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2100 Labieux Road, Nanaimo, BC, Canada, V9T 6E9, 250-751-7001

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CONTACT:

• Brian D'Anjou, Research Silviculturist, Vancouver Forest Region, BCMOF. 250-751-7001 Brian.Danjou@gems6.gov.bc.ca

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BRITISH COLUMBIA

Influence of Two Herbicides on a Red-Alder-Dominated Plantation of Grand Fir in Coastal British Columbia: Ninth Year Results

By Brian D'Anjou

INTRODUCTION

In the 1980s, field trials were initiated in the Vancouver Forest Region to evaluate registered and unregistered herbicides for controlling various vegetation species considered competitors in the establishment of conifer plantations. In 1984, southeast of Chilliwack (Figure 1) in southwestern British Columbia (BC), an operational trial was established to study the effectiveness of using triclopyr ester[1] as a late-summer foliar application at two rates on a site where red alder (*Alnus rubra*) overtopped a grand fir (*Abies grandis*) plantation. Triclopyr ester is a selective systematic herbicide absorbed by green bark, leaves, roots, and cut stems; it mimics plant growth hormones and causes uncontrolled growth (USDA/FS 2001). The efficacy data were required to support eventual registration of the herbicide for forestry use.

Triclopyr was applied in the summer of 1984. Response of several target species and grand fir were summarized and reported at Year 5 and Year 7 (D'Anjou 1990a, 1992a). This Extension Note reviews and compares the effects of the initial triclopyr ester application and the subsequent glyphosate treatment on both target vegetation and grand fir. Free-growing guidelines (BCMOF and BCMOE 2000) were introduced after the trial began, so the influence of the treatments on the plantations' abilities to meet free-growing status was assessed retrospectively.

[1] Release® and Garlon 4E® are manufactured by Dow AgroSciences. Mention of trade names or products does not constitute endorsement by the author or BCMOF.

SITE DESCRIPTION

The study site, 100 km east of Vancouver and about 10 km south of Chilliwack (Figure 1), is located in the Dry Maritime Subzone of the Coastal Western Hemlock Biogeoclimatic Zone (CWHdm) (BCMOF 1991). Elevation ranges from 350 to 370 m. Dominant soils were classified as Brunisol on Colluvial Blanket with mesic soil moisture and rich nutrient status.

The site was clearcut harvested (1981) and woody debris was moved into rows and burned. Grand fir (2+1 BR) seedlings were planted in the spring of 1982 and of 1983. Three years after harvesting, four vegetation species represented the majority of vegetation cover: thimbleberry (*Rubus parviflorus*) which dominated the shrub layer, red alder which dominated the tree layer, plus willow (Salix sp.) and salmonberry (*Rubus spectabilis*). By 1984, red alder (200 cm high) and other tree and shrub species overtopped 81% of the grand fir seedlings (average 176 cm high).

STUDY METHODS

Two triclopyr ester treatments were applied to a 16.7-ha block that was divided into two units by a skid road (Figure 2). The control was assigned to a 5.6-ha block, 700 m west of triclopyr ester treatment block. Three treatments were compared:

i) Triclopyr ester applied at 1.4 kg a.e./ha in 1984, plus glyphosate applied at 2.1 kg a.i./ha in 1987.

ii) Triclopyr ester applied at 2.9 kg a.e./ha in 1984.

iii) Untreated control.

Triclopyr treatments were applied in one day

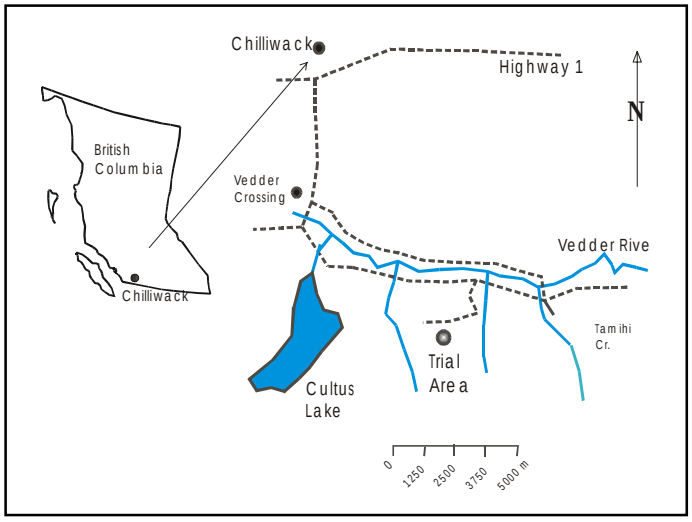

Figure 1. Location of the study site.

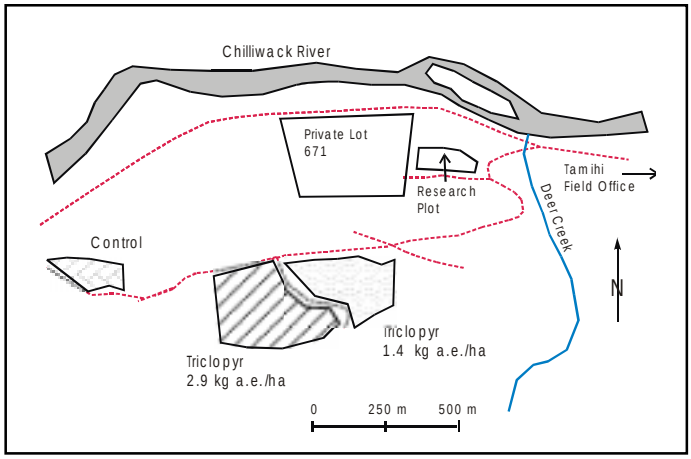

Figure 2. Location of the blocks at the study site.

(Sept.13, 1984) by helicopter; temperature ranged from 12 to 17° C and wind speed remained below 3 km/h. Twelve 100-cm^2 Kromekote cards were randomly placed throughout each treatment unit to assess herbicide coverage; red dye was added to the triclopyr/water mixture.

Three years later, an aerial application of glyphosate at 2.1 kg a.i./ha in the unit treated with triclopyr ester at 1.4 kg a.e./ha allowed comparison of the efficacy of the two treatments on several vegetation species, and evaluation of the effects on grand fir growth.

Measurements

Measurements of vegetation and planted conifer seedlings were conducted within the circular 10-m^2 (1.78-m radius) sampling area centered at forty grid points that were established systematically in each treatment unit. Total vegetation cover was visually estimated, and average height (weighted based on cover) was measured with height pole calibrated in cm. Cover and height of the three vegetation species with highest pre-treatment cover were also measured.

Species response to treatment were described using the ten-point Expert Committee on Weeds (ECW) rating system for herbicide efficacy (ECW 1992):

- Complete control of vegetation = 9 points.
- Fair to good control = 6–8 points.
- Poor control = 4–5 points.
- No effect to slight effect = 0–3 points.

Subsequent vegetation assessments included re-measurement of all previously identified vegetation species plus new species exceeding 5% cover. Density of deciduous trees was measured in Year 7 only. Height and stem caliper (20 cm above ground) of planted seedlings located within the 10-m^2 sampling area (44 seedlings in the control, 54 in the unit with triclopyr ester applied at the lower rate, and 59 in the unit with triclopyr ester applied at the higher rate) were measured.

Seedlings were also assessed for foliage and leader condition. The level of vegetation surrounding planted conifers was described using a three-class system:

- Vegetation overtopping seedling top whorl and leader = Overtopped.
- Vegetation at same level as seedling top whorl = Threatened.
- Vegetation below seedling top whorl and leader = Open growing.

An overall overtopping index was calculated to describe level of vegetation overtopping on individual seedlings since trial establishment. The index is the sum of the six overtopping ratings collected since pre-treatment assessment:

- Open growing = 0. • Threatened = 1. • Overtopped = 2.

Measurements began one month prior to treatment and were repeated one, two, three, five, seven, and nine growing seasons after the initial herbicide application.

Analysis

Total vegetation cover and height were averaged by treatment and measurement period, as were species-specific cover, and height plus herbicide effect based on ECW code. Vegetation species were classified into one of five life forms (tree, shrub, herbs, ferns, and grasses), and total cover of each was summarized by measurement period. Summary of grand fir response to treatment included height, height increment, stem diameter, stem diameter increment, survival, foliage and leader condition, and state of vegetation overtopping. Percentage of seedlings exceeding 150% of the height of within-plot vegetation that met free-growing guidelines (BCMOF and BCMOE 2000) was determined at each measurement period. Although the methodology used to assess free-growing status was different than that specified by the provincial guidelines (BCMOF and BCMOE 2000), the calculated free-growing figures are considered reasonable surrogates.

RESULTS

Vegetation Response

Pre-Treatment to Year 3. Post-treatment assessment of the Kromekote cards indicated good herbicide coverage in the 1.4-kg a.e./ha treatment, but less uniform coverage in the 2.9 kg a.e./ha treatment where 25% of the cards showed no herbicide residue.

Both triclopyr ester treatments reduced total vegetation cover to below pre-treatment levels for two growing seasons (Figure 3).

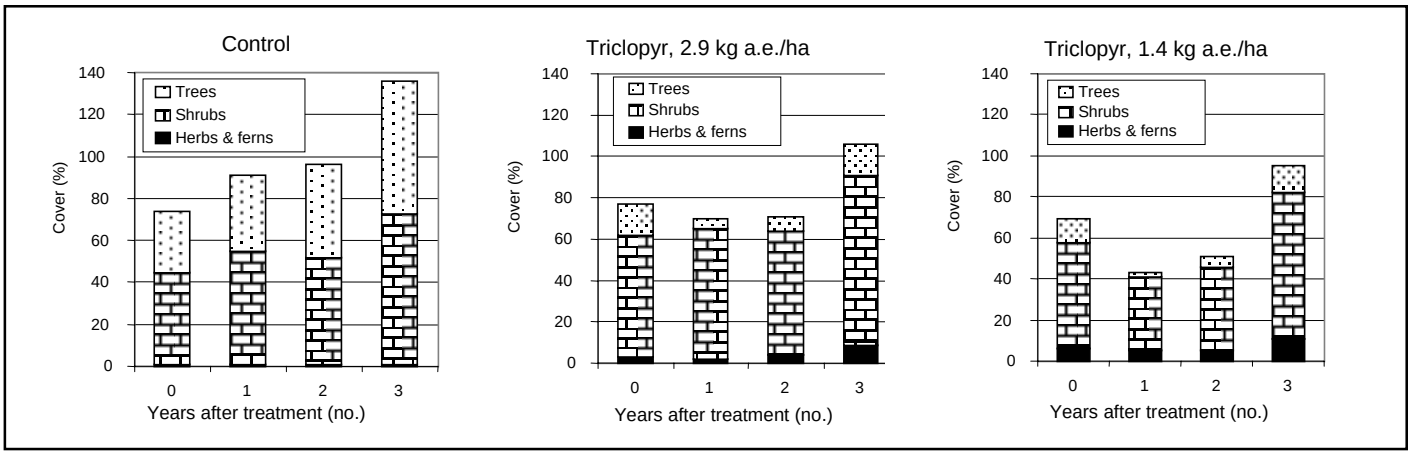

Figure 3. Tree, shrub, and herb/fern cover, by treatment and year after treatment: Years 0 to 3.

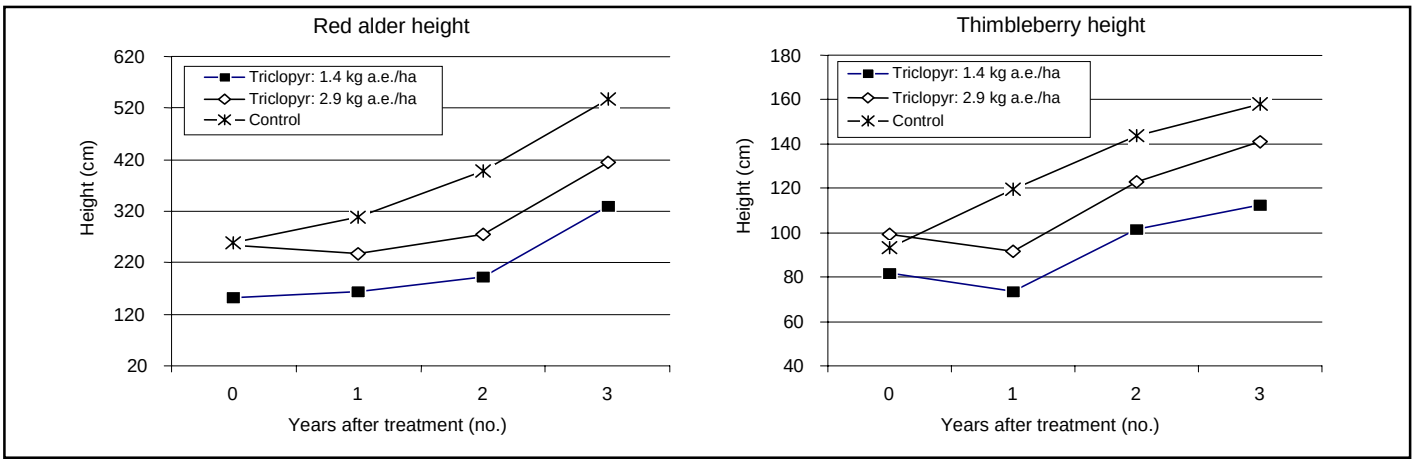

Figure 4. Red alder and thimbleberry height, by treatment and year after treatment.

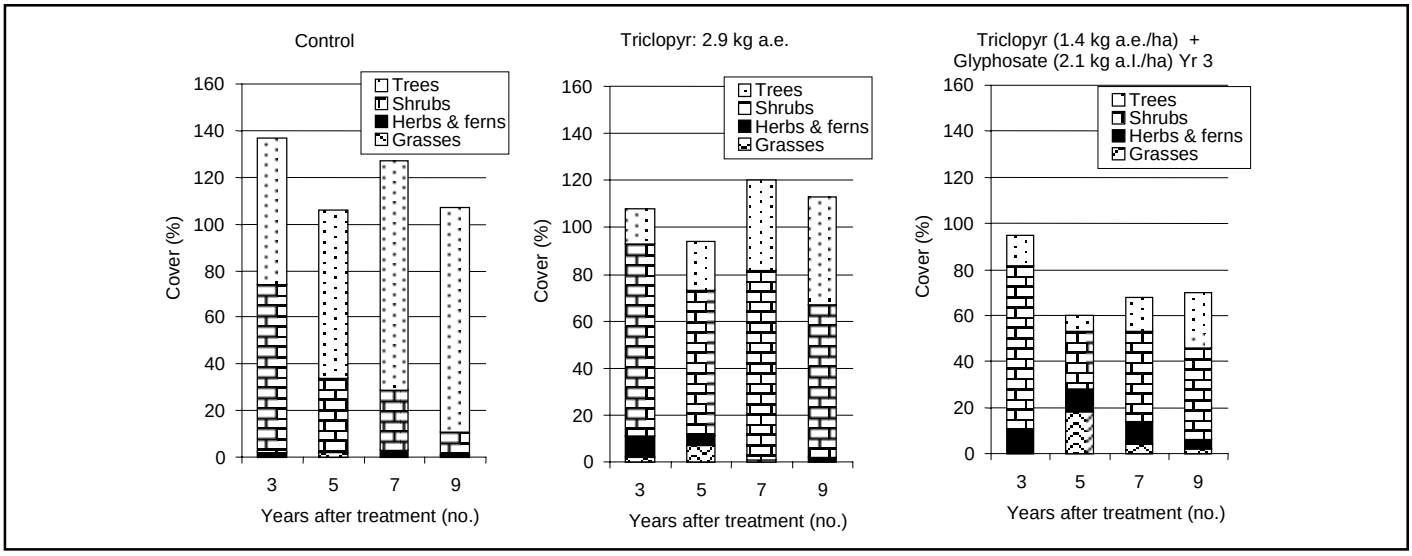

Figure 5. Tree, shrub, herb/fern, and grass cover by treatment, and year after treatment: Years 3 to 9.

Greater control of thimbleberry at the lower application rate caused greater decline in vegetation cover although both rates caused only partial topkill and slight height reductions of the species (ECW = 2–3). It is possible that the uneven herbicide application at the higher application rate resulted in the poor control of thimbleberry. Control of red alder and willow were greater (ECW = 9) at the higher application rate, although surviving stems recovered and exceeded pre-treatment cover and height (Figure 4) by Year 3. Triclopyr ester had varying effects on salmonberry and bigleaf maple (*Acer macrophyllum*).

Years 3 to 9. Compared to the initial treatments of triclopyr ester, glyphosate provided similar control of red alder but much better control of thimbleberry (ECW = 7–8) and longer term control of total vegetation cover (Figure 5). Enhancement in grass cover following the glyphosate application was short lived. Total vegetation cover changed little in the triclopyr-only treatment (2.9 kg); however, the red-alder-dominated tree cover increased annually. In the control unit, thimbleberry cover declined as overstory alder cover increased to 90% by Year 9 and reached a height of 10 m. In Year 7, densities of broadleaves, including alder, were highest in the control, and lowest in the triclopyr ester + glyphosate treatment (Table 1).

Based on cover, vegetation composition in Year 9 was similar in the three treatments, with red alder, willow, and thimbleberry amongst the five most abundant species. Seventeen years after the initial application of triclopyr ester, grand fir canopy in the glyphosate-treated unit has closed, while a sparse understory vegetation had a cover estimated at <5%. The grand fir canopy in the unit that received a single application of triclopyr ester (2.9 kg) had not closed. In the control, red alder is 13 m tall and appears to be self-thinning and stimulating understory herbaceous vegetation.

Grand Fir Response

Overtopping of grand fir by competing vegetation declined after both triclopyr ester treatments (15% at the lower application rate, 24% at the higher application rate), but Year 1 height growth and stem diameter growth were not enhanced (Figure 6). Lack of positive growth response is in part attributable to reduced growth of seedlings with needle loss (11% of seedlings) which, along with grand fir mortality (3%) in the unit with the higher triclopyr application rate, was attributed to herbicide toxicity. Positive grand fir growth response to triclopyr treatments began with an increase in stem diameter growth in Year 2 and an increase in height growth in Year 3. Height:stem diameter ratio initially declined following reductions in overtopping vegetation, but increased to pre-treatment levels by Year 3. By Year 3, overtopping of seedlings by vegetation was lowest (15%) in the unit with the lower triclopyr application rate and was just under half that (32%) in the unit with the higher triclopyr application rate, while overtopping remained highest in the control (55%). Fewer than 50% of seedlings in any treatment would have met the free-growing definition (BCMOF and BCMOE 2000), which states that seedlings should be greater than 150% of the height of surrounding vegetation.

Glyphosate applied three growing seasons after the initial triclopyr treatment raised the percentage of free-growing seedlings to 90%; but, this subsequently declined to 70% by Year 9 (or 945 seedlings/ha) as surviving alder recovered. The percentage of free-growing seedlings increased in the unit receiving single triclopyr treatment (2.9 kg) levelled off at 50% by Year 9 (738 seedlings/ha) as seedlings rose above the thimbleberry layer. Both herbicide treatments have improved height growth and diameter growth of grand fir as compared to the control (Figure 7). Average annual height growth and stem diameter growth in grand fir since Year 5 were greater in the unit treated with glyphosate (75 cm and 17.2 mm respectively) than in either the unit that received only triclopyr ester (55 cm and 12.3 mm respectively) or the control (32 cm and 4.5 mm respectively). This suggests that residual vegetation in the triclopyr ester treatment and the control was limiting seedling growth. Grand fir height:diameter ratio declined in both herbicide treatments compared to the control, and reached the lowest level amongst the faster growing seedlings in the combined triclopyr + glyphosate treatment. According to the most recent growth rates, trees in the unit that was treated with triclopyr ester alone are approximately two growing seasons behind those in the unit that received glyphosate. Grand fir survival at Year 9 remained highest in the unit that received glyphosate (100%), levelled off to 92% in the unit that received the single triclopyr ester application, and declined to 82% in the control as mortality occurred between most measurements periods. Compared to seedlings in the herbicide plots, grand fir seedlings in the control plot have more defects, including browsed foliage (15%), forked leaders (9%), and bent stems (6%).

Range in Overall Overtopping Index indicated the level of overtopping on individual seedlings ranged from those seedlings continuously above surrounding vegetation (Overall Overtopping Index = 1) to those continuously overtopped since trial establishment (Overall Overtopping Index = 12). Both height

Table 1. Density of red alder, willow, and cherry, by treatment and species: Year 7.

Treatment	Red alder (no. stems/ha)	Willow (no. stems/ha)	Cherry (no. stems/ha)	Total stems (no. stems/ha)
Triclopyr (1.4 kg a.e./ha) + Glyphosate	400	1200	0	1600
Triclopyr (2.9 kg a.e./ha)	700	1700	100	2700
Control	2650	25	850	4150

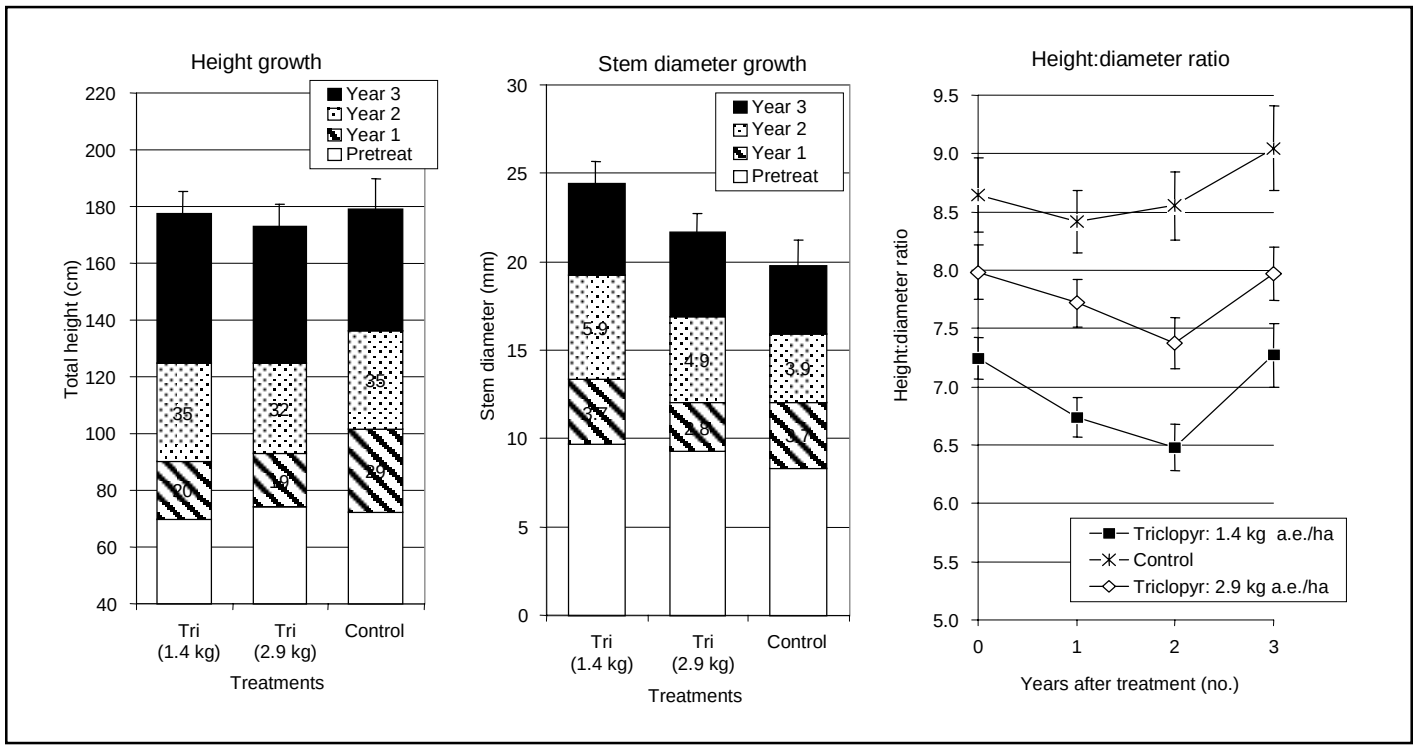

Figure 6. Grand fir height, stem-diameter growth, and height:diameter ratio, by treatment and year: Years 0 to 3. Error bars are ±1 standard error.

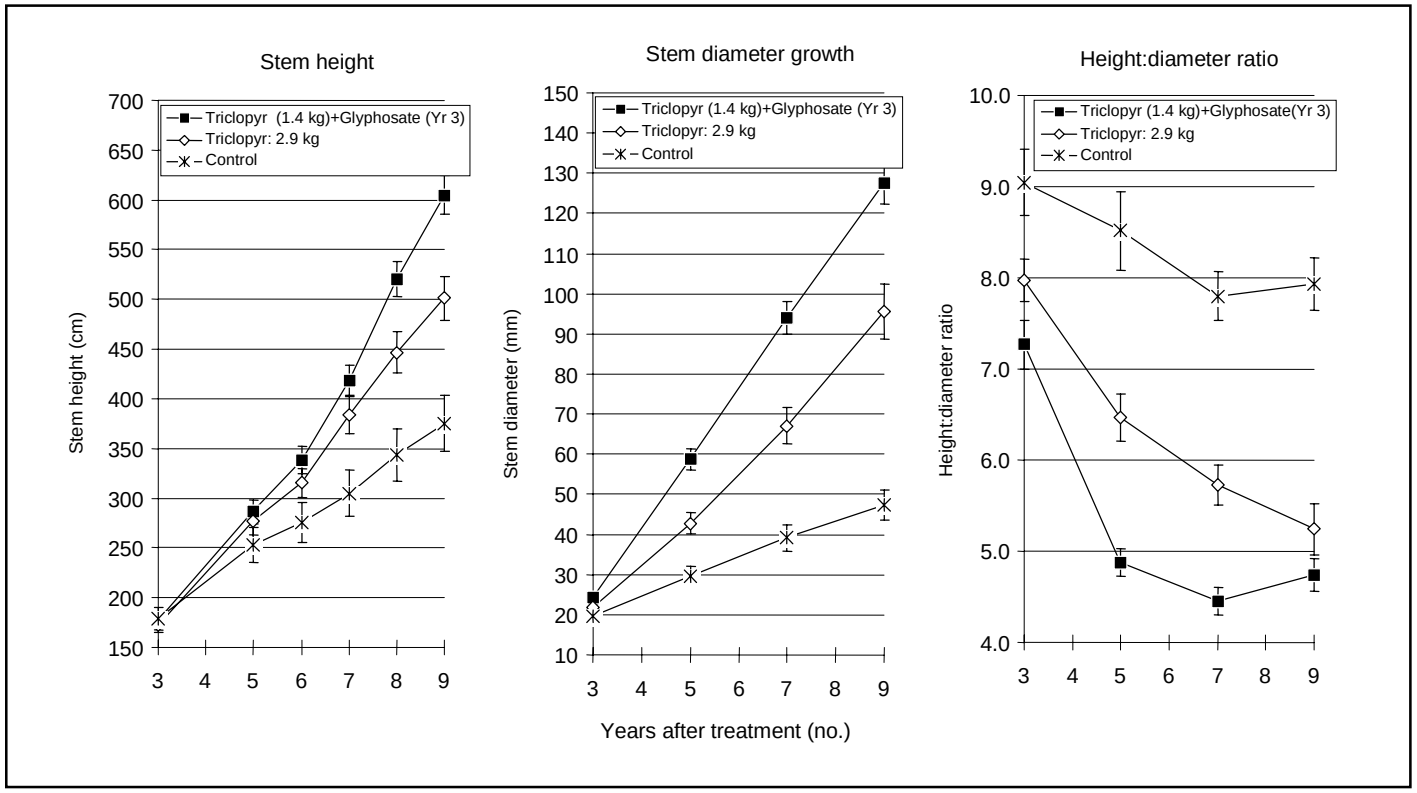

Figure 7. Grand fir height and stem-diameter growth, by treatment and year: Years 3 to 9. Error bars are ±1 standard error.

growth and stem diameter growth declined with increasing overtopping index, but stem diameter was more sensitive than height (Figure 8). Grand fir height:diameter ratio reached a low of 4 at highest growth rate and increased to above 8 for seedlings continuously overtopped.

SUMMARY AND CONCLUSIONS

In 1984, on a Coastal site in southwestern British Columbia, an operational unreplicated trial evaluated late-summer, aerial applications of triclopyr ester herbicide at two rates and a subsequent application of glyphosate herbicide for controlling a stand of dense red alder and other associated vegetation species that were overtopping a three-year-old plantation of grand fir. Site preparation by piling woody debris into rows with tracked machines had enhanced regeneration of red alder by exposing mineral soil. The combination of high density and rapid height growth allowed red alder to overtop, and eventually decrease, the growth and survival of planted grand fir seedlings. Applications of triclopyr ester followed by glyphosate were evaluated for their abilities to release the seedlings from competition from dense red alder and other associated species, and thereby assist the plantation in meeting current free-growing criteria.

Vegetation response to applications of glyphosate and triclopyr ester were similar to results from other local trials (D'Anjou 1990b) and to results summarized from western Oregon and Washington (Conard and Emmingham 1984). Results suggest that glyphosate, when applied aerially in Coastal ecosystems, is superior to triclopyr ester for releasing conifers from domination by mixed tree (red alder, cottonwood) and shrub (thimbleberry, salmonberry) communities, a conclusion supported by Schneider and Knowe (1993). The more selective nature of triclopyr ester can control overtopping alder while retaining a relatively intact understory (e.g. thimbleberry), thus enhancing aesthetics as well as benefiting organisms utilizing the lower shrub layer. Grand fir intolerance to triclopyr ester, demonstrated by both needle loss and mortality at the higher application rate, must be considered when prescribing this herbicide in a plantation with grand fir component. Other trials in the Vancouver Forest Region suggest that a manual brush treatment would not have been a suitable alternative for controlling red alder at younger age (3 years) nor for controlling thimbleberry because both species can resprout vigorously and display rapid height growth (D'Anjou 1990b, 1992b), possibly necessitating additional treatments.

Although triclopyr treatments enhanced the diameter growth of grand fir, vegetation control was short lived and failed to meet the target stocking of 900 well-spaced stems/ha recommended in the current free-growing guidelines (BCMOF and BCMOE 2000). Growth response and height:diameter ratios of grand fir suggest that the remaining vegetation continued to limit seedling growth; this was later confirmed by incremental growth response following a subsequent glyphosate application which hastened crown closure. Post-glyphosate densities of red alder exceeded levels of 50–100 uniformly distributed red alder which is the estimated acceptable level for maintaining site nitrogen capital without substantially reducing conifer growth (Miller and Murray 1978); a subsequent decline in the density of free-growing seedlings means long-term stocking standards may not be met without additional intervention. Because grand fir growth is maximized when surrounding vegetation remains below the top whorl, growth rates greater than achieved with either treatment tested at Deer Creek are operationally possible by minimizing development of post-harvest vegetation and undertaking effective conifer release treatments.

Understanding the autecology, including regeneration strategy, of the more competitive species will provide guidance in selecting treatments that reduce the abundance and competitive effects of vegetation yet enhance early growth of grand fir. Minimizing the development of the more competitive species will also improve the likelihood that a single vegetation management treatment would be needed to meet conifer-stocking requirements, reduce cost of meeting reforestation obligations, and enhance early plantation growth and survival.

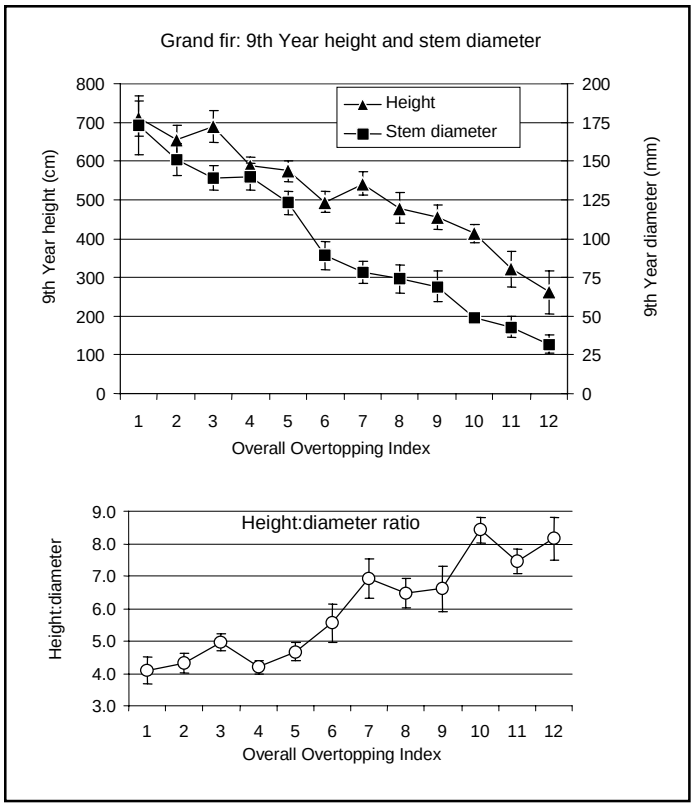

Figure 8. Total height and stem diameter of grand fir, over a range of overtopping intensity: Year 9. Error bars are ±1 standard error.

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NOTES