Commercial thinning as a mean to increase diurnal C uptake for jack pine and black spruce in eastern boreal forest

Goudiaby, Venceslas[1], Brais, Suzanne[1] Berninger, Frank[2], Camiré, Claude[3] and Grenier, Yvon[4]

1 Université du Québec en Abitibi-Témiscamingue, Rouyn-Noranda Québec, J9X 5E4 Canada
2 Université du Québec à Montréal, Faculté des sciences, Département des sciences biologiques, case postale 8888, succursale Centre-ville Montréal (Québec) H3C 3P8 Canada
3 Centre de Recherche en Biologie Forestière, Faculté de Foresterie et de Géomatique, Université Laval, Sainte-Foy, Québec G1K 7P4, Canada
4 Centre de recherche, de développement et de transfert technologique acéricole 3600 boul. Casavant Ouest St-Hyacinthe (Québec) J2S 8E3, Canada

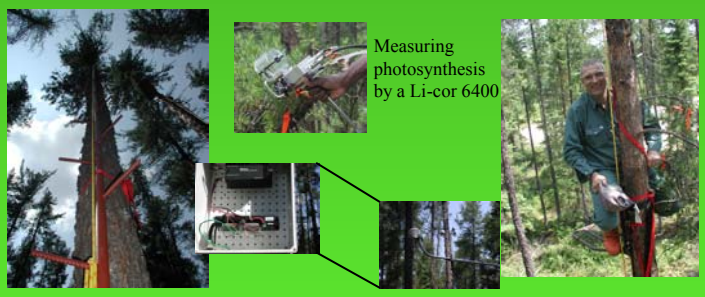
AXE III. Fonctions de la forêt et développement de nouvelles approches sylvicoles.
Sous-axe E. Développer de nouvelles approches sylvicoles à l'échelle du peuplement (pratiques sylvicoles) et à l'échelle du paysage.

Context

Jack pine and black spruce are two important commercial species. They were shown to respond to thinning by increasing their biomass (Robinson *et al.*, 2001). However, little is known about the ecophysiological processes underlying this response because a net increase in photosynthesis following canopy opening may result from an increase in resources availability, a greater photosynthetic efficiency, an aptitude to capture a greater amount of available resources or different carbon allocation patterns (Binkley *et al.*, 2004). The aim of this study was to determine to what extent ecophysiological processes of closed-crown jack pine and black spruce stands are affected by canopy opening following commercial thinning.

Material and Methods

Photosynthesis was measuring in the summer 2004 and 2005. Experiments were conducted with a factorial experimental design with 3-treatments replicated twice and representing 3 levels of canopy opening: heavy, moderate and control. Field measurements were made two growing seasons after thinning with a portable infrared gas analyser Li-cor 6400 on current-year and one-year-old needles with three such measurements per tree and two trees per experimental plot. Instantaneous photosynthesis was measured every two hours, before the onset, through all the day and after the sunset when the amount of light was approaching or becoming zero. Photosynthesis light response were conducted the time of the day when the photosynthesis is highest, between 9:00 and 12:00 am.



Measuring photosynthesis by a Li-cor 6400

Results

Either it was removed 0%, 50% and 60% of the stems in the control, moderate and heavy thinning, maximum photosynthesis (A_{max}), photosynthesis light compensation point (LCP), apparent quantum yield (AQY) and diurnal respiration (R_d) remained unaffected for jack pine. Similarly, A_{max}, AQY and R_d did not vary for black spruce while LCP was significantly lower in the heavy thinning.

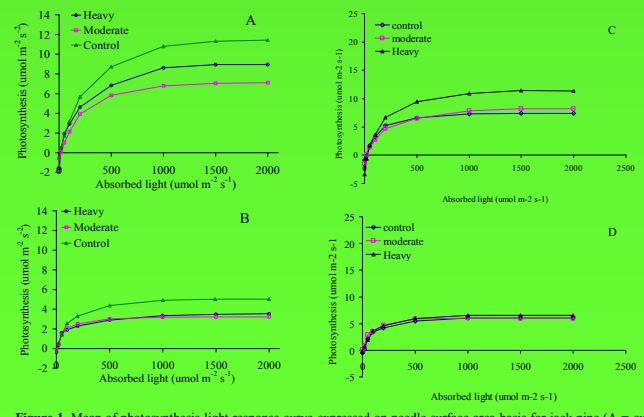


Figure 1. Mean of photosynthesis light response curve expressed on needle surface area basis for jack pine (A = current-year-old needles, B = one-year-old needles) and black spruce (C = current-year-old needles, D = one-year-old needles) for control, moderate and heavy thinning, two years after commercial thinning.

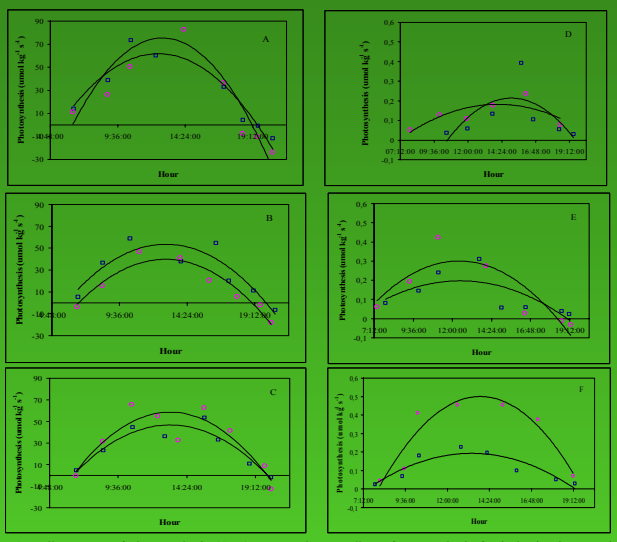


Figure 2. Daily courses of photosynthesis (Anet) expressed on needle surface area basis for jack pine in control (A), moderate (B) and heavy thinning (C) and black spruce in control (D), moderate (E) and heavy thinning (F) two years after commercial thinning (o : current-year-old needles; □: one-year-old needle) and regression (— : current-year-old needles; --- : one-year-old needles).

Diurnal amount of net C uptake at the needle scale (C_{day}) was 379.4, 301.2 and 817.17 mol m^{-2} day^{-1} for jack pine and 463.37, 342.12 and 738.78 mol m-2 day-1 for black spruce respectively for control, moderate and heavy thinning. Hence, C_{day} for both jack pine and black spruce was significantly higher in the heavy thinning treatment, while moderate thinning and control remained unchanged.

Discussion

While it is a generally assumed that forest canopy opening reduces competition for light, soil nutrients and water and hence could increase photosynthetic efficiency, our research conducted on mature jack pine trees growing in stands subjected to heavy and moderate canopy opening did not show such evidence two years after treatment application. Photosynthetic efficiency remained relatively unaffected despite the more favourable light environment due to canopy opening in the heavy treatment. These results are consistent to those of Sullivan *et al.* (1997) who made the same observations for needles located in the lower part of the canopy.

It was evidenced that light had the most environmental impact on tree functioning after thinning. Needles were exposed to light for longer periods when canopy was more open and fixed larger amount of C on a daily basis.

Acknowledgments

Financial support for this research was provided by funds from National Research Council of Canada (CSRSNG), The Ministry of Natural Ressources of Quebec (MRNFQ): Programme de Mise en Valeur des Ressources Forestières and Scierie Landrienne. The authors are grateful to Mario Major for his technical assistance.

References

Binkley, D., Stape, J. L., Ryan, M. G. 2004. Thinking about efficiency of resource use in forests. *For. Ecol. and Manage.* 193: 5-16.
Camiré, C and Bernier, B. 1981. Fertilisation azotée en forêt de pin gris (*Pinus banksiana*). III. Croissance du pin gris. *Can. J. For. Res.* 11 (2): 432-440.
Grenon, F, Brais, S and Lussier, J-M. 2006. (forthcoming)
Peek, M. S., Russek-Cohen, E. 2002. Physiological response curve analysis using nonlinear mixed models. *Oecologia*. 132: 175-180.
Robinson, D. E., Wagner, R. G., Bell, F. W. and Swanton, C. J. 2001. Photosynthesis, nitrogen-use efficiency, and water-use efficiency of jack pine seedlings in competition with four boreal forest plant species. *Can. J. For. Res.* 31: 2014-2025.
Shipley, B. and Almeida-Cortes, J. 2003. Interspecific consistency and intraspecific variability of specific leaf area with respect to irradiance and nutrient availability. *Ecoscience* 10 (1): 74-79.
Sullivan, J. H., Bovard, B. D. and Middleton, E. M. 1997. Variability in leaf-level CO2 and water fluxes in *Pinus banksiana* and *Picea mariana* in Saskatchewan. *Tree physiol.* 17: 553-561.