement
tree grafting
growth
tree/stand health
tree phenology

Abstract: Trees were grafted onto established rootstocks (grown from rooted cuttings from Oregon or seedlings from California) in Oregon in April 1979, and in Dec. 109 of these were transplanted to a site on the Monterey Peninsula, California. Grafts were examined in July 1981. More than 30% of the transplanted grafts had died of early incompatibility and the cumulative 1980 and 1981 leader growth of the survivors averaged 12 cm. Identical grafts in Oregon showed 2-10% death due to incompatibility and av. leader growth of 1-2 m. It is suggested that the atypical unreliable budflush and reduced leader elongation in Monterey was due to winter temperatures that were not cool enough to satisfy bud dormancy requirements. It had been hoped to establish seed orchards out of range of pollen contamination from local Douglas fir stands.

OSU Link
Non-OSU Link

59. Copes, D.L. 1999. Breeding graft-compatible Douglas-fir rootstocks (Pseudotsuga menziesii (MIRB.) FRANCO). Silvae-Genetica 48(3/4): 188-193.

Keywords: genetic tree improvement
tree grafting
tree/stand protection
growth
tree phenology
tree/stand health
genetic relationships

Abstract: A study encompassing 24 years was conducted to determine if a breeding programme could produce highly graft-compatible rootstocks for P. menziesii. A total of 27 trees of apparent high graft compatibility were selected and crossed to produce 226 control-pollinated families. Seedlings were grown, field planted and grafted with test scions. Graft unions from field tests were evaluated anatomically for internal symptoms of incompatibility. Average compatibility of progeny from the 226 crosses was 90.6%, compared with 65% in native populations. Breeding values were calculated for each parent by the best linear prediction (BLP) procedure. Average compatibility resulting from crossing among the top 10 parents was estimated by breeding values as 95.4%. Field-test results of progeny from 34 crosses among the 10 most compatible parents showed 96% compatibility. In addition to field-tests for graft compatibility, nursery tests of seedlings from 124 crosses were evaluated for second-year vegetative bud flush and seedling height. It was possible, while maintaining adequately high levels of graft compatibility, to breed both for resistance to spring frost damage and for increased seedling height.

OSU Link
Non-OSU Link

60. Crouch, G.L. and M.A. Radwan. 1981. Effects of nitrogen and phosphorus fertilizers on deer browsing and growth of young Douglas-fir. Pacific-Northwest-Forest-and-Range-Experiment-Station,-USDA-Forest-Service. Research-Note PNW-RN-368. 15 p.

Keywords: fertilization
tree/stand health
growth
tree physiology

Abstract: N and P fertilizers were applied in March 1968 singly or in combination at a rate equivalent to 200 lb/acre of N or P to young trees (2-5 ft tall) in Oregon and Washington. Trees were examined and measured for up to 4 yr. In the first year after treatment trees given the N-only fertilizer in Washington were more heavily browsed by black tailed deer (Odocoileus hemionus columbianus), but this effect disappeared in the second year. Height growth was increased by N-only treatment in taller trees in Oregon after 1 and 2 yr, but the effect had disappeared after 4 yr. Total N content was significantly increased by the N and N + P treatments in the first year, but this effect also disappeared after 2 yr. The amounts of moisture, ash, Ca and P, and diam. growth were not affected by any treatments.

OSU Link
Non-OSU Link

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

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

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

OSU Link
Non-OSU Link

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

Keywords: thinning
commercial thinning
growth

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

OSU Link
Non-OSU Link

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

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

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

OSU Link
Non-OSU Link

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

Keywords: thinning
commercial thinning
growth
yield

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

of the controls. A discussion of the results includes: a comparison with other thinning studies; an analysis of application of the Langsaeter hypothesis (that the same cubic volume production could be obtained over a wide range of stand densities); growth trends and rotations; thinning gains; non-timber values; and critical analysis of the study design. The continuing value of the demonstration stands is discussed.

OSU Link
Non-OSU Link

65. Dangerfield, J. and H. Brix. 1981. Comparative effects of ammonium nitrate and urea fertilizers on tree growth and soil processes. *In* Proceedings: Forest Fertilization Conference, University of Washington, Seattle, Washington, USA. *Eds.* S.P. Gessel, R.M. Kenady and W.A. Atkinson. pp. 133-139.

Keywords: fertilization
thinning
growth
tree physiology

Abstract: Growth response of Douglas-fir to ammonium nitrate and urea, applied at rates of 200 and 400 pounds per acre (224 and 448 kilograms of nitrogen per hectare), was studied over a 7-year period at Shawnigan Lake, B.C. Diameter growth was 21 and 9 percent better, respectively, for the two rates with ammonium nitrate than with urea in unthinned plots and 7 percent better for plots that had been thinned and received 400 pounds per acre (448 kilograms nitrogen per hectare). Foliar nitrogen concentrations also increased most with ammonium nitrate fertilzization during the first 2 years, indicating that nitrogen from this source was initially more readily available to the trees. This is explained in part by the greater mobility of nitrate supplied by ammonium nitrate and by nitrogen immobilization in buildup of bacterial populations with urea.

OSU Link
Non-OSU Link

66. DeBell, D.S., C.A. Harrington and J. Shumway. 2002. Thinning shock and response to fertilizer less than expected in young Douglas-fir stand at Wind River Experimental Forest. Pacific-Northwest-Research-Station,-USDA-Forest-Service Research-Paper PNW-RP-547. ii + 20 p.

Keywords: fertilization
thinning
precommercial thinning
growth

Abstract: Three thinning treatments (thinned to 3.7 by 3.7 m, thinned to 4.3 by 4.3 m, and an unthinned control treatment with nominal spacing averaging 2.6 by 2.6 m) were installed in a 10-year-old Douglas-fir (Pseudotsuga menziesii) plantation growing on a low-quality site at the Wind River Experimental Forest in southwest Washington, USA. Two years after thinning, two fertilizer treatments were superimposed on the design (0 and 224 kg per ha of nitrogen applied as ammonium nitrate). Diameter growth increased with increasing spacing throughout the 6-year study period, and it

was also increased by fertilizer in both the thinned and unthinned (control) treatments. Thinning shock, a reduction in height growth after thinning, was expected at this study site because severe thinning shock had been documented in earlier nearby trials. Height growth was initially reduced slightly by thinning, but by the third 2-year period after thinning, height growth in thinned, unfertilized treatments was equal to or greater than height growth in the unthinned, unfertilized treatment. Fertilizer application increased height growth on average by 13 per cent in the first 2 years after fertilizer application. In the third and fourth years after fertilizer application, however, fertilizer increased average height growth by 9 per cent, but the increase was substantial (16 per cent) only in the unthinned control treatment. The mild, ephemeral nature of thinning shock in our study was in contrast to the severe, long-lasting shock in earlier studies at Wind River. The milder shock in our study could be related to one or more of the following: (1) thinning was done at an early age, (2) impacts of fire (natural or prescribed) preceding planting were minor, and (3) seed source of the planted stock was appropriate for the location. Based on comparisons with other studies at Wind River and elsewhere, we suspect that use of nonlocal, maladapted seed sources in the earlier studies may have predisposed those trees to thinning shock. Furthermore, we suspect that the much higher responses to fertilizer application reported in the earlier studies may be associated with intense natural fires prior to planting, and the reduced nutritional status of those sites may have been further exacerbated by the use of maladapted seed sources.

OSU Link
Non-OSU Link

67. DeBell, D.S., R.R. Silen, M.A. Radwan and N.L. Mandel. 1986. Effect of family and nitrogen fertilizer on growth and foliar nutrients of Douglas-fir saplings. Forest-Science 32(3): 643-652.

Keywords: fertilization
growth
tree physiology

Abstract: Urea (224 kg N/ha) was applied to 12-yr-old Douglas fir of 12 open-pollinated families growing near Corvallis, Oregon. Ht. and d.b.h. were measured before fertilization in Feb. 1979 and 4 growing seasons later, and tree vol. were estimated. Vol. increment varied among families, but was increased by an av. 7% by fertilizer. Concentrations of foliar nutrients, analysed in winter 1979 and 1980, differed significantly between families and in response to fertilization. The familyxfertilizer interaction was not significant for any growth or foliar nutrient measured.

OSU Link
Non-OSU Link

68. Dimock, E.J., II and E.B. Collard. 1981. Postplanting sprays of dalapon and atrazine to aid conifer establishment. Pacific-Northwest-Forest-and-Range-Experiment-Station,-USDA-Forest-Service Research-Paper PNW-RP-280. iii + 16 p.

Keywords: release treatments
chemical release
growth
tree/stand health

stand conditions

Abstract: A mixture of dalapon and atrazine at 8 and 4 lb/acre, respectively, or dalapon or atrazine alone were applied to control perennial grasses and forbs competing with newly planted seedlings of ponderosa pine and Douglas fir. In 4 studies in Oregon in 1975, herbicides were spot sprayed around individual seedlings. In 2 studies in Washington and Oregon in 1976, herbicides were broadcast sprayed. The mixture consistently controlled grass and forbs better than either herbicide alone, reducing grass and forb cover respectively by 80-82% and 48-58% in the first year. Control persisted for 2-4 yr. Varying results are reported as to the effects of the different treatments on height growth and survival.

OSU Link
Non-OSU Link

69. Donald, D.G.M. and D.G. Simpson. 1985. Shallow conditioning and late fertilizer application effects on the quality of conifer nursery stock in British Columbia. B.C.-Ministry-of-Forests Research-Note 99. viii + 36 p.

Keywords: nursery operations
nursery fertilization
tree/stand protection
tree morphology
tree/stand health
growth

Abstract: Eight trials on 2+0 stock of Picea engelmannii, P. glauca, P. sitchensis, Pinus contorta and Pseudotsuga menziesii (var. glauca and var. menziesii) in 4 nurseries were conducted to compare the effects of shallow conditioning (undercutting and wrenching at 10 cm deep) with those of the standard conditioning regime (undercutting and wrenching at 20 cm) on nursery performance, storage and field performance. The application of a complete NPK fertilizer 50 days before lifting was also evaluated. Shallow conditioning and late fertilizer application improved the root growth capacity at lifting, but could not replace cold exposure for hardening Pseudotsuga menziesii. Shallow conditioning had little effect on survival after planting and reduced initial ht. increment of all species. Application of fertilizer just before lifting improved the early growth of the trees without adversely affecting survival. Planting seedlings some 5 cm deeper than they stood in the nursery improved establishment.

OSU Link
Non-OSU Link

70. Dosskey, M.G., L. Boersma and R.G. Linderman. 1993. Effect of phosphorus fertilization on water stress in Douglas fir seedlings during soil drying. Plant-and-Soil 150(1): 33-39.

Keywords: fertilization
tree/stand protection
growth
tree physiology
photosynthesis

Abstract: A growth chamber experiment was conducted to determine if P fertilizing to enhance the P nutrition of otherwise N and P deficient Douglas fir (Pseudotsuga menziesii) seedlings reduces water stress in the seedlings during drought periods. Seedlings were grown in pasteurized mineral soil under well watered conditions and fertilized periodically with a small amount of nutrient solution containing P at three levels: 0, 20, or 50 mg/litre. By age 6 months, leaf nutrient analysis indicated that N and P were deficient in control (0 mg P/litre) seedlings. The highest level of P fertilizer, which doubled leaf P concentration, did not affect plant biomass, suggesting that N deficiency was limiting growth. When these seedlings were subjected to drought, there was no effect of P fertilizing on leaf water potential or osmotic potential. Furthermore, P fertilized seedlings had lower stomatal conductance and net photosynthesis rate. These results indicate that enhanced P nutrition, in the presence of N deficiency, does not reduce water stress in Douglas fir seedlings during drought periods.

OSU Link
Non-OSU Link

71. Drew, A.P. 1983. Optimizing growth and development of 2-0 Douglas-fir seedlings by altering light intensity. Canadian-Journal-of-Forest-Research 13(3): 425-428.

Keywords: nursery operations
tree/stand protection
growth
tree morphology
carbon allocation

Abstract: Seedlings were grown outdoors in Michigan in pots under 71% of full light the first growing season and full light the second. Another group of seedlings was given full light continuously for 2 yr. At the end of the 1st year, seedlings given initial shade had grown larger in total wt. (root + shoot) than those grown under full light. With removal of shading, the larger plants began to allocate increased dry matter to root development relative to their shoots. By the end of 2 yr, shoot/root ratios for the 2 groups were no different, yet the plants shaded in their 1st year were significantly heavier (dry wt.) By proper use of shading during development, larger 2+0 planting stock with good root development may be produced. Such stock, grown without the use of costly fertilizer, may be better suited to regeneration of droughty sites in the Pacific Northwest USA than the usual 2+0 planting stock, nursery grown under full light.

OSU Link
Non-OSU Link

72. Driessche, R.v.-d. 1983. Growth, survival, and physiology of Douglas-fir seedlings following root wrenching and fertilization. Canadian-Journal-of-Forest-Research 13(2): 270-278.

Keywords: nursery operations
nursery fertilization
tree/stand health
tree morphology
tree physiology
growth

Abstract: Seedlings at different nurseries on Vancouver Island were subjected to wrenching treatments during their 2nd year of growth using a fixed blade at 20-25 cm below the bed surface. In the first experiment, wrenching reduced water potential of trees on unirrigated loam soil by an av. of 300 kPa during Aug. and Sept. Wrenched trees lifted in Oct. and stored at 2 degrees C until May, showed 25% higher survival than unwrenched trees 1 yr after planting. Trees lifted in Dec. had uniformly high survival (98%) and showed no effect of wrenching. Wrenched trees from irrigated plots had lower shoot length relative growth rates (RGR) than unwrenched trees during the year after planting. In the second experiment, wrenching treatments were applied to seedlings, growing in a loamy sand, for different periods between 15 May and 11 Sept. as follows: (a) no wrenching, (b) early summer, (c) midsummer, (d) late summer and (e) all summer. Three fertilizer treatments (none, and 2 amounts of NPK) were applied to each wrenching treatment, and seedlings were lifted for storage at 2 degrees C in Oct. and Dec. Stored trees and freshly lifted trees were planted at 700 m alt. on 3 March. Wrenching increased root dry wt., particularly when additional fertilizer was applied, but had no measurable effect on cold hardiness or root growth capacity. Nevertheless, late summer wrenching increased survival 5 and 7% above control 1 and 2 yr after planting. Wrenching had little subsequent effect on new shoot growth of planted trees during the 2 yr after planting. However, late-summer wrenched trees showed significantly more new shoot growth than all-summer wrenched trees. More fertilizer reduced cold hardiness and survival of cold-stored trees, but increased root growth capcity. Cold hardiness (measured by electrical impedance) was correlated with survival of cold-stored trees after planting (rsuperscript 2 = 0.82). Root growth capacity, averaged over all fertilizer treatments was closely correlated with survival of stored and freshly lifted trees (rsuperscript 2 = 0.93). Foliar nutrient concn. were reduced by wrenching, but fertilizing increased nutrient reserves within the seedling.

73. Driessche, R.v.-d. 1984a. Response of Douglas fir seedlings to phosphorus fertilization and influence of temperature on this response. Plant-and-Soil 80(2): 155-169.

Keywords: nursery operations
nursery fertilization
growth
tree physiology
carbon allocation
tree morphology

Abstract: In pot experiments levels of P fertilizers equivalent to 300 kg/ha were adequate for maximum growth of Douglas fir (Pseudotsuga menziesii var. menziesii) seedlings over 14-18 weeks, and resulted in available soil P levels of 80 ppm after 15 weeks' growth. Maximum growth in pots was obtained with shoot P concentrations of 0.18%-0.20%, with higher values at lower temperatures, but the optimum concentration for one-year-old (1-0) nursery seedlings was 0.16% P. Growth of seedlings was greatly restricted at a soil temperature of 5 degrees C and an air temperature of 12 degrees C. At a soil temperature of 10 degrees C and an air temperature of 14 degrees C seedling P requirement was greater than at soil and air temperatures of 20 degrees C. Monoammonium phosphate was more effective than calcium superphosphate in stimulating growth in pots and nursery beds. Triple superphosphate was also effective in the nursery. Diammonium phosphate, potassium dihydrogen phosphate and phosphoric acid had no advantages as P sources in the nursery. Available P levels of 100-130 ppm, in the loamy sand and sandy loam nurseries studied, and needle P concentrations of 0.18%,

when sampled in October, were associated with maximum growth of two-year-old (2-0) seedlings. P fertilization decreased the root/shoot ratio, but did not alter the allometric relationship of shoot to root. Improving the P status from a low level increased the root growth capacity in 2-0 seedlings and P fertilization of potted seedlings increased the dry weight/height ratio. Uptakes per seed bed ha of 236 kg N, 31 kg P, 81 kg K and 73 kg Ca by 2-0 seedlings were comparable with, or greater than, uptake rates of agricultural crops. Recoveries of 6-11% of P from fertilizer were recorded in the nursery.

OSU Link
Non-OSU Link

74. Driessche, R.v.-d. 1984b. Seedling spacing in the nursery in relation to growth, yield, and performance of stock. Forestry-Chronicle 60(6): 345-355.

Keywords: nursery operations
growth
tree morphology
carbon allocation
tree physiology
tree/stand health

Abstract: In 3 experiments at nurseries in coastal British Columbia Picea sitchensis, P. glauca, Pinus contorta var. latifolia, Thuja plicata and coastal and interior varieties of Pseudotsuga menziesii were sown in May 1979, 1980 or 1982 and grown at spacings ranging from 0.5 to 12 cm. A 1-cm increase in spacing increased seedling dry wt. by 0.5-1.5 g and root collar diam. by 0.2-0.25 mm up to a spacing of about 8-10 cm. Above this, response was less. Ht. of 2-yr-old seedlings was increased slightly or even decreased by wider spacing. Height : diameter ratios decreased sharply and shoot : root dry wt. decreased or remained unchanged with wider spacing. The number of needle primordia in 2-0 P. menziesii buds increased up to a spacing of 2 cm, and the number of 1st and 2nd order branches were also increased by wider spacing. Increases in root growth capacity were associated with wider spacing in T. plicata and Picea sitchensis. In a test of 3 types of precision seeders, none produced anything like accurate seed placement. Irregularity was increased by 10-20% non-viable seed and winter mortality. Increased spacing of 2-5 cm between seedlings was justified by the yield of acceptable seedlings only when the culling standard was increased to a root collar diam. of about 6 mm. Three yr after planting out the survival of P. glauca was increased 11% by wider spacing. After 2 yr P. sitchensis survival was increased 13% by wider spacing. Both species grown at wider spacing maintained a ht. and diam. advantage over those from close spacing.

OSU Link
Non-OSU Link

75. Driessche, R.v.-d. 1988a. Nursery growth of conifer seedlings using fertilizers of different solubilities and application time, and their forest growth. Canadian-Journal-of-Forest-Research 18(2): 172-180.

Keywords: nursery operations
nursery fertilization
growth
carbon allocation

tree physiology
tree/stand health

Abstract: Beginning in May 1982, seedlings of Douglas fir and white spruce were grown for 2 yr in a bare-root nursery in southern British Columbia. Seedlings were treated with four types of commercial fertilizers (slow-release Osmocote, ammonium phosphate, ammonium sulphate and Hi-Sol, a soluble fertilizer with 20-20-20 NPK) at 2 different frequencies during both years to give total N applications of 0, 210 or 350 kg/ha. In addition, Douglas fir seedlings that had been grown for 2 yr without fertilizer were treated with the same amounts of fertilizer as a late season treatment during 1 Sep.-20 Oct. 1983. Ammonium fertilizers produced larger seedlings than Osmocote and Hi-Sol. Dry wt. increased with application rate, but frequency of application had only a small effect. Fertilizer increased the proportion of stem dry matter and decreased the proportion of needle and root dry matter. Dry wt. of 2+0 white spruce seedlings was correlated with soil pH, extractable NO3 and available P measured in Sep. of the first growing season. Douglas fir seedlings were planted out in Mar. 1984. Late-season fertilized seedlings had greater N and P tissue concn. than seedlings fertilized during the growing season. Survival and growth rate after planting were also both greater in late-season fertilized seedlings. Results suggested that fertilizer composition was more important than fertilizer solubility for nursery growth.

OSU Link
Non-OSU Link

76. Driessche, R.v.-d. 1988b. Response of Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco) to some different fertilizers applied at planting. New-Forests 2(2): 89-110.

Keywords: nursery operations
nursery fertilization
fertilization
growth
tree/stand health
tree physiology

Abstract: Four fertilizer experiments to assess type of fertilizer, dosage and timing, were conducted on eastern Vancouver Island, BC, Canada. Two-yr-old, bare root planting stock was used except in experiment 3, where container stock was compared with bare root stock. Little growth response was obtained after one year, but height growth responses of 12 to 31% were measured after 3 to 6 yr with fertilizers supplying 8.4 to 16.8 g N per tree. Growth responses were little affected by type of fertilizer and were primarily due to N, with release rate having no marked effect. The exception to this was triple superphosphate which did not increase growth but did increase survival. Survival was reduced by ammonium sulphate and to a lesser extent by Agriform (NPK). Container seedlings responded more to fertilization at planting than bare root seedlings. Seedling N, P and K concn. and contents declined following planting for 6 months and only started to recover after July. Application of fertilizer caused a small increase in seedling nutrient concn. regardless of date, but this had no detectable effect on dry weight measured 6 wk later.

OSU Link
Non-OSU Link

77. Driessche, R.v.-d. 1991a. Influence of container nursery regimes on drought resistance of seedlings following planting. I. Survival and growth. Canadian-Journal-of-Forest-Research 21(5): 555-565.

Keywords: nursery operations
tree/stand protection
growth
tree morphology
carbon allocation
tree/stand health

Abstract: In a 2 year study, Douglas fir (Pseudotsuga menziesii), lodgepole pine (Pinus contorta) and white spruce (Picea glauca) seedlings, grown in Styroblock containers in a container nursery from February to July 1988, were exposed to three temperatures and three levels of drought stress applied factorially during 18 July to 29 September 1988. Mean temperatures of 13, 16 and 20 degrees C were imposed in growth chambers, in a cooled plastic house, and in an ambient plastic house, respectively. Control, medium and severe levels of drought stress were imposed in a series of eight cycles, resulting in mean xylem pressure potentials of -0.32, -0.50 and -0.99 MPa, respectively. Seedlings were kept in the ambient plastic house until January 1989, when they were lifted and cold-stored until transplanting to covered 0.5-m deep sand beds, which provided hygric, mesic, and xeric conditions for testing all species and treatments. At the end of nursery growth, an increase in nursery temperature increased height and height : diameter ratio in all species and shoot:root dry weight ratio in Douglas fir and lodgepole pine. Increase in temperature also increased the number of seedlings with large well-formed buds in white spruce, but reduced the number in Douglas fir. Drought stress reduced height and dry weight in all species and bud length in lodgepole pine. After 9 weeks in sand beds, low nursery temperature increased survival (19% for lodgepole pine and white spruce grown in the xeric bed), except for Douglas fir grown in the xeric bed. Nursery drought stress also increased survival (16% for Douglas fir and lodgepole pine in the xeric bed), but had little effect on white spruce. Low temperature and drought stress treatments that increased survival also reduced height and dry weight of lodgepole pine and white spruce after one growing season in sand beds. Survival showed significant negative correlations with height, dry weight and height:diameter and shoot : root weight ratios. Low nursery temperature continued to affect growth 16 weeks after planting, increasing relative growth rate and allometric ratio (K) of Douglas fir and reducing K of white spruce.

OSU Link
Non-OSU Link

78. Driessche, R.v.-d. 1992a. Absolute and relative growth of Douglas-fir seedlings of different sizes. Tree-Physiology 10(2): 141-152.

Keywords: nursery operations
growth

Abstract: Douglas fir (Pseudotsuga menziesii) seedlings of a single (Vancouver Island) seed source were grown in a nursery on Vancouver Island, British Columbia, Canada, for two years to produce five different bare rooted stock types through varying spacing and transplanting treatments: spacing of 1.2, 7.7 and 14.3 cm; 14 cm 1+1 transplant; and 14 cm container transplant. They were then planted in the forest together with one-year-old container seedlings of the same seed source (a sixth treatment). Stem volume mean relative growth rate (Rv) was low immediately after planting for all stock types except the

container seedlings, and increased over the following 7.6 years. An 8-week greenhouse test of the six stock types showed that dry weight mean relative growth rate (Rw) generally decreased with seedling dry weight, but this effect was less obvious after planting because only the three smaller stock types showed a decrease in Rw with size. In another experiment, bare root Douglas fir seedlings were grown at five different spacings (1.9, 2.8, 5.0, 7.4 and 10.6 cm) in a nursery for two years, and seedlings from each spacing treatment were sorted into 'large' or 'small' by height. Resulting 10 treatments were outplanted and stem volumes determined over 6.7 years. Effect of nursery spacing on stem volume was linear up to 3.6 years after planting, but large seedlings had greater stem volume than small seedlings throughout the 6.7 years of the study. There was no indication that Rv decreased with time, but small seedlings had a greater Rv than large seedlings. Relative growth rates of 2-year-old Douglas fir were depressed for a year or two after planting, but then remained relatively constant, or increased during the ensuing 5 years. Relative growth rates of smaller seedlings were greater than those of larger seedlings so that relative biomass differences decreased with time, and the time advantage of larger stock decreased. Absolute size differences increased with time.

OSU Link
Non-OSU Link

79. Driessche, R.v.-d. 1992b. Changes in drought resistance and rootgrowth capacity of container seedlings in response to nursery drought, nitrogen, and potassium treatments. Canadian-Journal-of-Forest-Research 22(5):740-749.

Keywords: nursery operations
nursery fertilization
tree/stand protection
tree/stand health
growth
carbon allocation
tree physiology

Abstract: Douglas fir (Pseudotsuga menziesii), lodgepole pine (Pinus contorta), and white spruce (Picea glauca) seedlings, each represented by two seed lots, were grown in Styroblock containers in a greenhouse and plastic shelter house from February 1989 to January 1990. The seedlings were exposed to two N treatments (20 and 200 mg/litre) and three K treatments (5, 25 and 100 mg/litre) arranged factorially within three drought treatments. After winter storage, seedlings from a complete set of treatments were planted into hygric, mesic and xeric sand beds during 12-14 March. Increasing nursery drought stress increased survival of Douglas fir and lodgepole pine after planting, and high N treatment level increased survival of lodgepole pine and white spruce. Under xeric conditions, combined nursery drought and high N treatments increased survival of lodgepole pine by 33%, indicating the importance of nursery cultural regime for stock quality. Increase in nursery drought stress did not decrease seedling size by much; increase in N increased seedling size one season after planting. A positive relation between shoot : root ratio and survival in lodgepole pine and white spruce indicated that increase in N increased both shoot growth and drought resistance over the N range investigated. Only Douglas fir showed an interaction between drought and N treatment and a small response in both survival and dry weight to K application. Root growth capacity, measured at the time of planting, showed an approximate doubling in all species due to high N treatment, and was also increased in white spruce by drought stress. Survival and root growth capacity were poorly correlated, but dry-weight growth in sand beds was well correlated with root growth capacity. Shoot dry weight and percentage N in shoots

measured after nursery growth were correlated with root growth capacity. Manipulation of root growth capacity by changing nursery treatment was possible without altering resistance to drought stress after planting.

OSU Link
Non-OSU Link

80. Dunsworth, B.G. 1985. Three-yr survival and height growth of 2+0 bareroot Douglas-fir seedlings treated with a Symbex root dip. Tree-Planters' Notes 36(1): 24-25.

Keywords: nursery operations
nursery fertilization
growth
tree/stand health

Abstract: Seedling roots were dipped in a sol. of Symbex [a stimulant containing fertilizer and microorganisms?] diluted 40:1 with water, or water before planting out in May 1980 on Vancouver Island, British Columbia. Although the ht. growth of Symbex-treated trees was significantly greater in 1981, there were n.s.d. in total ht., ht. growth or survival after 3 growing seasons.

OSU Link
Non-OSU Link

81. Dunsworth, B.G. 1988. Douglas-fir fall root phenology: a bioassay approach to defining planting windows. In Proceedings: 10th North American Forest Biology Workshop, 'Physiology and genetics of reforestation', University of British Columbia, Vancouver, British Columbia, July 10-22, 1988. Eds. J. Worrall, J. Loo-Dinkins and D.P. Lester. pp. 295-307.

Keywords: planting operations
growth
tree/stand health
tree phenology

Abstract: Natural seedling root phenology during the autumn and spring was observed in Douglas fir [Pseudotsuga menziesii] and western hemlock [Tsuga heterophylla] over several seasons on Vancouver Island, British Columbia. These observations were used to determine the soil climate conditions under which peak activity occurred. Mitotic indexing and total root tip counts were used to quantify root activity. Peak activity for both spring and autumn in both species could be reasonably bracketed by soil climate conditions of -1 bar soil tension and 4 degrees C. The hypothetical planting window defined by these soil climate conditions was then tested with a series of timing of planting studies for Douglas fir (autumn) and western hemlock (spring) containerized stock. The results indicated that although quality of planting stock and the season following planting are influential, a 10 to 15% survival and growth advantage can be gained by planting within the hypothetical window.

Non-OSU Link

82. Duponnois, R., J. Garbaye, D. Bouchard and J.L. Churin. 1993. The fungus-specificity of mycorrhization helper bacteria (MHBs) used as an alternative to soil fumigation for ectomycorrhizal inoculation of bare-root Douglas-fir planting stocks with Laccaria laccata. Plant and Soil 157:257-262.

Keywords: nursery operations
growth
mycorrhizal response

Abstract: Mycorrhization helper bacteria (MHBs) isolated and selected from the Douglas fir (Pseudotsuga menziesii)-Laccaria laccata symbiotic system have previously been shown to be fungus-specific: they promote ectomycorrhizal establishment of Laccaria laccata but inhibit mycorrhizal formation by other fungi. In this paper, two experiments in a nursery producing 2-yr-old bare rooted Douglas fir planting stock confirmed the specificity of MHBs (9 strains were tested) under field conditions. Mycorrhizal formation by Laccaria laccata, and the closely related L. bicolor was promoted by the specific MHBs tested, but mycorrhizal formation by Hebeloma cylindrosporum and a contaminant white fungus was inhibited; the strain of Paxillus involutus used was only poorly infective and not affected by MHBs. The experiments also showed that, by selectively helping the introduced L. laccata against the resident symbionts, MHBs are an interesting alternative (safer and easier) to soil fumigation for the success of routine controlled mycorrhization of planting stock in forest nurseries. The MHB strain BBc6 (a Pseudomonas fluorescens) is suggested as a suitable candidate for this system.

OSU Link
Non-OSU Link

83. Duryea, M.L. and S.K. Omi. 1987. Top pruning Douglas-fir seedlings: morphology, physiology, and field performance. Canadian-Journal-of-Forest-Research 17(11): 1371-1378.

Keywords: nursery operations
nursery pruning
tree phenology
tree/stand health
growth
yield

Abstract: Seedlings from 9 seed sources at 6 nurseries in Washington, Oregon and California were treated with various pruning treatments including tall and short ht. (25 and 15 cm, respectively), early and late timing (6 wk after bud burst or 6 wk after bud set, respectively), pruning twice or no pruning. Seedlings were evaluated for phenology and quality, and graded in the nursery. For each seed source, seedlings were planted at field sites in their own zone and on one common site. Seedlings pruned tall and early began growing again within 5 wk and set buds 2 wk later than unpruned seedlings. Shippable yield of seedlings pruned tall and early and of unpruned seedlings were n.s.d, although more pruned seedlings had multiple leaders. Pruned seedlings were smaller than unpruned seedlings at the time of planting. Survival and growth were the same for pruned and unpruned seedlings in the 1st year after planting. Pruned seedlings grew more than unpruned seedlings in the 2nd year, but were still shorter after 2 yr. Field growth was greater in seedlings pruned tall or early than in seedlings pruned short or late. It is concluded that pruning should be continued as a cultural practice if it benefits nurseries, but that late short pruning should be avoided.

OSU Link
Non-OSU Link

84. Edgren, J.W. 1981. Field performance of undercut coastal and Rocky Mountain Douglar-fir 2+0 seedlings. Tree-Planters' Notes 32(3): 33-36.

Keywords: nursery operations
tree/stand health
growth

Abstract: Seedlings from 1 seed source each of Pseudotsuga menziesii var. menziesii (coastal) and P. menziesii var. glauca (Rocky Mountain) were grown in a nursery in Washington and half were undercut at 15 cm below the surface at 1-yr-old. Seedlings were lifted in March the next yr (1968) and planted out at 2 sites in Oregon. Survival of undercut coastal firs 3 yr after planting was significantly better than controls. Survival of Rocky Mountain fir was not significantly affected by undercutting. Ht. growth of control seedlings of both varieties was significantly greater in their 1st season than that of undercut seedlings, but the differences disappeared the following year.

OSU Link
Non-OSU Link

85. Edmonds, R.L. and T. Hsiang. 1987. Forest floor and soil influence on response of Douglas-fir to urea. Soil-Science-Society-of-America-Journal 51(5): 1332-1337.

Keywords: fertilization
thinning
growth
soil properties

Abstract: Data from the Regional Forest Nutrition Research Project (RFNRP) in Washington and Oregon were analyzed to improve stand-specific prediction of Douglas-fir [Pseudotsuga menziesii (Mirb.) Franco] response to urea fertilization. The response variable (relative difference in volume growth between fertilized and control plots 4 yr after fertilization with 448 kg N/ha) was regressed against 28 stand and site variables (e.g., age, elevation, forest floor C/N ratio, soil cation exchange capacity, etc.) using stepwise multiple regression analysis. Data from 120 installations were stratified by thinning level (thinned or unthinned), geographic location (provinces), and site quality (site index and class). Forest floor C/N ratio was the dominant variable related to response. In thinned installations of high site quality (site classes 1 and 2), 60% of variation in response was explained by the forest floor C/N, and 75% of the variation in response was explained with inclusion of surface soil exchangeable K. In thinned, low site quality stands, response was not as well related to forest floor C/N. Analysis of the data by province indicated that S may be limiting in southwest Oregon and P in coastal Washington.

OSU Link
Non-OSU Link

86. El Kassaby, Y.A. and Y.S. Park. 1993. Genetic variation and correlation in growth, biomass, and phenology of Douglas-fir diallel progeny at different spacings. Silvae-Genetica 42(6): 289-297.

Keywords: genetic tree improvement
nursery operations
genetic relationships
growth
carbon allocation
tree phenology

Abstract: Parents of coastal Douglas fir (Pseudotsuga menziesii) selected from natural stands on sites ranging from 0 to 450 m altitude on Vancouver Island and in southeastern British Columbia were crossed and the resulting 104 full-sib families evaluated for 3 years after germination. The full-sib families were produced by a disconnected diallel mating scheme, consisting of 7 sets of 6-parent partial diallels, grown under 2 spacing treatments in a nursery. The objectives of the study were to determine the extent of genetic control of growth traits, biomass distribution and allocation strategies, and vegetative phenology. Spacing had a significant effect on 6 of the 11 traits studied. Significant GCA variance was found for all traits except 1-year height. Individual tree narrow-sense heritability varied from 0.06 to 0.69 for root dry weight and vegetative phenology, respectively. Spacing x family interaction variance was significant for only 2 traits. Two harvest indices, based on total and above-ground dry weights, were used to assess dry matter allocation strategy and to explore potential usefulness in tree breeding. Both indices had similar heritability estimates and their genetic correlation was high (0.91), indicating that use of an index based on above ground dry weight is a good surrogate for that based on total dry weight. Genetic correlations among growth and biomass traits were generally high, while those correlations with the harvest indices were variable.

OSU Link
Non-OSU Link

87. Entry, J.A., K. Cromack, Jr., R.G. Kelsey and N.E. Martin. 1991. Response of Douglas-fir to infection by Armillaria ostoyae after thinning or thinning plus fertilization. Phytopathology 81(6): 682-689.

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

Abstract: Second-growth stands of Douglas-fir (Pseudotsuga menziesii) were thinned to a 5- x 5-m spacing (TT); additional plots were thinned and fertilized once with 360 kg of N (as urea)/ha (TF). An unthinned, unfertilized stand (UT) served as a control. Ten years after treatment, trees were inoculated with 2 isolates of A. ostoyae. Trees receiving the TF and TT treatments produced greater diameter growth, leaf area, and wood production/msuperscript 2 leaf area per year than did those under the UT treatment. Rates of infection by A. ostoyae were highest in trees that received the TF and lowest in trees that received the TT treatment. Concn of sugar, starch and cellulose in root bark tissue were highest in

trees receiving the TF treatment and lowest in trees receiving TT treatment. Concn of lignin, phenolics and protein-precipitable tannins were highest in root bark from TT trees and lowest in root bark from TF trees. Biochemical parameters of root bark tissue were regressed with incidence of infection; coefficients of determination (rsuperscript 2) ranged from 0.07 (starch) to 0.57 (phenolic compounds). Ratios of the energetic costs of phenolic and of lignin degradation to the energy available from sugars (Epd:Eas and Eld:Eas) were correlated with incidence of infection (rsuperscript 2 = 0.77 and 0.70, respectively). It is concluded that thinning combined with fertilization may predispose P. menziesii trees to infection by A. ostoyae by lowering concn of defensive compounds in root bark and increasing the energy available to the fungus to degrade them.

OSU Link
Non-OSU Link

88. Feller, M.C. 1990. Herbicide application followed by prescribed fire to convert a brushfield into a conifer plantation in south coastal B.C.: a combination of the initial effects of two treatments. B.C. Ministry of Forests FRDA Report 146. 40 p.

Keywords: site preparation
chemical preparation
prescribed fire
growth
tree/stand health
soil properties
stand conditions

Abstract: A field study was carried out in Pseudotsuga menziesii stands in British Columbia, Canada, to investigate the effects on vegetation of glyphosate applications in September 1987 or July 1988, followed by burning in October 1988. Results did only show slight differences between treatments.

OSU Link
Non-OSU Link

89. Figueroa, P.F. 1993. Efficacy and cost of ground-applied herbicide methods for red alder control. Down to Earth 48(1): 6-10.

Keywords: release treatments
chemical release
stand conditions
growth
tree/stand health

Abstract: The effects on red alder [Alnus rubra] mortality, diam. at breast height and height, and any phytotoxic effects to Douglas fir [Pseudotsuga menziesii] of Garlon 4 (triclopyr) at 4 lb/gallon and Chopper EC (imazapyr) at 2 lb, applied by stream line, thin line and low vol. treatments, and of Garlon 3A (triclopyr) at 3 lb, Roundup (glyphosate) at 3 lb and Arsenal (imazapyr) at 4 lb applied by cut stump treatment were evaluated in streamside buffer zones in two 6-year-old P. menziesii plantations in SW Washington. All treatments resulted in good control of A. rubra, but the most cost-effective control was

achieved by the stream line application of Garlon 4, followed by low vol. basal or thin line treatments of Garlon 4 and cut stump treatment with 50% Garlon 3, 45% Roundup and 10% Arsenal. Negligible P. menziesii damage was caused by cut stump treatments, but damage occurred with basal-bark treatments although Garlon 4 generally caused less injury than Chopper EC.

OSU Link

90. Figueroa, P.F., R.C. Heald and S.R. Radosevich. 1990. Sensitivity of actively growing Douglas-fir to selected herbicide formulations. Proceedings-of-the-Western-Society-of-Weed-Science 43: 45-52.

Keywords: release treatments
chemical release
growth
tree/stand health

Abstract: The results of field studies at 2 sites in Washington and California indicated that aerial spraying of 2,4-D at 4 lb/acre, triclopyr ester at 4 lb/acre or 2,4-D + triclopyr ester at 1.2 lb/acre + 0.5 lb/acre to control red alder [Alnus rubra] led to a significant reduction in Douglas fir [Pseudotsuga menziesii] growth and survival if applied during periods of active conifer growth. Herbicides applied singly at high rates caused significantly more mortality than the herbicides in combination. At both sites, trees had not fully recovered 5 and 6 years after treatment; damaged trees were at least 1 year behind untreated trees in growth.

OSU Link
Non-OSU Link

91. Filip, G.M. and L.M. Ganio. 2004. Early thinning in mixed-species plantations of Douglas-fir, hemlock, and true fir affected by Armillaria root disease in Westcentral Oregon and Washington: 20 year results. Western-Journal-of-Applied-Forestry 19(1): 25-33.

Keywords: thinning
precommercial thinning
tree/stand protection
growth
tree/stand health

Abstract: Four 10- to 20-year-old plantations were treated to determine the effects of precommercial thinning on tree growth and mortality caused by Armillaria root disease in the Cascade Range of western Oregon and Washington, USA. One plantation was Douglas-fir (Pseudotsuga menziesii) and noble fir (Abies procera), one Douglas-fir and western hemlock (Tsuga heterophylla), one Douglas-fir alone, and one Shasta red fir (Abies magnifica var. shastensis) and mountain hemlock (Tsuga mertensiana). After 20 years, differences in crop tree mortality between thinned and unthinned plots were not significant (P=0.9768). Quadratic mean diameter growth of crop trees, however, was significantly (P=0.0053) greater in thinned than in unthinned plots. Crop tree basal area/ac growth was significantly (P=0.0008) greater in thinned plots. There were no significant (P=0.6647) differences in basal area/ac growth of all trees between thinned and unthinned plots. Apparently, from a root-disease

perspective, precommercial thinning does not affect incidence of crop-tree mortality after 20 years, but individual and per acre tree growth of crop trees increase significantly.

OSU Link
Non-OSU Link

92. Filip, G.M. and D.J. Goheen. 1995. Precommercial thinning in Pseudotsuga, Tsuga, and Abies stands affected by armillaria root disease: 10-year results. Canadian-Journal-of-Forest-Research 25(5): 817-823.

Keywords: thinning
precommercial thinning
tree/stand protection
growth
tree/stand health

Abstract: Four 10- to 20-year-old stands were pre-commercially thinned to determine the effects of thinning on tree growth and mortality caused by armillaria root disease (Armillaria ostoyae) in the Cascade Range of western Oregon and Washington, USA: one stand of Douglas fir (Pseudotsuga menziesii var. menziesii) and noble fir (Abies procera), one of Douglas fir and western hemlock (Tsuga heterophylla), one of Douglas fir alone, and one of Shasta red fir (Abies magnifica var. shastensis) and mountain hemlock (Tsuga mertensiana). After 10 years, differences in crop-tree mortality between thinned and unthinned plots were not significant in any of the four stands. Tree radial growth was significantly increased by thinning in 6 of 15 plots. Crop-tree basal area (per hectare) growth was significantly greater in thinned plots. Basal area (per hectare) growth of all trees was significantly greater in unthinned plots. Apparently, from a root-disease perspective, pre-commercial thinning does not affect the incidence of crop-tree mortality after 10 years, but tree growth increases significantly.

OSU Link
Non-OSU Link

93. Flint, L.E. and S.W. Childs. 1987. Effect of shading, mulching, and vegetation control on Douglas-fir seedling growth and soil water supply. Forest-Ecology-and-Management 18(3): 189-203.

Keywords: release treatments
chemical release
manual release
growth
soil properties

Abstract: Harsh environments on many harvested sites in SW Oregon necessitate site modifications for successful regeneration of Douglas fir. A 2-yr study was made with 350 seedlings to assess the effects of 12 soil-surface shading, mulching, and vegetation control techniques on seedling growth and soil temp. and moisture environments. Major effects of treatments were to lower soil surface temp., reduce soil surface evaporation, and reduce vegetative competition for soil water. These affected seedlings by adjusting the timing of seedling growth and reducing soil water loss to increase available water for seedling use. Final seedling shoot vol. and stem diam. both differed among treatments. Seedlings in treatments where competing vegetation was controlled showed significantly greater growth than

seedlings in other treatments. Soil water loss in treatments where either soil surface evaporation was controlled by mulching, or where competing vegetation was controlled, was significantly less than water loss from the shaded and control treatments. Soil water loss in treatments with vegetation controlled by herbicide was significantly less than in treatments with vegetation controlled by scalping. Seedlings showed greatest growth with treatments that elicited the most efficient use of available microsite water either by reducing soil surface evaporation or vegetation competition.

OSU Link
Non-OSU Link

94. Folk, R.S., S.C. Grossnickle, P. Axelrood and D. Trotter. 1999. Seed lot, nursery, and bud dormancy effects on root electrolyte leakage of Douglas-fir (Pseudotsuga menziesii) seedlings. Canadian-Journal-of-Forest-Research 29(8): 1269-1281.

Keywords: nursery operations
tree physiology
tree/stand health
photosynthesis
growth
tree phenology

Abstract: The effects of seed lot, nursery culture, and seedling bud dormancy status on root electrolyte leakage (REL) of Douglas-fir (Pseudotsuga menziesii) seedlings were assessed to determine if these factors should be considered when interpreting REL for seedling quality. The relationships of REL to survival, net photosynthesis (Pn), stomatal conductance (gwv) mid-day shoot water potential (Psi mid), root growth capacity (RGC), and relative height growth were determined for each factor in experiments in 1994-95 in nurseries inBritish Columbia. Nursery culture had no effect on the relationship between REL and all other measured attributes. Seed lot affected the relationship between REL and Pn, Psi mid, and survival. However, critical REL (i.e., lowest value associated with detectable root damage) and PS80 REL (i.e., level associated with an 80% probability for survival) were similar between seed lots. Bud dormancy status affected the relationship between REL and survival, RGC, and relative height growth. Control levels of REL, critical REL, and PS80 REL decreased as the number of days required for 50% terminal bud break declined. Thus, terminal bud dormancy status must be known before REL can be used to assess seedling quality. If the bud dormancy status of Douglas-fir populations is known, then critical and PS80 REL levels may be useful as indices of root damage.

OSU Link
Non-OSU Link

95. Frey Klett, P., J.L. Churin, J.C. Pierrat and J. Garbaye. 1999. Dose effect in the dual inoculation of an ectomycorrhizal fungus and a mycorrhiza helper bacterium in two forest nurseries. Soil Biology and Biochemistry 31:1555-1562.

Keywords: nursery operations
growth
carbon allocation
mycorrhizal response

soil properties

Abstract: Disinfected soil at two Douglas-fir (Pseudotsuga menziesii) bare-root forest nurseries was inoculated with three doses (8 X105, 8 X107 and 8 X109 cfu [colony forming units]/m2) of the rifampicin-resistant mycorrhiza helper bacterium Pseudomonas fluorescens strain BBc6R8 and the ectomycorrhizal fungus Laccaria bicolor strain S238N. In one of the two nurseries, two doses of fungal inoculum (50 and 100 mg/m2 dry weight (DW) mycelium entrapped in alginate beads at the constant dose of 1 litre/m2) were tested. For all bacterial treatments the density of P. fluorescens BBc6R8 in the soil, determined by dilution plating, dropped below the detection limit (10-2 cfu/g DW soil) 2 weeks after inoculation. Fifteen weeks after inoculation, the introduced bacterium was detected by enrichment only in the treatments inoculated with the highest bacterial dose. Two years after inoculation, P. fluorescens BBc6R8 was not detected in the soil of any of the bacterial treatments. Five months after inoculation and sowing, bacterial inoculation significantly increased the percentage of mycorrhizal short roots on plants inoculated with either low or high amounts of L. bicolor, in one of the nurseries. The lowest bacterial dose increased mycorrhizal colonization from 45 to 70% in plants inoculated with the low amount of fungal inoculum, and from 64 to 77% in plants inoculated with the high amount of fungal inoculum. The lowest bacterial dose increased mycorrhizal colonization more than the highest bacterial dose. The same L. bicolor mycorrhizal index (70%) was obtained with 50 mg/m2 DW mycelium plus the bacterium than with twice this fungal dose and no bacterium (64%). Two years after inoculation, the height of the mycorrhizal Douglas-firs in the other nursery was significantly increased by the lowest bacterial dose (from 40.7 to 42.6 cm). It was indicated that co-inoculating a helper bacterium together with an ectomycorrhizal fungus is an efficient way to optimize controlled mycorrhization techniques for the production of high-quality Douglas-fir planting stocks. It was confirmed that BBc6R8 acts at a low population density (less than 10-2 cfu/g soil), this contrasts with most PGPR [plant growth promoting rhizobacteria?] effects where the minimal inoculation dose of 105 cfu/g soil is required to obtain the beneficial effect.

OSU Link
Non-OSU Link

96. Fu, Y., A.D. Yanchuk and G. Namkoong. 1999. Spatial patterns of tree height variations in a series of Douglas-fir progeny trials: implications for genetic testing. Canadian-Journal-of-Forest-Research 29(6): 714-723.

Keywords: genetic tree improvement
growth

Abstract: Conventional statistics and geostatistical techniques were used to examine spatial variation patterns of tree heights at ages 6-12 years in a series of Douglas fir (Pseudotsuga menziesii) progeny trials conducted on 66 test sites over southern coastal British Columbia. Large variations in tree height were observed over the years within and among the 66 test sites. The estimated proportions of the within-site variance explained by family, row, column, patchiness and within-plot were on average 11, 7, 5, 12 and 47%, respectively, plus 7% due to unknown factors, and the applied blocking removed about 5% of the within-site variance. Significant gradients in row and column directions were observed in more than 44 test sites, and the estimated slopes ranged in average from 0.33 to 1.52 cm/plot. Patch sizes varied greatly over the test sites and ranged in average from 5.21 to 6.47 plots, indicating that the average patch size for these trials was 18 m across. Temporal variations were large for family variance but not much for those variance proportions explained by row, column and patchiness. More gradients

and larger patch sizes were found with older trees. The implications of these results are discussed in relation to forest genetic testing.

OSU Link
Non-OSU Link

97. Gagnon, J., C.G. Langlois, D. Bouchard, F.l. Tacon and F. Le Tacon. 1995. Growth and ectomycorrhizal formation of container-grown Douglas-fir seedlings inoculated with Laccaria bicolor under four levels of nitrogen fertilization. Canadian Journal of Forest Research 25:1953-1961.

Keywords: nursery operations
nursery fertilization
growth
carbon allocation
tree physiology
tree morphology
mycorrhizal response
soil properties

Abstract: Container-grown Douglas fir (Pseudotsuga menziesii) seedlings were inoculated at the time of sowing with a Laccaria bicolor mycelial suspension produced in a fermentor. They were grown in a peat moss-vermiculite substrate under four levels of N fertilization (7.2, 14.4, 21.6 and 28.7 mg/seedling per season (N1, N2, N3 and N4, respectively)) to determine the N level suitable for both ectomycorrhizal development and seedling growth. After 18 weeks in the greenhouse, seedlings inoculated with L. bicolor had 44%, 32%, 44% and 5% of their short roots mycorrhizal when fertilized with N1, N2, N3 and N4, respectively. Only when they were fertilized with N4 did the L. bicolor seedlings have significantly greater shoot height than the controls. For the other growth parameters, they were not significantly different from control seedlings for any of the N levels. After 18 weeks, regardless of the level of N, seedlings inoculated with L. bicolor had significantly lower N concentrations (%) and contents (mg/seedling) than the uninoculated ones. Consequently, for the same production of biomass, the mycorrhizal seedlings had taken up less N than the nonmycorrhizal ones. The efficiency of applied N, expressed in terms of produced biomass, decreased when the N fertilization increased; mycorrhizal and nonmycorrhizal seedlings did not tend to be different. The efficiency of the absorbed N also decrease with the level of applied N, but less rapidly, and tended to be greater for the mycorrhizal seedlings than for the nonmycorrhizal ones. Therefore, the mycorrhizal infection improved the utilization of the absorbed N. N3 was the best of the four N levels used, since it was the only one that maximized both the ectomycorrhizal formation and the growth of the seedlings. In other words, a total seedling N concentration of 1.6% and a substrate fertility of 52 p.p.m. N are appropriate to optimize both the ectomycorrhizal development and the growth of Douglas fir seedlings.

OSU Link
Non-OSU Link

98. Gardner, E.R. 1990. Fertilization and thinning effects on a Douglas-fir ecosystem at Shawnigan Lake: 15-year growth response. Canadian-Forest-Service, Pacific and Yukon Region Information-Report BC-X-319. ix + 42 p.

Keywords: fertilization
thinning
growth
yield
tree morphology
tree/stand health

Abstract: Responses after 15 yr to 3 rates of nitrogen (urea), applied at 0, 224 or 448 kg N/ha to a 24-yr-old Douglas fir (Pseudotsuga menziesii) stand in the very dry maritime region of British Columbia, were analysed on the basis of per hectare, individual tree, crop tree and tree size class. Thinned and unthinned plots were measured.

OSU Link
Non-OSU Link

99. Gertner, G.Z. 1984. Localizing a diameter increment model with a sequential Bayesian procedure. Forest-Science 30(4): 851-864.

Keywords: fertilization
growth

Abstract: A procedure is described for modifying a non-linear model taken from a regional forest growth projection system for use in a smaller subregion. Diameter growth monitored in the subregion of interest is used to adjust the parameters. The amount of adjustment required depends on the precision of the growth estimates from the regional model and of the estimates based on the local sample. More weight is given to the local estimates when their precision is relatively high in comparison with the regional estimates. An example is given of modifying a model developed for the Western Oregon Region for a Douglas fir stand in NW Oregon. In another example the procedure is used to adjust for the effects on diam. increment of fertilizing with urea.

OSU Link
Non-OSU Link

100. Gessel, S.P. and W.A. Atkinson. 1984. Use of fertilizers in sustained productivity of Douglas-fir forests. *In* Forest soils and treatment impacts: Proceedings, Sixth North American Forest Soils Conference, Department of Forestry, Wildlife and Fisheries, University of Tennessee, Knoxville, TN, June 1983. pp. 67-87.

Keywords: fertilization
growth
economics

Abstract: A review is given of studies leading to the establishment of nitrogen deficiency as a factor reducing growth and the development of N fertilization programmes. Data from several long-term fertilizer trials in Washington and Oregon support the conclusion that N deficiency is frequently a controlling factor in the growth of Douglas fir and that additions of N can result in long-term growth

increases. The economics of fertilization and the continued availability of nitrogen fertilizers are discussed.

OSU Link

101. Gessel, S.P., R.E. Miller and D.W. Cole. 1990. Relative importance of water and nutrients on the growth of coast Douglas fir in the Pacific Northwest. Forest-Ecology-and-Management 30(1-4): 327-340.

Keywords: fertilization
growth
soil properties

Abstract: The Douglas-fir region in northwestern North America is characterized by abundant moisture supply during winter, extended dry periods during the growing season and significant differences in water availability. Many soils have low fertility and indigenous tree species respond to nitrogen fertilization, especially Douglas fir (Pseudotsuga menziesii). Although irrigation of commercial forests in this region is currently impractical, questions arising about the relative importance of water and nutrients were examined using long-term growth data from three studies. At Pack Forest (Washington), fertilization without irrigation doubled growth rates, and no positive growth responses were measured from irrigation. Short-term (5 yr) irrigation with sewage effluent containing many nutrients resulted in a six-fold increase in biomass production for poplar and three-fold for Douglas fir as compared to irrigation with equal volumes of river water. Volume growth in 12- to 65-yr-old stands in southwestern Oregon was increased by fertilization at about 70% of the locations; annual gain averaged 2.73 msuperscript 3/ha for 5-12 yr. Response was not related to annual precipitation, which ranged from 81 to 279 cm, nor other moisture-related variables. Absolute and relative volume response showed highest correlation with soil carbon : nitrogen ratio. Compared with nutrition, moisture does not seem to be a major limiting factor for growth in the Douglas fir region of the Pacific Northwest.

OSU Link
Non-OSU Link

102. Gessel, S.P., E.C. Steinbrenner and R.E. Miller. 1981. Response of Northwest forests to elements other than nitrogen. In Proceedings: Forest Fertilization
Conference, University of Washington, Seattle, Washington, USA. Eds. S.P. Gessel, R.M. Kenady and W.A. Atkinson. pp. 140-149.

Keywords: fertilization
growth
economics

Abstract: This paper reviews the development of forest tree nutrition research in the Northwest. Field observations, foliar analysis, and greenhouse cultures using both solution and forest soil as media established deficiency symptoms and levels for major and minor elements. Field experimentation with the entire range of essential elements has failed to demonstrate widespread deficiencies of elements other than nitrogen. Certain test areas have shown somewhat better response to combinations of elements; but because of the limitations of experimental design and field variation, the response does not generally have a high statistical significance. In some cases of apparent response, application of

fertilizer materials other than nitrogen does not appear to be economic. There is sufficient evidence of response to other elements to suggest that much work needs to be done. Increased utilization of forest materials, shorter rotation, and greater yields with nitrogen fertilization all point to the fact that many of the Northwest forest areas could have future elemental deficiencies, other than nitrogen.

OSU Link
Non-OSU Link

103. Gourley, M., M. Vomocil and M. Newton. 1990. Forest weeding reduces the effect of deer-browsing on Douglas fir. Forest-Ecology-and-Management 36(2-4): 177-185.

Keywords: release treatments
chemical release
tree/stand protection
growth
tree/stand health

Abstract: In January and February 1981, three-year-old bare-root Douglas fir (Pseudotsuga menziesii) transplants were established in four clear-felled locations in the Oregon Coast Range where browsing by black tail deer (Odocoileus hemionus columbiana) was expected. Protection was provided against browsing by 5 physical (rigid protection tube 7.5x75 cm; protective netting, paper budcaps; leather guard 20x5 cm; and 'Remae' budcaps) and one chemical ('Deer Away') treatment, each of which was tested with and without complete wood control with glyphosate. After five years, none of the protective treatments provided any growth advantages; some even caused growth losses. In contrast, weed control, with or without additional protective measures, consistently improved growth. By the 5th year, weeded trees averaged twice the biomass of unweeded trees, regardless of browsing. Average tree size was largest in the treatment with no weed competition and with no barriers to prevent browsing. Advantages of weeding were greatest on the poorest site. Weed control, in conjunction with the large size of transplants, appeared to prevent most loss due to damage from moderate deer-browsing.

OSU Link
Non-OSU Link

104. Graff, J.E., Jr., R.K. Hermann and J.B. Zaerr. 1999a. Dry matter and nitrogen allocation in western redcedar, western hemlock, and Douglas fir seedlings grown in low- and high-N soils. Annals-of-Forest-Science 56(7): 529-538.

Keywords: nursery operations
nursery fertilization
growth
tree physiology

Abstract: Seedlings of western red cedar (Thuja plicata), western hemlock (Tsuga heterophylla), and Douglas fir (Pseudotsuga menziesii) were transplanted into each of 48 pots with soils of low or high levels of available NO3- (and total N) and assigned to one of four treatments: unamended control; amendment with 60 mg kg-1 (NH4)2SO4; amendment with 15 mg kg-1 of the nitrification inhibitor dicyandiamide (DCD) or amendment with both (NH4)2SO4 and DCD. Dry weight and N content

increments of seedling tissues were determined after 8 weeks. Seedlings grown on the low-N soil accumulated 65 % of the dry matter and 40 % of the N accumulated by seedlings grown on the high-N soil. Retranslocation of N from year-old foliage and the stem/branch components of western red cedar and Douglas fir, but not western hemlock, was an important source of N for current-year foliage and roots of low-N-grown seedlings. Western hemlock achieved the greatest relative dry-matter increment (Loge(DMfinal) - Loge(DMinitial); RDMI) and relative N increment (Loge(Nfinal) - Loge(Ninitial); RNI) in each soil and accumulated 35 % more N from the low-N and 10 % more N from the high-N soils than the other species. The RDMI of western red cedar was intermediate between that of western hemlock and Douglas fir, whereas its RNI on each of the soils was lowest. The results suggest that western hemlock is more efficient than western red cedar or Douglas fir in acquiring inorganic N, especially from low-N soils.

OSU Link
Non-OSU Link

105. Green, R.N. and R.E. Carter. 1993. Boron and magnesium fertilization of a coastal Douglas-fir plantation. Western-Journal-of-Applied-Forestry 8(2): 48-53.

Keywords: fertilization
growth
tree/stand health
tree physiology

Abstract: A study was made of the role of boron and magnesium nutrition in the occurrence of severe growth distortion symptoms in Douglas-fir (Pseudotsuga menziesii) in the Skwawka River valley of south coastal British Columbia. Four fertilizer treatments, including boron (2.25 kg/ha B), magnesium (42 kg/ha Mg), boron plus magnesium, and a control, were applied in conjunction with planting on a site believed to be deficient in these nutrients. After 5 growing seasons, only treatments containing boron (B and B + Mg) showed improved height growth compared to controls. The incidence of leader dieback, swollen leading shoots, and foliage distortion was significantly related to treatment, with virtually no occurrence in plots treated with boron. Seedling uptake of applied boron was high, with foliar concentrations of 45 p.p.m. found after the second growing season. Foliar B levels declined to 13-15 p.p.m. after 5 growing seasons. No significant increase in foliar magnesium levels was detected for either of the magnesium treatments. The reduction in the incidence of leader dieback, and shoot and foliar symptoms, in seedlings treated with B indicate that these symptoms were the result of boron deficiencies. This is the first study to verify boron deficiency in coastal Douglas fir through fertilizer trials.

OSU Link
Non-OSU Link

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

Keywords: thinning
commercial thinning
growth
tree/stand health

tree morphology

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

OSU Link
Non-OSU Link

107. Grier, C.C., K.H. Lee and R.M. Archibald. 1984. Effect of urea fertilization on allometric relations in young Douglas-fir trees. Canadian-Journal-of-Forest-Research 14(6): 900-904.

Keywords: fertilization
growth
carbon allocation
tree morphology

Abstract: Twenty three yr old trees growing on a class III site in Washington State were fertilized with 225 kg/ha N in March 1980. Trees were measured before fertilizing and after 1980-83 growing seasons and destructively sampled after 2 growing seasons (in Nov.-Dec. 1981 and Jan. 1982). Logarithmic regression equations using stem diam. to predict tree biomass components were not significantly ($p = 0.05$) different between fertilized and control trees for total foliage, total branch, dead branch, stembark, or stemwood. New foliage and new twig components, however, were higher in fertilized trees than in control trees. Analysis of data from this and earlier studies suggests that fertilizing will increase leaf biomass per tree relative to control trees on sites having low nitrogen availability; however, this response will decrease with increasing nitrogen availability. Regression equations based on regional analysis of unfertilized trees yield estimates of foliage biomass for average trees on average sites. If N fertilizing brings the site above average in terms of nitrogen availability then these regression equations will underestimate foliage biomass. However, on sites that are initially very nitrogen deficient, N fertilizing will bring the site closer to average in terms of nitrogen availability, resulting in more accurate predictions of foliage biomass for fertilized stands than for control stands.

OSU Link
Non-OSU Link

108. Haase, D.L., J.H. Batdorff and R. Rose. 1993. Effect of root form on 10-year survival and growth of planted Douglas-fir trees. Tree-Planters' Notes 44(2): 53-57.

Keywords: planting operations
growth
tree/stand health

Abstract: Douglas fir seedlings (Pseudotsuga menziesii) were planted with three root-form treatments including C-roots ('correctly' planted controls), L-roots, and J-roots. After 10 years, there were no significant differences in outplanting performance between the three root-form treatments on a good

site in western Oregon. The results are in agreement with those of other studies, which suggests that when no other confounding planting errors are present, deformed root systems play a less dramatic role in subsequent field performance than is generally thought. These results in no way imply that poor planting is acceptable.

OSU Link
Non-OSU Link

109. Haase, D.L. and R. Rose. 1993. Soil moisture stress induces transplant shock in stored and unstored 2+0 Douglas-fir seedlings of varying root volumes. Forest-Science 39(2): 275-294.

Keywords: nursery operations
tree/stand protection
growth
tree morphology

Abstract: Transplant stock was induced by applying a range of soil water contents (6, 12, 18 or 24%) to unstored and cold-stored 2-yr-old (2 + 0) bareroot Douglas fir (Pseudotsuga menziesii) seedlings graded by root volume. Moisture stress had the greatest influence on morphological characteristics that express transplant shock. Seedling terminal shoot growth, stem diameter growth, and needle length increased with increased soil moisture content. In addition, number of needles per centimeter on the terminal shoot greatly increased with increasing drought stress. Under high drought stress, seedlings with relatively high root volumes tended to exhibit reduced early growth, but later showed significantly increased overall growth regardless of soil water content. In every case, seedlings grown in the driest soil had the lowest dry weight components. Similarly, seedlings with the smallest initial root volumes had the lowest dry weights, and those with the largest root volumes had the greatest dry weights. The results indicate that drought stress is a cause of transplant shock, and that increased seedling root volume may enable seedlings to avoid shock following outplanting to a specific site.

OSU Link
Non-OSU Link

110. Haase, D.L. and R. Rose. 1994. Effects of soil water content and initial root volume on the nutrient status of 2+0 Douglas-fir seedlings. New-Forests 8(3): 265-277.

Keywords: nursery operations
tree/stand protection
tree physiology
growth
tree morphology

Abstract: Two-year-old bareroot Douglas fir (Pseudotsuga menziesii) seedlings from a NW Oregon provenance were graded on the basis of four root-volume categories - 5 to 8, 9 to 10, 11 to 13, and 14 to 20 cmsuperscript 3 - and transplanted into pots and subjected to one of four moisture-stress treatments (6, 12, 18, and 24% soil water content) for 16 weeks. Macronutrient concentrations and contents of both old (i.e. nursery-grown) and new (i.e. grown during moisture stress treatment) foliar tissue were determined. A reduction in soil water content resulted in high concn of phosphorus, potassium, and

particularly nitrogen in both old and new foliar tissue. This was attributed to reduced growth, translocation, metabolic activity, and nutrient requirement in response to moisture stress. Seedlings with relatively greater root volumes exhibited higher nutrient concn and contents, as well as increased growth. Thus, increased total root biomass per unit of soil area with increasing seedling root volume may have resulted in greater nutrient use, supply, uptake, and storage. It is suggested that relations between initial root volume and water stress can be applied to nursery cultural practices in order to increase seedling adaptation to a specific stress.

OSU Link
Non-OSU Link

111. Haase, D.L., J. Trobaugh and R. Rose. 1999. Douglas-fir container stock grown with fertilizer-amended media: some preliminary results. Rocky Mountain Research Station, USDA Forest Service National Proceedings: Forest and Conservation Nursery Associations 1999, 2000, and 2001. RMRS P-24. 31-32 pp.

Keywords: nursery operations
nursery fertilization
growth
tree physiology
tree/stand health

Abstract: This paper presents the initial results of a study conducted in a nursery in Oregon, USA, to quantify the response of container grown Douglas-fir (Pseudotsuga menziesii) seedlings to various fertilizer treatments (Simplot's 13-13-13 and 17-5-11, and Scotts Company's 18-5-12 and 15-9-10) in terms of height, stem diameter and foliar nutrient content.

112. Hahn, P.F. and A.J. Smith. 1983. Douglas-fir planting stock performance comparison after the third growing season. Tree-Planters' Notes 34(1): 33-39.

Keywords: nursery operations
planting operations
growth
tree/stand health

Abstract: Three types of containerized (40, 75 or 125 cmsuperscript 3 containers) and bare rooted (2+1, 3+0 and plug-1 stock) seedlings were planted out in Oregon in Feb. 1979 on N. and S. facing slopes, clear felled in 1978. In general, containerized seedlings showed superior survival rates and greater height growth - particularly on the harsh S. slope, and lower reforestation costs. The 75-cmsuperscript 3 containerized seedlings are recommended, except for N. facing and wet coastal areas, where brush competition can be severe shortly after planting. In such areas, taller bare-rooted seedlings performed better.

OSU Link
Non-OSU Link

113. Hall, T.H., R.V. Quenet, C.R. Layton and R.J. Robertson. 1980. Fertilization and thinning effects on a Douglas-fir ecosystem at Shawnigan Lake: 6 year growth response. Pacific-Forest-Research-Centre, Canadian Forestry Service Information-Report BC-X-202. 31 p.

Keywords: fertilization
thinning
growth

Abstract: Further results are given for this stand in British Columbia at 30 yr old [see FA 43, 1945]. Gains in gross vol. increment (over control at 24 yr old) for the 200 initially largest trees/ha were 20% for heavy thinning alone, 51% for heavy fertilizer (urea) application alone and 139% for heavy thinning plus heavy fertilizer application. Adjustments by covariance analysis for differences in intitial stocking and tree size distributions gave values of 47, 76 and 139% respectively.

OSU Link
Non-OSU Link

114. Hansen, E.M., J.K. Stone, B.R. Capitano, P. Rosso, W. Sutton, L. Winton, A. Kanaskie and M.G. McWilliams. 2000. Incidence and impact of Swiss needle cast in forest plantations of Douglas-fir in coastal Oregon. Plant-Disease 84(7): 773-778.

Keywords: tree/stand protection
growth
tree/stand health

Abstract: An epidemic of Swiss needle cast, caused by the ascomycete Phaeocryptopus gaeumannii, is causing defoliation and growth reductions in Douglas-fir forest plantations along the Oregon Coast. The area of symptomatic plantations has been monitored annually since 1996 by aerial survey; in spring 1999, 119,500 ha were affected. Pathogen and symptom development have also been monitored on nine permanent plots in stands of differing disease severity. Infection levels and symptom severity are greatest in low elevation plantations close to the coast. In areas of severe disease, trees retain only current year needles. Defoliation is proportional to the number of stomata occluded by pseudothecia of the fungus, with needles being shed when about 50% of stomata are occupied, regardless of needle age. Fungus sporulation and premature needle abscission are greatest on the upper branches of trees. Annual application of fungicides increases needle retention significantly. Tree height and diameter growth and total tree volume are reduced by disease, and tree volume is significantly correlated with needle retention on our plot trees. The epidemic continues to be most severe in Douglas-fir plantations established on sites where Sitka spruce and western hemlock or red alder predominated in earlier times.

OSU Link
Non-OSU Link

115. Harper, P.A. and A.S. Harestad. 1986. Vole damage to coniferous trees on Texada Island. Forestry-Chronicle 62(5): 429-432.

Keywords: thinning
precommercial thinning

tree/stand protection
tree/stand health
growth

Abstract: Microtus townsendii injured trees by removal of bark and cambium from stems, branches and roots of Douglas fir, western hemlock and, rarely, Pinus monticola on Texada Island, British Columbia. Damage occurred more frequently in precommercially thinned stands <40 yr old than in unspaced stands. Trees with d.b.h. <less or =>19 cm were damaged by voles, but there was no selection by diam. or age class. No trees of ht. >16 m were damaged. For trees <16 m, damage increased as ht. decreased. There were n.s.d. in growth rates of trees damaged by voles when comparing the 2-yr av. before spacing and vole damage with the av. after these events. Stands should continue to be monitored to evaluate long-term effects of vole damage. On the basis of these results, control of voles is not recommended.

OSU Link
Non-OSU Link

116. Harrington, T.B. and J.C. Tappeiner, II. 1997. Growth responses of young Douglas-fir and tanoak 11 years after various levels of hardwood removal and understory suppression in southwestern Oregon, USA. Forest-Ecology-and-Management 96(1/2): 1-11.

Keywords: release treatments
manual release
growth
tree/stand health

Abstract: Douglas fir (Pseudotsuga menziesii) was planted as 2-yr-old bare rooted seedlings on 2 sites in SW Oregon cleared of old-growth Douglas fir and understorey tanoak (Lithocarpus densiflorus) in 1980, and broadcast burned in 1981. Planting was done in 1981 at one site and in 1982 at the second site. Height, diameter, and crown width of the young Douglas fir and sprout-origin tanoak were measured 1-11 years after reducing the density of the tanoak stand (in 1983, at 2 yr old) to 0, 25, 50 and 100% of its initial cover. On some of the experimental plots suppression of understorey vegetation was also carried out. Tanoak cover developed linearly with time, with steepness of the growth trajectory increasing at a diminishing rate with increasing percentage of initial tanoak cover. Fifth-year cover of understorey vegetation declined linearly with increasing percentage of initial tanoak cover. Survival of Douglas fir (96-100%) differed little among initial abundances of tanoak, while growth trajectories for its size became increasingly exponential with decreasing percentage of initial tanoak cover. Eleventh-year heights of Douglas fir were similar for 0, 25 and 50% of initial tanoak cover; however, diameter increased linearly with decreasing percentage of initial tanoak cover, and the slope of the relationship steepened with understorey suppression. The results indicate that young stands exhibiting a wide range of stand compositions and productivities can be established by early manipulations of tanoak and understorey abundance. Complete removal of tanoak plus understorey suppression are necessary to maximize Douglas fir growth, while productive, mixed stands can be achieved by removing 50% or more of tanoak cover.

OSU Link
Non-OSU Link

117. Harrington, T.B., J.C. Tappeiner, II and T.F. Hughes. 1991. Predicting average growth and size distributions of Douglas-fir saplings competing with sprout clumps of tanoak or Pacific madrone. New-Forests 5(2): 109-130.

Keywords: release treatments
manual release
growth
stand conditions

Abstract: Average growth and size distributions of 3- to 6-year-old (in 1983) Douglas fir (Pseudotsuga menziesii) saplings in three plantations in SW Oregon were studied for 7 years (1983-1989) after thinning of associated sprout clumps of tanoak (Lithocarpus densiflorus) or Pacific madrone (Arbutus menziesii); in some cases shrubs and herbs were also suppressed. Biologically based nonlinear equations explained 66, 90, and 53% of variation in average annual increment of Douglas fir height, diameter-squared, and crown cover, respectively. Equations for annual increment of crown cover of broadleaved and understorey vegetation explained only 10 to 12% of the variation, because these parameters exhibited a high degree of variability. Model simulations demonstrated that, for the same initial levels of cover, tanoak had faster rates of crown cover growth than madrone and also caused greater limitations in Douglas fir growth. Suppression of shrubs and herbs increased growth of Douglas fir only when broadleaved species were absent. Weibull functions adequately described size distributions for Douglas fir in 92% of individual-tree data sets. Regression functions of broadleaved crown cover and average Douglas fir size explained 51, 93, and 24% of variation in the Weibull A, B, and C parameters, respectively. Model simulations with predicted Weibull parameters demonstrated that broadleaved competition caused a positive skewing in size distributions for height and stem diameter of Douglas fir.

118. Harrington, T.B., R.G. Wagner, S.R. Radosevich and J.D. Walstad. 1995. Interspecific competition and herbicide injury influence 10-year responses of coastal Douglas-fir and associated vegetation to release treatments. Forest-Ecology-and-Management 76(1/3): 55-67.

Keywords: release treatments
chemical release
manual release
growth
tree/stand health
tree physiology
stand conditions

Abstract: Responses of competing vegetation and planted Douglas fir (Pseudotsuga menziesii var. menziesii) were studied for 10 years after six herbicide and manual release treatments in the Washington and Oregon Coast Ranges. Studies were installed in six 2- or 3-yr-old plantations, with Douglas fir densities of 988 to 1482 plants/ha at time of planting and 721 to 1282/ha 2 to 3 years late. Research objectives were to quantify regional, long-term responses of vegetation (Douglas fir and non-coniferous species) to various levels of competition, light and soil water availability, and intensity versus importance of factors influencing Douglas fir growth. Three treatments reduced shrub cover relative to the untreated check: triclopyr in year 1, glyphosate in years 1-5, and repeated control (via several

herbicide applications) in years 1-10. Reductions in woody cover from glyphosate stimulated increases in herb cover in years 3 and 5, while repeated control reduced herb cover in years 1, 2 and 5. Through year 10, Douglas fir survival (86-99%) varied little among treatments. Visual symptoms of herbicide injury to Douglas fir from triclopyr (45% of trees) and glyphosate (17% of trees) were associated with 0.1-0.2 m reductions in first-year height. After adjusting for tree size, Douglas fir growth in stem basal area 2 years after triclopyr was less than that of the untreated check, suggesting prolonged effects of herbicide injury. Because it sustained low levels of interspecific competition, caused minimal tree injury, and prevented overtopping cover from red alder (Alnus rubra), repeated control was the only treatment in which Douglas fir size (9.8 m height and 21 cm basal diameter in year 10) significantly exceeded (P<less or =>0.02) that of the untreated check (7.8 m height and 12 cm diameter).

OSU Link
Non-OSU Link

119. Harrison, R.B., E.C. Turnblom, C.L. Henry, P. Leonard, R. King and R. Gonyea. 2002. Response of three young Douglas-fir plantations to forest fertilization with low rates of municipal biosolids. Journal-of-Sustainable-Forestry 14(2/3): 21-30.

Keywords: fertilization
growth
tree/stand health

Abstract: Growth responses were monitored in three Pseudotsuga menziesii stands (Units 2, 11 and 13) in Washington, USA, following single low applications (17-19 t/ha) of municipal biosolids amendment. At the last measurement, in 1995, there were a total of 162 vs. 137 live trees (per 0.121 ha of 3 plots) in unit 2, 94 vs. 137 in unit 11, and 100 vs. 110 in unit 13 in control vs. biosolids-treated plots, respectively. The response ranged from 0.4 to 2.2 cm for average diameter at breast height, and -0.03 to 0.64 m for average total height. The small negative response could be due to mortality of trees or small errors in height measurements. The response in per ha values ranged from 0.8-5.2 m2/ha for basal area, 9-39 m3/ha for volume, and 3965-16 107 kg/ha for dry weight.

OSU Link
Non-OSU Link

120. Heath, L.S. and H.N. Chappell. 1989. Growth response to fertilization in young Douglas-fir stands. Western-Journal-of-Applied-Forestry 4(4): 116-119.

Keywords: fertilization
thinning
growth

Abstract: Response surface methodology was used to estimate 6-yr vol. growth response to 1 application of 200 lb N/acre in unthinned and thinned Douglas fir (Pseudotsuga menziesii) stands of b.h. age <less or =>25 yr in W. Washington and W. Oregon. Regional mean fertilizer response was 16% in unthinned stands and 20% in thinned stands. Site index had an increasingly inverse effect on response as b.a. increased in both unthinned and thinned stands. Response varied little over site index in regions

of low b.a., decreased moderately as site index increased in the intermediate region, and decreased rapidly in the high b.a. region.

OSU Link
Non-OSU Link

121. Hedin, I.B. 1994. Mechanical site preparation on salal-dominated sites: five-year results. Forest-Engineering-Research-Institute-of-Canada

Keywords: site preparation
mechanical preparation
growth
stand conditions

Abstract: Trials began in 1987 on sites on Vancouver Island where salal (Gaultheria shallon) is a competitor to Douglas fir [Pseudotsuga menziesii]. Three equipment types were tested: the Mitsui Miike (an excavator-mounted rock grinding attachment), the TTS Delta disc trencher and an excavator with a ripper tooth and live thumb. All three mechanical site preparation treatments were equally effective at reducing the coverage of salal and other competing vegetation and improving Douglas fir growth performance. On sites where the disc trencher can operate, with gentle slopes and light to moderate slash, it is most cost effective because of greater productivity.

Non-OSU Link

122. Heilman, P. 1983. Effects of surface treatment and interplanting of shrub alder on rowth of Douglas-fir on coal spoils. Journal-of-Environmental-Quality 12(1): 109-113.

Keywords: planting operations
site preparation
mechanical preparation
growth
tree physiology
soil properties
tree/stand health

Abstract: Annual growth of Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco) planted on topsoiled spoils at a coal mine near Centralia, Wash., was monitored for the first 6 y after planting. Treatments were contour bedding, contour bedding plus interplanted Sitka alder (Alnus sinuata (Reg.) Rydb.), and unbedded control. The bedding significantly increased growth of Douglas-fir in all 5 y of the study. Total height growth after 5 y was 35% greater than control on the bedding only plots, and 43% greater on the bedding plus Sitka alder plots. Height growth of Douglas-fir in the mixed stand was significantly greater during the 2nd and 3rd y of the study, but after 5 yr, no significant difference was evident in total height between the mixed and pure Douglas-fir plots. Concentration of N in Douglas-fir foliage was significantly increased by bedding in the fifth but not in the fourth year. Interplanting with Sitka alder had no significant effect on N in Douglas-fir foliage. The top 0.3 m of soil in the ridged portion of the bedded area contained significantly less moisture over a summer than did the top 0.3 m of the unbedded soil. At deeper depths, however, soil moisture was not significantly affected by bedding. Wind damage caused

by a severe storm that occurred after 5 y was very much greater on the unbedded plots (49% wind-thrown vs. 9 to 15% wind-thrown on the bedded plots) despite the smaller size of the trees on unbedded plots.

OSU Link
Non-OSU Link

123. Helgerson, O.T. 1985. Survival and growth of planted Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco) and ponderosa pine (Pinus ponderosa Dougl. ex Laws.) on a hot, dry site in southwest Oregon. Tree-Planters' Notes 36(4): 3-6.

Keywords: nursery operations
planting operations
tree/stand health
growth

Abstract: One-yr-old containerized seedlings and 2-yr-old bare rooted seedlings of both species were planted in Feb. 1982 on a W.-facing 35% slope on Tin Pan Peak. The site receives <760 mm of precipitation annually. Weeds were controlled with herbicides applied before and after planting. Survival after 2 yr averaged 94% for all stock types; survival of bare rooted seedlings (98-99%) was significantly better than that of containerized seedlings (88-92%). Relative vol. growth was greater for pine than Douglas fir. After 2 yr, the 2+0 bare rooted pines were significantly larger than the 2+0 Douglas firs, despite a smaller starting size.

OSU Link
Non-OSU Link

124. Helgerson, O.T. 1990a. Effects of alternate types of microsite shade on survival of planted Douglas-fir in southwest Oregon. New-Forests 3(4): 327-332.

Keywords: planting operations
tree/stand protection
tree/stand health
growth

Abstract: Five-yr survival of 2+0 bare root Douglas fir (Pseudotsuga menziesii) seedlings was increased by 3 types of shading: cardboard shadecards placed S. or E. of seedlings; and bottomless styrofoam cups inverted around seedling base, on 2 S.-facing sites. On the drier site, seedlings survived well without shading (89% unshaded, 98% shaded), but on the wetter site, where seedlings were more stressed, shading was more beneficial (62% unshaded, 89% shaded). Shading did not affect growth. Seedlings grew more in 5 yr on the drier than the wetter site, possibly because of better handling and planting practices, less browsing by deer, and better weed control.

OSU Link
Non-OSU Link

125. Helgerson, O.T. 1990b. Response of underplanted Douglas-fir to herbicide injection of sclerophyll hardwoods in southwest Oregon. Western-Journal-of-Applied-Forestry 5(3): 86-89.

Keywords: nursery operations
release treatments
chemical release
stand conditions
tree physiology
tree/stand health
growth

Abstract: Low-value broadleaf sclerophyll forests in SW Oregon, typically composed of tanoak (Lithocarpus densiflorus), Pacific madrone (Arbutus menziesii) and chinkapin (Castanopsis chrysophylla), may be converted to commercially valuable Douglas fir (Pseudotsuga menziesii) by underplanting. Results are given of studies of container-grown plug and nursery-grown bareroot fir seedlings planted out in March 1983 on plots in which all broadleaf stems had been previously (September 1981) injected with triclopyr amine. Although 60% broadleaf cover was killed by injection, 7 years later ground cover was significantly greater on these treated plots because of sprouting. Seedlings planted beneath treated broadleaf trees experienced greater daytime, but less predawn, moisture stress; plugs survived better than bareroots; and survival of seedlings on treated plots was not significantly better until 2 years after planting. Herbicide injection also resulted in increased height, diameter and volume growth rates of Douglas fir seedlings, and is recommended for the establishment of a conifer stand.

OSU Link
Non-OSU Link

126. Helgerson, O.T., D.H. McNabb and S.D. Hobbs. 1991. Survival and growth of Douglas-fir seedlings after prescribed burning of a brushfield in southwest Oregon. Western-Journal-of-Applied-Forestry 6(3): 55-59.

Keywords: site preparation
prescribed fire
tree/stand health
growth

Abstract: Five years after planting, survival of 2-0 bare root Douglas fir (Pseudotsuga menziesii) seedlings was high on both burned and unburned plots (89 and 87%, respectively), but seedling stem height, diameter, and volume were greater in burned than in unburned plots.

OSU Link
Non-OSU Link

127. Helgerson, O.T., S.D. Tesch, S.D. Hobbs and D.H. McNabb. 1989. Survival and growth of ponderosa pine and Douglas-fir stocktypes on a dry low-elevation site in southwest Oregon. Western-Journal-of-Applied-Forestry 4(4): 124-128.

Keywords: nursery operations

planting operations
growth
tree/stand health

Abstract: Two stocktypes (1+0 container-grown plugs and 2+0 nursery-grown bareroots) of ponderosa pine (Pinus ponderosa) and of Douglas fir (Pseudotsuga menziesii) were planted on a hot, droughty, low-altitude site near Medford, Oregon, which had burned in 1981. The main objective was to assess the potential for reforesting this type of site. After 5 growing seasons, bare rooted stock survived (98%) significantly better than plugs (89%); survival did not differ significantly by species. Douglas fir was taller than pine, pine was larger in diam., and the 2 species had approximately equal stem volumes. Bare rooted stock was consistently larger than plugs. Results show that these species and stocktypes can provide good reforestation after 5 yr on this type of site when seedlings are of good quality, are planted properly, and are given good weed control.

OSU Link
Non-OSU Link

128. Helgerson, O.T., S.D. Tesch, S.D. Hobbs and D.H. McNabb. 1992. Effects of stocktype, shading, and species on reforestation of a droughty site in southwest Oregon. Northwest-Science 66(2): 57-61.

Keywords: nursery operations
planting operations
tree/stand protection
tree/stand health
growth

Abstract: On hot, dry sites, shading may differentially increase survival of planted Douglas fir (Pseudotsuga menziesii) according to seedling size, and Douglas fir may differ from ponderosa pine (Pinus ponderosa) in early survival and growth. The survival and growth of Douglas fir seedlings (1+0 container-grown plugs and 2+0 bare-rooted seedlings, unshaded or shaded with cardboard shadecards at planting) and unshaded 2+0 bare-rooted ponderosa pine were compared on a droughty south facing clear felling in Oregon. The site was clear felled and burned in 1982 and the seedlings were planted in 1983. Shading did not significantly increase survival of plugs, possibly because of a wetter than normal first summer, nor did shading affect growth of either Douglas fir stocktype 5 yr after planting. Bare-rooted Douglas fir remained significantly larger than plugs, but relative growth rates for the initially smaller plugs were significantly greater for diameter and volume. Survival and growth of ponderosa pine tended to be better than those of Douglas fir. It was concluded that both species appeared to be suitable for reforestation after clear felling on sites subject to drought.

OSU Link
Non-OSU Link

129. Henry, C.L. 1987. Growth response, mortality, and foliar nitrogen concentrations of four tree species treated with pulp and paper and municipal sludges. *In* The-forest-alternative-for-treatment-and-utilization-of-municipal-and-industrial-wastes. *Eds.* Cole, D.W., C.L. Henry, and W.L. Nutter. University of Washington Press, Seattle, Washington, USA. pp. 258-265.

Keywords: nursery operations
nursery fertilization
soil properties
growth
tree/stand health
tree physiology

Abstract: Four nursery beds at the University of Washington Charles Lathrop Pack Demonstration Forest were each divided into plots that received 8 sludge treatments before being planted with seedlings of Douglas fir, Abies procera or Pinus monticola, or cuttings of Populus deltoides X P. trichocarpa. Each sludge and the unamended soil were analysed for total solids, total C, P and K, total N and NH4-N. Ht. and diam. were measured after planting in April 1984 and again in Feb. 1985. N was determined in foliage sampled during Oct. (Populus) or Feb. (other species). Addition of pulp and paper sludge alone and combined with municipal sludge provided predictable growth responses when compared with the C : N ratio of each treatment. Av. response was positive when the C : N ratio was more favourable than that of untreated soil, but av. response was negative when soil was treated with primary pulp and paper sludge with a very high C : N ratio. Treatments that produced the greatest growth also increased seedling mortality.

Non-OSU Link

130. Henry, C.L., D.W. Cole and R.B. Harrison. 1994. Use of municipal sludge to restore and improve site productivity in forestry: The Pack Forest Sludge Research Program. Forest-Ecology-and-Management 66(1/3): 137-149.

Keywords: fertilization
growth
soil properties
stand conditions

Abstract: Municipal wastewater residuals - sludge or biosolids - represent a major waste by-product from society that must be managed in responsible ways. Because of its high nutrient and organic matter content, sludge can be beneficially recycled into forest sites for site improvement purposes. This paper reviews the opportunities and problems that have been encountered during 20 yr of research into sludge application in forests, based on data from studies carried out in the Pack Demonstration Forest, Washington, on a variety of sites - including clear-felled, young or mature Douglas fir [Pseudotsuga menziesii] stands, and rights-of-way. Research to date on forest application of sludge has been very encouraging, clearly demonstrating the validity of this management technique. Forest sites typically display benefits in two ways: (1) an immediate growth response by both overstorey and understorey species; (2) a long-term improvement to the productivity of the site. However, for this practice to have broad utility and acceptance, it is critical that the concerns of the regulatory agencies and general public be addressed regarding public health and environmental issues through continued research. These concerns include the fate of trace metals, including movement, uptake and potential phytotoxicity, and passage into wildlife and human food chains, the fate of pathogens, and leaching of nitrates into groundwater systems. Many concerns are a result of misconceptions or misunderstandings of the potential problems involved and require working with these agencies and the general public through education and demonstration programmes.

OSU Link
Non-OSU Link

131. Henry, C.L., D.W. Cole, T.M. Hinckley and R.B. Harrison. 1993. The use of municipal and pulp and paper sludges to increase production in forestry. Journal-of-Sustainable-Forestry 1(3): 41-55.

Keywords: nursery operations
nursery fertilization
fertilization
thinning
growth
tree/stand health
soil properties

Abstract: Because of their high nutritional content and soil conditioning properties, municipal and pulp and paper (P&P) sludges (biosolids) can serve as soil amendments for nutritionally deprived or organically poor soils on forest sites. Studies conducted over the past 20 years at an experimental forest site in Western Washington, USA, have largely confirmed the potential of biosolids to increase the productivity of many forest lands. These studies clearly demonstrated that application of biosolids at environmentally acceptable rates will result in growth responses for both young seedlings as well as established stands. Municipal biosolids have been applied to a number of Douglas fir (Pseudotsuga menziesii) stands. Young stands treated with 47 t/ha showed an average of 72, 14 and 2% height responses for Site Class IV, III and II, respectively, over a 10 year period. Thinned versus unthinned 55-year-old Douglas fir treated with 142 dry t/ha averaged 43 and 48%, respectively, for the 12 year period greater than controls. Average growth responses of 65 and 40% occurred in the 65-year-old stand for the Site Class IV and II, respectively, from a 47 dry t/ha application. Growth response resulting from application of P&P biosolids to a number of tree species (Douglas fir, Pinus monticola and Abies procera in nursery beds, and plots of Populus deltoides x P. trichocarpa rooted cuttings) has also been excellent. When properly applied, biosolids can provide an excellent alternative to chemical fertilizers as a means of enhancing forest production. Growth response is typically greater and lasts longer when compared with chemical fertilizers.

OSU Link
Non-OSU Link

132. 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

133. Hildebrand, D.M., J.K. Stone, R.L. James and S.J. Frankel. 2004. Alternatives to preplant soil fumigation for Western forest nurseries. Pacific-Northwest-Research-Station,-USDA-Forest-Service General-Technical-Report PNW-GTR-608. ii + 27 p.

Keywords: nursery operations
nursery fertilization
tree/stand protection
tree/stand health
growth

Abstract: Field trials were conducted at six bare-root forest tree (Pinus ponderosa, Pseudotsuga menziesii, Pinus contorta and Abies magnifica var. shastensis) nurseries in the Western United States: Bend Pine Nursery in Bend and J. Herbert Stone Nursery in Central Point (Oregon), Coeur d'Alene Nursery and Lucky Peak Nursery in Idaho, and Humboldt Nursery near McKinleyville and Placerville Nursery near Camino (California). These field experiments compared cultural treatments including timing and depth of sowing; bare fallow (with and without periodic tilling); organic amendments including sawdust, composts, and cover crops; mulches including pine needles, sawdust, and rice straw; and fumigation with methyl bromide/chloropicrin or dazomet. Measured effects included population levels of potential soil-borne pathogens (species of Fusarium and Pythium), disease incidence, seedbed density, and sizes of conifer seedlings. Several non-fumigation treatments resulted in production of seedlings with densities and sizes similar to or better than those produced in beds treated with chemical fumigation. Results varied within the nurseries depending on conifer species, field history, and disease presence. Beneficial cultural practices included: (1) incorporation of slowly decomposing organic soil amendments, e.g., aged sawdust with additional nitrogen provided later to seedlings; (2) bare fallowing with periodic tilling, and bare fallowing without periodic tilling plus supplemental weed control; and (3) sowing of conifer seed earlier and more shallow than sown conventionally, and covering seed with a nonsoil mulch such as aged sawdust or hydromulch.

OSU Link
Non-OSU Link

134. Hobbs, S.D. 1981. Stocktype selection and planting techniques for Douglas-fir on skeletal soils in southwest Oregon. *In* Reforestation of skeletal soils: proceedings of a workshop, Medford, OR, USA, November 17-19, 1981. *Eds.* S.D. Hobbs and O.T. Helgerson. pp. 92-96.

Keywords: planting operations
tree/stand health
growth

Abstract: Stocktype selection and planting techniques for Douglas-fir can have a significant impact on seedling survival and growth on droughty skeletal soils in southwest Oregon. In these environments important seedling characteristics are stock quality, shoot-root ratio, root morphology, and caliper. Planting and special ameliorative techniques for sites with skeletal soils are discussed.

OSU Link
Non-OSU Link

135. Hobbs, S.D., S.G. Stafford and R.L. Slagle. 1987. Undercutting conifer seedlings: effect on morphology and field performance on droughty sites. Canadian-Journal-of-Forest-Research 17(1): 40-46.

Keywords: nursery operations
tree morphology
growth
tree/stand health

Abstract: One-yr-old barerooted Douglas fir and ponderosa pine seedlings in an Oregon nursery were subjected during Feb.-June 1980 to 5 undercutting treatments that varied by number and depth of cuts and seedling phenology at time of treatment. Eight morphological variables were measured in Jan. 1981 before planting the seedlings at 2 sites in Oregon. Seedling survival and growth was recorded annually for 4 yr. All treatments significantly reduced shoot growth in the nursery, but changes in root system morphology depended on treatment severity and species. Treatment effects were generally more pronounced in ponderosa pine than in Douglas fir. Discriminant analysis showed that seedlings responded similarly in all undercutting treatments relative to control seedlings that were not undercut. No effects of undercutting were apparent after 4 yr in the field.

OSU Link
Non-OSU Link

136. Hobbs, S.D. and K.A. Wearstler, Jr. 1983. Performance of three Douglas-fir stocktypes on a skeletal soil. Tree-Planters' Notes 34(3): 11-14.

Keywords: nursery operations
tree/stand health
growth

Abstract: Plug-1 bare rooted seedlings, initially grown in containers and transplanted to a nursery for 1 yr, 2-0 bare rooted seedlings and 1-0 plug stock were planted on a steep, severe site in the Siskiyon Mts., SW Oregon, in 1980. Height and diameter were recorded after planting and in the autumn in 1980

and 1981. Survival was 91% for 1-0 plug seedlings, 87% for plug-1 seedlings and 56% for 2-0 bare rooted stock. There were n.s.d. in height and diameter growth.

OSU Link
Non-OSU Link

137. Hobbs, S.D. and K.A. Wearstler, Jr. 1985. Effects of cutting sclerophyll brush on sprout development and Douglas-fir growth. Forest-Ecology-and-Management 13(1/2): 69-81.

Keywords: release treatments
manual release
stand conditions
tree physiology
growth

Abstract: In SW Oregon, varying amount of brush were removed from a sclerophyll brushfield dominated by Quercus chrysolepis and Arctostaphylos patula with scattered Pseudotsuga menziesii saplings. Brush removal was accomplished by slashing (cut by chainsaw) near ground level at three intensities: (1) total removal, (2) partial removal, and (3) an untreated control. Sclerophyll brush species responded within 3 weeks of slashing by vigorous sprouting, which was greatest in total brush removal areas where 861 513 sprout stems/ha developed during the first year. Soil water potentials and predawn xylem pressure potentials of Douglas fir were less negative in total removal areas than in partial removal and untreated control areas. Relative growth rates of Douglas fir saplings temporarily increased in total and partial brush removal areas, but were not significantly different from the untreated control 3 yr after treatment. Slashing of sclerophyll brush to release long-suppressed Douglas fir is not recommended because of rapid brush recovery by sprouting.

OSU Link
Non-OSU Link

138. Hopmans, P. and H.N. Chappell. 1994. Growth response of young, thinned Douglas-fir stands to nitrogen fertilizer in relation to soil properties and tree nutrition. Canadian-Journal-of-Forest-Research 24(8): 1684-1688.

Keywords: fertilization
growth
soil properties
tree physiology

Abstract: Application of 224 kg N/ha to young, thinned stands of Douglas fir (Pseudotsuga menziesii) at 35 sites in W. Oregon and Washington significantly increased basal area and volume increment over 8 years following treatment. However, response varied considerably between sites, and relative volume increment exceeded 10% at only 19 of the 35 sites. Response to applied N was evaluated in relation to forest floor and soil variables as well as to levels of N in foliage. Relative responses in basal area and volume were significantly correlated with total N concentration and the C/N ratio of the soil. However, these relationships explained only part (18-22%) of the observed variation in response. In contrast, relative response was strongly correlated with the level of N in the foliage of non-fertilized trees at 11

sites, accounting for 94% of the variation between sites. It is suggested that foliar N could be used to predict growth responses to N fertilizers in young thinned Douglas fir stands.

OSU Link
Non-OSU Link

139. Hummel, S. and R. Hummel. 2004. Five-year thinning response of an overgrown Douglas-fir Christmas tree plantation. Western-Journal-of-Applied-Forestry 19(3): 171-174.

Keywords: planting operations
thinning
growth
yield
economics

Abstract: A 15-year-old Douglas-fir Christmas tree plantation in western Oregon was thinned in 1996 according to regional sawtimber conversion guidelines. The plantation comprised two strata, distinguished by initial planting density (Area 1=5x5 ft and Area 2=10x10 ft). Unthinned control plots were established in both Area 1 and Area 2 at the time of the thinning treatment. Five years later, the quadratic mean diameter (QMD) in Area 1 (thinned) was 6.4 in. versus 5.2 in. in Area 1 (unthinned), while in Area 2 (thinned) the QMD was 11.4 in. compared to 9.3 in. in Area 2 (unthinned). Over the same period, the volume/ac in Area 1 (thinned) (1,080 ft3/ac) was nearly twice that of Area 1 (unthinned) (576 ft3/ac). In contrast, the volume/ac in Area 2 (thinned) (2,318 ft3/acre) was almost half that of Area 2 (unthinned) (4,264 ft3/ac). These results suggest that while thinning was timely for Area 1, the thinning treatment could have been delayed for Area 2. By plantation age 30, the treated units in Area 1 and Area 2 have estimated yields of 9.6 and 11.6 thousand bd ft (mbf), respectively, with no additional thinning. Given 2002 average prices for #3 sawmill grade logs, gross return at age 30 would range between $5,000 and $6,000/ac.

OSU Link
Non-OSU Link

140. Hung, L.L.L. and J.M. Trappe. 1987. Ectomycorrhizal inoculation of Douglas-fir transplanted container seedlings with commercially produced inoculum. New-Forests 1(2): 141-152.

Keywords: nursery operations
mycorrhizal response
growth

Abstract: Commercially produced vegetative inocula of Laccaria laccata and Hebeloma crustuliniforme successfully formed ectomycorrhizae with Douglas fir transplanted container (plug + 1) seedlings. After 4.5 months in containers, 83% and 90%, respectively, of short roots were mycorrhizal. L. laccata- or H. crustiliniforme-inoculated seedlings had significantly more mycorrhizal and total short roots than Pisolithus tinctorius-inoculated (4% mycorrhizal root tips) or uninoculated control seedlings. No significant differences were detected in seedling growth at the end of the container phase. After transplantation and growth in nursery beds for 17 months, mean new short root colonization of all seedlings was 80%. H. crustuliniforme persisted as a dominant mycorrhizal fungus on seedlings initially

inoculated with this fungus. L. laccata-inoculated seedlings had 40% of their short roots colonized by L. laccata and another 40% by the native fungi Rhizopogon and Thelephora spp. All mycorrhizae of control seedlings and those inoculated with P. tinctorius were formed by fungi native to the nursery beds. A significant fungal treatment effect was detected for shoot height only. Control seedlings were significantly taller than L. laccata-inoculated seedlings after transplanting.

OSU Link
Non-OSU Link

141. Jacobs, D.F., R. Rose and D.L. Haase. 2003a. Development of Douglas-fir seedling root architecture in response to localized nutrient supply. Canadian-Journal-of-Forest-Research 33(1): 118-125.

Keywords: nursery operations
nursery fertilization
tree morphology
tree physiology
growth

Abstract: Three months following sowing, Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco) seedlings were transplanted into pots with controlled-release fertilizer (CRF) applied at rates of 0, 8, 16, and 24 g/2200 cm3 soil as a single uniform layer beneath the root system. Seedlings were destructively harvested periodically, and roots were divided into vertical segments above (S1), within (S2), and below (S3) the fertilizer layer. Two months following transplant, the number of active root tips was positively correlated with CRF rate in S1 and negatively correlated with rate in S2 and S3. At 6 months, root penetration into S3 was severely restricted at 16 and 24 g. This was attributed to detrimental changes in soil osmotic potential in S2. Fertilizer improved seedling growth at 8 g after 6 months compared with controls but was inhibitory at 24 g. Photochemical quantum yield was higher in all CRF treatments compared with controls 3 months following transplant, which corresponded with rapid initial CRF nutrient release. Despite improvements in nutrient release technology with CRF, high application rates may result in excessive concentrations of fertilizer nutrients in media, which can restrict root penetration and negatively affect seedling growth. Conservative application rates and improvements in CRF technology will help reduce the potential for adverse effects on seedling development.

OSU Link
Non-OSU Link

142. Jacobs, D.F., R. Rose, D.L. Haase and P.D. Morgan. 2003b. Influence of nursery soil amendments on water relations, root architectural development, and field performance of Douglas-fir transplants. New-Forests 26(3): 263-277.

Keywords: nursery operations
fertilization
tree physiology
tree morphology
growth
carbon allocation
soil properties

tree/stand health

Abstract: This experiment evaluated the influence of manure, peat, and vermiculite incorporated at low and high rates (0.0118 and 0.0236 m3/m2) and under two soil moisture regimes on Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco) seedling (1+0 for 1+1) xylem water potential (Phi xylem), whole-plant growth, root architectural development, and subsequent field performance under fertilized and non-fertilized conditions. Trends in soil moisture retention were observed (high manure > high peat > control) but there were no differences in Phi xylem. Root length in the wetter soil moisture experiment was initially (three months) greatest for seedlings in high vermiculite and least in high manure but there were no differences among treatments at lifting (eight months). Mean height was greatest for seedlings grown in vermiculite and peat (wetter nursery experiment) after two field seasons. Field fertilization (35 g/seedling) with controlled-release fertilizer in the planting hole stimulated height growth initially, but decreased height and diameter growth during the second growing season. Dramatic improvements associated with the use of nursery soil amendments were not realized, but the failure to identify negative effects, a potential reduction in disease incidence, and improvement of nursery soil physical and chemical properties may justify their use.

OSU Link
Non-OSU Link

143. Jaindl, R.G. and S.H. Sharrow. 1988. Oak/Douglas-fir/sheep: a three-crop silvopastoral system. Agroforestry-Systems 6(2): 147-152.

Keywords: planting operations
release treatments
manual release
tree/stand health
growth

Abstract: A small scale agroforestry study started in 1952 was revisited in 1985 to evaluate the long-term influence of site preparation and grazing on tree growth and survival in a system with Douglas fir, white oak (Quercus garryana) and sheep. In 1952-53, 2-yr-old Douglas fir seedlings were planted at the rate of 2500 trees/ha under 3 levels of site preparation: (1) no treatment; (2) oak thinned by 50%; and (3) oak clear felled. From 1954 to 1960, yearling ewes grazed half of each of the 3 thinning treatments for 3-4 wk each spring. The conifers were undisturbed since grazing was discontinued in 1960. Survival of planted conifers averaged 64% in 1985 and did not vary among either site preparation or grazing treatments. From 1964 to 1985, trees on the thinned and clear felled plantations grew an av. ht. of 1060 and 990 cm, respectively, compared with 900 cm on the unthinned plantation. D.b.h. averaged 3.8 and 5.6 cm greater on thinned or clear felled plantations, respectively, than on the unthinned control by 1985. Conifers on grazed plantations had increased ht. and d.b.h. growth during the first 12 yr of plantation life, averaging 63 cm taller and 0.7 cm greater in d.b.h. than the ungrazed plots by 1964. By 1985 the difference in ht. (122 cm) and d.b.h. (1.0 cm) between grazed and ungrazed plantations was not statistically significant. These data suggest that although site preparation can positively influence conifer growth, total clear felling is no better than thinning oaks. Furthermore, proper grazing can increase ht. and d.b.h. growth of the conifers during and immediately after the grazing years.

OSU Link
Non-OSU Link

144. Johnson, G.R. 2002. Genetic variation in tolerance of Douglas fir to Swiss needle cast as assessed by symptom expression. Silvae-Genetica 51(2/3): 80-86.

Keywords: genetic tree improvement
tree/stand protection
tree/stand health
growth
genetic relationships

Abstract: The incidence of Swiss needle cast (caused by Phaeocryptopus gaeumannii) on Douglas fir (Pseudotsuga menziesii) has increased significantly in recent years on the Oregon coast. Genetic variation in symptoms of disease infection, as measured by foliage traits, was assessed in two series of progeny trials to determine whether these "crown health" indicators were under genetic control and correlated with tolerance (tolerance being continued growth in the presence of high disease pressure). Foliage traits generally had lower heritabilities than growth traits and were usually correlated with diameter growth. Foliage traits of crown density and colour appeared to be reasonable indicators of disease tolerance. In the absence of basal area data, assessing crown density and colour can help screen for families that show tolerance to the disease.

OSU Link
Non-OSU Link

145. Johnson, G.R., R.A. Sniezko and N.L. Mandel. 1997. Age trends in Douglas-fir genetic parameters and implications for optimum selection age. Silvae-Genetica 46(6): 349-358.

Keywords: genetic tree improvement
growth
genetic relationships

Abstract: Trends in genetic variation in Douglas fir (Pseudotsuga menziesii) were examined over 51 progeny test sites throughout western Oregon. Narrow sense heritabilities for height and diameter showed an increasing trend to age 25, the oldest age examined. Before age 10, height heritabilities were relatively unstable. Type B site-site genetic correlations increased slowly with age for height and remained relatively stable for diameter. Age-age correlations were used to develop an equation to predict age-age correlations by using the log of the age ratios (LAR). Optimum selection age was calculated for a 60-year rotation by using two measures of efficiency: gain per year and discounted gain. The optimum selection age for height tended to be 2 to 3 years earlier than for diameter. Gain per year was maximized at age 10 for height and age 13 for diameter.

OSU Link
Non-OSU Link

146. Joseph, G. and R.G. Kelsey. 1999. Growth of Douglas-fir and ponderosa pine seedlings with foliar applications of methanol and ethanol. Western-Journal-of-Applied-Forestry 14(4): 183-185.

Keywords: nursery operations
growth

tree morphology
tree/stand health

Abstract: Ethanol and methanol have been reported to enhance the growth and development of several agricultural and horticultural species. To test whether methanol or ethanol stimulated growth of coast Douglas fir (Pseudotsuga menziesii var. menziesii) or ponderosa pine (Pinus ponderosa)in the nursery, seedlings were sprayed with concentrations of 1 to 10% (v/v) on the foliage twice a week for 13 wk during the growing season. Foliar applications of methanol and ethanol neither significantly stimulated nor inhibited growth, and signs of damage at these concentrations were lacking.

OSU Link
Non-OSU Link

147. 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

148. Kastner, W.W., Jr., S.M. Dutton and D.M. Roche. 2001. Effects of Swiss needle cast on three Douglas-fir seed sources on a low-elevation site in the northern Oregon Coast Range: results after five growing seasons. Western-Journal-of-Applied-Forestry 16(1): 31-34.

Keywords: genetic tree improvement
tree/stand protection
growth
tree/stand health

Abstract: Douglas-fir (Pseudotsuga menziesii var. menziesii) seedlings grown from three seed sources were evaluated for 5 years for their relative tolerance to Swiss needle cast (caused by the ascomycete Phaeoxryptopus gaeumannii), on a high-disease-hazard site located approximately 3 miles northeast of Tillamook, Oregon, USA. The seed sources were: (1) seed collected from trees showing an apparent degree of tolerance to Swiss needle cast in natural stands in the coastal fog belt, (2) open-pollinated seed orchard seed collected from random single-pair crosses of parent trees in natural stands outside of the coastal fog belt, but west of the Oregon Coast Range summit, whose progeny demonstrated an apparent degree of disease tolerance in coastal Douglas-fir progeny test sites, and (3) standard reforestation seed purchased from a commercial vendor. There were no significant differences among seed sources in basal diameter and total height for all five growing seasons. Needle retention varied among seed sources over the 5-year period, but current-year needle retention did not vary significantly after the fifth growing season, and retention of 1- and 2-year-old needles was relatively low for all seed sources. The intense disease pressure on this site may have overwhelmed expression of disease tolerance among seed sources. We do not recommend planting Douglas-fir on such high-hazard sites.

OSU Link
Non-OSU Link

149. Kaya, Z. 1992. The effects of test environments on estimation of genetic parameters for seedling traits in 2-year-old Douglas-fir. Scandinavian-Journal-of-Forest-Research 7(3): 287-296.

Keywords: genetic tree improvement
nursery operations
genetic relationships
growth
tree phenology

Abstract: The effects of test environments (dry versus wet) on the estimation of genetic parameters in seedling traits were studied in 160 open-pollinated families of Douglas fir (Pseudotsuga menziesii) from southwestern Oregon. Seedlings from four populations were grown in two test nursery environments between which a water potential difference of -9 bars was created over two growing seasons, by withholding water for 4 and 8 wk, respectively. Estimated genetic variances in most growth and phenology traits were considerably higher for seedlings grown in the wet environment than for those in the dry. Estimated genetic correlations between the same traits measured in different test environments indicated that most seedling traits studied for two growing seasons were genetically stable in both environments, suggesting that genotype environment interaction in these traits are weak. However, it is emphasized that the effect of test environment on estimation of genetic parameters in seedling traits, especially in adaptive seedling traits, should be evaluated very carefully when early evaluation of genetic entries is practised in Douglas-fir, since these traits (budburst timing, lammas growth and free growth) appear to be plastic in character.

OSU Link
Non-OSU Link

150. Kaya, Z. 1993. Genetic variation in shoot growth components and their correlations in Pseudotsuga menziesii var. menziesii seedlings. Scandinavian-Journal-of-Forest-Research 8(1): 1-7.

Keywords: genetic tree improvement
genetic relationships
growth

Abstract: Stem-unit measurements could be useful for early selection if these dimensions were highly heritable and strongly correlated with traits of commercial interest, such as height growth. Height increments and the number and length of stem segments were measured in the first and second growth period in predetermined and free growth of Douglas-fir (Pseudotsuga menziesii var. menziesii) seedlings from 40 families in each of 2 populations from southwestern Oregon, USA. Populations, or families in populations, exhibited genetic variation in all traits except number of stem units in predetermined growth. Heritabilities for stem-unit measurements were higher than those for height increment in the first growing season, but not in the second. Correlations among measurements of stem units and height increments were only moderate (generally <0.70). It is concluded that stem units are not likely to be better measurements of height in early selection of Douglas-fir than are measurements of either predetermined or free growth.

151. Kaya, Z., R.K. Campbell and W.T. Adams. 1989. Correlated responses of height increment and components of increment in 2-year-old Douglas fir. Canadian-Journal-of-Forest-Research 19(9): 1124-1130.

Keywords: genetic tree improvement
tree phenology
growth
genetic relationships

Abstract: The consequences for growth and phenology of early selection for height or its growth components were evaluated in 160 open-pollinated families of Douglas fir (Pseudotsuga menziesii) from SW Oregon. Seedlings from 2 inland and 2 coastal populations (40 families each) were grown for 2 growing seasons in a 'moist' and 'dry' nursery environment. Predicted response to selection suggests that risk of low juvenile-mature correlation and maladaptation with early selection would be less in the inland than in the coastal region. Early bud set in the 1st yr was genetically correlated with larger overwintering buds in seedlings from both inland and coastal regions. These larger buds yielded a large increment of predetermined growth in the 2nd yr, followed by little or no free growth and early bud set. Seedlings with late bud set in the 1st yr had the converse pattern. Inland seedlings set buds much earlier on av. than coastal seedlings, hence seedlings from the 2 regions had different growth patterns. Risks that can attend early selection for ht. generally would be decreased in both regions by selecting for predetermined growth, but several qualifications are discussed.

152. Khan, S.R., R. Rose, D.L. Haase and T.E. Sabin. 1996. Soil water stress: its effects on phenology, physiology, and morphology of containerized Douglas-fir seedlings. New-Forests 12(1): 19-39.

Keywords: nursery operations
growth
tree physiology
tree phenology

Abstract: Containerized 3-month-old Douglas fir (Pseudotsuga menziesii) seedlings were subjected to six moisture-stress treatment (ranging from 7 to 65% soil water content by volume) for 12 weeks. At the end of this period, there were significant differences in phenological, physiological, and morphological responses among the seedlings in the various moisture-stress treatments. In general, seedlings grown under very high or very low soil moisture conditions were adversely affected, while those grown under moderate conditions (29 to 53% water content) exhibited optimum growth, bud development, and nutrient and starch reserves. The use of vector analysis was found to be helpful in data interpretation. The results indicate the importance of closely monitoring nursery moisture regimes in order to achieve the best seedling quality.

OSU Link
Non-OSU Link

153. Kimball, B.A., G.R. Johnson, D.L. Nolte and D.L. Griffin. 1999. An examination of the genetic control of Douglas-fir vascular tissue phytochemicals: implications for black bear foraging. Forest-Ecology-and-Management 123(2/3): 245-251.

Keywords: genetic tree improvement
tree/stand protection
growth
tree physiology
genetic relationships

Abstract: Silvicultural practices can influence black bear (Ursus americanus) foraging preferences for Douglas fir (Pseudotsuga menziesii) cambial-zone vascular tissues, but little is known about the role of genetics. To study the impact of genetic selection, vascular tissue samples were collected from Douglas fir trees in 6 half-sib families from 5 different sites in north central Oregon. Four replications of 3-tree non-contiguous plots were sampled at each site to examine inter-and intra-site variation. Tree growth was measured as tree diameter at breast height, and the absolute concentrations of 26 different terpenoids were determined by gas chromatography/flame ionization detection from ethyl acetate extracts. The simple carbohydrates fructose, glucose, and sucrose, and the phenolic glycoside coniferin were quantified using anion-exchange chromatography with pulsed amperometric detection. Cluster analysis was used to reduce the number of variables used in analyses of variance. Results for the families studied here indicate that tree growth and some terpenoids were under some level of genetic control. Furthermore, allocation of constitutive terpenoids in vascular tissues was not at the expense of tree growth. The sugars present in vascular tissue were affected by environment (site) and genetics (family) and their interaction.

OSU Link
Non-OSU Link

154. 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

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

Keywords: thinning
commercial thinning
growth
yield
tree/stand health

Abstract: A study was conducted at the Skykomish Tree Farm, and at the Clemons Tree Farm, Washington, USA, to determine how the amount of growing stock in repeatedly thinned stands of Douglas Fir (Pseudotsuga menziesii) affects cumulative wood production, tree size and growth-growing stock ratios. Initial stands were thinned to the same level of growing stock so that all plots would have virtually the same growth potential except the unthinned controls. The Skykomish and Clemons stands were 24 and 19 years old, respectively, when the studies were started. Stand treatments were completed at ages 42 and 36, and measurements were continued to ages 56 and 50. After 32 years at Skykomish and 31 years at Clemons, the basal area per acre in the eight regimes ranged from 119-244 ft2 at Skykomish and 101-195 at Clemons. The corresponding gross yields in cubic feet per acre were 8709-13 579 at Skykomish and 6329-9072 at Clemons. Volume in thinnings were 18-53% of the gross

yield. Stand treatments included four regimes with different combinations of heavy and light thinning and four regimes with constant intensities of thinning. Variable regimes were found to have consistent advantage over constant regimes. Within a given level of growing stock, the constant regimes are recommended for applications where wood production is the primary objective. A substantial increase in the yield was produced in all regimes during the post thinning holding period. Based on standing volume after the last thinning, the holding period of 4 years produced approximately 30% more volume in all regimes. Extending the period to 9 years produced approximately 70% more volume, and at 14 years, the standing volume was more than double the volume remaining after the last thinning. This extra yield enhanced by the high quality of the stands makes the length of the holding period an important factor in the scheduling of final harvest.

OSU Link
Non-OSU Link

156. King, J.N., F.C. Yeh and J.C.H. Heaman. 1988. Selection of growth and yield traits in controlled crosses of coastal Douglas-fir. Silvae-Genetica 37(3-4): 158-164.

Keywords: genetic tree improvement
growth
genetic relationships

Abstract: Analysis of variance of several yield traits including height, height increment, diameter and volume in a full-sib progeny test of Douglas fir (Pseudotsuga menziesii) on 2 sites in British Columbia revealed significant amounts of additive genetic variance but small and non-significant amounts of dominance genetic variance. Individual tree heritabilities were between 0.08 and 0.16 for growth traits and family heritabilities were between 0.55 and 0.73. Acceptable gains were predicted with progeny test re-selection (10% volume gain per unit selection intensity). Age 6 height was an effective selection trait, and correlated well with age 12 volume, giving 70% relative efficiency for family selection. Age 12 height measurement and height increment between 10 and 12 did not express significant genetic differences on the individual site analyses due in part to uncontrolled within-plot variation. Diameter showed higher heritabilities and was less sensitive to inadequacies in experimental design than the later height measurements. Index selection for stem volume also demonstrated that diameter was the most effective growth trait to predict the breeding value of parents for individual tree stem volumes.

OSU Link
Non-OSU Link

157. Knapp, W.H., T.C. Turpin and J.H. Beuter. 1984. Vegetation control for Douglas-fir regeneration on the Siuslaw National forest: a decision analysis. Journal-of-Forestry 82(3): 168-173.

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

chemical release
manual release
growth
yield
economics

Abstract: Records from 324 plantations in Oregon were used to calculate the effect on stocking of various methods of controlling competing vegetation before and after plantation establishment. A decision tree analysis using 6 management regimes on 5 stocking classes indicated that if no site preparation or release (other than broadcast burning to reduce fuels) were practised, the forest would produce 63% of the m.a.i. and 35% of the present net worth (PNW) expected if all means of control (chemical, manual and burning) were available and used. If only manual control methods were used 78% of the max. m.a.i. and 57% of the max. PNW would be expected. When all methods except phenoxy herbicides were available, the expected m.a.i. and PNW were reduced to no less than 90%. The yield reduction varied with aspect, and the type of prelogging vegetation. Declines were least on SW-facing sites that were originally predominantly conifers, and greatest on NE-facing slopes that had supported broadleaves. Limitations of the analysis are discussed.

OSU Link
Non-OSU Link

158. Knowe, S.A. 1994a. Effect of competition control treatments on height-age and height-diameter relationships in young Douglas-fir plantations. Forest-Ecology-and-Management 67(1-3): 101-111.

Keywords: release treatments
chemical release
manual release
growth
tree morphology

Abstract: Height-age and height-diameter models for plantations of young Douglas fir (Pseudotsuga menziesii var. menziesii) were examined in relation to vegetation management treatments. The models were developed from 10 years of measurements in a competition release study installed on six sites in the Coast Ranges of Oregon and Washington. Analysis of height growth patterns for dominant trees indicated significant differences between the total vegetation control treatment and operational release treatments or no treatment. The resulting height-age function depicted exponential growth patterns for the total vegetation control treatment and nearly linear patterns for the operational release treatment and no treatment. The height-diameter function was compatible with dominant height growth and quadratic mean diameter prediction functions. Different height-diameter curve shapes were associated with total vegetation control and the operational release and no treatments. The resulting function implied that Douglas fir trees of a given diameter and age were slightly taller when under interspecific competition, especially for trees with smaller diameters. The height-age and height-diameter functions may be used in conjunction with diameter distribution or stand table projection models developed for these data to predict dynamics and stand structure in young Douglas fir plantations.

OSU Link
Non-OSU Link

159. Knowe, S.A. 1994b. Incorporating the effects of interspecific competition and vegetation management treatments in stand table projection models for Douglas-fir saplings. Forest-Ecology-and-Management 67(1-3): 87-99.

Keywords: release treatments
chemical release
growth
tree morphology

Abstract: A stand table projection system based on individual-tree and stand-level models for young Douglas fir (Pseudotsuga menziesii var. menziesii) plantations was developed from and evaluated with remeasurement data from xeric sites in the Siskiyou Mountains of SW Oregon (established in a competition gradient study), and mesic sites in the Coast Ranges of Oregon and Washington (established in a treatment efficacy study). A projection equation was developed for relative tree size, defined as the ratio of individual-tree diameter at 15 or 30 cm above ground level (depending on the study location) to quadratic mean diameter. The relative size projection equation for the Coast Ranges study included the effect of total vegetation control, which indicated that diameters of Douglas fir receiving total vegetation control tended to become more uniform over time in the Coast Ranges. An additional equation was developed to project quadratic mean diameter so that individual-tree diameters could be estimated from projected relative size. The effect of vegetation management treatments on projected quadratic mean diameters in the Siskiyou study was expressed as an interaction between proportion of cover removed by treatments (intensity) and dominant height of Douglas fir at time of treatment relative to current dominant height. In 1- and 2-yr projection periods, the stand table projection system performed similarly to a diameter distribution prediction system based on a Weibull distribution function. However, the difference between projected and predicted diameter distributions became more pronounced as the projection period increased to 5 years.

OSU Link
Non-OSU Link

160. Knowe, S.A., B.D. Carrier and A. Dobkowski. 1995. Effects of bigleaf maple sprout clumps on diameter and height growth of Douglas-fir. Western-Journal-of-Applied-Forestry 10(1): 5-11.

Keywords: release treatments
growth

Abstract: Diameter and height growth of 7- to 11-yr-old Douglas fir (Pseudotsuga menziesii) were examined in relation to bigleaf maple (Acer macrophyllum) competition. Growth models were developed for plantations in Oregon and Washington by joining a distance dependent model with a model that excluded competition effects. The fitted equations were based on Douglas fir size at plantation age 7 yr and distance from the stump and crown diameter of the bigleaf maple clump. The model suggests that bigleaf maple clumps between 5.7 and 14.6 m from planted Douglas firs reduce the latter's d.b.h. and height growth, and that this reduction becomes greater with increasing size of the clump. A procedure is suggested to use the models to guide vegetation management prescriptions on sites with bigleaf maple sprout clumps.

OSU Link
Non-OSU Link

161. Knowe, S.A., T.B. Harrington and R.G. Shula. 1992. Incorporating the effects of interspecific competition and vegetation management treatments in diameter distribution models for Douglas-fir saplings. Canadian-Journal-of-Forest-Research 22(9): 1255-1262.

Keywords: release treatments
manual release
chemical release
growth
tree morphology

Abstract: A parameter recovery procedure for the Weibull distribution function, based on diameter percentiles, was modified to incorporate the effects of competing vegetation in young Douglas fir (Pseudotsuga menziesii var. menziesii) plantations. The procedure was tested using data from sites in the Coast Ranges of Oregon and Washington and in the Siskiyou Mountains of SW Oregon. The Coast Ranges study was conducted in 2- to 3-yr-old plantations needing release from woody shrub (mainly Rubus spectabilis and R. parviflorus) and broadleaved tree (Alnus rubra and Acer macrophyllum) competition. Release treatments were an untreated control, manual cutting, triclopyr ester applied aerially, glyphosate applied aerially, and a total vegetation control treatment consisting of annual broadcast applications of hexazinone and spot treatments of glyphosate and triclopyr.
The Siskiyou Mountains study was conducted in 1- to 2-yr-old plantations on sites covered by tanoak (Lithocarpus densiflorus). Tanoak sprout clumps were left unthinned or were thinned to 50, 25 and 0% of the pretreatment cover. Four percentiles (0, 25th, 50th, 95th) of the cumulative probability distribution were predicted as functions of quadratic mean diameter and age. In the Siskiyou study, cover and total vegetation control affected quadratic mean diameter and all four percentiles; intensity of the vegetation treatments affected the 0 and 25th percentiles, and the interaction between intensity and timing of treatment affected mean diameter. In the Coast Ranges study, only quadratic mean diameter was affected by cover of woody vegetation, while quadratic mean diameter and the 25th percentile were significantly affected by total vegetation control. The predicted distributions showed decreasing variance with increasing cover, particularly in the Siskiyou Mountains. In the Coast Ranges study, the coefficient of variation increased with increasing cover, indicating that the variance of stem diameters was affected by average size. On xeric sites in the Siskiyou Mountains, high diameter variability in plots with total vegetation control suggests that interspecific competition may inhibit the expression of microsite variation.

OSU Link
Non-OSU Link

162. Knowe, S.A. and W.I. Stein. 1995. Predicting the effects of site preparation and protection on development of young Douglas-fir plantations. Canadian-Journal-of-Forest-Research 25(9): 1538-1547.

Keywords: site preparation
release treatments
tree/stand protection
growth
tree morphology

tree/stand health
stand conditions

Abstract: Diameter prediction models based on the Weibull distribution function and stand-table projection models based on changes in relative diameter were developed for 2- to 10-year-old Douglas fir (Pseudotsuga menziesii) plantations in Oregon. Both modelling approaches incorporated the effects of site preparation, animal protection, and competing vegetation. The diameter distribution approach is appropriate when information on initial diameters is not available. The stand-table projection approach may be applied when tree diameters in a plantation are measured two or more growing seasons after planting. At young ages, the stand-table approach provided more accurate representation of observed diameter distributions than the diameter distribution approach. At age 10 the two methods provided comparable diameter distributions. The equations derived for predicting survival, height growth of dominant trees, height-diameter relationships, and the development of woody vegetation over time will facilitate the study and comparison of stand structure and dynamics after various site-preparation and animal protection treatments.

OSU Link
Non-OSU Link

163. Korpela, E.J., S.D. Tesch and R. Lewis. 1992. Plantations vs. advance regeneration: height growth comparisons for southwestern Oregon. Western-Journal-of-Applied-Forestry 7(2): 44-47.

Keywords: planting operations
release treatments
growth

Abstract: Model projections of newly-planted Douglas fir (Pseudotsuga menziesii) seedlings grown under three competition regimes were compared across three site classes with growth of three height classes of Douglas fir and white fir (Abies concolor) advance regeneration for twenty years following overstorey removal (data from stem analysis of 359 Douglas fir and 344 white fir trees growing in 80 stands in SW Oregon and northern California). It is concluded that, on poor sites in SW Oregon, managing advance regeneration may be a viable alternative to reforestation.

OSU Link
Non-OSU Link

164. 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

165. 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

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

Keywords: thinning
commercial thinning
growth

Abstract: The positive growth response of healthy young trees to density reduction is well known. In contrast, large old trees are usually thought to be intrinsically limited in their ability to respond to increased growing space; therefore, density reduction is seldom used in stands of old-growth trees. We tested the null hypothesis that old-growth trees are incapable of responding with increased growth following density reduction. The diameter growth response of 271 Douglas-fir (Pseudotsuga menziesii), ponderosa pine (Pinus ponderosa) and sugar pine (Pinus lambertiana) trees in Oregon, USA, ranging in age from 158 to 650 years was examined 20 to 50 years after density reduction. Density reduction involved either light thinning with removal of less vigorous trees, or shelterwood treatments in which

overstorey trees were not removed. Ratios of basal area growth after treatment to basal area growth before treatment, and several other measures of growth, all indicated that the old trees sometimes benefited and were not harmed by density reduction. Growth increased by 10% or more for 68% of the trees in treated stands, and nearly 30% of trees increased growth by over 50%. This growth response persisted for at least 20 years. During this 20-year period, only three trees in treated stands (1.5%) exhibited a rapid decrease in growth, whereas growth decreased in 64% of trees in untreated stands. The length of time before a growth response to density reduction occurred varied from 5 to 25 years, with the greatest growth response often occurring 20 to 25 years after treatment. These results have important implications both for the basic biology of aging in woody plants as well as for silvicultural practices in forests with old-growth trees.

OSU Link
Non-OSU Link

167. Lee, Y.J. and H.J. Barclay. 1985. Ten-year growth response of a 25-year-old and a 55-year-old Douglas-fir stand to thinning and urea fertilization. Pacific-Forestry-Centre, Canadian-Forest-Service Information-Report BC-X-260. 14 p.

Keywords: fertilization
thinning
growth
tree/stand health

Abstract: In stands of medium site quality in British Columbia, 4 rates of nitrogen (0, 112, 224, and 336 k/ha of N), in the form of urea (46% N), were tested at two thinning intensities. Fertilizer was applied in spring or fall, but the season of application had little effect on growth. Thinning almost doubled diam. growth by 10 yr but affected only net vol. growth; gross vol. was only minimally affected by thinning. Fertilization in the 25-yr-old stand increased mean d.b.h. growth significantly in the second and third yr and increased vol. growth significantly in the first 3 yr, but the effect diminished thereafter. Different rates of fertilizer application on the 55-yr-old stand gave inconsistent results. Combined thinning and fertilizer treatment had the greatest growth response. In both stands the overall effect of 336 kg/ha N was to increase vol. growth by about 20%. Thinning significantly decreased mortality, but the effect of fertilizer was negligible. Combined treatment had the greatest effect on the advancement of trees by the number of d.b.h. classes. The effect of thinning and fertilizing on the cumulative growth will probably continue after 10 yr until crowding sets in.

OSU Link
Non-OSU Link

168. Leninger, W.C. 1984. Silvicultural impacts of sheep grazing in Oregon's coast range. Dissertation Abstracts International, B: Sciences and Engineering 44(11): 3258.

Keywords: release treatments
growth

Abstract: In field trials in 1980-2 herded sheep were used to suppress brush in Pseudotsuga menziesii plantations. Sheep browsing of P. menziesii was highest in May after bud opening and averaged over 2

years of grazing, the sheep ate 28% of the current year's growth. Browsing of growing points ceased when seedling height exceeded the reach of the sheep. Less than 3% of the trees were trampled down. Two-year-old P. menziesii showed growth damage by sheep but 4- to 6-year-old trees showed increased growth, possibly due to increased N from sheep excreta. P. menziesii represented 3% of the annual diet of the sheep, which was composed of 40% graminoids and 40% forbs in young plantations and 70% graminoids and 16% forbs in older plantations. Sheep weight gains followed seasonal trends typical of sheep grazing non-irrigated hill pasture in W. Oregon.

OSU Link
Non-OSU Link

169. Li, P. and W.T. Adams. 1993. Genetic control of bud phenology in pole-size trees and seedlings of coastal Douglas-fir. Canadian-Journal-of-Forest-Research 23(6): 1043-1051.

Keywords: genetic tree improvement
genetic relationships
tree phenology
growth

Abstract: The extent to which bud phenology is genetically controlled and related to growth traits was examined in seedlings and pole-size trees of coastal Douglas-fir (Pseudotsuga menziesii var. menziesii). Data on bud burst, bud set, and stem growth were collected from pole-size trees of 60 open-pollinated families growing in four plantations in Oregon, and from seedlings of 45 of these same families growing in a bare-root trial in Washington, and greenhouse and transplant trials in Washington and Oregon. In both age-classes, bud burst was under moderate to strong genetic control (hsuperscript 2<more or =>0.44) and family breeding values were stable across test environments, indicating that this trait could be readily altered in breeding programmes. Bud set was inherited strongly in pole-size trees (hsuperscript 2=0.81) but weakly in seedlings (hsuperscript 2<less or =>0.30). Both bud burst and bud set were positively correlated with growth in seedlings and pole-size trees. Thus, selection for greater growth at either age-class is expected to delay bud burst and bud set. An evaluation was made of the accuracy of two alternatives for assessing bud burst phenology in pole-size trees compared with the traditional method. It was shown that bud-burst date on lateral branches can be used to rank accurately both individuals and families for bud-burst date on less accessible leader shoots. In addition, it was found that families can be ranked for mean bud-burst date by the proportion of trees per family that have flushed on a given scoring day. This method is only effective, however, when between 25 and 75% of all trees in the test have flushed at the time of scoring.

OSU Link
Non-OSU Link

170. Li, P. and W.T. Adams. 1994. Genetic variation in cambial phenology of coastal Douglas-fir. Canadian-Journal-of-Forest-Research 24(9): 1864-1870.

Keywords: genetic tree improvement
genetic relationships
tree phenology
growth

Abstract: The objectives of this study were to (i) determine the extent of genetic variation and genetic control of cambial phenology in coastal Douglas fir (Pseudotsuga menziesii var. menziesii), (ii) assess the degree to which cambial phenology is genetically related to bud-burst timing, (iii) examine genetic relationships between cambial phenology and growth traits, and (iv) evaluate the potential for indirectly altering cambial phenology in breeding programmes when selection is for stem volume. Dates of diameter-growth initiation and cessation, and duration of diameter growth (i.e., cambial phenology traits), as well as diameter increment for the 1987 growing season (15-yr-old), were estimated from cumulative diameter growth curves of individual trees of 60 open-pollinated families growing in one plantation in Oregon. Data on stem height and diameter at breast height (d.b.h.), and date of bud burst in 1987 were also collected. Dates of diameter-growth initiation and cessation differed significantly among families, but had lower estimated individual heritabilities (<less or =>0.23) than date of bud burst (0.87). Weak genetic correlations between date of bud burst and dates of diameter-growth initiation and cessation (range -0.09 to 0.26) indicate that timing of diameter growth cannot be reliably predicted from observations of the more easily measured bud burst. Cambial phenology traits were weakly correlated with 1987 diameter increment and moderately correlated with 15-year d.b.h. and volume. Selection of parents in this study for stem volume at age 15 and subsequent crosses among them, would be expected to lead to earlier initiation of diameter growth in the offspring, and possibly later cessation as well. The practical implications of these indirect responses in terms of increased risk of frost damage are unclear, since projected changes are small (i.e., a few days).

OSU Link
Non-OSU Link

171. Little, S.N. 1983. Weibull diameter distributions for mixed stands of western conifers. Canadian-Journal-of-Forest-Research 13(1): 85-88.

Keywords: planting operations
growth

Abstract: The three-parameter Wiebull function was tested as a model for the diam. distributions of mixed stands of western hemlock and Douglas-fir in Oregon. Weibull distributions estimated by maximum likelihood (MLE) fitted 80 of 83 observed diameter distributions at alpha =0.20 level of significance. Weibull parameter prediction equations were developed by regressing characteristics of 42 stands against MLE of the parameters. The Weibull diameter distributions predicted from stand age, mean diam., mean ht., and stand density fitted 39 of 41 observed distributions in the test group at the alpha =0.20 level of significance. These results compared favourably with those found for various forest types by other authors.

OSU Link
Non-OSU Link

172. Lopushinsky, W. 1986. Effect of jellyrolling and acclimatization on survival and height growth of conifer seedlings. Pacific-Northwest-Research-Station,-USDA-Forest-Service Research-Note PNW-RN-438. 14 p.

Keywords: planting operations
growth

tree/stand health
tree physiology

Abstract: Jellyrolling is a preplanting treatment that involves dipping roots of seedlings in a vermiculite/water slurry and wrapping the roots in wet burlap to form a roll. Studies were made at 14 sites in Oregon and Washington during 1984 using bare root seedlings of Pinus ponderosa, P. contorta or Pseudotsuga menziesii. Results showed that there was no advantage in survival, ht. growth or moisture stress from jellyrolling or acclimatizing (storage in a tent or shed at ambient temp. for 24 h before planting) seedlings rather than dipping roots in a peat moss/water slurry at the planting site.

OSU Link
Non-OSU Link

173. Lu, S., K.G. Mattson, J.B. Zaerr and J.D. Marshall. 1998. Root respiration of Douglas-fir seedlings: effects of N concentration. Soil-Biology-and-Biochemistry 30(3): 331-336.

Keywords: nursery operations
nursery fertilization
growth
carbon allocation
tree morphology
tree physiology
mycorrhizal response

Abstract: Six-month-old Douglas-fir (Pseudotsuga menziesii) seedlings were grown at three N concentrations and with controlled root temperatures in Oregon, USA. Measurements of root respiration were conducted on undisturbed root systems by passing humidified air with 1000 micro l/litre CO2 through root boxes onto an infrared gas analyser. The effects of N on soil respiration were sought by examining total root respiration rate per seedling, specific root respiration rate/g root dry wt, and root dry wt after N fertilization. Total respiration rates of seedlings grown at 50 mg N/litre concentration were significantly higher than those grown at 10 or 200 mg N/litre. Seedlings grown at N concentration of 200 mg/litre had significantly smaller roots than those grown at the two lower N concentrations. The specific respiration rate increased as N concentration was increased from 10 to 50 mg N/litre, but remained constant as N was further increased from 50 to 200 mg/litre. The increase of total respiration rate with the increase in N concentration from 10 to 50 mg/litre was attributed to the increase in specific respiration, whereas the subsequent decrease in total respiration with the increase in N concentration from 50 to 200 mg/litre was attributed to the decrease in root dry wt. The depression of soil respiration after the addition of N fertilizers to relatively fertile soil may be explained by reduced root and mycorrhizal mycelial growth.

OSU Link
Non-OSU Link

174. Luxmoore, R.J., M.L. Tharp and R.A. Efroymson. 1999. Comparison of simulated forest responses to biosolids applications. Journal-of-Environmental-Quality 28(6): 1996-2007.

Keywords: fertilization

growth

Abstract: Organic matter and N were added to humus pools of the LINKAGES simulator of forest growth and N cycling at a range of application rates to investigate long-term effects of biosolids (sewage sludge) on forest productivity. The simulation was done for 2 conifer plantations (Douglas fir, Pseudotsuga menziesii var. menziesii on the coast range of Washington state, USA; and loblolly pine, Pinus taeda on the Piedmont soils of Georgia) and a northern hardwood forest located in New Hampshire. Single applications of biosolids were given at 0, 5, 10, 20, and 40 Mg/ha, and multiple applications on 7 occasions at 3-yr intervals at rates of 5 and 10 Mg/ha. Highly significant increases in aboveground phytomass and net primary productivity of Douglas fir plantations were obtained in a 100-yr simulation with increasing biosolids application rates. Results for loblolly pine from a 50-yr simulation produced about half the growth response of Douglas fir. Long-term simulations of northern hardwoods showed modest growth responses and small increases in NPP (net primary productivity) with added biosolids. The phytomass of one overstorey and 3 understorey species in the hardwood forest changed in response to different biosolids applications and varying species sensitivity to N supply. It is concluded that biosolids are a significant resource for enhancing forest productivity, particularly in conifer plantations. Estimates of N leaching losses from simulated forest sites combined with a literature review of leaching losses suggest that biosolids applications at 3-yr intervals with rates less than 8.5 Mg/ha (0.4 Mg N/ha) during active forest growth may pose little off-site contamination risk to ground water or surface waters.

OSU Link
Non-OSU Link

175. Magnussen, S. and A.D. Yanchuk. 1993. Selection age and risk: finding the compromise. Silvae-Genetica 42(1): 25-40.

Keywords: genetic tree improvement
growth

Abstract: Selection ages for height in coastal Douglas-fir (Pseudotsuga menziesii) at four sites on Vancouver Island, Canada, were determined by stochastic simulation of age-to-age correlations. Stochastic perturbations of expected age-to-age correlations at both family and within-family levels were derived from bootstrapping more than 4000 records of 23 years of observed height growth. Stochastic dominance principles were used to isolate stochastic efficient (risk averse) selection ages in both family and forward selection schemes. The optimum age for family selection depended strongly on the number of progenies tested in each family and on the test site. Early family selection (age <15) required at least 20 trees per family; very early family selection (age <10) is feasible at a low risk at family sizes above 40. Selection ages in forward selection schemes depend on gain expectations from the within-family selection and on the number of trees selected per family. Reliance on gain from within-family selection pushed the stochastic efficient selection age upwards. Selecting fewer trees per family, but more families, increased the recommended selection ages. Age 17 appears to be the minimum 'safe' age for conventional forward selection schemes.

OSU Link
Non-OSU Link

176. Magnussen, S. and A.D. Yanchuk. 1994. Time trends of predicted breeding values in selected crosses of coastal Douglas-fir in British Columbia: a methodological study. Forest-Science 40(4): 663-685.

Keywords: genetic tree improvement
genetic relationships
growth

Abstract: Analytical techniques for estimating time trends and projections of breeding values from sparse data, unbalanced mating designs and irregular assessments periods are presented and discussed. Time trends (ages 4 to 23 yr) in genetic parameters of tree heights in 14 full-sib and 4 half-sib Douglas fir (Pseudotsuga menziesii) crosses among six male trees from Coastal British Columbia and six female trees from Washington and Oregon planted on four test sites on Vancouver Island were examined, and tentative projections of genetic gains were made. Annual height estimates were derived by fitting splines to height measures at ages 4, 7, 12, 18 and 23 yr. Genetic variances were derived from direct computations of covariances among all possible half-sib combinations; a method deemed superior to the conventional factorial analysis. Irregular fluctuations in genetic parameter estimates vanished after minor adjustments (<1.5%) of variance-covariance matrices with negative eigenvalues. Sites effects were highly significant, but site-to-site correlations for pair-cross means were all nonsignificant. Additive genetic control of height growth was weak to moderate (hsuperscript 2=0.1), but generally increasing with age. The best genetic discrimination was observed on the more productive sites. A stable ranking of full-sib family means was reached at age 7 yr on one site versus age 18 for the other sites. Trends in breeding values were described with a mixed linear autoregressive time series model from which 10-yr projections were made. Projections took into consideration both the error structure surrounding the breeding values and the errors of the parameter estimates in the time series model. Selection of the best parent out of six for breeding and deployment on a single site type would generate an expected gain of about 2-5% in height growth between ages 4 and 23 yr.

177. Maher, T.F. 1990. Damage appraisal and pheromone trapping studies for the black army cutworm in British Columbia. B.C. Ministry of Forests FRDA-Report 117. iv + 41 p.

Keywords: planting operations
tree/stand protection
tree/stand health
growth

Abstract: Actebia fennica [Dissimactebia fennica] have damaged Picea spp., Pinus contorta, Pseudotsuga menziesii, Larix occidentalis and Populus tremuloides in recently planted stands in British Columbia.

178. Malavasi, M.d.-M., S.G. Stafford and D.P. Lavender. 1985. Stratifying, partially redrying and storing Douglas-fir seeds: effects on growth and physiology during germination. Annales-des-Sciences-Forestieres 42(4): 371-383.

Keywords: nursery operations
reproduction
growth

Abstract: Douglas fir seeds collected from one coastal and one inland source in Oregon, USA, were stratified at 3 degrees C for 28 days at 45% m.c., and then redried to 35% or 25% m.c. and/or stored at 3 degrees C for 1 or 3 months. Redrying stratified seeds to 35% m.c. did not affect the m.c. of embryos or gametophytes, but redrying to 25% m.c. reduced the m.c. of all seed structures. Three months storage did not alter moisture distribution within seeds. Stratification reduced the germination % of seeds from the inland source, but hastened germination speed of seeds from both sources. Redrying stratified seeds to 35% and 25% m.c. increased seed vigour and seedling length and dry weight. Storing stratified seeds without redrying them generally reduced seed vigour. These results suggest that it would be advantageous to redry seeds to a range of 25-35% m.c. directly before sowing in order to produce vigorous seedlings or allow expression of stratification benefits.

OSU Link
Non-OSU Link

179. Malavasi, U.C. and D.A. Perry. 1993. Genetic variation in competitive ability of some shade-tolerant and shade-intolerant Pacific Coast (USA) conifers. Forest-Ecology-and-Management 56(1-4): 69-81.

Keywords: planting operations
genetic relationships
growth

Abstract: Variability in growth response to stocking density and neighbour composition was compared in Oregon among half-sibling families of four tree species representing two pairs of shade-tolerant (ST) and shade-intolerant (SI) species, each pair from the same life zone. The hypothesis was that the wider regeneration niche of ST species, which can become established both in disturbed areas and within closed forests, would produce greater genetic variability among families than occurs in SI species, which establish primarily in disturbed areas. Families of western hemlock (Tsuga heterophylla - ST), coastal Douglas fir (Pseudotsuga menziesii - SI) and Pacific silver fir (Abies amabilis - ST) varied in their responses to stocking density, but those of noble fir (A. procera - SI) did not. As hypothesized, the ST species were significantly more variable than SI ones, a result consistent with electrophoretic studies of ST and SI plants and supportive of the hypothesis that at least a portion of genetic variability contained within populations represents adaptation to variable environments.

OSU Link
Non-OSU Link

180. Margolis, H.A. and R.H. Waring. 1986b. Carbon and nitrogen allocation patterns of Douglas-fir seedlings fertilized with nitrogen in autumn. II. Field performance. Canadian-Journal-of-Forest-Research 16(5): 903-909.

Keywords: nursery operations
nursery fertilization
tree phenology

growth
tree physiology

Abstract: Douglas fir seedlings (2+0), unfertilized or fertilized with ammonium nitrate in Oct. 1983, were planted out in Feb. 1984 near Corvallis, Oregon. Rye grass was grown on half the plots to induce water stress during the typical summer drought. Sucrose was applied to soil around each seedling to stimulate microbial growth and thus to immobilize nitrogen in the microbial biomass and create nitrogen stress in Douglas fir. Fertilized seedlings had earlier budbreak, produced more shoot growth and had higher relative growth rates, net assimilation rates and leaf area ratios than unfertilized seedlings. Grass significantly increased predawn moisture stress in both fertilized and unfertilized seedlings by early Aug. By 3 Sep., unfertilized seedlings growing with grass were significantly more stressed than other seedlings. Fertilizer did not have a significant effect on concn. of free amino acids and total N at the end of the growing season, but grass competition affected both N and carbohydrate chemistry.

OSU Link
Non-OSU Link

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

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

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

OSU Link
Non-OSU Link

182. Marshall, P.L. 1988. A decision analytic approach to silvicultural investment decisions. Forest-Economics-and-Policy-Analysis-Research-Unit, University-of-British-Columbia Working-Paper 110. 28 p.

Keywords: planting operations

thinning
precommercial thinning
economics
growth

Abstract: A brief review of the literature is presented on methods for achieving optimal silvicultural decisions. The methods are generally computationally cumbersome and difficult to convert to simpler approximations required for most silvicultural decisions. An alternative method is presented and illustrated with two examples. The method involves a simple decision analytic structure. Projections were made for pure coastal Douglas fir Pseudotsuga menziesii for several treatments using three previously published growth models. Present Net Worth (PNW) was used as the criterion for choosing the treatment option and rotation age. The first example involved an initial planting density decision. Three planting densities were considered, viz. (1) 2500, (2) 1100 or (3) 750 seedlings/ha. The second example involved the decision to thin a 15-yr-old stand to a spacing similar to that produced by (1). The options were: (a) no treatment; (b) thin to 1100 stems/ha; and (c) thin to 500 stems/ha. The best strategy depended on which growth model was used. The study showed that a simplified decision analytic approach is a useful method to evaluate a decision, when aided by several growth models.

OSU Link
Non-OSU Link

183. Marshall, P.L. 1989. The economic value of additional information about treatment-response information for coastal Douglas-fir. Forest-Economics-and-Policy-Analysis-Research-Unit, University-of-British-Columbia Working-Paper 121. 39 p.

Keywords: planting operations
thinning
precommercial thinning
economics
growth

Abstract: A simple decision analytic approach was applied to initial planting density and precommercial spacing decisions for coastal Douglas fir (Pseudotsuga menziesii) across a range of sites in British Columbia. The range of biological response was represented by the output from 3 growth and yield models. Recent production costs and product values were applied to obtain value per hectare after delivery of logs to the mill. Future costs and revenues were discounted at 4, 6 and 8%. The best decisions from each growth model are presented by scenario. Limitations of the analysis and managerial implications are discussed.

OSU Link
Non-OSU Link

184. Marshall, V.G. and H.J. Barclay. 1994. Response of young Douglas-fir to urea fertilizer applied on and off snow. Forestry-Chronicle 70(3): 294-298.

Keywords: fertilization
growth

Abstract: The effects of 200 kg N ha-1 applied as urea fertilizer on 50 cm of snow or on bare ground were studied in an 11-year-old Douglas fir (Pseudotsuga menziesii) plantation on Vancouver Island. Core samples were taken from all trees on the plot 6 yr after treatment; height was measured for 20 selected dominant trees per plot 3 months and 4 yr after treatment. Up to 2 years following treatment, urea significantly increased absolute DBH increments over controls in all trees and the 20 selected trees per plot; response to fertilizer application on snow was equal to that on bare ground. Between the 3rd and 9th year following treatment, mean DBH increments were not significantly different for any treatment. Four-year absolute volume increments were 63 and 87% greater than the controls for bare-ground and on-snow applications, respectively.

OSU Link
Non-OSU Link

185. Mason, R.R. and B.E. Wickman. 1991. Integrated pest management of the Douglas-fir tussock moth. Forest-Ecology-and-Management 39(1-4): 119-130.

Keywords: tree/stand protection
tree/stand health
stand conditions
growth

Abstract: The Douglas-fir tussock moth (Orgyia pseudotsugata) is one of the most destructive forest defoliators of Douglas fir (Pseudotsuga menziesii), grand fir (Abies grandis) and white fir (A. concolor) in western North America. An outline is given of current pest-management programmes used in Oregon, which emphasize the annual monitoring of insects in forests with outbreak histories to determine early changes in population numbers and to predict trends. When outbreaks develop, several environmentally safe chemical and microbial insecticides are effective in reducing larval numbers and preventing serious defoliation. Computer models predicting growth loss, tree mortality, and top-kill during outbreaks are available as aids to making management decisions. Silvicultural practices favouring seral nonhost species on high-risk sites may be the best prescription for reducing the effect of tussock moth outbreaks.

OSU Link
Non-OSU Link

186. Maze, J., S. Banerjee and Y.A. El-Kassaby. 1989. Variation in growth rate within and among full-sib families of Douglas-fir (Pseudotsuga menziesii). Canadian-Journal-of-Botany 67(1): 140-145.

Keywords: genetic tree improvement
growth

Abstract: Variation in growth rate in the 4 uppermost lateral branches of 2-yr-old seedlings in a common garden was greatest among individuals within full-sib families. Results are consistent with those from other studies on conifers which indicated that there is more within than between intraspecific group variation. Growth rate was greatest in seedlings produced by crossing trees with the highest av. increment (ht. and diam.) and least in seedlings produced by crossing trees with the lowest av. increment. Seedlings with the lowest growth rate, however, were similar to those produced by crosses

between other trees with high av. increment. This implies that phenotypically superior parents, as assessed in a natural stand, do not necessarily produce superior offspring in the second year of growth. Results are discussed in relation to evolutionary theory.

OSU Link
Non-OSU Link

187. McCreary, D.D., D.P. Lavender and R.K. Hermann. 1990. Predicted global warming and Douglas-fir chilling requirements. Annales-des-Sciences-Forestieres 47(4): 325-330.

Keywords: genetic tree improvement
nursery operations
tree phenology
growth

Abstract: Containerized Douglas fir (Pseudotsuga menziesii) seedlings from warm coastal and cool mountainous Oregon seed sources, grown under natural conditions, were chilled at constant temperatures of 5, 7 or 9 degrees C for 9, 11, 13 or 15 weeks beginning in mid-October. After a growth period of 9 weeks following chilling, degree of budbreak and dry weight of new shoot growth were measured. The longest and coldest chilling treatment produced the greatest growth response for all seed sources. Results are discussed with reference to predicted global warming, in particular the potential difficulty of reducing Douglas fir chilling requirements through tree breeding programmes.

OSU Link
Non-OSU Link

188. McDonald, P.M. and G.O. Fiddler. 1993. Feasibility of alternatives to herbicides in young conifer plantations in California. Canadian-Journal-of-Forest-Research 23(10): 2015-2022.

Keywords: genetic tree improvement
site preparation
prescribed fire
release treatments
manual release
chemical release
growth
economics

Abstract: A research programme (involving 40 studies) was started in 1980 to compare the effectiveness and cost of various vegetation management techniques used for enhancing growth of 1- to 3-yr-old conifer (Pseudotsuga menziesii, Pinus ponderosa, P. jeffreyi, Abies magnifica and A. concolor var. lowiana) plantations in California. The studies were ended after 10 yr when competition became intraspecific. The techniques used included direct methods such as manual manipulation, mulching, herbicides (Garlon 3A [triclopyr], 2,4-D or Velpar [hexazinone]), and grazing for releasing conifer seedlings from undesirable vegetation, and several silvicultural practices (broadcast burning, group selection, genetically improved seedlings) that serve as indirect methods for reducing or avoiding vegetation problems. Manual release and mulching were effective but expensive. Herbicides were

effective, applicable to almost all plant communities, and relatively inexpensive. Grazing was good for cattle and sheep, but did not significantly enhance conifer seedling growth. Silvicultural control of weeds was promising, but there was not enough information to evaluate feasibility. It was concluded that in most instances, forests cannot be managed economically without herbicides, if the objective is to grow seedlings at the potential of the site and the plant community includes sprouting broadleaves and shrubs or rhizomatous forbs and ferns. If the objective is to create a forest with several age-classes and variable structure, but with slower seedling growth, longer rotations, and less species diversity in early seral stages, then it is possible to accomplish this using other vegetation management techniques.

OSU Link
Non-OSU Link

189. McDonald, P.M. and G.O. Fiddler. 1996. Development of a mixed shrub-tanoak-Douglas-fir community in a treated and untreated condition. Pacific-Southwest-Research-Station, USDA-Forest-Service Research-Paper PSW-RP-225. iv + 16 p.

Keywords: release treatments
manual release
chemical release
tree/stand health
growth
tree morphology
stand conditions
economics

Abstract: On a medium site in northern California, a tanoak (Lithocarpus densiflorus)-mixed shrub community in a Douglas fir plantation was given several treatments (manual release two and three times, a combination chainsaw and cut surface herbicide (Garlon 3A [triclopyr]) treatment, two foliar herbicides (2,4-D or Garlon 4), and a tank mix of the two herbicides) to study its development in both a natural (control) and treated condition. The herbicides were each applied twice. Survival of planted Douglas fir (Pseudotsuga menziesii) seedlings was recorded for 11 years and growth was quantified for 9 years after the last treatment application. In addition to Douglas fir, data are presented individually for the two most abundant species (tanoak and snowbrush, Ceanothus velutinus var. hookeri), for greenleaf manzanita (Arctostaphylos patula), and for the hardwood tree and shrubs combined. At the study's end in 1992, combined vegetation in the control had a mean density of 1800 plants/acre, foliar cover of 23 700 ftsuperscript 2/acre, and height of 11.2 ft. In contrast, combined tree and shrubs in the most effective treatment for controlling them (cut and spray Garlon 3A) had a mean density of 150 plants/acre, foliar cover of 150 ftsuperscript 2/acre and height of 5.9 ft at study end. Because competition for site resources was low, Douglas fir seedlings developed best in this treatment. Mean Douglas fir diameter was 4.6 inches at 12 inches above mean ground line, height averaged more than 21 ft, and mean foliar cover was 39 850 ftsuperscript 2 at the end of the study. The cost was $227 per acre.

OSU Link
Non-OSU Link

190. McDonald, P.M. and G.O. Fiddler. 1999. Ecology and development of Douglas-fir seedlings and associated plant species in a Coast Range plantation. Pacific-Southwest-Research-Station, USDA-Forest-Service Research-Paper PSW-RP-243. ii + 18 p.

Keywords: release treatments
manual release
chemical release
stand conditions
growth
tree morphology
economics

Abstract: On an average site in northern coastal California, USA, a tanoak (Lithocarpus densiflorus)-mixed shrub community was given several treatments (manual release one, two, and three times; a combination chainsaw and cut surface chemical treatment; two foliar chemicals; and a tank mix of the two chemicals) to study its development over an 11-year period (1981-91) in both a broadcast-burned (untreated control) and released (treated) condition. The chemicals were 2,4-D, Garlon [triclopyr] 3A, and Garlon 4, each applied two times. The site had been planted with 2+0 seedlings of Douglas fir (Pseudotsuga menziesii) in 1979. In addition to Douglas-fir , data are presented individually for the four most abundant and well distributed species (tanoak, hairy manzanita (Arctostaphylos columbiana), huckleberries (Vaccinium ovatum and V. parviflorum), and rhododendron (Rhododendron macrophyllum)), and for these plus two more of the tallest and most abundant (but poorly distributed) species (snowbush (Ceanothus velutinus), elderberry (Sambucus mexicana)) combined. In 1991, combined shrubs in the control had a mean density of 4733 plants per acre, foliar cover of 16 800 ft2 per acre, and height of 9.5 feet. In contrast, combined shrubs in one of the most effective treatments for controlling them (2,4-D) had a mean density of 2000 plant per acre, foliar cover of 2600 ft2 per acre and height of 5.5 feet at the end of the study. Here, mean Douglas-fir diameter was 4.0 inches at 12 inches above mean ground line, height averaged 18.7 feet, and mean foliar cover was 34 800 ft2 per acre. The cost (including chemical) was $77 per acre. The biological and economical data in this paper provide the ecosystem manager, wildlife biologist, and fuels manager with knowledge on how to attain plant communities with different density and development potentials, and the cost of creating them.

OSU Link
Non-OSU Link

191. McDonald, P.M., G.O. Fiddler and H.R. Harrison. 1995. Mulching to regenerate a harsh site: effect on Douglas-fir seedlings, forbs, grasses, and ferns. Pacific-Southwest-Research-Station, USDA-Forest-Service Research-Paper PSW-RP-222. ii + 10 p.

Keywords: release treatments
manual release
growth

Abstract: Douglas fir (Pseudotsuga menziesii) seedlings, 2+0, were planted in February 1989 on pastureland in the Arcata District, central coastal California. The tree seedlings were released from a complex forb-grass-fern community by applying very large (100 ftsuperscript 2) or small (4 ftsuperscript 2) durable polypropylene mulches one month after planting. After 5 yr, stem diameter of tree seedlings with large and small mulches was 1.6 and 1.36 inches, respectively. Only seedlings with large mulches were significantly larger than seedlings on small scalps or control areas.

OSU Link
Non-OSU Link

192. McDonald, P.M. and O.T. Helgerson. 1990. Mulches aid in regenerating California and Oregon forests: past, present, and future. Pacific-Southwest-Research-Station, USDA-Forest-Service General-Technical-Report PSW-GTR-123. ii + 19 p.

Keywords: release treatments
manual release
growth

Abstract: A discussion of the effects of various types of mulches for controlling seedling environment in plantations, mostly of Pseudotsuga menziesii and Pinus ponderosa.

OSU Link
Non-OSU Link

193. McLeod, A.A., R.C. Evans and R.K. Scagel. 1993. Conversion of understocked salal sites at Woss Lake, British Columbia. B.C. Ministry of Forests FRDA-Report 194. vi + 15 p.

Keywords: nursery operations
site preparation
mechanical preparation
fertilization
growth
tree/stand health
economics

Abstract: A trial comparing the effect of spot scarification and slow release NPK fertilizer application on stock types of coastal Douglas fir (Pseudotsuga menziesii) was conducted in a 25-year-old backlog site occupied by a thick carpet of salal (Gaultheria shallon) in the CWHxm2 habitat of Vancouver Island, British Columbia. Bare root and container stock types were planted and treated, and mortality and growth were measured for 3 years. Despite the high fertilizer-related mortality of the bare-root stock type in the first year, the 3-year height growth performance of all treatments was better but more variable than that of the untreated seedlings. The value of site preparation and fertilizer for stimulating early growth varied by stock type. Bare-root stock did not respond strongly enough to fertilizer or site preparation to justify the cost of either of these treatments. Container stock types did not respond strongly enough to site preparation alone to justify the high cost of site preparation. The largest growth gains in the container stock types were associated with the combination of site preparation and fertilization.

OSU Link
Non-OSU Link

194. McNabb, D.H., K. Baker-Katz and S.D. Tesch. 1993. Machine site preparation improves seedling performance on a high-elevation site in southwest Oregon. Western-Journal-of-Applied-Forestry 8(3): 95-98.

Keywords: site preparation
mechanical preparation

tree/stand health
stand conditions
growth

Abstract: Douglas fir (Pseudotsuga menziesii) seedlings planted on areas receiving one of four site preparation treatments (scarify, scarify/till, soil removal, and soil removal/till) and on unprepared control areas were compared for 5 yr at a high-altitude, nutrient-poor site in the western Siskiyou Mountains. Fifth-year survival of seedlings was at least 85% among machine-prepared plots, compared to 42% on control plots. Cover of competing vegetation remained less than 25% during the period for all machine treatments. In contrast, vegetation cover on control plots was 30% at the time of planting and increased to nearly 75% after 5 yr. Competing vegetation clearly impeded seedling performance. The effects of unusually droughty conditions at the time of planting in 1982 were examined further by interplanting additional seedlings in the soil-removal treatment in 1985. The interplanting was followed by more normal spring precipitation, and seedlings grew better over 5 yr than those planted in 1982. The slow recovery of competing vegetation and generally poor seedling growth on all treatments during both planting years are attributed to low soil fertility.

OSU Link
Non-OSU Link

195. Mikels, R.A. 1983. Melamine, a controlled release fertilizer for conifer seedlings. Forestry-Abstracts 44(11): 698.

Keywords: fertilization
growth

OSU Link
Non-OSU Link

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

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

Abstract: Uneven-age management of Douglas-fir (Pseudotsuga menziesii) stands can be used to address aesthetic, wildlife habitat, biodiversity and sustainability concerns, but there has been little long-term experience with this type of management. To develop timely information on converting even-age stands to uneven-age forests, we used retrospective stand reconstruction methods to document harvest frequency, intensity and stand structural development at four sites in western Oregon, USA. We studied stands managed by selection thinning and identified strategies for creating and managing uneven-age forests. Selection thinning benefited mid- and understorey trees and stimulated natural regeneration. Although stand growth was less than expected from low thinning, growth per unit of

growing stock was similar to that in unmanaged stands. Douglas-fir often dominated natural regeneration and had satisfactory vigour at stocking levels about half that considered full stocking for even-age management, but good growth of regeneration may require even lower overstorey stocking. Shade-tolerant grand fir (Abies grandis) and western hemlock (Tsuga heterophylla), however, were more abundant at higher stocking levels. Selection thinning of young Douglas-fir (Pseudotsuga menziesii) stands can sometimes be effective in promoting viable regeneration while providing regular income and biodiversity. Because this was a retrospective study only, further, long-term testing is necessary.

OSU Link
Non-OSU Link

197. Miller, R.E. 1981. Response of Douglas-fir to foliar fertilization. *In* Proceedings: Forest Fertilization Conference, University of Washington, Seattle, Washington, USA. *Eds.* S.P. Gessel, R.M. Kenady and W.A. Atkinson. pp. 62-68.

Keywords: fertilization
tree/stand health
growth
economics

Abstract: This paper summarizes past research about spray application of 10 to 32 percent nitrogen solutions to seedlings and established stands of Douglas-fir. These investigations establish that Douglas-fir and associated conifers can be foliarly fertilized with concentrated nitrogen solutions at dosages of 50 to 200 pounds per acre; however, fertilization with these solutions requires more critical selection of nitrogen source, dosage, additives, and, perhaps, time of year than does fertilization with urea prill. Some burning, up to about 30 percent of the needle surface, is visually disturbing but probably has no measurable effects on growth. With low dosages and careful application, gains in cubic volume or height growth per pound of applied nitrogen were similar for both spray and prill. Yet costs per pound of applied nitrogen have been about 25 percent more for 32 percent nitrogen solutions than for prilled urea. Hence, foliar application of concentrated nitrogen solutions is currently less cost effective than conventional use of urea solids for fertilizing Douglas-fir and associated conifers.

OSU Link
Non-OSU Link

198. Miller, R.E., M.V. Atherton and J.E. Wilcox. 1986. Comparative effects of three nitrogen fertilizers applied in fall and spring to a 29-year-old Douglas-fir plantation. Canadian-Journal-of-Forest-Research 16(5): 910-917.

Keywords: fertilization
growth
tree/stand health
tree physiology

Abstract: Stand growth and mortality were monitored for 13 yr after application of urea, ammonium nitrate or urea + ammonium sulphate (224 kg N/ha) in autumn 1967 and spring 1968 to plots in a 29-yr-old Douglas fir plantation on Vancouver Island, British Columbia. The treatments and a control were

replicated 3 times. Foliar analysis indicated insufficient available N before treatment and an increase in available N 1 and 2 yr after fertilization. Addition of N at this location did not have a practical effect on stand growth and the field experiment was not sufficiently sensitive to detect real differences between N sources or season of application. Suggestions are included for improving field trials.

OSU Link
Non-OSU Link

199. Miller, R.E., R.E. Bigley and S. Webster. 1993a. Early development of matched planted and naturally regenerated Douglas-fir stands after slash burning in the Cascade Range. Western-Journal-of-Applied-Forestry 8(1): 5-10.

Keywords: planting operations
growth
yield

Abstract: Comparisons were made of matched planted and naturally regenerated plots in 35- to 38-yr-old Douglas fir (Pseudotsuga menziesii var. menziesii) stands at seven locations in western Washington and Oregon. The total number of live stems was similar in both stand types, but stands planted to Douglas fir averaged 26 more live stems/acre of Douglas fir and 39 fewer stems/acre of other conifers than did naturally regenerated stands. Despite an average 2 yr delay in planting after burning, dominant Douglas fir in planted stands average 3 fewer years than natural regeneration to attain breast height after burning. Volume of all live trees (1.6 in. diameter at breast height (d.b.h.) and larger) and of Douglas fir averaged 40% greater on planted plots. Volume of live conifers 7.6 in. d.b.h. and greater averaged 41% more on planted plots than on naturally regenerated plots (2977 vs. 2118 ftsuperscript 3/acre). Differences that developed on these plots were probably less than differences that would be shown by plantations being established today with prompt planting, and improved nursery stock and planting methods.

OSU Link
Non-OSU Link

200. Miller, R.E., G.W. Clendenen and D. Bruce. 1988. Volume growth and response to thinning and fertilizing of Douglas-fir stands in southwestern Oregon. Pacific-Northwest-Research-Station,-USDA-Forest-Service General-Technical-Report PNW-GTR-221. ii + 38 p.

Keywords: fertilization
thinning
growth

Abstract: Data were collected from 114 thinning (felling 15-80% of initial basal area) and/or fertilizer application (usually urea at 200 or 400 lb N/acre) trials in naturally regenerated Douglas fir (Pseudotsuga menziesii) stands in SW Oregon (111 stands) and N. California (3 stands). The data were used to develop regression equations to estimate volume growth for a 10-yr period of treated and untreated stands, aged 10-70 yr. The predictions for SW Oregon (SWOR) were compared with other growth predictions including DFSIM, a simulation model based on a broader, regional database. SWOR consistently showed greater gross and net growth of untreated Douglas fir and showed greater benefits of nitrogen

fertilization, especially on poor quality sites and in young stands in the subregion than did DFSIM. SWOR predicted reduced gross volume growth during the 10 yr after thinning, faster recovery from early thinning on good than on poor sites, and increased wood production after nitrogen treatment in 70% of thinned and unthinned Douglas fir stands.

OSU Link
Non-OSU Link

201. Miller, R.E., J.W. Hazard and D.C. Young. 1991. Effects of foliar spray and prill applications of nitrogen fertilizer on four mixed-conifer stands. Forest-Science 37(3): 741-754.

Keywords: fertilization
growth
tree/stand health

Abstract: Concentrated urea-ammonium nitrate solution (32% N) and urea prill (granules; 46% N) were applied by helicopter at dosages of 56, 112, 224 and 448 kg N/ha before (5 May) and during (14 July) the 1969 growing season to four 40- to 70-year-old mixed stands of Pseudotsuga menziesii and Tsuga heterophylla near Sequim, Washington. Stand growth was measured repeatedly in the next 10 years. Helicopter application of both fertilizers was variable and therefore weakened comparisons between prill and foliar sprays and spring vs. summer applications. Applying 112 kg N/ha or more to these poor-site stands increased gross and net volume growth; volume growth was related linearly to N dosage of both prill and spray. Gains from prill apparently exceeded those from spray, but a subsampling of plots indicated that actual dosages, especially of spray, were less than target dosages. At the target dosage of 224 kg N/ha, 10-year gains in gross growth averaged 34.0 msuperscript 3/ha (30%) and 8.0 msuperscript 3/ha (7%) after prill and spray, respectively. Although fertilizer treatment accelerated tree losses, cumulative volume of dead trees was less than 15% of gross volume growth. Season of fertilization seemed to have no effect on efficiency of either prill or spray, but suspected differences between actual and target dosages may have influenced this comparison. Concentrated N solution applied at dosages up to about 224 kg N/ha caused little or no increase in foliar or tip damage. Doubling this conventional dosage and applying in the growing season, however, increased visible damage and may have reduced gains in volume growth.

OSU Link
Non-OSU Link

202. Miller, R.E., D.H. McNabb and J. Hazard. 1989. Predicting Douglas fir growth and response to nitrogen fertilization in western Oregon. Soil-Science-Society-of-America-Journal 53(5): 1552-1560.

Keywords: fertilization
growth
soil properties
stand conditions

Abstract: The objective of this study was to determine the efficacy of various stand (site index, age, and relative density), climatic (total precipitation, average daily solar radiation), site (elevation, soil depth, and available water-holding capacity), and soil-test variables (anaerobically mineralized N, total N,

organic matter, and C:N ratio) to predict relative and absolute response of Pseudotsuga menziesii stands to a single application of 224 Kg/N ha as urea. The core equation with stand variables accounted for 70% of residual variation in average annual volume growth. Predicting response of fertilized stands proved much less precise. The best core equation explained 37% of the residual variation for average percentage response in volume growth and explained less variation in absolute response in both volume and basal area. Of the site, climatic, and soil-test variables, C:N ratio in the surface soil was the only one that significantly increased precision of the core equations. The best combined equation explained 46% of the variation in percent volume response. The anaerobic N mineralization test failed to make a significant contribution to the core equation and had a lower correlation with response than did the C:N ratio. Stand variables remain the most reliable predictors of fertilizer response in this region; any improvement from including soil data for N or organic matter is not justified because of their additional cost.

OSU Link
Non-OSU Link

203. Miller, R.E., E.L. Obermeyer and H.W. Anderson. 1999. Comparative effects of precommercial thinning, urea fertilizer, and red alder in a site II, coast Douglas-fir plantation. Pacific-Northwest-Research-Station,-USDA-Forest-Service Research-Paper PNW-RP-513. ii + 25 p.

Keywords: fertilization
thinning
precommercial thinning
growth
yield
tree/stand health
soil properties

Abstract: The number of red alder (Alnus rubra) trees retained with 300 Douglas-fir (Pseudotsuga menziesii) per acre was varied on a high-quality site in coastal Oregon. Alder densities of 0, 20, 40, and 80 per acre were tested. A fifth treatment eliminated nitrogen-fixing alder, but substituted nitrogen fertilizer. Treatment 6 had neither thinning nor alder control. Treatments were randomly assigned within each of three blocks in a 9-year-old plantation. Stand density was reduced within 15 of these 18 experimental units. Surplus conifers were cut, but surplus red alder were controlled by the "hack-and-squirt" method. Because numerous trees of other species regenerated naturally, combined density of all species before thinning ranged from 1400 to 5700 trees per acre. Subsequent 17-year change in number, average height, basal area, and volume of Douglas-fir were compared. Retaining 20, 40, or 80 alder per acre reduced numbers of associated Douglas-fir by about 10, 17, and 23 percent, respectively. In pure Douglas-fir plots, gross volume growth was similar for non-fertilized and fertilized plots, indicating no measurable benefits of additional nitrogen. In mixed stands, red alder reduced yield of associated Douglas-fir, but not yield of combined species. Similar comparisons are needed at other locations, especially those with known nitrogen deficiency.

OSU Link
Non-OSU Link

204. Miller, R.E., D.L. Reukema and H.W. Anderson. 2004. Tree growth and soil relations at the 1925 Wind River spacing test in coast Douglas-fir. Pacific-Northwest-Research-Station,-USDA-Forest-Service Research-Paper PNW-RP-558. iii + 41 p.

Keywords: planting operations
growth
soil properties

Abstract: The 1925 Wind River (Washington, USA) spacing test is the earliest field trial seeking to determine the most appropriate spacing for planting Douglas-fir (Pseudotsuga menziesii). Spacing treatments were not replicated, although individual spacings were subsampled by 2 to 4 tree-measurement plots. Previously, greater growth occurred at the wider spacings (10 and 12 ft) than at the closer spacings (4, 5, 6 and 8 ft). We considered three possible explanations: (1) close spacing eventually retarded growth, (2) soil quality may be better in the 10- and 12-ft spacings than at closer spacings, and (3) tree spacing and soil quality combined affected growth. To test these explanations, we measured and mapped several site factors (topographic relief, depth to bedrock, and soil properties), and related these factors to tree and stand growth. We infer from the strong correlation between spacing and soil variables that the influence of soil and spacing cannot be separated; differences in soil depth and available water capacity confound spacing effects and vice versa. Because soils in the wider spacings were generally deeper and had more available water capacity than do soils in the closer spacings, we conclude that some of the superior tree growth attained in the 10- and 12-ft spacings is due to more favourable soil conditions. Visual comparisons of tree size, however, suggest that spacing is probably the stronger factor affecting tree growth at this location.

OSU Link
Non-OSU Link

205. Miller, R.E., D.L. Reukema and J.W. Hazard. 1996. Ammonium nitrate, urea, and biuret fertilizers increase volume growth of 57-year-old Douglas-fir trees within a gradient of nitrogen deficiency. Pacific-Northwest-Research-Station,-USDA-Forest-Service Research-Paper PNW-RP-490. 12 p.

Keywords: planting operations
fertilization
growth

Abstract: Growth of dominant and codominant Pseudotsuga menziesii given 224 kg N/ha as ammonium nitrate, urea or biuret (a slow-release N source) in a N-deficient plantation in SW Washington was recorded over an 8-year period in relation to distance of the trees from a strip of the plantation interplanted with N-fixing Alnus rubra. Adjusted mean volume growth of the measured trees was increased by 22-28% on the east side of the mixed stand centreline and by 11-14% on the west side, with no difference in response to the 3 fertilizers. Only biuret stimulated growth within the mixed strip of the stand. Biuret had no visible toxic effect on competing vegetation.

OSU Link
Non-OSU Link

206. Miller, R.E., D.L. Reukema and T.A. Max. 1993b. Size of Douglas-fir trees in relation to distance from a mixed red alder - Douglas-fir stand. Canadian-Journal-of-Forest-Research 23(11): 2413-2418.

Keywords: planting operations
growth

Abstract: Variation in diameter, height, and stem volume of 57-year-old Douglas fir (Pseudotsuga menziesii var. menziesii) was studied in relation to distance of these trees from a 27 m wide strip in the same Douglas fir plantation that had been interplanted with red alder (Alnus rubra) at a poor quality site in SW Washington. Measurements were made in 1983. Within the interplanted strip, and despite its greater total stand density, stem volume of dominant and codominant Douglas fir averaged 1.27 msuperscript 3 compared with 0.55, 0.45, 0.46, or 0.49 msuperscript 3, respectively, in trees 15, 30, 45, or 60 m distant from the edge of the mixed stand. It is concluded that some positive influence of nitrogen-fixing red alder apparently extended about 15 m beyond the edge of the mixed stand. It was inferred that similar ribbon-like distributions of naturally regenerated red alder could be retained to improve growth of nearby conifers on nitrogen-deficient sites.

207. Miller, R.E., J. Smith and H. Anderson. 2001. Detecting response of Douglas-fir plantations to urea fertilizer at three locations in the Oregon Coast Range. Pacific-Northwest-Research-Station,-USDA-Forest-Service Research-Paper PNW-RP-533. 20 p.

Keywords: fertilization
thinning
growth
tree/stand health

Abstract: Fertilizer trials in coast Douglas-fir (Pseudotsuga menziesii var. menziesii) in the Oregon Coast Range (USA) usually indicate small and statistically non-significant response to nitrogen (N) fertilizers. Inherently weak experimental designs of past trials could make them too insensitive to detect growth differences that actually exist. Ability to detect real differences among treatments should be improved by having more than two replications per treatment and by using covariance analysis to adjust observed treatment means for unequal starting conditions among experimental treatments. To demonstrate these assumptions, we used size at fertilizer application and a pre-fertilizer application (calibration) period of growth as covariates when analysing data from five coastal plantations at three locations: Toledo North, Toledo South and Bone Mountain. The trials had three to six replications per treatment and calibration periods of 6 or 7 years. Nitrogen fertilizer (urea at 200 lb N/acre) was assigned randomly to half the plots at each location when trees were 16 or 17 years old from seed. Our objectives were to quantify 4- or 7-year response to N fertilizer and to demonstrate practical means for detecting response. Effects of fertilizer application on tree diameter and height, and on basal area and volume growth per acre were estimated. Among the five non-thinned plantations, observed gross basal area growth was changed by -2 to 13% in the 4 or 7 years after fertilizer application. In the thinned portion of one plantation, there were few differences in response to fertilizer between thinned and unthinned plots. Observed responses were increased substantially by covariance analyses at some plantations but decreased at others. Random assignment of three to six plots per treatment did not ensure balanced or comparable plots for fertilized and non-fertilized treatments.

OSU Link
Non-OSU Link

208. Miller, R.E. and S.R. Webster. 1981. Fertilizer response in mature stands of Douglas-fir. *In* Proceedings: Forest Fertilization Conference, University of Washington, Seattle, Washington, USA. *Eds.* S.P. Gessel, R.M. Kenady and W.A. Atkinson. pp. 126-132.

Keywords: fertilization
growth
economics

Abstract: Published and unpublished response data from fertilizer trials in mature stands of Douglas-fir (Pseudotsuga menziesii [Mirb.] Franco) in western Washington and Oregon are examined. Stand age ranged from 60 to 120 years. It is concluded that: (1) nitrogen fertilization increased volume growth by 9 to 60 percent in these 60- to 120-year-old stands, (2) sizeable gains occurred in the first decade after fertilization, (d) the economics of high stumpage values and short investment periods make fertilizing mature Douglas-fir economically attractive.

OSU Link
Non-OSU Link

209. Minore, D. 1986a. Effects of site preparation on seedling growth: a preliminary comparison of broadcast burning and pile burning. Pacific-Northwest-Research-Station,-USDA-Forest-Service Research-Note PNW-RN-452. 12 p.

Keywords: site preparation
prescribed fire
growth
soil properties

Abstract: In studies in SW Oregon, measured and potential heights were similar for 5-yr-old planted seedlings of Douglas fir (Pseudotsuga menziesii) on areas that had been broadcast burned. Measured heights were less than potential heights on most of the pile-and-burn plantations, suggesting that site quality is damaged by this site preparation method.

OSU Link
Non-OSU Link

210. Minore, D. 1986b. Germination, survival and early growth of conifer seedlings in two habitat types. Pacific-Northwest-Forest-and-Range-Experiment-Station,-USDA-Forest-Service Research-Paper PNW-RP-348. ii + 25 p.

Keywords: planting operations
reproduction
tree/stand health
growth

Abstract: Seed germination, and seedling survival and early growth of Douglas fir, western hemlock, Abies procera and A. amabilis were studied on clear felled sites in the A. amabilis/Achlys triphylla and A. amabilis/Vaccinium membranaceum/Xerophyllum tenax habitat types in the McKenzie River basin, Oregon. Severe seed predation and high surface soil temp. in both habitat types resulted in almost total seedling mortality during the first season when seeds had been sown on a few large, consolidated seedbeds. Seedling survival was n.s.d. between habitat types. Survival of Douglas fir (the only species tested) was better when seeds were sown in small scattered spots. Habitat type and addition of forest humus did not affect survival and growth, but shading by stumps and protection from predation using plastic berry baskets were both beneficial. Soils from both habitats had similar colour, texture, pH and nutrient content. In greenhouse studies, seeds of all species began germinating earlier and continued to germinate for longer in soil from Achlys sites than in soil from Xerophyllum sites. It is suggested that unmeasured biological activity may have been responsible for differences in germination activity between the two soil types.

OSU Link
Non-OSU Link

211. Minore, D. and H.G. Weatherly. 1990. Effects of site preparation on Douglas-fir seedling growth and survival. Western-Journal-of-Applied-Forestry 5(2): 49-51.

Keywords: site preparation
mechanical preparation
prescribed fire
growth
tree/stand health
soil properties

Abstract: The effects of 5 site preparation treatment combinations (A: cable yarding + broadcast burning - B: tractor yarding + broadcast burning - C: machine piling + broadcast burning - D: machine piling + off-site burning - and E: machine piling + off-site burning + tilling) on Douglas fir (Pseudotsuga menziesii) growth and survival were studied in 1984-87. Seedling height, potential seedling height, survival percentages, soil-penetration resistances, and occurrence of visible soil humus were evaluated on 149 progeny-test plantations in westernOregon. Survival was not improved by mechanical site preparation (survival at 5 years was 84.8% for treatment A, 73.7% for C and 78.1% for E). Seedlings grown on compacted soils with low humus, associated with piling slash off site, did not grow as tall during their first 5 years as seedlings grown on similar sites where slash had been broadcast-burned (height 77 cm for treatments D and E, compared to 93 cm for A). Mechanical site preparation was not essential for Douglas fir survival, as long as competing vegetation is controlled. Increased soil compaction, loss of humus, and reduced 5 year height growth associated with mechanized slash removal indicated detrimental effects on site quality as well as tree growth.

OSU Link
Non-OSU Link

212. Minore, D., H.G. Weatherly and P.G. Cunningham. 1993. Sowing at 1.5-cm (0.6-inch) depth produces heaviest Douglas-fir roots in small containers. Tree-Planters' Notes 44(3): 122-124.

Keywords: nursery operations
tree morphology
growth
reproduction

Abstract: Sowing seeds of Douglas fir (Pseudotsuga menziesii) at five depths in Leach Super Cells indicated that the only benefit of deep sowing in small containers occurred at a depth of 1.5 cm. Sowing at this depth produced heavier roots without a significant reduction in seedling emergence. Sowing at greater depths significantly reduced seedling emergence and growth.

OSU Link
Non-OSU Link

213. Mitchell, A.K., H.J. Barclay, H. Brix, D.F.W. Pollard, R. Benton and R. DeJong. 1996. Biomass and nutrient element dynamics in Douglas-fir: effects of thinning and nitrogen fertilization over 18 years. Canadian-Journal-of-Forest-Research 26(3): 376-388.

Keywords: fertilization
thinning
precommercial thinning
carbon allocation
tree physiology
growth
soil properties

Abstract: The effects of thinning (two-thirds of basal area removed) and N fertilizer (448 kg N/ha as urea) on biomass and nutrition of a 24-year-old Douglas fir (Pseudotsuga menziesii) stand at Shawnigan Lake, British Columbia, were studied over 18 years. At years 0, 9, and 18 after treatments, the aboveground biomass and N, P, K, Ca, and Mg contents of stemwood, stem bark, foliage, and dead and live branches were determined (kg/ha), and increments in these properties (kg/ha per year) were calculated for the 0-9 and 9-18 year periods. Foliar biomass was increased by both treatments during the first period and also by thinning in the second period. Aboveground net primary production (ANPP) per unit of foliage biomass (foliage efficiency) was increased by treatments in the 0-9 year period. The combined effects of increased foliage mass and foliage efficiency resulted in increased total biomass production. Thinning and fertilizer application increased the uptake of all elements except for P with fertilizer. This increase may have contributed to the long-term increase in stem growth. Retranslocation of elements before foliage shedding was important for tree nutrition, but was not improved by fertilizer during the 9-18 year measurement period. The efficiency of N use in dry matter production (ANPP/unit of N uptake) was decreased by fertilizer. This implied that poor sites would respond to fertilizer better than rich sites.

OSU Link
Non-OSU Link

214. Mitchell, K.J. and J.R. Cameron. 1985. Managed stand yield tables for coastal Douglas-fir: initial density and precommercial thinning. Ministry-of-Forests, British-Columbia

Keywords: planting operations
thinning
precommercial thinning
growth
yield

Abstract: Yield tables are presented for second growth stands of Pseudotsuga menziesii, established naturally (4440 trees/ha) or planted with 300, 500, 750, 1110 or 2500 trees/ha in British Columbia. Separate tables describe the development of stands thinned to 500 or 1100 stems/ha when 6 m tall. The yield tables were produced by a biologically oriented tree and stand simulation model (TASS) calibrated to conform with the yield of remeasured plots.

OSU Link
Non-OSU Link

215. Mitchell, S.J. 2000. Stem growth responses in Douglas-fir and Sitka spruce following thinning: implications for assessing wind-firmness. Forest-Ecology-and-Management 135(1/3): 105-114.

Keywords: thinning
tree morphology
carbon allocation
growth

Abstract: Diagnosing the stand hazard component of windthrow risk requires evaluation of the 'acclimation' of trees to wind loads. Height-diameter ratio is a commonly used indicator of relative wind-firmness. A sample of coastal Sitka spruce (Picea sitchensis) and interior Douglas fir (Pseudotsuga menziesii) trees, representing a range of initial slenderness, were sampled from stands in British Columbia, Canada, which had very high densities (about 6000 and 23,000 stems/ha, respectively) prior to thinning. Annual height increment, radial increment, allocation of radial increment along the bole, and height-diameter ratio were reconstructed using stem analysis. Thinning treatments affected growth responses compared to trees in control (unthinned) stands: temporary reduced height increment, increased radial increment and increased basal allocation contributed to a reduction in height-diameter ratio. This reduction was most pronounced in trees which were initially more slender. The reverse-S pattern of height-diameter ratio adjustment and the patterns of growth allocation suggest a period of acclimative growth during which the trees re-equilibrate with post-thinning wind loads. Observing the rate of stem form adjustment could be useful in diagnosing wind-firmness when scheduling multiple thinning entries in high-density stands.

OSU Link
Non-OSU Link

216. Mohammed, G.H., K.R. Patel and W.E. Vidaver. 1989. The control of adventitious root production in tissue-cultured Douglas-fir. Canadian-Journal-of-Forest-Research 19(10): 1322-1329.

Keywords: nursery operations
reproduction
growth

tree morphology

Abstract: Rooting percentage and root number in tissue-cultured Douglas fir (Pseudotsuga menziesii) were examined to assess the influence of rooting substrate, the concentrations of sucrose and boron in the rooting medium, shoot height, and shoot generation. Peat/perlite was a better substrate than agar, producing 70% compared with 0% rooted shoots, respectively. On peat/perlite, cell divisions were organized and were associated with tracheid nests, whereas on agar proliferation was neither organized nor restricted to the nests. An optimum sucrose concentration of 4% was found for the production of nodular or rooted shoots. At 4% sucrose and 3 mg/litre boric acid, 100% of the shoots rooted, and the mean root number was 11. Rooting percentage and root number were significantly greater with shoots that were 3 cm tall rather than 2 or 1 cm tall. Shoot responses were more rapid in third and fourth generation shoots, with at least 80% rooted or nodular after 4 weeks, compared with only 36% from the second generation.

OSU Link
Non-OSU Link

217. Molina, R. and J. Chamard. 1984. Use of the ectomycorrhizal fungus Laccaria laccata in forestry. II. Effects of fertilizer forms and levels on ectomycorrhizal development and growth of container-grown Douglas-fir and ponderosa pine seedlings. Canadian-Journal-of-Forest-Research 13(1): 89-95.

Keywords: nursery operations
nursery fertilization
mycorrhizal response
growth

Abstract: [See FA 44, 2464] Seedlings were grown in peat/vermiculite medium with or without pre-germination inoculation with L. laccata, using three rates of soluble NPK fertilizer (low, high, and a combination of low changed to high) or full or half strength of a slow-release fertilizer. Ectomycorrhizal development was excellent for both hosts regardless of fertilizer treatment; ectomycorrhizal short roots averaged 93.6% for Douglas fir and 94.5% for ponderosa pine. Inoculation did not affect the size of Douglas fir but significantly reduced growth of ponderosa pine at low fertility.

OSU Link
Non-OSU Link

218. Monleon, V.J., M. Newton, C. Hooper and J.C. Tappeiner, II. 1999. Ten-year growth response of young Douglas-fir to variable density varnishleaf ceanothus and herb competition. Western-Journal-of-Applied-Forestry 14(4): 208-213.

Keywords: site preparation
chemical preparation
release treatments
chemical release
growth

Abstract: The effect of different densities of varnishleaf ceanothus (Ceanothus velutinus var. laevigatus) and herbaceous vegetation control on stem diameter, height, and volume of Douglas-fir (Pseudotsuga menziesii var. menziesii) seedlings was examined during the 10 yr following planting on a site near Springfield, Oregon, in winter 1996-97. Initial densities of ceanothus ranged between 0 and 15 000 seedlings/ha and were obtained by interplanting ceanothus germinants or chemical thinning after clearcutting and broadcast-burning. Herbaceous vegetation control was achieved by a single application of glyphosate following planting, with shrub seedlings covered. Ceanothus density in the range of 0 to 6750 plants/ha did not have an effect on Douglas fir diameter, height, or volume at age 10; however, Douglas fir growth was significantly decreased when ceanothus densities reached 15 000 plants/ha. Ten years after planting, Douglas fir volume in the treatments with <less or =>6750 ceanothus/ha was 1.7 times greater than that in the 15 000 ceanothus/ha treatment. In contrast, removal of herbaceous vegetation after planting significantly increased tree diameter, height, and volume, regardless of ceanothus density. Even 10 yr after application of the treatment, trees without early herb competition grew faster and had mean dbh, height, and volume that were 1.02 cm, 0.55 m, and 12.98 dmsuperscript 3/tree greater respectively than those with herbs. Thus, a treatment at plantation establishment to control herbaceous vegetation and to reduce ceanothus density to less than 7000 plants/ha will ensure an increase in growth and stocking for at least 10 yr.

OSU Link
Non-OSU Link

219. Montigny, L.d. and S. Stearns-Smith. 2001. Douglas-fir fertilization with biosolids: five-year results at Whistler, B.C. B.C.-Ministry-of-Forests Extension-Note 50. 6 p.

Keywords: fertilization
growth
tree/stand health

Abstract: Biosolids (from municipal waste water treatment facilities) at 750, 1000, and 1500 kg-N/ha and conventional fertilizer at 225 kg-N/ha were applied in each of three seasons (spring, summer, and fall) to a 15-year-old B.C. coastal Douglas-fir (Pseudotsuga menziesii) plantation that had recently been precommercially thinned and pruned. Five-year results showed that rate and timing effects were independent. No height-growth response was evident, but annual diameter growth for all biosolids treatments averaged three times higher than for conventional fertilizer. Seasonal application differences were small but statistically significant. All plots, including the controls, experienced extensive top damage from snow and ice. Similar to growth, damage was greatest with biosolids fertilization. The study shows promise for biosolids fertilization as a viable alternative to conventional fertilization, but application in locations prone to snow and ice damage should be avoided.

OSU Link
Non-OSU Link

220. Murray, M.D. 1988. Growth and yield of a managed 30-year-old noble fir plantation. Pacific-Northwest-Research-Station,-USDA-Forest-Service Research-Note PNW-RN-475. 8 p.

Keywords: planting operations
growth

yield
economics

Abstract: Yield of noble fir (Abies procera) from a managed (urea application 15 yr after planting, precommercially thinned after 17 and 24 yr) stand in the Doty Hills, western Washington was measured and compared with the simulated yield of a Douglas fir (Pseudotsuga menziesii) plantation of the same age. Noble fir produced 3450 ftsuperscript 3/acre at age 30 yr; more than half this volume was in trees of <more or =>10 inches d.b.h. Current annual increment during the 6 yr after the second thinning (to 300 trees/acre) was 295 ftsuperscript 3/acre. Ornamental boughs had been harvested annually for 15 yr. Total noble fir volume was about 5% less than the simulated volume of Douglas fir. The estimated value of noble fir after 48 yr, including sawlogs and boughs, could exceed the value of Douglas fir at the same age grown on the same site.

OSU Link
Non-OSU Link

221. Murray, M.D. and R.E. Miller. 1986. Early survival and growth of planted Douglas-fir with red alder in four mixed regimes. Pacific-Northwest-Research-Station,-USDA-Forest-Service Research-Paper PNW-RP-366. ii + 13 p.

Keywords: planting operations
release treatments
growth
stand conditions

Abstract: To quantify interactions between species, the survival and growth of planted Douglas fir in association with volunteer or planted red alder (Alnus rubra) were studied at a site on the W. side of the Cascade Range, Washington. The planted alders were wildings taken either from a nearby site or from a distant coastal site and interplanted in a 3-yr-old Douglas fir plantation. The volunteer alders established during the first year and were cut when the plantation was 3 or 7 yr old. There was no apparent advantage in using non-local alder to reduce aboveground competition with Douglas fir. Survival of both sources of transplanted alder was high. Retaining about 1100 plants/ha of volunteer alders until plantation age 7 yr had no measurable effect on Douglas fir. It is recommended that, with alder densities of <1250/ha, alder control on most land of average or below average site quality can be delayed until 6-8 yr after planting Douglas fir. This will reduce alder sprouting and allow simultaneous control of alder and precommercial thinning of Douglas fir.

OSU Link
Non-OSU Link

222. Nelson, E.E., M.G. McWilliams and W.G. Thies. 1994. Mortality and growth of urea-fertilized Douglas-fir on a Phellinus weirii-infested site in Oregon. Western-Journal-of-Applied-Forestry 9(2): 52-56.

Keywords: planting operations
fertilization
tree/stand protection

growth
tree/stand health
soil properties

Abstract: Twelve plots were established in 1972 in an 11-yr-old Douglas fir (Pseudotsuga menziesii) plantation infected with Phellinus weirii, the cause of laminated root rot. All plots were thinned and either interplanted with red alder (Alnus rubra) or fertilized at 5- to 10-yr intervals with urea to determine the effect of nitrogen on tree growth and mortality caused by P. weirii, or left untreated. Interplanted alder, however, failed to survive. Mortality was assessed at intervals of 2 to 3 yr. Plots were inventoried (100% cruise) in 1978 and 1990. Growth over 12 yr appeared better on fertilized than nonfertilized plots, but the difference was not significant. Mortality caused by the preferential feeding of black bears [Ursus americanus] on the inner bark of fertilized trees reduced the overall gain. Mortality caused by laminated root rot did not differ significantly among treatments. Three months after the initial application of urea at 448 kg N/ha, soil sampled to a depth of 30 cm was higher in ammonium and nitrate forms of nitrogen on fertilized than nonfertilized plots, but increases were not significant. Numbers of soil bacteria were directly correlated with soil ammonium content (P = 0.1092). Numbers of aerobic actinomycetes were inversely correlated with soil nitrate content (P = 0.0398).

OSU Link
Non-OSU Link

223. Newton, M. and E.C. Cole. 1991. Root development in planted Douglas-fir under varying competitive stress. Canadian-Journal-of-Forest-Research 21(1): 25-31.

Keywords: planting operations
release treatments
carbon allocation
growth

Abstract: Roots of 5-year-old Douglas fir (Pseudotsuga menziesii) on three Oregon sites were excavated with explosives and analysed for the effects of competition on root biomass and for planting-induced root deformities. The plantations were in Nelder designs with graduated spacing from 300 to 15 250 cmsuperscript 2 per tree (about 17x17 to 123x123 cm spacing). Competition treatments consisted of weed-free intraspecific competition, grass cover seeded after 1 year of seedling growth, and red alder (Alnus rubra) interplanted 1:1 among the Douglas fir. All plantations were kept at low water stress in year 1. The ratio of standing aboveground to belowground biomass was the same for each competition type. Shoot:root ratios averaged about 4:1, except in severely suppressed trees, where ratios decreased toward 1:1 in those near death. Neither shoot:root ratio nor tree size was affected by planting-induced root deformities such as J- or L-rooting, indicating that if conditions are favourable for 1st-year survival and growth, root deformities at the time of planting have no subsequent effect on root and shoot development.

OSU Link
Non-OSU Link

224. Newton, M., E.C. Cole and D.E. White. 1993. Tall planting stock for enhanced growth and domination of brush in the Douglas-fir region. New-Forests 7(2): 107-121.

Keywords: nursery operations
site preparation
prescribed fire
release treatments
chemical release
growth
tree/stand health

Abstract: Two long-term experiments in Oregon followed the development of planted stock of various sizes, origins, and species. In one experiment, multi-year comparisons of container, 2+0 bare rooted, and 3-yr-old Douglas fir (Pseudotsuga menziesii) transplants showed a strong positive relation between initial height and long-term (10-14 yr) growth under a range of site conditions with high probability of brush development. In another experiment, Douglas fir, western hemlock (Tsuga heterophylla), and Sitka spruce (Picea sitchensis) were planted on brushfield sites (disturbed by logging 0 and 4 yr previously) where salmonberry (Rubus spectabilis) was or had been dominant. Half the seedlings were released with glyphosate 6 months after planting. Western hemlock and Douglas fir bare rooted stock all grew well if planted in a fresh burn, despite rapid regrowth of salmonberry, but virtually all seedlings less than 60 cm tall except Sitka spruce were killed by 4-yr-old salmonberry if not released. Release improved growth of seedlings in the fresh burn by 6%, gaining an average of about 0.6 year toward reaching a height of 6 m. Release improved growth of survivors in 4-yr-old salmonberry by 51% in height, 72% in diameter, and 325% in volume at age 12 yr. Sitka spruce grew well until damaged by insects. Western hemlock growth was equal to or greater than that of Douglas fir of comparable initial height. In all comparisons, the probability of being overtopped by brush decreased with increasing initial stock height, and the effect of suppression on growth was also inversely related to initial height. Tall wilding seedlings had comparable advantages to nursery-grown seedlings, although Sitka spruce survival was not reliable.

OSU Link
Non-OSU Link

225. Newton, M. and D.S. Preest. 1988. Growth and water relations of Douglas fir (Pseudotsuga menziesii) seedlings under different weed control regimes. Weed-Science 36(5): 653-662.

Keywords: release treatments
chemical release
growth
soil properties
tree physiology

Abstract: Growth of Douglas fir (P. menziesii) was increased by controlling grasses and broadleaved weeds with combinations of 4.4 kg atrazine/ha and 2.2 kg 2,4-D or 2,4,5-T during the first 3 years after planting on a well-drained moist site in the Oregon Coast Range. The greatest growth occurred if weeds were controlled in the same growing season that tree seedlings were transplanted to the field; smaller increments came from second- and third-year weed control. Growth increases attributable to early weed control continued through the fifth year, indicating that conditions during establishment strongly influenced later growth. Plots with no herbaceous vegetation had more available soil water than those with competing vegetation, and tree seedlings on these plots experienced less water stress. Irrigation in the third year increased stem diameter of seedlings in that year but had no effect thereafter. Increases

in average seedling stem volume at 5 years after transplanting were linearly related to the difference in observed xylem potential during the first three seasons after transplanting and the xylem potential at which photosynthesis ceased, -2 MPa.

OSU Link
Non-OSU Link

226. Newton, M., D.S. Preest and D.E. White. 1987. Effect of relieving moisture stress with extended weed control in Douglas-fir. Proceedings-of-the-Western-Society-of-Weed-Science (Vol.40): 129-130.

Keywords: release treatments
chemical release
growth
tree physiology
soil properties
photosynthesis

Abstract: The growth of Douglas fir Pseudotsuga menziesii seedlings was increased during the first 5 years by controlling grasses and forbs in 7 herbicide regimes during the 1st 3 years, the effect diminishing with time after planting. Devegetated plots had more available moisture through the growing season than those with Agrostis tenuis or mixed mixed grass/forb cover dominated by A. tenuis or Hypochaeris radicata. Tree moisture stress followed soil moisture but only after allowing for large fluctuations of diurnal stress. Weed control relieved moisture stress in trees. P. menziesii photosynthesis tended to shut down in the region of -2.0 MPa moisture stress. For the 1st 3 years in a favourable coastal environment approx. 1700 MPa-h above -2.0 MPa was estimated to be required for survival. Increments of moisture beyond that would contribute significantly to growth.

OSU Link
Non-OSU Link

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

Keywords: thinning
commercial thinning
growth
tree morphology
carbon allocation

Abstract: The growth of individual trees from four thinning treatments in a 64-yr-old Pseudotsuga menziesii stand in western Washington was analysed to determine desirable residual stand structures after thinning. Dominant and codominant trees had the highest individual tree stem vol. growth rates over the previous 5 yr and accounted for most stand vol. growth in thinned and unthinned stands. Two measures of growing space, crown projection area and sapwood b.a. (a surrogate for leaf area), were used to measure how efficiently individual trees used their growing space. Crown classes were useful in characterizing growing space efficiency (vol. growth per unit of growing space) only in the unthinned treatment. In thinned treatments, tall trees with medium-sized crowns were most efficient, while in the

unthinned treatment tall trees with relatively large crowns were most efficient. A large crown in an unthinned stand was comparable in size to a medium-sized crown in a thinned stand. Results suggest growing space is not limiting individual tree growth in thinned stands and that thinning to a particular stand structure is more appropriate than thinning to a particular stand density.

OSU Link
Non-OSU Link

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

Keywords: thinning
commercial thinning
growth
carbon allocation
tree morphology

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

OSU Link
Non-OSU Link

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

Keywords: thinning
commercial thinning
growth
yield

Abstract: Results are presented of a 28-year thinning study of a dense (182-452 tree/acre) natural, second growth Douglas fir (Pseudotsuga menziesii) stand at Delezenne, which compared 3 thinning treatments with an unthinned control. Treatments were: an increasing basal area treatment; a constant basal area treatment (of approximately 140 ftsuperscript 2/acre); a decreasing/increasing reserve basal area treatment; and control plots, which were 35 to 37-years-old with basal area 80-203 ftsuperscript 2/acre in 1957 when the tests were started. Gross, net, and total recoverable periodic cubic volume increments of the control treatment (10 396, 9108 and 16 092 ftsuperscript 3/acre, respectively) were not significantly different from the highest yielding treatment, which was the increasing reserve basal area thinning treatment (8896, 8594 and 16 636 ftsuperscript 3/acre, respectively). These results, and options for thinning schedules, are discussed; it is suggested that commercial thinnings of dense or fully

stocked plantations of Douglas fir may produce similar results, that is, vigorous stands with rapid growth potential.

OSU Link
Non-OSU Link

230. 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

231. O'-Hara, K.L. and C.D. Oliver. 1988. Three-dimensional representation of Douglas-fir volume growth: comparison of growth and yield models with stand data. Forest-Science 34(3): 724-743.

Keywords: planting operations
thinning
growth
yield
computer modeling

Abstract: Growth and yield estimates for unthinned stands from the Douglas fir Stand Simulator (DFSIM) and the Tree and Stand Simulator (TASS) were used to construct graphical three-dimensional representations of Douglas fir (Pseudotsuga menziesii) stand growth on site index 44 m (50 yr). The three-dimensional models used three variables: trees per hectare, b.h. age, and either mean tree vol. or stand vol. The TASS and DFSIM models were in agreement over most of their common range of age and number of trees. At wider spacings and older ages, however, the volumes predicted by the DFSIM model exceeded those predicted by the TASS model by as much as 25%. Comparisons of these three-dimensional models to unthinned and thinned stand data from a site of similar quality in the Delezenne thinning trial, Washington, found the models to be reasonably accurate representations of unthinned stand growth. The thinned stands, however, had greater mean tree and stand volumes than those indicated by the TASS model for unthinned stands at similar spacings. Complete comparisons were not possible with the DFSIM model because of its limited range of number of trees. These results suggest that the TASS model, and to a lesser extent, the DFSIM model may be underestimating the growth of widely spaced stands, or thinning may actually increase the growth of thinned trees over that of trees which had always grown at the post-thinning spacing.

OSU Link
Non-OSU Link

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

Keywords: thinning
commercial thinning
growth
stand conditions

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

OSU Link
Non-OSU Link

233. Omule, S.A.Y. 1984. Results from a correlated curve trend experiment on spacing and thinning of coastal Douglas fir. B.C. Ministry-of-Forests Research-Note 93. ix + 22 p.

Keywords: thinning
precommercial thinning
growth
yield
tree/stand health

Abstract: Plots were established in 1952 in 13-yr-old plantations and given a variety of thinning treatments to produce post-thinning densities of 125-3000 stems/ha. Trees were measured at intervals up to 1980. Analysis showed that diam., ht. and their growth increased with decrease in density. Mortality, b.a., total vol. and b.a. growth decreased as density decreased. Stand merchantable vol. was not affected by density except at extremes. Prolonged early suppression appeared to reduce the ability of a stand to respond to subsequent thinning in terms of b.a. and total vol.

OSU Link
Non-OSU Link

234. Omule, S.A.Y. 1987a. Comparative height growth to age 28 for seven species in the CWHd subzone. B.C. Ministry of Forests FRDA-Report 005. vi + 9 p.

Keywords: planting operations

growth

Abstract: Ht. growth curves to total age 28 yr were developed from remeasurement of 49-tree plots planted at 8 ft spacing with (a) Douglas fir (Pseudotsuga menziesii), (b) Sitka spruce (Picea sitchensis), (c) western hemlock (Tsuga heterophylla), (d) Abies grandis, (e) Chamaecyparis lawsoniana, (f) Thuja plicata and (g) A. amabilis on a moist site of medium nutrient status within the Hypermaritime Coastal Western Hemlock (CWHd) subzone on the W. coast of Vancouver Island, British Columbia. Av. top ht. at age 28 yr were 20.2, 19.9, 16.9, 15.9, 14.3, 12.2 and 12.0 m respectively in (a)-(g), with b.h. being reached at age 4 yr in (a), (b), (c) and (e), 5 yr in (d) and (f) and 8 yr in (g). Growth curves were similar in shape to those published for the Pacific Northwest and the UK. Extrapolation of results to other sites within the CWHd should be cautious because the study site appears to be on a unique soil type.

OSU Link
Non-OSU Link

235. Omule, S.A.Y. 1987b. Early growth of four species planted at three spacings on Vancouver Island. B.C. Ministry of Forests FRDA-Report 009. vii + 22 p.

Keywords: planting operations
tree/stand health
growth
yield

Abstract: Seedling survival and 24- to 26-yr growth were measured of (a) Douglas fir (Pseudotsuga menziesii), (b) western hemlock (Tsuga heterophylla), (c) Sitka spruce (Picea sitchensis) and (d) Thuja plicata grown at 2.7x2.7, 3.7x3.7 and 4.6x4.6 m spacings on the W. coast of Vancouver Island, British Columbia. Initial spacing had no significant effect on survival, which was 86% in (a), 56% in (b), 87% in (c) and 91% in (d). Effects of spacing on growth and yield were as expected (little effect on ht.; wider spacings produced larger trees, but vol./ha was lower) in (a), but were delayed or confounded in (b) by poor seedling survival, in (c) by weevil (Pissodes strobi) damage and in (d) by salal (Gaultheria shallon) competition and browsing.

OSU Link
Non-OSU Link

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

Keywords: thinning
commercial thinning
growth
yield
tree/stand health

Abstract: Remeasurement data over a period of 35 years from fourteen 0.2023-ha permanent plots were analysed to determine the growth and yield effects of commercially thinning 50-year-old Douglas fir (Pseudotsuga menziesii) stands on a good site on Vancouver Island, British Columbia. Compared to

unthinned stands, the commercially thinned stands had: virtually the same total volume gross annual increment, top height and top height increment; 12% more potentially usable total volume yield (including thinnings); 18% less total volume at final harvest age 86 yr; virtually the same crop tree (193 largest diameter trees per hectare) average diameter, but 24% larger entire stand quadratic mean diameter; and 11% less total volume production lost to mortality. These results show that commercial thinning slightly increased total stand yield (including thinnings) and produced larger stand diameter at rotation age 86 yr, but that it also reduced usable total volume at final harvest and had virtually no effect on size of the crop trees. Data from this study are useful for validating growth models, and for constructing and comparing managed stand yield tables for various commercial thinning regimes.

OSU Link
Non-OSU Link

237. Omule, S.A.Y. 1990. Net basal area response 9 years after fertilizing thinned and unthinned Douglas-fir. B.C. Ministry of Forests FRDA-Report 097. vi + 20 p.

Keywords: fertilization
thinning
growth

Abstract: Equations were developed to estimate net basal area response of Douglas fir (Pseudotsuga menziesii) to nitrogen (urea) fertilizer in terms of initial stand attributes, based on remeasurement data over a 9-yr period from 176 plots on Vancouver Island, British Columbia.

OSU Link
Non-OSU Link

238. Owens, J.N., J.E. Webber, S.D. Ross and R.P. Pharis. 1985. Interaction between gibberellin A4/7 and root-pruning on the reproductive and vegetative processes in Douglas-fir. III. Effects on anatomy of shoot elongation and terminal bud development. Canadian-Journal-of-Forest-Research 15(2): 354-364.

Keywords: seed orchard management
tree physiology
tree phenology
growth

Abstract: The relative importance of cell division and cell elongation to shoot elongation and the anatomical changes in vegetative terminal apices were assessed for 9- and 10-yr-old seedlings in a seed orchard in British Columbia after two effective cone-induction treatments, gibberellin A4/7 (GA4/7) and root-pruning (RP). Root-pruning was done in mid-April 1981 at the start of vegetative bud swelling and GA treatments were begun at vegetative bud flushing in mid-May and continued until early July. Shoot elongation before flushing resulted primarily from cell divisions and was not affected by the RP treatment. Shoot elongation after flushing resulted primarily from cell expansion which was reduced by RP treatments. Root-pruning significantly slowed mitotic activity, apical growth, and development of vegetative terminal buds from mid-June to mid-July. Apical growth then resumed during leaf initiation and the final number of leaf primordia initiated was not affected. This resulted in a delay of 2-4 wk in the transition from bud-scale to leaf initiation. Retarded terminal vegetative apices anatomically

resembled latent axillary apices but were never completely inhibited. GA + RP had the same effect as RP. GA4/7 alone had no effect on shoot or apical development. These results show that RP and GA + RP significantly retard shoot elongation and terminal bud development but still allow normal development of vegetative terminal buds. Retardation of bud development by a few weeks shifts the critical morphogenetic phase of transition from bud scale to leaf initiation to a later time when endogenous and environmental conditions may differ from the normal.

OSU Link
Non-OSU Link

239. Owston, P.W., W.G. Thies and W. Fender. 1986. Field performance of Douglas-fir seedlings after treatment with fungicides. Canadian-Journal-of-Forest-Research 16(6): 1369-1371.

Keywords: nursery operations
tree/stand protection
tree/stand health
growth
mycorrhizal response

Abstract: Douglas fir seedlings grown in containers with pasteurized or unpasteurized potting mixture, and treated in the nursery with benomyl, captan, fenaminosulf or ethazol [etridiazole], or left untreated (control) were planted out in the Cascade Range, western Oregon. The seedlings from all treatments appeared to be in similar condition at the time of planting, except for variations in ht. After 7 yr, seedlings grown in pasteurized potting mixture had better survival than those grown in unpasteurized mixture. Benomyl-treated seedlings in pasteurized potting mixture had significantly better survival than control seedlings in pasteurized mixture and seedlings treated with ethazol and grown in unpasteurized potting mixture had significantly lower survival than control seedlings in unpasteurized mixture. Ht. differences after 7 yr were n.s.d. between treatments. Benomyl, captan and ethazol appeared to have no detrimental effect on the development of mycorrhizas after planting non-mycorrhizal seedlings. There were insufficient seedlings to determine the effects of fenaminosulf on mycorrhizas.

OSU Link
Non-OSU Link

240. Pabst, R.J., J.C. Tappeiner, II and M. Newton. 1990. Varying densities of Pacific madrone in a young stand in Oregon alter soil water potential, plant moisture stress, and growth of Douglas fir. Forest-Ecology-and-Management 37(4): 267-283.

Keywords: release treatments
manual release
soil properties
tree physiology
growth

Abstract: In a study to evaluate the effects of mixed conifer/broadleaf stands on soil water potential, and Douglas fir (Pseudotsuga menziesii) moisture stress and growth, Pacific madrone (Arbutus menziesii) and associated shrub and herbaceous vegetation were thinned to represent the following

range of conditions: high-density madrone (H) with associated shrubs and herbs controlled; medium-density madrone (M), shrubs and herbs controlled; low-density madrone (L), shrubs and herbs controlled; no madrone (N), shrubs and herbs controlled; and no madrone (U), shrubs and herbs predominate. The study was carried out in 1985 and 1987 at a 2-ha droughty site in the Klamath Mountains, SW Oregon, planted in 1979 with 2+0 Douglas fir. Soil water-potential (psi) at a depth of 0-30 cm was consistently higher in treatment N than in all other treatments; in 1987 this difference was significant ($P<0.025$). Average psi in treatment U reached -1.5 MPa (permanent wilting point) between June and July in both years of the study, whereas in the other treatments that level was never reached. Soil water conditions were also relatively severe in treatment H. Predawn plant moisture stress (PMS) of Douglas fir was significantly ($P=0.0001$) less in treatment N than in all other treatments. Seasonal moisture-stress relief (SMSR) of Douglas fir was significantly related to madrone leaf area index (LAI) and was greatest in treatment N. Seasonal moisture stress relief of madrone was also significantly correlated with LAI. There were highly significant linear relationships between both predawn and midday PMS and soil water potential for Douglas fir and madrone. Results clearly show that conditions for maximum Douglas fir growth occurred in treatment N. Average diameter growth of Douglas fir was greatest in treatment N, although not significantly different from that in treatment U, and least in treatment H. In 1987, Douglas fir growth in diameter, stem basal area, and stem volume was strongly related to SMSR and madrone LAI, and to a lesser extent, seasonal soil tension relief.

OSU Link
Non-OSU Link

241. Parke, J.L., R.G. Linderman and J.M. Trappe. 1983b. Effects of forest litter on mycorrhiza development and growth of Douglas-fir and western red cedar seedlings. Canadian-Journal-of-Forest-Research 13(4): 666-671.

Keywords: site preparation
mechanical preparation
prescribed fire
mycorrhizal response
growth

Abstract: Preparation of forest regeneration sites for conifer planting often includes slash burning or physical removal of soil organic matter. Experiments were conducted to determine if organic matter contributes to the mycorrhizal fungus inoculum potential in forest soils and to compare the growth of Douglas fir and western red cedar (Thuja plicata) in untreated or pasteurized soils from undisturbed or cleared and burned forest sites with and without addition of untreated or pasteurized litter. Mycorrhizas were abundant on Douglas fir seedlings grown in undisturbed forest soil but developed similarly on red cedar seedlings in either type of soil. Litter and humus were found to include inoculum of both vesicular-arbuscular (VA) and ectomycorrhizal fungi. Litter amendment usually enhanced growth of host seedlings, but growth enhancement could not be fully attributed to addition of mycorrhizal inoculum or nutrients provided by litter. These findings suggested that other biological factors stimulated the growth of conifer seedlings and (or) activity of mycorrhizal fungi.

OSU Link
Non-OSU Link

242. Petersen, T.D. and M. Newton. 1983. Growth of Douglas-fir following release from snowbrush and forbs in the Oregon Cascades. Proceedings-of-the-Western-Society-of-Weed-Science (Vol. 36):58-59.

Keywords: release treatments
chemical release
growth

Abstract: Ceanothus velutinus and other weeds such as Epilobium angustifolium, Rubus ursinus and Pteridium aquilinum suppressed the growth of Douglas fir in plantations of the central Cascades of W. Oregon. Stem vol. increases of Douglas fir after 4 yr were greatest when all competing vegetation had been controlled for 1 growing season with herbicides. It is suggested that C. velutinus competes with Douglas fir by depleting soil moisture although the cause of competition by other weeds is unknown. The best time for releasing Douglas fir from competition is discussed.

OSU Link
Non-OSU Link

243. Petersen, T.D., M. Newton and S.M. Zedaker. 1988. Influence of Ceanothus velutinus and associated forbs on the water stress and stemwood production of Douglas-fir. Forest-Science 34(2): 333-343.

Keywords: release treatments
chemical release
tree physiology
soil properties
growth

Abstract: In studies in the central Cascade Mts., Oregon, three regimes were established in 1978 around individual trees in four 5-yr-old and four 10-yr-old stands, viz. no treatment (control), elimination of C. velutinus with 2,4-D or elimination of C. velutinus and forbs with 2,4-D and glyphosate. Seasonal and diurnal variation in stem and soil water potentials were measured during 1979. Soil water potential during late summer was <-1.5 MPa at depths of 10, 40 and 100 cm on control plots and at depths of 10 and 40 cm in 5-yr-old stands and 10 cm in 10-yr-old stands in plots where only C. velutinus was eliminated. In the absence of shrubs and forbs, soil water potential at 100 cm was near field capacity throughout the season. Predawn stem water potential during late summer was significantly lower on control plots than on the treatment plots for all 5-yr-old stands and for two of the 10-yr-old stands. By 1986, tree stems were 2-6 cm larger in basal diam. and 1-2 m taller in the absence of competitors. The increase in stem size was greater in the stand treated at 5 yr old than in that treated at 10 yr old. The correlation between growth and water stress suggests that interspecific competition for soil water during summer drought is a limiting factor in stemwood production.

OSU Link
Non-OSU Link

244. Peterson, C.E. 1984. Fertilization of Douglas-fir plantations in the Pacific Northwest RFNRP Cooperative. *In* Proceedings IUFRO Symposium on Site and Productivity of Fast Growing Plantations

Volume 2, South African Forest Research Institute, Pretoria, South Africa. Eds. D.C. Grey, A.P.G. Schonau and C.J. Schutz. pp. 637-645.

Keywords: planting operations
fertilization
thinning
precommercial thinning
growth

Abstract: Since 1975, the RFNRP cooperative has established 26 installations in young widely spaced plantations of Douglas-fir for testing response to 224 kg-N/ha. These plantations ranged in breast-height age from 3 to 23 years, and although response to fertilization was favorable in all Douglas-fir plantations, those which were spaced to 1000 trees/ha responded significantly better than plantations of 725 trees/ha, in both absolute and relative 2-year basal area increment (msuperscript 2 ha-1 year-1). Response also appears to be greater when fertilizer was applied 2 years after precommercial thinning, as opposed to fertilizing and thinning at the same time. The relationship of growth response with stocking level is discussed, as well as the timing of fertilization relative to spacing, in young Douglas-fir plantations.

OSU Link
Non-OSU Link

245. Peterson, C.E. and J.W. Hazard. 1990. Regional variation in growth response of coastal Douglas-fir to nitrogen fertilizer in the Pacific Northwest. Forest-Science 36(3): 625-640.

Keywords: fertilization
thinning
growth

Abstract: Hypothesis-testing for differences in growth responses among physiographic strata, thinning levels, and fertilizer dosage levels resulted in a set of empirical models for predicting the volume increment response of even-aged coastal Douglas fir (Pseudotsuga menziesii) in W.
Washington and Oregon to N fertilizer treatment. Absolute and percentage responses are estimated for both thinned and unthinned stands as a function of dosage levels and physiographic provinces. Although not 'highly' significant, the physiographic factor was retained in the models for purposes of refinement.

OSU Link
Non-OSU Link

246. Peterson, C.E., P.J. Ryan and S.P. Gessel. 1984. Response of northwest Douglas-fir stands to urea: correlations with forest soil properties. Soil-Science-Society-of-America-Journal 48(1): 162-169.

Keywords: fertilization
thinning
growth
soil properties

Abstract: Replicated forest floor and surface soil (0-15 cm) samples were obtained from control plots at 160 field installations in western Washington and Oregon. Six-year growth responses of thinned and unthinned Douglas-fir [Pseudotsuga menziesii] treated with 0, 224, and 448 of urea-N ha-1 were correlated with 18 forest floor and surface soil properties of the control plots. Forest floor nitrogen properties were the most highly correlated with various estimates of response in both thinned and unthinned stands; these correlations were generally independent of methods used to estimate response. For unthinned stands, C/N ratios of both forest floor and surface soil were well correlated with growth response to fertilizer, whereas for thinned stands, N content (kilograms per hectare) of the forest floor was consistently correlated with response.

OSU Link
Non-OSU Link

247. Peterson, M. and J.R. Sutherland. 1989. Grey mould control by seedling canopy humidity reduction through under-bench ventilation and styroblock aeration. B.C. Ministry of Forests FRDA-Report 077. 15 p.

Keywords: nursery operations
growth
tree/stand health
tree morphology

Abstract: The potential for grey mould control on Douglas-fir seedlings was investigated using under-bench ventilation and aerated styroblocks. Twenty-five percent of all ventilated styroblock seedlings were infected with Botrytis cinerea while 75% of the control seedlings showed signs of infection. The reduced incidence of grey mould in the ventilated treatments was attributed to a more rapid drying of the seedling canopy following watering. The lowest frequency of ideal conditions for B. cinerea infection by spore germination was observed in the seedling canopy of the treatment receiving unheated, forced air ventilation.

OSU Link
Non-OSU Link

248. Peterson, M.J. and J.R. Sutherland. 1990. Controlling gray mold on container-grown Douglas-fir by modified styroblocks and under-bench, forced air ventilation. Western-Journal-of-Applied-Forestry 5(3): 75-79.

Keywords: nursery operations
tree/stand protection
growth
tree/stand health

Abstract: The control of grey mould (Botrytis cinerea) on Douglas fir (Pseudotsuga menziesii) seedlings was investigated in Vancouver, Canada. Incidence of mould on seedlings sown in June 1988 and assessed January 1989 was reduced in 3 treatments of modified styroblocks (vertical holes, allowing air movement from below): vented with heated, forced air; vented with unheated, forced air; and vented with unheated, unforced air. Overall, mould occurred on 25% of 7-month-old seedlings in vented

styroblocks, compared with >75% incidence in unmodified styroblocks. No significant differences in seedling height or root collar diameter among treatments were observed. Use of ventilated styroblocks is recommended, to reduce both losses from grey mould and fungicide usage in nurseries.

OSU Link
Non-OSU Link

249. Piatek, K.B., C.A. Harrington and D.S. DeBell. 2003. Site preparation effects on 20 year survival and growth of Douglas-fir (Pseudotsuga menziesii) and on selected soil properties. Western-Journal-of-Applied-Forestry 18(1): 44-51.

Keywords: site preparation
mechanical preparation
prescribed fire
tree/stand health
growth
soil properties

Abstract: Long-term effects of site preparation on tree performance and soil properties are not well known. Five site preparation treatments were evaluated to determine how they affected survival and growth of Douglas-fir (Pinus menziesii) 3, 10, and 20 years after planting, and soil bulk density, C, N, P, and organic matter concentrations at 0 to 20 cm soil depth 21 years after planting. The site preparation treatments were imposed following logging of three harvest units of old-growth forest on a volcanic soil in southwestern Washington, USA; the units were logged to leave 17, 38, and 53 tonnes/ha of woody residue. The site preparation treatments were hand-pile-and-burn, machine-pile-and-burn, scarification, broadcast burn, and control. Mean survival ranged from 86% at age 3 to 70% at age 20, and average tree heights at 3, 10, and 20 years were 0.6, 4.1, and 11.7 m. The scarification treatment had the best growth; at age 20, its average tree was 21% taller, 26% larger in diameter, and 82% greater in volume than the control. The hand-pile-and-burn treatment did not differ from the control in tree growth; the machine-pile-and-burn and broadcast burn treatments were intermediate in their growth response. Average soil bulk density was 0.74 g/cm3, organic matter concentration was 118 g/kg, and C, N, and P concentrations were 49, 1.6, and 0.7 g/kg with no significant treatment effects. Site preparation may have benefited growth of the trees on these units by decreasing competition from invading and regrowing vegetation, increasing nutrient availability, or increasing soil temperature.

OSU Link
Non-OSU Link

250. Pilz, D. and R.M. Znerold. 1986. Comparison of survival enhancement techniques for outplanting on a harsh site in the western Oregon Cascades. Tree-Planters' Notes 37(4): 24-28.

Keywords: nursery operations
planting operations
growth
tree/stand health
mycorrhizal response

Abstract: Bare rooted 2+0 seedlings of Pseudotsuga menziesii survived and grew better during the first year than container-grown 1+0 stock on a droughty site. After 3 yr, survival still differed significantly, but height growth did not. Shading improved survival and growth. Application of a liquid suspension of spores of Pisolithus tinctorius was ineffective and no mycorrhizas developed from this fungus.

OSU Link
Non-OSU Link

251. Prasad, R. 2000. Some aspects of the impact and management of the exotic weed, Scotch broom (Cytisus scoparius (L.) Link) in British Columbia, Canada. Journal-of-Sustainable-Forestry 10(3/4): 341-347.

Keywords: release treatments
manual release
growth
photosynthesis

Abstract: A recent cutover area near Maple Mountain, Duncan, British Columbia, was planted with 2+1 Douglas fir (Pseudotsuga menziesii) seedlings in 1994. Scotch broom (Cytisus scoparius) invaded the site rapidly. Growth (height and root collar diameter) of Douglas fir seedlings was monitored for 2 years on uncleared plots and on plots where the dense canopy of broom was manually cut and completely removed. Results showed that the broom reduced photosynthetically active radiation by 71% and growth of Douglas fir by 45-46%. Formulations of 3 fungal pathogens (Fusarium tumidum, Pleiochaeta setosa, Chondrostereum purpureum) were tested in a greenhouse for their effects on growth of Scotch broom seedlings. Only F. tumidum was effective, suppressing the growth of 1-, 3- and 6-month-old seedlings.

OSU Link
Non-OSU Link

252. Prescott, C.E., L.P. Coward, G.F. Weetman and S.P. Gessel. 1993a. Effects of repeated nitrogen fertilization on the ericaceous shrub, salal (Gaultheria shallon), in two coastal Douglas-fir forests. Forest-Ecology-and-Management 61(1-2): 45-60.

Keywords: fertilization
growth
stand conditions

Abstract: Understorey vegetation changes were quantified following nitrogen fertilizer trials at two sites in the Pacific Northwest. In the Pack Forest, Washington, USA, - second growth (70-yr-old) Douglas fir (Pseudotsuga menziesii) - salal (Gaultheria shallon) was eliminated in a plot that had been fertilized with nitrogen alone (1540 kg N/ha as ammonium nitrate and urea between 1950 and 1982), but was unchanged in a plot that received phosphorus and sulfur in addition to nitrogen (1082 kg N/ha). In a trial near Parksville, Vancouver Island - logged in 1947, stand comprising 75% Douglas fir, site index 33 m at age 50 yr - salal cover was reduced with increasing amounts of nitrogen, and was eliminated in plots that received 600 kg N/ha as urea in three applications. Reductions were less pronounced in plots that received sulphur in addition to nitrogen. In the Pack Forest trial, the cover of snowberry

(Symphoricarpos albus) increased in the plot where salal was eliminated; in the Parksville trial, no other species became more abundant in the absence of salal. Tree stem volume and stem volume increment in each plot were not related to salal cover in the plots. Results suggest that high concentrations of ammonium and nitrate in the forest floors of N-fertilized plots may render salal less competitive, or may interfere with ericoid mycorrhizae, contributing to reduced cover of salal in forests receiving repeated N-applications.

OSU Link
Non-OSU Link

253. Price, D.T., T.A. Black and F.M. Kelliher. 1986. Effects of salal understory removal on photosynthetic rate and stomatal conductance of young Douglas-fir trees. Canadian-Journal-of-Forest-Research 16(1): 90-97.

Keywords: release treatments
manual release
photosynthesis
tree physiology
soil properties
growth

Abstract: Studies were made in a thinned 32-yr-old Douglas fir stand on a drought-prone site on the E. coast of Vancouver Island. Four pairs of similar trees were selected and the salal (Gaultheria shallon) understorey was removed completely from around one of each pair. The root zones of each tree were isolated using plastic sheeting buried to bedrock. Photosynthesis, stomatal conductance, soil water potential and canopy microclimate were measured intensively in one pair on 4 clear days during an extended dry period in June 1982. B.a. increment of the four pairs of trees was measured over 3 growing seasons. To determine the effect of soil water potential on tree photosynthesis, the same variables were measured for 3 consecutive days in Aug. 1982 for another tree initially subjected to a soil water potential of approx. -1.6 MPa, but irrigated to approx. -0.02 MPa between days 1 and 2. Solar irradiance decreased markedly between days 2 and 3, thus creating a unique data set. Results showed that removal of the understorey significantly increased rates of photosynthesis in Douglas fir, both diurnally and seasonally. Photosynthesis was not generally limited by stomatal conductance unless vapour pressure deficit was high and photon flux density was saturating. Improved tree growth after understorey removal was due to the increased soil water potential that increased both photosynthetic capacity and stomatal conductance.

OSU Link
Non-OSU Link

254. Puettmann, K.J., D.W. Hann and D.E. Hibbs. 1993. Evaluation of the size-density relationships for pure red alder and Douglas-fir stands. Forest-Science 39(1): 7-27.

Keywords: planting operations
growth
tree/stand health

Abstract: Using previously published data, size-density relations were developed for pure red alder (Alnus rubra) and pure Douglas fir (Pseudotsuga menziesii) stands in Oregon, Washington and British Columbia, using quadratic mean diameter of the stand as the tree-size variable. The resulting self-thinning or maximum size-density line for red alder had a steeper slope (-0.64) than that for Douglas fir (-0.52). The assumption of a common slope for all species is, therefore, not supported by this study. For red alder, the shape of the size-density trajectory and the height of the maximum size-density line were not influenced by initial density or stand origin. Red alder and Douglas fir mortality started at a relative density of 44% and 58%, respectively.

OSU Link
Non-OSU Link

255. Puttonen, P. 1987. Abscisic acid concentration in Douglas-fir needles in relation to lifting date, cold storage, and postplanting vigor of seedlings. Canadian-Journal-of-Forest-Research 17(5): 383-387.

Keywords: nursery operations
growth
tree/stand health
tree physiology
tree phenology

Abstract: Spring-lifted seedlings (2+0) were grown outside in pots at Corvallis, Oregon, in 1982. In late July pots were watered weekly to induce dormancy. From early Sep., plants received either a natural photoperiod or an extended (16 h) photoperiod for 6 wk. In mid-Nov. 1982 or mid-Jan. 1983, the plants were lifted and stored in a cold room (4 degrees C) for 25 days, bare rooted in polyethylene bags in the dark, or in pots in the dark or with an 8 h photoperiod. After storage, seedlings were planted in a cold frame or in pots in a growth room with 16-h photoperiod and day/night temp. of 21/16 degrees . In Sep. 1983, seedling ht., length of leader for 1982 and 1983, root collar diam. and survival were recorded. ABA concn. in needles was analysed after 48h and 25 days in storage, after 48h in a cold frame or growth room and at bud break. Lifting times and storage treatments did not have a significant effect on ABA concn. Seedling vigour was not indicated by ABA concn. There were treatment differences in performance after storage. Compared with seedlings lifted in mid-Jan., those lifted in mid-Nov. had reduced survival and more days to bud burst.

OSU Link
Non-OSU Link

256. Radwan, M.A. 1992. Effect of forest floor on growth and nutrition of Douglas-fir and western hemlock seedlings with and without fertilizer. Canadian-Journal-of-Forest-Research 22(9): 1222-1229.

Keywords: nursery operations
nursery fertilization
growth
tree physiology

Abstract: Experiments were conducted to determine the effects of four different forest soils from western Washington, USA, on growth and shoot nutrients of potted Douglas fir (Pseudotsuga menziesii)

and western hemlock (Tsuga heterophylla) seedlings, in the absence and presence of forest floor, and with and without N and P fertilizers. Nine-month-old seedlings from low-altitude seed sources were used, and seedlings were grown for 2 years in a roofed lathhouse. Soils were of the Klone, Vesta, Bunker, and Shelton series; samples of Klone and Vesta soils, and of Bunker and Shelton soils (to 20 cm depth), were collected from western hemlock and Douglas fir stands, respectively. Forest floor samples were collected from the same sites. Fertilizer was added as ammonium nitrate at 100 kg N/ha and triple superphosphate at 226 kg P/ha. The forest floor, at 70 g/7.6-litre pot, and the N and P fertilizers were added to the top of the planting pots without mixing. The P, N, K, Ca and Mg contents of the forest floor, mineral soils and shoots were measured. The forest floors and mineral soils differed by source in many of the chemical characteristics determined. Overall, seedling growth of Douglas fir and western hemlock was better in the Klone and Shelton soils than in the Bunker and Vesta soils. Seedlings, especially those of western hemlock, grew better in soils with forest floor than without forest floor. The N fertilizer reduced seedling growth of both species and, in some soils, reductions were more in soils with forest floor. The P fertilizer improved seedling growth of both species in all soils, and with one exception, growth was much greater in the presence than in the absence of the forest floor. With both species, soil, forest-floor, and fertilizer treatments affected concentrations and contents of the various shoot nutrients determined. The nutritional changes observed varied by nutrient and reflected differences in uptake of native and fertilizer nutrients, as well as changes in shoot dry weight. The results demonstrate the importance of the forest floor to growth and nutrition of Douglas fir and western hemlock seedlings, especially when fertilizers are used.

OSU Link
Non-OSU Link

257. Radwan, M.A. and J.S. Shumway. 1984. Site index and selected soil properties in relation to response of Douglas-fir and western hemlock to nitrogen fertilizer. *In* Forest soils and treatment impacts: Proceedings of the Sixth North American Forest Soils Conference, Department of Forestry, Wildlife and Fisheries, University of Tennessee, Knoxville, TN, June 1983. *Ed.* E.L. Stone. pp. 89-104.

Keywords: fertilization
growth
soil properties

Abstract: Studies were made in 25 Douglas fir stands in Washington and Oregon and in 16 western hemlock stands in Washington. Site index, total and mineralizable soil N were the only variables correlated with growth response to N fertilizer by Douglas fir. Growth response of hemlock was correlated with extractable P/total N in the soil. Total N and mineralizable S in mineral soil were highly correlated and showed moderate negative correlations with growth response of hemlock, but site index was not correlated with response. Results suggest that site index and soil N seem promising indicators of the response of Douglas fir to N fertilizer, while extractable P and the P/N ratio may indicate the response of hemlock. Soil N appears to be more important than soil P in predicting the response of Douglas fir on the sites studied. Soil S did not appear to limit the response of either species to N fertilizer and does not seem promising for estimating the response to N.

OSU Link
Non-OSU Link

258. Radwan, M.A., J.S. Shumway, D.S. DeBell and J.M. Kraft. 1991. Variance in response of pole-size trees and seedlings of Douglas-fir and western hemlock to nitrogen and phosphorus fertilizers. Canadian-Journal-of-Forest-Research 21(10): 1431-1438.

Keywords: nursery operations
nursery fertilization
fertilization
tree physiology
growth

Abstract: A study was made of the effects of N, P and NP fertilizer treatments on plant nutrients and growth of Douglas fir (Pseudotsuga menziesii) and western hemlock (Tsuga heterophylla). Three trials were conducted, (1) and (2) on pole-size trees at two different sites inWashington and (3) on potted seedlings in a lathhouse; only T. heterophylla was studied in (2). Soil series were Bunker for Douglas fir and Klone for western hemlock in trials 1 and 3, and Vesta in trial 2. Nitrogen fertilizers used were urea in trial 1 and ammonium nitrate in the other two trials; P was applied as triple superphosphate in all three trials. For each species in trial (1), P was applied at 0, 100, 300 and 500 kg P/ha and N was applied at 0 and 224 kg N/ha in a factorial design. In trial (2), P was applied at 0, 100 and 300 kg P/ha and N was applied at 0 and 112 kg N/ha in a factorial design. In trial (3), N and P were applied individually to seedlings at a rate of 100 kg N/ha and 226 kg P/ha. In general, fertilizer treatments changed the levels of some plant-tissue nutrients of the pole-size trees and potted seedlings. Neither height nor basal area growth of the trees were significantly affected by any of the treatments in the first two trials. Seedling growth of both Douglas fir and western hemlock was improved by P fertilizer, but was negatively affected by N fertilizer. The results clearly show differences between pole-size trees and seedlings in response to N and P fertilizers. It is concluded that N should not be applied where soils are high in N and low in P, and that P applications should be confined to sites with low-P soils, when trees are young, before canopy closure.

OSU Link
Non-OSU Link

259. Randall, W. and G.R. Johnson. 1998. The impact of environment and nursery on survival and early growth of Douglas-fir, noble fir, and white pine - a case study. Western-Journal-of-Applied-Forestry 13(4): 137-143.

Keywords: nursery operations
planting operations
tree/stand protection
growth
tree/stand health

Abstract: Survival and third-year height were examined on 2383 reforestation units in Cascade Range of western Oregon, USA, from 1983 to 1994, to determine which factors affect reforestation success. The three species examined made up 92% of the total trees planted in the region. Survival of Douglas fir (Pseudotsuga menziesii) varied by as much as 20% from year to year. The most significant factor affecting reforestation success was the nursery that provided the seedlings. Nursery affected both survival and height of Douglas fir and height for noble fir (Abies procera) and white pine (Pinus monticola). No nursery was best for all species. Other factors that were important for all three species

were the administrative unit where the seedlings were planted, initial plant height, aspect, and length of storage prior to planting. Other significant factors that were important for Douglas fir were seed origin, planting month, protection, stock type, and aspect. For noble fir, other important factors were planting month and stock type; for white pine, the other important factor was slope. Altitude of the seed source and the planting unit affected Douglas fir survival and height but did not affect the other two species. This supports the smaller altitudinal bands for Douglas fir compared with noble fir and white pine.

OSU Link
Non-OSU Link

260. 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

261. 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

262. Reynolds, P.E., K. King, R. Whitehead and T.S. MacKay. 1986. One-year results for a coastal British Columbia glyphosate conifer release trial. Proceedings-of-the-Western-Society-of-Weed-Science (Vol.39): 107-117.

Keywords: release treatments
chemical release
stand conditions
growth
tree/stand health

Abstract: In trials on the W. coast of Vancouver Island in 1984, fir plantations on a reclaimed watershed were aerially treated with 2 kg glyphosate/ha. A single spray gave good control of Rubus spectabilis but very variable control of Alnus rubra ranging from 0 to 100%. Gaultheria shallow [G. shallon] was not controlled by glyphosate. Control of many species was greater on upper slopes than in the watershed valley bottom. There was minor crop tree injury to Tsuga heterophylla and Thuja plicata with recovery after 1 year, but no injury to Picea sitchensis, Pseudotsuga menziesii, Abies amabilis or A. grandis. Some increases in crop tree height were noted after herbicide treatment.

OSU Link
Non-OSU Link

263. Riitters, K. and J.D. Brodie. 1984. Implementing optimal thinning strategies. Forest-Science 30(1): 82-85.

Keywords: thinning
economics
growth
yield

Abstract: [See FA 41, 3436; 44, 201] A method is described for comparing the results of optimal thinning analyses based on different management or economic criteria (such as soil expectation value, forest rent or m.a.i.). Optimal thinning regimes for Douglas fir and ponderosa pine were calculated using dynamic programming algorithms based on 2 stand growth simulators. Residual mean tree volumes were then plotted against stand density at varying time intervals. On a graph of this kind, the time trajectory of optimal thinning regimes for even-aged stands is approximately parallel to the line of maximum size/density.

OSU Link
Non-OSU Link

264. Riitters, K.H. and D.A. Perry. 1987. Early genetic evaluation of open-pollinated Douglas-fir families. Forest-Science 33(2): 577-582.

Keywords: genetic tree improvement

genetic relationships
growth
tree phenology

Abstract: A summary is given of experiments to determine the correlation of seed wt. and growth and phenology of seedlings of 14 families in a cold frame with ht. of saplings from earlier seed crops of the same families in 5 plantations at 9, 12 and 15 yr old. With some exceptions, correlations of seedling variables with field ht. were poor. Highest correlations with 15-yr ht. were for budset at 117 days, ht. and branching index of seedlings. Seedling growth and phenology values were generally poorly correlated with seed wt. Seedling/sapling correlations, however, were related to seedling/seed wt. correlations. Seedling/sapling correlations improved between 9 and 15 yr old.

OSU Link
Non-OSU Link

265. Ritchie, G.A. 1986. Relationships among bud dormancy status, cold hardiness, and stress resistance in 2+0 Douglas-fir. New-Forests 1(1): 29-42.

Keywords: nursery operations
tree/stand protection
growth
tree/stand health
tree phenology
carbon allocation

Abstract: Seedlings were lifted from a western Washington nursery on six dates spanning the 1980-81 lifting season. On each date samples of seedlings were subjected to the following treatment: tumbling for 5 min, desiccation of roots for 30 min at 30 degrees C and 2.1 kPa vapour deficit, exposure of shoots to temp. of -10 degrees C, -15 degrees C or -20 degrees C for 2 h, and unstressed control. On two lift dates sub-samples of seedlings were placed into -1 degrees C storage and held for 2 months before the above treatments were administered. Bud dormancy status was determined, using a bud break test, on seedlings from each lift date before and after storage. After one growing season in the field, percent survival, vigour, height growth and shoot and root weight were determined on stressed and unstressed seedlings. Survival and vigour were less affected by treatments than were height and weight. Severity of stress was in the order -20 degrees C>-15 degrees C>desiccation> handling>-10 degrees C. Degree of cold injury was directly related to seedling dormancy status whether dormancy status had been attained in the nursery from natural chilling or in frozen storage. Seedlings in a mid-range of dormancy release (between deep rest and quiescence) were most resistant to all imposed stresses.

OSU Link
Non-OSU Link

266. Ritchie, G.A., J.W. Keeley and P.A. Ward. 1997. Effects of shade and root confinement on the expression of plagiotropic growth in juvenile-origin Douglas-fir rooted cuttings. Canadian-Journal-of-Forest-Research 27(7): 1142-1145.

Keywords: nursery operations

growth
tree morphology

Abstract: The purpose of this experiment was to determine why juvenile-origin Douglas fir (Pseudotsuga menziesii) rooted cuttings, which remain plagiotropic (branch-like) when grown in containers in shaded greenhouses, become orthotropic (vertical) after they are transplanted to an outdoor environment. Plagiotropic rooted cuttings (mean angle from vertical = 45-50 degrees) from three full-sib families were transplanted into an outdoor nursery in Olympia, Washington, and subjected to four treatments consisting of a factorial of (1) shaded or unshaded and (2) bareroot or confined roots. After two growing seasons, treatments had significantly affected plant size and biomass in the order unshaded-bareroot > shaded-bareroot > unshaded-confined > shaded-confined, but plants in all treatments had become nearly orthotropic. It is concluded that neither shading nor root confinement is, but other greenhouse environmental conditions are, responsible for the persistence of plagiotropic growth.

OSU Link
Non-OSU Link

267. Ritchie, G.A., Y. Tanaka and S.D. Duke. 1992. Physiology and morphology of Douglas-fir rooted cuttings compared to seedlings and transplants. Tree-Physiology 10(2): 179-194.

Keywords: nursery operations
tree phenology
tree physiology
growth
tree morphology
carbon allocation

Abstract: Cuttings of Douglas fir (Pseudotsuga menziesii) from three open-pollinated families were rooted in two types of tray and then grown for 1.5 years in a nursery in Washington State. During their second winter they were sampled periodically and tested for cold hardiness, dormancy status, root growth potential and various morphological characteristics. Two-year-old seedlings and transplants were tested concurrently for comparison. Rooted cuttings, seedlings and transplants cold hardened at similar rates during early winter, achieving the same level of midwinter hardiness (LT50 = -18 degrees C) in early January. However, rooted cuttings remained hardier later into spring than did seedlings or transplants. Rooted cuttings exhibited deeper dormancy in early winter than seedlings or transplants but these differences disappeared after January. Root growth potentials of all three stock types remained above threshold values established for transplants throughout winter. Rooted cuttings had greater stem diameter, higher stem diameter : height ratio, and greater root weight than either seedlings or transplants. This may reflect lower growing densities for rooted cuttings. Root : shoot ratios of rooted cuttings were greater than for seedlings and similar to those of transplants. Rooted cuttings also had deeper and coarser root systems, which probably reflected lack of wrenching at the nursery.

OSU Link
Non-OSU Link

268. Ritchie, G.A., Y. Tanaka, R. Meade and S.D. Duke. 1993. Field survival and early height growth of Douglas-fir rooted cuttings: relationship to stem diameter and root system quality. Forest-Ecology-and-Management 60(3-4): 237-256.

Keywords: nursery operations
tree/stand health
growth

Abstract: In 1990, three studies involving 11 half-sib families of Douglas fir (Pseudotsuga menziesii) rooted cuttings were established at three sites in western Washington State (two with low regeneration difficulty (RD) and one with high RD). One of the studies, a grading study, compared performance of nine classes of rooted cuttings based on stem diameter and root system quality. A second, cull, study evaluated five different types of putative culls. A third study determined the correlation between number of initial roots and field performance. In the grading study, survival and height growth reflected stem diameter and relative root quality on all three sites. Mean survival by treatment was in the range 92-100%, 82-97% and 66-87% for good, fair and poor relative root quality, respectively. First year height growth varied from approximately 10 cm to 20 cm and was greatest on low RD sites. Second year height growth was from 3 to 4x greater than first year height growth on low RD sites and 2 to 3x greater on the high RD site. Performance of seedlings and transplants was nearly identical to that of rooted cuttings of corresponding stem diameter and root system quality. In the cull study, only trees with stem diameter <less or =>4 mm were deemed true culls owing to significantly reduced survival and height growth. In the root number study, rooted cuttings generally increased in size in the nursery in proportion to root number. However, after 2 years in the field, root number was a very poor predictor of survival and height growth. Results are discussed in the context of the development of culling standards for rooted cuttings of Douglas fir nursery stock, and the use of root morphology as an indicator of stock plant quality and potential.

269. Roberts, S.D., C.A. Harrington and T.A. Terry. 2005. Harvest residue and competing vegetation affect soil moisture, soil temperature, N availability, and Douglas-fir seedling growth. Forest-Ecology-and-Management 205(1/3): 333-350.

Keywords: site preparation
chemical preparation
release treatments
chemical release
soil properties
growth
tree physiology

Abstract: Decisions made during stand regeneration that affect subsequent levels of competing vegetation and residual biomass can have important short-term consequences for early stand growth, and may affect long-term site productivity. Competing vegetation clearly affects the availability of site resources such as soil moisture and nutrients. Harvest residues can also affect the availability of site resources. We examined second and third year seedling performance of a Douglas fir (Pseudotsuga menziesii) plantation with different vegetation control and biomass retention treatments on a highly

productive site in the coast range of Washington, USA. Treatments included a bole-only harvest without vegetation control (BO-VC), a bole-only harvest with complete vegetation control (BO+VC), and a total tree harvest with complete vegetation control that also included removal of all coarse woody debris and harvest residues (TTP+VC). The VC treatment involved: (a) in the first year, broadcast application of Oust and Accord concentrate applied with a surfactant 2 weeks before planting; (b) in the second year, a March broadcast application of Atrazine and a directed spot-spray of Accord Concentrate on the vegetation between rows in April-May; and (c) in the third year, a March broadcast application of Atrazine and Oust, a direct spot-spray application of Accord Concentrate, and a spot-spray of Transline with surfactant on April-May to control persistent shrub species. The study was conducted to determine if vegetation control and residue retention treatments affected soil moisture, soil temperature, and apparent nitrogen (N) availability, and whether these differences in site resources were correlated with seedling size and growth. In both second and third growing seasons, volumetric soil moisture at 0-20 cm depth was lowest on plots that did not receive vegetation control (BO-VC). Seedlings on these plots also had the lowest diameter and volume growth. In year 2, which was fairly moist, volume growth on TTP+VC plots was slightly higher than on BO+VC plots. TTP+VC plots did have lower soil moisture, but soil temperatures were slightly warmer. In year 3, a drier year, growth was greatest on BO+VC plots, which had consistently higher soil moisture levels. Apparent N availability in year 3 also varied with vegetation control. Douglas fir foliar N concentrations averaged 2.3% on the plots where competing vegetation was eliminated, compared to 1.8% on plots where competing vegetation was not controlled. Douglas fir foliar N concentrations did not differ between residue retention treatments, although N concentrations of competing vegetation were higher where residual biomass was retained. Higher apparent N availability was correlated with greater seedling growth. Based on the results from years 2 and 3, it appears that soil moisture, particularly late in the growing season, had the greatest effect on seedling growth in both years. Available N may also have played a role, although the effects of N cannot be completely separated from those of soil moisture. When soil moisture is adequate, it appears that available N and soil temperature exert greater influence on growth. Vegetation control and residue retention can influence all 3 of these factors. The relative importance of each factor may depend on the year-to-year variation in environmental conditions.

OSU Link
Non-OSU Link

270. Rollwagen, B.A. 1983. Effects of ammonium and nitrate application on rhizosphere pH, growth and nutrient uptake by Douglas-fir, Sitka spruce and western hemlock. Forestry-Abstracts 44(11): 699.

Keywords: fertilization
soil properties
growth
tree physiology

OSU Link
Non-OSU Link

271. Rose, R., M. Atkinson, J. Gleason and T. Sabin. 1991. Root volume as a grading criterion to improve field performance of Douglas fir seedlings. New-Forests 5(3): 195-209.

Keywords: nursery operations
fertilization

tree/stand health
growth

Abstract: Three Oregon seed sources of Douglas fir (Pseudotsuga menziesii) were grown as 2+0 bare-root seedlings, and graded into three root-volume categories (<9, 9-13, and >13 cmsuperscript 3) before outplanting in Columbia County, Oregon in January 1987. The following were assessed: (1) differences in survival and growth after one and two growing seasons in the field; (2) relation(s) of seedling height after one and two seasons to preplanting nursery root volume, total fresh weight, root-collar diameter, and height; and (3) differences in field performance due to application of NPK fertilizer at planting. Field survival was >90% among all root-volume categories. Seedlings in the largest category grew significantly better than those in the two smaller categories over two seasons. Fertilization at time of planting had no effect on survival or growth because of shallow placement (3 cm below soil surface) of the fertilizer pellet. The results suggest that using root volume as well as height and diameter as a seedling grading parameter is worthwhile where morphological quality must be maximized to improve field performance.

OSU Link
Non-OSU Link

272. Rose, R., J.F. Gleason and M. Atkinson. 1993. Morphological and water-stress characteristics of three Douglas-fir stocktypes in relation to seedling performance under different soil moisture conditions. New-Forests 7(1): 1-17.

Keywords: nursery operations
tree phenology
tree physiology
growth
tree morphology

Abstract: Phenology, morphology, frost hardiness and response to moisture stress were examined for three Douglas fir (Pseudotsuga menziesii) stocktypes grown from the same seed lot in a nursery near Olympia, Washington, USA. The types were mini-plugReg. transplants (MPT), 1+1 bareroot transplants (1+1), and 2+0 bareroot seedlings (2+0). In the late summer and autumn before lifting, 2+0 seedlings set bud before 1+1 seedlings and 1+1 seedlings before MPT seedlings. The 2+0 seedlings appeared slowest to acquire frost hardiness and seemed to deharden most rapidly in spring. Although 2+0 seedlings were taller than the MPT stocktype, MPT and 2+0 seedlings were relatively similar in other morphological respects, but 1+1 seedlings were much larger. All stocktypes were potted on 20 January 1989, placed in a greenhouse, and subjected to 39%, 18%, 16%, or 6% soil water-content (% dry weight) until the end of the experiment in mid-July 1990. The largest decrease in pre-dawn xylem water potential occurred with 16% and 6% soil water content; pre-dawn xylem water potential averaged over the three stocktypes generally declined 219% from low to high soil moisture stress. The 1+1 seedlings used more water than the other two stocktypes, and at maximum soil moisture stress, plant moisture stress increased in the order MPT < 2+0 < 1+1. During the 6-month greenhouse experiment, the larger 1+1 stocktype showed the most absolute growth, but the smaller stocktypes grew more on a relative scale. Growth of the stocktypes appeared to be related to differences in morphology and water-use patterns as the seedlings competed for available water within each pot. The results show that MPT seedlings, a new stocktype, performed as well as the more traditionally used 2+0 and 1+1 seedlings and that stocktype selection is important in reforestation efforts.

OSU Link
Non-OSU Link

273. Rose, R. and D.L. Haase. 1995. Effect of the antidesiccant Moisturin on conifer seedling field performance. Tree-Planters' Notes 46(3): 97-101.

Keywords: nursery operations
growth
tree/stand health

Abstract: Two concentrations of the antidesiccant Moisturin were applied to Douglas fir (Pseudotsuga menziesii) and ponderosa pine (Pinus ponderosa) seedlings after lifting by either dipping or spraying. Seedlings were outplanted to 5 typically dry sites in Oregon and to a garden plot at Oregon State University. Seedling performance was assessed at the end of the first growing season. Despite trends in plant moisture stress measurements that suggest reduced transpirational loss, there were no significant treatment effects on height growth, survival, or stem diameter growth at any of the study sites nor in the garden plot.

OSU Link
Non-OSU Link

274. Rose, R. and D.L. Haase. 2000. The use of coir as a containerized growing medium for Douglas-fir seedlings. Native-Plants-Journal 1(2): 107-111.

Keywords: nursery operations
growth
carbon allocation
tree physiology
tree morphology
soil properties

Abstract: In response to environmental concerns and the need for peatland conservation, alternative growing media for conifer seedling production must be investigated. Douglas-fir (Pseudotsuga menziesii) seedlings were grown in 6 media; components included peat moss, peat moss amended with sawdust, and 2 sources of coir (coconut fibre) mixed with and without peat moss. Coir had higher pH, P, K, and Na and lower Ca and N than peat moss and a peat moss-sawdust mixture. Bulk densities of coir and coir-based media were lower than those in peat moss and a peat moss-sawdust mixture. After 21 weeks, seedlings grown in coir-based media were significantly smaller and had lower foliar N and Ca than those grown in peat moss. Because of coir' many favourable qualities, further research is recommended using culturing regimes specific to the substrate's nutrient properties.

OSU Link
Non-OSU Link

275. Rose, R., D.L. Haase, F. Kroiher and T. Sabin. 1997. Root volume and growth of ponderosa pine and Douglas-fir seedlings: a summary of eight growing seasons. Western-Journal-of-Applied-Forestry 12(3): 69-73.

Keywords: nursery operations
growth
tree/stand health

Abstract: Survival, growth, and stem volume were determined for 2+0 bare-root ponderosa pine (Pinus ponderosa) and Douglas fir (Pseudotsuga menziesii) seedlings, 8 growing seasons after planting in 1987 on sites near, respectively, Wamic or Vernonia, Oregon. For each species, seedlings from three seedlots were assigned to one of three root-volume categories (<4.5, 4.5-7 and >7 cmsuperscript 3 for ponderosa pine; <9, 9-13 and >13 cmsuperscript 3 for Douglas fir). On a dry harsh ponderosa pine site on the eastern slopes of Mt. Hood, where gopher [Thomomys sp.] and cattle damage decreased the number of seedlings, more seedlings in the highest root-volume category survived (70%) than in the smaller root-volume categories (62% and 50%). Douglas fir on a good site in the Coast Rangeshowed significantly greater height and stem volume for the largest root-volume category, whereas annual shoot growth and survival did not differ. Root volume is one of several potentially useful criteria for predicting long-term growth and survival after outplanting.

OSU Link
Non-OSU Link

276. Rose, R. and J.S. Ketchum. 1998. Early results of the 'Herb II' study: evaluating the influence vegetation control has on fertilization at the time of planting. *In* Proceedings of the Annual Meeting of the Western Society of Weed Science, Waikoloa, Hawaii, 10-12 March, 1998. pp. 55-59.

Keywords: release treatments
chemical release
fertilization
growth

Abstract: Field trials were conducted at 5 sites in the Pacific Northwest region of the USA to assess the interactive effects between increasing levels of control of deerbrush (Ceanothus integerrimus), snowbrush (C. velutinus), black cottonwood (Populus trichocarpa), Scotch broom (Cytisus scoparius), Portuguese broom (C. striatus), trailing blackberry (Rubus sp.), thimbleberry (R. parviflorus) and salmonberry (R. spectabilis) with hexazinone or sulfometuron, and fertilizer treatments using slow release briquettes of N:P:K at 14:3:3 or 9:9:4 applied at planting for Douglas fir (Pseudotsuga menziesii), ponderosa pine (Pinus ponderosa), western hemlock (Tsuga heterophylla) and coastal redwood (Sequoia sempervirens). Results indicated that at all but one site, weed control +or- fertilizer led to increased tree growth, while at the fifth site weed control + fertilizer gave the greatest growth. Fertilizer alone did not increase growth at any site.

Non-OSU Link

277. Rose, R. and J.S. Ketchum. 2002. Interaction of vegetation control and fertilization on conifer species across the Pacific Northwest. Canadian-Journal-of-Forest-Research 32(1): 136-152.

Keywords: fertilization
release treatments
chemical release

growth
tree/stand health
tree physiology
stand conditions

Abstract: An experiment evaluating three levels of vegetation competition control (no control, 1.5 m2 of vegetation control, and 3.3 m2 of vegetation control), each with two fertilizer application treatments (fertilizer application at the time of planting with complete slow-release fertilizer (WoodaceReg. IBDU), or no fertilizer application), was installed at five sites. Two of these sites were planted with Douglas-fir (Pseudotsuga menziesii) in the Oregon Coast Range, one with ponderosa pine (Pinus ponderosa) in eastern Washington, one with western hemlock (Tsuga heterophylla) in the coastal hemlock zone in Oregon, and one with coastal redwood (Sequoia sempervirens) in northern California, USA. At four of the five sites, mean stem volume, basal diameter, and height of seedlings increased significantly with increasing area of weed control, and the magnitude of difference between treatments increased with time. Fertilizer application significantly increased seedling size only at the two sites with adequate soil moisture; increases were marginally significant at a third. Response to fertilizer application was less than from weed control and impacted growth for only the first year, whereas the influence of weed control continued to influence growth the entire length of the study (4 years). Area of vegetation control and fertilizer application did not interact significantly at any site.

OSU Link
Non-OSU Link

278. Rose, R. and J.S. Ketchum. 2003. Interaction of initial seedling diameter, fertilization and weed control on Douglas-fir growth over the first four years after planting. Annals-of-Forest-Science 60(7): 625-635.

Keywords: nursery operations
fertilization
release treatments
chemical release
growth
tree/stand health
stand conditions

Abstract: Planting larger stock, fertilizer application and added years of weed control are often employed to increase growth rate of plantations. We evaluated these techniques using a replicated factorial study design repeated in two diverse locations in western Washington State, USA. Two different sizes of planting stock, NPK fertilizer application at planting and in the following year, and two or three years of weed control using herbicides were tested. No significant interactions among the treatment levels were found with all treatments influencing Douglas-fir (Pseudotsuga menziesii) growth in an additive manner. Fourth year stem volume gains were greatest from planting larger initial stock: planting seedlings 2 mm larger in basal diameter resulted in fourth-year stem volume gains of 35 and 43%. The fertilizer application treatments used produced early gains, but they were short lived. The third-year weed control treatment had no observable effect on fourth-year stem volume or on volume growth in years three or four.

OSU Link
Non-OSU Link

279. Rose, R., J.S. Ketchum and D.E. Hanson. 1999. Three-year survival and growth of Douglas-fir seedlings under various vegetation-free regimes. Forest-Science 45(1): 117-126.

Keywords: release treatments
chemical release
growth
tree morphology
tree/stand health
stand conditions

Abstract: Responses of Douglas-fir (Pseudotsuga menziesii) seedlings were studied for 3 yr (1993-96) following eight vegetation-control treatments in three western Oregon clearcuts. The objectives were to determine seedling growth response to different areas of spot vegetation control and to determine the relative influence of early woody and herbaceous competition on seedling growth. Herbicide treatment areas varied in size from those receiving no control to full control (9.3 msuperscript 2). Controlled areas were maintained free of herbaceous vegetation for 2 yr and all woody vegetation was controlled for 3 yr. Two additional treatments, complete control of woody vegetation only and complete control of herbaceous vegetation only, were also examined. On two sites (Summit and Marcola), seedling growth parameters were maximized at or near full vegetation control with a tree spacing of 3 m x 3 m. On the third site (Pedee), maximum growth response occurred between 5 and 6 msuperscript 2 of control. Herbaceous vegetation control resulted in increased seedling growth at all sites while woody vegetation control yielded increased seedling growth only at the Pedee site. Cumulative 3 yr herbaceous cover accounted for 68% and 41% of the variability in stem volume at Summit and Marcola, respectively. Adding cumulative 3 yr woody cover to the model accounted for an additional 18% and 49% of the variability in stem volume at Summit and Marcola, respectively. At Pedee, neither herbaceous nor woody cover significantly influenced 3 yr stem volume, suggesting that factors other than vegetation cover were responsible for differences measured.

OSU Link
Non-OSU Link

280. 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

281. Roth, B.E. and M. Newton. 1996a. Role of Lammas growth in recovery of Douglas-fir seedlings from deer browsing, as influenced by weed control, fertilization, and seed source. Canadian-Journal-of-Forest-Research 26(6): 936-944.

Keywords: planting operations
release treatments
chemical release
fertilization
tree/stand protection
growth
tree/stand health

Abstract: This study examined the effects of weed control, nitrogen fertilizer, and seed source on Lammas growth (second flushing) in Douglas fir (Pseudotsuga menziesii) seedlings on 3 sites in the Oregon Coast Range. It also assessed the occurrence of deer (Odocoileus hemionus columbianus) browsing as related to these silvicultural treatments and examined the role of Lammas growth in seedling recovery and escape from deer browsing. Seedlings (averaging 54 cm tall, 6 mm diameter at 15 cm above ground) were planted in February 1992, and measured at the time of planting and in autumn 1992 and 1993. Complete weed control with hexazinone (annual applications + spot treatments as necessary) significantly increased the occurrence of Lammas growth. Nitrogen fertilizer (220 kg/ha urea) decreased Lammas growth significantly, at least in part by favouring weed growth. Lammas growth was not influenced by seed source (genetically improved from a seed orchard or local wild stock). The increased Lammas growth associated with weed control mediated the effects of deer browsing. Although multiple-year browsing occurred more commonly on weeded than unweeded seedlings, after two growing seasons weeded seedlings that were repeatedly browsed were twice as large as unbrowsed, unweeded seedlings. On one site, stock of wild origin was more heavily browsed than that from a seed orchard.

OSU Link
Non-OSU Link

282. Roth, B.E. and M. Newton. 1996b. Survival and growth of Douglas-fir relating to weeding, fertilization, and seed source. Western-Journal-of-Applied-Forestry 11(2): 62-69.

Keywords: planting operations
fertilization
release treatments
chemical release
growth
tree physiology
tree morphology
tree/stand health

Abstract: The goal of this study was to quantitatively evaluate the individual and interactive effects of weed control, nitrogen fertilizer, and seed source on Douglas fir (Pseudotsuga menziesii) survival and growth in plantations on a range of sites and growing conditions in western Oregon. Weed control with hexazinone (broadcast application after planting) was the dominant factor influencing seedling survival and growth and accounted for 49% of the explained variation in seedling volume after 2 years. Nitrogen fertilizer (urea) had no effect when used in conjunction with weed control and a negative effect when used without weed control. Seedlings from a seed orchard source were significantly larger in diameter and volume than those from a wild local source after two growing seasons, but second-year heights were similar for the two seedling types. Initial seedling size was positively correlated with growth rate.

OSU Link
Non-OSU Link

283. Sachs, D. and J.A. Trofymow. 1991. Testing the performance of FORCYTE-11 against results from the Shawnigan Lake thinning and fertilization trials on Douglas-fir. Canadian-Forest-Service, Pacific and Yukon Region Information-Report BC-X-324. viii + 58 p.

Keywords: fertilization
thinning
precommercial thinning
growth
yield
tree physiology
carbon allocation
tree/stand health
computer modeling

Abstract: FORCYTE-11 is an ecosystem-based forest growth simulation model. Its performance was evaluated with data on stand and tree biomass, height, stocking (mortality) and foliar assimilation and loss rates for Douglas fir (Pseudotsuga menziesii) in thinning/fertilizer trials in British Columbia.

OSU Link
Non-OSU Link

284. Scagel, C.F., R.G. Linderman and R.K. Scagel. 2000. Ten-year growth and survival of Douglas-fir seedlings treated with plant growth regulating substances at transplant. Canadian-Journal-of-Forest-Research 30(11): 1778-1787.

Keywords: nursery operations
growth
tree/stand health
tree morphology

Abstract: Commercially available plant growth regulators (PGRs) or moisture retention gels, applied to the roots of Douglas fir (Pseudotsuga menziesii) before planting, can modify IAA levels in roots, root growth responses, and tree survival. Two different 1+0 stock types (PSB313B and PSB323, interior and coastal Douglas fir, respectively, the latter having a larger root mass) were treated with IBA, ethephon (Ethrel), alginate, or a combination of IBA and alginate. New root growth and IAA levels in roots were measured 2 weeks after planting, and aboveground growth and tree survival were monitored over 10 growing seasons after planting in May 1988 on a site clear felled in winter 1988 in British Columbia, Canada; no site preparation was carried out. Treatment with IBA or the combination of IBA and alginate increased IAA conjugate and free IAA levels in roots, root growth, and tree survival. Alginate treatment alone increased new root growth and tree survival, but did not increase free IAA levels in roots. Ethephon treatment increased free IAA levels and root growth, but had no effect on IAA conjugates or tree survival. A cost analysis suggested that use of certain PGRs or alginate decreased the cost required to attain target stocking and increased tree size. The results suggest that application of PGRs or other root-promoting materials to the roots of Douglas fir before planting has the potential to be a cost-beneficial method for increasing root growth and tree survival.

OSU Link
Non-OSU Link

285. 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

286. Scott, W., R. Meade, R. Leon, D. Hyink and R. Miller. 1998. Planting density and tree-size relations in coast Douglas-fir. Canadian-Journal-of-Forest-Research 28(1): 74-78.

Keywords: planting operations
growth

Abstract: Test plantations were established in western Washington and Oregon to compare tree growth at six initial planting densities ranging from 300 to 2960 trees/ha. A size-density relation was visually apparent 3 to 4 years after planting. Inventory data collected in 1990 from the oldest 11 trials (5 or 6 years after planting, 10 in Washington, one in Oregon) showed that initial spacing strongly influenced early growth of coast Douglas fir (Pseudotsuga menziesii var. menziesii). Average height and diameter at breast height were progressively larger as planting density increased; at the widest spacing (lowest stand density), average height was 75% and average diameter at breast height was 67% of that at the closest spacing. Trees planted at 2960 trees/ha attained breast height (1.3 m) 2 years earlier than trees planted at a density of 300/ha. This finding has practical significance to current efforts to achieve early establishment of plantations.

OSU Link
Non-OSU Link

287. Shainsky, L.J., M. Newton and S.R. Radosevich. 1992. Effects of intra- and inter-specific competition on root and shoot biomass of young Douglas-fir and red alder. Canadian-Journal-of-Forest-Research 22(1): 101-110.

Keywords: planting operations
growth
tree morphology
carbon allocation
tree physiology

Abstract: Two-year-old seedlings of Douglas fir (Pseudotsuga menziesii) and red alder (Alnus rubra) were planted in Oregon in 1985 at densities of 1, 2, 4, 8 and 16 trees/msuperscript 2 in a two-way density matrix composed of 5 monoculture densities and 25 mixtures of all possible pairwise combinations of monoculture densities. Roots and shoots were harvested after the fourth growing season. Response surfaces for root, shoot and total biomass per tree were generated within the matrix. Regression analysis quantified the effect of each species' density on biomass components. Alder overtopped the

Douglas fir in all mixed stands. Alder density influenced the root and shoot biomass of both species more than Douglas fir density did, the greatest reduction in root biomass of Douglas fir taking place at an alder density of <less or =>1 tree/msuperscript 2. Douglas fir density interacted with red alder density to influence all biomass components. Douglas fir density effects were inconsistently significant across alder densities. While increasing the density of each species reduced root and shoot biomass per tree, allocation of biomass to roots and shoot was not affected by competition, nor were the allometric equations relating biomass to stem diameter and stem volume index. Foliar concentrations of N and P in the Douglas fir understorey are reported.

OSU Link
Non-OSU Link

288. Shainsky, L.J. and S.R. Radosevich. 1991. Analysis of yield-density relationships in experimental stands of Douglas-fir and red alder seedlings. Forest-Science 37(2): 574-592.

Keywords: planting operations
growth

Abstract: Seedlings of red alder (Alnus rubra) and Douglas fir (Pseudotsuga menziesii) were planted into a two-species density matrix composed of five monoculture densities and mixed stands with all possible pairwise combinations of the monoculture densities. The experiment was set up in the Willamette Valley, Oregon, in January 1985. Regression equations were fitted to the response of mean tree stem volume to the two species' densities generated in this matrix. Regression coefficients quantifying the intensity of competition indicated that alder density had approximately twice the effect of Douglas fir density on individual tree stem volume of both species. The densities of the two species had a multiplicative effect on mean tree stem volume. In addition, the effects of alder and Douglas fir densities on tree size were interdependent. The effects of alder density on stem volume varied with Douglas fir density and declined as Douglas fir density increased. Similarly, the effects of Douglas fir density on stem volume varied with alder density. The interdependency of the two species' densities resulted in an unusual pattern in which Douglas fir individual stem volume increased as Douglas fir density increased at high densities of alder.

OSU Link
Non-OSU Link

289. Sharrow, S.H., W.C. Leininger and K.A. Osman. 1992b. Sheep grazing effects on coastal Douglas fir forest growth: a ten-year perspective. Forest-Ecology-and-Management 50(1-2): 75-84.

Keywords: release treatments
tree/stand health
stand conditions
growth

Abstract: In a study evaluating effects of controlled sheep grazing on Douglas fir (Pseudotsuga menziesii) growth, tree diameter and height growth were measured during 1981-1990 in ungrazed and grazed tree stands in the Siuslaw National Forest, Oregon. Grazed stands were intensively used by a herded flock of 700-900 sheep for 3-4 days each May and August 1981 and 1982. The stand had been clear felled in

1977, burned in 1978, and planted with 3-year-old trees in 1980. Orchardgrass (Dactylis glomerata) was also sown aerially in 1980 to provide a food source for large indigenous herbivores and help slow the establishment of unwanted woody vegetation. Understorey vegetation phytomass and its utilization by sheep was evaluated using a before-and-after technique in 1981 and 1982. Sheep removed 28% and 64% of new tree lateral branches in 1981 and 1982, respectively. The major effect of browsing, however, appeared to be removal of terminal leaders which reduced 1990 Douglas fir tree height by 61 cm and diameter at breast height (d.b.h.) by 1.9 cm for each terminal removed. Sheep browsed terminal leaders of 38% and 77% of grazed plantation trees in 1981 and 1982, respectively. Grazing proved very effective in reducing red alder (Alnus rubra) establishment and growth. Total tree basal area in 1990 was similar for grazed and ungrazed stands. However, red alder trees contributed over 45% of tree basal area on ungrazed stands compared with 19% on grazed stands. Vegetation control by sheep, without associated browsing of terminal leaders, increased 1990 Douglas fir height by 16% and d.b.h. by 34%. Net effect of grazing (taking into account the negative effects of browsing together with the positive effects of reduced competing vegetation) was to increase 1990 Douglas fir height by 6% and d.b.h. by 22% on grazed compared with ungrazed timber stands.

OSU Link
Non-OSU Link

290. Sharrow, S.H., W.C. Leininger and B. Rhodes. 1989. Sheep grazing as a silviculture tool to suppress brush. Journal-of-Range-Management 42(1): 2-4.

Keywords: release treatments
stand conditions
growth

Abstract: Three 4- to 6-year-old Douglas fir (Pseudotsuga menziesii) plantations were grazed by sheep once each year during the May to Sep. grazing season in 1981-82. Estimates of current year's growth present in Oct. both inside and outside a livestock exclosure on each plantation, were used to evaluate the effects of grazing on the growth of Acer circinatum and Rubus spp. In general, utilization of brush by sheep was moderate to heavy, except in the spring of 1982, when brush was lightly utilized. Sheep grazing effectively reduced both total understorey plant growth and brush net current year's growth on all plantations. Reduced brush biomass on grazed areas was associated with greater Douglas fir diam. growth in 1981-82 and 1982-83. By 1985, trees in grazed areas were 5% higher and 7% greater in diam. than trees on ungrazed controls.

OSU Link
Non-OSU Link

291. Shepherd, R.F. 1994. Management strategies for forest insect defoliators in British Columbia. Forest-Ecology-and-Management 68(2/3): 303-324.

Keywords: tree/stand protection
growth
tree/stand health
stand conditions

Abstract: A synthesis is presented of outbreak characteristics of common defoliating insects in forests (mainly Pseudotsuga menziesii) in British Columbia. Two types of outbreak are identified: fast-cycling and sustained outbreaks. Species with fast-cycling outbreaks rise quickly to visible defoliation levels, cause significant growth loss, tree deformation and mortality, and disappear just as quickly. Fast-cycle species noted include the Douglas fir tussock moth (Orgyia pseudotsugata), western blackheaded budworm (Acleris gloverana), black army cutworm (Actebia fennica [Ochropleura fennica]), western hemlock looper (Lambdina fiscellaria lugubrosa), false hemlock looper (Nepytia freemani), greenstriped forest looper (Melanolophia imitata), and the saddleback looper (Ectropis crepuscularia). The effect of such outbreaks is closely related to the severity of defoliation during the first year; consequently, the objective of managing these species should be to reduce populations before defoliation occurs, i.e. to prevent the outbreak. To accomplish this objective, identification of susceptible habitats and monitoring with sensitive pheromone traps in areas of expected outbreaks are necessary to detect upwelling populations. Species with sustained outbreaks (typified by the various species of spruce budworms (Choristoneura spp.), e.g., the western spruce budworm, C. occidentalis, the 2-year cycle budworm, C. biennis, and C. orae) cause significant growth losses only after defoliation continues for a number of years. Tree mortality usually is not important except where regeneration is being nurtured under a selective or shelterwood silvicultural system. Impact can be significant over the life of a stand because of the length and frequency of outbreaks, but treatments effective for only 1 year usually cannot be justified except where it is important to retain a full crown. Long-term cultural methods appear to be the preferred management system and, of these, utilizing non-host species or resistant or phenologically asynchronous host species may be the best option. Again, determining the location of expected outbreaks is an important component of a management system and, at present, identifying stands by frequency of outbreak within zones of climatic suitability would be useful in selecting treatment areas.

292. Shumway, J.S. and H.N. Chappell. 1995. Preliminary DRIS norms for coastal Douglas-fir soils in Washington and Oregon. Canadian-Journal-of-Forest-Research 25(2): 208-214.

Keywords: fertilization
thinning
growth
soil properties

Abstract: The Diagnosis and Recommendation Integrated System (DRIS) has been used successfully to evaluate interactions between nutrients and fertilizer response and for diagnosing nutrient deficiency in agricultural crops. This study used soil tests to develop DRIS norms and evaluate their effectiveness in coastal Douglas fir (Pseudotsuga menziesii) forests. DRIS norms for nitrogen, phosphorus, potassium, and calcium were developed using soil test and site index data from 72 soil series that commonly support Douglas fir in westernWashington. The norms were tested using soil test and stand basal area growth response data from 20 thinned and 30 unthinned N fertilizer test sites in coastal Washington and Oregon. Response to urea fertilizer in thinned stands averaged 34% and 43% for 224 and 448 kg N.ha-1, respectively, when N was identified as the most limiting nutrient. When N was not the most limiting nutrient, N response averaged 8% and 10% for 224 and 448 kg N.ha-1, respectively. Results were similar in unthinned stands and thinned stands, although response to fertilizer appeared to be slightly less in unthinned stands when N was the most limiting nutrient. DRIS correctly classified 25 of the 33 sites (76%) where N fertilizer increased growth by more than 15%. More

importantly, 13 of the 17 (76%) sites that responded by less than 15% were correctly identified by DRIS. The results clearly indicate that N fertilizer response is dependent on the interactions (balance) between soil nutrients at a given site. Future soil diagnostic work needs to focus on techniques, like DRIS, that provide an assessment of these interactions.

OSU Link
Non-OSU Link

293. Simpson, D.G. 1984. Filmforming antitranspirants: their effects on root growth capacity, storability, moisture stress avoidance, and field performance of containerized conifer seedlings. Forestry-Chronicle 60(6): 335-339.

Keywords: nursery operations
tree physiology
growth
tree/stand health

Abstract: One of 6 antitranspirants was sprayed on Pinus contorta, Picea glauca, Tsuga heterophylla and Pseudotsuga menziesii seedlings before or after a 12-wk storage period at 2 degrees C. Root growth capacity and pre-dawn water potential were measured immediately after treatment or after storage. Sample seedlings were planted out in British Columbia in April and May 1981 and survival and growth recorded after one season (Sept.). XEF-4-3561-A, Wilt Pruf, Folicote and Vapor Gard increased moisture stress avoidance (water potential) in all species. Plantgard and Clear Spray increased it only in T. heterophylla. Root growth capacity was reduced by Folicote and Vapor Gard in Pinus contorta, and by XEF, Wilt Pruf and Vapor Gard in Pseudotsuga menziesii. Growth in the first season was reduced by XEF and Wilt Pruf in P. menziesii, T. heterophylla and Picea glauca, and by Vapor Gard in T. heterophylla and Pseudotsuga menziesii. Growth in Pinus contorta was significantly increased by Wilt Pruf and unaffected by the others. Further trials of Wilt Pruf and XEF on Pinus contorta are recommended.

OSU Link
Non-OSU Link

294. Simpson, D.G. 1990. Frost hardiness, root growth capacity, and field performance relationships in interior spruce, lodgepole pine, Douglas-fir, and western hemlock seedlings. Canadian-Journal-of-Forest-Research 20(5): 566-572.

Keywords: nursery operations
tree/stand protection
tree physiology
tree/stand health
growth

Abstract: Interior spruce (Picea glauca-P. engelmannii complex), lodgepole pine (Pinus contorta), interior and coastal Douglas fir (Pseudotsuga menziesii) and western hemlock (Tsuga heterophylla) were grown from seed for 20 wk in containers in a greenhouse, with 18-h photoperiods. Seedlings were then acclimatized under natural daylength and temperature conditions at Vernon, British Columbia, for up to 12 wk (7 September-1 December). To create planting stock batches of varying quality, at 2-wk intervals

during the acclimatization period separate samples of seedlings were taken (1) for immediate measurement of foliage frost hardiness or (2) for overwinter storage at 2 degrees C (western hemlock and coastal Douglas fir) or -2 degrees C (interior spruce, lodgepole pine and coastal Douglas fir). After storage, samples were used either for root growth capacity (RGC) measurement or for outplanting at various forest sites in British Columbia. In all species, frost hardiness and RGC increased with increasing weeks of acclimatization. Frost hardiness and RGC were correlated with each other in western hemlock, lodgepole pine and Douglas fir, and with field performance (survival or growth) in interior spruce, lodgepole pine and Douglas fir.

OSU Link
Non-OSU Link

295. Smith, S.H. and J.F. Bell. 1983. Using competitive stress index to estimate diameter growth for thinned Douglas-fir stands. Forest-Science 29(3): 491-499.

Keywords: thinning
growth

Abstract: A set of linear growth equations was developed using initial diam. (d.b.h.), initial competitive stress index (CSI, based on area of overlap of growing space), and change in CSI due to thinning as independent variables to predict periodic diam. growth response for 3- and 4-yr growth periods. CSI values were calculated from data collected in a naturally developed, pure, even-aged stand in Oregon [see FA 34, 2219]. Study plots were established in 1963, when the stand was 20 yr old, and thinned at varying intensities in 1963, 1966, 1970 and 1973. The data was divided into 2 periods: 1966-70 and 1970-73. Functions including all 3 independent variables accounted for the greatest variation in periodic diam. increment for both growth periods. Including transformations of initial CSI and change in CSI in the model provided significant improvements over a model based only on functions of initial d.b.h.

OSU Link
Non-OSU Link

296. Sorensen, F.C. 1996. Effects of length of seed chilling period and sowing date on family performance and genetic variances of Douglas-fir seedlings in the nursery. New-Forests 12(3): 187-202.

Keywords: nursery operations
tree phenology
growth
tree/stand health

Abstract: Seeds of four full-sibling Douglas fir (Pseudotsuga menziesii) families (F) - randomly chosen from about 30 control-pollinated crosses in a second-growth stand in the central Oregon Cascade Range (USA) - were moist chilled (C) for 14, 33, and 77 days and sown (S) 29 March, 26 April, and 24 May at two densities (D = 111 and 200 seeds/msuperscript 2), grown for 2 years in nursery beds and phenology and size traits recorded. The study was analysed in two parts: part I evaluated seed treatment effects and their interactions with families; and part II investigated the effect of treatments on genetic variances, particularly among-family (sigma superscript 2F) and within-plot (sigma superscript 2w)

components and the intraclass correlation for families (tf). In part I there were large and highly significant differences associated with C and S and among F for all traits. Early S combined with long C resulted in early emergence and gave large seedlings with little loss and damage. Many interactions between C and F, and S and F, were significant. Interactions involved rank changes for size but not for phenology traits, and were larger for CxF than for SxF. Seedling density affected seedling size but not phenology, did not interact with seed treatments, and interacted significantly but weakly with families. In part II, C and S, but not D, had significant effects on sigma superscript 2F, sigma superscript 2w, and tf, but not in a predictable manner. Because of significant interactions, it is recommended that standardized seed treatments be used in family nursery tests. This should help to keep the results from these tests as repeatable as possible. Long chilling and sowing as early as practicable are recommended to minimize disease losses and winter damages and to provide good nursery stock.

OSU Link
Non-OSU Link

297. Sorensen, F.C. 1997. Effects of sib mating and wind pollination on nursery seedling size, growth components, and phenology of Douglas-fir seed-orchard progenies. Canadian-Journal-of-Forest-Research 27(4): 557-566.

Keywords: genetic tree improvement
nursery operations
growth
tree/stand health
tree morphology
tree phenology

Abstract: Polymix outcross (X), full-sib (FS), and wind-pollination (WP) families were produced on 25 seed trees and 10 half-sib families on 10 of the same trees in a Pseudotsuga menziesii var. menziesii seedling seed orchard in Oregon. Seedlings were raised at 2 sowing densities for 2 years in the nursery, and inbreeding depression (ID) in seedling size related to inbreeding effect on growing season length and growth rate. Seedling mortality was light and not affected by inbreeding. Mean ID for 2-year size traits was 6% (height) and about 8% (diameter) per 10% increase in F, the inbreeding coefficient, and was linear with the increase in F over the range of F used. Both amount of ID and its fit to linearity differed greatly among seed trees. Elongation season was significantly and slightly shorter for FS than for X families; second-year relative elongation rate was nonsignificantly larger for FS than for X families. Inbred families had nonsignificantly larger within-plot variance and significantly larger coefficients of within-plot variance than X families. Sowing density was not a significant factor except in diameter and height/diameter ratio. Results are discussed in terms of plant growth habit and possible gene action. WP compared with X families were significantly shorter by 3.8% and significantly smaller in diameter by 4.6%, with much variation among family groups. About half of the height difference could be explained by seed weight; the remainder could have been due to pollen contamination or natural inbreeding. Progenies of the two pollen types did not differ for phenological traits, even though the seed orchard was in a drier, more inland location than the parent-tree locations. Progenies of WP had nonsignificantly larger within-plot variance than X progenies.

OSU Link
Non-OSU Link

298. Sorensen, F.C. 1999. Relationship between self-fertility, allocation of growth, and inbreeding depression in three coniferous species. Evolution 53(2): 417-425.

Keywords: genetic tree improvement
seed orchard management
growth
tree/stand health
carbon allocation

Abstract: Mortality and growth of self and outcross families of three wind-pollinated, mixed-mating, long-lived conifers - Douglas fir (Pseudotsuga menziesii), ponderosa pine (Pinus ponderosa), and noble fir (Abies procera), were followed from outplanting to age 26 (25 for noble fir) in spaced plantings at a common test site in the Oregon Coast Range, near Monmouth. Response to inbreeding differed greatly among species over time and in all regards. Only Douglas fir and noble fir are discussed, because ponderosa pine usually was intermediate to the other two in its response to inbreeding. In earlier reports, compared with noble fir, Douglas fir had a higher rate of primary selfing and larger inbreeding depression in seed set. Douglas fir continued to have higher inbreeding depression in nursery and early field survival. The species differed in time courses of inbreeding depression in height and in allocation of growth due to crowding. Between ages 6 and 12, the relative elongation rate (dm/dm per year) of Douglas fir was significantly greater in the selfs than in the outcrosses. The response was not observed in noble fir. At final measurement, inbreeding depression in diameter relative to inbreeding depression in height was greater in Douglas fir than in noble fir. At final measurement inbreeding depression in height was inversely related to inbreeding depression in survival. Cumulative inbreeding depressions from time of fertilization to final measurement were 0.98, 0.94, and 0.83 for Douglas fir, ponderosa pine, and noble fir, respectively, which indicates that selfs will not contribute to the mature, reproductive populations.

299. Sorensen, F.C. and R.K. Campbell. 1985. Effect of seed weight on height growth of Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco var. menziesii) seedlings in a nursery. Canadian-Journal-of-Forest-Research 15(6): 1109-1115.

Keywords: seed orchard management
nursery operations
growth
reproduction

Abstract: Seeds of different mean wt. were produced within each of 10 young Douglas fir trees in a second growth stand in Oregon by leaving some developing cones unbagged and by enclosing others in paper bags for 164 days (from shortly before floral bud flush) or for 117 days (from 26 days after floral buds had been at max. receptivity for pollen). Bagging increased numbers of filled seeds per cone and wt. of individual seeds; 117 days in a bag increased seed wt. by an av. 10.7%. Seed from wind pollinated cones (unbagged or bagged after 26 days receptivity to pollen) were sown in an outdoor nursery at Corvallis, Oregon. Bagging did not affect numbers of cotyledons, but 1st-yr epicotyl length and 2nd-yr total ht. increased by 9.1 and 4.0% respectively. Relations between seed wt. and seedling growth are compared with other reports and inconsistencies are discussed. A growth model was used to project

seed wt. differences to later ages and practical implications of long-term effects of seed wt. on plant size, of increasing seed size by cultural techniques and of grading seed lots by size were considered.

OSU Link
Non-OSU Link

300. Sorenson, F.C. and R.K. Campbell. 1993. Seed weight-seedling size correlation in coastal Douglas-fir: genetic and environmental components. Canadian-Journal-of-Forest-Research 23(2): 275-285.

Keywords: genetic tree improvement
growth
genetic relationships

Abstract: The effect of seed weight of coastal Douglas fir (Pseudotsuga menziesii var. menziesii) on nursery seedling height was analysed in two experiments. In the first experiment, 16 seeds per family from 111 families were individually weighed and sown in the autumn. In the second experiment, another group of 16 seeds were individually weighed and stratified and sown in the spring. Four-tree non-contiguous family plots were randomly assigned to two densities in two replications in each experiment. Date of emergence and duration and rate of shoot elongation were determined over 2 years of growth. Seedlings in the first experiment were unintentionally exposed to damaging frost after emergence. Some seedlings in the second experiment suffered Lygus bud damage to the terminal shoot. Developmental associations between seed weight, a maternally inherited trait, and seedling height and its components were examined using sets of path analyses with and without adjustments for planned and accidental treatment effects. Results suggested both 'environmental' and 'genetic' contributions of seed weight to seedling height. The weight (environmental) component, alone, decreased with time. The genetic component, which was indicated by lack of direct effect of seed weight on seedling height in the path analyses and by changing female:male variance ratios over time, was quite stable across treatment effects. Because of the genetic relation, seed weight adjustment is not recommended as a procedure for increasing precision in early selection of coastal Douglas fir families.

OSU Link
Non-OSU Link

301. Sorensen, F.C. and R.K. Campbell. 1997. Near neighbor pollination and plant vigor in coastal Douglas-fir. Forest-Genetics 4(3): 149-157.

Keywords: genetic tree improvement
seed orchard management
growth

Abstract: Nineteen seed parents in a young, patchy second-growth stand of Pseudotsuga menziesii were manually pollinated by near (NN; 12 m) and far neighbours (FN; 100-500 m), and by wind (W) in a heavy-flowering year (1971). Progenies were compared in the nursery and for 10 additional years at close spacing (0.75 m) in the field. In a separate test, the effects of conelet bagging were evaluated using plants of 10 of the same seed parents. Progeny from W and NN pollinations were slightly, but non-significantly smaller than progeny from FN pollination. seed parent x pollen type interactions were highly significant. Bagging effects were significant at the seedling stage, but disappeared in field tests,

and did not interact with seed parent at any age. Estimated rates of biparental inbreeding, based on these results and previous reports, are 0 to ~20%. Such variation seems compatible with the variation in natural regeneration habits of the species. If biparental inbreeding is considered as resulting from half-sib mating, the associated inbreeding depression in height is estimated as 0 to 2.3%. At the close spacing used in this study, depression in biomass appeared to be 4-5 times as great as depression in height at age 12.

OSU Link

302. Stapanian, M.A. and D.W. Shea. 1986. Lignosulfonates: effects on plant growth and survival and migration through the soil profile. International-Journal-of-Environmental-Studies 27(2): 45-56.

Keywords: release treatments
chemical release
growth
stand conditions

Abstract: The effects of a refined lignosulfonate product obtained from the sulfite pulping process, on growth and survival of plants were investigated. After applications of 0, 7500, 15 000 and 22 500 cmsuperscript 3/msuperscript 2 to plots within a forest plantation, the following were monitored: (1) live aboveground biomass of vascular plants, (2) growth of Douglas fir (Pseudotsuga menziesii) and (3) lignosulfonate migration through the soil profile. Biomass of woody vegetation was not affected, and that of herbaceous plants was significantly decreased only at the two greatest application rates. Growth of the Douglas fir trees was not significantly affected. Lignosulfonates disappeared from the soil profile at the same rate regardless of initial concentration. Although it is not practical to use this material as a herbicide in western Washington, land application of lignosulfonates may be environmentally more attractive than traditional disposal methods.

OSU Link
Non-OSU Link

303. Staudhammer, C. and V. LeMay. 2000. Height prediction equations using diameter and stand density measures. Forestry-Chronicle 76(2): 303-309.

Keywords: planting operations
growth

Abstract: Height equations for western hemlock (Tsuga heterophylla), western red cedar (Thuja plicata), Douglas-fir (Pseudotsuga menziesii), and alder (Alnus rubra and Alnus tenuifolia) in the Coastal Western Hemlock zone of southwestern British Columbia were fitted using dbh as the predictor variable. A simple, non-linear equation gave very similar results to the Weibull distribution, except for hemlock, which was better modelled using the more flexible Weibull distribution function. Introducing stand density variables into the base equations resulted in increased accuracy for predicting heights of alder. Smaller improvements were found for Douglas-fir, cedar, and hemlock.

OSU Link
Non-OSU Link

304. 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

305. St-Clair, J.B. and W.T. Adams. 1991a. Effects of seed weight and rate of emergence on early growth of open-pollinated Douglas-fir families. Forest-Science 37(4): 987-997.

Keywords: genetic tree improvement
nursery operations
reproduction
genetic relationships
growth

Abstract: Open-pollinated seeds were collected from 39 Douglas fir (Pseudotsuga menziesii var. menziesii) families in second-growth stands in the Coast Range of west-central Oregon (150-500 m altitude) in autumn 1985. Seed weight, time of emergence, and three measures of seedling size were recorded for each family in order to assess family variation in seed weight and emergence, and the influence of these seed traits on early growth. Seeds were dewinged, cleaned and stored at 0 degrees C. In April 1986, seeds and germinants were sown at a depth of 8 mm to test whether using germinants minimized seed effects on early growth. To evaluate the effect of competition on the relationships of seed weight and rate of emergence to seedling size, individuals of families were planted in mixed-family blocks at close spacing (4x4 cm), in single (pure) family blocks at close spacing (4x4 cm) and in mixed family blocks at a wide, noncompetitive spacing (16x16 cm). Families differed significantly in seed weight, total emergence percentage and rate of emergence. However, correlations of seed weight to rate of emergence, and seed weight and rate of emergence to seedling size, were not strong. Using

germinants was ineffective in diminishing seed effects. Interfamily competition had a minor influence on enhancing the effect of seed traits on seedling growth.

OSU Link
Non-OSU Link

306. St-Clair, J.B. and W.T. Adams. 1991b. Relative family performance and variance structure of open-pollinated Douglas-fir seedlings grown in three competitive environments. Theoretical-and-Applied-Genetics 81(4): 541-550.

Keywords: genetic tree improvement
nursery operations
genetic relationships
growth

Abstract: Open-pollinated Douglas fir (Pseudotsuga menziesii) var. menziesii families were tested in 3 contrasting competitive environments to test the hypothesis that relative performance as measured by total seedling dry weight is dependent upon distance or genotype of neighbours. The 3 environments included (1) a mixture of individuals from all families sown at close spacing, (2) single (pure) family blocks sown at close spacing, and (3) individuals from all families sown at a wide, non-competitive spacing. Despite occasional large changes in rank between competitive environments and only moderate correlations of family means between competitive environments, the family x competitive environment interaction was non-significant. Furthermore, families did not differ significantly in competitive ability or density tolerance. The competitive environment in which seedlings were grown, however, had a large effect on estimates of variance components, which in turn led to large differences in estimates of heritability and genetic gain. Evaluation of families in mixture resulted in the largest estimates of heritability, while evaluation in pure family blocks resulted in the lowest. Analysis of correlated response to selection indicated that testing and selection in mixture resulted in the largest estimated gain, even if progeny of selected individuals are subsequently grown in a pure or non-competitive environment.

OSU Link
Non-OSU Link

307. St-Clair, J.B. and W.T. Adams. 1993. Family composition of Douglas-fir nursery stock as influenced by seed characters, mortality, and culling practices. New-Forests 7(4): 319-329.

Keywords: genetic tree improvement
reproduction
growth
genetic relationships

Abstract: Changes in family composition during nursery production were evaluated by following individual seeds and seedlings of 36 wind-pollinated Douglas fir (Pseudotsuga menziesii var. menziesii) families sown in mixture in two operational nurseries in westernWashington and Oregon. Families differed significantly in emergence (measured after 5 wk) and in percentage of seedlings culled for being too small (at end of second growing season: <4 mm stem diameter or <20 cm stem height). Filled seed

germination rates (tested in the laboratory) were not related to emergence rates. Differences overall were small enough that family composition was largely unaffected. Observed changes in family composition did not markedly reduce genetic diversity and did not affect the genetic gain that may be expected from an improved population. The plantable nursery stock was, for the most part, representative of the composition of families originally sown.

OSU Link
Non-OSU Link

308. St-Clair, J.B., N.L. Mandel and K.J.S. Jayawickrama. 2004. Early realized genetic gains for coastal Douglas-fir in the Northern Oregon Cascades. Western-Journal-of-Applied-Forestry 19(3): 195-201.

Keywords: genetic tree improvement
growth

Abstract: Block-plot realized genetic gain trials were established for coastal Douglas-fir (Pseudotsuga menziesii var. menziesii) at five sites in the northern Oregon Cascades. The long-term objectives of these trials are to explore the growth trajectories and productivity of genetically improved stands and their relationship to predicted genetic gains based on performance in progeny tests. Measurements 5 years after planting provide an opportunity for an early assessment of realized genetic gains as compared to predicted gains and provide data for determining the number of replicates needed to detect statistically significant differences between improved and unimproved populations using large block plots. Results indicate that progress from selection and breeding of Douglas-fir is readily achievable, and realized genetic gains 5 years after planting are similar to those predicted based on results from progeny tests. Realized genetic gains were about 6% for height, 8% for diameter, and 28% for stem volume, compared to predicted genetic gains of about 8% for height, 7% for diameter, and 25% for stem volume. Large numbers of replicates (30-50) are required to detect statistically significant differences in height and diameter between improved and unimproved populations given genetic gains expected in a typical tree improvement program.

OSU Link
Non-OSU Link

309. St-Clair, J.B. and R.A. Sniezko. 1999. Genetic variation in response to shade in coastal Douglas-fir. Canadian-Journal-of-Forest-Research 29(11): 1751-1763.

Keywords: genetic tree improvement
growth
tree morphology
carbon allocation
tree phenology

Abstract: Tree improvement programmes have generally relied on testing families in open light environments. With increased interest in multiaged silvicultural systems, some people have questioned whether families selected in the open are appropriate for planting in the shade. Douglas-fir (Pseudotsuga menziesii var. menziesii) families from two climatically distinct seed sources in the Coast Range (NW Oregon) and Siskiyou Mountains (SW Oregon) were grown for 2 years under four

levels of shade. The response to shade differed for several traits between the two populations and among families within populations. The magnitude of variation associated with the interaction, however, was small compared with the overall effects of genetic selection or of shade. Families selected based on performance in an open light environment resulted in nearly the same response to selection when grown under shade as families selected based on performance in the shade. It is concluded that seedlings from families selected in an open light environment are appropriate for use in the low-light environments of alternative silvicultural systems and that use of such genetically selected stock may compensate for the less favourable growing conditions. Genetic selection may contribute importantly to meeting multiple objectives, including the production of significant amounts of wood as well as the efficient and timely creation of large stand structures needed for other forest values.

OSU Link
Non-OSU Link

310. Stegemoeller, K.A. and H.N. Chappell. 1990. Growth response of unthinned and thinned Douglas-fir stands to single and multiple applications of nitrogen. Canadian-Journal-of-Forest-Research 20(3): 343-349.

Keywords: fertilization
thinning
growth

Abstract: Basal area and volume growth response of unthinned and thinned Douglas fir (Pseudotsuga menziesii) stands to single and multiple applications of N fertilizer (as urea) were estimated for eight 2-yr periods in second-growth stands in Washington and Oregon. Response estimates, as differences between growth rates on fertilized and control plots after adjusting for initial volume (or basal area), and trends, were analysed on a regional scale. Average responses to the initial fertilization and to both the second and third fertilizer applications, 8 and 12 yr later, were statistically significant ($P < 0.05$). In thinned stands, average duration of response to the initial treatment was approximately 8 yr; unthinned stands continued to show significant volume growth response through 14 yr although basal area growth response decreased to nonsignificant levels between years 10 and 12. In both cases, the response to refertilization, while significant, was smaller than the response to the initial fertilization. N applied after the 8th yr and a refertilization after the 12th, on one initially untreated plot at each site, also produced significant average growth responses.

OSU Link
Non-OSU Link

311. Stegemoeller, K.A. and H.N. Chappell. 1991. Effects of fertilization and thinning on 8-year growth responses of second-growth Douglas fir stands. Canadian-Journal-of-Forest-Research 21(4): 516-521.

Keywords: fertilization
thinning
growth

Abstract: An evaluation is presented of a regional research project on basal area and volume increment responses to fertilizer (N) and fertilizer with thinning treatments of Pseudotsuga menziesii in W.

Washington and Oregon for four 2-year measurement periods. Fertilization generally increased both basal area and volume growth for at least 8 years. Thinning tended to have an even greater effect than fertilization on basal area and volume growth on an individual-tree basis. Overall, however, the removal of growing stock by thinning caused volume growth to be less than that of the control. The magnitude and duration of this negative response was dependent on the level of thinning and on site quality. A significant positive interaction between fertilization and thinning exists. The combined treatment resulted in the greatest absolute basal area and volume increments, and the response became greater than that to fertilizer alone in the 3rd and 4th years, and remained so for at least 8 years.

OSU Link
Non-OSU Link

312. Stein, W.I. 1984. Wrenching Douglas-fir seedlings in August: immediate but no lasting effects. Pacific-Northwest-Forest-and-Range-Experiment-Station,-USDA-Forest-Service Research-Paper PNW-RP-317. 12 p.

Keywords: nursery operations
tree morphology
growth
carbon allocation
tree/stand health

Abstract: Seedlings in a nursery in Oregon were wrenched in their 2nd growth season in 1976. Wrenched and unwrenched seedlings were sampled at intervals from Aug. 1976 until Jan. 1977, and measured. The entire bed was lifted in Jan. and 100 treated and 100 control seedlings were planted out. After 24 days (Aug.), the number of lateral roots, shoot length, and root dry wt. were significantly smaller in wrenched seedlings. Shoot/root ratio was also smaller and remained so until early Oct. By late Oct., shoot length and the number of lateral roots were significantly greater in wrenched seedlings. During the first 5 yr after planting out, there were n.s.d. between wrenched and unwrenched trees in survival and growth, which were both good.

OSU Link
Non-OSU Link

313. Stein, W.I. 1988. Nursery practices, seedling sizes, and field performance. *In*: Proceedings, combined meeting of the Western Forest Nursery Associations; 1988 August 8-11; Vernon, British Columbia. *Tech Coord.* T.D. Landis. Rocky Mountain Forest and Range Experiment Station, USDA Forest Service General Technical Report RM-GTR-167. 15-18 pp.

Keywords: nursery operations
growth
tree morphology
tree/stand health

Abstract: Highlights are presented from a large cooperative study in Oregon to determine the combined effects of nursery cultural practices on the size and field performance of 2+0 Douglas fir [Pseudotsuga menziesii] seedlings. Seedlings were grown in 3 nurseries using seed from 7 sources; field plantings were

made over 3 yr on 28 sites in SW Oregon. Seedbed density had more effect than irrigation frequency, undercutting or wrenching on seedling size, and survival and growth 4 yr after planting.

OSU Link
Non-OSU Link

314. Stein, W.I. 1997. Ten-year survival and growth of planted Douglas-fir and western redcedar after seven site-preparation treatments. Western-Journal-of-Applied-Forestry 12(3): 74-80.

Keywords: site preparation
chemical preparation
prescribed fire
tree/stand protection
growth
tree/stand health
stand conditions

Abstract: Western redcedar (Thuja plicata) and Douglas fir (Pseudotsuga menziesii) were planted together after applying seven site-preparation methods at one cable-logged site in the Oregon Coast Ranges. The treatments, applied during 1980, were: untreated control; spot clear by cutting; aerial spraying with glyphosate; broadcast burning; slash and burn; spray with Tordon 101 (picloram + 2,4-D) and burn; and burn and sow grass. Planting was done in early 1991, and vegetation and trees were measured periodically to 1990. Survival and growth of cedar were markedly less than Douglas fir on this favourable site where both species were components of the original stand. Repeated browsing severely impeded the cedar. Site preparation by broadcast burning generally yielded the best results, but sowing grass after broadcast burning produced Douglas fir responses similar to those for no site preparation. Where grass was sown, herbaceous cover was more abundant and taller, salmonberry (Rubus spectabilis) differed little in density but was slightly taller, and development of red alder (Alnus rubra) was delayed. Red alder is currently overtopping conifers in all treatments, and release is needed to ensure sufficient conifer survival.

OSU Link
Non-OSU Link

315. Steinfeld, D., D. Davis, S. Feigner and K. House. 2002. Fall versus spring transplanting of container seedlings: a comparison of seedling morphology. *In* National Proceedings: Forest and Conservation Nursery Associations 1999, 2000, and 2001, USDA-Forest-Service Rocky-Mountain-Research-Station RMRS-P-24. 196-200 pp.

Keywords: nursery operations
growth
tree/stand health
tree morphology

Abstract: In a study in Oregon, USA, containerized seedlings of Engelmann spruce (Picea engelmannii), sugar pine (Pinus lambertiana), Douglas-fir (Pseudotsuga menziesii), western redcedar (Thuja plicata), and western hemlock (Tsuga heterophylla) transplanted in the early fall and later in the early spring

were compared for differences in stem diameter, height, root area, and shoot area. Fall-transplanted Pseudotsuga menziesii and the Thuja plicata showed an increase in stem diameter of 13 (2.0 mm) and 4% (0.4 mm), respectively. Fall-transplanted seedlings developed larger root systems - Picea engelmannii by 18%, Pinus lambertiana by 48%, Pseudotsuga menziesii by 58%, and Tsuga heterophylla by 47%.

Non-OSU Link

316. Stevenson, J.F., B.J. Hawkins and J.H. Woods. 1999. Spring and fall cold hardiness in wild and selected seed sources of coastal Douglas-fir. Silvae-Genetica 48(1): 29-34.

Keywords: genetic tree improvement
tree/stand protection
tree/stand health
tree phenology
growth

Abstract: Breeding for increased growth in coastal Douglas fir (Pseudotsuga menziesii) could affect the level of cold hardiness of seedlings used for reforestation. If increased growth is achieved by initiating growth earlier in the spring or prolonging growth later into autumn, cold hardiness could be reduced during these seasons. Cold hardiness was measured in top-cross and first generation seed orchard trees selected for increased growth rates, and wild stand trees on Vancouver Island and near Mission, BC, throughout one growing season by visual assessment of artificial freeze tests. Significant differences in freezing damage between genetically selected and wild stand trees were found during both spring and autumn. In April, LT50 of top-cross trees was 0.7-2.4 degrees C below that of wild stand trees, while in October, LT50 of wild stand trees was 1.9-3.4 degrees C below that of top-cross trees. Mitotic index was investigated as an indicator of dormancy, and a negative correlation between mitotic index and cold hardiness was found. A significant difference in mitotic index between the genetic groups was found once in March when mitotic index in wild stand and seed orchard trees was 1.4% and mitotic index in top-cross trees was 0.9%. There were no significant differences in mitotic index at any other times during the year. Date of bud burst and rates of shoot extension were related to levels of cold hardiness in the three groups of seedlings. The stage of bud burst in May was significantly correlated with levels of hardiness found earlier in March and April. Trees that completed shoot extension earlier in the season were significantly more hardy in autumn. Top-cross trees may extend their growing season later into the fall, thereby gaining a height advantage over wild stand seedlings. These top-cross families do not have an increased mid to late autumn frost damage risk, and in fact may have reduced risk of critical spring frost damage due to delayed deacclimation.

OSU Link
Non-OSU Link

317. 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

318. Stjernberg, E.I. 1997. Mechanical shock during transportation: effects on seedling performance. New-Forests 13(1/3): 401-420.

Keywords: nursery operations
tree physiology
tree/stand health
growth

Abstract: A study was carried out to monitor shocks to seedling planting stock during transport from nursery to the planting site in normal commercial reforestation operations. Size and exact time of mechanical shocks were measured by a recorder placed inside seedling boxes. Seedling shipments by refrigerated semi-trailer, 5-t truck, pickup truck, small trailer and all-terrain vehicles were monitored in Alberta and British Columbia. Number of shocks, peak acceleration and average drop height were tabulated for travel on both paved and gravel roads. Twenty-two trials involving 7 conifer species (Douglas fir, Pseudotsuga menziesii; western hemlock [Tsuga heterophylla]; western red cedar [Thuja plicata]; amabilis fir [Abies amabilis]; white spruce, Picea glauca; lodgepole pine, Pinus contorta; Engelmann spruce, Picea engelmannii) were established at nurseries and field locations covering several ecological zones in both provinces. Frozen-stored, cool-stored, and freshly lifted seedlings were used in the trials. Seedlings were given 2 mechanical stress treatments by dropping them 30 times from 0.5 or 1 m height. Control seedlings were not dropped. Treatments were applied to nursery-trial seedlings not exposed to normal handling and transport, and to field-trial seedlings after transport to the planting site. Six root growth potential tests were made with treated and control seedlings in conjunction with the nursery trials. Seedling survival and volume growth were recorded for two growing seasons and the results are statistically analysed. They indicated that seedlings should not be affected by normal transport and handling activities - some of the shock treatments tested were much more stressful than those resulting from normal procedures. There was some evidence that mechanical shocks could reduce the growth and survival of bare rooted stock, but normal mechanical stresses had no effect on containerized stock. However, it is recommended that care be taken to reduce extreme mechanical shocks during planting stock transportation.

OSU Link
Non-OSU Link

319. Stoehr, M.U., J.E. Webber, C.C.A. Hollefreund and R.A. Painter. 2004. Potential pollen contamination effects on progeny from an off-site Douglas-fir seed orchard: 9-year field results. Canadian-Journal-of-Forest-Research 34(4): 981-984.

Keywords: genetic tree improvement
seed orchard management
reproduction
tree/stand health
growth

Abstract: To evaluate the potential effects of seed orchard pollen contamination from surrounding background sources, we made control pollinations with outside orchard pollen and inside orchard pollen on trees of a Douglas-fir (Pseudotsuga menziesii) coastal-interior transition zone seed orchard. This zone encompasses the coast mountains from the Washington border to Alaska, USA. The resulting progeny were tested on a transition zone and a coastal site. After nine growing seasons, survival was above 90% on both sites for both pollen sources, and the tree height differences due to pollen source were statistically non-significant. Wildstand operational seedlots, used as controls, were 17% shorter than the contaminated seedlings. Orchard management implications of these results are discussed.

OSU Link
Non-OSU Link

320. Stoehr, M.U., J.E. Webber and R.A. Painter. 1994. Pollen contamination effects on progeny from an off-site Douglas-fir seed orchard. Canadian-Journal-of-Forest-Research 24(10): 2113-2117.

Keywords: genetic tree improvement
seed orchard management
growth
genetic relationships
reproduction

Abstract: The effects of background pollen contamination were evaluated for first-year height growth pattern of seedlings originating from a Douglas fir (Pseudotsuga menziesii) coastal-interior transition zone seed orchard located on southern Vancouver Island, British Columbia. Pollen collected from five stands surrounding the orchard (background pollen) and pollen from five half-sib families of the seed orchard were applied to six individual trees in the orchard. The resulting 60 seed lots were raised outdoors in a coastal-climate nursery with five seed lots collected from wild stands of the transition zone. Heights were measured at 10-day intervals during the growing season. Final heights, maximum height growth rate and growth cessation were subjected to analysis of variance. Growth rate and cessation were derived from data fitted to the logistic growth curve using nonlinear regression analysis. Seedlings sired by the background pollen had significantly greater final heights and growth rates. There were no differences in orchard seedlings in growth cessation probably because all seedlings were exposed to a blackout treatment to force bud set in mid-August. The average final height of wild-stand seedlings from the transition zone was 15% and 21% lower than that of pure orchard seedlings and seedlings sired by the background pollen lots, respectively. Standard deviations for measured traits were similar between orchard seedlings sired by background pollen and orchard pollen. If pollen contamination is not prevented, the faster growing seedlings sired by the background pollen may be

preferentially selected during culling in the nursery and outplanted on sites to which they are maladapted.

OSU Link
Non-OSU Link

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

Keywords: thinning
commercial thinning
economics
growth
yield

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

Non-OSU Link

322. Stonecypher, R.W., R.F. Piesch, G.G. Helland, J.G. Chapman and H.J. Reno. 1996. Results from genetic tests of selected parents of Douglas-fir (Pseudotsuga menziesii [Mirb.] Franco) in an applied tree improvement program. Forest-Science-Monograph (32): 35.

Keywords: genetic tree improvement
planting operations
growth
tree phenology
genetic relationships

Abstract: Results from genetic tests, and genotype x environment interaction studies in six low-elevation breeding zones of Weyerhaeuser Company's Western Washington and Oregon Douglas fir (Pseudotsuga menziesii) tree improvement programme are summarized. Phenotypic selection in natural stands resulted in a 5% improvement in juvenile height over nonselect seed lots. Comparisons with nonselect sources, of offspring from parents in the top 50% performers in tests, indicated a 10% increase for the same trait. Seed produced in a 50% rogued seed orchard is thus expected to provide improved planting stock with a gain of 10% in juvenile height growth. Several select parents are producing offspring that are consistently performing in excess of 10% over nonselects. Estimates of breeding zone, breeding zone by location, and family by location interaction effects are small relative to family and planting location effects. Tests of families established on environmentally diverse sites indicate a striking lack of large family by planting location interaction. In tests showing statistically significant interactions, such interactions are caused by a relatively small number of families. Earlier budbreak and a higher spring frost susceptibility of Oregon sources established on Washington sites were observed. It is concluded that allocation and utilization of select families within

Weyerhaeuser's Oregon and Washington ownership should not be constrained by the currently defined breeding zone boundaries, but based on parental performance and stability for growth and adaptive traits in general. It is suggested that the necessity for maintaining separate breeding zones, within Washington and Oregon, in subsequent cycles of recurrent selection is questionable. Average individual tree heritability, from 65 6-parent disconnected diallels, is 0.13 for age 6 and age 8 height. Dominance genetic variance is estimated to be one-half that of additive genetic variance for the same traits.

OSU Link
Non-OSU Link

323. Strader, R.H. and D. Binkley. 1989. Mineralization and immobilization of soil nitrogen in two Douglas-fir stands 15 and 22 years after nitrogen fertilization. Canadian-Journal-of-Forest-Research 19(6): 798-801.

Keywords: fertilization
growth
soil properties

Abstract: Additions of 15N-labelled NH4Cl were used to examine the role of microbial immobilization in long-term growth response of Douglas fir (Pseudotsuga menziesii) plantations to N fertilizer treatment. Soil samples were collected in summer 1986 from fertilized (448 or 470 kg/ha N) and nonfertilized plots at previously established N fertilization experiments near Shawnigan Lake, British Columbia, and the Wind River Experimental Forest near Carson, Washington. Douglas fir on these sites were reported to still be responding to N fertilization after 12 and 18 years. Less than 2% of the added 15N was recovered as mineral N after a 14-day laboratory incubation of soil samples from the fertilized and nonfertilized plots. This indicates that gross mineralization could be >50x greater than net mineralization in these infertile soils if the remaining 98% of the added 15N were all biologically immobilized. Net mineralization was significantly greater (p <less or =>0.10) in soils from the fertilized plots than in those from the nonfertilized plots at the Wind River site. Although the current differences in N availability did not appear to be related to differences in microbial immobilization, such large rates of immobilization require further investigation as a factor in long-term response to fertilization.

OSU Link
Non-OSU Link

324. Strand, R.F. and D.S. DeBell. 1981. Growth response to fertilization in relation to stocking levels of Douglas-fir. In Proceedings: Forest Fertilization
Conference, University of Washington, Seattle, Washington, USA. Eds. S.P. Gessel, R.M. Kenady and W.A. Atkinson. pp. 102-106.

Keywords: planting operations
fertilization
thinning
growth

Abstract: Growing stock levels affect the response of Douglas-fir stands to applications of nitrogen fertilizer. Response is maximum at intermediate stocking levels, and is less at higher or lower levels of stand density. Nitrogen fertilization accelerates growth and therefore increases the rate of buildup of stand density. Thinnings will be required to reduce stocking to appropriate levels if good responses to repeated nitrogen applications throughout a rotation are to be obtained.

OSU Link
Non-OSU Link

325. Tait, D.E. 1988. The dynamics of stand development: a general stand model applied to Douglas-fir. Canadian-Journal-of-Forest-Research 18(6): 696-702.

Keywords: planting operations
thinning
growth
tree/stand health

Abstract: A linked pair of hypotheses are developed that represent causal explanations for plant growth and stand mortality for an even-aged stand. The pair of dynamic equations lead to a four-parameter Douglas fir simulation model that relates the development of stand volume and density to site quality, initial stocking density and alternative thinning regimes. The mortality hypothesis, a dynamic hypothesis related to stand density and stand growth, generates the -superscript 3/2 power law as an equilibrium solution.

OSU Link
Non-OSU Link

326. Tanaka, Y., B. Carrier, A. Dobkowski, P. Figueroa and R. Meade. 1988. Field performance of mini-plug transplants. Rocky-Mountain-Forest-and-Range-Experiment-Station,-USDA-Forest-Service General-Technical-Report RM-GTR-167. 172-181 pp.

Keywords: nursery operations
tree/stand health
growth

Abstract: Mini-plug transplants (MPTs) are grown for 5-6 months in the greenhouse under extended daylength and are transplanted by machine into nursery beds in May when the plants are 4-5 inches tall. Seedlings are grown for one season before planting. Field performance of MPTs was compared with that of other stock types of Douglas fir [Pseudotsuga menziesii] in 6 regions of Washington and Oregon. Based on survival, vigour and height growth, MPTs generally performed as well as or better than other bare rooted stock. Because of their smaller initial height, MPTs had less total height than other stock types after 3 yr. MPTs were not preferred over other stock types in terms of frequency of big-game browsing and rabbit clipping, but, because of their small size, they were unable to withstand heavy animal damage.

327. Tappeiner, J.C., J.F. Bell and J.D. Brodie. 1982. Response of young Douglas-fir to 16 years of intensive thinning. Forest-Research-Laboratory,-Oregon-State-University

Keywords: thinning
growth
yield
tree/stand health
economics

Abstract: The report of the thinning study in the Oregon Coast Range includes a financial analysis of representative thinning regimes.

OSU Link
Non-OSU Link

328. 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

329. 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

330. 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. Forest Research 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 [Pseudotsuga menziesii], 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

331. Tesch, S.D. and S.D. Hobbs. 1989. Impact of shrub sprout competition on Douglas-fir seedling development. Western-Journal-of-Applied-Forestry 4(3): 89-92.

Keywords: site preparation
chemical preparation
growth

Abstract: In 1983, 1+0 container-grown Douglas fir (Pseudotsuga menziesii) seedlings were planted on a site in Oregon, USA, subject to summer drought under 3 amounts of sprout competition from greenleaf manzanita (Arctostaphylos patula) and canyon live oak (Quercus chrysolepis). Seedlings were planted among 0.25-m herbicide-killed sprouts, mature shrubs slashed just before planting, or 1-m tall sprouts, which represent an increasing order of competition. After 3 yr, Douglas fir survival did not differ significantly between treatments. However, percent cover of competing shrubs was negatively correlated with conifer root and shoot biomass. Under the least competition, root biomass increased 25x and shoot biomass 103x over dry wt. at planting, but dry wt. in other treatments increased <5 times. Douglas fir seedling growth did not increase significantly following shrub removal when vigorous sprouting occurred during the first year. After 3 yr, however, competitor cover in the minimum-competition plots was less than 15%, and conifer biomass had increased exponentially.

332. Thies, W.G. and E.E. Nelson. 1988. Bulldozing stumps and nitrogen fertilization affect growth of Douglas-fir seedlings. Canadian-Journal-of-Forest-Research 18(6): 803-806.

Keywords: site preparation
mechanical preparation
fertilization
growth

Abstract: Eight treatments involving stump removal (either all stumps removed or the plot left undisturbed) and broadcast application of ammonium nitrate (N at 0, 336, 672 or 1345 kg/ha) were applied to 0.04-ha circular plots in a clear felling on the Olympic Peninsula, Washington. Pseudotsuga menziesii seedlings were planted several months after treatment; d.b.h. and height were recorded 5 and 8 yr after planting. Results showed that either bulldozing stumps or application of nitrogen increased seedling growth. After 8 yr, bulldozing had increased seedling height and d.b.h. by 23 and 43%, respectively; increases caused by nitrogen fertilizer were 13 and 17%, respectively.

333. Thies, W.G., E.E. Nelson and D. Zabowski. 1994. Removal of stumps from a Phellinus weirii infested site and fertilization affect mortality and growth of planted Douglas-fir. Canadian-Journal-of-Forest-Research 24(2): 234-239.

Keywords: site preparation
mechanical preparation
fertilization
tree/stand protection
tree/stand health
growth
soil properties

Abstract: A field study was established in a 4.9 ha clearcut on the west slope of the Cascade Range (44 degrees 21'N, 122 degrees 39'W), Oregon, to evaluate the effects of stump removal (of both infested and non-infested stumps) and fertilizing with ammonium nitrate on the incidence of laminated root rot (caused by Phellinus weirii) in Douglas fir (Pseudotsuga menziesii) seedlings. A 2x4 set of factorial treatments of stump removal in combination with nitrogen fertilizing was applied in August 1980 to 0.04-ha circular plots within the clearcut. Treatments included stump removal (either all stumps removed or the plot left undisturbed) and broadcast application of ammonium nitrate (0, 336, 672, or 1345 kg N/ha). Diameter at breast height and height of Douglas fir, planted as 2+1 bare root seedlings 4 months after treatment (in January 1981), were recorded 5 and 9 seasons after outplanting. Soil bulk density in the upper 20 cm was measured with a single-probe neutron densimeter. Stump removal reduced the number of seedlings killed by laminated root rot but had no significant effect on seedling growth. Stump removal increased soil bulk density only 7% as measured 9.7 years after treatment. Fertilizer increased the growth in diameter at breast height, and height growth of the seedlings but had no effect on mortality. There were no significant interactions between fertilizing and stumping treatments. Increased total soil N could still be detected on fertilized, nonstumped plots 9.7 years after treatment.

OSU Link
Non-OSU Link

334. Thompson, G. 1995. Nitrogen fertilization requirements of Douglas-fir container seedlings vary by seed source. Tree-Planters' Notes 46(1): 15-18.

Keywords: nursery operations
nursery fertilization
growth
carbon allocation
tree morphology

Abstract: Growth of container-grown Douglas fir (Pseudotsuga menziesii) from different seed sources from western Washington, northern Idaho and western Montana was evaluated following application of 100, 150, or 200 p.p.m. nitrogen during the rapid growth phase. The optimum level of N varied between seed sources for height, stem diameter, and bud growth, as well as for root shoot ratio. Target seedling specifications were met adequately for the westernmost sources at 100 and 150 p.p.m. N, whereas eastern sources required 150 or 200 p.p.m. Nitrogen levels should thus be tailored to individual Douglas fir seed sources to maximize the number of shippable seedlings per lot.

OSU Link
Non-OSU Link

335. Thomson, A.J. and H.J. Barclay. 1984. Effects of thinning and urea fertilization on the distribution of area increment along the boles of Douglas-fir at Shawnigan Lake, British Columbia. Canadian-Journal-of-Forest-Research 14(6): 879-884.

Keywords: fertilization
thinning
tree morphology

growth

Abstract: Assessments were made using radial growth measurements made 6 and 9 yr after treatment. Within treatments, av. area increment per tree was linearly related to d.b.h. and this relation was used to evaluate the effects of treatment on growth rate. Fertilizing had the greatest effect on av. area increment, and for a particular fertilization regime, thinning increased the response. Thinning modified the distribution of growth over the bole of all trees and increased butt flare, especially in smaller trees. The effect declined from the 4- to 6-yr measurement period to the 7- to 9-yr measurement period. Fertilizing had no consistent effect on growth distribution. The regression methods used in this study provided a more sensitive measure of form changes than previous methods, were independent of size distribution, and facilitated extrapolations and evaluation of temporal trends.

OSU Link
Non-OSU Link

336. Thomson, A.J., K.D. Tudor, V.J. Korelus and D.R. Ralph. 1988. Detecting the response of Douglas-fir to nitrogen fertilization by regression of periodic annual basal area increment against basal area. Canadian-Journal-of-Forest-Research 18(10): 1343-1346.

Keywords: fertilization
growth

Abstract: Douglas-fir (Pseudotsuga menziesii) b.a. response to urea application at 112 and 224 kg N/ha was studied on a medium site on Vancouver Island, British Columbia. Regression of tree periodic annual b.a. increment against b.a. was used to estimate within-plot growth rates. Higher growth rates were observed in the plots treated with fertilizer. The slope coefficients of the regressions were used to investigate spatial and temporal variation in growth rates.

OSU Link
Non-OSU Link

337. Tung, C.H., J. Batdorff and D.R. DeYoe. 1986a. Survival and growth of Douglas-fir seedlings with spot-spraying, mulching and root-dipping. Western-Journal-of-Applied-Forestry 1(4): 108-111.

Keywords: nursery operations
release treatments
chemical release
manual release
tree/stand health
growth

Abstract: In trials near Coos Bay, Oregon, 480 bare-rooted 2+0 Douglas fir seedlings, half of which had roots treated with Terra Sorb (a hydrolysed starch material capable of absorbing large amounts of water), were planted on a harsh site where several regeneration attempts had failed. After planting, seedlings received no further treatment, or glyphosate or paper mulch were applied around seedlings for 1 or 2 yr. Root dipping in Terra Sorb did not enhance survival or growth. Survival was significantly greater after the third season when competing vegetation was controlled with mulch or glyphosate

during the first one or two seasons. Survival of seedlings treated twice with glyphosate was 26, 23 and 21% greater, respectively, than seedlings receiving one glyphosate treatment and one or two mulch applications. Ht. growth was n.s.d. among treatments.

OSU Link
Non-OSU Link

338. Tung, C.H., L. Wisniewski and D.R. DeYoe. 1986b. Effects of prolonged cold storage on phenology and performance of Douglas-fir and noble fir 2+0 seedlings from high-elevation sources. Canadian-Journal-of-Forest-Research 16(3): 471-475.

Keywords: nursery operations
tree phenology
tree/stand health
growth
carbon allocation

Abstract: Seedlings of Douglas fir and noble fir (Abies procera) were lifted on 7 Nov. 1981 and 1 Mar. 1982 at Wind River Nursery, Washington, and stored at 1-2 degrees C until planting during the third week of June 1982 at 1500 m alt. in the Oregon Cascade Range. There was no difference in survival of Douglas fir attributable to storage treatment during the first two growing seasons. Noble fir seedlings stored for 7 months survived better during the first season than seedlings stored for 3 months, but no difference was evident after the second growing season. Time of bud burst did not differ between treatments for either species and no difference between treatments in rate of bud burst was seen in Douglas fir. Rate of bud burst was significantly greater in noble fir seedlings stored for 7 months than in those stored for 3 months. Shoot/root ratio decreased significantly during the first season for both species and treatments, but stabilized during the second season. Regardless of species, no differences were found in ht. growth and diam. increment between storage treatments. Results suggest that seedlings of these species originating from high alt. sources can be lifted in autumn and cold-stored for 7 months without adverse effects on performance after planting.

OSU Link
Non-OSU Link

339. Turner, J. 1982. The mass flow component of nutrient supply in three western Washington forest types. Acta Oecologica Oecologia Plantarum 3(4): 323-329.

Keywords: fertilization
soil properties
growth
tree physiology

Abstract: [See FA 37, 7318; 38, 5185; 39, 1857; 41, 3566; 44, 4913] The mass flow component of nutrient uptake, defined as the product of bulk soil sol. concn. and water uptake was calculated for a series of forest stands from previously published data. Stands were of Douglas fir of varying ages and nutrient status (both undisturbed and fertilized), red alder (Alnus rubra), Pacific silver fir (Abies amabilis) and beech (Fagus sylvatica). Uptake of N, P, K, and Mg increased, and Ca uptake remained stable as

stands matured; the proportion of nutrient uptake fulfilled by mass flow tended to increase with stand age. Fertilizer application gave various results related to changes in soil sol. nutrient concn. and tree growth. The stands of red alder and silver fir showed variable patterns between nutrients and these are discussed in relation to soil nutrients, productivity and previously unpublished data.

OSU Link
Non-OSU Link

340. Turner, J., M.J. Lambert and S.P. Gessel. 1988. Nitrogen requirements in young Douglas-fir of the Pacific Northwest. Fertilizer-Research 15(2): 173-179.

Keywords: fertilization
growth
tree physiology

Abstract: A series of fourteen Pacific Northwest Douglas-fir installations, ranging in age from 6 to 26 years were analysed with respect to site factors, foliage nutrients, and growth response to applied fertilizer. Unfertilized basal area increment ranged from 1.2 to 3.1 msuperscript 2 ha-1yr-1 with no apparent relationship with soil, stand age or site index. Basal area increment was correlated with foliage N and a critical level of N was calculated as 1.7%. Applications of 220 kg N ha-1 as urea increased growth between 0 and 95% of the unfertilized basal area growth, with an average of 24.9%. Response could be predicted from foliage N and unfertilized basal area increment. When the same relationships were applied to previously older stand data, results were more variable as elements such as B and S showed evidence of being limiting.

OSU Link
Non-OSU Link

341. Turner, J. and S.J. Mitchell. 2003. The effect of short day treatments on containerized Douglas-fir morphology, physiology and phenology. New-Forests 26(3): 279-295.

Keywords: nursery operations
growth
tree morphology
tree physiology
photosynthesis
tree phenology

Abstract: The effect of short day treatments ('blackout') on Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco) container seedlings at the time of lift and following cold storage was investigated. Variables measured included height, root collar diameter (RCD), root growth capacity (RGC), photosynthetic efficiency after -18 degrees C freezing (PEF), and days to terminal bud break (DBB). From one to four blackout dormancy induction treatments were started on three dates (July 12, July 26, and August 10) with 10 or 20 d between multiple blackouts. Increasing the number of blackout treatments resulted in lower RCD, lower DBB in the late winter/early spring, and higher PEF in the early fall. Later blackout start dates decreased PEF in the early fall, and increased overall height and late fall RGC as compared to earlier blackout start dates. Nurseries growing Douglas-fir seedlings from coastal Pacific

Northwest provenances should be aware that blackout regimes can decrease RGC in the late fall, and cause quicker dormancy release in the early spring. Coastal Douglas-fir can be lifted and planted in the early fall, when RGC and DBB are relatively high. If planting between February and April is necessary, seedlings given blackout should be cold stored in January to maintain an adequate level of dormancy, RGC and PEF.

OSU Link
Non-OSU Link

342. 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.

OSU Link
Non-OSU Link

343. 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.

OSU Link
Non-OSU Link

344. 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

345. 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 6 msuperscript 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 trees favour 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.

OSU Link
Non-OSU Link

346. Vihnanek, R.E. 1987. The effects of prescribed burning on the growth and nutrition of young Douglas-fir plantations in some salal [Gaultheria shallon]-dominated ecosystems [in British Columbia, Canada]. Forestry-Abstracts 48(11): 641.

Keywords: site preparation

prescribed fire
growth
tree physiology

OSU Link
Non-OSU Link

347. Vihnanek, R.E. and T.M. Ballard. 1988. Slashburning effects on stocking, growth, and nutrition of young Douglas-fir plantations in salal-dominated ecosystems of eastern Vancouver Island. Canadian-Journal-of-Forest-Research 18(6): 718-722.

Keywords: site preparation
prescribed fire
growth
tree physiology
stand conditions

Abstract: Stocking, ht. growth, basal diam. growth, and foliar nutrient concn. of 5- to 15-yr-old Douglas fir (Pseudotsuga menziesii) were evaluated on burned and unburned areas within each of 20 sites on eastern Vancouver Island, which were characterized by ecosystems dominated by salal (Gaultheria shallon). Burning significantly reduced salal ht. and cover and significantly increased Douglas fir stocking, ht. growth, basal diam. and foliar P, K, Ca, Fe, and B concn. Foliar concn. of N, Mg, S, Zn and Cu were not significantly affected. Foliar Mn concn. were significantly reduced but remained very far above the deficiency threshold.

OSU Link
Non-OSU Link

348. Wagner, R.G. and S.R. Radosevich. 1991a. Interspecific competition and other factors influencing the performance of Douglas-fir saplings in the Oregon Coast Range. Canadian-Journal-of-Forest-Research 21(6): 829-835.

Keywords: site preparation
prescribed fire
growth
tree morphology

Abstract: Regression models describing total height, stem diameter, stem volume index, and crown volume index of individual 4- to 9-year-old saplings of Douglas fir (Pseudotsuga menziesii) were developed from a retrospective analysis of two site preparation experiments (with/without prescribed burning). Measurements of 787 Douglas fir saplings were taken at nine sites during July and August 1984. The variables included in the models were age, interspecific competition index, height, animal damage (browsing and clipping), use of prescribed burning, and slope angle and azimuth. The models, which integrate environmental and morphological factors that can influence the performance of Douglas fir saplings into one set of equations, accounted for 64-73% of the variation in individual tree size. Interspecific competition and amount of animal damage were negatively correlated with tree size. Tree age, 1st-year height, and the use of prescribed burning were positively correlated with tree size.

When factors were held constant, trees were largest on steep southeast slopes. The models indicated that tree age, competing vegetation, animal damage, and initial seedling size had a dominant influence on the performance of Douglas fir saplings, while prescribed burning and topography were of relatively minor importance.

OSU Link
Non-OSU Link

349. Wagner, R.G. and S.R. Radosevich. 1991b. Neighborhood predictors of interspecific competition in young Douglas-fir plantations. Canadian-Journal-of-Forest-Research 21(6): 821-828.

Keywords: site preparation
stand conditions
growth

Abstract: Neighbourhood models describing the effect of interspecific competition on the height and stem diameter of 4- to 9-year-old saplings of Douglas fir (Pseudotsuga menziesii) were developed from site preparation experiments in the Oregon Coast Range. Existing study records and maps were used to randomly select 787 saplings from 78 study plots at nine sites. The influence of abundance measures, height, distance, and spatial arrangement of nonconiferous woody plants surrounding individual saplings was examined. Optimum neighbourhood heights and radii were defined. The best interspecific competition index for predicting Douglas fir height and stem diameter was total percentage cover for all woody species within a 2.1-m radius. Visual estimates of neighbour cover were superior to objective measures of crown area. The cover of woody species equalling or exceeding the height of the tree provided the best prediction for tree height. Woody species cover equalling or exceeding one-half the height of the tree provided the best index for predicting stem diameter. Accounting for the spatial arrangement of neighbouring woody plants did not improve the competition index. Interaction between the competition index and tree age indicated that the negative effect of interspecific competition on Douglas fir size increased with time. The age-adjusted competition index accounted for 11% of the variation in height and 19% of the variation in stem diameter. Douglas fir stem diameter was more sensitive to neighbouring woody plants than was height.

OSU Link
Non-OSU Link

350. Walker, R.B., S.P. Gessel and R.E. Miller. 1994. Greenhouse and laboratory evaluation of two soils derived from volcanic ash. Northwest-Science 68(4): 250-258.

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

Abstract: This study assessed the mineral nutrient status of two soils derived from volcanic ash in SW Oregon. The study was initiated because conifers in some of the field plots on such soils had failed to

give an expected yield response to the application of nitrogen fertilizer. Soil pot tests were carried out using both Romaine lettuce (Lactuca sativa) and Douglas fir (Pseudotsuga menziesii) seedlings, with a wide range of fertilizer treatments. Heavy phosphorus fertilization was necessary for satisfactory growth of lettuce, which also showed a 26% response to sulfur addition. With Douglas fir, pot tests showed no response to nitrogen alone, but gave a statistically significant response to phosphorus fertilization together with nitrogen (seedlings were non-mycorrhizal), and some suppression of yield with sulfur additions. There was a favourable effect of sulfur fertilization on foliar colour, and a chlorosis in younger foliage probably attributable to iron deficiency. Most of the tissue analyses showed low concentrations of magnesium (<0.05%), and also of calcium (<less or =>0.08%), iron (<70 mg/kg), boron (mostly 20 mg/kg) and copper (<less or =>2.6 mg/kg) in the younger foliage. Thus there is an implication from the field trials, and evidence from the greenhouse and laboratory study, that elements besides nitrogen need to be added to provide proper nutrition on these volcanic ash soils. The information can aid in guiding further fertilizer trials in forests on volcanic ash derived soil in SW Oregon and elsewhere.

OSU Link
Non-OSU Link

351. Walstad, J.D., J.D. Brodie, B.C. McGinley and C.A. Roberts. 1986. Silvicultural value of chemical brush control in the management of Douglas-fir. Western-Journal-of-Applied-Forestry 1(3): 69-73.

Keywords: release treatments
chemical release
growth
yield
economics

Abstract: Retrospective analyses were made of 3 Douglas fir plantations (age 12-39 yr) in western Oregon and Washington, to determine the long-term silvicultural effects and economic value of chemical brush control 10-25 yr earlier. Stocking and growth of Douglas fir were significantly greater on areas that received at least one aerial application of 2,4-D or 2,4,5-T than on untreated areas. On two sites, invading Alnus rubra virtually excluded Douglas fir in the absence of brush control. On the third site, Ceanothus velutinus var. laevigatus reduced Douglas fir stocking and diam. growth on untreated areas. On all three sites, projections of mature yield and economic returns based on current stand conditions indicated substantial benefits for areas where brush control treatments were applied.

OSU Link
Non-OSU Link

352. Wang, Z., M. Newton and J.C. Tappeiner, II. 1995. Competitive relations between Douglas-fir and Pacific madrone on shallow soils in a Mediterranean climate. Forest-Science 41(4): 744-757.

Keywords: release treatments
manual release
soil properties
growth

Abstract: A large area of Pacific Coast forests is characterized by shallow soil, with negligible rainfall in the growing season. The availability of bedrock water and its effects on growth and ecophysiology of 11-yr-old planted Douglas fir (Pseudotsuga menziesii) and sprouting Pacific madrone (Arbutus menziesii) was studied. The study was carried out at 3 regulated densities (0, 330 or 1322 clumps/ha) of madrone sprouts on shallow (<50 cm) residual soils in the Klamath Mts of SW Oregon. Total bedrock water depleted from March to September, as observed in drill holes by neutron probe, and did not suffer significantly among the 3 densities of madrone sprouts. However, cover in plots with the highest density of madrone depleted 50 mm of water from the 1.5 m layer by June, whereas vegetation on lower density treatments withdrew 15-28 mm by June, with later withdrawal distributed more uniformly through the growing season. Madrone density significantly affected basal diameter and height growth of Douglas fir. Madrone was consistently taller than Douglas fir in all plots. The height of 11-yr-old madrone sprout clumps (424-465 cm) did not differ significantly among densities. Madrone leaf area index and biomass were higher at the high density of madrone than at medium density. Physiological advantages and rooting habits of madrone give it a competitive advantage over Douglas fir at this site, that it might not have if bedrock did not provide the principal water reservoir for summer growth.

353. Wass, E.F. and R.B. Smith. 1997. Impacts of stump uprooting on a gravelly sandy loam soil and planted Douglas-fir seedlings in south-coastal British Columbia. Pacific-Forestry-Centre,-Canadian-Forest-Service Information-Report BC-X-368. vi + 15 p.

Keywords: site preparation
mechanical preparation
tree/stand protection
soil properties
stand conditions
growth

Abstract: Studies to determine levels and impacts of soil disturbance caused during root-disease control by stump removal were initiated on a cutover on southern Vancouver Island immediately prior to the control operation and the establishment of a plantation of Douglas-fir (Pseudotsuga menziesii). Soil surface condition was assessed on the stumped area. Soil disturbance was measured at 699 planting spots. Vegetation development was assessed at 10% of the spots. Of all planting spots, 180 were undisturbed soil, 277 deposits and 242 gouges. The soil, a gravelly sandy loam, increased naturally in soil density with depth from 1.05 t/msuperscript 3 at the surface to over 1.60 t/msuperscript 3 at depths more than 40 cm. Disturbance did not significantly increase soil density. Unlike previous studies of this nature, ease of soil penetrability was increased by the stump uprooting disturbance and vegetation development was not greatly dissimilar between disturbed and undisturbed soil. The relatively low soil impacts were attributed to the ability of the excavator to pile stumps without pushing topsoil, and the low site sensitivity to compaction. These low impacts on soil and reduced vegetative competition on disturbed soil resulted in tree growth rates which were significantly greater after 10 years on deposits (12% in height and 18% in diameter) and gouges (6% in height and 8% in diameter) than on undisturbed soil.

354. Webber, J.E., S.D. Ross, R.P. Pharis and J.N. Owens. 1985. Interaction between gibberellin A4/7 and root-pruning on the reproductive and vegetative process in Douglas-fir. II. Effects on shoot elongation and its relationship to flowering. Canadian-Journal-of-Forest-Research 15(2): 348-353.

Keywords: seed orchard management
reproduction
growth

Abstract: [See FA 45, 3761 and previous paper] Shoot elongation and female flowering response were assessed for gibberellin A4/7 (GA4/7) and root-pruning (RP) treatments applied in 1981 to 9- and 10-yr-old seedlings of families with good- and poor-flowering histories in a seed orchard in British Columbia. In families with a poor-flowering history, stem injections of GA4/7 significantly enhanced elongation of third-whorl terminal shoots but produced no flowering response. In families with a good-flowering history, GA4/7 treatment had no effect on shoot elongation but resulted in a significant increase in seed-cone buds. In contrast, root-pruning significantly retarded shoot growth in families with both good- and poor-flowering histories and was also the single most effective treatment for enhancing flowering. Combined, GA4/7 and RP had a synergistic effect on flowering, and GA4/7 partially overcame the inhibition of shoot growth caused by RP alone. These results are consistent with a hypothesis that exogenous and endogenous gibberellins are used preferentially for vegetative growth processes, with increased flowering occurring only after a threshold concentration of effector gibberellins is reached.

OSU Link
Non-OSU Link

355. Weber, C.D., Jr. 1983. Height growth patterns in a juvenile Douglas-fir stand, effects of planting site, microtopography and lammas occurrence. Forestry-Abstracts 44(11): 701.

Keywords: planting operations
growth

OSU Link
Non-OSU Link

356. Weetman, G.F., C.E. Prescott, F.L. Kohlberger and R.M. Rournier. 1997. Ten-year growth response of coastal Douglas-fir on Vancouver Island to N and S fertilization in an optimum nutrition trial. Canadian-Journal-of-Forest-Research 27(9): 1478-1482.

Keywords: fertilization
growth
yield
tree physiology

Abstract: A 27-year-old stand of coastal Douglas fir (Pseudotsuga menziesii) on Vancouver Island, British Columbia, was fertilized four times (1981, 1983, 1986 and 1988) with N as urea at six rates from 0 to 250 kg N/ha, with and without S coating (0-50 kg/ha). Current-year foliage was collected annually during 1981-85 and in 1990. Foliar N levels declined in the control plots over the 10-year period, but remained elevated in the fertilized plots. The increase in foliar N concentrations was commensurate with the

amount of N added. Stand basal area response increased with increasing rates of N addition. The greatest response in relative basal area net increment was 4.52 msuperscript 2/ha (40%) in plots that received a total of 1000 kg N/ha during the 10 years. Over a 60-year rotation, about 62 msuperscript 3 of extra wood would be produced under this regime. There was no additional response to S added in conjunction with N, so the N + S plots received only a single application of fertilizer. Mortality was confined to smaller suppressed stems, mostly of species other than Douglas fir. Foliar N concentrations and basal area increment declined steadily following cessation of fertilizer application in these plots, but remained greater than those in control plots for the 10-year measurement period. The results suggest that sustained increases in growth response of Douglas fir can be achieved through repeated additions of N that maintain elevated concentrations of N in foliage.

OSU Link
Non-OSU Link

357. Wheeler, N.C. 1987. Effect of paclobutrazol on Douglas fir and loblolly pine. Journal-of-Horticultural-Science 62(1): 101-106.

Keywords: seed orchard management
nursery operations
growth

Abstract: Paclobutrazol (1.0 and 10.0 mg/10 cc pot) significantly reduced the growth of Pseudotsuga menziesii and Pinus taeda seedlings when applied as a soil drench to newly germinated, container-grown trees. Shoot growth was generally inhibited more than root growth. Older trees (3- to 9-year-old) were not affected appreciably by a soil drench or stem injection. Dose response varied significantly among half-sib families for nearly all growth traits. It is suggested that the utility of paclobutrazol as a growth regulating agent in conifer seed orchards appears to be limited, although it may find use in container-grown conifer nurseries.

OSU Link
Non-OSU Link

358. White, D.E. and M. Newton. 1983. Effects of glyphosate and two formulation of hexazinone in young conifer plantations. Proceedings-of-the-Western-Society-of-Weed-Science (Vol.36): 54-56.

Keywords: release treatments
chemical release
growth
stand conditions
tree/stand health

Abstract: In April 1979, 1 month after transplanting 3-yr-old Douglas fir (Pseudotsuga menziesii), hexazinone liquid and solid formulations at 0, 1.11, 1.68 or 2.23 kg/ha were applied to the plots separately and in combination with 0 or 0.62 kg glyphosate/ha. There was no significant difference between formulations of hexazinone in effect on the herbaceous community which was dominated by Arrhenatherum elatius, Holcus lanatus, Elymus glaucus and Rubus ursinus. However, addition of glyphosate increased the mean weed-free condition from 67.25 to 85.1%. At the same time, in

glyphosate-treated plots, mean ht. of 4th yr trees was 149.9 cm compared with 162.6 cm in hexazinone-only plots. Survival of 2nd yr trees was also affected.

OSU Link
Non-OSU Link

359. White, D.E. and M. Newton. 1989. Competitive interactions of whiteleaf manzanita, herbs, Douglas-fir, and ponderosa pine in southwest Oregon. Canadian-Journal-of-Forest-Research 19(2): 232-238.

Keywords: release treatments
chemical release
growth
stand conditions

Abstract: Whiteleaf manzanita (Arctostaphylos viscida) was established on 3 sites in Oregon in 1983 at densities ranging from 0 to 27 000 seedlings/ha in 2-yr-old mixed Douglas fir (Pseudotsuga menziesii)/ponderosa pine (Pinus ponderosa) stands. Invading herbs were controlled by spraying all plots with glyphosate and hexazinone, except one at each site at the 13 500 density. Intraspecific manzanita competition reduced individual shrub basal diameter, leaf area, biomass, and canopy volume by the 3rd year of the study. Stem volume of 5-yr-old conifers was reduced in relation to manzanita density, biomass, LAI, and canopy cover. The presence of herbaceous vegetation reduced both manzanita and conifer growth by the 3rd year.

OSU Link
Non-OSU Link

360. White, D.E. and M. Newton. 1990. Herbaceous weed control in young conifer plantations with formulations of nitrogen and simazine. Canadian-Journal-of-Forest-Research 20(11): 1685-1689.

Keywords: release treatments
chemical release
fertilization
stand conditions
tree/stand health
growth

Abstract: Weed control and second year survival and growth of newly planted 2+0 Douglas fir (Pseudotsuga menziesii) and 2+0 noble fir (Abies procera) seedlings were measured at 3 sites in Oregon after application of herbicide and fertilizer in a replicated complete factorial experiment with 4 levels of simazine (0, 2.2, 4.4, 8.8 kg/ha), 3 levels of N (0, 110, 220 kg/ha), 2 types of N (urea prill; urea + trimamino-s-triazine (TST) prill) and 2 kinds of formulations (co-granular prill of simazine + nitrogen; nitrogen prill followed by liquid simazine). For the first growing season, total weed and grass control increased with increasing simazine rates. Total weed control was better when urea + TST, rather than urea alone, was applied in conjunction with simazine. Formulation and nitrogen rate were not significant. After plot treatment with 1.1 kg liquid hexazinone/ha at the beginning of the second growing season, Douglas fir survival decreased as the rate of urea alone increased; survival decreased with little or no weed control and remained constant or increased with good weed control as the rate of urea +

TST increased. Noble fir height and diameter, and Douglas fir diameter, decreased with poor weed control, but increased at least to the levels of untreated seedlings with good weed control. Noble fir diameter responded positively to added nitrogen. Although simazine may be toxic to first year conifers, this study suggests that more complete weed control in conjunction with fertilization may benefit young conifer plantations.

OSU Link
Non-OSU Link

361. White, D.E., L. Witherspoon-Joos and M. Newton. 1990. Herbaceous weed control in conifer plantations with hexazinone and nitrogen formulations. New-Forests 4(2): 97-105.

Keywords: release treatments
chemical release
fertilization
stand conditions
growth
tree/stand health

Abstract: In order to determine if herbicide efficacy is affected by nitrogen fertilizer, and to examine the effects of treatments on growth and survival of newly-planted 2-year-old Douglas fir (Pseudotsuga menziesii) and 3-year-old noble fir (Abies procera), the influence of different nitrogen fertilizers applied in different combinations with hexazinone formulations were evaluated on three herbaceous weed communities in Oregon. Field studies comparing three application methods in conifer plantations showed greatest reduction in total weed cover with a co-granular formulation of hexazinone and the slow-release nitrogen fertilizer triamino-s-triazine (TST). Slightly less control was achieved with separate applications of liquid hexazinone and TST granules, and poorest control with granular urea followed by liquid hexazinone. Weed control increased with an increase in hexazinone rate. Statistical analysis of the effect on conifers showed that the highest hexazinone rate significantly increased survival of noble fir, stem diameter of both noble fir and Douglas fir, and that the highest nitrogen rate significantly reduced survival of both species but did not affect stem diameter. Survival of noble fir and diameter of both noble fir and Douglas fir were significantly increased where a co-granular formulation of hexazinone and TST granules was used.

OSU Link
Non-OSU Link

362. Wigmore, B.G. and J.H. Woods. 2000. Cultural procedures for propagation of rooted cuttings of Sitka spruce, western hemlock, and Douglas-fir in British Columbia. B. C. Ministry of Forests Research Program Working Paper WP-46. 30 p.

Keywords: nursery operations
growth
reproduction

Abstract: The use of rooted cuttings is explored as a means of bulking-up genetically improved families of Sitka spruce (Picea sitchensis), western hemlock (Tsuga heterophylla), and Douglas-fir (Pseudotsuga

menziesii) for reforestation. The number of propagules produced from a small quantity of seed can be multiplied by taking cuttings from seedling stock plants. All methods are developed for 1-year-old cutting production in containers for consistency with most operational seedling production in British Columbia. This report describes cultural techniques for growing stock plants and rooted cuttings of Sitka spruce, western hemlock, and Douglas-fir, based on 3 years of nursery research and observations. It is concluded that 1-year container cutting production is technically feasible for Sitka spruce and western hemlock, but plagiotropism problems (including cuttings with bent stems and those with unflushed terminal buds and bent sub-terminal branches) could not be overcome for the production of 1-year-old cuttings of Douglas-fir. A discussion of plagiotropism is included.

OSU Link
Non-OSU Link

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

Keywords: thinning
commercial thinning
growth

Abstract: A 110-yr-old stand in Washington was given light or heavy thinning or left unthinned in 1952 and 1971. Stem sections were taken from trees removed in 1971 and analysed to show volume growth for the 19 yr before and 19 yr after the 1952 thinning. Estimates of volume growth for the same stand were also made from 4 volume tables and the results compared. The agreement between volume table estimates and the stem analysis results was within 10%, and was unaffected by thinning severity.

OSU Link
Non-OSU Link

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

Keywords: thinning
commercial thinning
growth
tree/stand health

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

OSU Link
Non-OSU Link

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

Keywords: thinning
commercial thinning
growth

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

OSU Link
Non-OSU Link

366. Wimberly, M.C. and B.B. Bare. 1996. Distance-dependent and distance-independent models of Douglas-fir and western hemlock basal area growth following silvicultural treatment. Forest-Ecology-and-Management 89(1/3): 1-11.

Keywords: fertilization
thinning
growth

Abstract: Distance-independent and distance-dependent individual-tree basal area growth equations for Douglas fir (Pseudotsuga menziesii) and western hemlock (Tsuga heterophylla) growth following thinning and fertilizer treatments were developed using regression analysis. Data came from an even-aged, naturally regenerated, mixed species stand near Jordan River, SW Vancouver Island, Canada. Distance-independent models included only non-spatial competition and thinning indices, while distance-dependent models included both spatial and non-spatial indices. The distance-independent models with the highest adjusted multiple coefficient of determination (adjusted Rsuperscript 2) for both species included diameter at breast height, crown class, percent basal area removed in thinning, plot basal area greater than the subject tree and stand age as independent variables. The distance-dependent models with the highest adjusted Rsuperscript 2 included all of these variables in addition to a variant of the area potentially available index, which is based on the spatial tessellation of the point pattern of trees in the stand. Addition of this spatial index produced only a small (<.01) increase in adjusted Rsuperscript 2 for models of both species. The relatively small amount of increase was due to three factors: thinning resulted in an even distribution of growing space among residual trees; tree size explained much of the variation in local competitive stress; and the competitive neighbourhood of individual trees was large relative to sample plot size. The results suggest that the additional effort and expense required to obtain spatially referenced stand data for developing empirical forest growth models in similar stands is not justified.

OSU Link
Non-OSU Link

367. Woodruff, D.R., B.J. Bond, G.A. Ritchie and W. Scott. 2002. Effects of stand density on the growth of young Douglas-fir trees. Canadian-Journal-of-Forest-Research 32(3): 420-427.

Keywords: planting operations
growth
photosynthesis
tree physiology

Abstract: The objectives of this study were (i) to provide further evidence of a positive correlation of stand density with early growth of coastal Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco var. menziesii); (ii) to determine when after planting the positive growth response occurs and how long it lasts; and (iii) to use stable isotopes of carbon to test whether the mechanism(s) responsible for the positive growth response to density are related to variables affecting photosynthesis, such as nutrient or moisture availability. We measured annual height (h) and diameter (d) growth (retrospectively) of 8- and 12-year-old trees in initial planting densities of 300, 1360, and 2960 trees/ha. Both height and diameter growth increased with density through the fifth year after planting and decreased with density by year 7. Diameter squared x height (d2h) was used as a volume index to assess increase in tree volume. Second-year increase in d2h for the high-density treatments was 300% of that in the low-density treatments. The delta 13C values of wood cellulose from annual rings of the second and third years after planting were not significantly different among densities, suggesting either (i) no significant differences in the effects of water availability, nutrient availability, or source air on photosynthesis in the three density treatments or (ii) differences that produced no net effect on delta 13C.

OSU Link
Non-OSU Link

368. 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.

OSU Link
Non-OSU Link

369. Woods, J.H., T. Wang and S.N. Aitken. 2002. Effects of inbreeding on coastal Douglas fir: nursery performance. Silvae-Genetica 51(4): 163-170.

Keywords: genetic tree improvement
growth
tree/stand health
reproduction
genetic relationships

Abstract: In advanced generation seed orchards, low levels of inbreeding may be inevitable as relatedness among individuals in breeding populations increases with each generation. Unlike selfing, low level inbreeding can produce relatively large number of viable seeds. Following previous study on the effects of inbreeding on coastal Douglas fir (Pseudotsuga menziesii var. menziesii) filled seed production, the present study investigated inbreeding on nursery performance over various cross-types, including outcrosses (inbreeding coefficient F=0), crosses between half-sibs (F = 0.125), between full-sibs (F = 0.25), between parents and offspring (F = 0.25), and selfing (F = 0.5). Significant differences were found among cross-types for germination, seedling mortality, seedling diameter and height, and nursery cull rate. Inbreeding also increased among-family genetic variability. Cumulative losses of seedlings at the nursery stage were 18, 33, 31, 36 and 43%, respectively for the above types of crosses. This result indicates that seeds with low levels of inbreeding may produce relatively large numbers of seedlings that meet nursery culling standards and could be used for reforestation, resulting in negative impacts on the genetic gain realized in field plantations.

OSU Link
Non-OSU Link

370. Yanchuk, A.D. 1996. General and specific combining ability from disconnected partial diallels of coastal Douglas-fir. Silvae-Genetica 45(1): 37-45.

Keywords: genetic tree improvement
growth
genetic relationships

Abstract: GCA and SCA were examined in 36, 6-parent disconnected partial diallels across 4 experimental series in coastal Douglas-fir (Pseudotsuga menziesii var. menziesii) in British Columbia, to examine the ratios of the 2 genetic variances, the distribution of GCA and SCA effects, and estimates of genetic gain from GCA and SCA for 3 growth traits. Height at age 7 and height and volume at age 12 were measured on approximately 150 trees per full-sib family in each diallel, across 11 different test sites within each series. The average percentage ratio of SCA variance to GCA variance was 36% across all series and the 3 growth traits, with a range of 19 to 65%. GCA and SCA variances did not appreciably change for height growth from age 7 to age 12. Diallel set effects were generally negligible. From theoretical considerations assumed for the diallel model, clear separations of additive and dominance effects (vis-a-vis the assumptions of selecting on GCA and SCA variances) are likely not possible: the effects are subject to degrees of dominance, epistasis and linkage in the population. However, these genetic details did not manifest themselves in any noticeable pattern or correlation among GCA and SCA effects. While these results confirm current strategies in Douglas-fir breeding to select primarily on GCA, there are opportunities to utilize SCA variance in the production population. Controlled matings for elite production populations are now common in coastal Douglas-fir improvement programmes, and controlled crossing with specified parents could (i) elevate gains by as much as 3.0% in 12-year volume (assuming competition effects have not biased volume estimates), and (ii) access additional sets of parents that would otherwise be disregarded. Gains for height growth from utilizing SCA are lower, which reflect either (i) lower SCA variances associated with height, or (ii) competition has biased upward volume SCA variance by age 12 (relative to height).

371. Yeh, F.C. and J.C. Heaman. 1987. Estimating genetic parameters of height growth in seven-year old coastal Douglas-fir from disconnected diallels. Forest-Science 33(4): 946-957.

Keywords: genetic tree improvement
genetic relationships
growth

Abstract: A disconnected diallele mating scheme was carried out on 10 sets each of 6 parents. Seedlings were raised at Cowichan Lake Research Station and planted out after 1 yr at 11 plantations in British Columbia where coastal Douglas fir would be a good choice for reforestation. Data on ht. and survival were collected after 7 yr and analysed to partition total phenotypic variation in ht. into portions of additive genetic effect (GCA), dominance genetic effect (SCA), interaction of plantations with additive and dominance genetic effects, residual effect and random error. The GCA of the parents within the sets was highly significant and its variance was the most important source of genetic variation. The GCA by plantation interaction was large and its variance was approx. 42% of the GCA variance. Effects due to SCA of parent trees and SCA by plantation interaction were also significant, but their variances were small in comparison with the GCA variance. The heritability estimate for 7-yr ht. was 0.13. Results are discussed in relation to gains to be expected from the improvement of this species.