WESBOGY Research Note #2020-1

Results from age 26 remeasurement of the Big River WESBOGY LTS installation

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Introduction

Mixtures of trembling aspen (*Populus tremuloides* Michx.) and white spruce (*Picea glauca* (Moench) Voss) are a common natural stand type on upland sites in the western boreal forests of Canada. In the past these stands would have developed through natural regeneration of both species following fire or other stand destroying disturbances, while today white spruce are planted to regenerate spruce and mixedwood stands following harvesting.

Thinning of stands can improve growth of aspen and spruce (Bokalo et al. 2007; Kabzems et al. 2016) and studies indicate that growing spruce in mixture with aspen may reduce impacts of climatic and other stresses and that mixedwood stands may provide higher total yield than monocultures (Kabzems et al. 2016; Kweon and Comeau 2016). Enhancing spruce yields from mixedwood stands is one option for mitigating future conifer timber supply shortages.

The Big River WESBOGY Long-Term Study installations were established by Weyerhaeuser Canada in 1992 approximately 30 km north of the town of Big River, Saskatchewan. It is one of 11 pairs of Long-Term Study installations established in western Canadian since 1990 to examine the effects of trembling aspen and white spruce densities on the dynamics of mixed stands. The LTS involved planting white spruce seedlings in recently clearcut areas where aspen regeneration was establishing. Spruce and aspen were thinned to desired treatment densities at age 5 (Table 1). Each installation consists of two replications of 15 treatments. Big River includes two installations, one on a Median and one on a Superior site.

Table 1. Treatment numbers associated with spruce and aspen treatment densities established in each replicate in the WESBOGY Long-Term Study. White spruce were measured in the Big River Installations in the 10 treatments shown in bold.

	Trembling aspen (Aw) density (#/ha)					
White spruce (Sw) density (#/ha)	**0**	**200**	**500**	**1500**	**4000**	**Natural**
1000	1	2	3	4	5	6
500	7	8	9	10	11	12
0	x	x	x	13	14	15

NOTES:
1. Treatment numbers (1-15).
2. Empty cells (X) for treatments not established.

The Median (54.09°N 107.07°W, elev=515 m) and Superior (54.05°N 106.98°W, elev=505 m) installations were harvested in June of 1992, with aspen allowed to regenerate naturally by root suckering and with spruce planted (at double the treatment density) in September of 1992. Thinning to target densities was completed in September of 1996. Both installations were level, with moderately well drained Gray Luvisolic soils and with mesic to subhygric soil moisture regimes. Year 26 measurement of the Median installation was completed during August 2018 and measurement of the Superior was completed during May 2019.

Key Findings

Aspen densities have declined substantially in the unthinned plots from initial values of between 40,000 and 200,000 stems ha^{-1} in year 1 to approximately 2,600 stems ha^{-1} in year 26. At age 26, aspen densities have declined below treatment targets, with the 4,000 tph treatment currently at 2,000 tph, the 1,500 tph treatment at 1,050 tph, the 500 tph treatment at 390 tph, and the 200 tph treatment at 160 tph. In addition, some mortality of the planted spruce has resulted in 300 spruce tph in the 500 spruce tph treatments and 710 spruce tph in the 1000 spruce tph treatments.

Thinning treatments have increased average size of aspen, with size declining with increasing aspen density (Table 2). While analysis using only the four top height aspen in each indicated no significant effect of density on the average top height of 15.8 m, significant effects of aspen density on DBH, slenderness, crown with and live crown ratio of the top height trees was observed. Results for aspen are consistent with other studies (e.g. Kabzems et al. 2016) which show that thinning in young, healthy aspen stands with high densities can accelerate growth of residual trees, reduce slenderness , and increase crown width and live crown ratio.

Reductions in aspen density have resulted in significant increases in height, dbh, crown width and live crown ratio and a decrease in slenderness of white spruce at age 26 (Table 3). Spruce are largest and have the smallest slenderness at the lowest aspen densities. However, spruce height is not different amongst aspen densities of 4000 tph and lower, and only differs between the unthinned and the 0, 200, 500 and 1500 tph aspen densities. These results are consistent with other studies, which indicate that aspen leads to reductions in spruce dbh and increases in spruce slenderness but only affects spruce height when competition is at high levels.

Table 2. Effects of aspen density on average size of aspen at age 26. Within each column, means followed by different letters were found to differ significantly (α=0.05) based on Tukey's HSD test.

Aw treatment density	Height (m)	DBH (cm)	Slenderness	Crown Width (m)	Live Crown Ratio
200	8.89a	11.87a	0.811d	3.63a	0.769a
500	8.07ab	9.81ab	0.881d	3.02ab	0.723a
1500	7.76ab	7.81bc	1.053c	2.46bc	0.673b
4000	7.37ab	6.23cd	1.269b	1.95cd	0.589c
Unthinned	6.47b	4.37d	1.682a	1.34d	0.463d
p	*0.0097*	*<0.0001*	*<0.0001*	*<0.0001*	*<0.0001*

Table 3. Effects of aspen density on average size of white spruce at age 26. Within each column, means followed by different letters were found to differ significantly (α=0.05) based on Tukey's HSD test.

Aw treatment density	Height (m)	DBH (cm)	Slenderness	Crown Width (m)	Live Crown Ratio
0	3.03a	4.32a	1.274b	1.66a	0.813a
200	3.07a	3.85ab	1.364b	1.61ab	0.780a
500	3.26a	3.80ab	1.321b	1.65a	0.806a
1500	3.09a	3.30bc	1.456ab	1.63ab	0.789a
4000	2.86ab	2.51cd	1.763a	1.36bc	0.771a
Unthinned	2.41b	2.16d	1.781a	1.28c	0.701b
p	*0.0069*	*<0.0001*	*0.0002*	*0.0009*	*<0.0001*

The Mixedwood Growth Model (MGM18_VS1_2_18_37_Rev6115, March 2020) was used to examine effects of treatments on growth and yield. MGM was initialized for each plot using treelists created from measurements collected in 2018/2019. Site Index was calculated using Alberta Site Index curves (Huang et al. 2009) for each installation based on average spruce top height in plots 1 and 7 (zero aspen density) and average aspen top height in plots 6, 12 and 15 (natural aspen with no spruce) measured in 2018/2019 (age 26). Site index for the Median installation was 17.9 m@age50 for white spruce and 23.1 m@age50 for trembling aspen and site index for the Superior installation was 16.8 m@age50 for white spruce and 23.2 m@age50 for trembling aspen. Yield curves (Figure 1) indicate that increasing aspen densities lead to increased aspen yield and decreased spruce yield and delayed culmination ages for both species.

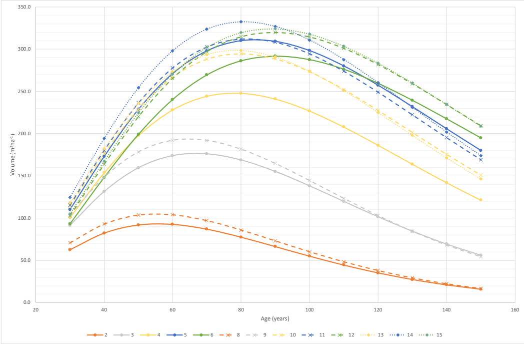

Figure 1a. Deciduous yield curves for each treatment based on MGM simulations.

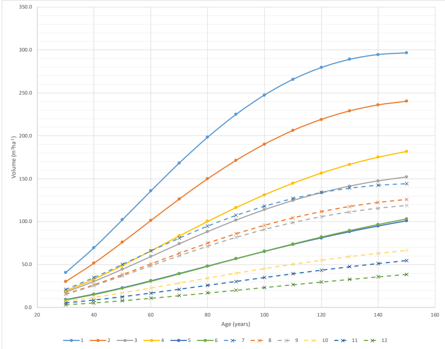

Figure 1b. Conifer yield curves for each treatment based on MGM simulations.

Treatments (trees/ha at age 5): 1=1000Sw/0Aw; 2=1000Sw/200Aw; 3=1000Sw/500Aw; 4=1000Sw/1500Aw; 5=1000Sw/4000Aw; 6=1000Sw/unthinned Aw; 7=500Sw/0Aw; 8=500Sw/200Aw; 9=500Sw/500Aw; 10=500Sw/1500Aw; 11=500Sw/4000Aw; 12=500Sw/unthinned Aw; 13=0Sw/1500Aw; 14=0Sw/4000Aw; 15=0Aw/unthinned Aw.

At Big River, spruce MAI for the 1000 spruce/ha treatment was 2.5 $m^3ha^{-1}y^{-1}$, 3.0 $m^3ha^{-1}y^{-1}$for the pure aspen stands with 4000 aspen/ha or unthinned, and 3.7 $m^3ha^{-1}y^{-1}$ for the mixture with 1500 aspen/ha and 1000 spruce/ha (Figure 2). Results suggest that the 1500 Aw/1000 Sw mixture can provide a 23% increase in total (aspen plus spruce) MAI over the pure aspen stands, with little reduction in aspen MAI and with a 44% reduction in spruce MAI. This is consistent with results from other studies (Kabzems et al. 2016; Kweon and Comeau 2019) that indicate the potential for overyielding in these mixtures.

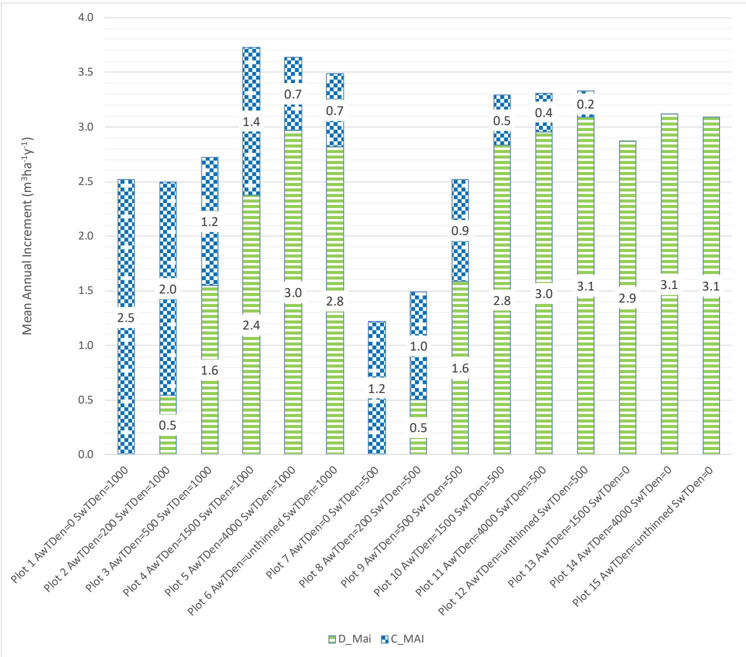

Figure 2. Effects of aspen and spruce densities on Deciduous (aspen) (D_Mai) and Conifer (spruce) (C_Mai) Mean Annual Increment at age 100 based on MGM simulations.

Conclusions

Results from analysis of data collected at age 26 (21 years after precommercial thinning) for the Big River WESBOGY LTS installations indicate:

1. Thinning lead to significant increases in aspen average height and DBH and reductions in slenderness;
2. Spruce height and diameter increased and spruce slenderness decreased with reductions in aspen density;
3. Crown width and live crown ratio of both aspen and spruce increased following thinning, with values being highest at the lowest aspen densities.
4. Aspen yield (at age 100) is potentially reduced by thinning of the aspen while spruce yield was increased by thinning the aspen. Spruce yield was higher for 1000 trees/ha than for 500 trees/ha initial densities.
5. Yield projections suggest that the mixture of 1500 aspen and 1000 spruce per hectare has the potential to provide a 23% increase in total MAI with a single harvest at age 100, compared to unthinned aspen stands, but with a 44% reduction in spruce MAI compared to pure spruce stands.

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