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High Speed Soil Mixing: 4th Year Response of Black Spruce and Selected Competitor Species

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HIGH SPEED SOIL MIXING: 4TH YEAR RESPONSE OF BLACK SPRUCE AND SELECTED COMPETITOR SPECIES Author; Brad Sutherland

INTRODUCTION

Mechanical site preparation involving the removal or displacement of organic matter has demonstrated little or, at best, short-term control of competing vegetation and, in addition, has been criticized on the grounds that it promotes nutrient depletion and so threatens long-term sustainability (MacKinnon and McMinn 1988). High-speed soil mixing (incorporating the surface organic layers into the underlying mineral soil) is a relatively new site preparation method that has the potential to control competing vegetation (McMinn and Hedin 1990) and to improve soil condition, such as aeration and moisture relationships, for conifer regeneration (Örlander et al. 1990). Mixing instead of removing the organic layer completely will preserve the longer-term nutrient status of the soil and can enhance tree growth (Moehring 1977; Foster and Morrison 1989). Mixing that incorporates the surface organic materials deep into the mineral soil can have a moderating effect on the rate of mineralization of nutrients by avoiding the temperature extremes commonly experienced by the exposed surface organic layers (Salonius 1983). Wood and bark can also conserve soil fertility when buried, as the microbial activity that results from their decomposition can temporarily immobilize nutrients (Binkley 1986).

Currently available high speed mixing machines or rototillers have not been adopted for use in forest conditions due to certain more or less significant operational deficiencies (Cormier 1994). In order to address these problems the Forest Engineering Research Institute of Canada (FERIC) undertook the development of a mixing machine in 1991 capable of working under a broad range of site conditions and whose operating cost would be below that of other mixing machines currently available.

In 1992, the Canadian Forest Service (CFS) undertook an interdisciplinary study[1] based on mixing compared with conventional screefing and herbicide treatment to compare the efficacy of these treatments for controlling competing vegetation and to determine their effects on soil and on soil organism interrelationships and diversity. FERIC evaluated their single row, prototype mixing machine used in this study to determine the effects of various machine settings upon soil properties while the CFS set out to correlate these results with the biological impact of vegetation response. Third season results of the CFS study indicate that, compared to the controls, mechanical mixing has a positive affect on black spruce volume and a negative affect on trembling aspen growth. This technical note presents comparative results of black spruce seedling and competing vegetation response among five mixing machine settings after four growing seasons.

METHODS AND MATERIALS

The site consisting of an uneven-aged mixedwood of mainly trembling aspen (*Populus tremuloides* Michx.) and balsam fir (*Abies balsamea* [L.] Mill.)is located in Adamson Township, Thunder Bay District, Ontario, Approximately 32 km NW of the town of Nipigon on the north shore of Lake Superior. Soils were classified as a Dystric Brunisol in profile (Canada Soil Survey Committee 1978) developed in a deep, stone-free silt loam.

A single head prototype version of the FERIC mixing machine was used in this trial (Figure 1). The machine settings used in this study are described in Table 2.

Table 2. Settings of the FERIC mixing machine (adapted from Cormier, 1994[2])

Carrier speed (m/min)	Nominal speed of rotor (rpm)	Depth of treatment (cm)	Name of treatment
40	120	20	120/40/20
25	120	20	120/25/20
40	150	20	150/40/20
25	90	20	90/25/20
25	120	10	120/25/10

The effective width of mixing was 80cm. Actual depths of mixing recorded following treatment were variable but tended to be shallower than the 20cm machine setting and deeper than the 10cm machine setting.

Between June 14 and 19, 1993, one week following the completion of mechanical site preparation all plots were planted with black spruce (*Picea mariana* [Mill.] B.S.P.) container stock seedlings. The trees were grown in Leach tube containers and were~ 1-1/2 years old. They were planted at approximately 2 m spacing, to yield 30-50 seedlings/plot. Planting spots on all mixing plots were compacted by foot (approximately 60cm diameter) prior to planting, in order to alleviate excessive air space resulting from the lack of time for natural settlement of the mixed product.

Seedling survival, and diameter were monitored in October, 1996 after four growing seasons. Vegetation height and leaf area coverage for each species were assessed during August of 1996 using crop tree-centred circular plots following procedures outlined by Towill and Archibald (1991).

RESULTS

By October, 1996 (i.e., four growing seasons after planting) black spruce seedling survival averaged >90% with only one treatment plot averaging <80%. Seedling performance expressed in terms of stem volume, revealed no significant differences ($p < 0.05$) between treatments.

Vegetation index, which is the product of average leaf area and height of target species assessed inside of crop tree-centred cylinders, provides a useful means of comparing the relative growing space volume occupied by noncrop species (Towill and Archibald 1991) and for providing a sense of impact of each species in terms of its potential for crowding and overtopping other plant individuals (Walsh and Krishka 1991). Of a total of 45 species or species classes recorded, 5 species (trembling aspen, balsam poplar (*Populus balsamifera* L.), wild red raspberry (*Rubus idaeus* L. var. strigosus [Michx.] Maxim.), carex and vine species) accounted for over 69% of the total vegetation index tallied. Of these, 3 species, trembling aspen, balsam poplar and wild red raspberry represent 53 % of the total vegetation index tallied. By the end of the fourth growing season, the total vegetation index for all species combined revealed no significant differences ($p < 0.05$) between the five machine settings. Likewise there was no significant difference ($p < 0.05$)in vegetation indices between the machine settings for trembling aspen and balsam poplar combined, and raspberry.

DISCUSSION AND CONCLUSIONS

In the design of a cost effective mixing machine, one of the objectives is to strike a balance between productivity, power requirements and the achievement of a specified product. For example, what intensity and depth of mixing is sufficient to adequately control unwanted vegetation or promote crop tree response? Going beyond these threshold values of response may prove uneconomical due to high power requirements or equipment costs if the return in terms of vegetation control or crop tree response is only minimal. Due to the lack of case studies of mixing machines in boreal forest conditions, little information exists on the relationship between machine settings (e.g.,depth and intensity) and the impact on biological parameters such as plant response. Results from this study indicate that among the five high speed mixing machine settings, there was no significant impact on crop tree and competing vegetation performance after four growing seasons. It may be premature however to conclude, based on these results, that the machine settings representing either the highest productivity (120/40/20), the slowest rotor speed (90/25/20) and/or the shallowest depth setting (120/25/10) are the best options. Additional results from the other companion studies dealing with soil nutrients and soil organism interrelationships and diversity may help to evaluate more thoroughly, mixing as a site preparation tool.

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Foot notes

[1]Sutherland, B.J.;Morrison, I.K.; Dumas, M.;Addison J.A. 1997. Environmental impacts of alternative vs. current site preparation methods on forest soil and implications for vegetation control and biodiversity. Nat. Resourc. Can., Can. For. Ser.-Ont., Sault Ste. Marie, ON. NODA Tech. Rep. (In preparation)

[2]Cormier, D. 1994.Evaluating changes of microsite properties effected by high-speed mixing site preparation methods. For. Eng. Res. Inst. of Can. (FERIC), Pointe Claire, Qué. Internal report. 14p.

Figure 1. View of the FERIC mixing machine in action and a static shot showing the double rotor with scarifying blades.

Figure 1. The prototype one-row rototiller, powered by an auxiliary motor and mounted on a forwarder.

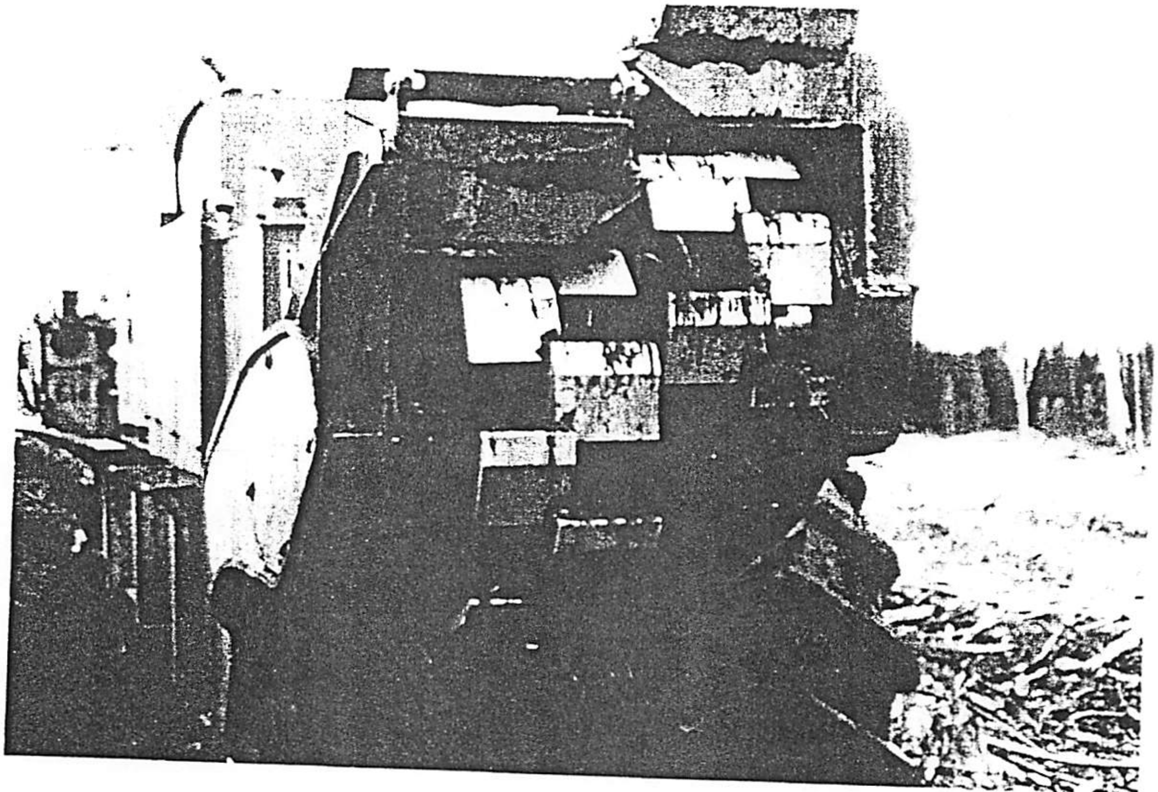

Figure 2. Each scarified strip is produced by a rotor, comprising two independant scarifying heads set side by side.