Climate influence on tree growth in the northern portion of the black spruce-moss domain of western Quebec inferred from tree-ring data

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1. CONTEXT AND CONTENT

Climate change is generally associated with an increase in the width of tree rings in the boreal forest, an ecosystem in which growth is limited by temperature (1, 2). This is also the ecosystem in which the consequences of the increase in atmospheric CO_2 concentrations are the most evident. However, there are alternative explanatory variables that can affect the growth of trees in the boreal forest: forest management, the presence of pathogens or herbivores, the availability of carbohydrates or nutrients, etc. Forest harvesting notably contributes in a significant way to changing the vegetation's distribution (3) via changes in the dynamics of the stands (4). In spite of the uncertainties associated with climatic models, the development of some adaptation strategies in forest management is a necessity that forest stakeholders need to prioritize.

2. OBJECTIVES

One of the recommendations of the *Comité sur la limite nordique des forêts attribuables* (5) was the necessity to study the growth of trees by ecological types and to determine the productivity of forest regions and their capacity to support management in a long-term perspective. Our objectives are aligned with this recommendation through the use of the ecophysiological models of the ECOLEAP project (*Effort COncerté pour Lier l'Écophysiologie À la Productivité forestière*) to predict Net Ecosystem Productivity (NEP) in the black spruce-moss domain of western Quebec, between 51°00' and 52°30' N.

3. METHODOLOGY

Based on the dendrochronological and dendrometric analysis of 114 wood discs from mature black spruce harvested in the context of the Quebecor sampling campaign in 2006, long series of radial growth were built at the Laurentian Forestry Centre (LFC) of the Canadian Forest Service (CFS), Quebec City, Quebec (Canada). The ring-width data were subjected to a transformation (detrending) to remove unwanted noise (6). This procedure was conducted using smoothing splines whose length corresponded to 50% of the length of the series. The low frequency changes in growth characterizing the last decades are assumed to be kept in the final chronology (Tree Growth Index, TGI). Finally, a model describing photosynthesis at the leaf level was used to simulate the crown's properties per species and their interaction with the variability of radiation, temperature and vapour pressure deficit. The productivity at the landscape level was simulated for the period 1930-2005 using a bioclimatic model to estimate forest productivity (StandLEAP (4)), which captured the variability within the stand canopy.

4. ANALYSIS AND INTERPRETATION OF THE RESULTS

Results showed that Net Ecosystem Productivity (NEP), calculated as the difference between annual gross primary productivity and respiration in the ecosystem during the previous year, explains approximately 21% of the variance in the dendrochronological series over the period 1930-2005 (Figure 1).

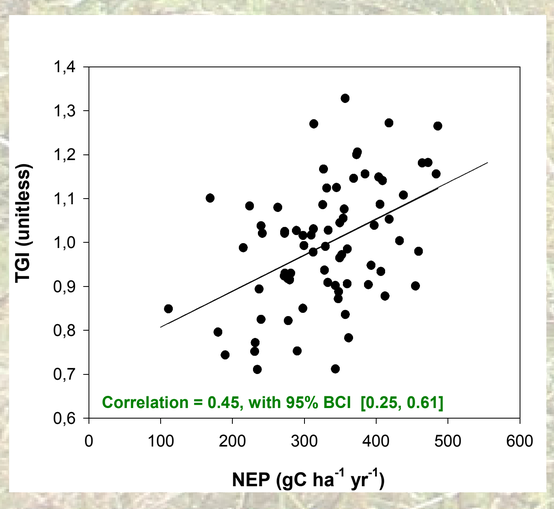

Figure 1 — Representation of the strength of the relation between the Tree Growth Index (TGI) and the Net Ecosystem Productivity (NEP) for *Picea mariana* (Mill.) BSP. The variance of the TGI explained by NEP is approximately 21%.

Comparisons between the model and the real data (Figure 2) do not take into account the "noise" caused by herbivores. These could have modified the climatic signals recorded in tree rings. For this particular region, neither the indication of tree growth nor the simulations of NEP present significant evidence ($P > 0.05$) for an increase in tree growth at the end of the 20th century.

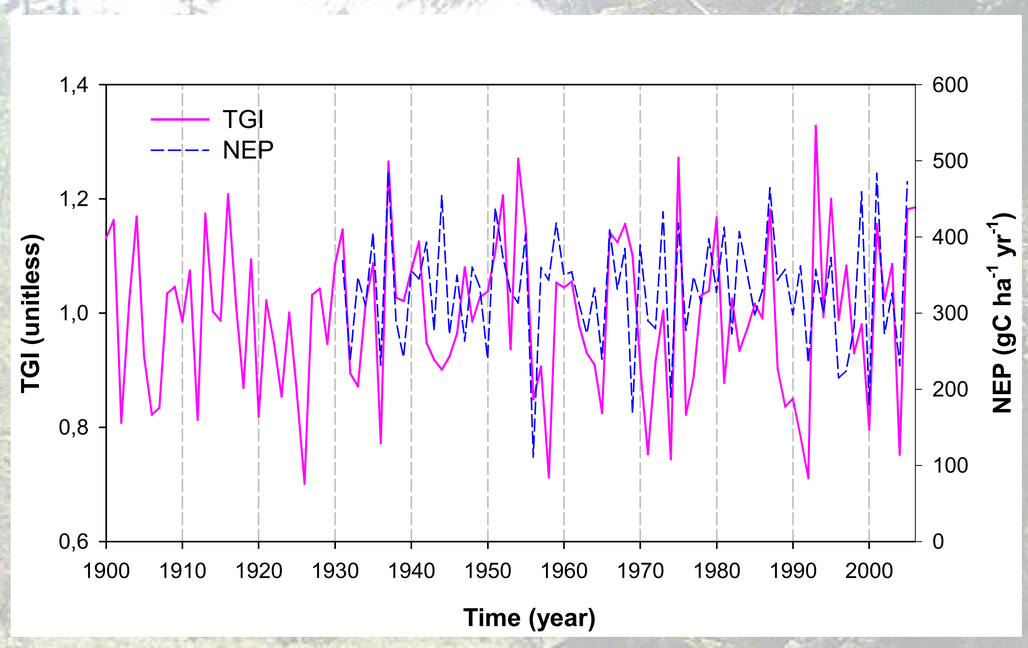

Figure 2 — Observed TGI (continuous line) and simulated NEP (dashed line).

5. FINAL CONSIDERATIONS AND IMPLICATIONS

Estimating forest productivity helps us to evaluate the commercial productivity of a stand. The knowledge acquired by models will allow us to identify areas where silvicultural work will have the best chances of success and the best profits. Our results suggest that the study area might have not yet responded to climate change. However, the interest shown by the forest industry for this region is an incentive for the various forest stakeholders to plan new strategies for sustainable forest management.

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