Prince George Forest Region

Forest Resources & Practices Team

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FOREST RESEARCH NOTE

Boreal Long Term Soil Productivity Study

by Richard Kabzems, Research Ecologist

Introduction

Maintaining the long term productivity of forest soils is essential for future forest growth. Organic matter losses and decreases in aeration porosity (soil compaction) are considered to be the fundamental factors contributing to observed declines in forest productivity. (Powers et. al., 1990)

On a number of sites across North America, an international network of research trials is examining the relationships between organic matter removal and soil compaction and their effects on long term soil productivity. This network includes several aspen sites throughout Canada and the U.S., and three spruce and pine forest trials in British Columbia.

By gathering information from a wide range of forests and soils, the research collaborators will improve their understanding of the complex interrelationships between soil conditions and productivity. They hope to quantify the impact of management decisions made today and determine the implications of those decisions on future forest productivity. Ultimately, this work will lead to specific management recommendations for different forest types.

In the Dawson Creek Forest District, Richard Kabzems is conducting research trials in the Boreal White and Black Spruce zone (BWBS) to determine the effects of organic matter removal and soil compaction on aspen and white spruce growth. The purpose of this study is to examine the interaction between organic matter removal and compaction in aspen and spruce forests over the short and long term.

Aspen is a fast growing deciduous tree that is becoming a very important commercial species in Canada. Clearcutting is the recommended silvicultural system for aspen as it stimulates regeneration via root suckering and minimizes shading from other vegetation. However, heavy disturbance during timber harvesting appears to reduce both the quantity and productivity of regenerated aspen.

The results outlined in this report represent the initial growth response of aspen to disturbance treatments. The data are also compared to results gathered over a five year period on a similar aspen forest type in Minnesota.

The short term data from the Dawson Creek site show that heavy disturbance actually stimulates aspen regeneration in the first year, as measured by the rate of suckering. At the same time, this disturbance appears to reduce vigour and productivity, as measured by average tree height in the first year. According to the Minnesota work, there is a rapid die off on those heavily disturbed sites so that by 5 years after harvest, the most vigorous and productive aspen stands were growing on the least disturbed sites. These observations would support the view that heavy soil disturbance during harvesting operations does indeed reduce long term aspen productivity on regenerated sites, in spite of the initial stimulating effect on suckering.

These studies suggest that there is a trade off between harvesting efficiency and future forest productivity.

TABLE 1
Original stand description

Property	Aspen	Balsam & Poplar	White Spruce	Lodgepole Pine
Stocking (st/ha)	600	4	15	7
Height (m)	26	25	27	28

Study Site and Research Design

The research site is representative of mesic aspen ecosystems. Soils on the study site are silt loam veneers, 20-30 cm thick, over clay loam. The pretreatment forest floor averaged 7 cm in depth. Soil and vegetation samples were collected and the site was described prior to harvest. (Figure 1 and Tables 1 and 2)

The area was whole tree harvested in January and February of 1995. (Figure 2) Winter harvest on frozen ground ensured that no soil disturbance occurred during the harvesting phase. Nine 40 x 70 meter treatment plots were established in May, 1995. (Figure 7) They represent a combination of three organic matter removal and 3 soil compaction treatments. The compaction treatments were prepared using a vibrating pad mounted on an excavator.

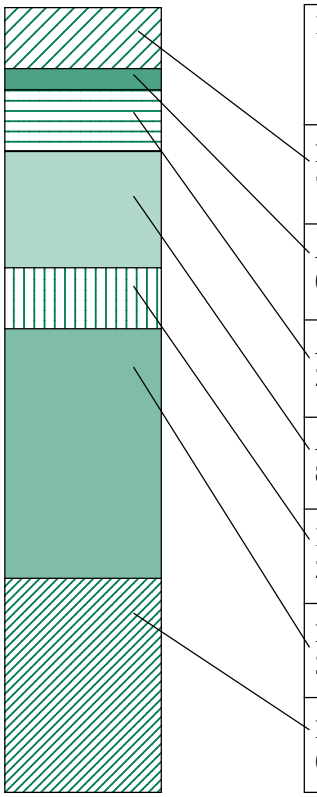
- The undisturbed plots (C0) did not receive any post harvest compaction treatment.
- The mineral soil was depressed 1 to 2 cm to achieve moderate compaction (C1)
- The mineral soil was depressed 4 to 5 cm to achieve severe compaction (C2).

Organic matter removal plots were treated as follows.

- For minimal organic matter removal, (OM1), the trees were delimbed in the forest and the tops, limbs and all nonmerchantable woody material were left on the forest floor.
- All merchantable timber and their tops were removed from the moderate organic matter removal plots, (OM2).
- All the woody and non woody material was removed from the plot and the forest floor was stripped to mineral soil with an excavator to create the extreme organic matter removal condition (OM3).

Nine 3.99 m radius subplots were randomly selected within each treatment for regeneration performance assessment. In October 1995, the aspen suckers within these plots were assessed for regeneration (numbers of suckers), productivity (height) and insect and disease damage.

FIGURE 1
Original Soil Profile Description



Horizon	Texture	pH ($CaCl_2$)	Total Carbon (%)	Total Nitrogen (%)
LFH 7 cm	Organic	5.7	45	2.1
Ahj 0-2 cm	Loam	5.3	2.95	0.23
Ae1 2 - 8 cm	Silt loam	7.3	1.08	0.11
Ae2 8 - 25 cm	Silt loam	6.2	0.97	0.11
II Bt 25 -33 cm	Clay	4.6	0.68	0.10
BC1 33-68 cm	Clay	4.8	0.35	0.06
BC2 68-94 cm	Silty Clay	4.8	0.56	0.06

Results & Discussion

Regeneration:

There was a dramatic difference in the number of aspen suckers among the nine treatment plots.

The number of regenerated aspen suckers was considerably greater in the OM3 treatment plots where all the organic matter was removed. The greater stem density on these plots is likely due to the combination of soil warming and disturbance to the root system. This is similar to the results found in the Minnesota aspen study. (Alban et. al. 1994) (Figure 3)

TABLE 2
Selected soil physical and chemical properties — pre-treatment

	Bulk density (kg/m^3)	***Aeration Porosity*** (%)	***Total Carbon*** (kg/ha)	***Total Nitrogen*** (kg/ha)	***Mineralizable Nitrogen*** (kg/ha)
Forest Floor	75	(NA)	24,641	1167	73.3
0-10 cm depth mineral soil	1136	23.9	9,077	857	29.8
10 - 20 cm depth mineral soil	1484	7.7	6,377	599	8.5
20 - 30 cm depth mineral soil	1494	5.0	6,368	764	5.7

When comparing treatments with the same level of organic matter removal, the severely compacted plots (C3) had the greatest number of aspen suckers. This indicates that compaction on its own may also stimulate sucker production in the first year.

The combination of complete organic matter removal with severe compaction (OM3C2) produced the greatest number of suckers (Figure 4).

Heavily disturbed sites in Western Canada, Minnesota, and Colorado have been observed to have reduced aspen stocking rates, compared to adjacent undisturbed plots, when measured 5 to 15 years after harvesting. At first, this may appear to be inconsistent with the results of the Dawson Creek study. However, the Dawson Creek numbers represent the initial regeneration response. The studies cited above were conducted 5 or more years after harvest and represent the longer term outcome. As the Dawson Creek study progresses, it will also monitor changes in stocking rate over time. (Navratil, 1991 and Shepperd, 1993)

Productivity

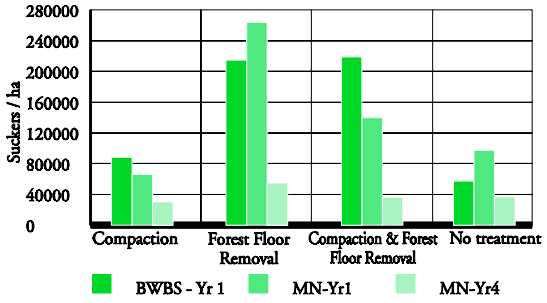
The tallest aspen trees were an average height of 136 cm and were found on the least disturbed plots (Figure 5). The shortest aspen trees were found on the plots with complete organic matter removal (OM3), and were notably shorter (73 to 89 cm) than those observed on the other plots (107 to 136 cm). When complete organic matter removal had occurred (OM3), the degree of soil compaction did not appear to have any effect on the height of aspen suckers (OM3C0, OM3C1, OM3C2).

Three possible factors affecting sucker height may be:

- root carbohydrate reserves
- genetic differences among aspen clones
- moisture availability

At this time it is not clear which, if any of these factors may be responsible for the difference noted in sucker height.

FIGURE 3
Comparison of first year aspen sucker numbers on the Dawson Creek site (BWBS-Yr1) to similar treatments in Minnesota in the first year after treatment (MN-Yr1), and four years after treatment (MN - Yr 4).



Disease

"Shepherd's crook" symptoms were present on the shoot tips of aspen suckers in all 9 treatment plots, indicating the presence of twig blight disease, *Venturia macularis*. Disease incidence varied from 8% to 78%, but there did not appear to be any direct association between the disease incidence and any of the treatments applied in this experiment.

FIGURE 2
Schedule of activities

Summer '94	Plot layout, timber cruise, soil chemical and physical sampling
Fall '94	Soil profile descriptions, hydraulic conductivity measurements
Jan/Feb '95	Harvesting, stem analysis
May '95	Treatments • organic matter removal • soil compaction • re-spreading woody debris • spruce seedlings planted
July '95	Microclimate instrumentation installed Soil atmosphere sampling tubes installed
August '95	First manual brushing for spruce seedlings
Sept '95	First measurements, aspen regeneration
Summer '96	Post-harvest soil sampling, physical and chemical Manual brushing, spruce treatments Aspen & spruce regeneration measurements Microclimate & soil atmosphere monitoring

Conclusions

The Dawson Creek and Minnesota (Alban et. al, 1994) studies indicated that heavy soil disturbance is negative to long term aspen growth and productivity. Though soil disturbance stimulates suckering in the first years, that trend changes over time. Even after four years, the Minnesota research showed that while various treatments had similar aspen densities, the least disturbed plots displayed much greater biomass productivity (Figure 6).

Further research will be directed towards quantifiying the impact of low to moderate levels of soil compaction (< 5 cm depression in mineral soil) on biomass productivity. This further work will assist managers in developing guidelines for the identification of sensitive sites, the

FIGURE 4
Average number of aspen suckers present on the nine treatment plots

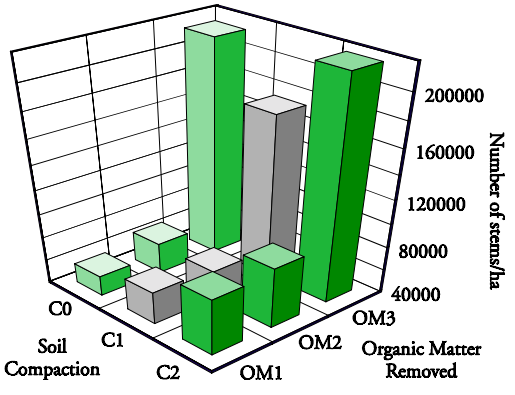
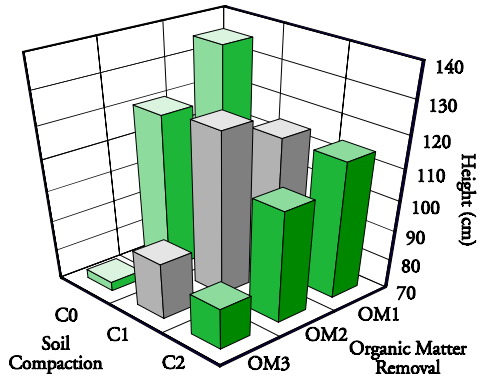
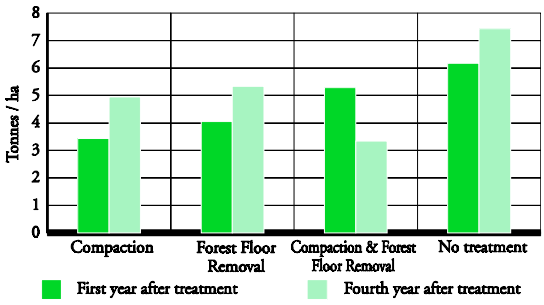


FIGURE 5. Average height of the tallest aspen trees on the nine treatment plots



please note, OM labels are opposite to Figure 3

FIGURE 6. Comparison of aspen productivity (biomass) for soil disturbance treatments in Minnesota



selection of appropriate harvesting and site preparation equipment and the refining of machine operating practices in order to maintain soil productivity.

References

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For further information

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FIGURE 7
Research Plot Maps

Plot 7
OM_1C_0
- stems only removed
- no compaction

Plot 5
OM_2C_0
- stems and crowns removed
- no compaction

Plot 1
OM_2C_1
- stems and crowns removed
- moderate compaction

Plot 9
OM_3C_2
- stems, crowns and forest floor removed
- severe compaction

Plot 6
OM_3C_1
- stems, crowns and forest floor removed
- moderate compaction

Plot 2
OM_1C_2
- stems only removed
- severe compaction

Plot 8
OM_1C_1
- stems only removed
- moderate compaction

Plot 3
OM_2C_2
- stems and crowns removed
- severe compaction

Plot 4
OM_3C_0
- stems, crowns and forest floor removed
- no compaction

N

1 centimetre = 15 metres