Responses of hybrid spruce and the *Fern* complex to foliar glyphosate: A summary of 5 year PROBE results

About the *Fern* complex

This community is characterized by the presence of lady fern, bracken, and lesser amounts of spiny wood fern. A variety of shrub species may also be present. It occurs most abundantly on medium to wet sites in the ICH zone, where ferns were present in the understory prior to logging. Where abundant, the *Fern* complex reduces light to understory conifers, and causes physical damage them through snow- and vegetation-press. (Full complex description)

Results

This section summarizes 5-year results from the fully replicated PROBE experiment that studies hybrid spruce and vegetation responses to foliar glyphosate treatment (1.24-1.78 kg ai/ha applied in August) of the *Fern* complex in 2-4 year-old plantations in the ICH zone. Study sites were mesic, moderately to steeply sloping (40-50%), with variable aspect. Elevation ranged from 800-1400 m, and total vegetation cover averaged 86% at the time of treatment. (Full Methods description)

Table 1. A summary of 5-year hybrid spruce responses

Was there a significant[a] improvement in conifer performance 5 years after treatment?	
Survival	No
Basal stem diameter	No
Stem diameter increment	No
Height	Yes
Leader length	No
Height:diameter ratio	Yes

a Differences are significant where $p \leq 0.05$ according to ANOVA.

Spruce responses 5 years after brushing

- ***Survival*** - Five years after glyphosate treatment of the *Fern* complex, hybrid spruce survival did not differ significantly between the treatment (97%) and the control (89%).
- ***Vigour*** - Spruce vigour was declining in the control relative to the treatment by year 5 (Figure 1). Less than 2% of treated spruce were of poor vigour, compared with 10% of control spruce. This suggests survival could continue to decline slightly more in the control than the treatment.
- ***Stem diameter*** - Five years after brushing, mean spruce stem diameter was 59% larger in the treatment than the control, but this difference was marginally statistically insignificant ($p=0.0668$, Figure 2a).
- ***Height*** - Five years after foliar glyphosate application, 7-9 year-old hybrid spruce were significantly taller in the treatment than the control (Figure 2b).

- ***Height:diameter ratio*** - Foliar glyphosate treatment had resulted in a significant reduction in spruce height:diameter ratio within 3 years of treatment. The difference continued to be significant in year 5.

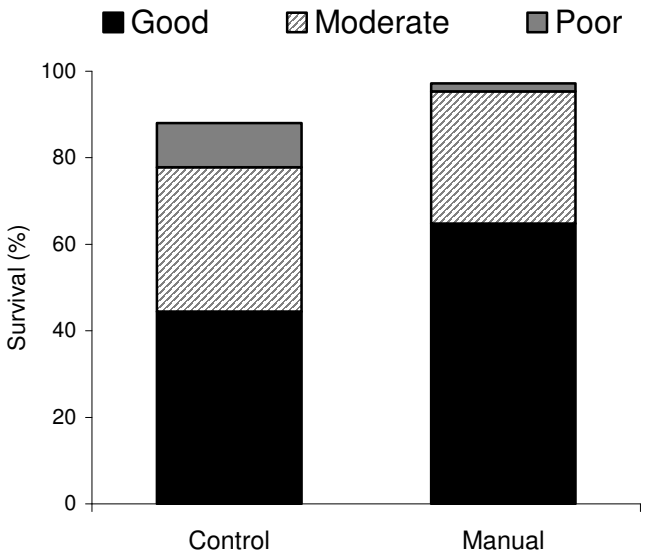

Figure 1. A comparison of hybrid spruce survival and vigour in the control and treatment 5 years after foliar glyphosate application.

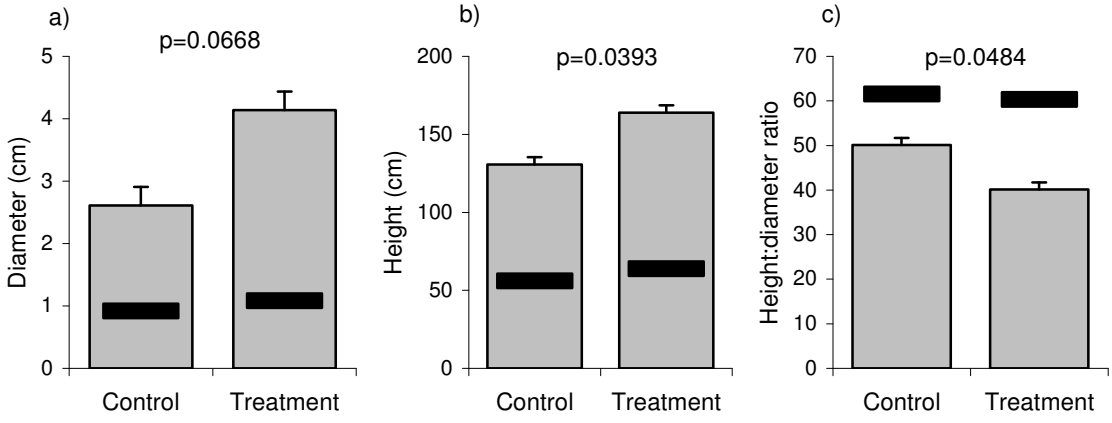

Figure 2. Comparisons of hybrid spruce (a) basal stem diameter and (b) height in the control and treatment 5 years after foliar glyphosate application. Horizontal bands represent spruce size at the time of treatment. Error bars represent 1 standard error.

Vegetation responses

Table 2. Duration of vegetation responses

Years of significant[a] vegetation reduction	
All vegetation cover	> 5 years
All vegetation height	None
Herb cover	> 5 years
Herb height	None
Shrub cover	None
Shrub height	None
Lady fern cover	None†
Lady fern height	None†
Thimbleberry cover	>1 and <3 years
Thimbleberry height	>3 and <5 years

a Differences are significant where p≤0.05 according to ANOVA.
† There were large differences between the treatment and control, but they were not statistically significant because of high variability between sites.

Foliar glyphosate significantly reduced total vegetation cover and herb cover for at least 5 years. The treatment reduced lady fern cover from 35 to 2%, and lady fern height from 90 to 27 cm. After 5 years, lady fern cover had increased to 5%, and height had increased to 37 cm. Despite the magnitude of these differences, they were not statistically significant because of high variability among sites. Thimbleberry cover was also reduced for between 1 and 3 years after treatment, and height was reduced for between 3 and 5 years. Glyphosate treatment immediately reduced mean vegetation height below that of spruce, whereas untreated spruce required an additional 3 years to grow as tall as vegetation (Figure 3). There were no significant treatment effects on the richness or diversity of vascular plant species within 5 years of glyphosate application.

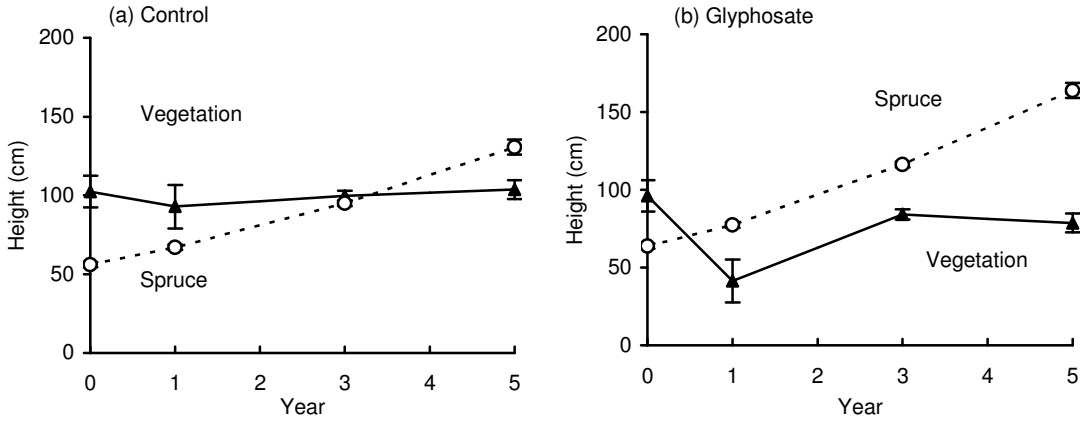

Figure 3. A comparison of average hybrid spruce and vegetation height profiles in (a) the control and (b) the foliar glyphosate treatment.

Management interpretations

Survival - Our 5-year results suggest that brushing is not needed to ensure good survival (average 93%) of hybrid spruce growing among the *Fern* complex. However, larger survival differences may have been obtained if treatments had been applied when seedlings were younger. Although the study sites were planted within 1 year of harvesting or site preparation, brushing did not occur until spruce were 2-4 years-old, and silviculture survey information suggests that considerable mortality had occurred by that time. Year 5 vigour differences also suggest that mortality could increase in the control relative to the treatment between years 5 and 10.

Conifer growth - Competition from the *Fern* complex was intense enough to reduce spruce growth in plantations that were 2-4 years-old at the time of treatment. On the basis of our results, foliar glyphosate application can be expected to increase both diameter and height growth of hybrid spruce, and to result in a decrease in height:diameter ratio.

Effects of brushing on free-growing status - Glyphosate treatment immediately reduced vegetation height below that of spruce, but untreated spruce also outgrew the vegetation canopy by the time they were 6-8 years-old.

Treatment efficacy –Foliar glyphosate can be expected to significantly reduce height and cover of the *Fern* complex, and the effects will persist for at least 5 years. It was clear, despite the lack of statistical significance caused by high variability among sites, that lady fern was severely impacted by the treatment. The abundance of thimbleberry, which is common in this community, was also reduced for at least 3 years.

Richness and diversity - Foliar glyphosate applied to the *Fern* complex did not affect species richness or species diversity (according to the Shannon-Weaver diversity index) within 5 years of treatment. Full results are described in LMH 48 (Simard et al. 2001).

References

Simard, S.W., J.L. Heineman, W.J. Mather, D.L. Sachs, and A. Vyse. 2001. Effects of operational brushing on conifers and plant communities in the southern interior of British Columbia: Results from PROBE 1991-2000. Res. Br., Min. For., Victoria, B.C. Land Manage. Handb. No. 48.

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