

SFM Network  
Research Note Series  
No. 46

# Growing conditions and tree productivity in boreal mixedwoods: hidden opportunities for forest managers

## Highlights

- Tree-growing conditions are more favourable in mixed stands as compared to pure conifer stands.
- Decomposition rates are faster in mixed stands as compared to pure conifer stands.
- 'Adding' low densities of aspen to spruce stands can result in increased total volume at rotation age.
- Spruce 'added' to aspen stands do not negatively affect aspen productivity.
- Protecting understory spruce while harvesting mature aspen stems could result in harvesting more wood in the long term.

## Synthesizing mixedwood knowledge

Over the last few decades, forest managers and research scientists have come to appreciate the importance of the mixed nature of the boreal forest and to understand the need to focus on both broadleaf and conifer tree species. Indeed the southern edge of the boreal forest across Canada is a distinct biome characterised by a high proportion of mixed stands.

Although many research initiatives and operational trials have been undertaken in the boreal mixedwoods, the absence of an integrated understanding of the knowledge gained from these efforts may be hindering the application of ecosystem management in the boreal mixedwood biome. As part of the 'State of Knowledge' program of the Sustainable Forest Management Network (SFMN), a group of research scientists from across Canada synthesized available research results to address the ecological implications of altering the composition of the boreal mixedwoods. Specifically, the research team

addressed the significance of a change in composition of mixedwood landscapes on biodiversity, tree productivity and soil processes.

This research note is one of a series arising from this project and addresses the question of whether a productivity gain is associated with maintaining mixed stands in boreal mixedwood landscapes. Three preliminary generalizations emerged from this research.

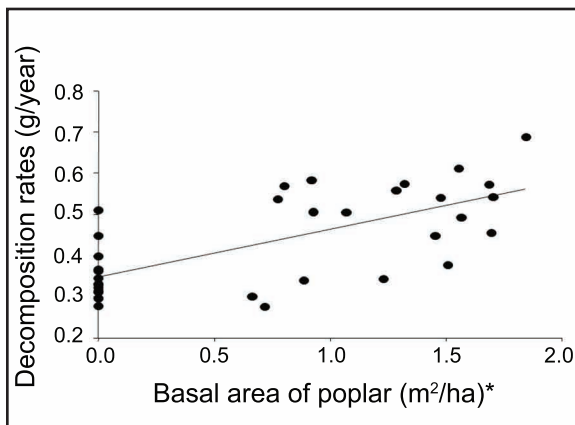
## Aspen improves growing conditions in conifer-dominated stands

Studying the effect of forest composition on tree growing conditions is a difficult task, as it requires comparison among sites which have similar environmental conditions, but which differ in the relative abundances of broadleaf and conifer trees. However, a few studies in north-western Québec have shed some light on how different mixtures of conifer and broadleaf trees can affect nutrient availability, soil processes and attributes. One such study along a successional gradient in boreal mixedwoods of

north-western Québec has clearly shown that as stands age and become progressively more dominated by coniferous species, soil attributes change dramatically. For example, soil pH and cation exchange capacity decrease which results in a decrease in soil availability of some cations (e.g.,  $Mg^{2+}$  and  $Ca^{2+}$ ). Similar trends were found with respect to soil phosphate and nitrogen availability. Although in this case, a change in composition goes hand in hand with the aging of stands, this study demonstrates that progressive dominance by conifer species is accompanied by deterioration of soil conditions for tree growth.

Another study in the black spruce feathermoss area of north-western Québec, which controlled for stand age by comparing soil properties in stands of the same age but that differed in tree composition, found similar results. This study compared stands that expressed a gradient of tree composition from pure black spruce to a mixture of black spruce and trembling aspen. The researchers found that, concurrent with an increase in trembling aspen representation in the stand, soil pH and cation exchange capacity increased. Further, forest floor organic matter depth decreased and wood decomposition rates

increased, which could lead to increased availability of nutrients for tree growth (Figure 1).



**Figure 1.** Soil decomposition rates of wood in mixed boreal forest stands in the black spruce feathermoss area of North-western Québec, as a function of the trembling aspen content of the stand (adapted from Légaré et al. 2005). \*Log transformed

Currently, little information exists to indicate whether or not similar trends in soil attributes and processes occur in white spruce-aspen dominated mixedwoods in western Canada. In the western Canadian boreal, mixed stands (aspen-white spruce) were found to have higher rates of nitrogen mineralization than either 'pure' aspen or conifer stands but this may not translate into increased soil nitrogen availability. Studies in Alberta do indicate, however, that the presence of aspen serves to decrease white spruce frost and winter injury problems and suppresses understory vegetation that may compete with white spruce.

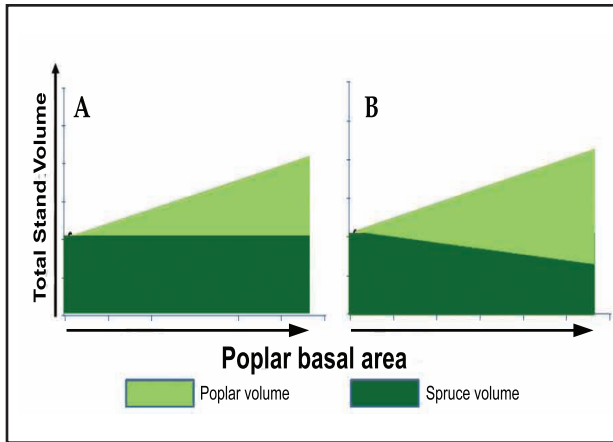
These studies suggest that increasing abundance of broadleaf trees, up to a point, in conifer-dominated

stands results in increased nutrient cycling and improved soil and environmental conditions for tree growth.

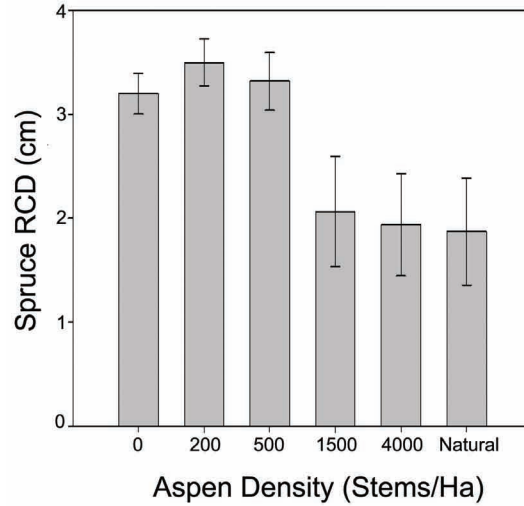
## Aspen can increase quality and volume in conifer-dominated stands

The same study in Québec that looked at soil properties and processes along a gradient of tree composition from pure black spruce to a mixture of black spruce and trembling aspen also looked at stand-level tree productivity. These researchers found that in all stands, as trembling aspen abundance increased (up to about 40% of total stand basal area), total stand volume at rotation age increased. In all cases this increase in stand volume was due to the addition of trembling aspen volume and in most, but not all, cases this increase in trembling aspen did not negatively affect black spruce volume (Figure 2). While an increase in trembling aspen volume may come at the cost of a slight drop in black spruce volume at rotation age, in all cases the quality of the black spruce increased, as the volume was distributed among fewer but larger stems. Another study in the eastern mixedwoods looked at natural mature white birch and jack pine mixtures and found no evidence that an increasing birch component led to greater wood volume at rotation age; however, researchers did observe better quality jack pine stems in mixed stands. A study in Alberta indicated that stand-level productivity (mean annual increment) may be 15 to 20% higher for mixed stands as compared to either pure aspen or pure white spruce stands, although it is unclear how this would translate into merchantable volume at rotation age.

These results from studies of natural stands are supported by recent research on 15 year-old managed mixtures of white spruce and trembling aspen stands in Alberta which found that low densities (up to 1000 stems/ha) of trembling aspen had no effect on growth of planted white spruce (Figure 3). While natural regeneration of aspen usually occurs at substantially higher densities (e.g., 20,000 stems/ha), managing aspen at low densities to benefit spruce growth has potential benefits (see management implications below).



**Figure 2.** Total stand volume at rotation age in natural stands within the black spruce feathermoss area of north-western Quebec as the quantity of trembling aspen increases within black spruce dominated stands. Two scenarios were observed: A) total stand volume increases as the poplar component increases without affecting total black spruce volume; and B) total stand volume increases as the poplar component increases but spruce volume decreased slightly (adapted from Légaré et al. 2005).



**Figure 3.** Mean root collar diameter (RCD) of planted white spruce in 15 yr-old managed stands in Alberta as the density of aspen stems increases (adapted from Griffiths MSc, University of Alberta, unpublished data).

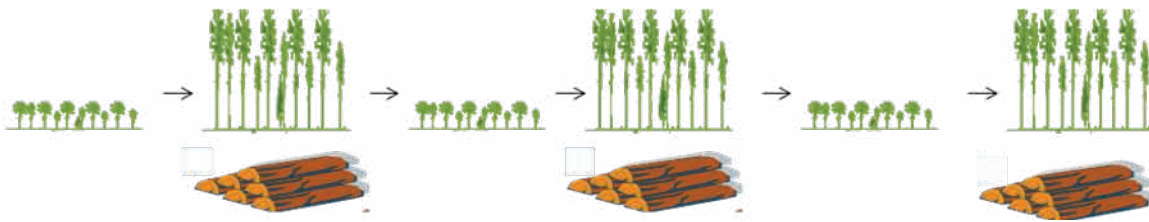
From these studies of natural and managed stands it appears that addition of low to moderate densities of broadleaf trees in conifer-dominated stands can result in better quality conifer stems, and sometimes more total wood volume at rotation age due to the addition of broadleaf volume.

## Protection of spruce volume in broadleaf-dominated stands

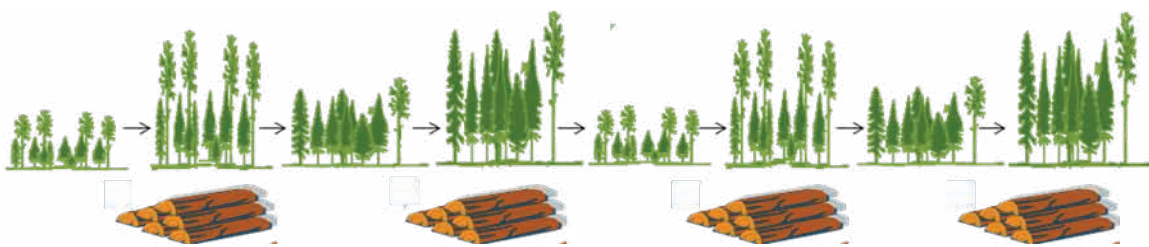
Studies demonstrate that while both white and black spruce may grow less vigorously under closed broadleaf canopies, understory spruce are still able to survive and grow. Mixed species stands of rotation age often contain understory conifers that could be retained during harvesting operations. Studies have also shown that in understory protection harvesting the retained conifer stems show improved growth following removal of the broadleaf canopy. Simulations over numerous rotations have demonstrated that by protecting and maintaining understory conifers (10-20 cm DBH) when the mature broadleaf trees are harvested it is possible to shorten the next rotation and hence have more harvests within a given time period (Figure 4).

It therefore appears that by managing mixed stands as mixtures and by carefully harvesting stems when they are mature, it may be possible to obtain more wood from a given stand over several rotations. This approach should be applied with caution, however, as studies have shown that when broadleaf canopies are removed the understory conifers can be very susceptible to windthrow. Loss of stems to windthrow could negate any productivity gain that could have been achieved through this management system.

### A) Traditional management approach



### B) Mixedwood management approach with protection of understory



**Figure 4.** Comparison of hypothesized number of harvests for a given time period under: A) the traditional approach consists of harvesting all merchantable stems at harvest age; B) a mixedwood management approach consists of alternating between the protection of understory spruce and harvesting all merchantable stems at harvest age.

## What can managers and policy makers do?

- **Control mixedwood-friendly competition** - Allowing a certain percentage of aspen stems to be maintained in conifer stands could ameliorate growing conditions and increase total wood volume and the quality of conifer stems harvested at rotation age. In Alberta and Ontario, this might require modifying herbicide applications (strip applications and/or one instead of two applications) to allow some trembling aspen to be maintained in conifer-dominated stands. In Québec, this could be achieved by altering silvicultural prescriptions during brushing operations of young stands such that some broadleaf trees are retained between conifer crop trees and in gaps in the stand. In the end, allowing a certain percentage of broadleaf stems in conifer-dominated stands will likely entail some changes to regeneration standards that currently focus on ensuring that conifers in conifer-dominated regenerating stands are free of potentially competing vegetation.
- **Retain conifer seed trees** - To maintain mixed stands in the landscape and favour the establishment of conifer stems under broadleaf canopies, managers could adopt strategies such as leaving mature spruce in cut blocks to provide a seed source. Favourable seed beds could be created through the implementation of mild site preparation techniques prior to seed cast in white spruce mast seed years.
- **Protect conifer understory**- To maximize tree growth and attempt to have more harvests in a given time period, managers could utilize understory protection harvesting systems that protect understory conifer stems during the harvesting of mature broadleaf stems. This should shorten rotation periods thus increasing the number of rotations for a given

time period. To minimize the risk of losing conifer stems to windthrow, managers can: 1) take into account predominant wind patterns and soil properties when planning cutblocks; and 2) maintain some broadleaf stems that could act as nurse trees, protecting the conifer stems from wind damage.

## Further reading

Brais, S., Camiré, C., Bergeron, Y., and Paré, D. 1995. *Changes in nutrient availability and forest floor characteristics in relation to stand age and forest composition in the southern part of the boreal forest of northwestern Quebec*. For. Ecol. and Manag. 76:181-189.

Comeau, P.G., Kabzems, R., McClarnon, J. and Heineman, J.L. 2005. *Implications of selected approaches for regenerating and managing western boreal mixedwoods*. For. Chron. 81: 559-574.

Filipescu, C.N. and Comeau, P.G. 2007. *Aspen competition affects light and white spruce growth across several boreal sites in western Canada*. Can. J. For. Res. 37: 1701-1713.

Groot, A. and Carlson, D.W., 1996. *Influence of shelter on night temperatures, frost damage, and bud break of white spruce seedlings*. Can. J. For. Res. 26, 1531-1538.

Légaré, S., Bergeron, Y. and D. Paré. 2005. *Effect of aspen (Populus tremuloides) as a companion species on the growth of black spruce (Picea mariana) in the southwestern boreal forest of Quebec*. For. Ecol. and Manag. 208: 211-222.

Légaré, S., Paré, D. and Y. Bergeron. 2005. *Influence of aspen on forest floor properties in black spruce-dominated stands*. Plant and Soil 275: 207-220.

Légaré, S., Paré, D. and Y. Bergeron. 2004. *The responses of black spruce growth to an increased proportion of aspen in mixed stands*. Can. J. For. Res. 34: 405-416.

MacIsaac, D. and Krygier, R. 2004 *White spruce understory protection research at Hotchkiss River, Alberta. Tenth year re-measurement and third-pass assessment*. Mixedwood Management Association, Edmonton, Alberta. MWMA Report MWMA-2004-01. Available online: <http://www.mwma.rr.ualberta.ca/Publications/CF%20Hotchkiss%2010%20Year%20Report%20-%20Executive%20Summary.pdf>

Man, C.D., Comeau, P.G., Pitt, D., 2008. *Competitive effects of woody and herbaceous vegetation in a young boreal mixedwood stand*. Can. J. For. Res. 38 :1817-1 828.

Voicu, M.F. and Comeau, P.G. 2006. *Microclimatic and spruce growth gradients adjacent to young aspen stands*. For. Ecol. and Manag. 221 (2006) 13-26.

## Management Implications

- Control mixedwood-friendly competition in conifer-dominated stands to maximise wood quantity and quality.
- Retain conifer seed trees in mixedwood cutblocks to encourage conifer establishment after harvesting.
- Protect conifer understory in broadleaf-dominated stands to shorten rotation periods.



Written by: Nicolas Lecomte<sup>1</sup>, Ellen Macdonald<sup>2</sup>, Suzanne Brais<sup>3</sup>, and Phil Comeau<sup>2</sup>

<sup>1</sup>Valeur Nature, Beaucanton, Canada

<sup>2</sup>Department of Renewable Resources, University of Alberta, Edmonton, Canada

<sup>3</sup>Université du Québec en Abitibi-Témiscamingue, Rouyn-Noranda, Canada

The views, conclusions and recommendations contained in this publication are those of the authors and should not be construed as endorsement by the Sustainable Forest Management Network.

For more information on the SFM Network Research Note series and other publications, visit our website at <http://sfmnetwork.ca> or contact the Sustainable Forest Management Network University of Alberta, Edmonton, AB. Tel.: 780-492-6659. Email: [info@sfmnetwork.ca](mailto:info@sfmnetwork.ca)

Coordinating editor: R. D'Eon  
Graphics & Layout: K. Kopra

© SFM Network 2009

**ISSN 1715-0981**