

JULY 1999

First-year Growth Responses of Young Red Alder Stands to Fertilization

Kevin Brown
Research Branch
B.C. Ministry of Forests
P.O. Box 9519, Stn Prov Govt
Victoria, BC V8W 9C2
(250) 387-3474
kevin.brown@gems7.gov.bc.ca

The Significance of Red Alder

Red alder (*Alnus rubra* Bong.) is the most abundant deciduous broad-leaved tree species in coastal British Columbia. It is a source of products ranging from firewood to furniture, cabinets, and turned-wood novelties (Plank and Willits 1994). In addition, red alder seedlings are planted to restore roads and landings, to stabilize slides, and to reduce laminated root rot (*Phellinus weirii*) on infected sites. Understanding how to maximize the growth and quality of red alder is important, because more is being planted and harvested in British Columbia. Historically, red alder was unwanted in the Pacific Northwest. In recent years, however, increasing demand for red alder has led to localized shortages in Oregon and Washington (Raettig et al. 1995). In British Columbia, volumes harvested on Crown land have averaged 228 000 m³ per year from 1994 through 1998.¹ Meanwhile, the number of red alder seedlings produced for planting on Crown and private land increased from a yearly average of about 14 000 from 1994 to 1996 to a yearly average of 251 000 from 1997 to 1999.²

Silvical characteristics that make alder an appealing species to grow include (1) juvenile growth rates that greatly exceed those of associated conifers on optimal sites, (2) immunity to laminated root rot, and (3) the ability to fix atmospheric nitrogen, in symbiotic association with the soil actinomycete *Frankia* sp. The ability to fix nitrogen is unique among native trees in British Columbia.

Is Red Alder Growth Limited by Nutrient Availability?

Fertilization is a recognized means of increasing tree growth in coastal forests of British Columbia, but the effects of nutrient additions on the growth of alder in the province are unknown. Nitrogen deficiencies probably do not limit the growth of red alder, in contrast to other native coastal trees, because alder fixes atmospheric nitrogen. However, the availability of elements *other* than nitrogen may affect growth and nitrogen-fixation. For example, site indices of red alder increased with foliar phosphorus concentrations on some rich and very rich sites in southwestern coastal British Columbia (Courtin 1992). Also,

1 B.C. Min. For., Revenue Br., Victoria, B.C., data on file.

2 B.C. Min. For., Nursery and Seed Operations Br., Victoria, B.C., data on file.

fertilization of young red alder with phosphorus, sulphur, and trace elements increased the growth of young red alder in some western Washington soils (Radwan 1987; Radwan and DeBell 1994).

This note summarizes first-year effects of fertilization on stem growth in young red alder plantations on Vancouver Island.

Field Fertilization Trials of Young Red Alder on Vancouver Island

Fertilization trials have been established at nine locations on the east side of Vancouver Island between Duncan and Campbell River (Table 1). Plantation ages at the time of fertilization ranged from 1 to 4 years. Soil moisture regimes range from moderately dry to very moist and soil nutrient regimes range from poor to very rich.

Seedlings were fertilized in the spring with phosphorus, as triple super phosphate (0-45-0), with or without a blend of potassium-magnesium-sulphate (0-0-22-11-22) and fritted trace elements. The latter ("C") fertilizer supplied essential elements other than nitrogen, phosphorus, and

calcium. Treatments were applied to single-tree plots and the number of treatments varied with the number of trees available. Treatments are described further in the sidebar.

To maximize the uptake of added fertilizer, competing understorey vegetation was removed manually. Fertilizers were added in a band around trees in the older plantations and placed in dibble holes around trees in the 1- and 2-year-old plantations. Basal diameters (10 cm above ground level) and heights were measured before fertilization in the spring and again in the following autumn. Stem volume was calculated as basal area² × height/3.

Stem Growth Responses during the Year of Fertilization

Three- and four-year-old plantations: 1997 trials at Bowser, Malaspina, and Quinsam sites

At Bowser, the highest rate of fertilization increased stem volumes by 23% in 1997, compared with unfertilized trees (Figure 1). Fertilization did not increase growth at either the Malaspina or Quinsam sites.

TABLE 1 Alder fertilization trial locations

Site	Year fertilized	Age ^a	Bio-geoclimatic subzone	Soil moisture regime ^b	Soil nutrient regime ^c
Malaspina (Nanaimo)	1997	4	CDF	MD	M-R
Bowser	1997	4	CWHxm	SD-F	M-R
Quinsam (Campbell River)	1997	3	CWHxm	F	R
French Creek (Coombs)	1998 ^d	4	CWHxm	MD	P-M
Hillcrest Road (Duncan)	1998	2	CDFmm	MD	P
Fanny Bay-W	1998	1	CWHxm	VM-W	R-VR
Fanny Bay-D	1998	1	CWHxm	M	VR
Campbell River-L	1998	1	CWHxm	VM	R-VR
Campbell River-U	1998	1	CWHxm	MD	P-M

a Number of years since planting.

b MD=moderately dry; SD=slightly dry; F=fresh; M=moist; VM=very moist; W=wet.

c P=poor; M=medium; R=rich; VR=very rich.

d Competing vegetation was manually removed in June 1997 and in April 1998.

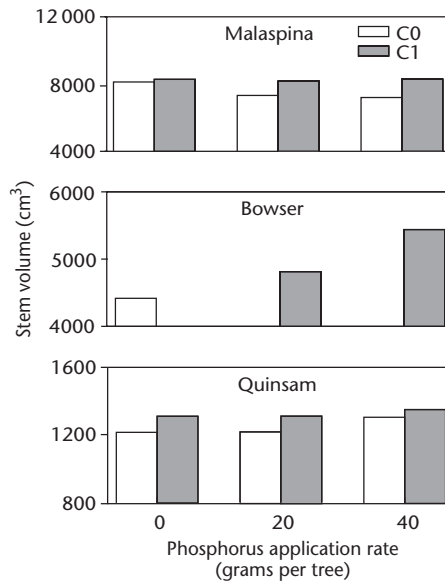


FIGURE 1 Mean stem volumes at the Malaspina, Bowser, and Quinsam sites as of November 1997. Trees were fertilized in May 1997. C0 and C1 refer to trees not fertilized (C0) or fertilized (C1) with the "C" fertilizer.

Fertilization increased foliar concentrations of phosphorus (0.22–0.25%) in conjunction with increased stem growth, but only at Bowser. The foliar concentrations of phosphorus in unfertilized trees at Bowser appeared limiting, based on separate studies of the responses of red alder seedlings to phosphorus fertilization.³ At Malaspina, concentrations of phosphorus were low (0.21–0.22%) but the trees were unresponsive to fertilization. The fertilization rates may have been too low to increase foliar phosphorus concentrations and growth. At Quinsam, concentrations of phosphorus were relatively high (0.27–0.28%) and the trees were unresponsive to fertilization. Foliar concentrations of phosphorus appeared to be adequate, but it is unclear why foliar concentrations did not increase with fertilization.

Fertilization also increased the foliar concentrations of boron at all

three sites. Even though foliar concentrations of boron were similar in the three sites, growth increased only at Bowser. Hence, boron is probably not limiting at these three sites.

Four-year-old plantation: 1997 and 1998 trials at French Creek

Control of understory vegetation appeared important for maximizing the growth responses of alder to fertilization on this relatively dry and infertile site. Vegetation removal in June 1997 increased stem volumes by 21% through November 1998 in unfertilized plots (Figure 2). In contrast, 1998 fertilization increased stem volumes only when combined with the removal of understory vegetation. When this vegetation was removed, the highest rate of phosphorus fertilization, combined with the "C" fertilizer, increased volumes by 25% relative to unfertilized trees. However, stem volumes did not increase (and may have decreased) when only the phosphorus fertilizer was added. When vegetation was removed and the "C" fertilizer added, volumes of

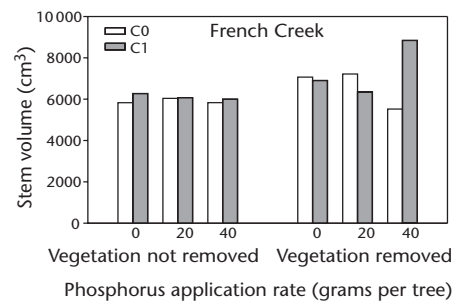


FIGURE 2 Mean stem volumes at French Creek in relation to understory vegetation removal and fertilization with phosphorus and the "C" fertilizer (C), as of November 1998. Understorey vegetation was removed in June 1997 and again in April 1998; fertilizers were applied in April 1998. C0 and C1 refer to trees not fertilized (C0) or fertilized (C1) with the "C" fertilizer.

³ K. Brown, B.C. Min. For., unpubl. data, 1997.

TABLE 2 *First-year changes in stem volume, height, and basal diameter of red alder seedlings with phosphorus fertilization; 1998 trials. See Table 1. Seedlings at Campbell River-U that were frost-damaged and resprouted were not included in the analysis. Percent increase (%) is shown when fertilized trees were significantly larger (P value < 0.10) than unfertilized trees (Fanny Bay and Campbell River-L). For the Fanny Bay and Campbell River sites, growth means associated with a given phosphorus rate include trees that also received the "C" fertilizer; at Hillcrest Road, trees that received phosphorus also received the "C" fertilizer. See text and sidebar for fertilization details.*

Variable	Phosphorus rate (grams per tree)	Fanny Bay-D (n = 99)		Fanny Bay-W (n = 96)		Campbell River-L (n = 164)		Campbell River-U (n = 157)	Hillcrest Road (n=42)
		mean	%	mean	%	mean	%	mean	mean
Volume (cm ³)	pre-treatment	18		17		44		33	300
	0	141		104		285		266	1163
	10	215	+53	124	+19	362	+27	235	1418
	20	200	+42	133	+28	387	+36	293	1134
	30					408	+43	273	
Height (cm)	pre-treatment	77		78		101		79	174
	0	172		151		197		198	298
	10	193	+12	163	+8	214	+9	186	309
	20	191	+11	166	+10	212	+8	204	297
	30					218	+11	199	
Basal diameter (mm)	pre-treatment	9		8		12		12	23
	0	16		14		21		22	36
	10	19	+18	15	+8	23	+11	21	36
	20	19	+13	16	+13	24	+14	22	35
	30					24	+15	21	

trees given the highest rate of phosphorus fertilization were 33% greater than those of trees fertilized with less phosphorus.

One- and two-year-old plantations: 1998 trials at Fanny Bay, Campbell River, and Hillcrest Road

Fertilization with phosphorus significantly increased stem growth (Table 2) at the Campbell River-L and both Fanny Bay sites. Increases in stem volume (relative to unfertilized trees) ranged from 23% at the Fanny Bay-W site to 47% at the Fanny Bay-D site. Fertilization with the "C" fertilizer did not increase growth at any site.

Fertilization did not significantly increase the stem growth of trees at Hillcrest Road, nor at Campbell River-U. At Hillcrest Road, volumes of trees fertilized at the intermediate

rate of fertilization averaged 22% more than in the unfertilized trees. However, small sample sizes (14 trees per treatment) limit our confidence in these results.

Summer drought in 1998 probably minimized growth responses to fertilization at Hillcrest Road and Campbell River-U, both of which were classified as moderately dry. Visible symptoms of drought stress ranged from wilting to senescence of most foliage by early August to seedling death. Seedlings at the Campbell River-U site were also damaged by early March frost. Some tree leaders were killed, but a more widespread effect was the blackening of portions of lower stems and their subsequent infection with the fungus *Gnomonia* sp.⁴ Trees with the most pronounced symptoms resprouted from the base and exhibited little, if

4 Dr. Brenda Callan, pers. comm., April 1998.

Rates of fertilizer and elemental addition per tree, Malaspina, Bowser, Quinsam River, and French Creek sites.

Treatment	Element	Fertilizer added (grams per tree)	Elements added (grams per tree)
P0	---	0.0	0.0
P1	P	102.4	20.1
	Ca		12.3
P2	P	204.8	40.2
	Ca		24.5
C0	---		0.0
C1	K	60.0	11.0
	Mg		6.6
	S		13.2
	Fe		43.6
	Mn		2.6
	Zn		2.4
	B		1.1
	Cu		1.1
	Mo		0.03

- Phosphorus was added as triple superphosphate (TSP, 0-45-0); potassium, magnesium, and sulphur were added as K-Mag (0-0-22-11Mg-22S), and micronutrients were added in a fritted form.
- Application rates in the 1- and 2-year-old plantations (Hillcrest Road, Fanny Bay, Campbell River-L, and Campbell River-U) were half those in the older plantations. Hence, trees in the P1 and P2 regimes at the younger plantations received 10 and 20 grams phosphorus per tree. A P3 treatment, supplying 30 grams phosphorus per tree, was also applied at Campbell River-L and Campbell River-U.
- At Hillcrest Road and Bowser, trees were either unfertilized (P0C0) or fertilized with phosphorus and the "C" fertilizer (P1C1 and P2C1 treatments).
- In the older plantations (Malaspina, Bowser, Quinsam, and French Creek), understorey vegetation was removed to a distance of 100 cm from the stem and fertilizer was applied around each tree in a band 60–80 cm from the stem. In the younger stands, fertilizer application rates per tree were half of those for older plantations in a comparable treatment; fertilizer was applied 20–30cm from the tree in 2 (P1), 4 (P2), or 6 (P3) dibble holes. Understorey vegetation was removed to a maximum of 40 cm from the tree.

any, net increment in stem volume, compared with their volumes at the start of the growing season.

Management Implications

Fertilization can improve the growth of young red alder in the first year, even on sites classified as rich or very rich. However, the first-year effects of fertilization varied considerably among these plantations. Possible reasons for this variability include differences in:

1. the amounts of phosphorus available at each site before fertilization;
2. the availability of essential nutrients other than phosphorus;
3. mid- and late-summer moisture availability; and
4. the effectiveness of understorey vegetation control on a given site.

Ongoing analysis of soil and foliage will clarify the importance of pre-fertilization phosphorus status and availability of other elements. Clarifying the importance of moisture stress and vegetation control awaits further study.

Knowing how long a tree responds to fertilization is also important. These trees will be remeasured in the future to assess the duration of growth responses to fertilization. However, fertilizers were applied only to a limited area around single trees in this study. The effects of fertilizer may be relatively short under such conditions.

Fertilization of red alder at the time of planting may be more effective than fertilizing seedlings at the start of the second growing season, because the root systems of newly planted seedlings are compact and relatively easy to target with fertilizer. Also, competition for added nutrients from other vegetation may be less at the time of planting than in subsequent years. Conversely, fertilization with phosphorus in the first year may render seedlings more prone to frost damage

(Peeler and DeBell 1987) late in the first season or early in the second growing season. Frost damage may minimize growth increases (as observed during our trials), and lead to poor stem form (Dobkowski et al. 1994).

Acknowledgements

Forest Renewal BC funded this project (HQ96397-RE). Rick Erikson (Campbell River Forest District), Dean Stewart (South Island Forest District), Phil O'Connor (Coast Mountain Hardwoods), Paul Lucas, Malaspina University College, and Paul Courtin (Vancouver Forest Region) suggested possible sites and otherwise facilitated establishment of the trials. Rob Brockley and Susan Chen (Research Branch, Ministry of Forests) provided useful comments on the experimental design. David Ponsford, Keith Lawrence, Sarah Locking, Robin Pike, and Carol Cutforth (Research Branch, Ministry of Forests) supplied technical assistance. Rick Erikson and Paul Courtin provided useful comments on the manuscript, as did Phil Comeau, Ray Addison, and Patrick Daigle (Research Branch, Ministry of Forests).

Literature Cited

Courtin, P.J. 1992. The relationships between ecological site quality and the site index and stem form of red alder in southwestern B.C. M.F. thesis, Univ. B.C., Vancouver, B.C.

Dobkowski, A., P. Figueroa, and Y. Tanaka. 1994. Red alder plantation establishment. *In* The biology and management of red alder. D.E. Hibbs, D.S. DeBell, and R.F. Tarrant (editors). Oreg. State Univ. Press, Corvallis, Oreg., pp. 186–201.

Peeler, R. and D.S. DeBell. 1987. Variation in damage from growing-season frosts among open-pollinated families of red alder. U.S. Dep. Agric. For. Serv., Res. Note PNW-RN-464.

Plank, M.E. and S. Willits. 1994. Wood quality, product yield and economic potential. *In* The biology and management of red alder. D.E. Hibbs, D.S. DeBell, and R.F. Tarrant (editors). Oreg. State Univ. Press, Corvallis, Oreg., pp. 243–7.

Radwan, M.A. 1987. Effects of fertilization on growth and foliar nutrients of red alder seedlings. U.S. Dep. Agric. For. Serv. Res. Pap. PNW-RP-375.

Radwan, M.A. and D.S. DeBell. 1994. Fertilization and nutrition of red alder. *In* The biology and management of red alder. D.E. Hibbs, D.S. DeBell, and R.F. Tarrant (editors). Oreg. State Univ. Press, Corvallis, Oreg., pp. 216–28.

Raettig, T.L., K.P. Connaughton, and G.R. Ahrens. 1995. Hardwood supply in the Pacific Northwest: a policy perspective. USDA For. Serv. Res. Pap. PNW-RP-478.