Prince George, Prince Rupert and Cariboo Forest Regions

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Note #LTSPS-03

LTSPS RESEARCH NOTE

Fourth-Year Plant Community Responses: The BWBS Long-Term Soil Productivity Study

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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 medium- to fine-textured soils, compaction of the mineral soil produces a series of linked effects on the soil environment (Bates *et al.* 1993, Greenway 1999). When wet, these soils have low soil strength, and slow drainage when saturated. Machine traffic during wet conditions causes loss of macropores, resulting in decreased gas exchange and internal soil drainage. Prolonged saturation slows soil warming, and reduces soil aeration.

The consequences of changes to these soil properties are not well documented, particularly in boreal ecosystems. Changes to soil moisture regimes and nutrient availability will also result in changes in plant communities. Plants may be regarded as sensitive integrators of all the environmental conditions created by forest harvesting practices.

PHOTO 1. Forest floor removal plot immediately after treatment in May 1995.

After harvesting in the boreal forest, there can be increases in plants such as bluejoint (*Calamagrostis canadensis*) which compete with white spruce seedlings, often resulting in reduced spruce survival and growth (e.g., Coates *et al.* 1994). Changes to site conditions may also affect the role of vegetation in providing habitat and food for insects, birds and wildlife. Changes in plant communities can influence the essential functions of plant roots and organic matter in maintaining soil structure and nutrient availability.

This note describes the initial effects of soil compaction and organic matter removal on plant communities in aspen ecosystems of northeastern British Columbia. The Boreal Long Term Soil Productivity Study is part of an international research effort with sixty-two installations in North America (Powers 1999).

Methods

The Boreal Long-Term Productivity site was established in the Dawson Creek Forest District in 1995 (Kabzems 1996). The research site is representative of mesic aspen ecosystems in the Boreal White and Black Spruce Zone (BWBS). Soils on the study site are silt loam veneers, 20 - 30 cm thick, over clay loam. The pre-treatment forest floor averaged 7 cm in depth.

Prior to harvest, a dominantly aspen forest, averaging 600 stems per hectare and 26 metres in height formed the tree layer. Common shrubs were prickly rose (*Rosa acicularis*), soopolallie (*Shepherdia canadensis*), and high-bush cranberry (*Viburnum edule*). A lush and varied herb layer was present. Moss cover was very limited, being restricted to the bases of trees and woody debris on the forest floor.

The area was harvested in January and February of 1995 (Kabzems 1996). Approximately 15 cm of ground frost was present on the site at that time. In addition, machine traffic on the plots was limited to ensure that no soil disturbance occurred during the harvesting phase. The first group of nine 40 m by 70 m treatment plots was established in May, 1995. The compaction treatments were applied using a vibrating pad mounted on an excavator.

- The undisturbed plots (C0) received no post-harvest compaction treatment
- The mineral soil was depressed 1 - 2 cm to achieve moderate compaction (C1)
- The mineral soil was depressed 4 - 5 cm to achieve severe compaction (C2)

Organic matter removal plots were treated as follows:

- For merchantable bole harvest (MBH), trees were delimbed in the forest and tops, limbs and all woody debris were left on the forest floor
- All the 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 (forest floor removal, FFR).

The initial nine plots of the study described in this note are an incomplete set of the treatment combinations. There were three forest floor removal plots (FFR). Each FFR plot had a different level of deliberate soil compaction (C2 —5 cm depression, C1 —2 cm depression, and C0 —no deliberate compaction). For the merchantable bole harvest treatment (MBH), there were two replicate plots for each level of soil compaction (C2, C1, C0). Quantities of woody debris retained on each site averaged 34 tonnes/ha. Over 65% of the retained woody debris was coarse woody material (greater than 7 cm diameter), usually from snags or woody debris present on the plot prior to harvest. By the fourth year post-treatment, most of this material was in contact with the ground.

PHOTO 2. Merchantable bole harvest with severe compaction treatment plot (MBHC2) in August 1998. Note irregular distribution of aspen stems and dominance of bluejoint.

PHOTO 3. Roadside work area in aspen cutblock harvested in September 1996 (July 1998 photo). Note limited aspen regeneration and abundance of bluejoint cover.

A vegetation description was done for each treatment plot in July 1994. After harvest, four vegetation description sub-plots (3.99 m radius) were established within each treatment plot. The changes in plant communities were monitored by recording the species present on each plot for each stratum (shrubs, herbs and mosses) and their percent cover. Vegetation descriptions for the permanent sub-plots were done the second (1996) and fourth (1998) years after harvest.

Results and Discussion

Compaction

Where the forest floor materials were retained, the cover of bluejoint (*C. canadensis*) increased with the degree of soil compaction (Figure 1). Scalping of the forest floor removed the majority of the bluejoint rhizomes (Photo 1).

Prior to harvest of the mature aspen forest, all plots had similar amounts of bluejoint cover (Figure 1). In the second growing season after harvest, the heavily compacted treatment (C2) had a greater cover of bluejoint than at the pre-harvest stage. In contrast, the no compaction treatment (C0) had bluejoint cover that was similar to pre-harvest levels (Figure 1). By the fourth growing season, all treatments had greater amounts of bluejoint cover than the mature forest. Short-term increases in bluejoint cover after harvest are commonly observed in boreal ecosystems (e.g. Landhausser and Lieffers 1998). However, after four growing seasons, the amount of cover in the C2 treatment (59%), far exceeded that of the C0 treatment (35%) (Figure 1 and Photo 2).

In a greenhouse experiment with aspen seedlings, Landhausser and Lieffers (1998), found that aspen were strongly affected, directly and indirectly, by bluejoint competition. Cool soil temperatures appeared to have stronger effects on aspen seedlings than litter, nutrient or root competition. Landhausser and Lieffers (1998) suggested that slower growth rates of aspen were observed approximately two years after harvest when bluejoint cover peaks.

The initial results from the Boreal LTSP study suggest that the relative amount of bluejoint cover may indicate changes in soil properties (loss of large macropores, which decrease soil gas exchange, and decrease soil drainage). These changes in soil properties contribute to cooler soil temperatures.

Accumulation of bluejoint litter would further depress soil temperatures by acting as an insulating blanket. Removal or control of bluejoint to improve aspen growth would not address the disturbance-induced change in soil conditions. Once established, a dense bluejoint cover effectively prevents aspen establishment, either from suckers or seed (Navratil 1996).

Aspen Cover

After four growing seasons, the MBHC0 plots had the greatest amount of aspen cover and compacted plots (MBHC1 & C2) had about 8% less (Figure 2). These results are consistent with long-term soil productivity studies for aspen ecosystems in the United States. Both greater aspen biomass (Alban *et al.* 1994), and the greatest number of large aspen suckers (minimum 2.5 cm dbh, Stone and Elioff 1998), were present on plots with the least amount of disturbance.

Harvesting of aspen when soils are too wet, insufficiently frozen, or insufficiently buffered by snow, has the potential to physically damage aspen roots, and change soil properties in favor of a plant species (bluejoint) which may further depress aspen establishment and growth. At this site, the C0 treatment indicates that removal of the mature tree canopy could increase bluejoint cover from 12% pre-harvest to 35% cover after harvest. However, rapid establishment of a complete aspen canopy will begin to suppress bluejoint by shading. Prevention of detrimental harvesting disturbances allows the site to reach its full potential for aspen stocking, and maintain soil conditions that favor maximum aspen growth.

Forest Floor Removal

The forest floor removal treatments had divergent effects on the species richness (the total number of plant species present) of shrubs and herbs. Scalping of the forest floor reduced the number of shrub species to four (Table 1). Species richness of herbaceous plants increased on FFR treatments because a variety of weedy forbs, grasses and sedges became established after scalping (Table 1).

With the exception of prickly rose, all other shrubs, including high bush cranberry, soopolallie, and black twinberry (*Lonicera involucrata*) were reduced in cover (Figure 3) and vigor on the FFR plots. The cover of prickly rose ranged from 2.5% to 11.0 % on plots where the forest floor was retained, and 6.3 to 10.5% where the forest floor had been removed.

TABLE 1. Average plant species richness prior to treatment and four years after treatments were applied at the Boreal LTSP site.

	Shrub	Herb (including weedy species)	'Weedy' species
Pre-treatment	10	24	0
MBHC0	9	24	1
MBHC1	8	22	1
MBHC2	8	21	1
FFR	4	29	7

Herbs

Although, the number of species increased, the FFR treatment reduced the percentage cover of the herb layer (Figure 3). Plant species which decreased in cover on the FFR plots included strawberry (*Fragaria virginiana*), twinflower (*Linnaea borealis*), cow parsnip (*Heracleum lanatum*), baneberry (*Actaea rubra*), Canada goldenrod (*Solidago canadensis*), pink wintergreen (*Pyrola asarifolia*), and slender wheatgrass (*Agropyron trachycaulum*).

The exposed mineral soil on the FFR plots created suitable conditions for invasive species such as common plantain (*Plantago major*), common dandelion (*Taraxacum officinale*), and dwarf hawksbeard (*Crepis nana*). Invasive plant species indicative of wet, poorly drained soils were present on FFRC1 and FFRC2. These included species such as slender rush (*Juncus tenuis*), purple-leaved willow herb (*Epilobium ciliatum*), hair bentgrass, (*Agrostis scabra*) and golden sedge (*Carex aurea*).

A plant community dominated by balsam poplar (*P. balsamifera*), willow and bluejoint is commonly observed in roadside work areas of aspen cutblocks with a summer harvesting history in northeastern BC (Photo 3). Bluejoint dominated MBHC2 plots are the experimental treatments most similar to heavily disturbed operational sites. To date, there has been a limited establishment by seeding of balsam poplar and willow into experimental plots of the Boreal LTSP study.

FIGURE 1. Bluejoint cover (%) in 1994 (pre-harvest), 1996 and 1998 at the Boreal LTSP site.

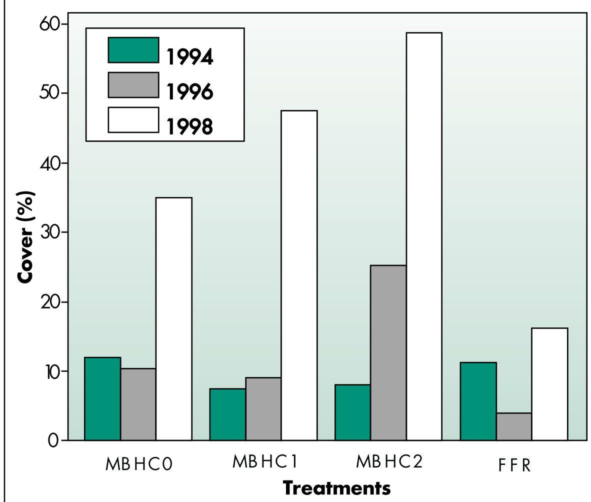
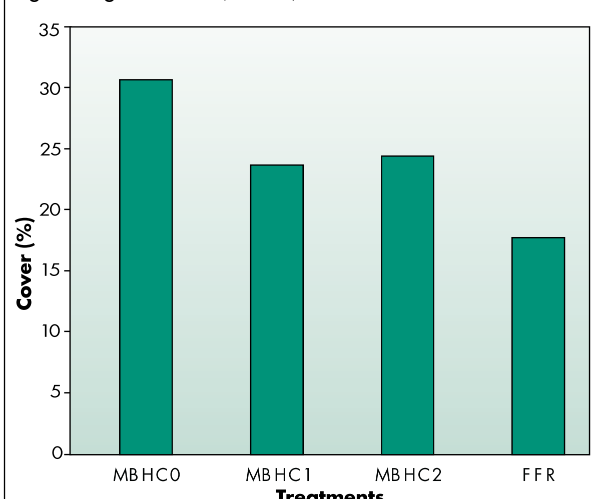


FIGURE 2. Mean aspen cover after four growing seasons (1998) at the Boreal LTSP site.



Mosses

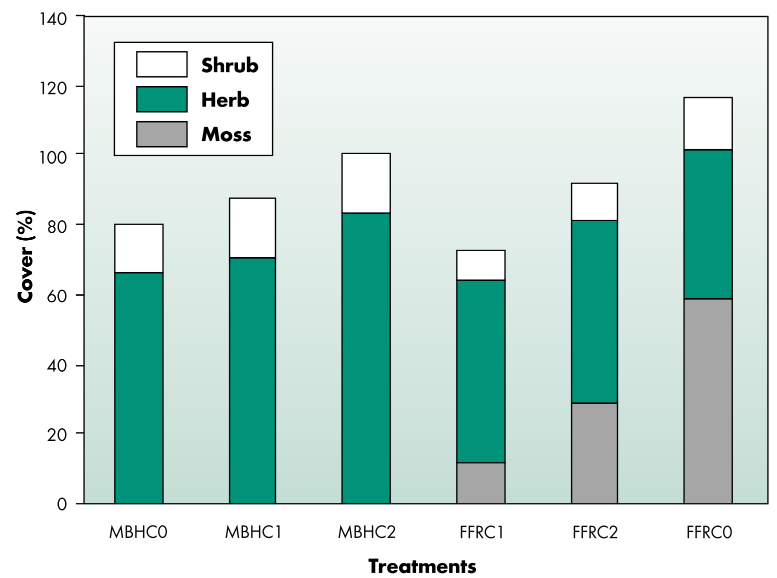
Four growing seasons after treatment, exposed mineral soil in the FFR plots had been colonized by fire moss (*Ceratodon purpureus*), a weedy species common on disturbed sites. There appeared to be an increase in the amount of moss cover with an increase in the degree of soil compaction within the FFR treatments (Figure 3).

Summary and Conclusions

The results of the first four years of this study can be summarized as follows:

- Harvest of aspen when soils were frozen did not dramatically alter the plant community on this site
- Increasing levels of soil compaction were associated with more rapid expansion and greater cover of bluejoint after four growing seasons
- The compaction treatment did not result in dramatic changes in plant species richness after four years; however, the herb layer was increasingly dominated by bluejoint as the severity of the compaction treatment increased
- The forest floor removal treatments had the greatest influence on species richness, by:
  1) decreasing the number of shrubs;
  2) increasing the number of herbaceous species by creating exposed mineral soil for establishment of invasive species; and
  3) moss establishment on exposed mineral soil.

FIGURE 3. Mean plant cover after four growing seasons (1998) at the Boreal LTSP site.



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