Effects of herbaceous vegetation control and aspen stem density on boreal mixedwood stand development.

Partners Report - 2008 Field Season

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The problem

Mixedwood forests dominated by white spruce (*Picea glauca* [Moench] Voss) and trembling aspen (*Populus tremuloides* Michx.) are prominent in the boreal forests of Canada. These forests contribute significantly to Canada's wood supply and serve important roles in the provision of wildlife habitat, biodiversity, water resources, and aesthetics. Across Canada, demands from both conifer and deciduous users are creating land-use conflicts, particularly where regeneration focuses on a single species. There is a need for practical regeneration strategies that will reproduce the temporal, spatial, compositional, and structural diversity of mixedwood forests and sustain the values they support on our landscape.

The proposed solution

In March 2002, a study was initiated to increase our understanding of the silvicultural regimes necessary to establish a mixture of white spruce and trembling aspen following clear felling on upland boreal sites. The hypothesis being tested is that a relatively low density of white spruce (e.g., 400 stems/ha) can be planted and managed on an individual-tree basis, while aspen are grown to an early technical rotation in the intervening areas between the spruce. The aspen may enhance spruce stem quality and provide a cash crop midway through the spruce sawlog rotation. A key objective of the study is to explore the relationship between early competition control around the planted spruce and aspen stem density, so that mixed yields of the two species might be optimized. The research sites, situated near Whitecourt Alberta and Timmins Ontario, contain identical experimental installations.

Methods

The study employs a **response-surface** design that combines the effects of ***radial*** vegetation control (0, 2, and 4 years duration) with aspen stem density (400, 800, 1200, 2000 and natural (i.e., unthinned)) (Fig. 1). Five reference ***broadcast*** treatments are also established to represent selected alternative practices: a) untended mixedwood plantation; b) mixedwood plantation with control of grass and herbaceous vegetation only; c) pure spruce plantation with control of all competition; d) pure spruce plantation with control of woody competition only, and e) pure aspen.

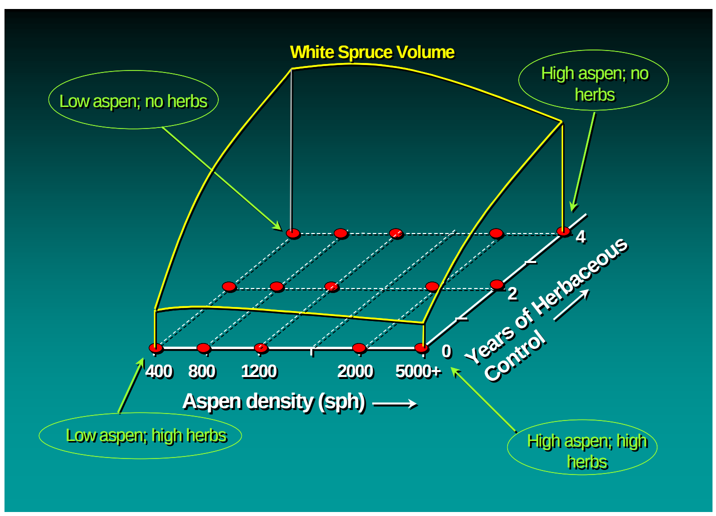

Fig. 1. Theoretical response surface resulting from treatment combinations of aspen stem density and duration of herbaceous vegetation control.

In each response-surface plot, all aspen and other woody competition situated within a 2-m radius of each planted spruce (5-m spacing) were removed at the end of the growing season prior to planting. This site preparation reduced initial aspen densities on the plots by approximately 50%. Herbaceous vegetation control treatments were applied within the 2-m radius of each planting location, at the end of the growing season prior to planting, and maintained for 2 or 4 years, as defined by the assigned treatment. Aspen situated between the spruce were to be thinned to the prescribed densities at the end of the 5^{th} growing season, after some natural thinning took place. Note that the prescribed aspen densities apply to the plot area, inclusive of the radial treatment areas around the spruce. Three replications at each of the four corners and center of the response surface permit the evaluation of pure error and lack of fit in resulting models; a total of 25 experimental plots (45 x 45 m) comprise this part of the experiment.

The five reference broadcast treatments quantify stand composition extremes as well as benchmark some of the operational approaches that are currently taken on mixedwood sites. Each of the plots in this part of the study is 35 x 35 m in size and, with the exception of the pure aspen plots, is planted to white spruce at 2.5-m spacing. Each broadcast treatment is replicated 3 times (15 additional plots, for a total of 40 plots).

All measurements are being conducted within the inner 25 x 25 m of the treatment plots. Individual and combined growth responses of the aspen and spruce are being compared among treatments and the treatment impacts on environmental factors and plant growth resources (e.g. air temperature, soil temperature, soil moisture, and light) measured. Microclimate (light, soil moisture, soil temperature, and air temperature) is being monitored at selected points within selected treatment plots. Light, overtopping leaf area index, and neighboring vegetation cover are being measured at selected spruce in each plot.

Results

Following five growing seasons at the Alberta site (to the end of 2007) (Figure 2), planted white spruce receiving early woody and herbaceous competition control, either as a broadcast or radial treatment, exhibited nearly 3-fold gains in stem diameter over untended trees, resulting in over 12-fold gains in stem volume index (Figure 3). In contrast, spruce receiving control of only woody or herbaceous competition exhibited close to 3 and 4.5-fold gains in stem volume index, respectively. Spruce receiving 4 years of radial complete vegetation control had a 43% growth advantage over their counterparts receiving only 2 years of control. Aspen crop trees on the site also exhibited a response to herbaceous weed control (Figure 3). The broadcast herbaceous treatment provided a small 6% gain in stem volume index over untended aspen; radial treatment provided a 49 to 55% gain, possibly due to the combined thinning effect of the radial treatments, and the adjacent herbaceous weed control. Across the site, aspen growth has still not fully recovered from the July 2005 hail storm, prompting us to continue delay of the planned year-5 aspen thinning. To maintain full spruce stocking of the radial treatment plots into the future, locations where trees had died were replanted in 2007. These seedlings are not included in the growth data presented. Across all treatments, mean spruce mortality rose only slightly from 11% in 2006 to 12% in 2007.

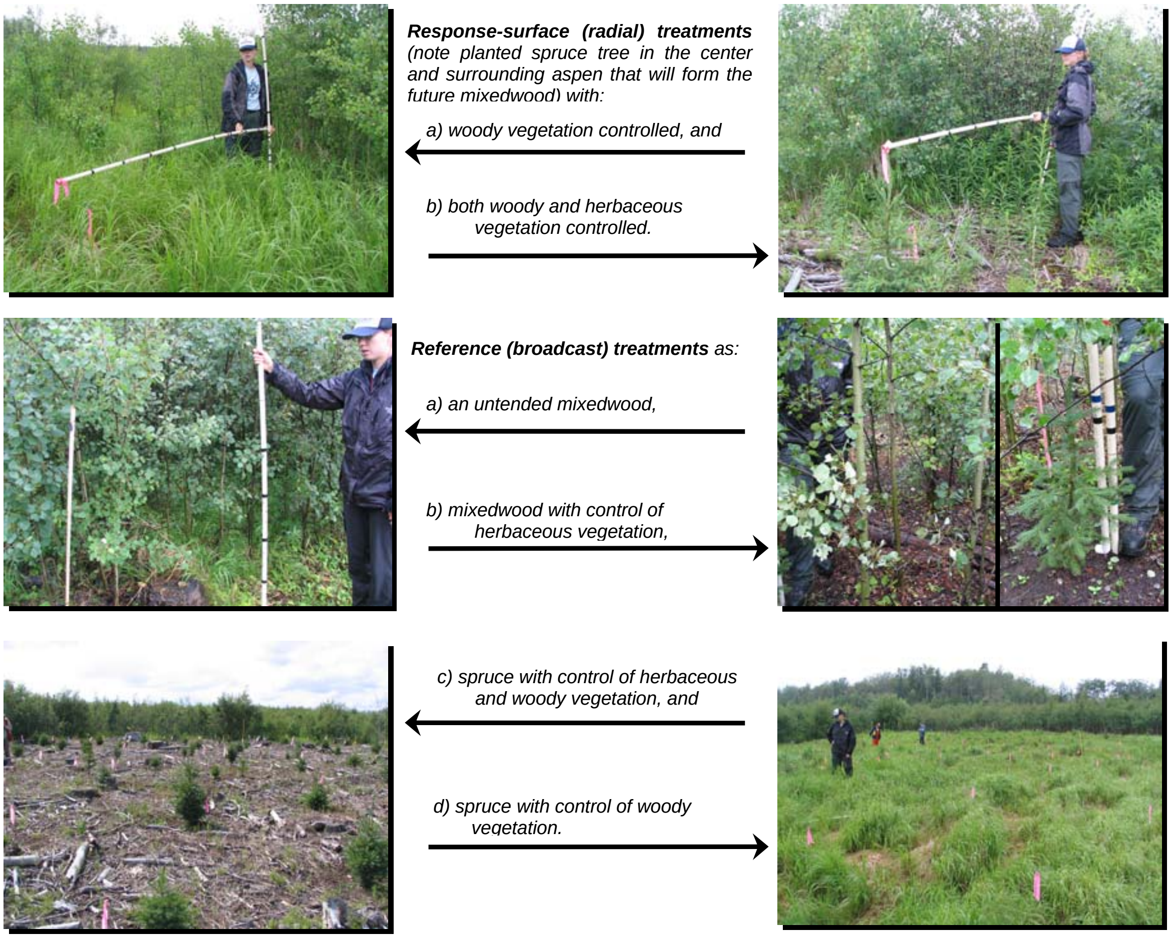

Figure 2. Key response-surface (radial) and reference (broadcast) treatments illustrated during the 5th growing season (2007) at the Alberta site.

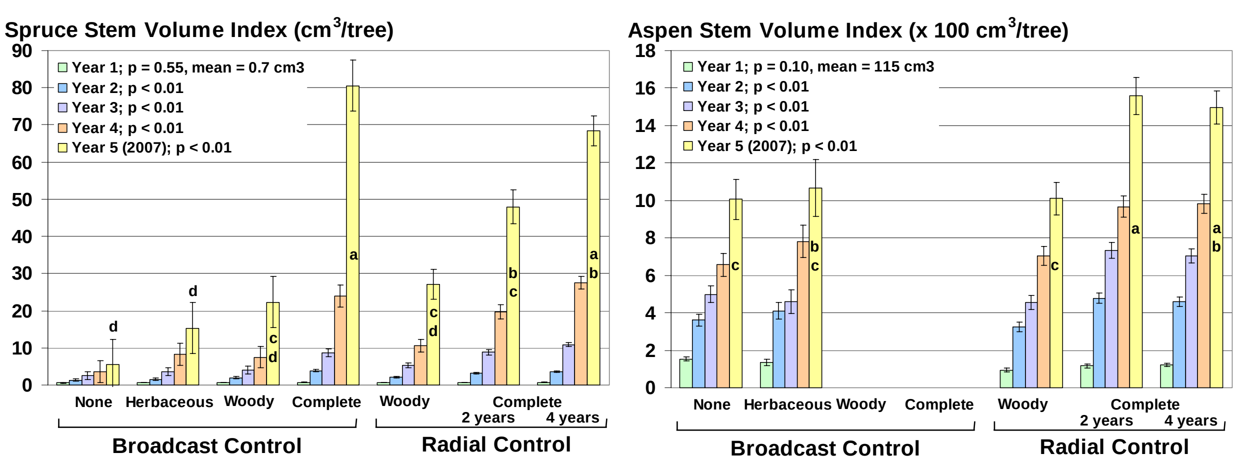

Figure 3. Stem volume index of spruce and aspen crop trees through 5 growing seasons at the Alberta site. Means with the same letter do not differ in year 5 (α=0.05, Tukey's HSD).

Through five growing seasons at the Ontario site (to the end of 2008) (Figure 4), plots exhibited similar patterns of vegetation development to those observed in the west, with the exception that ferns, broad-leaf forbs, and low shrub cover dominate in place of *Calamagrostis* cover. Thus far, spruce and aspen growth responses on this site have also closely resembled those observed at the Alberta site. Planted spruce receiving either woody or herbaceous control exhibited 72 or 158% gains, respectively, in stem volume index over untended trees; control of both types of vegetation resulted in 2.6-fold gains (Figure 5). The rate of aspen gain in stem volume index in broadcast herbaceous control decreased from a 31% yearly gain in 2007 to only a 14% yearly gain in 2008. Likewise, the rate of aspen gain in stem volume index decreased in radial control from a 30% yearly gain in 2007 to only a 20% yearly gain in 2008. Two frost events were recorded in early June 2007 that lead to high incidences of frost damage on the spruce noted, in the 2007 assessment. In the September 2008 assessment, the spruce seedlings seem to have recovered well from this frost damage; although, mortality did rise 3% to a site average of 10.9%. Consistent with Alberta plots, fill planting was completed in June 2008 in the radial treatments to maintain stocking into the future (these seedlings are excluded from above analyses). Patchy aspen regeneration and moose browsing in some plots still continues to delay aspen thinning.

Growth of the spruce was related to increased resources made available by the treatments. Results from Alberta indicated that although moisture was generally not limiting during the 2005 to 2007 growing seasons, radial complete control treatments resulted in the fewest hours with soil moisture below 30%. Soil nitrogen availability in 2005 was higher in the complete-control than in the woody-control treatments and higher in the broadcast than in the radial treatments. Complete vegetation control resulted in higher light availability than woody-only control and untreated, with the latter consistently having the lowest light availability. Although woody and herbaceous vegetation appear to have similar impacts on spruce growth per unit of leaf area, control of only the woody vegetation results in substantial increases in the total leaf area of competitors, largely due to increases in the abundance of grass. Similar analyses for the Ontario site are underway and it is expected that moisture and nutrient availability results will be similar to those observed at the Alberta site.

Early "take-home messages"

Effective control of both woody and herbaceous competition is beneficial to the early growth of white spruce. Treatments that control only woody competition generally result in increased herbaceous vegetation and reduced seedling survival and growth. Two-meter radius, individual-tree treatments that control both woody and herbaceous competition appear to have potential for the establishment of spruce and aspen as intimate mixtures. Through 5 growing seasons, adjacent aspen have not significantly hindered the growth of planted spruce and may offer some benefit in mitigating climatic extremes and reducing exposure injuries. Long-term monitoring is needed to document the dynamic interactions between these two species, as established, and formulate practical regeneration strategies and crop plans for spruce-aspen mixedwoods. We will begin publishing the 5-year results of these studies shortly.

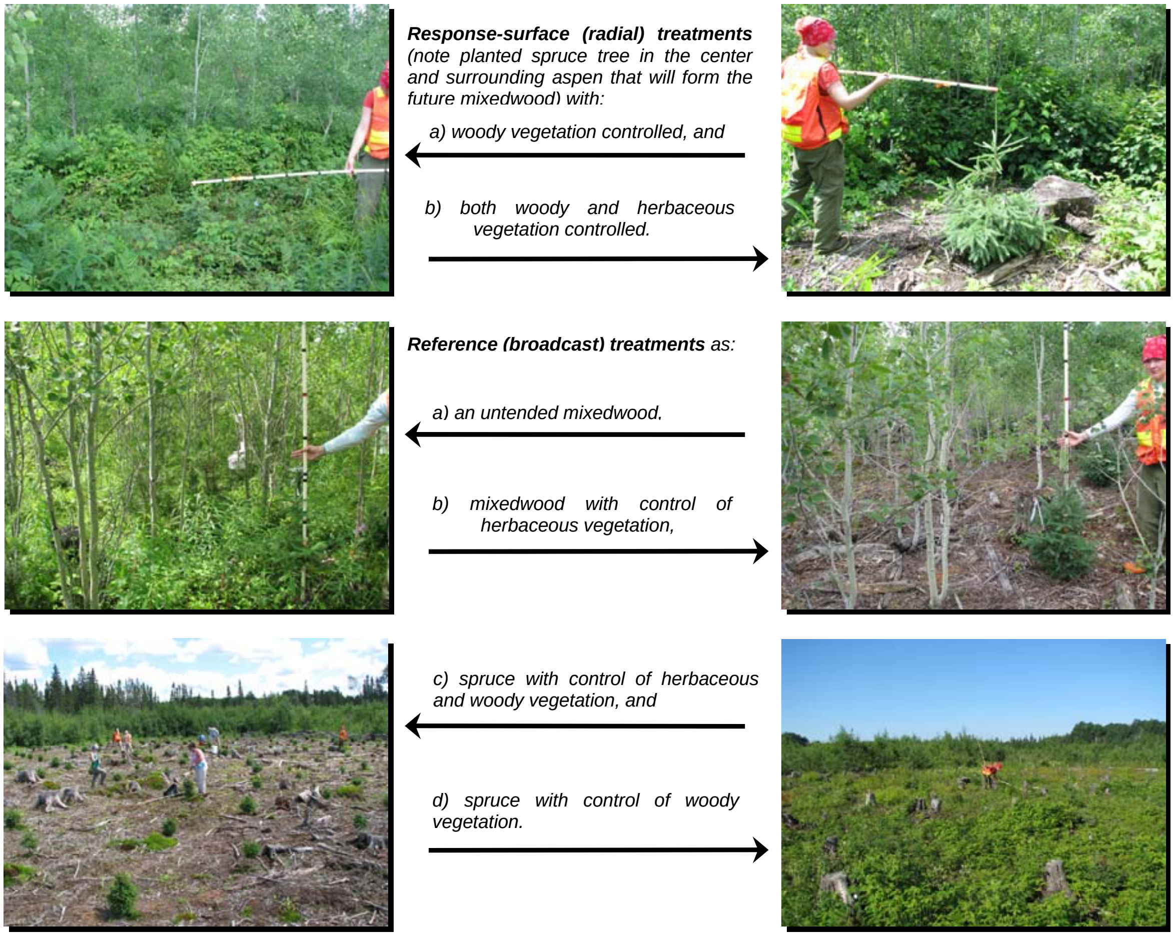

Figure 4. Key response-surface (radial) and reference (broadcast) treatments illustrated during the 5th growing season (2008) at the Ontario site.

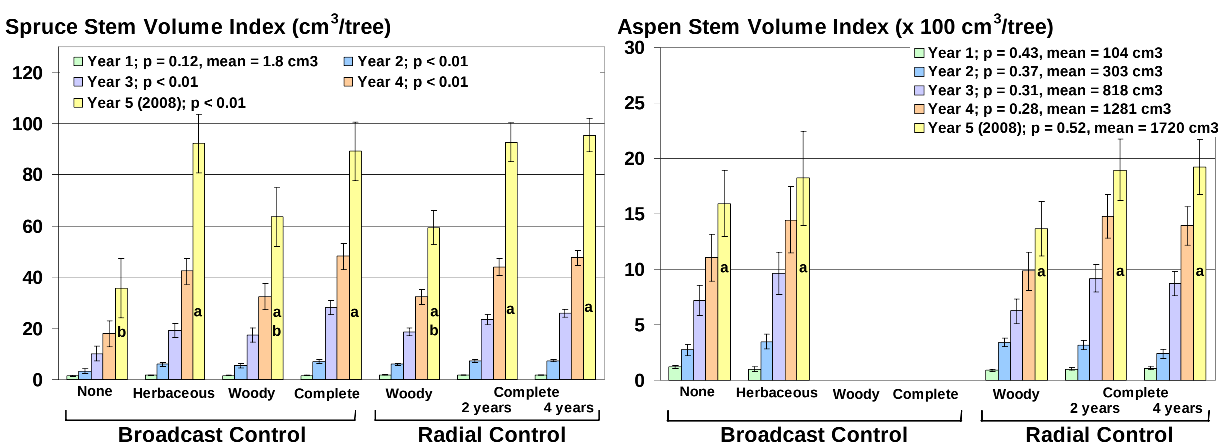

Figure 5. Stem volume index of spruce and aspen crop trees through 5 growing seasons at the Ontario site. Means with the same letter do not differ in year 5 ($\alpha = 0.05$, Tukey's HSD).

Research team

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Sponsors

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For more information, see the Canadian Ecology Centre – Forestry Research Partnership website at *www.forestresearch.ca* [RP-41 (2007); 38 (2006); 29 (2005); 26 (2004); 17 (2003)],
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