Southern Interior Forest Region

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LTSPS RESEARCH NOTE

Establishment of Long-term Soil Productivity Studies on Acidic Soils in the Interior Douglas-fir Zone

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Introduction

A clear understanding of the impacts of forest practices on long-term soil productivity is required to maintain the productivity of forest soils while forests continue to be managed for timber production. Although current regulations governing soil conservation in British Columbia are partially based on historic and ongoing research, there are few clear and unambiguous long-term results. The need for these results led to the development of a Long-term Soil Productivity (LTSP) project by a group of U.S. Forest Service researchers (Powers et al. 1990). The study focuses on soil organic matter retention and compaction.

The LTSP project is the world's largest co-ordinated effort to understand how soil disturbance affects long-term forest productivity. The effort has resulted in the establishment of more than 62 major research installations across a broad range of forest types in the United States and Canada. The British Columbia Ministry of Forests (MOF) was a major collaborator during the inception of the LTSP, and MOF staff have established sites in the British Columbia Interior covering the boreal, sub-boreal, interior cedar-hemlock, and interior Douglas-fir forests (see http://www.for.gov.bc.ca/hre/ltsp/ for a description of the British Columbia project). Ultimately, this research will lead to a better understanding of soil sensitivity and resiliency to disturbance, and help develop specific management recommendations for different forest and soil types.

In the Southern Interior of British Columbia, the dry Douglas-fir forests (the Interior Douglas-fir biogeoclimatic zone, or IDF zone) were of particular interest because, compared with other forests in the region, they have more sensitive soils, less organic matter reserves, more partial cutting, and more harvesting in the spring and early summer when soils are most susceptible to compaction. In the IDF zone, three sites were established near Kamloops and three sites near Invermere. The Kamloops sites are on slightly acidic soils that are representative of the Interior Plateau area, whereas the Invermere sites are on calcareous soils that are representative of the East Kootenay.

The LTSP project is designed to provide long-term (rotation length) information on the effects of organic matter removal and compaction on soil and site productivity. However, the trial and related studies will also provide answers to short-term questions. This note summarizes the establishment of the project in the IDF zone near Kamloops, and offers short-term information on soil and microclimate changes after treatment, vegetation response, and early seedling survival and growth.

Forest floor removal (OM3 treatment) at Dairy Creek, followed by heavy compaction, and the same plot (OM3C2) after three growing seasons at Dairy Creek.

Research Design

Three replicate sites (Dairy Creek, Black Pines, O'Connor Lake) are located in the IDFdk subzone, between 25 and 50 km northwest of Kamloops. Each site has relatively homogeneous soil properties and vegetation attributes. Plots are located in areas that represent the mesic (average or characteristic) IDFdk/01 site series (FdPl—Pinegrass—Feathermoss). Before harvest the dominant tree species on all sites was Douglas-fir (*Pseudotsuga menziesii*), with lesser amounts of lodgepole pine (*Pinus contorta*), and minor amounts of spruce and subalpine fir. Canopy trees varied in age from about 100 to 220 years, with a few veteran trees >250 years.

Soils on all three sites are deep, moderately well drained, and derived from morainal blankets, with a thin capping (<10 cm) of aeolian material at the soil surface. Soils are classified as Brunisolic Gray Luvisols, with Mor humus forms. All sites are flat or very gently sloping (<5%). More detailed soil information for each site is listed in Table 1. Soil compaction hazard is high to very high, soil displacement hazards are moderate, and forest floor displacement hazards are high. Grass species, especially pinegrass (*Calamagrostis rubescens*), dominate post-harvest vegetation.

TABLE 1. Selected soil and site characteristics of the three Kamloops LTSP sites

	Dairy Creek	Black Pines	O'Connor Lake
Elevation (m)	1150	1180	1075
Dominant pre-harvest tree species	Fd, S, Pl, (Bl, At)	Fd, (Pl)	Fd
Age (yr)	210	210	180
Net merch. vol. (m^3/ha)	327	448	407
Site index, Fd and Pl (m @ 50 yr)	18.1, 18.0	15.6, 14.7	16.8, 14.3
Mineral soil[a]			
Soil texture	silt loam	silt loam	silt loam
Subsoil	silt loam (- loam)	loam (- silt loam)	silt loam
Coarse fragments (%)	20	17	21
Total C (%)	2.43	1.90	2.18
Total N (%)	0.12	0.10	0.13
CEC (cmol/kg)	10.2	9.7	12.3
pH (in $CaCl_2$)	4.9	5.0	5.3
pH Subsoil	5.2	5.2	5.3
Forest floor			
Average thickness and range (cm)	5.2 (1–16)	4.0 (1.5–15)	5.4 (3–12)
Humus form	Hemimor	Hemimor	Hemimor (Mormoder[b])
Total C (%)	47.9	43.4	43.9
Total N (%)	1.5	1.3	1.6
CEC (cmol/kg)	75.4	83.1	92.5
pH (in H_2O)	5.3	5.5	5.8

a *0–20 cm depth except where noted as subsoil (20–40 cm).*
b *Secondary component.*

Nine 40-×70-m plots were established before harvest at each of the study sites. Each plot was randomly assigned a combination that included one of three compaction treatments and one of three organic matter retention treatments (Table 2). The sites were installed sequentially, with pre-treatment sampling beginning on a new site each year. Pre-treatment sampling, harvesting, treatments, and planting of all sites occurred from 1997 to 2001.

Each site was harvested during the winter when some snow was present. To ensure that harvesting equipment travelled only on the buffer strips surrounding the 40-×70-m plots, directional hand falling and long-line skidding techniques were used. The year following harvest, the treatments were applied to the plots. Organic matter treatments were as follows: on the stem-only removal plots (OM1), all tops, limbs, and non-merchantable woody material were retained; on the moderate organic matter removal plots (OM2), all timber and logging slash were removed; on the extreme organic matter removal plots (OM3), the forest floor down to the mineral soil and all woody material were scraped off with an excavator. The compaction treatments were carried out using a vibrating pad mounted on an excavator (a hoe-pack): the undisturbed plots (C0) were not compacted, moderate compaction (C1) was achieved by depressing the mineral soil 1–2 cm, and the mineral soil was depressed 4–5 cm to achieve heavy compaction (C2) (Table 2).

One half of each plot was planted to Douglas-fir, the other half to lodgepole pine, in the spring following treatment.

Data on timber volumes and height/age curves (stem analysis) were collected pre-harvest. Soil and vegetation data, including soil physical properties (bulk density, porosity, and water retention), soil chemical properties, and vegetation species and cover were collected pre-harvest, 1-year post-treatment, and will be periodically reassessed throughout the trial. Slash remaining after treatment was also measured. Post-treatment microclimate and plantation performance are also being monitored.

Results (Treatment Effects)

Soil bulk density

Mineral soil bulk densities increased after compaction by approximately 25% in the 0- to 20-cm layer (Figure 1), and by approximately 15% in the 20- to 40-cm layer (data not shown). However, there was no significant difference in the final bulk densities between the C1 and C2 treatments. Compaction caused greater increases in bulk density on bare mineral soils (the OM3 treatment) than on the OM1 and OM2 treatments. The forest floor removal treatment, without compaction, increased soil density of the 0- to 20-cm layer, but not of the 20- to 40-cm layer, at two sites (data not shown). Very few bulk density values exceeded 1300–1400 kg/m^3, which may be the growth-limiting density on these silt loam soils (Daddow and Warrington 1983; C. Bulmer, Research Branch, MOFR, pers. comm., 2004).

Soil aeration porosity

Aeration porosity is a measure of the proportion of the soil volume occupied by the large pores (macropores) that are important for soil aeration. Harvesting trees alone caused a decrease of about 5% in aeration porosity, with no further effect from organic matter removal. Compaction caused a further significant decrease in porosity (Figure 2). However, all treatments had average porosity values above the threshold of 10%, below which root growth may be limited (see Powers et al. 1998 and references therein).

Vegetation

Vegetation response two seasons after treatment has been statistically analyzed only for pinegrass (the dominant species on site), and total herb, shrub, and moss cover. Pinegrass and total herb cover were significantly reduced by the most severe organic matter removal treatment (OM3), but not by compaction. Neither treatment affected total shrub and total moss cover. No individual species have been identified as responding to compaction.

Microclimate

Soil temperatures during the growing season decreased in the order OM3>OM2>OM1 at each soil depth (2, 10, and 30 cm) (Table 3). The number of days when soil moisture levels were very dry (< -1.5 MPa) was increased by the OM3 treatment (Table 3). Compaction appeared to have little or no effect on soil temperature and soil drying. Notably, very similar results for both temperature and moisture relationships have been observed at the LTSP sites in the Sub-Boreal Spruce biogeoclimatic zone.

Seedling performance

Pine seedling survival was very high (>90%) at all sites. Douglas-fir survival was generally very high on scalped plots, but was more variable on unscalped plots, depending on grass cover and adverse frost or drought conditions. After three growing seasons, no treatment effects on lodgepole pine growth were statistically significant (Figure 3). The OM3 treatment increased total Douglas-fir height (Figure 3), probably through both improvement of soil temperature regime and reduction of vegetation competition. Compaction decreased height and diameter of Douglas-fir on scalped plots, but not on plots with forest floor retention.

TABLE 2. Treatment matrix for core LTSP treatments

		Organic Matter Retention*		
		OM1 (stems only)	**OM2** (whole tree)	**OM3** (whole tree + FF)
No compaction	C0	OM1C0	OM2C0	OM3C0
Moderate compaction	C1	OM1C1	OM2C1	OM3C1
High compaction	C2	OM1C2	OM2C2	OM3C2

* *The notation is different from U.S. LTSP sites. In British Columbia, the base organic matter level (OM0) is considered the unharvested forest. In the United States, OM0 is equivalent to OM1 in British Columbia.*

FIGURE 1. Effect of compaction treatments on mean bulk density of the three Kamloops IDF LTSP sites. Error bars are 1 standard error.

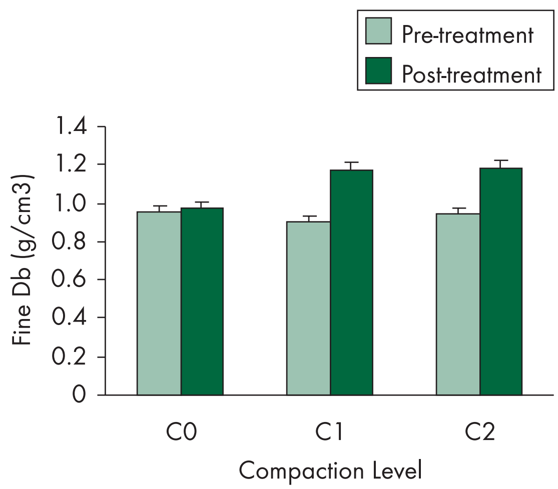
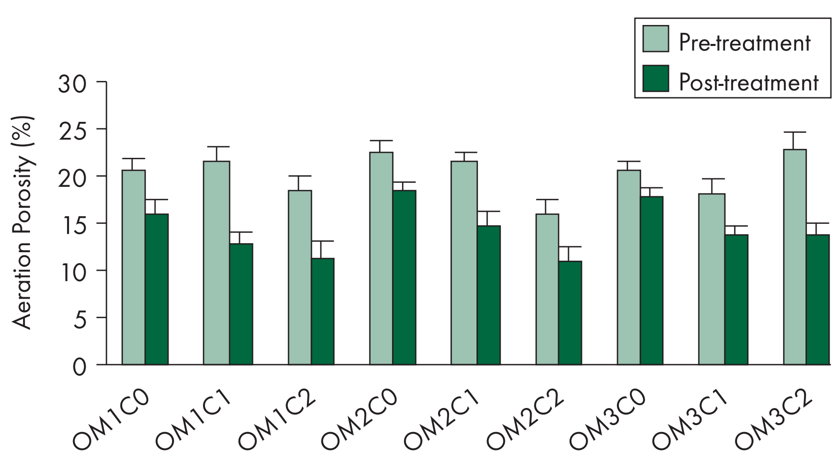


FIGURE 2. Comparison of pre-harvest and post-treatment aeration porosities for the three Kamloops IDF LTSP sites. Error bars are 1 standard error.



Summary

Soil physical properties were altered by treatments, although it is unclear if the altered properties will be growth limiting. Scalping decreased pinegrass cover; other treatments had insignificant effects on vegetation. Scalping increased soil temperature and soil drying. Compaction and slash retention had no detectable significant effect on microclimate. The growth of 3-year Douglas-fir, but not lodgepole pine, was increased by scalping, and reduced by compaction on scalped plots. Continued monitoring of the study over the long term will allow any changes in these short-term effects to be followed through the length of a rotation.

FIGURE 3. Response of mean height of planted Douglas-fir and lodgepole pine after three growing seasons at the Kamloops IDF LTSP sites to compaction (**A**) and organic matter removal (**B**). Error bars are 1 standard error.

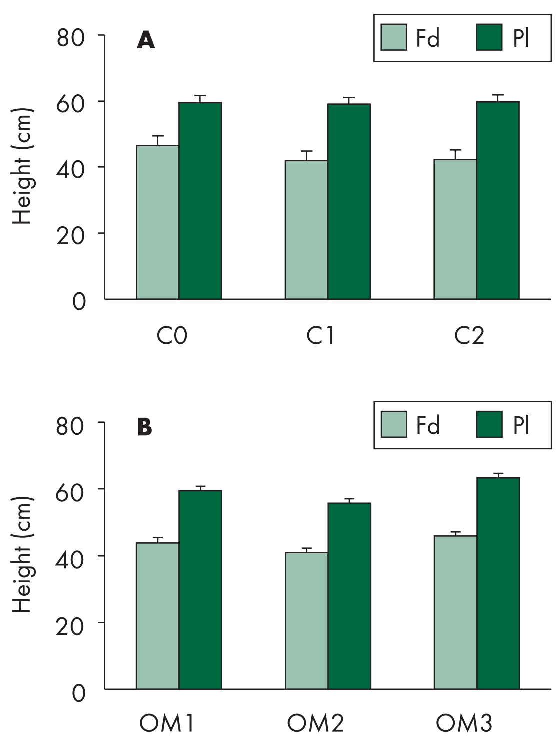


TABLE 3. Some treatment effects on soil temperature and moisture variables at the Dairy Creek LTSP site

Treatment	**Average growing degree days** (>5°C at 10 cm May 15–Sept 15, 2001–2003)	**Average number of days** (with soil moisture <–1.5MPa at 10 cm May 15–Sept 15, 2000–2003)
OM1 C0	776	18
OM2 C0	904	35
OM3 C0	1232	36
OM1 C2	773	19
OM2 C2	910	28
OM3 C2	1124	45

Acknowledgements

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Further Reading

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