Planting Operations

1. Adams, W.T., J. Zuo, J.Y. Shimizu, J.C. Tappeiner and J.H. Zuo. 1998. Impact of alternative regeneration methods on genetic diversity in coastal Douglas-fir. Forest Science 44:390-396.

Keywords: planting operations
genetic relationships

Abstract: Genetic markers (17 allozyme loci) were used to study the genetic implications of natural and artificial regeneration following 3 regeneration methods (group selection, shelterwood, and clearcut) in coastal Douglas fir (Pseudotsuga menziesii var. menziesii) forests in the Willamette Valley, Oregon, USA. In general, harvesting followed by either natural or artificial regeneration resulted in offspring populations which were very similar to those in the previous generation. The removal of the smallest trees to form shelterwoods resulted in the removal of rare, presumably deleterious, alleles. Fewer alleles per locus were observed among residual trees (2.76) and natural regeneration (2.75) than were found in uncut (control) stands (2.86). The shelterwood regime appeared quite compatible with gene conservation, and it was considered that it was best to leave parent trees of a range of sizes to act as gene conservation reserves, in order to maximize the number of alleles (regardless of current adaptive value) in naturally regenerated offspring. Seedling stocks used for artificial regeneration in clearcut, shelterwood, and group selection stands (7 total) had significantly greater levels of genetic diversity, on average, than natural regenerated seedlings.

OSU Link
Non-OSU Link

2. 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

3. Amaranthus, M.P., C.Y. Li and D.A. Perry. 1990. Influence of vegetation type and madrone soil inoculum on associative nitrogen fixation in Douglas-fir rhizospheres. Canadian-Journal-of-Forest-Research 20(3): 368-371.

Keywords: planting operations
soil properties

Abstract: In studies in SW Oregon in 1985, Douglas fir (Pseudotsuga menziesii) seedlings grown at a site cleared of whiteleaf manzanita (Arctostaphylos viscida) and an adjacent, cleared, annual grass meadow were either inoculated with 100-120 ml per seedling of pasteurized or unpasteurized soil from a nearby Pacific madrone (Arbutus menziesii) stand, or left uninoculated. After one growing season, Douglas fir seedling whole-plant soil systems were assayed for nitrogenase activity by the acetylene reduction method. The rate of acetylene reduction in rhizospheres of uninoculated seedlings from the manzanita site (1.40 +or- 0.44 nmol/h) was significantly greater than that of uninoculated seedlings from the meadow site (0.67 +or- 0.15 nmol/h). Unpasteurized madrone soil increased the rate of acetylene reduction by >500% for inoculated seedlings grown on the manzanita site, but decreased it by 80% for those grown on the meadow site. The influence of madrone soil was apparently biotic: pasteurized madrone soil did not have a significant effect. No acetylene was reduced in soil without seedlings. Azospirillum sp., a microaerophilic nitrogen (N2) fixing bacterium, was isolated from within the mycorrhizas of inoculated seedlings harvested from the manzanita site. These results suggest that early successional ectomycorrhizal shrubs and broadleaved trees may be important in maintaining mycorrhizal fungi and associated N2 fixers after severe disturbance.

4. 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

5. 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

6. Amaranthus, M.P. and D.A. Perry. 1989b. Rapid root tip and mycorrhiza formation and increased survival of Douglas-fir seedlings after soil transfer. New-Forests 3(3): 259-264.

Keywords: planting operations
mycorrhizal response
root development
tree/stand health

Abstract: In order to re-inoculate soil with mycorrhizal fungi, small amounts (about 150 ml) of soil from an established Douglas fir (Pseudotsuga menziesii) plantation were added to planting holes when Douglas fir seedlings were planted on an old, unrevegetated clearcut in
the Klamath Mountains of Oregon. Seedlings were lifted throughout the growing season to determine the influence of soil transfer on the rate of root tip initiation and mycorrhiza formation. Six weeks after planting, seedlings receiving plantation soil had formed 62% more root tips than controls; however, no statistically significant differences were apparent 15 weeks after planting. By that time, a small

percentage of root tips were visibly mycorrhizal; seedlings receiving transferred soil had the most colonization (13.6 vs. 3.5 per seedling, p <less or =>0.05). Of seedlings receiving transfer soil, 36.6% survived the first growing season, compared to 11.3% of control seedlings. At this high altitude, soils often remain frozen well into spring, leaving only a brief period between the time when soils become warm enough for root growth and the onset of summer drought. Under these conditions, the rapid root growth and mycorrhiza formation stimulated by plantation soil increases the ability of seedlings to survive the first growing season.

OSU Link
Non-OSU Link

7. 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

8. Axelrood, P.E., W.K. Chapman, K.A. Seifert, D.B. Trotter and G. Shrimpton. 1998. Cylindrocarpon and Fusarium root colonization of Douglas-fir seedlings from British Columbia reforestation sites. Canadian Journal of Forest Research 28:1198-1206.

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

Abstract: Poor performance of Douglas fir (Pseudotsuga menziesii) plantations established in 1987 has occurred in southwestern British Columbia. Affected sites were planted with 1-yr-old container stock that exhibited some root dieback in the nursery. A study was initiated in 1991 to assess Cylindrocarpon and Fusarium root infection in planted and naturally regenerating (natural) Douglas fir seedlings from 7 affected plantations. Percentages of seedlings harbouring Cylindrocarpon spp. and percentage root colonization were significantly greater for planted seedlings than natural seedlings. A significant linear trend in Cylindrocarpon root colonization was observed for planted seedlings with colonization levels being highest for roots closest to the remnants of the root plug and decreasing at distances greater than 10 cm from that region. This trend in Cylindrocarpon colonization was not observed for natural seedlings. Cylindrocarpon destructans var. destructans [Nectria radicola var., radicola] and C. cylindroides var. cylindroides were the only species isolated from planted and natural conifer seedlings. For most sites, percentage of seedlings harbouring Fusarium spp. and percentage Fusarium root colonization were less than for Cylindrocarpon. Recovery of Fusarium spp. from seedlings and root colonization levels were not significantly different for planted and natural seedlings from all sites.

OSU Link
Non-OSU Link

9. Bloomberg, W.J. 1988. Modeling control strategies for laminated root rot in managed Douglas-fir stands: model development. Phytopathology 78(4): 403-409.

Keywords: planting operations
site preparation
mechanical preparation
tree/stand protection
tree/stand health

Abstract: A model of laminated root rot caused by Phellinus [Inonotus] weirii was developed to assess potential control strategies in managed Pseudotsuga menziesii stands. The model mimicked key processes in disease initiation and development quantified as functions of time and space. These processes were horizontal and vertical tree root distribution, root contact with inoculum and among root systems, spread of mycelium through root systems, root decay, reduction of diam. growth in infected trees, tree mortality and persistence of inoculum in roots of stumps and killed trees. The processes were expressed as mathematical functions which were integrated in a computer program to calculate spread of the disease and stand-growth loss and mortality. Data for quantification of functions were obtained by experiments and from the literature. Simulated control practices included infected

stump removal, sanitation fellings and mixed planting of Douglas fir and resistant species. Accuracy of the model was tested by comparing calculated disease spread and mortality with the following data: (1) spread and damage in two 60-yr-old, 1-ha stands in Oregon, (2) results from a statistically based model for spread and damage that had performed satisfactorily, and (3) observed spread and damage behaviour in stands of different ages and growth rates. Results from the model compared favourably with all of the above situations.

OSU Link
Non-OSU Link

10. 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

11. 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

12. 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

13. 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

14. 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

15. 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

16. Childs, S.W. and L.E. Flint. 1987. Effect of shadecards, shelterwoods, and clearcuts on temperature and moisture environments. Forest-Ecology-and-Management 18(3): 205-217.

Keywords: planting operations
tree/stand health
soil properties
tree physiology
tree phenology

Abstract: A comparison was made of two common techniques used to improve seedling survival on hot, dry reforestation sites. Adjacent shelterwood and clearcut sites in SW Oregon, USA, planted with 2+0 Douglas fir, were located and instrumented to compare temp.and moisture. In addition, cardboard shadecards were placed beside half of the seedlings studied. Seasonal measurements or observations of soil moisture, soil temp., solar radiation, air temp., stomatal diffusion resistance, seedling phenology and survival provided the basis for comparisons. Shelterwoods and shadecards improved seedling survival in relation to the clearcut. Both treatments affected soil temp. but the nature of the effects was different. The shelterwood canopy reduced solar radiation incident at the soil surface and caused cooler soil temp. throughout the soil profile. Shadecards reduced soil temp. only to a depth of 20 mm. Both treatments reduced the duration of periods of high soil temp. Shelterwood treatment delayed seasonal water loss and reduced seedling water stress as measured by stomatal resistance. Shadecards did not significantly affect seedling stomatal resistance. Differences in seedling survival caused by shadecards and shelterwoods are apparently due to different influences on the seedling microclimate. Shelterwood causes a large reduction in soil temp. aswell as decreased seedling water stress. Shadecards modify the soil temp. less extensively and so have less effect on seedling survival.

OSU Link
Non-OSU Link

17. Childs, S.W., H.R. Holbo and E.L. Miller. 1985. Shadecard and shelterwood modification of the soil temperature environment. Soil-Science-Society-of-America-Journal 49(4): 1018-1023.

Keywords: planting operations
soil properties

Abstract: A study was conducted on steep, south-facing slopes in southwest Oregon to assess the effect of two common reforestation practices on the soil thermal environment. Three clearcut sites and three

shelterwood sites were instrumented to measure soil temperature at five depths in the vicinity of shaded and unshaded Douglas-fir seedlings. Since the soils studied were skeletal, heat capacities of both fine and coarse soil fractions were determined for each site. These data were used to estimate soil heat fluxes. Shelterwoods decrease soil temperatures approximately 6 K when compared with clearcuts. This result holds at both 20- and 320-mm depths. Shelterwoods also decrease the depth of diurnal heating and decrease maximum hourly heat loss and gain values by 73 and 80 W/msuperscript 2, respectively. Shadecards, cardboard rectangles placed to the southwest of seedlings, generally have little effect on the soil temperature regime of skeletal soils but are effective in reducing daily heat flux. The dominant shadecard effect is a decrease in average daytime heat flux by 22 W/msuperscript 2, but shadecards also decrease average nighttime fluxes. Shelterwoods ameliorate seasonal soil temperature conditions significantly and may be an appropriate technique in situations where cumulative soil heating limits reforestation success. Shadecards should be useful in situations where heat stress events of only a few days are a problem. Over a season, shadecards exert little control, and their influence on stress is limited. Since all soils studied had high heat capacities due to large rock fragment content the conclusions of this study may be limited to soils with large soil heat capacity.

OSU Link
Non-OSU Link

18. Colinas, C., R. Molina, J. Trappe and D. Perry. 1994a. Ectomycorrhizas and rhizosphere microorganisms of seedlings of Pseudotsuga menziesii (Mirb.) Franco planted on a degraded site and inoculated with forest soils pretreated with selective biocides. New-Phytologist 127(3): 529-537.

Keywords: planting operations
fertilization
soil properties
mycorrhizal response

Abstract: Inoculation of planting holes with small amounts of soil from a mature forest or a plantation can improve formation of ectomycorrhizas on Pseudotsuga menziesii seedlings in degraded clearcuts in southwestern Oregon. To determine the component(s) of transferred soil responsible for increased ectomycorrhiza formation, soil from a clearcut, a mature forest and a plantation was treated with one of the following: (1) fertilizer to test for the effect of nutrients, (2) dimethoate and carbofuran to test for the effect on microarthropods or nematodes, (3) fumagillin to test for the effect on protozoa, (4) captan to test for the effect on fungi, (5) penicillin and oxytetracycline to test for the effect on bacteria, (6) pasteurization to test for the effect of active forms of organisms, (7) Tyndallization to test for the effect of resting forms of organisms, or (8) water as a control. The effect was studied of inoculation with soil subjected to these treatments on number and types of ectomycorrhizas, on length of active mycelium, and on number of active bacteria in the rhizosphere. Inoculation with untreated forest or plantation soils increased the number of ectomycorrhizas but did not change the mycorrhizal types present. Most agents had different effects in different soils. Inoculation with pasteurized and Tyndallized clearcut and plantation soils increased the number of Rhizopogon- and Thelephora-type ectomycorrhizas and decreased the number of active bacteria, as did untreated forest soil. It is hypothesized that the role of the soil transfer is to provide a rhizosphere environment free from a deleterious organism present in the clearcut. In this environment, beneficial organisms present in the clearcut or brought in with the seedling from the nursery can proliferate.

OSU Link
Non-OSU Link

19. 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

20. Comeau, P. and D. Sachs. 1992. Simulation of the consequences of red alder management on the growth of Douglas-fir using FORCYTE-11. B.C. Ministry of Forests FRDA Report 187. 45 p.

Keywords: planting operations
yield
computer modeling

Abstract: The ecosystem model FORCYTE-11 was used to investigate the effects of initial red alder (Alnus glutinosa) density on yields of Pseudotsuga menziesii and alder over a 80-year rotation, the effects of delayed planting of red alder on stand yields, and the effects of 5 management strategies on the total yield over a 240-year period.

OSU Link
Non-OSU Link

21. Copes, D.L. and M. Bordelon. 1994. Effects of tree spacing and height reduction on cone production in two Douglas-fir seed orchards. Western-Journal-of-Applied-Forestry 9(1): 5-7.

Keywords: seed orchard management
planting operations
reproduction

Abstract: Two treatments involving tree spacings (12 and 24 ft) within rows spaced 24 ft apart and height control (topped or not topped at 20 ft) were evaluated in 17- and 22-yr-old coast Douglas fir (Pseudotsuga menziesii var. menziesii) seed orchards in Oregon. Treatment differences for cone production were not significant because of the large tree-to-tree variation in cone production and, at one orchard, the confounding of location with treatment. Cone production in 1990 averaged slightly more than 2 bushels per tree (range 0 to 11.7 bushels). Average production per 96 linear ft of orchard row was 14.8 bushels.

OSU Link
Non-OSU Link

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

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

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

OSU Link
Non-OSU Link

23. DeYoe, D.R., H.R. Holbo and K. Waddell. 1986. Seedling protection from heat stress between lifting and planting. Western-Journal-of-Applied-Forestry 1(4): 124-126.

Keywords: nursery operations

planting operations
tree/stand protection
tree/stand health

Abstract: Seven protective treatments were evaluated for preventing overheating of 2+0 Douglas fir seedlings in Kraft paper bags. Trials were conducted in May 1982 at Corvallis, Oregon on 3 clear days with max. air temp. of 78 degrees F and a hazy day with max. temp. 66 degrees . Seedlings were returned to cold storage (35 degrees) overnight. Seedling temp. differed significantly between treatments. Unprotected seedlings (paper bag only) in full sun reached 89 degrees after 7 h. Green canvas caused increased heating rates and higher temp. (104 degrees after 7 h). A white sheet and a crinkled foil wrap performed no better than a paper bag alone. Canvas painted off-white reduced max. temp. to 80 degrees . Heavy shading (2% of full sun) and Mylar with white surface towards the sun were the most effective materials for preventing overheating (max. temp. 59-60 degrees). Mylar with the silver surface facing the sun was less effective (max. temp. 71 degrees).

OSU Link
Non-OSU Link

24. Donegan, K.K., L.S. Watrud, R.J. Seidler, S.P. Maggard, T. Shiroyama, L.A. Porteous and G. DiGiovanni. 2001. Soil and litter organisms in Pacific Northwest forests under different management practices. Applied Soil Ecology 18:159-175.

Keywords: planting operations
site preparation
prescribed fire
soil properties

Abstract: Soil and litter organisms were monitored for their response to different forest management practices. Litter and soil cores (0-10, 10-20 cm) were collected at approximately 8-week intervals over a 19-month period from a low elevation 110-140-year-old Douglas fir (Pseudotsuga menziesii) forest and adjacent 8-year-old clearcut in the Oregon Cascades, and from a high elevation 200-250-year-old Douglas fir forest and adjacent 5-year-old clearcut in the McKenzie River drainage. The low elevation clearcut had been broadcast burned and replanted with Douglas fir trees and a grass (Dactylis and Lolium)-legume (Trifolium and Lotus) mixture whereas the high elevation clearcut was not burned, large woody debris was left, and it was replanted with Douglas fir, Noble fir [Abies procera], Grand fir [Abies grandis], and western white pine [Pinus monticola]. The litter and soil cores were analysed for types of microarthropods and numbers of nematodes, fungi, culturable, aerobic bacteria, spore-forming bacteria, and chitin-degrading bacteria. Microbial community metabolic profiles, using the Biolog method, were also generated for the 0-10 cm soil samples. Populations of Pseudomonas spp. were analysed in the litter and soil samples using 16S rDNA fingerprints. Plant surveys were conducted to identify potential relationships of soil organisms to plant community composition. At both elevational field sites, there were significantly ($P < 0.05$) higher levels of nematodes and microarthropods in litter and soil in forest plots than in clear felled plots. Bacterial and fungal populations were also significantly higher in litter in forest plots than in clear felled plots at the high elevation site. In the litter and soil at the low elevation site and the soil at the high elevation site, however, microbial levels were higher in clear felled plots than in forest plots. The Pseudomonas spp. populations and the microbial community metabolic profiles in the 0-10 cm soil differed significantly between the forest and clear felled plots at the low elevation site but not at the high elevation site. At both elevational field sites, the plant cover

(%) and plant density were significantly higher in clear felled plots than in forest plots. These observed differences in the population size and composition of organisms between mature forests and both low management and high management clearcuts demonstrated the impacts forest management practices may have on the soil ecosystem.

OSU Link
Non-OSU Link

25. 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

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

Keywords: pruning
planting operations
wood quality
economics

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

OSU Link
Non-OSU Link

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

Keywords: planting operations
tree morphology
wood quality

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

OSU Link
Non-OSU Link

28. 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

29. 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

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

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

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

OSU Link
Non-OSU Link

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

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

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

OSU Link
Non-OSU Link

32. 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

33. 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

34. 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

35. 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

36. 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

37. 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

38. 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

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

Keywords: planting operations
fertilization
thinning
wood quality

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

OSU Link
Non-OSU Link

40. 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

41. 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

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

Keywords: planting operations
wood quality
tree morphology

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

OSU Link
Non-OSU Link

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

Keywords: planting operations
wood quality

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

OSU Link
Non-OSU Link

44. 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

45. Knowe, S.A. 1994c. Silvicultural and economic value of vegetation management in the Pacific northwest. *In* Weed science education: the cost of ignorance: Proceedings of the 47th annual meeting of the Southern Weed Science Society, Dallas, Texas, USA, 17-19 January, 1994. pp. 92-97.

Keywords: planting operations
release treatments
yield
economics

Abstract: Models indicated that the yield and net present value (NPV) of young Pseudotsuga menziesii stands in Oregon varied with site index and planting density. Effects of hardwood competition in 20-year-old plantations were predicted using the Regional Vegetation Management Model (RVMM). A stand table so produced was used for developing ORGANON, which simulated silvicultural treatments and growth for 40-60 years. Output from this was used to evaluate the economic consequences of hardwood competition using ORGECON. It was found that the least impact was observed at low site index with high planting density. Modifications to the models are suggested.

46. Knowe, S.A., W.I. Stein and L.J. Shainsky. 1997. Predicting growth response of shrubs to clear-cutting and site preparation in coastal Oregon forests. Canadian-Journal-of-Forest-Research 27(2): 217-226.

Keywords: planting operations
site preparation
chemical preparation
mechanical preparation
prescribed fire
stand conditions

Abstract: Cover-projection models were developed based on algebraic difference formulations of an exponential-power function to describe shrub recovery and development patterns following clear cutting, site preparation and Douglas fir (Pseudotsuga menziesii) planting at 4 sites in the Siuslaw National Forest, Oregon. The sites formed part of the Coastal Site Preparation Study initiated in 1980, in which the effects were tested of 6 treatments on shrub growth patterns. Treatments were: none other

than scalping a 30-cm spot when each 2-0 seedling was planted (control); spot clearing by cutting to 15 cm height all woody vegetation within a 1.2 m radius of the seedling; spraying with glyphosate (2.52 kg a.e./ha) in early autumn 1980; broadcasting burning slash in midsummer 1980; manually slashing all woody vegetation in June 1980 and broadcast burning later in the summer; and spraying with picloram + 2,4-D (Tordon 101) in May or June 1980 (at 1.49 + 5.97 kg a.e./ha) and broadcast burning in the summer. Results on the development of Douglas fir and associated vegetation to age 10 yr have already been reported for this study (Stein (1995) Research Paper - Pacific Northwest Research Station, USDA Forest Service, No. PNW-RP-473; Knowe & Stein (1995) Canadian Journal of Forest Research 25 (9) 1538-1547). The shrub cover-projection models were developed by incorporating indicator variables into the model rate and shape parameters for the recovery of 3 specific shrubs (salal, Gaultheria shallon; thimbleberry, Rubus parviflorus; and salmonberry, Rubus spectabilis), and all shrubs. For salal, the shape parameter included an adjustment for burning treatments that delayed maximum cover by several years in comparison with unburned treatments. The rate parameter in the thimbleberry model was adjusted for burning treatments; maximum cover occurred about 2 yr earlier in burned than in unburned treatments. Both rate and shape parameters in the salmonberry model were adjusted for burning treatments; delayed established but increased growth rate and less salmonberry cover are characteristic of burned treatments compared with the unburned treatments. The rate and shape parameters in the model for the shrub group included adjustments for burning treatments. Overstorey removal fostered shrub development, whereas site preparation treatments slowed and curtailed it. The final cover-projection models accounted for 68-92% of the total variation in cover, with the adjustments for burning accounting for 1.5-3.3% of the variation. The predicted growth patterns are consistent with trends in site occupancy and published autecological characteristics.

OSU Link
Non-OSU Link

47. 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

48. 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

49. 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

50. Livingston, N.J. and T.A. Black. 1987a. Stomatal characteristics and transpiration of three species of conifer seedlings planted on a high elevation south-facing clear-cut. Canadian-Journal-of-Forest-Research 17(10): 1273-1282.

Keywords: planting operations
tree physiology

Abstract: One-yr-old containerized seedlings of Douglas fir, western hemlock and Abies amabilis were planted in spring 1981-82 with various shade and irrigation treatments on a 30 degrees S.-facing slope at 1150 m alt. on Mt. Arrowsmith, Vancouver Island, British Columbia. Stomatal responses to

environmental and physiological variables were measured for 2 yr. Responses of stomatal conductance to global solar irradiance, air temp., changes in turgor and soil water potentials, and changes in vapour pressure deficit did not differ between years or between planting dates for any species. A simple multiplicative boundary-line model was developed to describe the variability in stomatal conductance and to estimate daily seedling transpiration.

OSU Link
Non-OSU Link

51. Livingston, N.J. and T.A. Black. 1987b. Water stress and survival of three species of conifer seedlings planted on a high elevation south-facing clear-cut. Canadian-Journal-of-Forest-Research 17(9): 1115-1123.

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

Abstract: Container-grown seedlings (1+0) of Douglas fir, western hemlock and Abies amabilis were planted in spring 1981 and 1982 at 1150 m alt. on a 30 degrees S.-facing slope on Mt. Arrowsmith, Vancouver Island, British Columbia. Treatments at planting included inclining seedlings to the SW (thus shading the root collar with the foliage) and provision of shade cards and/or irrigation. Control seedlings received no treatment. Seasonal and diurnal courses of twig xylem water potential, turgor potential and osmotic potential were measured and the relation between transpiration and soil water potential was determined. Seedling survival was recorded in April 1982-84. Douglas fir seedlings showed a high degree of drought tolerance by considerable osmotic adjustment that enabled seedlings to maintain turgor throughout the growing season. Douglas fir seedlings thus survived severe drought and maintained daily transpiration rates that were never less than 50% of those of irrigated seedlings. Transpiration rates were reduced, however, on days of high vapour pressure deficits because of stomatal closure. Western hemlock and, especially, A amabilis lacked both stress avoidance and stress tolerance mechanisms and consequently suffered high mortality. In April 1984, untreated Douglas fir seedlings had 72-82% survival, while treated seedlings had 81-95% survival. Shade cards and/or irrigation increased survival of western hemlock and A. amabilis, but not to the rates shown by Douglas fir.

OSU Link
Non-OSU Link

52. 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

53. Lopushinsky, W. and T.A. Max. 1990. Effect of soil temperature on root and shoot growth and on budburst timing in conifer seedling transplants. New-Forests 4(2): 107-124.

Keywords: planting operations
tree morphology
tree phenology
tree physiology

Abstract: Results are presented of studies of tree seedling morphological responses to a wide range (0-30 degrees C) of soil temperatures and the effects of soil temperature on needle water potential and stomatal conductance in ponderosa pine (P. ponderosa). Bare-root 2-year-old seedlings from high-altitude seed sources in the Cascade Mountains (Washington and Oregon states) were used for the morphological study. Root growth in Douglas fir (Pseudotsuga menziesii), Pacific silver fir (Abies amabilis), noble fir (Abies procera), lodgepole pine (Pinus contorta) and ponderosa pine began when soil temperature exceeded 5 degrees C. Root growth increased rapidly after 10 degrees C and attained maximum values at 20 degrees C. At 30 degrees C, no root growth occurred in the firs; in the pines, root growth was 30 to 39% of maximum. Maximum shoot growth also occurred at 20 degrees C. In ponderosa pine, height growth of seedlings from a high-altitude source was unaffected by cold soil, but in low-altitude seedlings it was reduced. Budburst in Douglas fir and the pines was delayed up to 11 days by cold soil, whereas in silver fir and noble fir, it was only slightly delayed. Prior to new root growth in ponderosa pine, xylem pressure potentials and stomatal conductances during the afternoon indicated reduced stomatal opening at all soil temperatures, whereas 23 days later, stomata were open to a greater degree when temperatures exceeded 10 degrees C. Implications of these results are briefly discussed: although root growth was initiated at soil temperatures of 5 degrees C, this does not imply that seedlings should not be transplanted until soils reach that temperature.

OSU Link
Non-OSU Link

54. 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.

OSU Link
Non-OSU Link

55. 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

56. 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 NetWorth (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

57. 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

58. McKay, H.M. and A.D. Milner. 2000. Species and seasonal variability in the sensitivity of seedling conifer roots to drying and rough handling. Forestry-Oxford 73(3): 259-270.

Keywords: planting operations
tree physiology
tree/stand health
tree phenology

Abstract: The ability of the fine root system of 2-year-old bare-rooted planting stock of Picea sitchensis of Queen Charlotte Islands (British Columbia, Canada), Oregon and Alaskan (USA) provenances, Pseudotsuga menziesii, Larix kaempferi and Pinus sylvestris to withstand standard drying and rough handling treatments was tested at regular intervals from September 1990 until April 1991, at a nursery in NE England. Details are given of nursery treatments (sowing in spring 1989; undercutting in year 2 in June-mid-August, depending on species, and wrenching at 2-wk intervals until mid-October; and lifting at 2-wk intervals from September-November 1990 to April 1991). Electrolyte leakage was used to quantify the damage to the fine roots. Stressed seedlings had significantly greater leakage values than untreated seedlings and dried seedlings had significantly greater leakage values than roughly handled seedlings, but the responses varied with species and lifting date. After drying, leakage values increased in the order P. sitchensis (Oregon and Queen Charlotte Islands), P. sylvestris, L. kaempferi, P. sitchensis (Alaskan), P. menziesii. Leakage values after rough handling increased in the order P. sitchensis (Alaskan

and Queen Charlotte islands), L. kaempferi, P. sitchensis (Oregon), P. sylvestris, P. menziesii. Leakage values were greatest in early September. During September and October there was a rapid downward trend in leakage. From December to February, leakage values decreased very slowly. In March leakage values of untreated and roughly handled seedlings increased slightly but decreased further in dried seedlings. These results indicate that great care must be taken during autumn planting to protect bare-rooted seedlings, particularly P. menziesii, from drying and to a lesser extent rough handling. Fine root leakage values following drying and rough handling had a significant linear relationship with the logarithm of the number of days required for the terminal bud to burst.

OSU Link
Non-OSU Link

59. 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

60. 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

61. 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

62. 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.

OSU Link
Non-OSU Link

63. 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

64. 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

65. 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

66. 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

67. 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

68. 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

69. 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

70. 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

71. 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

72. 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

73. 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

74. Prescott, C.E. and L.M. Zabek. 1999. Decomposition and nitrogen mineralization in forests of British Columbia: effects of forest management practices. *In* Proceedings: Pacific Northwest forest and rangeland soil organism symposium; 1998 March 17-19; Corvallis, OR.Pacific-Northwest-Research-Station, USDA-Forest-Service General-Technical-Report PNW-GTR-461. *Eds.* R.T. Meurisse, W.G. Ypsilantis, and C. Seybold. 124-136 pp.

Keywords: planting operations
fertilization
soil properties

Abstract: The productivity of most forests in the Pacific Northwest is limited by the availability of nitrogen. Nitrogen availability is largely controlled by the rate at which N is recycled from organic matter, through the processes of decomposition and mineralization. These processes are controlled by the factors that limit the activities of the soil organisms involved, particularly temperature, moisture, and the physical and chemical nature of the organic matter. Forest management activities may influence each of these factors and thereby affect rates of decomposition, N mineralization and N availability. The influences of several common forest management activities on decomposition and N mineralization were examined in a suite of experiments across British Columbia, Canada. Rates of decomposition were compared in forests and adjacent clear felled areas at 22 sites, and rates were either the same or slower in the felled areas. Several sites had additional silvicultural treatments that provide a range of either opening size or removal intensity. Decomposition rates were not influenced by opening size, but rates of net N mineralization and nitrification were increased in openings greater than 0.1 ha. Tree species influences N mineralization in the forest floor, with highest rates occurring in Douglas-fir and broadleaf species and lowest rates in cedar and pines. The decomposition rates of foliar litters was best predicted

by its lignin concentration. The influence of managing to maintain a component of broadleaf species was examined in decomposition experiments with pure and mixed litter of aspen and spruce, Douglas-fir and alder, and lodgepole pine, Douglas-fir and paper birch. There was no effect of mixing litters on their rates of decomposition. Likewise, N fertilization had no effect on decomposition rates in trials in coastal Douglas-fir and aspen.

OSU Link
Non-OSU Link

75. 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

76. 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

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

Keywords: planting operations
pruning
wood quality

OSU Link
Non-OSU Link

78. 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

79. 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.

80. 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

81. 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

82. 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

83. 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

84. 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

85. 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

86. 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

87. Sullivan, T.P. and D.S. Sullivan. 1985. Operational direct seeding of Douglas-fir and lodgepole pine with alternative foods in British Columbia. B.C.-Ministry-of-Forests Research-Note 97. vi + 16 p.

Keywords: planting operations
tree/stand protection
tree/stand health
economics
reproduction

Abstract: Direct sowing of clear-felled areas in temperate coniferous forests of N. America has often been hampered because of seed predation by rodents and birds. In trials in British Columbia, seed predation was considerably reduced when Douglas fir (Pseudotsuga menziesii) seed was mixed with sunflower seed (7:1 sunflower to Douglas fir) or with sunflower seed and oat kernals (5:2:1 sunflower/oats/Douglas fir) or when lodgepole pine (Pinus contorta) seed was mixed with sunflower seed (2:1 sunflower to pine). The economics of providing alternative food for the predators and operational considerations are discussed.

OSU Link
Non-OSU Link

88. 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

89. Tarrant, R.F., B.T. Bormann, D.S. DeBell and W.A. Atkinson. 1983. Managing red alder in the Douglas-fir region: some possibilities. Journal-of-Forestry 81(12): 787-792.

Keywords: planting operations
fertilization
yield

economics

Abstract: An economic comparison of 3 systems for growing Alnus rubra (rotations of 13,20 and 28 yr) in the Pacific Northwest USA, with or without alternating rotations (45 yr) of Douglas fir, and 2 continuous systems for growing Douglas fir (45-yr rotations with or without treatment with N fertilizer). Anticipated stand yield, and costs of site preparation, planting, fertilization etc. were used to estimate m.a.i. (vol.), present net worth and internal rate of return. The 2 most profitable systems were Douglas fir, thinned and treated with fertilizer twice in 45 yr (present net worth $623/acre) and red alder grown to sawlog size (28 yr) alternating with Douglas fir thinned twice in 45 yr (present net worth $578/acre). The least profitable system was red alder grown continuously in 13 yr rotations (present net worth -$251/acre). Alternate cropping of red alder and Douglas fir or continuous red alder production would be as profitable as growing Douglas fir alone if there were increases in real interest rate, alder stumpage price, or the cost of N fertilizer, or alder sawlog rotation length decreased.

OSU Link
Non-OSU Link

90. Tedder, P.L. 1981. Reforestation of steep sites with skeletal soils - is it economically realistic? *In* Reforestation-of-skeletal-soils. *Eds.* S.D. Hobbs and O.T. Helgerson, Forest Research Laboratory, Oregon State University, Corvallis, OR. pp. 105-108.

Keywords: planting operations
economics

Abstract: The lack of data concerning volume yields from steep sites with skeletal soils precludes any substantive analysis. However, with projections of moderate increases in real stumpage prices of Douglas-fir, regeneration of Sites IV and below indicate that a rate of return less than five percent (real) will be realized.

Non-OSU Link

91. Thies, W.G. and R.N. Sturrock. 1995. Laminated root rot in Western North America. Pacific Northwest Research Station, USDA Forest Service General Technical Report GTR-PNW-349. iv + 32 pp. p.

Keywords: planting operations
site preparation
mechanical preparation
fertilization
thinning
tree/stand protection
tree/stand health

Abstract: Laminated root rot, caused by Phellinus weirii, is a serious root disease affecting Douglas fir (Pseudotsuga menziesii) and other commercially important species of conifers in northwestern North America. This report gives an overview of the disease as it occurs in the Pacific Northwest in Canada and the USA. Information on recognizing crown symptoms and signs of the disease is presented. The disease cycle of laminated root rot, from initiation to intensification and distribution within infected stands, is

described. Finally, disease management strategies during stand development and at stand regeneration are discussed. Features on the nomenclature of the fungus and on its management by silvicultural and mechanical approaches also are included.

OSU Link
Non-OSU Link

92. 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

93. Wilson, J. 2004. Vulnerability to wind damage in managed landscapes of the coastal Pacific Northwest. Forest-Ecology-and-Management 191(1/3): 341-351.

Keywords: planting operations
thinning
tree/stand protection
computer modeling
tree/stand health

Abstract: Managed forested landscapes in the coastal Pacific Northwest follow a pattern of transition from dominance by naturally regenerated second growth to dominance by planted stands. This transition should have dramatic influence on many characteristics of these landscapes and the larger region, including susceptibility to wind damage. In this paper, inventory and spatial information from an example landscape are integrated using the Landscape Management System to produce alternative management scenarios and evaluate the projections using a wind damage vulnerability rating system. Planted Douglas-fir stands tend to develop higher height to diameter ratios in the dominant trees, are thinned more often, and tend to have more exposed windward edges; characteristics which increase susceptibility to wind damage. In this analysis, the increasing vulnerability factors are mostly compensated for by the reduced rotation lengths expected in the plantations. The pattern of transition in managed landscapes generates an associated pattern of vulnerability to wind damage. Homogeneously and heterogeneously aged landscapes have distinct patterns of vulnerability. These differences could be harnessed to enhance the particular goals associated with managing individual ownerships.

OSU Link
Non-OSU Link

94. Wilson, J.S. and P.J. Baker. 2001. Flexibility in forest management: managing uncertainty in Douglas-fir forests of the Pacific Northwest. Forest-Ecology-and-Management 145(3): 219-227.

Keywords: planting operations

thinning
yield
tree morphology
economics
tree/stand health

Abstract: Long planning horizons generate substantial uncertainty in forest management, making management flexibility, the ability to choose between multiple options or opportunities, a desirable attribute of managed forests. Flexibility in forest management reflects both the relative rigidity of intervention requirements and the potential range of development pathways for a stand. The wind stability of Pacific Northwest Douglas-fir (Pseudotsuga menziesii) plantations is used to demonstrate the concept of management flexibility. Dense Douglas-fir plantations develop high height to diameter ratios in the dominant trees making them unstable and prone to wind damage. The management of these plantations is inflexible, because without early and timely thinning, the stands do not contain stable trees that could be expected to survive long rotations or late thinnings. A combination of reduced planting densities and site-specific management reduces both the necessity and rigidity of intervention requirements (e.g., thinning) and expands the number of potential developmental pathways for these stands. The cost of greater management flexibility is reduced efficiency of wood volume production; however, greater adaptability to changing markets, labour conditions, and management objectives may be more important for many forest owners. While this approach to management is complex, it frees owners and managers from rigid management requirements and allows for a wider range of future stand conditions.

OSU Link
Non-OSU Link

95. Wilson, J.S. and C.D. Oliver. 2000. Stability and density management in Douglas-fir plantations. Canadian-Journal-of-Forest-Research 30(6): 910-920.

Keywords: planting operations
thinning
tree/stand protection
tree morphology
tree/stand health

Abstract: Limited tree size variation in Douglas fir (Pseudotsuga menziesii) plantations in coastal Oregon, Washington, and British Columbia makes them susceptible to developing high height to diameter ratios (H/D) in the dominant trees. The H/D of a tree is a relative measure of stability under wind and snow loads. Experimental plot data from three large studies were used to evaluate the impact of initial planting densities and thinning on plantation H/D values. The H/D predictions from the experimental plot data match spacing trial results closely but are substantially different from distance-independent growth model predictions. The results suggest that plantation H/D values can be lowered and stability promoted through reduced planting densities or early thinning; however, later thinnings may not be effective in promoting stability, since they do not appear to lower H/D values. Higher initial planting densities shorten the time period during which thinning can be expected to effectively lower future H/D values. Time-sensitive thinning requirements in dense plantations make their management inflexible. The flexibility with which a stand can be managed describes the rigidity of intervention requirements and/or potential range of stand development pathways.

OSU Link
Non-OSU Link

96. 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

97. 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.