Carbon Allocation

1. Barclay, H.J., P.C. Pang and D.F.W. Pollard. 1986. Aboveground biomass distribution within trees and stands in thinned and fertilized Douglas-fir. Canadian-Journal-of-Forest-Research 16(3): 438-442.

Keywords: fertilization
thinning
carbon allocation

Abstract: Nine years after heavy thinning and fertilization with urea, 34-yr-old Douglas firs at Shawnigan Lake (British Columbia) were destructively sampled. Dry wt. of seven aboveground components (wood, bark, dead branches, new or old foliage, new twigs and live branches) were determined and regression equations from d.b.h. were developed. Differences among treatments were shown for all biomass components and for the proportion of the total biomass allocated to each component. Thinning reduced the proportion of wood, bark and dead branches while increasing the proportion of foliage and live branches. Fertilization increased the proportion of branches but had negligible effects on the proportions of other components.

OSU Link
Non-OSU Link

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

Keywords: fertilization
thinning
tree morphology
carbon allocation
growth

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

OSU Link
Non-OSU Link

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

Keywords: fertilization

thinning
growth
carbon allocation
tree morphology

Abstract: [See FA 43, 1948, 3839] On Vancouver Island, aboveground biomass and annual production over 7 yr was studied in relation to thinning and nitrogen fertilization at 24 yr old. Biomass yield of both treatments increased during the first 3-4 yr then decreased for fertilization but not with thinning. Treatments doubled biomass production of individual trees over the study period when applied separately and quadrupled it when combined. Annual biomass production per unit of foliage (E) increased during the first 3-4 yr, but was at or below control level after 7 yr. E accounted for 20, 37, and 27% of the stemwood dry matter response to thinning, fertilization and the combined treatments, respectively; the remainder was attributed to an increase in foliage biomass. Thinning, but not fertilization, influenced distribution of radial growth along the stem, increasing growth only below the top one-third of the stem. This pattern was related to crown development.

OSU Link
Non-OSU Link

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

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

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

OSU Link
Non-OSU Link

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

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

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

OSU Link
Non-OSU Link

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

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

Abstract: In pot experiments levels of P fertilizers equivalent to 300 kg/ha were adequate for maximum growth of Douglas fir (Pseudotsuga menziesii var. menziesii) seedlings over 14-18 weeks, and resulted in available soil P levels of 80 ppm after 15 weeks' growth. Maximum growth in pots was obtained with shoot P concentrations of 0.18%-0.20%, with higher values at lower temperatures, but the optimum concentration for one-year-old (1-0) nursery seedlings was 0.16% P. Growth of seedlings was greatly restricted at a soil temperature of 5 degrees C and an air temperature of 12 degrees C. At a soil temperature of 10 degrees C and an air temperature of 14 degrees C seedling P requirement was greater than at soil and air temperatures of 20 degrees C. Monoammonium phosphate was more effective than calcium superphosphate in stimulating growth in pots and nursery beds.
Triple superphosphate was also effective in the nursery. Diammonium phosphate, potassium dihydrogen phosphate and phosphoric acid had no advantages as P sources in the nursery. Available P levels of 100-130 ppm, in the loamy sand and sandy loam nurseries studied, and needle P concentrations of 0.18%, when sampled in October, were associated with maximum growth of two-year-old (2-0) seedlings. P fertilization decreased the root/shoot ratio, but did not alter the allometric relationship of shoot to root. Improving the P status from a low level increased the root growth capacity in 2-0 seedlings and P fertilization of potted seedlings increased the dry weight/height ratio. Uptakes per seed bed ha of 236 kg N, 31 kg P, 81 kg K and 73 kg Ca by 2-0 seedlings were

comparable with, or greater than, uptake rates of agricultural crops. Recoveries of 6-11% of P from fertilizer were recorded in the nursery.

OSU Link
Non-OSU Link

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

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

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

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Non-OSU Link

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

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

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

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

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

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

nursery temperature continued to affect growth 16 weeks after planting, increasing relative growth rate and allometric ratio (K) of Douglas fir and reducing K of white spruce.

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Non-OSU Link

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

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

Abstract: Douglas fir (Pseudotsuga menziesii), lodgepole pine (Pinus contorta), and white spruce (Picea glauca) seedlings, each represented by two seed lots, were grown in Styroblock containers in a greenhouse and plastic shelter house from February 1989 to January 1990. The seedlings were exposed to two N treatments (20 and 200 mg/litre) and three K treatments (5, 25 and 100 mg/litre) arranged factorially within three drought treatments. After winter storage, seedlings from a complete set of treatments were planted into hygric,mesic and xeric sand beds during 12-14 March. Increasing nursery drought stress increased survival of Douglas fir and lodgepole pine after planting, and high N treatment level increased survival of lodgepole pine and white spruce. Under xeric conditions, combined nursery drought and high N treatments increased survival of lodgepole pine by 33%, indicating the importance of nursery cultural regime for stock quality. Increase in nursery drought stress did not decrease seedling size by much; increase in N increased seedling size one season after planting. A positive relation between shoot : root ratio and survival in lodgepole pine and white spruce indicated that increase in N increased both shoot growth and drought resistance over the N range investigated. Only Douglas fir showed an interaction between drought and N treatment and a small response in both survival and dry weight to K application. Root growth capacity, measured at the time of planting, showed an approximate doubling in all species due to high N treatment, and was also increased in white spruce by drought stress. Survival and root growth capacity were poorly correlated, but dry-weight growth in sand beds was well correlated with root growth capacity. Shoot dry weight and percentage N in shoots measured after nursery growth were correlated with root growth capacity. Manipulation of root growth capacity by changing nursery treatment was possible without altering resistance to drought stress after planting.

OSU Link
Non-OSU Link

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

Keywords: genetic tree improvement

nursery operations
genetic relationships
growth
carbon allocation
tree phenology

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

OSU Link
Non-OSU Link

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

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

Abstract: Second-growth stands of Douglas-fir (Pseudotsuga menziesii) were thinned to a 5- x 5-m spacing (TT); additional plots were thinned and fertilized once with 360 kg of N (as urea)/ha (TF). An unthinned, unfertilized stand (UT) served as a control. Ten years after treatment, trees were inoculated with 2 isolates of A. ostoyae. Trees receiving the TF and TT treatments produced greater diameter growth, leaf area, and wood production/msuperscript 2 leaf area per year than did those under the UT treatment. Rates of infection by A.ostoyae were highest in trees that received the TF and lowest in trees that received the TT treatment. Concn of sugar, starch and cellulose in root bark tissue were highest in trees receiving the TF treatment and lowest in trees receiving TT treatment. Concn of lignin, phenolicsand protein-precipitable tannins were highest in root bark from TT trees and lowest in root bark from TF trees. Biochemical parameters of root bark tissue were regressed with incidence of infection; coefficients of determination (rsuperscript 2) ranged from 0.07 (starch) to 0.57

(phenolic compounds). Ratios of the energetic costs of phenolic and of lignin degradation to the energy available from sugars (Epd:Eas and Eld:Eas) were correlated with incidence of infection (rsuperscript 2 = 0.77 and 0.70, respectively). It is concluded that thinning combined with fertilization may predispose P. menziesii trees to infection by A. ostoyae by lowering concn of defensive compounds in root bark and increasing the energy available to the fungus to degrade them.

OSU Link
Non-OSU Link

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

Keywords: nursery operations
growth
carbon allocation
mycorrhizal response
soil properties

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

OSU Link
Non-OSU Link

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

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

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

OSU Link
Non-OSU Link

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

Keywords: fertilization
growth
carbon allocation
tree morphology

Abstract: Twenty three yr old trees growing on a class III site in Washington State were fertilized with 225 kg/ha N in March 1980. Trees were measured before fertilizing and after 1980-83 growing seasons

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

OSU Link
Non-OSU Link

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

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

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

OSU Link
Non-OSU Link

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

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

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

OSU Link
Non-OSU Link

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

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

Abstract: The effects of thinning (two-thirds of basal area removed) and N fertilizer (448 kg N/ha as urea) on biomass and nutrition of a 24-year-old Douglas fir (Pseudotsuga menziesii) stand at Shawnigan Lake, British Columbia, were studied over 18 years. At years 0, 9, and 18 after treatments, the aboveground biomass and N, P, K, Ca, and Mg contents of stemwood, stem bark, foliage, and dead and live branches were determined (kg/ha), and increments in these properties (kg/ha per year) were calculated for the 0-9 and 9-18 year periods. Foliar biomass was increased by both treatments during

the first period and also by thinning in the second period. Aboveground net primary production (ANPP) per unit of foliage biomass (foliage efficiency) was increased by treatments in the 0-9 year period. The combined effects of increased foliage mass and foliage efficiency resulted in increased total biomass production. Thinning and fertilizer application increased the uptake of all elements except for P with fertilizer. This increase may have contributed to the long-term increase in stem growth. Retranslocation of elements before foliage shedding was important for tree nutrition, but was not improved by fertilizer during the 9-18 year measurement period. The efficiency of N use in dry matter production (ANPP/unit of N uptake) was decreased by fertilizer. This implied that poor sites would respond to fertilizer better than rich sites.

OSU Link
Non-OSU Link

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

Keywords: thinning
tree morphology
carbon allocation
growth

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

OSU Link
Non-OSU Link

20. 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

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

Keywords: thinning
commercial thinning
growth
tree morphology
carbon allocation

Abstract: The growth of individual trees from four thinning treatments in a 64-yr-old Pseudotsuga menziesii stand in western Washington was analysed to determine desirable residual stand structures after thinning. Dominant and codominant trees had the highest individual tree stem vol. growth rates over the previous 5 yr and accounted for most stand vol. growth in thinned and unthinned stands. Two measures of growing space, crown projection area and sapwood b.a. (a surrogate for leaf area), were used to measure how efficiently individual trees used their growing space. Crown classes were useful in characterizing growing space efficiency (vol. growth per unit of growing space) only in the unthinned treatment. In thinned treatments, tall trees with medium-sized crowns were most efficient, while in the unthinnedtreatment tall trees with relatively large crowns were most efficient. A large crown in an unthinned stand was comparable in size to a medium-sized crown in a thinned stand. Results suggest growing space is not limiting individual tree growth in thinned stands and that thinning to a particular stand structure is more appropriate than thinning to a particular stand density.

OSU Link
Non-OSU Link

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

Keywords: thinning
commercial thinning

growth
carbon allocation
tree morphology

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

OSU Link
Non-OSU Link

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

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

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

OSU Link
Non-OSU Link

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

Keywords: nursery operations

tree phenology
tree physiology
growth
tree morphology
carbon allocation

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

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

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

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

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

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

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

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

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

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

OSU Link
Non-OSU Link

28. 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

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

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

Abstract: Mortality and growth of self and outcross families of three wind-pollinated, mixed-mating, long-lived conifers - Douglas fir (Pseudotsuga menziesii), ponderosa pine (Pinus ponderosa), and noble fir (Abies procera), were followed from outplanting to age 26 (25 for noble fir) in spaced plantings at a

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

OSU Link
Non-OSU Link

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

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

Abstract: Genetic variation and covariation among traits of tree size (volume, basal area, diameter at breast height and height) and structure were assessed in 1991 in an 18-year-old Douglas fir (Pseudotsuga menziesii var. menziesii) genetic test in the Coast Range of Oregon. Considerable genetic variation was found in size, biomass partitioning and wood density, and genetic gains may be expected from selection and breeding of desirable genotypes. Estimates of heritability for partitioning traits, including harvest index (the proportion of fixed carbon converted to stemwood), were particularly high. Foliage efficiency (stem increment per unit leaf area) was correlated with harvest index and may represent an alternative measure of partitioning to the stem. Estimates of foliage efficiency where leaf area was estimated based on stem diameter or sapwood area were unrelated to foliage efficiency where leaf area was measured directly. Strong negative genetic correlations were found between harvest index and stem size, and between wood density and stem size. Large trees were more tapered than small trees. It is concluded that simultaneous genetic gain in stem size and either harvest index or wood density would be difficult to achieve.

OSU Link
Non-OSU Link

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

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

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

OSU Link
Non-OSU Link

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

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

Abstract: Tree improvement programmes have generally relied on testing families in open light environments. With increased interest in multiaged silvicultural systems, some people have questioned whether families selected in the open are appropriate for planting in the shade. Douglas-fir (Pseudotsuga menziesii var. menziesii) families from two climatically distinct seed sources in the Coast Range (NW Oregon) and Siskiyou Mountains (SW Oregon) were grown for 2 years under four levels of shade. The response to shade differed for several traits between the two populations and among families within populations. The magnitude of variation associated with the interaction, however, was small compared with the overall effects of genetic selection or of shade. Families selected based on performance in an open light environment resulted in nearly the same response to selection when grown under shade as families selected based on performance in the shade. It is concluded that seedlings from families selected in an open light environment are appropriate for use in the low-light environments of alternative silvicultural systems and that use of such genetically selected stock may compensate for the less favourable growing conditions. Genetic selection may contribute importantly to meeting multiple objectives, including the production of significant amounts of wood as well as the efficient and timely creation of large stand structures needed for other forest values.

OSU Link
Non-OSU Link

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

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

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

OSU Link
Non-OSU Link

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

Keywords: nursery operations
nursery fertilization
growth
carbon allocation
tree morphology

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

OSU Link
Non-OSU Link

35. Tung, C.H., L. Wisniewski and D.R. DeYoe. 1986b. Effects of prolonged cold storage on phenology and performance of Douglas-fir and noble fir 2+0 seedlings from high-elevation sources. Canadian-Journal-of-Forest-Research 16(3): 471-475.

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

Abstract: Seedlings of Douglas fir and noble fir (Abies procera) were lifted on 7 Nov. 1981 and 1 Mar. 1982 at Wind River Nursery, Washington, and stored at 1-2 degrees C until planting during the third week of June 1982 at 1500 m alt. in the Oregon Cascade Range. There was no difference in survival of Douglas fir attributable to storage treatment during the first two growing seasons. Noble fir seedlings stored for 7 months survived better during the first season than seedlings stored for 3 months, but no difference was evident after the second growing season. Time of bud burst did not differ between treatments for either species and no difference between treatments in rate of bud burst was seen in Douglas fir. Rate of bud burst was significantly greater in noble fir seedlings stored for 7 months than in those stored for 3 months. Shoot/root ratio decreased significantly during the first season for both species and treatments, but stabilized during the second season. Regardless of species, no differences were found in ht. growth and diam. increment between storage treatments. Results suggest that seedlings of these species originating from high alt. sources can be lifted in autumn and cold-stored for 7 months without adverse effects on performance after planting.

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

Keywords: fertilization
thinning
pruning
growth
carbon allocation
tree physiology
tree morphology

Abstract: The effect of thinning and silvicultural practices (multinutrient fertilization and/or pruning) on total aboveground biomass increment and growth efficiency was studied over three consecutive 2-year periods (1981-1987) in young Douglas fir (Pseudotsuga menziesii) plantations in the central Oregon Cascades. Plantations were 21-27 yr old in 1987. Plots were heavily thinned (leaving 300 trees/ha), moderately thinned (leaving 604 trees/ha) or left unthinned (leaving 3459 trees/ha) in 1981. Fertilizer (N, P, K, Ca, S and Fe) was applied with slow-release tabs. Net above-ground biomass annual increment over the 6-year period averaged 14.5, 7.8, and 5.5 t/ha for the high-, medium-, and low-density plots, respectively. Growth efficiency, after dropping sharply between leaf area indexes (LAI) of 1 and 6msuperscript 2/msuperscript 2, remained relatively constant up to the highest measured LAI of 17.

Consequently, above-ground biomass increment continued to increase at LAIs well above that at which the Beer-Lambert law predicts maximum light should be absorbed. Foliage analyses indicated that thinning improved N, K and Mg nutrition and increased the translocation of K from 1-yr-old foliage to support new growth. However, fertilizer application increased foliar N and P contents only when coupled with pruning, suggesting that treesfavour total leaf area over individual needle nutrition. Indications of K and Mg limitations in this study are supported by other recent studies of Douglas fir.

OSU Link
Non-OSU Link

37. Walker, R.B., S.P. Gessel and R.E. Miller. 1994. Greenhouse and laboratory evaluation of two soils derived from volcanic ash. Northwest-Science 68(4): 250-258.

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

Abstract: This study assessed the mineral nutrient status of two soils derived from volcanic ash in SW Oregon. The study was initiated because conifers in some of the field plots on such soils had failed to give an expected yield response to the application of nitrogen fertilizer. Soil pot tests were carried out using both Romaine lettuce (Lactuca sativa) and Douglas fir (Pseudotsuga menziesii) seedlings, with a wide range of fertilizer treatments. Heavy phosphorus fertilization was necessary for satisfactory growth of lettuce, which also showed a 26% response to sulfur addition. With Douglas fir, pot tests showed no response to nitrogen alone, but gave a statistically significant response to phosphorus fertilization together with nitrogen (seedlings were non-mycorrhizal), and some suppression of yield with sulfur additions. There was a favourable effect of sulfur fertilization on foliar colour, and a chlorosis in younger foliage probably attributable to iron deficiency. Most of the tissue analyses showed low concentrations of magnesium (<0.05%), and also of calcium (<less or =>0.08%), iron (<70 mg/kg), boron (mostly 20 mg/kg) and copper (<less or =>2.6 mg/kg) in the younger foliage. Thus there is an implication from the field trials, and evidence from the greenhouse and laboratory study, that elements besides nitrogen need to be added to provide proper nutrition on these volcanic ash soils. The information can aid in guiding further fertilizer trials in forests on volcanic ash derived soil in SW Oregon and elsewhere.

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