Evaluation of White spruce growth response to partial harvest

DENDROECOLOGY GROUP

(forest productivity and management)

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1. Introduction:

Canadian forestry faces several social, economic and ecological issues, all of them being interrelated. To conserve biodiversity and habitats is required to ensure forest ecosystem resilience, especially in the context of climate change (Gauthier et al, 2008). A complex forest structure is related with the high habitat diversity and variety of organisms and thus, enhances the forest resilience (Drapeau et al. 2000). However, forest structure is altered by some silviculture techniques such as “clear cut”, where the managers look for regular and even-aged stands, leading to a less complex, homogenized and, sometimes, monocropped forest (Simon and Bode, 2012).

In Canada, in 2020, a total of 710,000 hectares were harvested for timber commercialization, 28% of which came from Quebecois forests. In this province, almost 75% of the timber area is managed using clear-cutting techniques (National Forest Database). Aiming towards a more sustainable and resilient forest, new silvicultural techniques that integrate ecological and economic factors (i.e.: stand growth, tree quality, product yields and botanical and zoological biodiversity) started to be applied. It is noteworthy the use of “partial cutting” in North America, particularly in Eastern Canada. Nevertheless, research is required to better understand which treatment is the best for each species according to the different ecological factors, so managers can maximize radial growth while preserving the ecosystem (Girona et al., 2017).

Partial harvest has different effects over non-touched forest areas, thus affecting tree ring growth. This depends mainly on competition factors, since it was inferred by Girona et al. (2017) that black spruce trees present different growth patterns regarding its proximity to the harvest trial as well as its previous status (i.e., dominant, codominant or suppressed). Those close to the edge showed the greatest radial growth after cutting, as well as the younger ones.

There are multiple studies looking at treatment effects on black spruce, but there are less regional studies looking at white spruce response after treatments. As such, the present study offers an unique opportunity to monitor effects of silvicultural treatments of white spruce growth 20 years after harvest. It also allows a better understanding of the long term effects of silvicultural treatments on tree growth and forest structure in boreal forests.

The objectives of the study are: a) to evaluate the growth response of white spruce to partial cutting 22 years after harvest. b) To understand the roles of climate and species competition in the growth of *Picea glauca*. c) To evaluate how competition influences white spruce growth in treated stands.

2. Material and methods

We used an long-term experimental setup corresponding to the SAFES project in the Forest Forêt d’enseignement et de recherche du lac Duparquet (FERLD). The SAFE project has spent many years studying how silvicultural treatments can mimic natural disturbances to study forest dynamics, gap dynamics, structural characteristics, and successional responses to harvest in boreal forests (Bergeron and Harvey, 1997). We used the ⅓ and ⅔ harvest removal treatments to test our hypotheses. Treatment 1 (T1) consisted in one third of the stems harvested with priority given to the removal of the lowest quality stems. The stand thus retains most of the attributes of natural stands while seeing its mortality reduced. Treatment 2 (T2) corresponds to two-thirds of the stems harvested with priority given to the most vigorous stems. The trees left standing, combined with the ability of aspen to regenerate by root suckering after cutting, and the response of understory softwoods to canopy opening, should allow the stand to evolve towards a structure and composition similar to that of older natural stands.

2.1. Sampling and data collection

We used a 400 m2 circular plot (11.28 m radius) to describe the stand structure of each site. In total we have a plot for T1, T2 and two control plots. We characterized the stand structure by sampling species, diameter at breast height, which we used to calculate tree density, basal area and species richness. Due to time constraints, collecting field data from the control plots was not feasible, so control plot data were taken from repository data cited in Aussenac et al., (2016). Additionally, there were many studies already existing in the region that were representative of our desired control plot conditions.

To evaluate how species competition influences white spruce growth, we created four meter radius sub-plots within our larger plot, each sub-plot having a white spruce tree as the plot center. We then measured every tree and shrub taller than 1.3 meters in height (DBH) within a 4 meter radius of the white spruce tree of interest.

2.2. Dendroecological data

For both T1 and T2, we cored all white spruce trees with a DBH greater than 9 cm, taking a core of both radii from each white spruce tree. The dendroecological data for the control plots were taken from a data repository (Aussenac et al., 2016). It is important to note that our dendrological data from our treatment units were not the same age as those from our control plots. The control plots contained trees that were established 100 years before the trees in the treatment plots, which impacts our ability to compare the treatment and control plot data in analyses. Additionally, the tree core data from the control plots is dated to 2015, while the tree core data from our treatment plots are dated to 2021. Growth values were converted to basal area increment values.

2.3. Statistical analyses

Stat analysis for Forest Inventory Data:

After collecting stand inventory measurements in the field, tree density (TPH) and tree basal area was calculated for control and treatment plots, for each species present, and for the total plot density and basal area. For our target species, *picea glauca,* there was much higher

density of white spruce in our treatment areas than in our control areas, with the highest density and basal area in treatment 2 (⅔ cut).
to determine the effect of treatment on growth (BAI) we built a general additive model (GAM) using as explanatory variables the age, DBH, climatic variables and treatment.

3. Results:

In Figure 1 we can observe that after a silviculture treatment, white spruce in a partial cut stands, present an increase in the tree ring growth compared to the tendency they were following for forty years before harvesting; they both follow a similar tendency. Nevertheless, it can be seen that white spruce tree rings in Treatment 2 stand, with a two thirds cut, grew significantly more (on the order of 0.5mm in the peak) than the Treatment 1 stand.On the other hand, control stands follow a completely different tendency since it is affected by other factors.

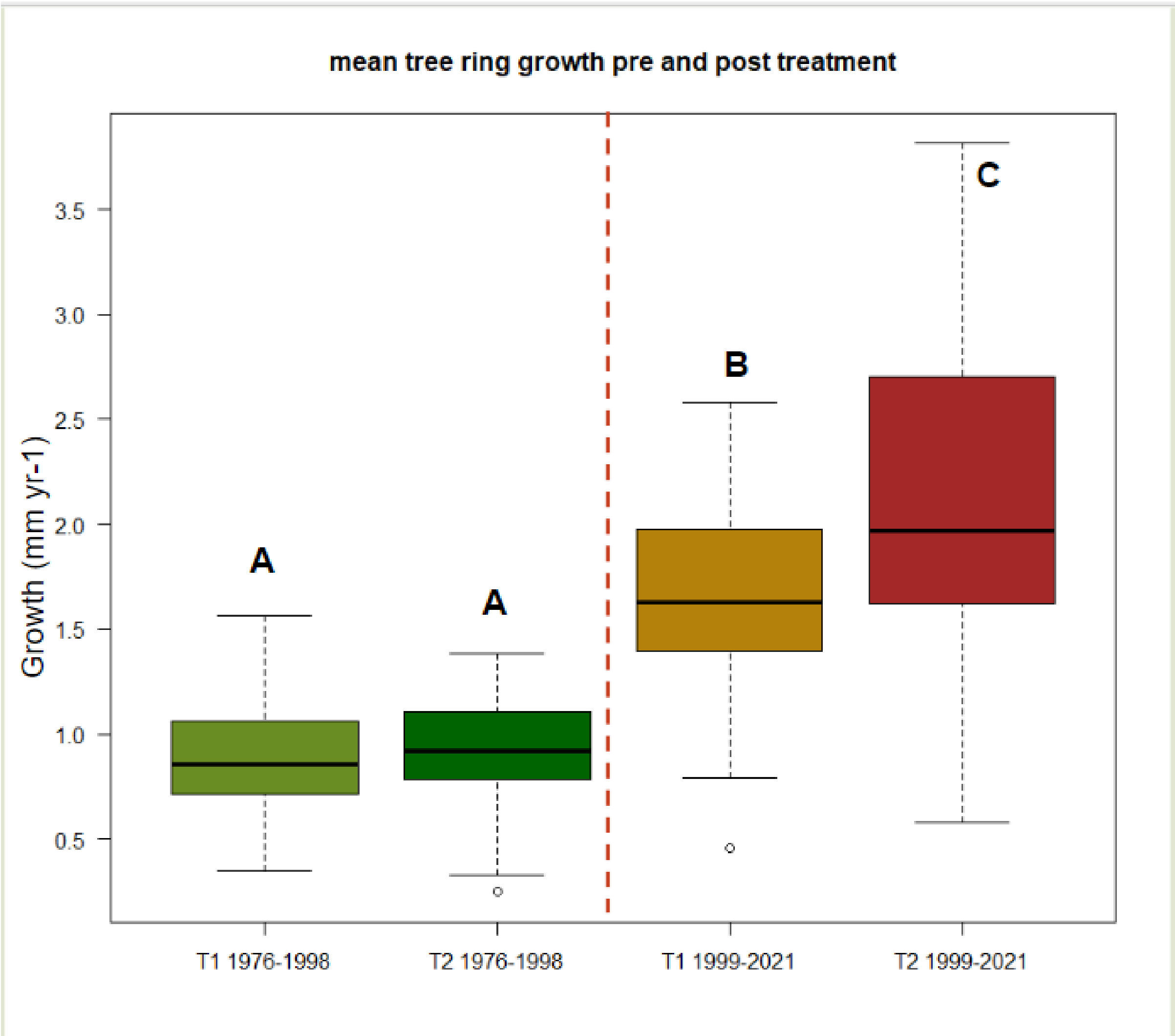
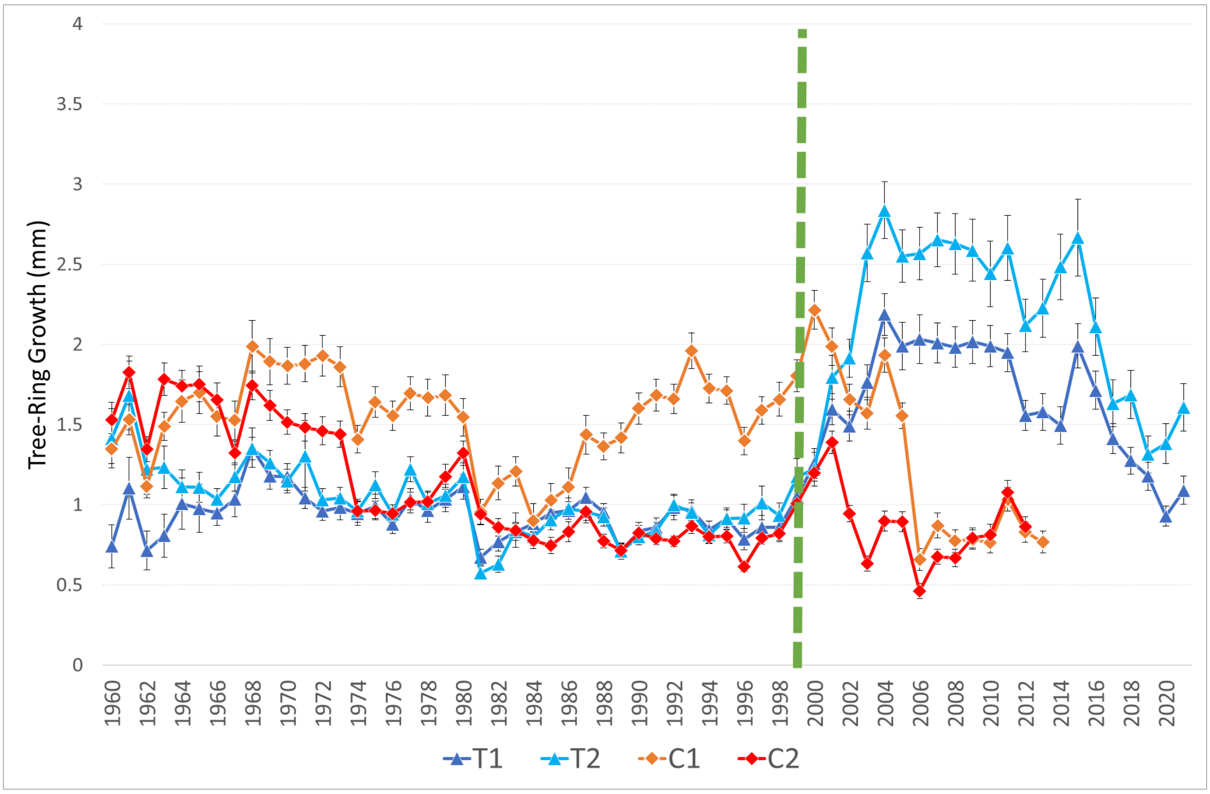
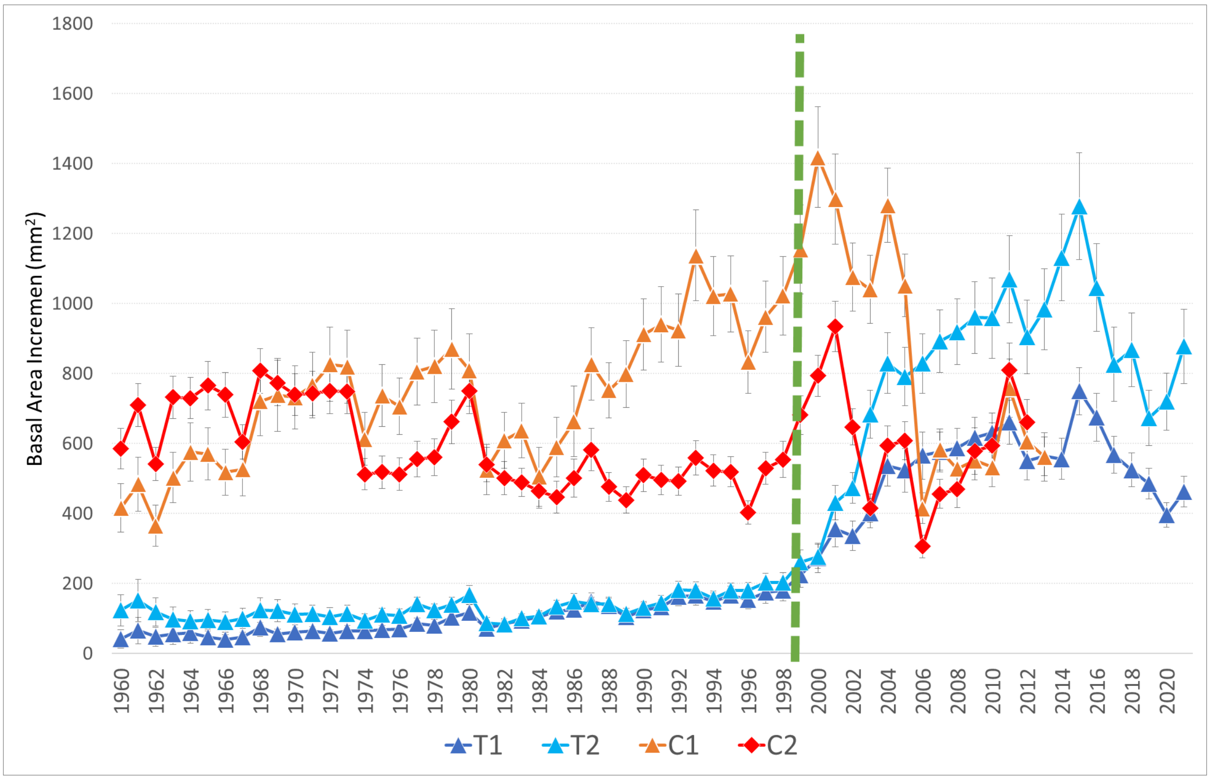


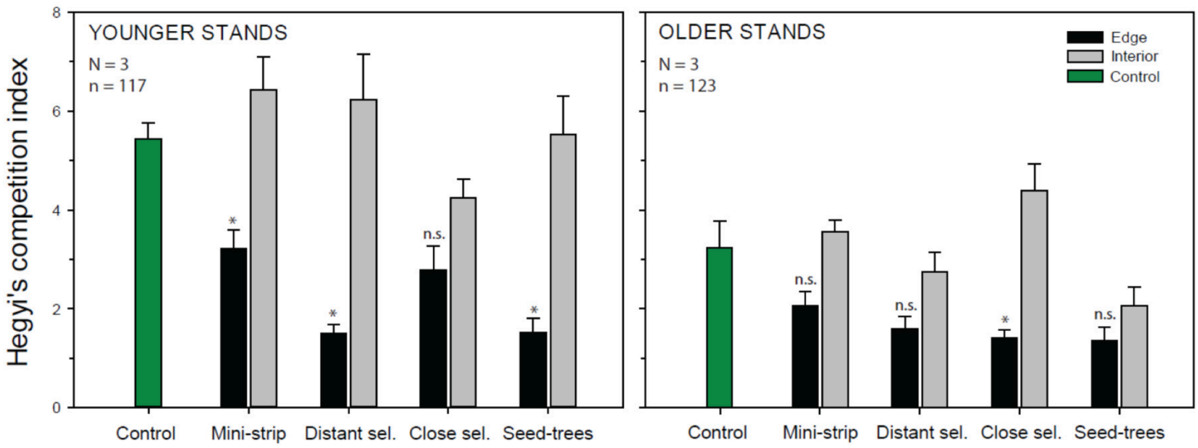
Figure 1: Interaction Analysis of Variance (2-way ANOVA) to look at the interaction between treatment type (⅓ vs ⅔) and time period (before and after harvest treatments) on mean tree ring growth. Results were statistically significant, so a post hoc test was conducted to evaluate where the sources of variance were happening. Post hoc test found that there was not

a significant difference in growth for treatment area 1 (A) or treatment area 2 (A) prior to harvest, but after harvest, both the ⅓ cut (B) and ⅔ cut (C) areas saw a significant increase in growth in the last 22 years.





Basal Area Incremen (mm²)
T1
T2
C1
C2



Hegyi's competition index
YOUNGER STANDS
N = 3
n = 117
OLDER STANDS
N = 3
n = 123
Edge
Interior
Control
Control
Mini-strip
Distant sel.
Close sel.
Seed-trees

4. References

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