Applying an Understanding of Stand and Competition Dynamics For Natural Regeneration and Achievement of Alternative End Products: Examples From Western Canadian Mixedwood Forests

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Mixedwood stands, dominated by aspen and white spruce, are a prominent and important component of Canada's western boreal forests. Expanded industrial utilization of aspen during the past 15 years, as well as a strong interest in management that emulates natural disturbance and succession has resulted in heightened interest in management of aspen and of mixedwood stands. These stands provide the opportunity to produce both aspen and spruce from the same stands. Without planned management there is a risk of converting mixedwood stands to either pure conifer or pure deciduous stands. In addition, aspen can serve as a nurse crop for white spruce by reducing frost injury (Pritchard and Comeau 2004), reducing winter injury to white spruce, reducing the level of damage from white pine weevil (Taylor et al. 1996), and reducing the vigour of competing grasses and shrubs (Lieffers and Stadt 1994).

Following fire or clearcutting natural regeneration of aspen occurs primarily from root suckers, with white spruce regenerating from seed and establishing within the first few years after disturbance. When spruce is present it will grow in the understory for 40 years or longer, eventually overtopping the aspen and becoming increasingly dominant in the stand as aspen drops out of the stand over the period between 70 and about 140 years. Spruce may also establish on decaying wood and windthrow mounds under aspen and mixedwood canopies when the aspen canopy begins to open up after age 40. When spruce does not regenerate in the understory or when few spruce are present, new aspen saplings may regenerate in the understory of senescing aspen stands. Bluejoint reedgrass (*Calamagrostis canadensis*) and several shrubs (i.e., beaked hazel (*Corylus cornuta*), willow (Salix spp.), red raspberry (*Rubus idaeus*), wild rose (*Rosa acicularis*), red-osier dogwood (*Cornus sericiea*) and green alder (*Alnus crispa*)) are important components of the mixedwood plant community.

Aspen suckering is inhibited by flooding, soil compaction, root crushing, heavy slash, log decks left over the summer, hot intense burns (eg. slash piles), and cold soils (grass cover) (Frey et al. 2003). Harvesting when soils are dry or frozen is desirable to minimize soil compaction and root crushing. Regeneration is often at very high densities, but self-thinning occurs rapidly and results in stands with densities below 20,000 stems/ha at age 10. Self-thinning continues to occur, resulting in a decline in stand density with age.

When aspen cover fails to develop or when aspen is removed by treatments designed to control only woody vegetation, bluejoint reedgrass may become dominant and can be a serious competition problem for white spruce. Grass, herbs and shrubs compete for light, water and nutrients, with the nature, intensity and importance of competition changing from season to season and from year to year. In young stands substantial aspen cover is required to inhibit development of this grass (understory light levels must be below 20%), while in older stands grass cover is reduced by moderate canopies (Lieffers and Stadt 1994).

Spruce can regenerate from seed provided there is a seed source and seedbed conditions are suitable. The periodicity of white spruce seed crops (with good seed crops every 3 to 7 years), high levels of seed predation, and the short period during which seedbed remains available after disturbance, have made reliance on natural regeneration unattractive in western Canada (Greene et al. 1999). In addition, spruce germinants grow slowly (taking 8 to 10 years to reach 50 cm height).

When present, advance regeneration of white spruce can be protected during harvest and subsequently release well. Since use of advance regeneration can avoid problems with high levels of competition, frost and winter injury encountered following planting in a clearcutt and may shorten the rotation length for white spruce, there is also interest in establishing spruce under aspen canopies (ie. underplanting) at age 40 or later (Comeau et al. 2004). Stands selected for underplanting should have at least 20 m^2/ha basal area of aspen, and be located away from

black spruce stands and willow thickets to reduce hare browsing problems. When seed producing white spruce are present in the canopy, blading can create favourable seedbed conditions and lead to establishment of natural regeneration in the understory, (Stewart et. al. 2000) suggesting that seedbed is a primary factor limiting natural regeneration in the understory of aspen stands. However this treatment may lead to mortality of the aspen due to root system and stem damage.

During early stages of stand development, the overtopping aspen canopy reduces light available to the understory white spruce. Aspen canopies can develop rapidly, with light levels in the understory dropping below 20% in the second growing season. Competition for light appears to reach maximum levels during the first 15 to 40 years (Lieffers et al. 2002). Light levels under aspen canopies can be related to aspen basal area (Comeau 2002) and these relationships can be used as a basis for thinning guides designed to maintain light at appropriate levels for understory white spruce. Timely application of thinnings or removal of aspen around a component of spruce (either individuals or clusters of trees) can be used to increase growth of white spruce.

Tending in mixedwood stands generally means reducing the volume of one species in favour of the other (Figure 1). Creating and maintaining mixedwood stands is likely to be more expensive than growing single species stands (Table 1), except when very long rotations are accepted for white spruce.

The role of facilitation relative to competition is highly variable in western boreal mixedwood stands, complex and not well understood. It is easy to overstate role of either competition or facilitation. There are clear advantages to growing spruce in a mixedwood setting in low snowfall and summer dry areas where winter injury and competition for soil moisture by bluejoint reedgrass may be limiting. However, these benefits may be overshadowed by the effects of competition on other sites. Consequently, key limiting factors should be evaluated on a site specific basis.

Continued research is needed to improve our understanding of the interplay between competition and facilitation in these mixtures, to support development of models for estimating outcomes of different stand management practices and to support development of tools to assist with effective decision making. Long-term studies, such as those established by the Western Boreal Growth and Yield Association, which document and examine the dynamics of mixtures are essential for improving our understanding of the benefits of tending mixedwoods.

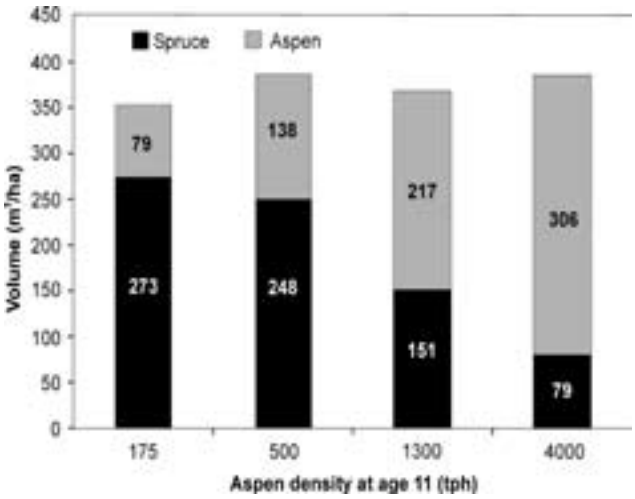

Figure 1. *Estimated effects of aspen density at age 11 on spruce and aspen volume at age 80 based on simulations using MGM2005. [Aspen site index of 20 m and a spruce site index of 16 m at age 50].*

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Table 1. *Estimates of Mean Annual Increment (MAI) and costs for six scenarios estimated using the Mixedwood Growth Model (Version MGM2005A) (after Comeau et al. 2005).*[1]

Scenario	Rotation Length (years)	MAI			Cost ($/ha)				
		Spruce	Aspen	Total	MSP & Plant	Herbicide	Spacing	Other	Total
1 Pure aspen.	60	0	3.8	3.8	0	0	0	0	0
2 Pure white spruce with a minor component (200 stems/ha) of aspen.	90	3.2	0.7	3.9	$1100	$300			$1400
3 Mixedwood resulting from the planting of white spruce at 1100 stems/ha and no tending, followed by a single-stage harvest.	90	0.7	2.2	2.9	$1100	0	0	0	$1100
4 Patch mixture of 50% spruce and 50% aspen resulting from the planting of white spruce at 1100 stems/ha, followed by tending spruce in patches 20 to 30 m across, and leaving the remainder of the block untended.	90	1.1	1.0	2.2	$600	$150	0	0	$750
5 Mixedwood resulting from planting white spruce at 1100 stems/ha and thinning aspen to 1100 stems/ha at age 5 years.	90	1.6	2.3	3.9	$1100	0	$600	0	$1700
6 Mixedwood resulting from allowing aspen to regenerate and grow to age 40 years, with white spruce underplanted at 1600 stems/ha in year 40. Aspen are harvested at age 60 with understory protection and a mixture of spruce and aspen are harvested at 120 years (spruce age 80 years).	120	1.8	3.5	5.3	$800	0	0	$200[2]	

[1]Simulations are for a site with white spruce SI50=16 m and aspen SI50=20 m and are started from age 10. In scenarios 1, 3, 5, and 6, aspen density was 10,000 stems/ha at age 10. Scenario 4 is calculated from scenarios 2 and 3, based on the assumption that conifer yield is 45% of the value obtained in scenario 2. Merchantable volumes assume a minimum DBH of 12.5 cm, a minimum top diameter of 7.5 cm, and a stump height of 30 cm. A 20% reduction in volume was included to account for variation in stocking and for other losses.

[2]Extra harvesting costs.