Prince George Forest Region

Forest Resources & Practices Team

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Note #PG-24

FOREST RESEARCH NOTE

Regenerating Boreal Mixedwoods: Three – year results of a Group Shelterwood Silviculture System in Trembling aspen – White spruce Stands

By Richard Kabzems

Mixed species stands provide options for creating a wide variety of future stand conditions. Forest managers are increasingly being asked to consider and apply a diversity of silviculture systems to address the variety of social, economic and ecological values found in forest ecosystems.

A widespread and distinctive feature of the boreal forest are mixed stands of white spruce and trembling aspen, often referred to as 'mixedwoods'. These can be horizontal mixtures of white spruce and aspen trees (Photo 1) or vertical mixtures where the white spruce are growing under taller aspen (Photo 2). An almost infinite number of combinations can be found, reflecting the type and intensity of disturbance, vegetation on site, seed sources and ecological characteristics of the plant species (Lieffers *et al.* 1996).

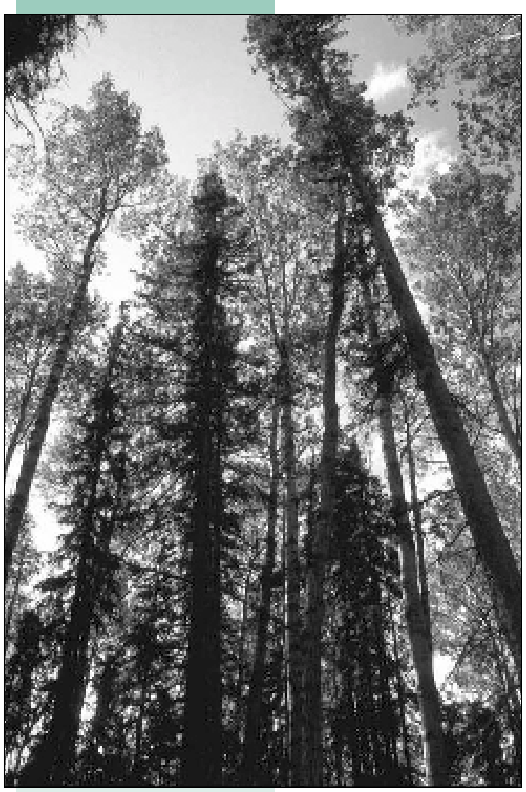


PHOTO 1. Boreal mixedwood stand where both aspen and white spruce are within the dominant and co-dominant crown classes.

The Canadian Forest Service established a number of partial cutting trials in the boreal mixedwoods of western Canada between 1924 and the mid 1960's (e.g. Ball and Walker 1995, 1997, Lees, 1964, 1970, Waldron 1959). Natural regeneration of white spruce was the focus of many of these earlier experiments. Recently, there has been a resurgence of interest in alternative silviculture techniques in response to ecosystem based approaches to forest management.

The purpose of this research note is to describe the third year results of application of a group shelterwood system in boreal mixedwood forests in the Fort Nelson Forest District of northeastern British Columbia.

Study Area

This research was done in the Fort Nelson Forest District (Figure 1). Two sites (SY43B, SY45) were harvested in December 1996, near Hoffard Creek, approximately 40 km east of Fort Nelson. The third and fourth sites (FN47E, FN47W) were harvested in March 1998, north of the Fort Nelson River, approximately 60 km northwest of Fort Nelson.

All study sites were located in the Boreal White and Black Spruce biogeoclimatic subzone, moist — warm variant (BWBSmw2). All sites were classified as belonging to the aspen — white spruce step-moss association (DeLong *et al.* 1990) with average soil moisture and nutrient conditions. Soil textures were loam or silt loam surface horizons over dense, clay-loam Bt horizons at 15 to 35 cm depths.

The study stands had established naturally after wildfires. The Hoffard Creek sites were approximately 90 years old and the Fort Nelson River Sites approximately 150 years old. Net merchantable volumes ranged from 300 to 400 m3/ha.

The height of aspen dominants was between 26 and 32 m, with some exceptional heights over 35 m. White spruce heights were much more variable, ranging from regeneration less than 1.3 m in height to dominants of over 30 m. The majority of white spruce at the Hoffard Creek sites were advanced regeneration with diameters (at 1.3 m, dbh) of less than 17.5 cm (Figure 2). Stand structure was generally stratified, with white spruce forming a layer under the aspen canopy (Photo 2). In contrast, many of the white spruce at the Fort Nelson River sites were greater than 17.5 cm dbh, (Figure 3) forming a dominant — co-dominant stand structure with the aspen (Photo 1).

Two different sizes of circular openings were created in the study (Photo 3), 0.13 ha (40 m diameter), and 1.0 ha (113 m diameter). The small openings were approximately 1.25 the height of dominant aspen. The large openings were three to four tree heights in diameter.

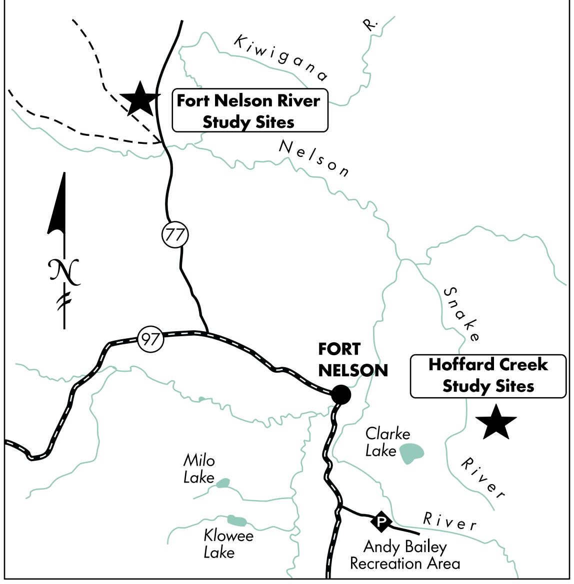
On all sites, a conventional feller buncher and grapple skidder combination was used to bring whole trees to landings for processing.

Findings to Date

Snags and coarse woody debris

The objective of this component is to compare the quantity and distribution of snags and coarse woody debris in naturally occurring mixedwoods to those occurring in the group shelterwood treatments. Snags and coarse woody debris (CWD) are significant features for maintaining the long term productivity of boreal forests. For example, they provide key habitat for reproduction, feeding and shelter of a variety of wild life species. Prior to harvest, snags and coarse woody debris were measured along continuous transects in these study stands. Tree species, size and decay class were recorded.

FIGURE 1. Study site locations. Hoffard Creek study sites are SY43B and SY45. Fort Nelson River study sites FN47E and FN47W are near the located seven km north of the Fort Nelson River, along Highway 77.



At the Hoffard Creek sites, aspen was the dominant species for both snags and coarse woody debris (Tables 1, 2). At this stage of stand development, self-thinning of aspen was the major source of new snags, and large pieces of wood which fall to the forest floor. At the Hoffard Creek sites, the majority of live aspen stems were between 17.5 and 27.5 cm in diameter, while the majority of snags were less than 17.5 cm in diameter.

PHOTO 2. Stratified boreal mixedwood where white spruce form a distinct layer under trembling aspen.

At the Fort Nelson River sites, aspen was the dominant species for both snags and CWD (Tables 1, 2). However, white spruce made up a larger proportion of the snags at the Fort Nelson River site (particularly FN47W), than at the Hoffard Creek sites (Table 1).

Light environments

The objectives of this component were: 1) to quantify the light environments in the two different sizes of openings created by the group shelterwood treatments; and 2) to examine relationships between growth of planted white spruce in these openings and the amount of light that they receive. In the third growing season a limited study to quantify light environments within the group shelterwood treatments was done on the FN47E site. Light environments in the openings were quantified using hemispherical and fish-eye photographic images analyzed using the model LITE (Comeau 1998). Light environments of individual white spruce seedlings were measured using LAI-2000 plant canopy analyzers (Li-Cor, Inc., Lincoln, Neb).

The group shelterwood treatments had created two contrasting light environments (Figure 4A, 4B). Within each gap, a variety of light environments were created reflecting factors such as the height of adjacent stand, tree species composition of adjacent stand (proportion of spruce or aspen), and size of opening. The within gap pattern of variation was also different between the two sizes of openings (Figure 4A, 4B). The northern portions of small gaps had substantially greater light availability compared to other locations (Figure 4B).

The LITE model predicted that light levels at the centre of the gaps increased with increasing gap size, with 40% of open sky light levels achieved when gap radius is approximately 28 m and 60% of open sky light achieved when gap radius is approximately 50 m.

For the large opening, on a northern transect, average growing season light levels were predicted to remain above 60% light right up to the dripline of the adjacent mature stand (Figure 4A). On the southern transect, light levels were below 60% for points located within 20 m of the adjacent stand, which contrasted strongly with the small opening treatments (Figure 4B). The maximum % transmittance value (27%) is reached 15 m north of plot centre (Figure 4B). All other transects in the small opening had light transmittance values of 15% or less.

These estimates of light levels provided by the LITE model should be interpreted relative to each other, and should not be considered as absolute estimates of % light transmittance (Comeau and Kabzems 2001). For smaller openings, LITE consistently underestimates light conditions compared to LAI 200 measurements of diffuse intercepted light (Gendron *et al.* 1998). Thus the values of 27% light for the small opening treatments of the example above should not be regarded as an absolute. However, the LITE model analysis identifies relative differences between the two treatments.

Vegetation

The objective of this component of the study was to examine the development of herbaceous and shrub plant communities in two different sizes of group shelterwood openings in the BWBS.

After three growing seasons (Figure 5) there was significantly more shrub cover (which included aspen regeneration) in the large opening treatment (42%) than the small opening treatments (32.6%). The trends for aspen cover indicate that the large opening treatment is developing more aspen cover over time (Figure 6), although this difference was not statistically significant after three growing seasons.

Total cover of herbaceous species or moss was not significantly different between treatments in the first three growing seasons. Herbaceous plants rapidly expanded their cover in both treatments over the first three growing seasons (Photo 4). There were no significant differences between treatments for any individual plant species.

Aspen regeneration

The objective of this component of the study was to examine the survival and growth of aspen regeneration in two different sizes of group shelterwood openings in the BWBS. Aspen regeneration was recorded along three continuous transects within each treatment opening. At three locations along each transect, aspen regeneration was measured for height and basal diameter.

In the first year after harvesting, the amount of aspen regeneration ranged from 13,000 to 35,000 stems/ha. This was similar to other aspen sites in the Fort Nelson area (Table 3). Moose browsing of aspen stems was common. Almost all the aspen regeneration at the Hoffard Creek sites was browsed by September of the first growing season.

There were significantly more aspen stems in the large opening treatment (31,180 st/ha) than in small openings (24,203 st/ha) by the third year after harvesting. There was no significant difference in height or basal diameter of the aspen regeneration between the two treatments after three growing seasons (Table 3).

The lower numbers of aspen regeneration in the small opening treatment are consistent with the lower levels of available light predicted by the LITE model. Even though these numbers were lower in the small openings, they were still well above those considered as acceptable for aspen regeneration stocking (Table 3). This is consistent with the results of Groot *et al.* (1997) in Ontario, where numbers of aspen regeneration within 18 m canopy gaps (1.0 tree height) were not significantly different than aspen regeneration numbers within a clearcut.

Differences in aspen productivity (measured by height or diameter growth) are not apparent at this early stage of stand development. The great variation in light environments predicted by LITE, would indicate that there will be portions of the small opening treatments which will maintain adequate light for not only survival but productive growth of aspen. Further monitoring of this study could establish if size of canopy gap results in different patterns of aspen self-thinning over time.

PHOTO 3. Aerial view of group shelterwood treatments within FN47E.

TABLE 1. Pre-harvest values for snags (>10 cm diameter) for study sites and comparative data from other studies.

Site	Species	Snags / ha	Live aspen /ha
FN47E	Aspen	67	307
	White spruce	21	
FN47W	Aspen	86	395
	White spruce	82	
SY45	Aspen	63	640
	White spruce	8	
SY43B	Aspen	108	890
	White spruce	15	
Norton & Hannon '97	Aspen	63 - 103	240 - 417
Lee et al. 1995	Aspen	66	535

TABLE 2. Coarse woody debris (>10 cm diameter) for study sites and comparative data from other studies.

Site	Species	Number of CWD / 100 m transect	Volume (m3/ha)
FN47E	Aspen	28	133
	White spruce	2	10
FN47W	Aspen	24	117
	White spruce	9	37
SY45	Aspen	21	55
	White spruce	2	8
SY43B	Aspen	16	46
	White spruce	2	5
Merkens & Booth '97	Aspen		40.9 (>5 cm diameter)
Lee et al. 1995	Aspen	13	101.4

White spruce natural regeneration

The objective of this component was to quantify and monitor white spruce natural regeneration in the group shelterwood.

White spruce natural regeneration was monitored in September 2000 after three (Fort Nelson River) or four (Hoffard Creek) growing seasons since harvest. Only six spruce seedlings were observed in 208 monitoring plots. There were no significant differences between treatments.

Neither seed source nor seedbed was favourable for white spruce natural regeneration in the first three years of this study. White spruce cone crops were below average in each of the years following harvest. Harvesting occurred on a snow pack after the ground was frozen enough to support logging equipment. As a result, harvesting activities did not create exposed mineral soil seedbeds for the establishment of white spruce.

TABLE 3. Third year trembling aspen regeneration characteristics for group shelterwood treatments and operational partial cutting sites in the Fort Nelson Forest District.

Treatment	Total stems/ha	Well spaced stems/ha (@ 1.4 m intertree)	Avg aspen height (cm)	Avg aspen basal dia. (mm)
Large (1.0 ha) gap	31,180	N/A	125	12.4
Small (0.13 ha) gap	24,203	N/A	128	11.8
Retention of Sw advance regeneration (247 st/ha, 94J080-5)	17,788	2,519	200 (est)	
Retention of Sw advance regeneration (240 st/ha,CCMC demo)	32,240	N/A	150 (est)	
Retention of Sw advance regeneration (104 st/ha, 94J079-19)	17,365	2,600	160 (est)	
Retention of Sw advance regeneration (399 st/ha, 94J088-14)	10,063	2,200	150 (est)	
Retention of Sw advance regeneration (10 st/ha, 94J078-03)	29,540	2,720	150 (est	

White spruce artificial regeneration

The objective of this component was to compare survival and growth of planted white spruce seedlings within two different sizes of shelterwood openings.

At each study site the first season after harvest, one half of the treatment openings (randomly selected) were planted with white spruce seedlings (1+0 415B) to a density of 1600 stems/ha. Seedlings along the monitoring transects were numbered and tagged. Height, leader growth and basal diameter were measured annually.

There were no significant differences in survival, height, height increment, or basal diameter in the first three growing seasons. Over the entire study, after three growing seasons, white spruce seedling heights averaged 44 cm, with 12 cm leaders (Photo 6).

As noted previously, vegetation response after harvesting has been very similar for both opening sizes. The white spruce seedlings are growing in very similar plant communities irrespective of canopy gap size. Initial analyses of light environments at the FN47E site (Fig. 7) show a very weak positive relationship between available light and growth of white spruce seedlings to date.

FIGURE 2. Pre-harvest diameter classes and species composition for SY45.

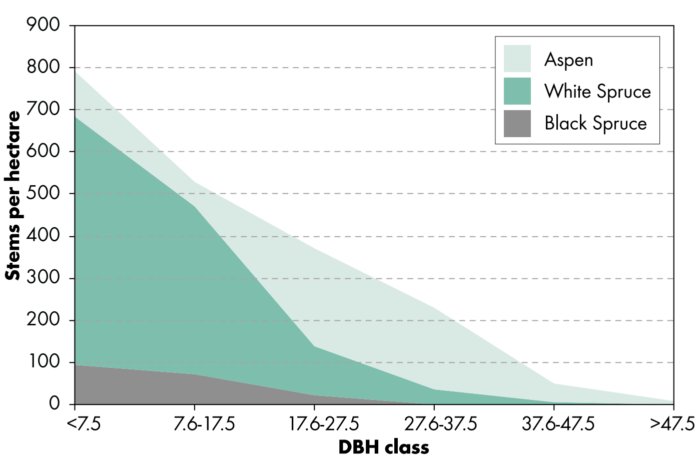
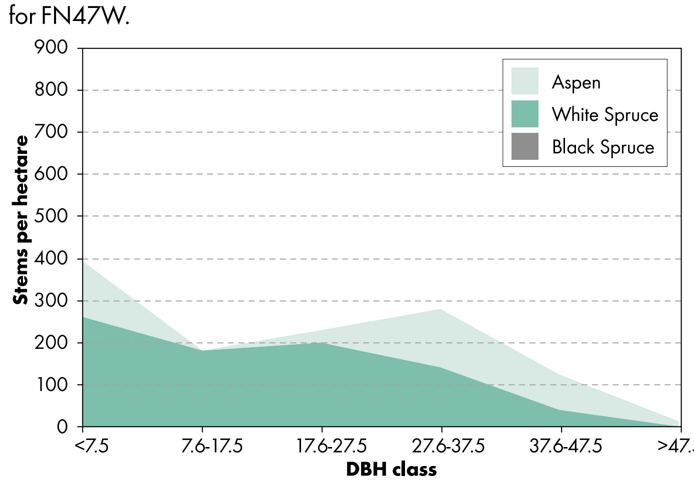


FIGURE 3. Pre-harvest diameter classes and species composition for FN47W.



Conclusions to Date

Although monitoring of the Fort Nelson group shelterwood trial is planned to continue, some preliminary conclusions may be drawn from the results, three years following the initial harvest.

1) Treatments had created two contrasting light environments. These light environments differed in both: a) total available light and b) the pattern of available light within the canopy gap.
2) Three years post-harvest the plant communities in both treatments were very similar. However, the initial trends for shrub and aspen cover would indicate development of increasing differences between the two treatments.
3) The numbers of aspen regeneration were significantly less in the small opening treatment. However the 24,000 stems per hectare which were present three years after harvest, would be adequate to fully regenerate the sites to aspen.
4) After three years, there were no significant differences in aspen growth performance between the two sizes of openings. Over time, differences in light levels between treatments may be reflected in the radial or height growth rates of aspen.
5) White spruce natural regeneration has been very limited to date. This is primarily due to limited available seedbed and seed source. The rapid expansion of vegetative cover post harvest will further limit white spruce recruitment in the near future.
6) Survival and growth of white spruce artificial regeneration on both treatments was similar. If the plant community structure and light availability of growing environments continue to diverge between the treatments, differences in white spruce growth performance may develop over time.

FIGURE 4A. Gradients in % transmittance over the growing seasons with distance and direction from the center of a large (56 m radius) opening at FN47E.

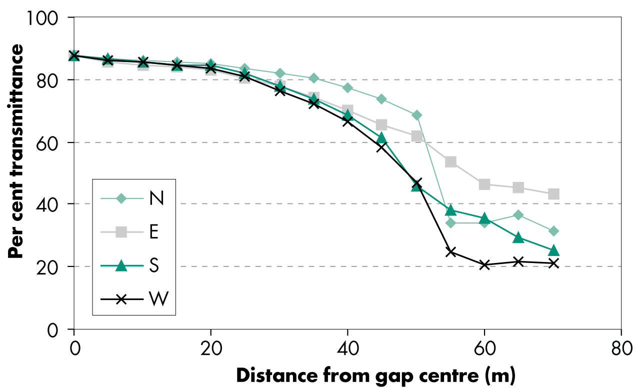


FIGURE 4B. Gradients in % transmittance over the growing seasons with distance and direction from the center of a small (20 m radius) opening at FN47E. The % transmittance was estimated for 1.5 m above ground level for the period from June 1 to September 30 using the LITE model (from Comeau and Kabzems 2001).

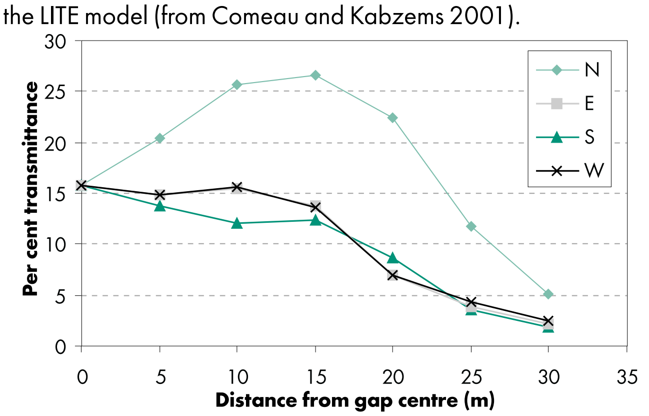


FIGURE 5. Changes in total shrub cover (%) for the large and small opening treatments over the first three growing seasons. Vertical lines indicate standard errors of the estimates.

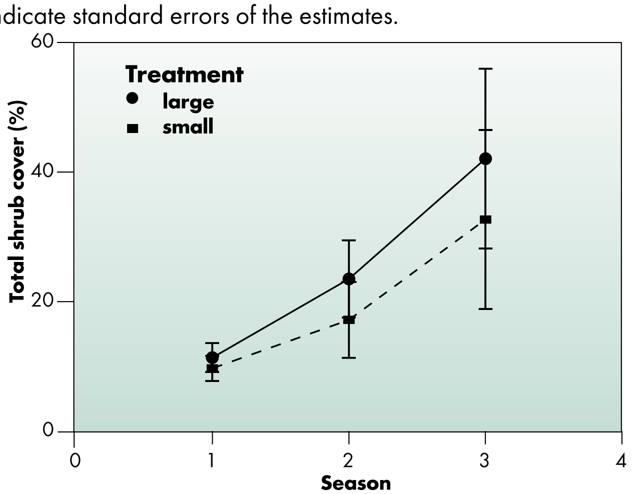


FIGURE 6. Changes in aspen cover (%) for large and small opening treatments over the first three growing seasons. Vertical lines indicate standard errors of the estimates.

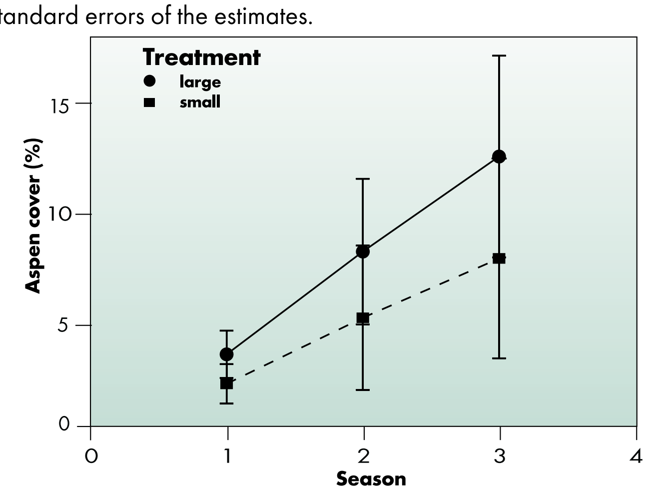


FIGURE 7. Scatterplot showing the relationship between diffuse intercepted light (difn) and basal diameter or height of white spruce seedlings at FN47E in 2000 (from Comeau and Kabzems 2001). The regression equations: BD2000 = 2.6095 + 0.6468 x BD1999 + 0.6050 x difn (n=227 R^2=0.360 RMSE=0.815); HT2000 = 5.0459 + 0.9720 x HT1999 + 5.0316 x difn (n=227 R^2=0.603 RMSE=5.694).

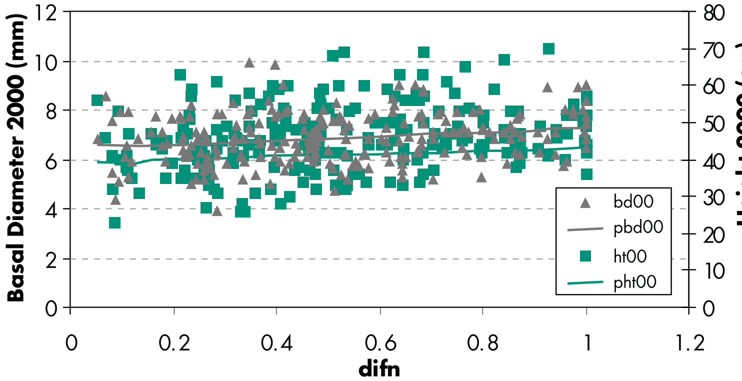


PHOTO 4. Shrub and herb vegetation in small opening treatment three growing seasons after harvest (September 2000).

PHOTO 5. Aspen regeneration in large opening treatment, three growing seasons after harvest (September 2000).

PHOTO 6. White spruce seedling in SY43B after four growing seasons (September 2000).

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