Effect of competition on the growth rates of residual balsam fir (*Abies balsamea* (L.) Mill.) and trembling aspen (*Populus tremuloides* Michx.) trees in the mixed stands after partial cuttings

Ari Kainelainen[1], Fabio Gennaretti[1], Alexander Kryshen[2], Igor Drobyshev[3]

1. Université du Québec en Abitibi-Témiscamingue (UQAT). 2. Karelian Research Center (KaRC RAS). 3. Swedish University of Agricultural Sciences (SLU)

Context:

According to recent studies, species mixtures are more productive to monocultures, allowing to harvest more timer and obtain higher economic benefits. However, the management of species mixtures is more complex, and more knowledge is required for development and large-scale implementation of mixed-species silviculture.

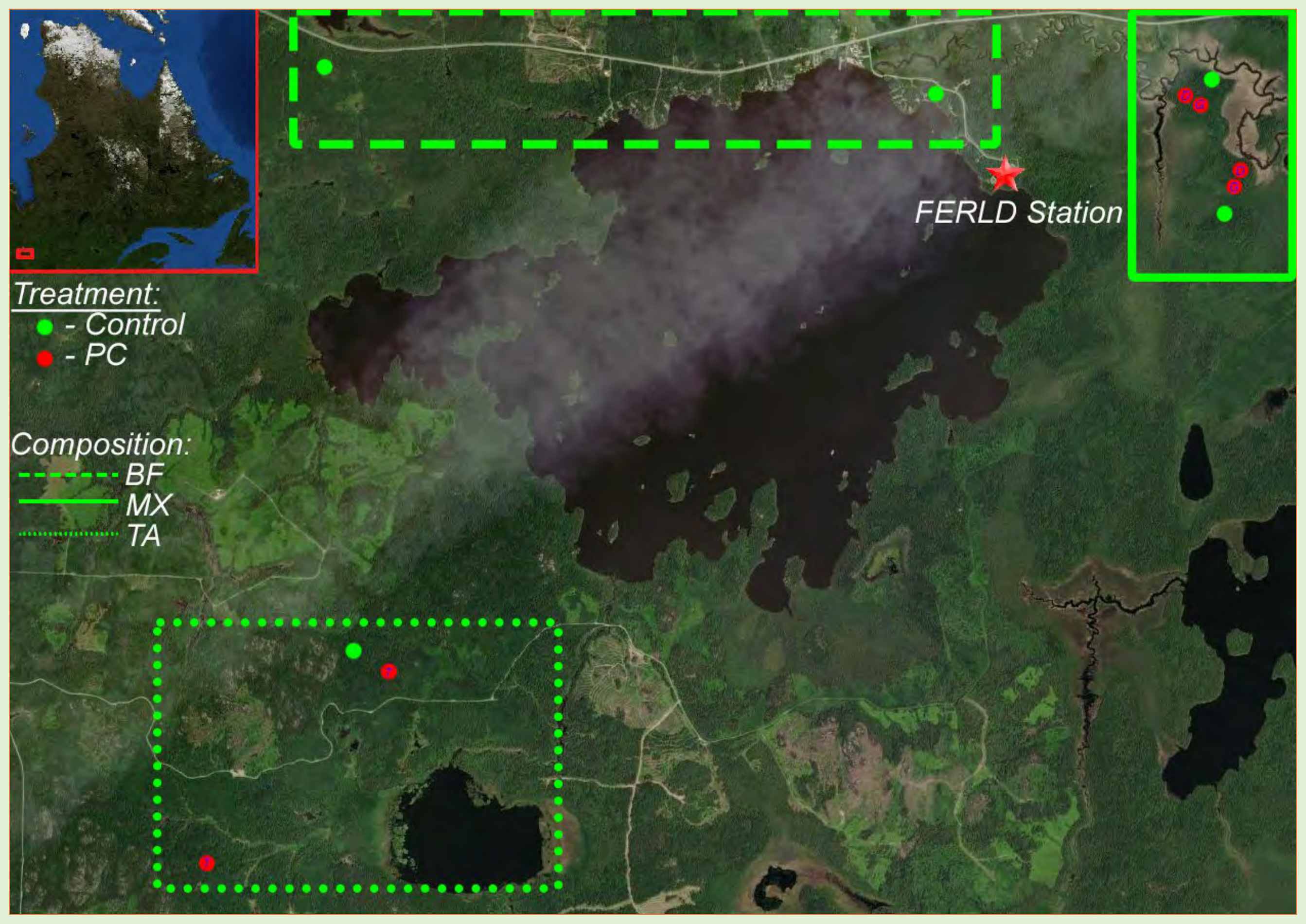
Study objective:

Investigate the effects of neighborhood competition and partial cutting (PC) on the growth rates, estimated as wood volume increments (V.I.), of residual balsam fir and trembling aspen trees, interactions between the treatment and sensitivity to competition and temporal dynamic of these effects.

Materials and Methods:

Study Area:

- *Abitibi region of Northwestern Quebec, the "Forêt d'enseignement et de recherche du lac Duparquet" (FERLD), (≈ 48°48'N, 79°37'W).*
- *Low-intensity PC (33 – 40% merchantable BA), carried out in winter 1998 – 1999 and 2000 – 2001.*

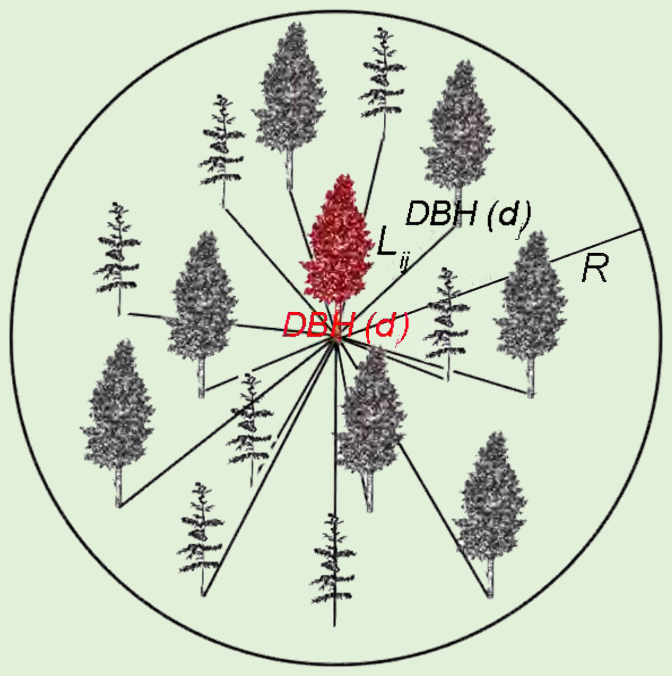


Sampling Material:

- *Selection of 5 – 7 mature residual trees as focal, for the extraction of wood samples.*

Competition Assessment:

- *Neighboring competition of focal trees, calculated based on the parameters of neighboring and focal trees (aspen and fir separately), using common NCI equations.*



- *Testing performance of each equation with AICc in LMM mode , using V.I., accumulated since PC as response and NCI as predictors.*

$$NCI_1 = \sum_{j=1}^{n} \frac{d_j^{\alpha}}{L_{ij}^{\beta}}$$

$$NCI_2 = \sum_{j=1}^{n} \frac{(d_j/d_i)^{\alpha}}{L_{ij}^{\beta}}$$

$$NCI_3 = \sum_{j=1}^{n} \arctan(d_j/L_{ij})$$

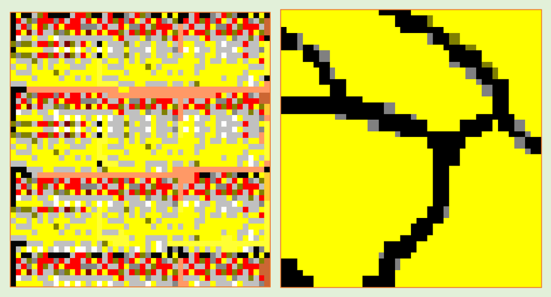
$$NCI_4 = \sum_{j=1}^{n} (d_j/d_i)\arctan(d_j/L_{ij})$$

$L_{ij} \leq R$

α, β = 0;0.5;1;2
R = 3;4;5;6;7 m

Laboratory Analysis:

- *Processing wood samples with standard dendrochronology techniques.*
- *Calculation of growth rates, expressed as volume increments.*
- *Assessment of temporal dynamic of competition and relative growth response to PC (V.I. accumulated after PC, relative to pre-treatment V.I.) with LMM, using best-performing NCI equation, pre-treatment V.I., stand type (random effect), and 3-year long time periods as predictors.*



Results:

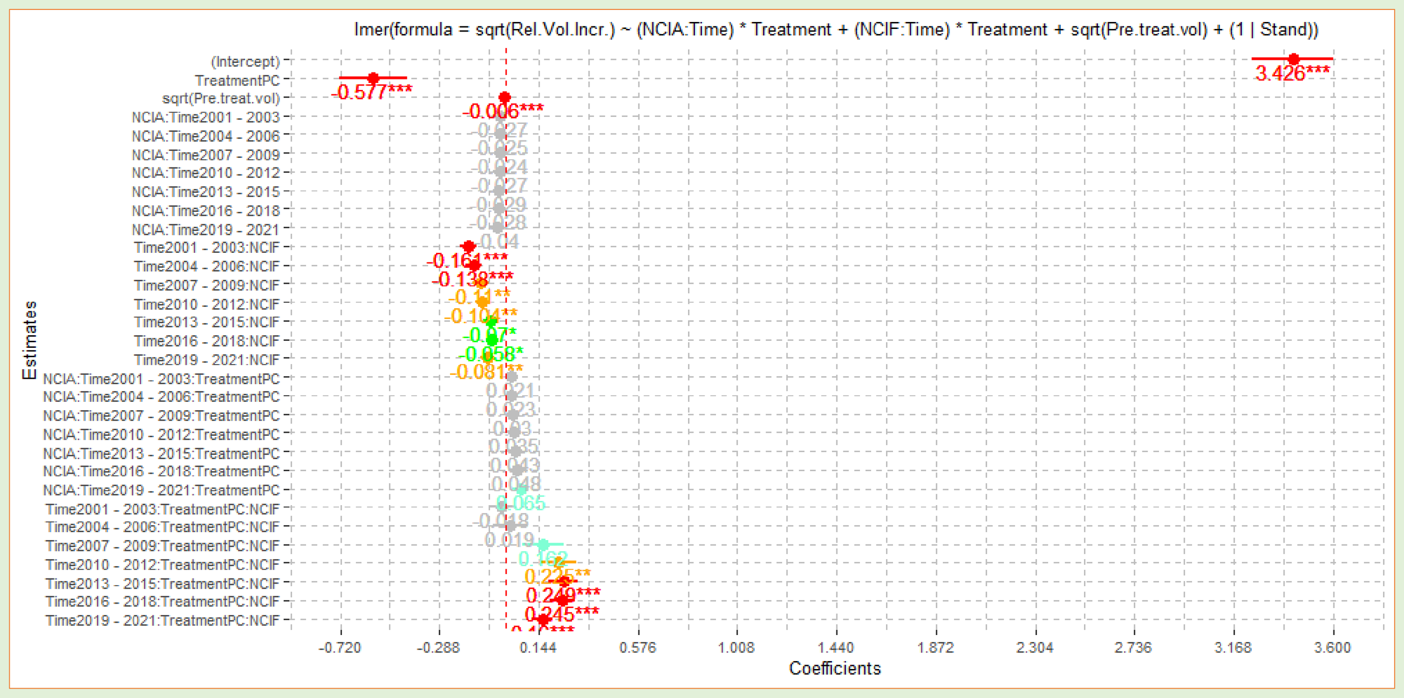
Balsam Fir

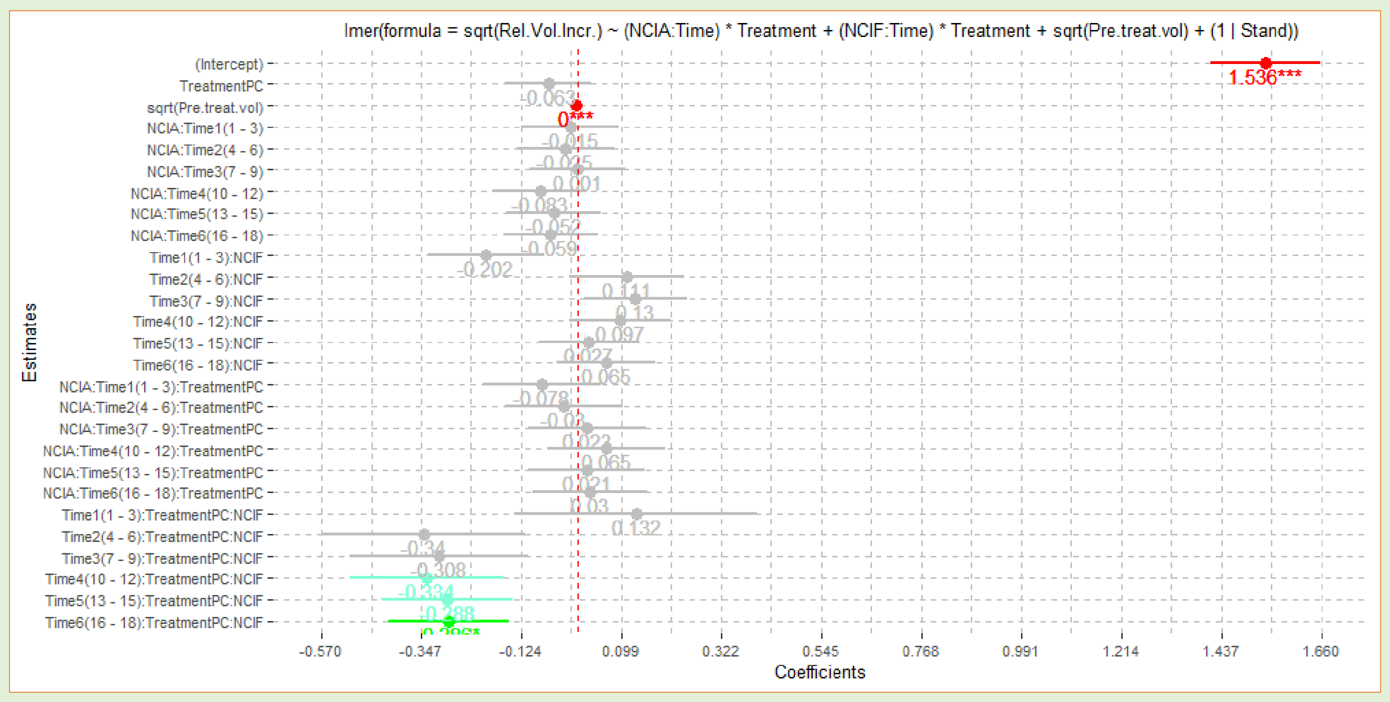
- The most likely NCI equation was NCI_2, $\alpha = 2$; $\beta = 0{,}5$; $R = 7$
- Interspecific competition had strong negative effects on growth rates. PC decreased the effect in the second decade after the treatment.
- Interspecific competition had no significant effect on the growth rates.
- PC led to increase of the growth rates, starting from 2004 – 2006 up until the last studied period (2019 – 2021).

Trembling Aspen

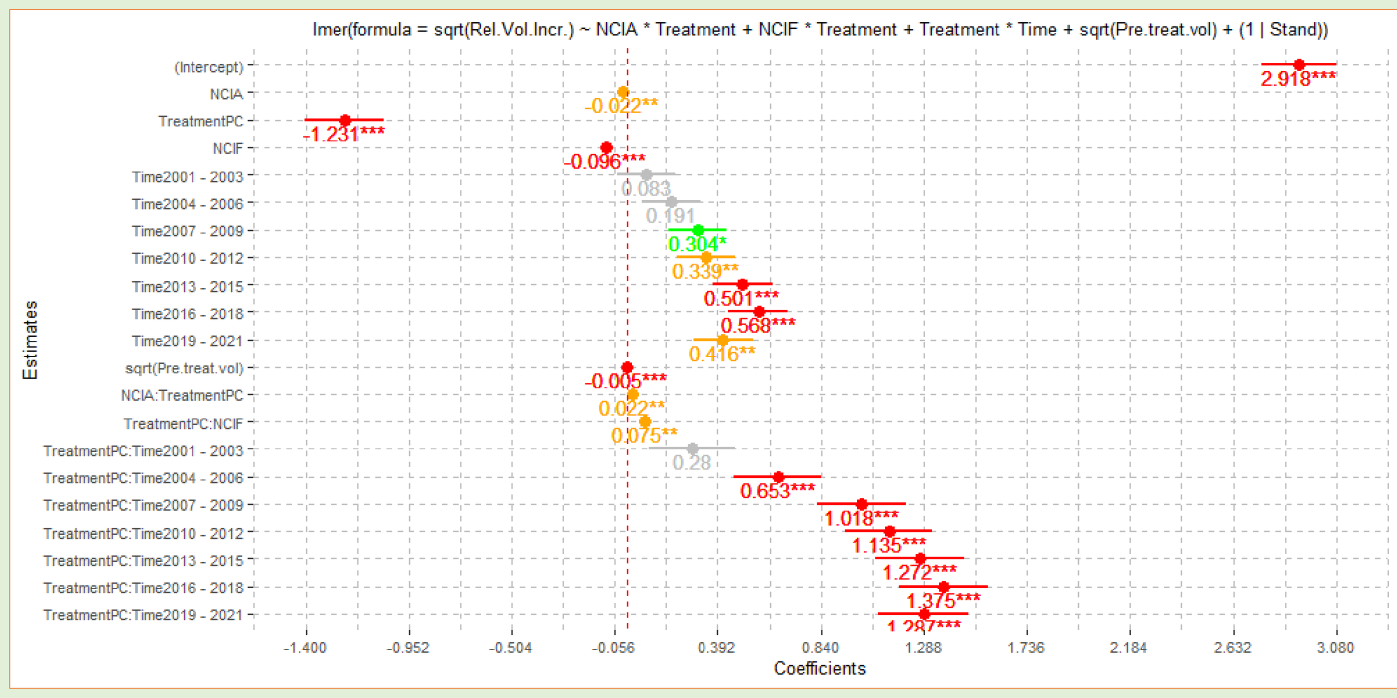
- The most likely NCI equation was NCI_2, $\alpha = 0.5$; $\beta = 0$; $R = 7$
- Both interspecific and intraspecific competition had no effects on growth rates.
- PC have not changed sensitivity to competition significantly, except for a decrease of interspecific NCI 16 – 18 years after the treatment.
- No effect of PC on the growth rates was detected.

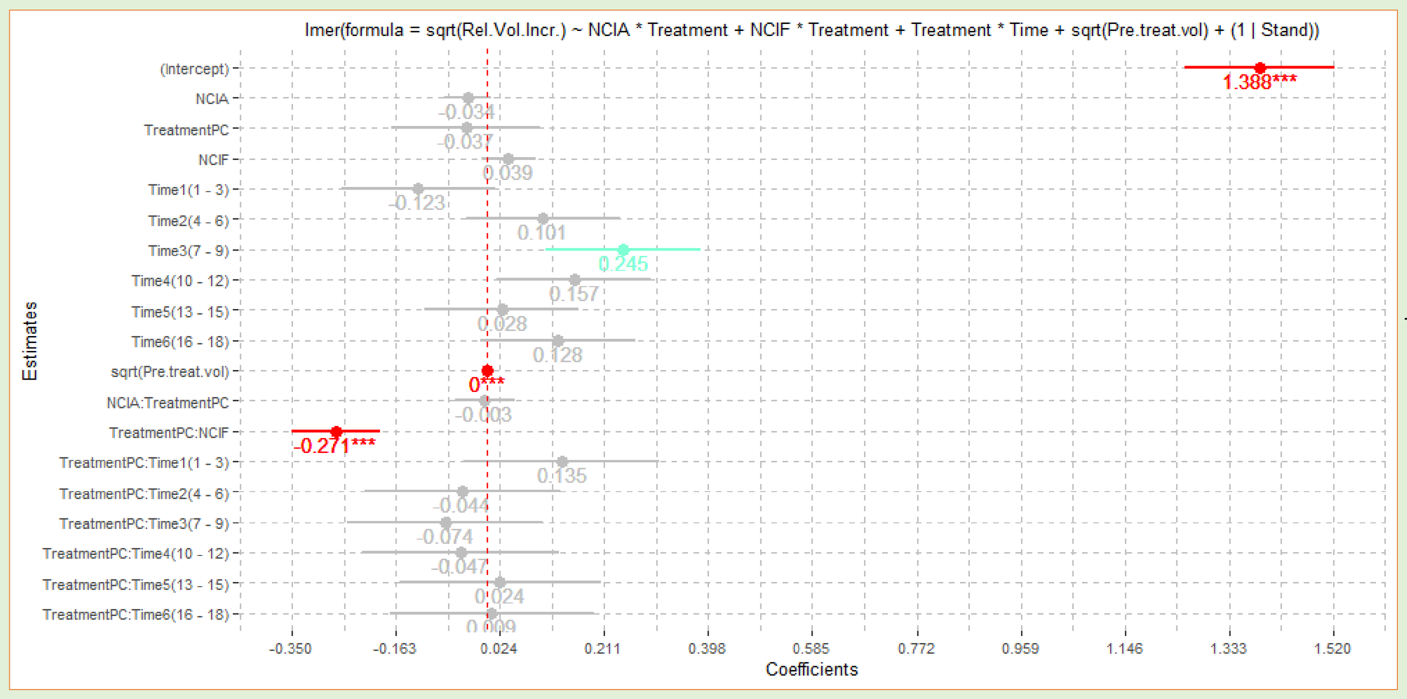
Effects of PC on the sensitivity of residual trees to competition:





Effects of PC on the growth rates of residual trees:





References:

Bascietto, M., Scarascia-Mugnozza, G. 2004. A collection of functions to determine annual tree carbon increment via stem-analysis.
Bose, A., Brais, S., Harvey, B. 2014. Trembling aspen (Populus tremuloides Michx.) volume growth in the boreal mixedwood: Effect of partial harvesting, tree social status, and neighborhood competition. Forest Ecology and Management. 327. 209–220.
Bunn, A.G. 2010. Statistical and visual crossdating in R using the dplR library. Dendrochronologia, 28, 251-258.
Burnham, K. P., Anderson, D. R. 2002. Model selection and multimodel inference: a practical information-theoretic approach. 2nd ed. New York, Springer-Verlag.
Cybis AB CooRecorder/CDendro 9.6 (http://www.cybis.se/forfun/dendro/)
Girona, M., Rossi, S., Lussier, J.-M., Walsh, D., Morin, H. 2017. Understanding tree growth responses after partial cuttings: A new approach. PLOS-ONE.
Jactel, H., Gritti, E.S., Drössler, L., et al. 2018. Positive biodiversity–productivity relationships in forests: climate matters. Biology Letters, 14. 8.
Hartmann, H., Beaudet, M., Mazerolle, M.J., Messier, C., 2009. Sugar maple (Acer saccharum Marsh.) growth is influenced by close conspecifics and skid trail proximity following selection harvest. For. Ecol. Manag. 258, 823–831.
Holmes, R. L.. 1983. Computer-assisted quality control in tree-ring dating and measurement. Tree-Ring Bulletin 43: 69–78.
Kuznetsova A., Brockhoff P.B., Christensen R.H.B. 2017. "lmerTest Package: Tests in Linear Mixed Effects Models." Journal of Statistical Software, 82(13), pp. 1–26.
Pretzsch, H., Schütze, G. 2009. Transgressive overyielding in mixed compared with pure stands of Norway spruce and European beech in Central Europe. European Journal of Forest Research. 128. 183-204.
Rouvinen, S., Kuuluvainen, T. 1997. Structure and asymmetry of tree crowns in relation to local competition in a natural mature Scots pine forest. Canadian Journal of Forest Research-revue Canadienne De Recherche Forestiere – CAN. J. FOREST RES. 27. 890-902.

UQAT Université du Québec en Abitibi-Témiscamingue
cef
GREMA