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Extension Note

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Ten-year Responses of White Spruce and Associated Vegetation after Glyphosate Treatment at Tsilcoh River

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Introduction

For a stand of desirable trees to be successfully established, vegetation management is usually needed as part of site preparation or during the first few years after regeneration, especially when the vegetation competition is very intense. However, long-term growth and yield gains and economic returns are still unknown. Also needed is long-term information to address various forest management issues, including free growing, green-up, biodiversity, stand dynamics, and stand structure.

This extension note reports the 10-year results of a study site near Tsilcoh River (Fireweed Block) in the Fort St. James Forest District.

The purpose of the study has been to:

- assess the long-term effects of glyphosate treatment on growth of white spruce,
- assess the impacts of glyphosate treatment on the development of the stand and vegetation community; and
- assess the impact of glyphosate treatment on stand timber yield.

Study Site

The study site is classified as the Stuart Dry Warm subzone variant of the Sub-Boreal Spruce biogeoclimatic zone (SBSdw3) (DeLong et al. 1993). The site has medium to good productivity, a mesic moisture regime and mesotropic nutrient regime, well- to moderately well-drained soils, an elevation of 1075 m, and an average slope of 10% facing east-southeast. The site association is SxwFd-Pinegrass (01 site series).

In 1971, a stand dominated by mature hybrid spruce was logged using a clearcut silvicultural system. Prior to planting, mechanical site preparation treatments (cable knockdown and winter shearing) were applied to clear the natural vegetation. In 1987, 1-year-old (1+0 PSB 313) white spruce (*Picea glauca*) seedlings were planted at a 2.9-m espacement.

Methods

At the study site, two 100 × 100 m (1 ha) treatment plots with a minimum 10-m buffer on all sides were established in July 1988. On August 15, 1988, the herbicide glyphosate (Roundup®) was applied aerially at a rate of 2.14 kg a.i./ha to only one of the treatment plots. Glyphosate was applied to control the primary target species: fireweed (*Epilobium angustifolium*), black twinberry (*Lonicera involucrata*), red raspberry (*Rubus* *idaeus*), thimbleberry (*Rubus parviflorus*), and grasses.

Within each treatment plot, 100 white spruce seedlings were systematically selected along a 10 × 10 m grid. Over the years, seedlings were measured for total height, basal diameter, and crown diameter. Spruce seedlings were also assessed qualitatively for vigour. During the summer of 1998, four 3.99-m radius (0.005 ha) regeneration measurement plots (RMPs) were established in each treatment plot using the EXPLORE methodology (Biring et al. 1998) to collect vegetation community data (species percent cover and modal height) and stand data (density and free growing).

Statistical analysis included a one-way analysis of variance (ANOVA), analysis of covariance (ANCOVA), and a chi-square (χ^2) test of homogeneity, which was calculated using SAS statistical software (SAS Institute Inc. 1990). Data from tagged spruce seedlings and four RMPs in each treatment area were considered an experimental unit and used as replicates (pseudo-replicates) to test for significant differences between treatment means. While analysis based on pseudo-replication must be interpreted cautiously (since differences in vegetation and differences in site factors between plots can confound treatment differences), the 10-year measurements of this study offer a number of preliminary conclusions about the treatment used.

Results and Discussion

White spruce growth response

Ten years after application, glyphosate treatment had a significant effect on white spruce basal diameter, height, height-to-diameter ratio (HDR), and crown radius (Table 1). The increases in height and diameter and decreases in HDR of white spruce after glyphosate application are consistent with results reported in other studies (Sutton 1995; Harper et al. 1997; Biring and Hays-Byl 2000).

Despite the significant improvements in spruce growth parameters (diameter and height), significant differences in spruce volume were not detected. Therefore, further growth and yield projections using a model were not made at this point. Although no statistically significant differences in estimated volume were found, the practical difference may be substantial (Table 1). In addition, trends (see Figures 1 and 2) suggest that differences in growth parameters between treated and untreated seedlings are still diverging. If these trends continue, the effect of the glyphosate in tree volume may be reflected in the future.

In 1998, no significant differences in white spruce vigour could be detected. However, 14% of white spruce seedlings (planted) in the glyphosate-treated plot exhibited good vigour as compared to 6% in the untreated control plot.

Establishment to free growing

Ten years after treatment, survival of planted white spruce seedlings was 86% in the control plot compared to 74% in the glyphosate-treated plot. Total density of well-spaced spruce trees (including naturals and ingress) in treated plots was not significantly different from that in the control (Table 2). Both plots met the minimum stocking requirements (700 sph) based on existing free-growing stocking standards for the region in 1998 (B.C. Ministry of Forests and BC Environment 1995) (Table 2).

Although the spruce growth parameters improved significantly,

TABLE 1 *Means and standard deviations for white spruce in 1998*

Treatment	Basal diameter (mm)	Height (m)	Height-to-basal diameter ratio	Crown radius (cm)	Volume (m^3/ha)
Glyphosate	41.1±2.7	1.92±0.10	49.7±1.8	0.485±0.027	1.03±0.16
Control	30.1±2.4	1.62±0.11	56.0±1.4	0.388±0.027	0.69±0.16
p-value*	*0.003*	*0.038*	*0.007*	*0.013*	*0.14*

* p-values from ANCOVA using 1988 data as co-variates.

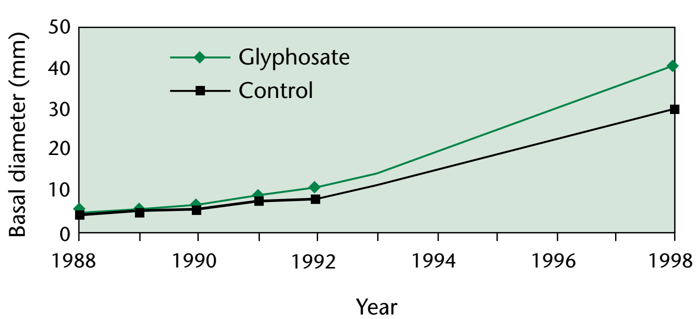

FIGURE 1 *Effects of glyphosate treatment on basal diameter of white spruce, 1988–1998.*

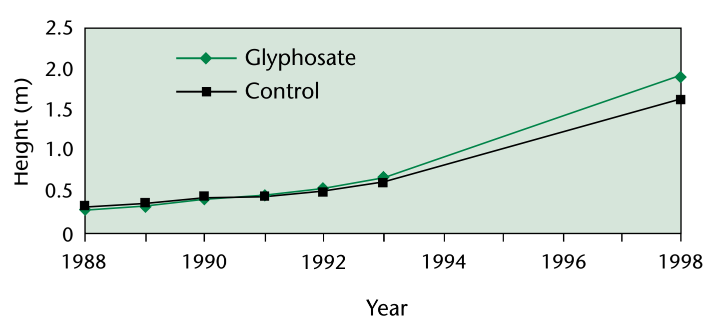

FIGURE 2 *Effects of glyphosate treatment on height of white spruce, 1988–1998.*

TABLE 2 *Means and standard deviations for density: stand, conifers, trembling aspen, white spruce, other conifers, spruce well-spaced, and spruce free-growing, 11 years after planting*

Treatment	Stand (sph)	Conifers (sph)	Trembling aspen (sph)	White spruce (sph)	Other conifers (sph)	White spruce well-spaced (sph)	White spruce free-growing (sph)
Glyphosate	6050±8649*	1500±600	4550±8646	1150±300	350±341	1050±379	300±258
Control	1250±914	1000±432	250±500	950±341	50±100	900±200	400±0
p-value†	0.31	0.23	0.35	0.41	0.14	0.51	0.47

* A patch of trembling aspen percent cover in one of the treated plots resulted in higher standard deviation.
† p-values from ANOVA.

the herbicide treatment applied to control fireweed did not increase the number of free-growing white spruce stems. However, the block is still in the free-growing window and further assessment may be needed, in keeping with the new free-growing guidelines that accommodate more broadleaved species in the stand (B.C. Ministry of Forests 2000).

Vegetation community responses

A count of vegetation species to determine species richness in each treatment plot found this measure to be similar in both the treated and untreated plots: 44 and 47 species, respectively (Table 3). However, non-vascular plants were not sampled thoroughly enough to provide reliable information. Rare species may also have been missed because of the relatively small sample area.

Both treatment plots had similar plant species composition (Figures 3 and 4). Just five shrubs differed between the treatments: willow (*Salix* spp.), common juniper (*Juniperus communis*), and red elderberry (*Sambucus racemosa*) were found only in the control plot; Saskatoon (*Amelanchier alnifolia*) and red swamp currant (*Ribes triste*) were found only in the treated plot.

Plant species cover showed that there was very little difference (40% fireweed in both plots) between the plant communities in the two treatments. The glyphosate-treated plot had a higher percent cover of blue wildrye grass (*Elymus glaucus*) and bunchberry (*Cornus canadensis*), and the untreated control plot had a higher percent cover of bluejoint grass (*Calamagrostis canadensis*). Compared to the treated plot, the untreated control plot also had a higher percent cover of shrubs—including Sitka alder (*Alnus crispa* ssp. *sinuata*), thimbleberry, and black twinberry—and conifers (Table 3). However, the treated plot had a higher percent cover of birch-leaved spirea (*Spiraea betulifolia*), highbush-cranberry (*Viburnum edule*), and trembling aspen. The higher trembling aspen percent cover in one of the treated RMPs, compared to the untreated control plot, was due to a very dense patch of aspen that occurred in the plot in question, while very little or no cover occurred in the rest of the sampling plots.

It appears that the glyphosate did not have a lasting effect on the vegetation community, as differences in species abundance between treatments were not visible 10 years after treatment.

Conclusions

From the 10-year measurements collected in this study, the following can be concluded:

- Controlling competing vegetation using glyphosate 1 year after planting significantly increased white spruce height and basal diameter, and reduced height-to-diameter ratio.
- Glyphosate treatment did not result in more free-growing spruce trees per hectare 11 years after planting because aspen patch was present in a portion of the treated

TABLE 3 *Means and standard deviations for percent cover: total, conifers, broadleaves, shrubs, and herbs, 10 years after treatment application in summer of 1998*

	Total		Conifers		Broadleaves		Shrubs		Herbs	
Treatment	% cover	No. of species*	% cover	No. of species	% cover	No. of species	% cover	No. of species	% cover	No. of species
Glyphosate	94.5±3.3	44	9.8±5.6	2	15.3±29.8	1	32.5±28.7	12	62.5±31.0	27
Control	98.5±1.0	47	16.3±16.4	2	0.1±0.2	1	52.5±12.6	13	67.5±15.0	29
p-value†	0.07	—	0.5	—	0.3	—	0.2	—	0.8	—

* Total number of species includes lichens and mosses.
† p-values from ANOVA

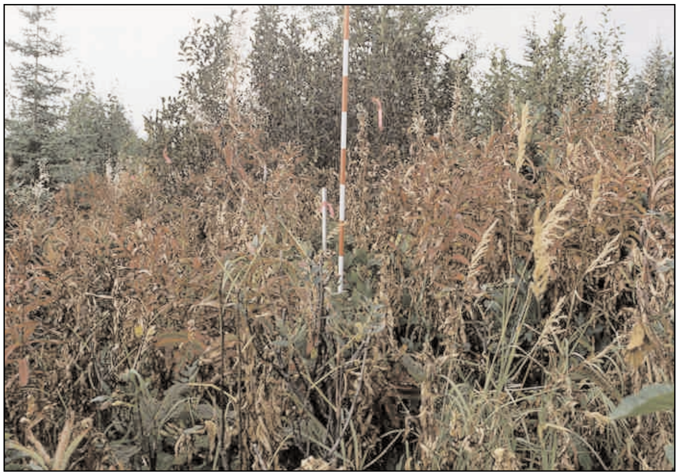

FIGURE 3 *A vegetation community in an untreated control plot (August 26, 1998).*

FIGURE 4 *A vegetation community in a glyphosate-treated plot (August 26, 1998).*

plot. Further assessment may be needed because the trees are still in a free-growing window.
- Glyphosate treatment did not have much effect on species composition of the vascular plant community.

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