Does the visual assessment of tree vigor in the selection system reflect actual tree survival probabilities?

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Introduction

In order to test whether a visual tree vigor classification (Fig.1) in selection cutting reflects actual tree vigor, we:

(i) compared survival probabilities of sugar maple trees belonging to different vigor classes, and

(ii) verified whether predicted timing of tree death (20-25 yrs) is corroborated by tree survival probabilities.

Figure 1. Large Eutypella cankers with wood decay are a classification criterion for moribund trees

Results

Survival probability predictors

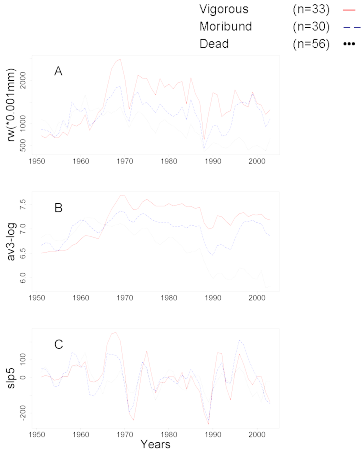

Figure 3. Median annual ring-width (rw, A), mean annual growth level (av3-log, B), and mean annual growth trend (slp5, C) of vigorous, moribund and now-dead trees form 1950 – 2003.

Vigorous trees had consistently higher growth rates (Fig.1 A & B) than either moribund or now-dead trees. However, their past growth was more variable with extremes being more positive and negative (Fig. 1C). Remarkably, moribund trees showed a more pronounced gain in growth rates after the 1993 selection harvest.

Figure 2. Sugar maple tree close to a logging road of the 1993 selection harvest. Note the crown dieback that may have been caused by the sudden exposure to solar radiation

Results

Survival probabilities

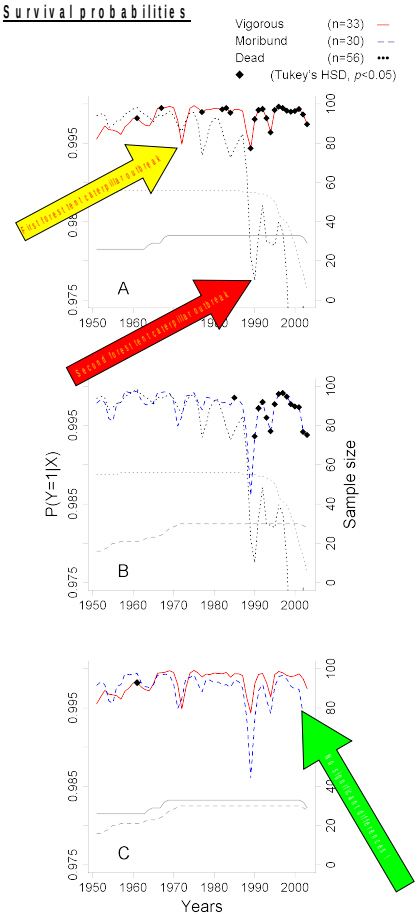

Figure 4. Comparison of survival probabilities of vigorous, moribund and now-dead trees form 1950 – 2003. Sample sizes are given in respective grey lines. ◆= significant differences at $p<0.05$, Tukey's HSD following ANOVA.

Survival probabilities of now-dead trees started deviating from vigorous (Fig. 4A) and moribund (Fig. 4B) trees shortly after the 1971 forest tent caterpillar outbreak (yellow arrow).

Dead trees never recovered completely from this disturbance and were predisposed to further decline when a second heavy disturbance took place in 1988 (red arrow). This disturbance triggered the onset of their death.

However, survival probabilities of moribund trees were not significantly different from vigorous trees even toward the end of the series (green arrow), i.e., when vigor was assessed in the field (Fig. 4C).

Conclusions

Our results show that trees are predisposed to death by disturbance, as Manion's (1981) conceptual tree disease model predicts.

Since moribund trees did not show an onset of a final vigor decline (as observed in now-dead trees following the 1988 disturbance) we conclude that the vigor classification underestimates the predicted time to death

Appendix

Materials & methods

Live sugar maple trees were classified in the field into 4 vigor classes based on pathological symptoms (Fig. 1), mechanical damages, and other criteria (e.g., crown characteristics, Figure 2).

We sampled live trees with increment cores and took cross sections of dead trees both at 1.3m above ground.

We used a longitudinal approach of the logistic regression analysis (Bigler and Bugmann 2004), based on live and dead tree-ring data, to develop a survival model for sugar maple trees.

The logistic model is:

$$P(alive) = \frac{e^{\alpha G_L + \beta G_T}}{1 + e^{\alpha G_L + \beta G_T}}$$

α and β: estimated regression parameters

G_L (3-yr mean) and G_T (5-yr slope): predictor variables.

We formed groups of 56 dead, 33 live vigorous and 30 live moribund trees and compared survival probabilities among these groups. ANOVAs were performed for each calendar year to verify whether survival probabilities were statistically different ($p<0.05$) between groups and Tukey's HSD test for pairwise comparisons among groups when ANOVA results were significant.

Survival probabilities of dead trees served as a baseline standard of how survival probabilities of moribund trees should behave, time lagged, if the classification system was to be adequate.

Literature cited

Manion, P. 1981. Tree disease concepts. Prentice Hall Inc. Englewood Cliffs, N.J. 389p.,

Acknowledgments

We thank Catherine Malo for her help during the long weeks of field work and dendrochronological analyses.

We also thank Mr. Denis Boileau of the Quebec ministry of natural resources for his help on explaining historical tree growth disturbances.

Financial support has for this project has been provided by the SFMN (Sustainable Forest Management Network).

WARNING: Logging trucks are a major traffic disturbance and may cause vigor decline or even death to oncoming vehicle operators

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