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Factors Associated with Beech (*Fagus grandifolia* Ehrh.) Dominance in New Brunswick

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Technical Note

Silviculture

INTRODUCTION

In New Brunswick, American beech (BE) is widely distributed in tolerant hardwood stands. It is considered as a species of low commercial importance. Beech bark disease (BBD) infection is commonly present in stands having a dense BE understory. This dense BE understory also inhibits the regeneration and growth of other desirable hardwood species (e.g.: sugar maple, yellow birch), thus reduces stand productivity. Studies had shown that local and large scale variation in BE abundance is the outcome of several interacting factors (Messier et al. 2011, Bose et al. 2017).

In general, (1) abiotic factors such as soil (moisture and nutrients), topography (slope, aspect, and altitude), and climate (temperature and precipitation); and (2) biotic factors such as insect/pest (BBD), wildlife browsing, and harvesting (season, intensity, and root damages) are considered responsible for BE dominance. In this context, a comprehensive study is necessary to assess factors associated to BE dominance. Thus, this study aimed to (i) identify key abiotic and biotic factors related to BE dominance, (ii) establish their relationship with BE dominance, and (iii) provide necessary information to help design silvicultural solutions for managing BE-present tolerant hardwood stands in New Brunswick.

HIGHLIGHTS

- **Beech abundance is related to abiotic factors (soil, altitude, depth of water table, temperature, and precipitation) and biotic factors (stand condition, treatment type and intensity).**
- **Beech was more abundant in hardwood forests located in nutrient poor, warmer sites where a low intensity partial cut was conducted.**
- **Beech abundance is likely to increase in the absence of silviculture intervention and in situations where harvesting promotes vegetative propagation. Current practices must change!**

METHODOLOGY

Forest inventory data of the most recent New Brunswick Forest Development Survey (FDS) cycle (between 2003 and 2012) was obtained from the New Brunswick Department of Energy and Resource Development. Weather (temperature and precipitation), soil, bedrock, topography (slope, altitude, and aspect), site productivity (BGI), and stand history information were obtained from various sources (Table 1). All FDS plots that had at least one individual of BE irrespective of their size (n=1113) were used for analysis. Total and BE live tree (DBH ≥ 9cm) and saplings (1cm ≤ DBH < 9cm) density and basal area for each plot were calculated. This information was used to calculate species importance value of BE using equation (1). Importance value is widely used in ecology to assess species prominence. It was calculated based equally on relative basal area and the relative stem density contained within each plot, with a maximum value of 100 in monotypic stands. Plot-level BE IV obtained from equation (1) was regressed against several plot-level biotic (treatments and stand attributes) and abiotic (climate and topography) variables to identify key factors associated with beech prominence. Noting that in equation (1), BE stands for “Beech” and BA stands for “Basal Area”.

$$BE\ IV = \frac{\left(\frac{BE_{density}}{Total_{density}}\right) \times 100 + \left(\frac{BE_{BA}}{Total_{BA}}\right) \times 100}{2} \qquad (1)$$

Table 1: Source of biotic and abiotic information used in this study

Variables	Data Source
Weather (temperature and precipitation)	Thorton et al. (2014)
Topographic data (from digital elevation model)	UNB Forest Watershed Research Center (2015)
Depth to water table	UNB Forest Watershed Research Center (2015)
Bedrock information	NBDNR (2008)
Soil	Fahmey et al. (2010).
Biomass growth index (BGI)	Hennigar et al. (2016)
Treatment history	NBDNR (2015)

RESULTS

The result of regression analysis (Table 2) showed that BE was more dominant in hardwood forests that were subjected to low intensity partial cut in the recent past. It was mostly dominant in higher altitude areas in southern latitude of the province where mean annual temperature and depth to water table is relatively higher. In northern latitude, it was more abundant in middle slopes (Figure 4). The positive relationship between beech abundance and dead tree proportion indicates that dead beech trees were regenerating more beech. However, BE was less dominant in stands that had higher heterospecific (other than beech) live tree basal area and stands that were developed from stand replacement disturbance (e.g. clear cutting). BE was less dominant in those areas where there was more precipitation during spring (Table 2). Similarly, areas with soil types associated with low % base saturation were found to have higher BE dominance (Figure 1). The majority of plots containing BE had low abundance of BE (IV < 25%). However, it is likely that there will be higher number of plots with higher BE abundance in the future if management practices remain the same (Figure 2).

Table 2: Key variables associated with BE dominance (Importance Value). Note that soil type interacts with ecoregion and ecodistrict.

	Positively related (More BE)	Negatively related (Less BE)
Biotic	Hardwood proportion Dead tree proportion Low intensity partial cut	Heterospecific tree basal area High intensity treatment
Abiotic	Depth to water table Altitude × Mean Annual Temperature	Precipitation during dry season (Spring)

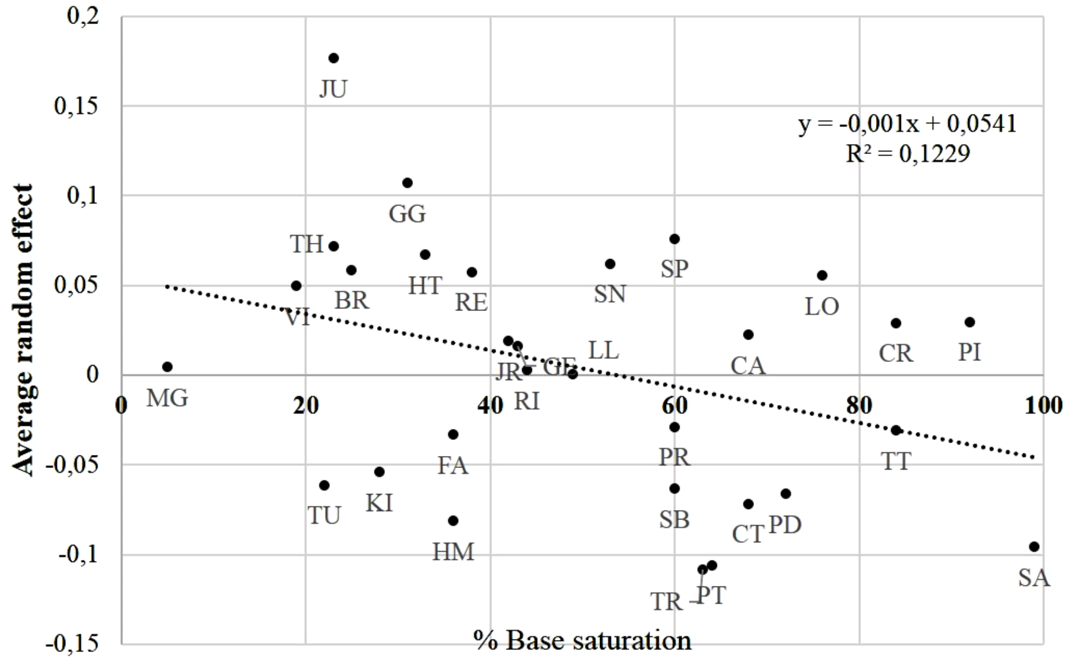

Figure 1: Relationship between average random effect for a given soil type and % base saturation. Higher value for average random effect is associated to higher dominance of beech.

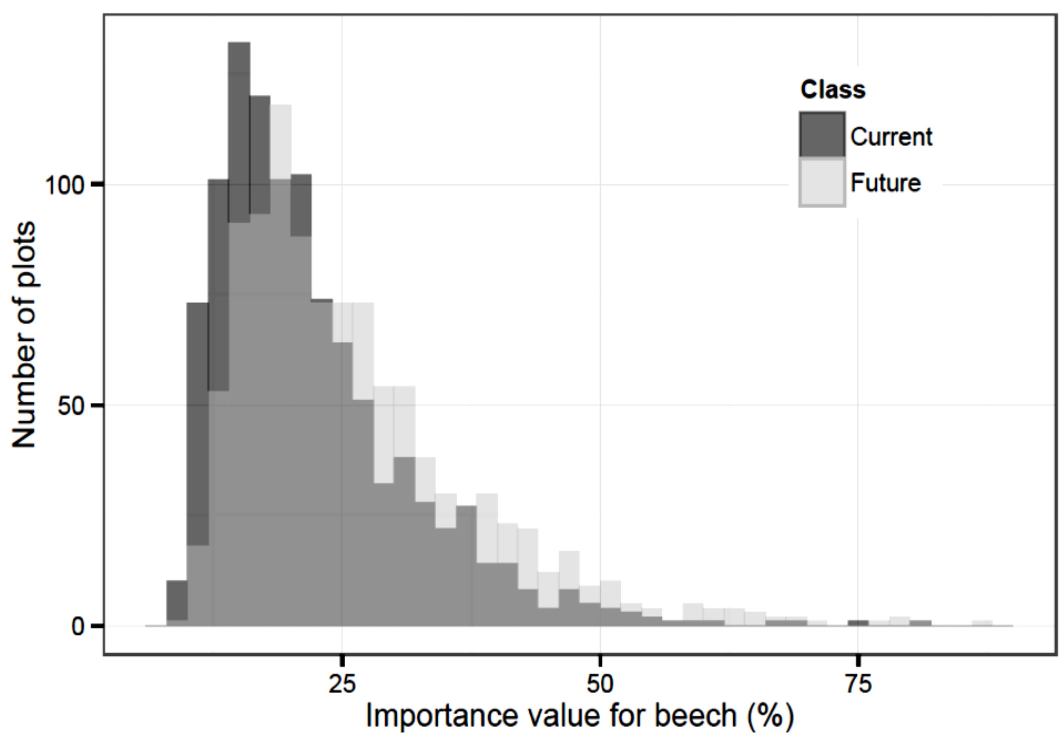

Figure 2: Current distribution of beech: during observation period, Future: scenario of increase in mean annual temperature by 2100. Increase in mean annual temperature by 4 ^{0}C was assumed according to Swansberg et al. (2004).

DISCUSSION AND CONCLUSION

The result of this study demonstrates that beech is widely distributed across the province, and its abundance in New Brunswick is related to both biotic as well as abiotic factors. If other factors remain the same, beech abundance is likely to increase in the future due to climate change. This will have negative consequences on growth and yield of our tolerant hardwood stands as these stands have been plagued by beech bark disease for a long time (about 70 years or more). Results of our analysis and other published literature showed that growth rate of infected beech trees declines rapidly. Tree-cutting or physical damage to the root system produce profuse stump/root sprouts. Those sprouts grow faster than seed-originated regeneration of other species, and, when beech dies, it produces many of those sprouts, forming a dense BE understory, inhibiting the regeneration and growth of other desirable hardwood species such as sugar maple and yellow birch. In this context, the goal of our hardwood silviculture must be to supress beech regeneration to promote the regeneration and growth of desirable species.

The close investigation of these biotic and abiotic factors related to beech abundance provides us some useful hints for suppressing beech. In conclusion, there are 3 key factors that need to be considered while choosing silviculture treatments for beech-present hardwood stands (Figure 3). Tree species site suitability assessment is one of the 3 key factors. It is important to detangle the environmental niche for sugar maple, yellow birch and American beech. The results showed that beech was more abundant in nutrient poor warmer sites that were subject to low intensity partial cut. This is most likely due to competitive exclusion of sugar maple as it grows poorly in nutrient poor sites (low % base saturation). Tree species (SM,YB and BE) site suitability mapping at the provincial scale is recommended to help silviculture decision making. Detailed assessment of existing stand structure is another key factor. It is important to assess proportion of different species at different cohort class (including advance regeneration). This will inform us about type, season and intensity of silviculture treatment required for a particular stand to supress beech. The NHRI silviculture prescription system is recommended to use as a guide through the process.

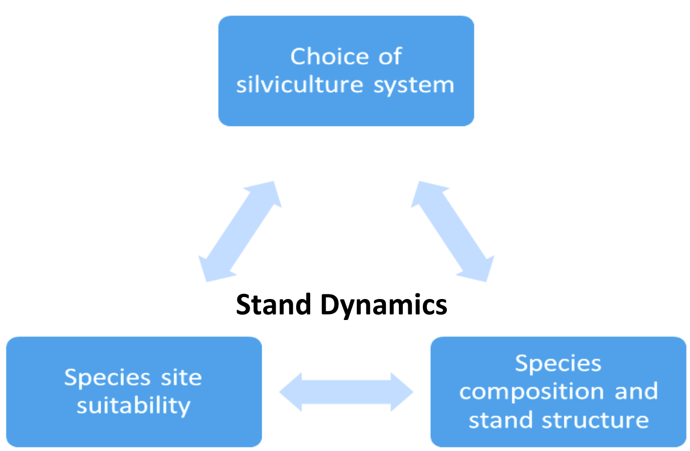

Figure 3: Key factors controlling dynamics of beech-present stands

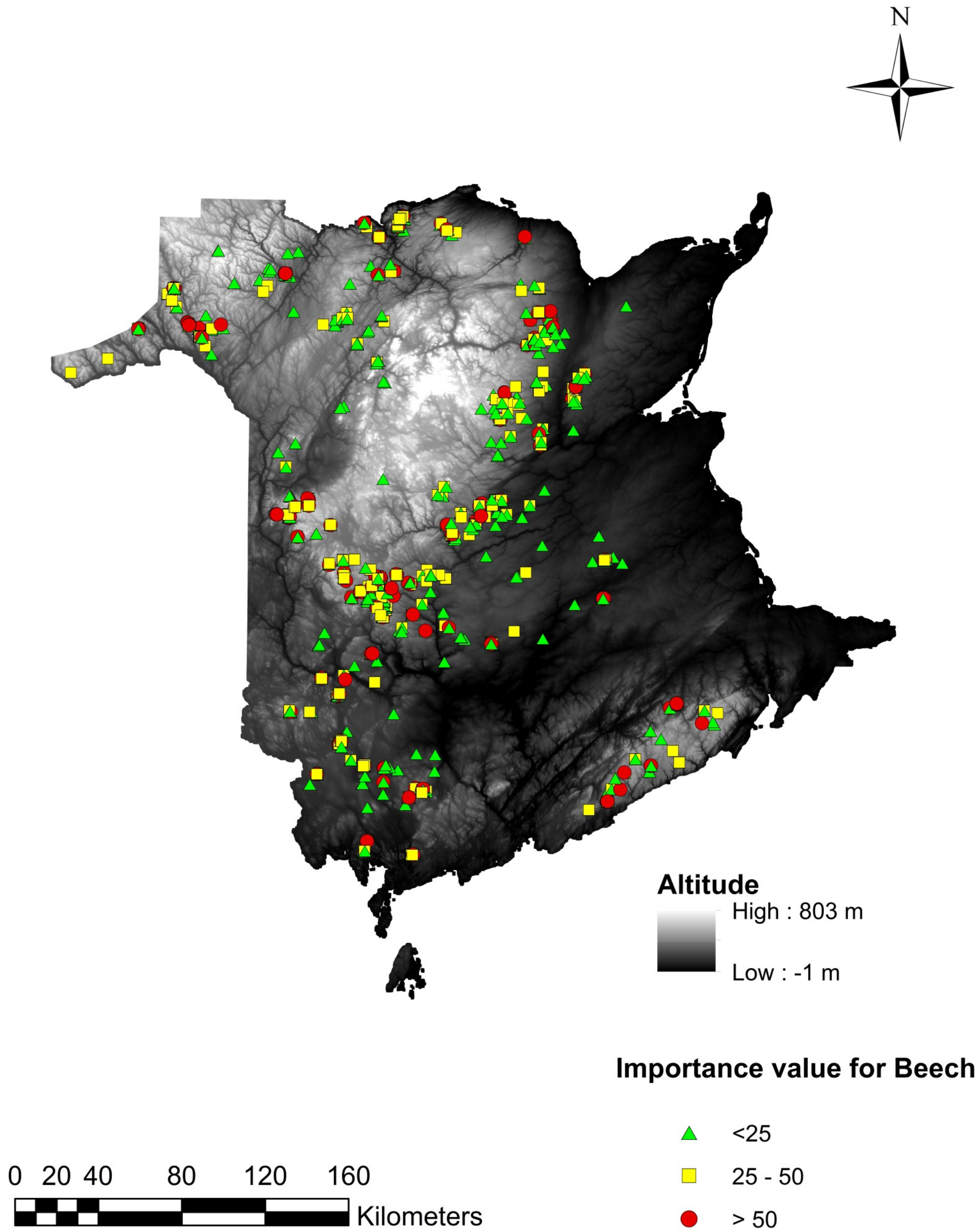

Figure 4: Spatial distribution of plots containing beech. Green triangles = low abundance of BE, yellow squares = moderate abundance of BE, and red circles = high abundance of BE. Lighter shade of gray indicates higher altitude and darker shade indicate lower altitude.

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