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REGRESSION MODELS DESCRIBE AND PREDICT BENEFITS OF VEGETATION MANAGEMENT FOR BLACK SPRUCE

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CATEGORY: Vegetation management
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INTRODUCTION

In Ontario, interest in vegetation management has increased dramatically since the mid 1980s; in part, a result of the steady expansion of the provincial reforestation program from 50 million trees in the mid 1970s to 171 million trees in 1988. According to Kuhnke (1989), much of this expansion was directed toward black spruce (*Picea mariana* [Mill.] B.S.P.). Since competition for site resources is a constraint on conifer establishment, there has also been a rapid increase in the area treated with herbicides (from 30 100 ha in 1980–81 to 93 800 ha in 1989–90 [Deloitte and Touche Management Consultants 1992]).

Increasing public pressure to reduce the quantity of herbicide being used in the forest has resulted in the need for forest managers to base their tending decisions upon timely quantitative data. In addition, an overall decline in silvicultural budgets will require that all forest vegetation management decisions be highly effective. In response to these needs, the short-term beneficial effects of controlling weeds in black spruce plantations have been well documented (Weetman 1989, Hearnden et al. 1992).

It remains unclear, however, whether these beneficial effects will change over time. Thus, to better quantify the long-term growth response of black spruce to weed control, individual outplants were sampled up to 11 years after planting as part of a vegetation management and stock comparison experiment in Kenogaming Township in northeastern Ontario (Wood and Mitchell 1995).

In this study, the Kenogaming data were used to develop quantitative models describing the effects of stock type, planting season, and weed control on changes in basal diameter, tree height, tree volume, and tree survival up to 11 years after planting. One potential use for these models is in filling information gaps in the decision support systems for vegetation management in Ontario. Currently these systems lack fitted models that can describe the longer-term effects of vegetation management on crop tree growth. The purpose of this paper is to illustrate the models that have been developed from the Kenogaming data.

METHODS

The experiment was conducted in Kenogaming Township (48°10'N, 82°00'W) in the Missinaibi–Cabonga Forest Sections of the Boreal Forest Region (Rowe 1972). The site was productive and well drained with silty to loamy sand soils (Hardwood Mixedwood–Coarse Soil site type [McCarthy et al. 1994]). The forest cover before harvest (which occurred in 1979–1980) consisted of black spruce, white spruce (*Picea glauca* [Moench] Voss), trembling aspen (*Populus tremuloides* Michx.), balsam fir (*Abies balsamea* [L.] Mill.), and white birch (*Betula papyrifera* Marsh.).

A straight blade mounted on a bulldozer was used to mechanically prepare the site for planting in the summer of 1981. Bladed strips were 5–6 m wide with 3–8 m of logging

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debris and standing deciduous and cedar (*Thuja occidentalis* L.) trees left between strips. Planting of bareroot or container-grown black spruce occurred in May and July 1982.

Eight years after weed control the principal competitor species were beaked hazel (*Corylus cornuta* Marsh.), mountain maple (*Acer spicatum* Lam), birch (*Betula* spp.), pin cherry (*Prunus pensylvanica* L. fil), red raspberry (*Rubus idaeus* L. var. *strigosus* [Michx.] Maxim), trembling aspen, and graminoides. The effects of weed control were still evident within the treated bands eight growing seasons after treatment.

Treatments were distinguished by stock type (bareroot transplant or one of three sizes of paperpot) and planting season (May or July 1982). The two herbicide treatments involved an untreated control, and glyphosate (356 g a.e./L) applied on 30 August 1984 at a rate of 70 L/ha with a hand held applicator at 2.1 kg a.e./ha.

Samples of 50 seedlings were taken before planting and after 1, 2, 3, 5, and 11 growing seasons. Measurements included basal diameter, height, seedling vitality, and (estimated) stem volume. Additional information about methods may be found in Wood and Mitchell (1995).

Weighted, time-dependent, nonlinear regression models were developed to project the effects of the imposed management regimes on tree volume, height, survival, and basal diameter. The models were built and refined according to accepted regression methods to ensure that all assumptions were satisfied (Draper and Smith 1981, Ralston 1983).

RESULTS AND DISCUSSION

There was evidence of statistically significant effects of weed control on height growth in only two of the six treatments. After 11 growing seasons the predicted (i.e., fitted) height of the spring planted, 1.5-g paperpot stock was 42 cm greater in the weeded than in the nonweeded plots (Fig. 1). On the other hand, the predicted height of the summer planted, bareroot stock was 13 cm less after 11 growing seasons in weeded versus nonweeded plots. The seemingly negative influence of weeding on this latter treatment is not, however, due to poor performance of the trees in the weeded plots. Weed competition had such little detrimental effect on the height growth of these trees that sampling error may be responsible for both the statistical significance and small magnitude of the difference.

The greatest relative advantage in basal diameter for weed control occurred with the summer planted, 0.6-g paperpot stock. The predicted basal diameters for these trees in weeded plots (3.14 cm) were twice as large as those for nonweeded plots after 11 growing seasons (Fig. 2). At that time, the greatest absolute benefit for weed control occurred with the spring planted, 0.4-g paperpots. Here the predicted average basal diameter of trees in the weeded plots (4.40 cm) was 1.80 cm wider than that of trees in the nonweeded plots. If present trends continue, however, eventually the greatest absolute advantage for weed control will occur with the spring planted, bareroot stock.

In all treatments, tree volume increased faster on weeded plots than on nonweeded plots. This difference in volume growth rates also increased with time. The greatest relative benefit for the use of weed control occurred with the summer planted, 0.6-g paperpots (Fig. 3). After 11 growing seasons, the predicted average volume for the weeded plots (760 cm^3) was about 3.8 times that for nonweeded plots. At the same time, the spring planted, 1.5-g paperpot stock demonstrated the largest absolute benefit for weed control (2 000 cm^3 in the weeded plots vs 600 cm^3 in the nonweeded plots).

The only statistically significant effect of weed control on seedling survival occurred with the spring planted, bareroot stock. Beginning from 100 percent survival on all plots, the predicted survival fell to approximately 82 percent on the weeded plots and 73 percent on the nonweeded plots after 11 growing seasons (Fig. 4).

In general, wherever reduction of weed competition had a statistically significant effect on trends in crop growth or survival, the effect was almost always beneficial to the crop. To some extent, weeding effects were found in all six treatments. The seedling characteristics (and number of treatments for which significant benefits were incurred by weed control) were: volume (all six treatments), basal diameter (four), height (one), and survival (one). This pattern suggests that tree volume, followed by diameter, may be most sensitive to weed competition.

These results are consistent with the observation that crop trees often respond to interspecific competition by sacrificing diameter growth in order to maintain height growth (Lanner 1985, Zutter et al. 1986). But after the trees become over-topped by competitors and even height growth slows, survival starts to fall.

Where differences in growth or survival between the weeded and nonweeded treatments were statistically significant, these differences continued to increase even 8 years after weed control was applied. This is an example of the general observation (Wagner and Radosevich 1991) that size is a key determinant of tree growth and survival; in general, the larger a growing tree's present size, the faster its absolute rate of growth and the larger its future size.

SUMMARY

Various time-dependent regression models were tested and fitted to describe and interpolate the effects of these treatments over time on tree volume, height, survival, and basal diameter. These models showed that reduction of weed competition almost always had a beneficial effect on crop growth. This benefit was evident in the volume in all six planting treatments

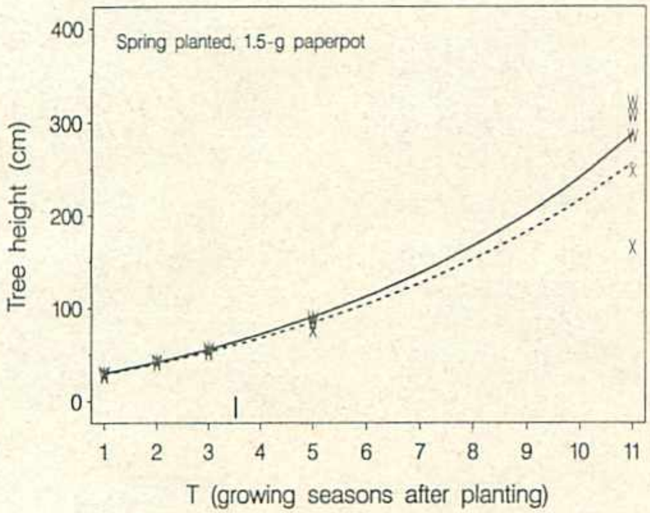

Figure 1. Predicted relationships between tree height (cm) and time for the spring planted, 1.5-g paperpot stock.

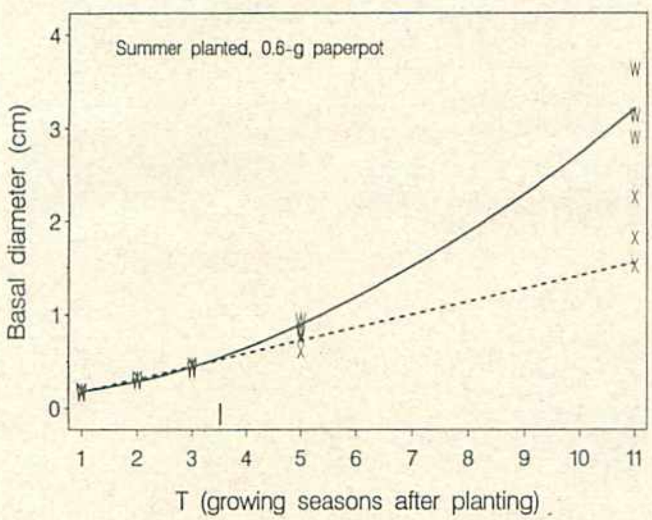

Figure 2. Predicted relationships between basal diameter (cm) and time for the summer planted, 0.6-g paperpot stock.

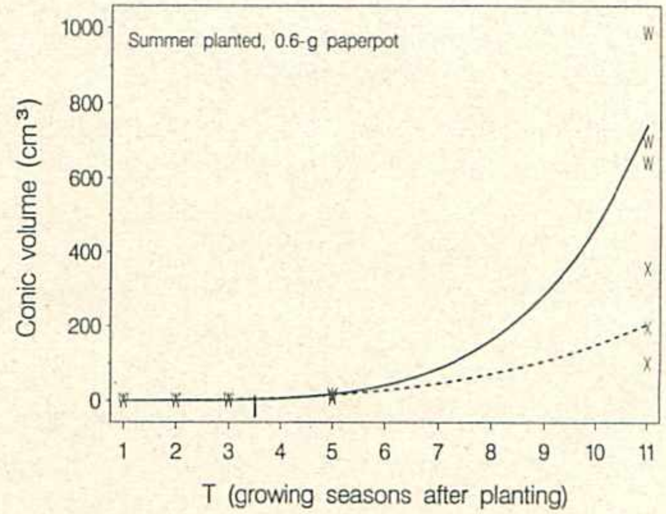

Figure 3. Predicted relationships between conic volume (cm^3) and time for the summer planted, 0.6-g paperpot stock.

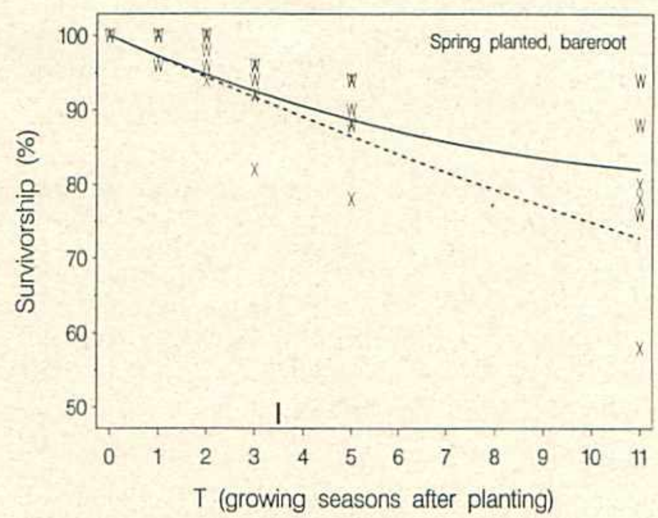

Figure 4. Predicted relationships between percent survivorship and time for the spring planted, bareroot stock.

Note: The solid and dashed curves distinguish the weeded and nonweeded plots, respectively. The three W's and X's at each time, T, when measurements were recorded indicate the corresponding sample means for the weeded and nonweeded plots, respectively. (When some sample means are nearly identical overprinting occurs in the figure.) The solid bar above T=3.5 indicates that weed control occurred after the 3rd growing season.

examined (and in the basal diameter of four of these treatments). But even 8 years after weed control, tree height and survival showed little discernible response to weed control. Where weed control effects were evident, the models indicated that these increased with time.

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