FOREST PRACTICES

Practices and Strategic Investment Section

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SILVICULTURE NOTE 31

Mechanical Site Preparation and Windrow Burning: 20-year effects on Soil Properties and Lodgepole Pine Nutrition

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Summary

Mechanical site preparation (MSP) and windrow burning were studied on a mesic site in the SBSdw3 near Prince George, BC. After 20 years, none of the treatments had a negative effect on soil bulk density. The coarse mixing (bedding plow) treatment caused increases in organic matter-related properties (total C, total N, ammonium-N, and the C/N ratio) that persisted for at least 20 years. In contrast, windrow burning was associated with ongoing increases in pH-related properties (CEC, exchangeable Ca and K). Windrow burning also relieved a deficiency in foliar boron levels. Full results from this study are reported in Boateng et al. (2010).

Introduction

Mechanical site preparation has been widely used in northern and central British Columbia to surmount environmental constraints to conifer seedling establishment on boreal and sub-boreal sites. These factors include low soil and air temperature, excess soil moisture, poor soil aeration, and reduced light availability (e.g., Örlander et al. 1990). Mechanical treatments are the most commonly used form of site preparation in northern British Columbia (BC Min. For. 2007) but their application in absolute terms has decreased since 1990 due to the perceived high cost and potential for site degradation. However, there are indications that moderate use of MSP treatments can be cost-effective and beneficial to the future timber supply (Hawkins et al. 2006). In this project, we collected 20 year soils and foliar data from the Bednesti site where mechanical site preparation and windrow burning effects on lodgepole pine are being studied in the SBS zone. Our objectives were to compare the 20-year effects of various methods of mechanical site preparation on soil physical and chemical properties and on lodgepole pine foliar nutrient status and to determine whether differences were reflected in 20 year lodgepole pine growth.

Site descriptions and methods

The Bednesti site is about 50 km west of Prince George, BC in the SBSdw3 biogeoclimatic variant (dominant site series 05). It is at an elevation of 850 m on rolling terrain with slope of 0-15%. Soils are silty clay loam to sandy loam with10-65% coarse fragment content and a rooting depth of 10-50 cm. The site was strip harvested in 1963-1964, with remaining strips removed in a second entry in 1971.The study was established in 1987 using a randomized complete block design.

Treatments (Table 1) were installed in 1987 and planted with 1+0 lodgepole pine container stock in 1988. In years 5, 10 and 20, soils were sampled at two mineral soil depths (0-10 cm and 10-20 cm). Foliage samples were collected in fall 2007 from 15 randomly selected target pine in each treatment according to Brockley (2001).

Soil bulk density was determined and soil chemical analysis was carried out to determine total C, total N, pH, conductivity, available P, mineralizable N, available ammonium-N, available nitrate-N, and exchangeable cations. Needle mass was determined based on oven dried material. Foliar samples were analyzed for Al, B, Ca, Cu, Fe, Mg, Mn, P, K, S, and Zn. Analysis of variance was used to examine differences between treatments in soil physical and chemical properties, and in lodgepole pine foliar nutrient status.

Table 1. A summary of treatments applied at Bednesti

Treatment	Machinery	Description
Untreated control (UC)	None	No site preparation, and therefore no soil exposure. Seedlings were planted with the root collar 1-2 cm below surface organic material.
Plow-inverting (PI)	Double-bottom agricultural breaking plow pulled by D7 mover	Inverted furrow slices laid down in somewhat irregular berms separated by gaps. Material was loose even after over-winter settling. Soil exposure was 100%. Seedlings were planted deeply into the loose berm material.
Burned windrows (BW)	None	Slash and some mineral soil were piled in long rows that were 2-3 m wide and burned. All fine and medium slash was fully consumed, leaving a thick ash layer over a 1-2 cm thick residue of burned mineral material. The original forest floor was more or less intact beneath these layers. Burned windrows occupied approximately 10% of the surface area. Seedlings were planted in well-burned microsites that were free of slash.
Coarse mixing (CM)	Eden relief bedding plow with 6 hydraulically controlled discs pulled by a rubber-tired skidder	A single pass produced continuous raised beds approximately 160 cm wide, composed of coarse mixtures of mineral soil and forest floor materials. Beds were separated by approximately 50 cm wide strips of exposed subsoil. Soil exposure was nearly 100%. Seedlings were deeply planted in the loose material at the high point of the beds.
Disk trenching (DT)	TTS Delta disk trencher pulled by a rubber-tired skidder	Continuous, shallow, linear furrows with loosely mixed berms that were spaced 3 m apart. Soil exposure averaged 48%. Seedlings were planted to the root collar at the edge of the berm, close to the furrow.
Fine mixing (FM)	Madge rotoclear with a toothed cylindrical drum rotating at a speed of 300 rpm	Forest floor and mineral soil were thoroughly mixed to a depth of 10 cm and a width of 1.75 m, creating planting spots that were level with the surrounding ground surface. Soil exposure was 100%. Seedlings were planted to the root collar in the mixed material.

Results and discussion

Bulk density

Coarse mixing reduced bulk density for 10 years at Bednesti, but by year 20 there were no differences between treatments at any of the depths sampled. In year 20, bulk density averaged 614 kg/m^3 in the surface 0-3 cm of mineral soil, 613 kg/m^3 at a depth of 0-10 cm, and 733 kg/m^3 at a depth of 10-20 cm. Bulk density declined over time, even in the control (Figure 1). This is probably due to root growth from planted trees and other vegetation.

Carbon and nitrogen

After 20 years, the coarse mixing (bedding plow) treatment was associated with higher concentrations of total carbon and nitrogen than the untreated control (Figure 2). Differences in carbon and nitrogen status between the control and other treatments generally did not persist past year 10. On a per hectare basis, carbon content in mineral soil to a depth of 10 cm was significantly higher in the coarse mixing (bedding plow) treatment than the untreated control in both year 10 and year 20 (Figure 3). Forest floor material was incorporated into upper mineral horizons in the mechanical treatments, and so could be sampled as a separate entity only in the untreated control, and in burned windrows up to year 10. Carbon content in the forest floor declined between years 5 and 10 in both these treatments (Figure 3).

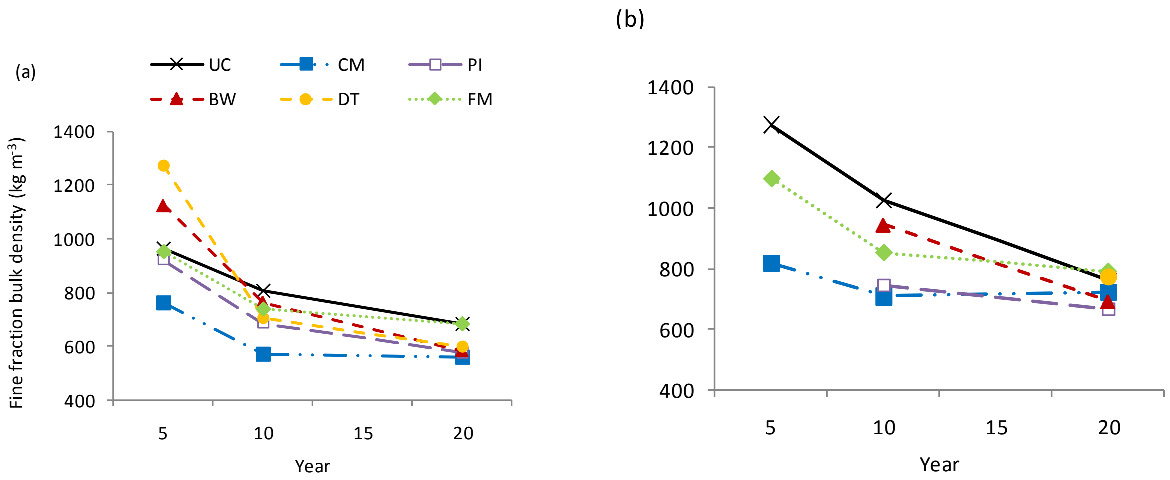

Figure 1. Fine fraction (<2mm) bulk density of mineral soil at depths of (a) 0-10 cm and (b) 10-20 cm from year 5 to year 20 after treatment. UC=untreated control, CM=coarse mixing (bedding plow), PI=plow inverting (breaking plow), BW=burned windrows, DT=disk trench (hinge position), FM=fine mixing (Madge). Samples were not collected at a depth of 10-20 cm for all treatments in years 5 and 10.

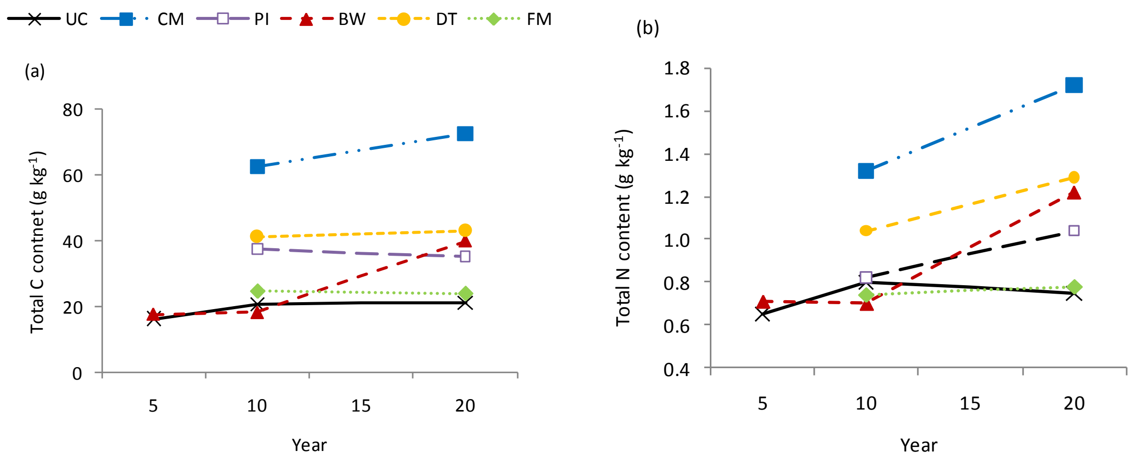

Figure 2. 0-10 cm mineral soil (a) total C and (b) total N. UC=untreated control, CM=coarse mixing (bedding plow), PI=plow inverting (breaking plow), BW=burned windrows, DT=disk trench (hinge position), FM=fine mixing (Madge). Year 5 data were available only for UC and BW.

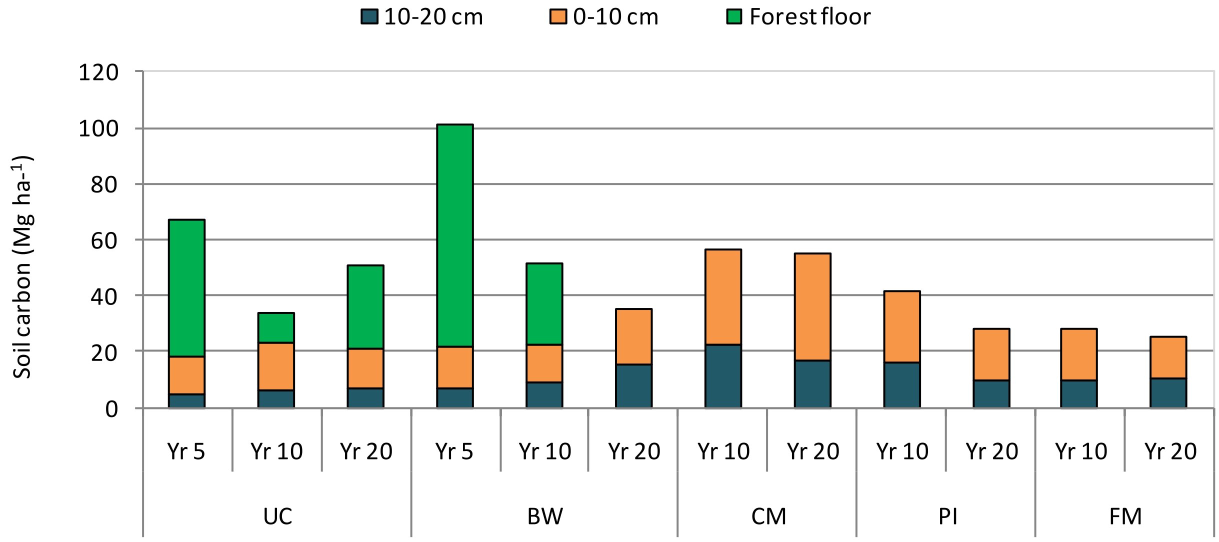

Figure 3. Soil carbon content per hectare to a depth of 20 cm in years 5, 10, and 20 for the untreated control and burned windrows, and in years 10 and 20 for coarse mixing (bedding plow), plow inverting (breaking plow), and fine mixing (Madge) (forest floor data could not be collected for burned windrows in year 20). UC=untreated control, BW=burned windrows, CM=coarse mixing, PI=plow inverting, FM=fine mixing.

pH, CEC and exchangeable cations

Windrow burning caused a significant increase in pH, relative to the untreated control, which persisted for at least 20 years (Figure 4). In early years, the largest differences in pH were found in forest floor materials between the untreated control and burned windrows. After 20 years, mineral soil in burned windrows also had higher cation exchange capacity (CEC) (Figure 4) and higher concentrations of calcium and potassium to a mineral soil depth of 10 cm. None of the mechanical treatments continued to have a significant effect on these soil characteristics after 20 years.

Foliar nutrients

Twenty years after site preparation, there were very few significant differences in foliar nutrient status between the untreated control and mechanical treatments. Differences in soil nitrogen status that were observed as a result of the coarse mixing treatment did not translate into differences in foliar N (Figure 5a).

Windrow burning, however, resulted in increased levels of foliar boron that persisted to year 20. Foliar boron levels declined between years 10 and 20 in all treatments. By year 20, pine were deficient in boron to some extent in all treatments except burned windrows (Figure 5b). Boron is commonly deficient in lodgepole pine growing in north-central BC.

Levels of sulphate, which is the form of sulphur available for plant uptake, were highly variable between treatments and years (Figure 5c). However, differences were not statistically significant.

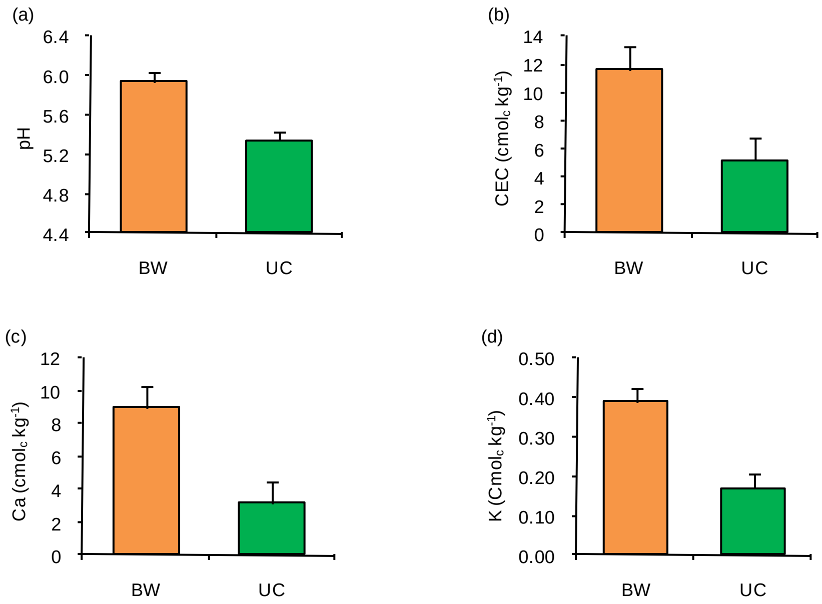

Figure 4. Year 20 mineral soil (a) pH, (b) CEC, (c) Ca content, and (d) K content at a depth of 0-10 cm in burned windrow (BW) and the untreated control (UC). Error bars are 1 standard error.

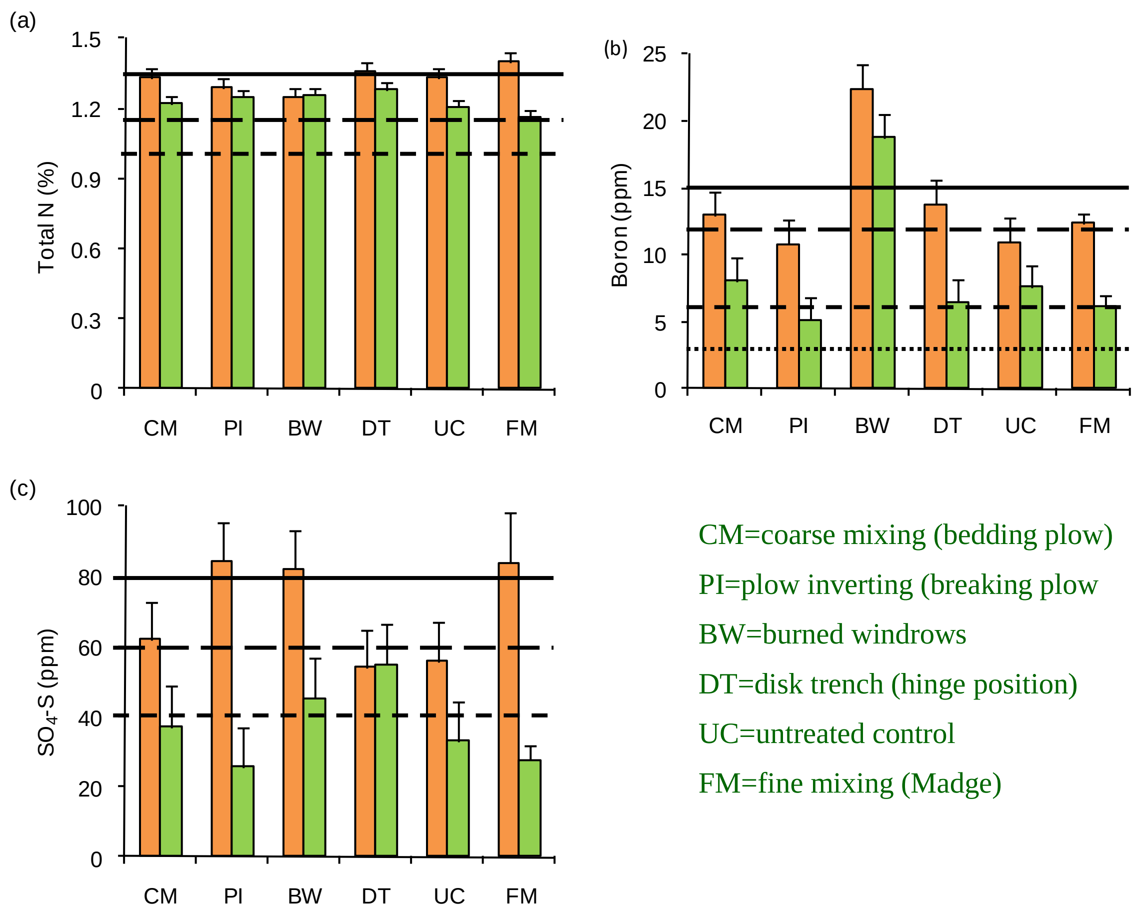

Figure 5. Foliar (a) nitrogen, (b) boron and (c) sulphate concentrations in years 10 (orange bars) and 20 (green bars). For N and S, above the solid line is adequate, between the solid and long dash line is slightly to moderately deficient, between the long dash and short dash lines is moderately to severely deficient, and below the short dash line is severely deficient. For B, above the solid line is adequate, between the solid and long dash line is likely not deficient, between the long dash and short dash lines is possibly deficient, between the short dash and dotted lines is probably deficient, and below the dotted line is severely deficient (based on Brockley 2001). Error bars are one standard error.

Interpretations

1. After 20 years, none of the mechanical treatments had a lasting negative effect on soil bulk density or chemical properties.
2. Bulk density decreased over time in all treatments, including the untreated control, possibly due to root growth of lodgepole pine and other plants. However, bulk density was not expected to be a strong limitation to lodgepole pine growth on the Bednesti site due to the medium-coarse soil texture. The site had low-moderate sensitivity to compaction.
3. The coarse mixing treatment was associated with ongoing elevated levels of carbon and nitrogen in upper mineral soil horizons relative to the control, which suggests it

could be conserving nutrient capital on site. However, the treatment also caused lasting increases in C/N ratio. Foliar nitrogen levels and lodgepole pine growth results confirm that the treatment was not enhancing N availability for conifer uptake.

4. Windrow burning, on the other hand, was associated with ongoing increases in mineral soil pH, CEC, and concentrations of exchangeable Ca, Mg, and K. It also relieved a possible B deficiency. Windrow burning was also the only treatment that was associated with significant increases in lodgepole pine diameter and volume growth relative to the control. However, slash piling and windrow burning are applied mainly to reduce slash abundance and improve planter access and affect only a minor proportion of cutblock area. The responses found in burned windrows are not representative of those that would occur with broadcast burning.
5. Given the high cost of MSP treatments and the potential for forest floor disturbance to exacerbate existing sulphur deficiencies, we conclude that windrow burning, with no additional site preparation would be the best option for submesotrophic SBSdw3 sites with medium-coarse soil texture.

Acknowledgements

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