Responses of Douglas-fir and the *Mixed Broadleaf-Shrub* complex to manual cutting, cut stump-glyphosate, and girdling: A summary of 10 year PROBE results

About the *Mixed Broadleaf-Shrub* complex

This community has the potential to interact with young conifers for long periods of time because of the rapid juvenile growth of paper birch, aspen, and black cottonwood, and because these are tree species that are a natural component of mature ICH zone stands. Broadleaves benefit sites through annual cycling of nutrients, reduced spread of *Armillaria* root disease, reduced spruce weevil damage, protection against frost damage, reduced incidence of ungulate browsing, increased complexity in vertical stand structure, and possibly the transfer of nutrients to conifers via root contact. However, at high densities broadleaves can also negatively affect conifer seedling growth and vigour by reducing light availability under and within the broadleaf canopy. (Full complex description)

Results

This section summarizes 10-year results from three fully replicated PROBE experiments where the *Mixed Broadleaf-Shrub* complex is being studied (Full Methods description):

1. Douglas-fir and vegetation responses to manual cutting in 5-8 year-old stands in the ICH and IDF zones. Study sites were mesic, gently to moderately sloping (10-45%), with northerly or northwesterly aspect. Elevation ranged from 450-1200 m, and broadleaf cover averaged 17% at the time of treatment.
2. Douglas-fir and vegetation responses to cut stump-glyphosate treatments in 8-9 year-old stands in the ICH zone. Study sites were mesic, gently sloping (25-30%), with northeasterly or northwesterly aspect. Elevation ranged from 870-1070 m, and broadleaf cover averaged 54% at the time of treatment.
3. Douglas-fir and vegetation responses to girdling in 5-17 year-old stands in the ICH zone. Study sites were mesic, gently to moderately sloping (5-35%), with easterly or southeasterly aspect. Elevation ranged from 520-1200 m, and broadleaf cover averaged 25% at the time of treatment.

Table 1. A summary of 10 year Douglas-fir responses

Was there a significant[a] improvement in conifer performance 10 years after treatment?	Manual cutting	Cut stump-glyphosate	Girdling
Survival	No	No	No
Basal stem diameter	Yes	No	Yes
Stem diameter increment	No	Yes	Yes
Height	Yes	Yes	No
Leader length	No	Yes	No
Height:diameter ratio	No	No	No

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

Douglas-fir responses 10 years after brushing

- ***Survival*** - of Douglas-fir was moderate to good regardless of whether brushing treatments were applied, and none of the treatments significantly improved survival by year 10 (Figure 1). To the contrary, for 3-5 years after treatment, there was a trend for Douglas-fir mortality due to *Armillaria* root disease to be higher in manually cut and girdled plots than their controls. However, vigour data suggests that, for all treatments, survival may eventually decrease in the controls relative to the treatments.
- ***Vigour*** - Douglas-fir vigour was declining in the controls relative to the treatments by the time stands were 15-27 years-old (Figure 1).
- ***Stem diameter*** - Stem diameter or stem diameter increment increased following all three brushing treatments. Cut stump-glyphosate resulted in the largest diameter increase relative to its untreated control, probably because the treatment caused an immediate and sustained reduction in broadleaf abundance (Figure 2). Douglas-fir took longer to respond to girdling than to the other two treatments, possibly because (a) girdled broadleaves died slowly, and (b) Douglas-fir were, on average, older than in the other treatments at the time treatments were applied.
- ***Height*** - Douglas-fir height increased within 10 years of manual cutting and cut stump-glyphosate treatments, but did not increase following girdling (Figure 3).

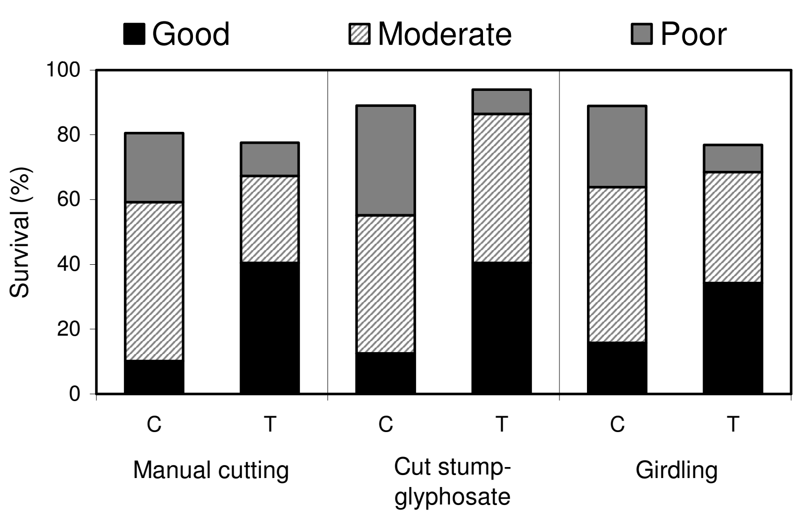

Figure 1. A comparison of Douglas-fir survival and vigour in controls (C) and treatments (T) 10 years after manual cutting, cut stump-glyphosate, and girdling treatments.

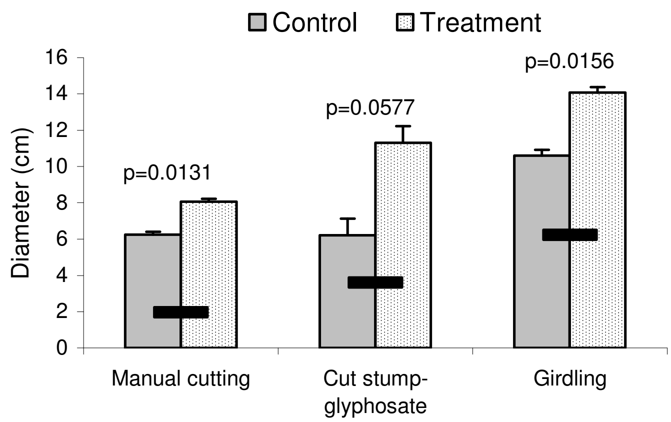

Figure 2. A comparison of Douglas-fir basal stem diameter in controls and treatments 10 years after manual cutting, cut stump-glyphosate, and girdling treatments. Horizontal bands represent Douglas-fir diameter at the time of treatment. Error bars represent 1 standard error.

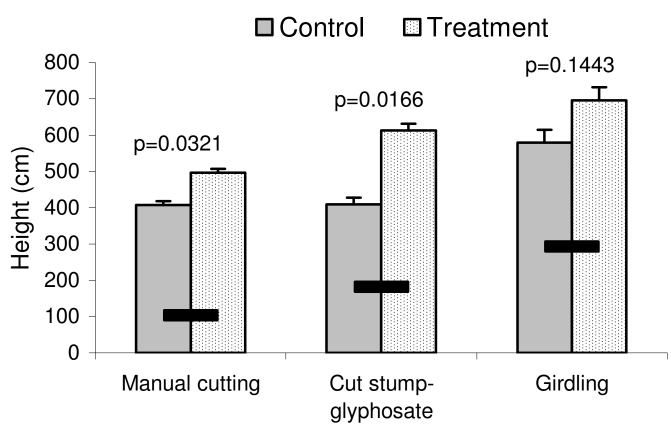

Figure 3. A comparison of Douglas-fir height in controls and treatments 10 years after manual cutting, cut stump-glyphosate, and girdling treatments. Horizontal bands represent Douglas-fir diameter at the time of treatment. Error bars represent 1 standard error.

Vegetation responses

Table 2. Duration of vegetation responses

Years of significant[a] vegetation reduction	Manual cutting	Cut stump-glyphosate	Girdling
Broadleaf cover	None	Years 5 - 10+	None
Broadleaf height	Years 1 - 10+	Years 1 - 10+	None

a Differences are significant where p≤0.05 according to ANOVA.

Manual cutting significantly reduced mean broadleaf height for at least 10 years. However, within 3 years of treatment, Douglas-fir was again overtopped by rapidly growing sprouts (Figure 4). Nonetheless, between years 5 and 10 in the treatment, the height differential between broadleaves and Douglas-fir was only about 100 cm, compared to approximately 400 cm in the untreated control. As a result, Douglas-fir in the treatment were receiving more light than those in the control (Comeau and Heineman 2003). Manual cutting had no effect on overall broadleaf cover because of sprout abundance. There were no significant treatment effects on other vegetation components (e.g., shrubs and herbs), and neither were there significant treatment effects on the richness or diversity of vascular plant species.

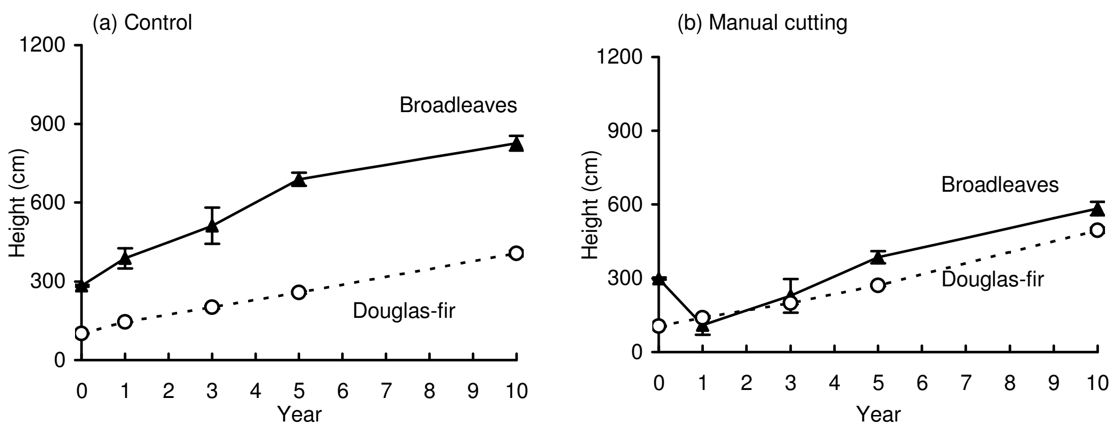

Figure 4. A comparison of average Douglas-fir and broadleaf height profiles in (a) the control and (b) the manual cutting treatment.

Cut stump-glyphosate significantly reduced mean broadleaf height for at least 10 years, which freed Douglas-fir of overtopping vegetation throughout the 10 year measurement period (Figure 5). Broadleaf cover was also significantly reduced by the treatment between years 5 and 10. There were no significant treatment effects on other vegetation components (e.g., shrubs and herbs), and neither were there significant treatment effects on the richness or diversity of vascular plant species.

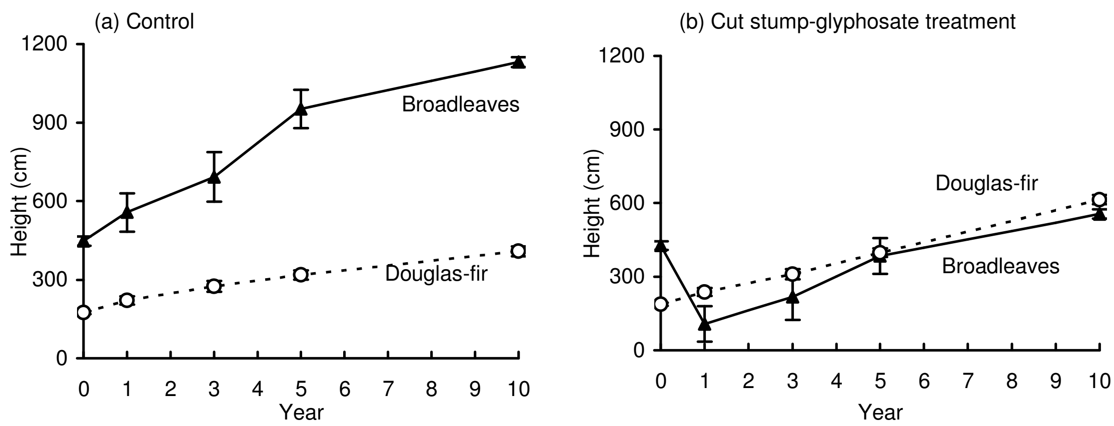

Figure 5. A comparison of average Douglas-fir and broadleaf height profiles in (a) the control and (b) the cut stump-glyphosate treatment.

Girdling had no significant effects on broadleaf height or cover during the 10 year measurement period. The lack of statistical significance is largely due to the high variability among girdled sites as broadleaves gradually died. Broadleaves continued to overtop Douglas-fir throughout the 10 year measurement period (Figure 6). During that period, despite the lack of statistical significance, broadleaf canopy cover was reduced by 62-76% in comparison with the untreated control. This implies that light availability was greater in the treatment than the control. There were no significant treatment effects on other vegetation components (e.g., shrubs and herbs), and neither were there significant treatment effects on the richness or diversity of vascular plant species.

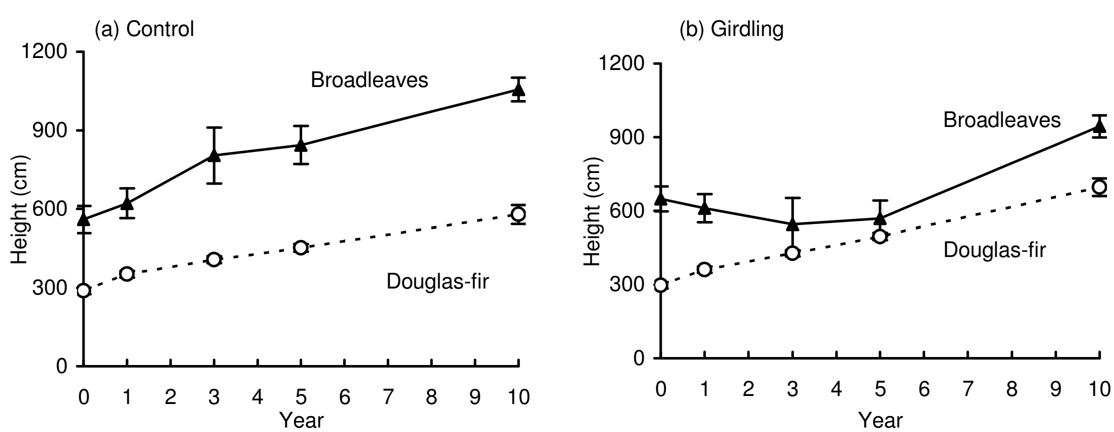

Figure 6. A comparison of average Douglas-fir and broadleaf height profiles in (a) the control and (b) the girdling treatment.

Management interpretations

Survival - On average, competition from the *Mixed Broadleaf-Shrub* complex in 15-27 year old untreated stands has not been severe enough to reduce Douglas-fir survival below an average of approximately 80%. However, as of year 10, Douglas-fir vigour has been declining in controls relative to all three treatments, and longer-term assessments are required to determine whether mortality increases as stands age.

Armillaria root disease - Early in this study, results suggested that the incidence of *Armillaria* related Douglas-fir mortality increased as a result of applying manual cutting or girdling treatments to the *Mixed Broadleaf-Shrub* complex. The relationship between brushing and *Armillaria* root disease requires further study, but in the interim, we suggest that in stands where *Armillaria* is present: (a) brush only in high broadleaf-density areas, and (b) if possible, use spot glyphosate treatments rather than manual cutting or girdling treatments.

Conifer growth - Competition from the *Mixed Broadleaf-Shrub* complex was intense enough to reduce Douglas-fir growth. Growth improved as a result of all types of brushing treatments applied to this community, but the largest growth increases occurred as a result of the treatment that most reduced broadleaf height and cover (i.e., the cut stump-glyphosate treatment). After 10 years, girdling had the next largest effect, even though Douglas-fir had responded more quickly to the manual cutting treatment.

Treatment efficacy – The cut stump-glyphosate treatment had a more severe and longer lasting effect on broadleaf height and cover than the girdling or manual cutting treatments. It immediately reduced broadleaf height below that of Douglas-fir and prevented vigorous sprouting, which allowed conifers to maintain their superior height position for at least 10 years after brushing. The manual cutting treatment also immediately reduced broadleaf height below that of conifers, but sprouting was vigorous and Douglas-fir were again overtopped within 3 years of treatment. Broadleaves died slowly following the girdling treatment, with the result that broadleaf cover was affected more than broadleaf height. Nonetheless, all three treatments can be assumed to have increased light availability to Douglas-fir because of their effects on the height of broadleaves relative to conifers, and on the density of the broadleaf canopy (Comeau and Heineman 2003).

Richness and diversity - None of the brushing treatments affected species richness or species diversity (according to the Shannon-Weaver diversity index) within 5 years of treatments. Full results are described in LMH 48 (Simard et al. 2001).

References

Comeau, P.G. and J.L. Heineman. 2003. Predicting light microclimate from stand parameters in young paper birch (*Betula papyrifera* Marsh.) stands. For. Ecol. Manage. 180: 303-315.

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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