FOREST PRACTICES

Practices and Strategic Investment Section

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SILVICULTURE NOTE 30

Twenty-Year Effects of Windrow Burning, Chemical and Mechanical Site Preparation, and Repeat Brushing on Survival and Growth of White Spruce

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Summary

The effects of mechanical and chemical site preparation, windrow burning, and repeat brushing on white spruce survival and growth were studied at two BWBSmw1 sites. After two decades, repeat brushing, chemical site preparation, and windrow burning improved spruce performance just as much as medium to high severity mechanical treatments. Manipulating the seedling microenvironment with mechanical site preparation treatments may have contributed to early spruce responses, but after 19-20 years, it was clear that the largest increases in spruce growth were associated with ongoing reductions in the abundance of tall shrubs and aspen. A range of treatments produced equivalent spruce responses at our sites, and we use results from related studies to also compare the treatments in terms of their effects on biodiversity, ecosystem health, and relative economic cost. This extension note summarizes information presented by Boateng et al. (2009).

Introduction

In northern British Columbia (BC), mechanical site preparation (MSP) is used to improve microenvironmental conditions for conifer seedling establishment and early growth. Objectives include increasing soil temperature and aeration in the rooting zone, improving soil drainage, increasing nutrient and light availability, and reducing the risk of physical damage from surrounding vegetation. Although MSP is the most extensively prescribed site preparation method in northern BC (BC Ministry of Forests 2007), its overall use declined during the past decade because of increased interest in raw planting, concerns about soil degradation, and perceived high treatment costs.

Interest in the use of MSP techniques peaked in the mid-1980s during a period of concerted effort to rehabilitate a backlog of insufficiently stocked sites in BC. During that era, a series of experiments was established in northeastern BC to examine the effectiveness of scalping, mounding, mixing, plowing, and disc trenching as techniques for improving early seedling performance. Where possible, these methods were also compared with broadcast burning and chemical site preparation or early brushing. Two studies located northwest of Fort St. John, BC (Inga Lake and Iron Creek), are now 20 years old and are helping to answer the following questions:

1. Was site preparation necessary to achieve adequate survival of planted spruce?
2. Which treatments resulted in the greatest improvements in spruce survival and growth?
3. Did early spruce responses persist over the long term?
4. Can we explain spruce responses?
5. Do the treatments differ in their effects on biodiversity and overall ecosystem health?

Site characteristics, treatments, and measurements

Site characteristics for the Inga Lake and Iron Creek studies are described in Table 1. At each site, seven treatments were randomly assigned to five blocks in a randomized complete block design (Table 2). Prior to the start of the experiment, the two sites supported dense communities of willow, alder, and aspen, and had well-developed herb layers. One year prior to installation of MSP treatments, vegetation was mechanically sheared and debris was piled in long windrows. There was little mineral soil exposure. Site preparation treatments were installed in 1986 at Iron Creek and in 1987 at Inga Lake. Following overwinter settling, white spruce container stock was planted in 1987 at Iron Creek (PSB 313 1+0) and in 1988 at Inga Lake (PSB 313 2+0). Ground-level diameter and height of planted spruce were measured at the end of the growing season (in the fall) nine times over 20 years at Iron Creek, and 16 times over 19 years at Inga Lake. Estimates of overtopping were made in the most recent assessments when spruce were 19-20 years-old. Microclimate, vegetation, and soils data were collected by other researchers, and were used to interpret spruce responses.

Table 1. Site characteristics

	Inga Lake	Iron Creek
Latitude/longitude	56°37’ N/121°38’ W	56°38’N/122°19’W
BEC unit/site series	BWBSmw1/01	BWBSmw1/06
Elevation	890 m	820 m
Soil moisture regime	Fresh to moist	Moist (fresh)
Slope	0-15%	5-10%
Aspect	Variable rolling terrain	Easterly
Soil texture	Silt loam to clay loam	Silt loam to clay loam
Coarse fragment content	15%	<5%
Effective rooting depth	20-25 cm	10-25 cm
Treatment history	Fire origin, no harvest history	Selectively logged 1966; clearcut1977

Results

Five year spruce survival averaged 98 and 92% at Inga Lake and Iron Creek, respectively. After 19-20 years, survival was relatively good at both sites, even in the untreated controls (≥ 77%, Table 3). By year 5 at Inga Lake, significant increases in spruce stem diameter relative to the untreated control were associated with the fine mixing (Madge), breaking plow, and burned windrow treatments. Spruce diameter had not responded to the repeat brushing treatment by year 5 because the initial application of glyphosate did not take place until year 3. However, by year 19, repeat brushing, fine mixing, breaking plow, and burned windrow treatments had all resulted in significant increases in white spruce stem diameter and height relative to the control. With the exception of disk trenching, year 19 spruce stem volume was significantly higher in all treatments than in the control (Figure 1a).

Table 2. Treatment descriptions, potential long-term effects, and relative cost

Treatment type	Equipment	Site	Treatment description	Effects on plant community	Relative cost per hectare [3]
Mechanical site preparation					
Mixing	Madge rotoclear	Inga	Fine broadcast mixing of forest floor and mineral soil to 17 cm depth.	Increase in non-native plant species[1]	High
	Bedding plow	Inga	50 cm wide beds of coarsely mixed forest floor and mineral soil.		Medium
Plowing	Breaking plow	Inga & Iron	Side-by-side beds of 15 cm deep mineral soil inverted over forest floor.		Medium
Disk trenching	TTS Delta trencher	Inga	Continuous shallow trenches with loosely mixed berms, spaced 3 m apart (planting at hinge).		Low
Mounding	Bräcke mounder	Iron	Small 20 cm tall mounds with average 3 cm mineral cap.		Medium
	Ministry mounder	Iron	Large 36 cm tall mounds with average 10 cm mineral cap.		High
Scarification	Bräcke scarifier	Iron	Small patches of exposed mineral soil. Patches were fertilized in one treatment and unfertilized in another.		Low
Fire					
Windrow burning	None	Inga	Slash and some mineral soil were piled in long rows and burned.	Increase in non-native plant species[1]	Medium
Chemical site preparation					
Broadcast glyphosate	None	Iron	Broadcast application of glyphosate prior to planting.	Increases in herb richness and structural diversity[2]	Medium
Vegetation control					
Repeat brushing	None	Inga	Broadcast glyphosate was applied after 3 growing seasons but did not adequately control willow, possibly because of defoliation by insects earlier in the year. Repeat manual cutting was applied until year 14 to provide continuous vegetation control.		High (due to multiple manual cutting entries)

[1] Haeussler et al. (1999)
[2] Boateng et al. (2000)
[3] Cost information was collected from a variety of sources dating from 1990 to 2008, from which we developed three treatment cost classes for comparative purposes. Low cost treatments were <$350/ha, medium cost treatments were $350-$700/ha, and high cost treatments were >$700/ha.

At Iron Creek, the breaking plow and chemical treatments improved white spruce growth relative to the control by year 5. This trend continued to year 20. The mounding and scarification treatments did not improve growth relative to the control (Table 3, Figure 1b).

At both sites, there was an inverse relationship between spruce growth at age 19-20 years, and the degree of overtopping by vegetation. At Inga Lake, no more than 15% of spruce were overtopped in the repeat brushing, fine mixing, burned windrow, and breaking plow treatments, compared with 35% in the bedding plow treatment, and 76 and 93% in the disk trenching and untreated control, respectively (Figure 1a). At Iron Creek, the chemical site preparation and breaking plow treatments had the lowest overtopping levels (1 and 21%, respectively), compared with greater than 60% in the other treatments (Figure 1b).

Table 3. Treatment effects[a] on white spruce growth in years 5 and 19 at Inga Lake and years 5 and 20 at Iron Creek

	Year 5				Year 19 or 20			
	Survival (%)	GLD (cm)	Height (cm)	HDR (cm/cm)	Survival (%)	GLD (cm)	Height (cm)	HDR (cm/cm)
Inga Lake								
Repeat brushing	98 a	1.1 b	63 c	56 b	90 ab	13.1 a	633 a	49 c
Fine mixing (Madge)	99 a	1.5 a	78 abc	52 b	95 ab	12.0 a	620 a	53 bc
Burned windrow	98 a	1.7 a	84 ab	51 b	93 ab	12.0 a	638 a	55 bc
Breaking plow	99 a	1.5 a	90 a	59 b	98 a	10.6 ab	640 a	63 ab
Bedding plow	99 a	1.1 b	79 abc	71 a	95 ab	8.8 b	548 a	67 a
Disk trench	98 a	1.0 b	72 abc	72 a	85 ab	5.2 c	362 b	69 a
Untreated	98 a	1.0 b	68 bc	72 a	82 b	4.1 c	292 b	70 a
p-value	*0.819*	***<0.0001***	***0.001***	***<0.0001***	***0.015***	***<0.0001***	***<0.0001***	***<0.0001***
Iron Creek								
Chemical site prep	95 a	1.1 ab	69 ab	62	93 ab	12.7 a	612 ab	50 b
Breaking plow	96 a	1.3 a	82 a	67	95 ab	12.6 ab	694 a	58 ab
Ministry mound	96 a	1.1 abc	68 ab	66	94 a	9.1 abc	541 abc	66 ab
Small mound	90 a	0.9 bcd	64 abc	70	89 ab	8.2 bc	505 abc	65 a
Scarified patch+fert	93 a	0.8 d	58 bc	75	91 ab	8.0 bc	470 bc	62 a
Scarified patch	87 a	0.7 d	47 c	70	79 ab	6.1 c	381 c	67 a
Untreated	86 a	0.8 cd	54 bc	69	77 b	6.8 c	430 c	67 a
p-value	*0.104*	***<0.0001***	***0.0004***	*0.082*	***0.003***	***<0.0001***	***0.0002***	***0.0045***

[a] P-values in bold are significant at $p \leq 0.05$ according to analysis of variance. Means not assigned the same letter are significantly different according to the Bonferroni test.

Discussion and management interpretations

Spruce survival and growth

After 19-20 years, spruce survival was relatively good, even with no site preparation or brushing. When this study was established in the mid-1980s, achieving adequate seedling survival was an important objective. Today, due to improvements in nursery and stock handling techniques, high rates of survival are the norm. Where objectives include enhancing white spruce growth, vegetation control appears to be the critical factor on BWBSmw1 sites with abundant alder, willow, and aspen. In the 1980s, site preparation effects on soil often had a higher profile than the effects on vegetation community attributes. After two decades however, it was clear that the largest increases in spruce growth at the Inga Lake and Iron Creek sites were associated with reduced tall shrub and aspen abundance. Treatments that left surface soil intact but reduced vegetation abundance (e.g., repeat brushing at Inga Lake and chemical site preparation at Iron Creek) were just as effective as the most severe mechanical and burning treatments.

Biodiversity and ecosystem health

White spruce growth responses were equivalent across a range of site preparation techniques at both Inga Lake and Iron Creek, which facilitated consideration of other factors such as treatment effects on long-term ecosystem health. In a detailed study of the effects of site preparation on vascular plant species composition at Inga Lake, Haeussler et al. (1999) recommended the breaking plow or bedding plow over higher severity fine mixing (Madge) or windrow burning. Despite similar spruce growth responses among these four treatments, fine mixing and windrow burning encouraged invasion of non-native plant species, whereas the lower severity treatments had a minimal effect on species composition.

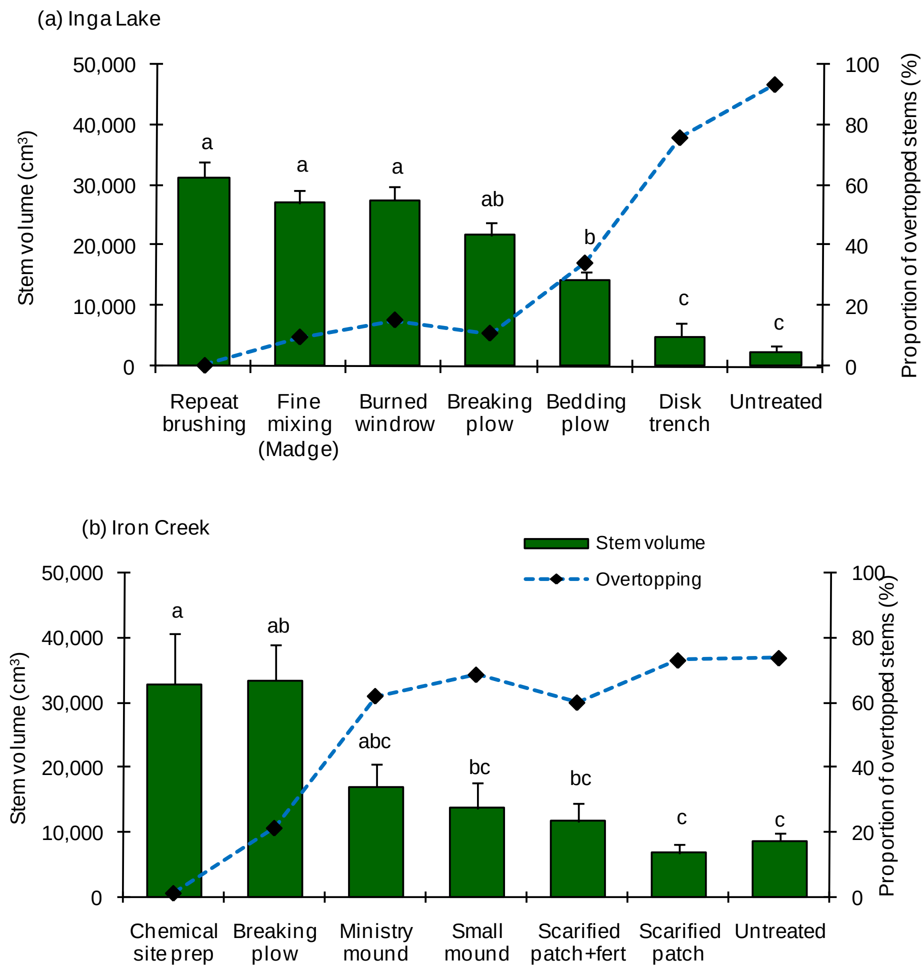

Figure 1. White spruce stem volume and proportion of trees that were overtopped by vegetation (a) after 19 years at Inga Lake and (b) after 20 years at Iron Creek. Error bars are one standard error. Means having the same letter do not differ significantly at $p \leq 0.05$.

In other studies, Boateng et al. (2000, 2006) concluded that chemical site preparation could improve spruce growth without incurring long-term negative effects on the vegetation community, especially when glyphosate was applied as a spot treatment. In all cases, the researchers acknowledged that negative treatment effects could be minimized by applying treatments as spot rather than broadcast treatments.

Treatment cost

It is difficult to provide up-to-date cost information for the full range of treatments in this study because some of them are not used operationally. Costs are also highly variable with time and location. We gathered cost information from a variety of sources dating from 1990 to 2008, and assigned treatments to low (<$350/ha), medium ($350-$700/ha), or high (>$700/ha) cost classes (Table 2) to provide a relative comparison. In general, costs increased with the severity of the treatment effect. The brushing option in this study was costly because repeat manual treatments were needed to provide continuous vegetation control for study purposes (~$600/ha per entry). This is not the operational norm and brushing costs would have been lower if the initial glyphosate treatment (~$875/ha per backpack entry) had been successful.

Conclusions

From our study and related work we conclude that:

1. Adequate survival of planted white spruce container stock can be achieved without site preparation on mesic sites in the BWBSmw1.
2. Where the objective is enhanced spruce growth, a lasting reduction in overtopping vegetation is the most important factor at these sites.
3. In terms of biodiversity, spot chemical site preparation, medium severity MSP treatments, or brushing treatments (chemical or manual) that effectively decrease abundance of overtopping vegetation are recommended over high severity MSP treatments that have lasting effects on vegetation community composition.

References

BC Ministry of Forests and Range. 2007. 2007/08 Annual service plan report. BC Ministry of Forests and Range, Victoria, BC.

Boateng, J.O., Haeussler, S., and Bedford, L. 2000. Boreal plant community diversity 10 years after glyphosate treatment. W. J. Appl. For. 15(1): 15-26.

Boateng, J.O., Heineman, J.L., McClarnon, J., Bedford, L. 2006. Twenty year responses of white spruce to mechanical site preparation and early chemical release in the boreal region of northeastern British Columbia. Can. J. For. Res. 36: 2386-2399.

Boateng, J.O., Heineman, J.L., Bedford, L., Harper, G.J., Nemec, A.F.L. 2009. Long term effects of site preparation and post-planting vegetation control on *Picea glauca* survival, growth, and predicted yield in boreal British Columbia. Scand. J. For. Res. 24(1): 111-129.

Haeussler, S., Bedford, L., Boateng, J.O., MacKinnon. A. 1999. Plant community responses to mechanical site preparation in northern interior British Columbia. Can. J. For. Res. 29: 1084-1100.

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