CENTRE FOR BOREAL RESEARCH
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# Soil Site Preparation Options for Enhancing Woody Seedling Establishment Part 1: Mechanical Tools

## CONTEXT

As the process of soil stripping, stockpiling and replacement of soil layers invariably has negative impacts on soil properties including loss of structure and potentially compaction, processes aimed at restoring both structure (or facilitating the processes needed to do so) and alleviating soil compaction are critical to the development of a functional forest. Deep ripping can be used to improve compacted soils and facilitate the natural regeneration of woody species under responsible management.[1] The rough surface from deep ripping produces microsites at a variety of scales, and this, combined with reduced compaction, can facilitate natural regeneration and early establishment of planted woody species. Variable concave microsites facilitated the early establishment of trembling aspen seedlings in recently reclaimed mine sites.[2] More recently, intensive decompaction tools, such as the RipPlow™, have been developed to create many deeper cavities and voids, which contribute to continued decompaction of soils (through freeze-thaw cycles) for years following treatment.[3]

There is a practical need to find tools and approaches that facilitate forest species development following industrial activities in previously forested sites. While soil decompaction is known to be beneficial to commercial tree species and surface roughening has experimentally been shown to also benefit native species establishment, these practices are still not always used due to concerns with soil admixing and excessive surface drying. The purpose of this technical note is to illustrate the forest vegetation development outcomes following use of contrasting surface soil treatments on a large, recently reclaimed industrial site.

## STUDY DESIGN

This study was conducted on a decommissioned airstrip located approximately 30 km northeast of Peace River, Alberta (lat 56° 23.792´N, long 116 52.887´W). The Canadian Natural Resources Limited (CNRL) airstrip is an 18-hectare area that was stripped, graded, and paved in the 1980s and was regularly used to fly in personnel. The area is within the dry mix-wood sub-region of the boreal mix-wood natural region of Alberta.[4] In 2012, the asphalt was removed, and reconstruction of the landform was initiated in June 2014. The area of the upland aspen/white spruce mixed-wood forest study, particularly where the asphalt had been previously overlain, was ripped (with straight ripper shanks) in both the east-west and north-south direction with a straight ripper to loosen the compacted clay. Following the ripping, the surface was disced and then bladed to further break up large clods and aid in smoothing the ground in preparation for topsoil spreading. The upland aspen/white spruce mixed-wood forest study site was divided into 15 strips with an equal size of 120 m x 35 m. Stockpiled topsoil was then spread with a dozer with a target placement depth of approximately 10-15 cm. Within each strip, one of three soil surface treatments were applied to create contrasting levels of surface heterogeneity:

- Smooth: this was the baseline or control condition - topsoil spread with dozer.
- Disc: where the surface topsoil was treated with an agriculture disc attachment to a tractor following topsoil placement in July 2014. This created a rougher soil surface compared with the baseline condition but less extreme than in plow treatment below.
- Plow: In November 2014, a dozer with two RipPlow™ attachments were used to create a heterogeneous soil surface. The core intent of this treatment was to create a highly heterogeneous soil surface, but this treatment also results in many deeper cavities and voids, contributing to continued decompaction of soils (through freeze-thaw cycles) for years following treatment.

**Table 1.** Summary of target planting densities of tree and shrub species established in May 2015 on the study site.

| | COMMON NAME | SCIENTIFIC NAME | DENSITY (STEMS $HA^{-1}$) |
|---|---|---|---|
| TREES | Jack pine | *Pinus banksiana* | 500 |
| | White spruce | *Picea glauca* | 1000 |
| | Balsam poplar | *Populus balsamifera* | 500 |
| | Aspen | *Populus tremuloides* | 1200 |
| SHRUBS | Green alder | *Alnus viridis* | 200 |
| | Western dogwood | *Cornus sericea* | 250 |
| | Willow (various species) | *Salix spp.* | 500 |
| | Buffaloberry | *Shepherdia canadensis* | 50 |

## KEY FINDINGS

**Figure 1 (below).** Summary of target planting densities of tree and shrub species established in May 2015 on the study site. Vegetation surveys were conducted annually in late July through early August for the first five growing seasons during the summers of 2015 to 2019. (**A**) Smooth treatment where soil was spread with a dozer and plow treatment where the soil was surface roughened using a RipPlow™ attachment on a dozer in year 1, (**B**) plow and disc treatments in year 1, (**C**) smooth and (**D**) plow soil treatments in year 5.

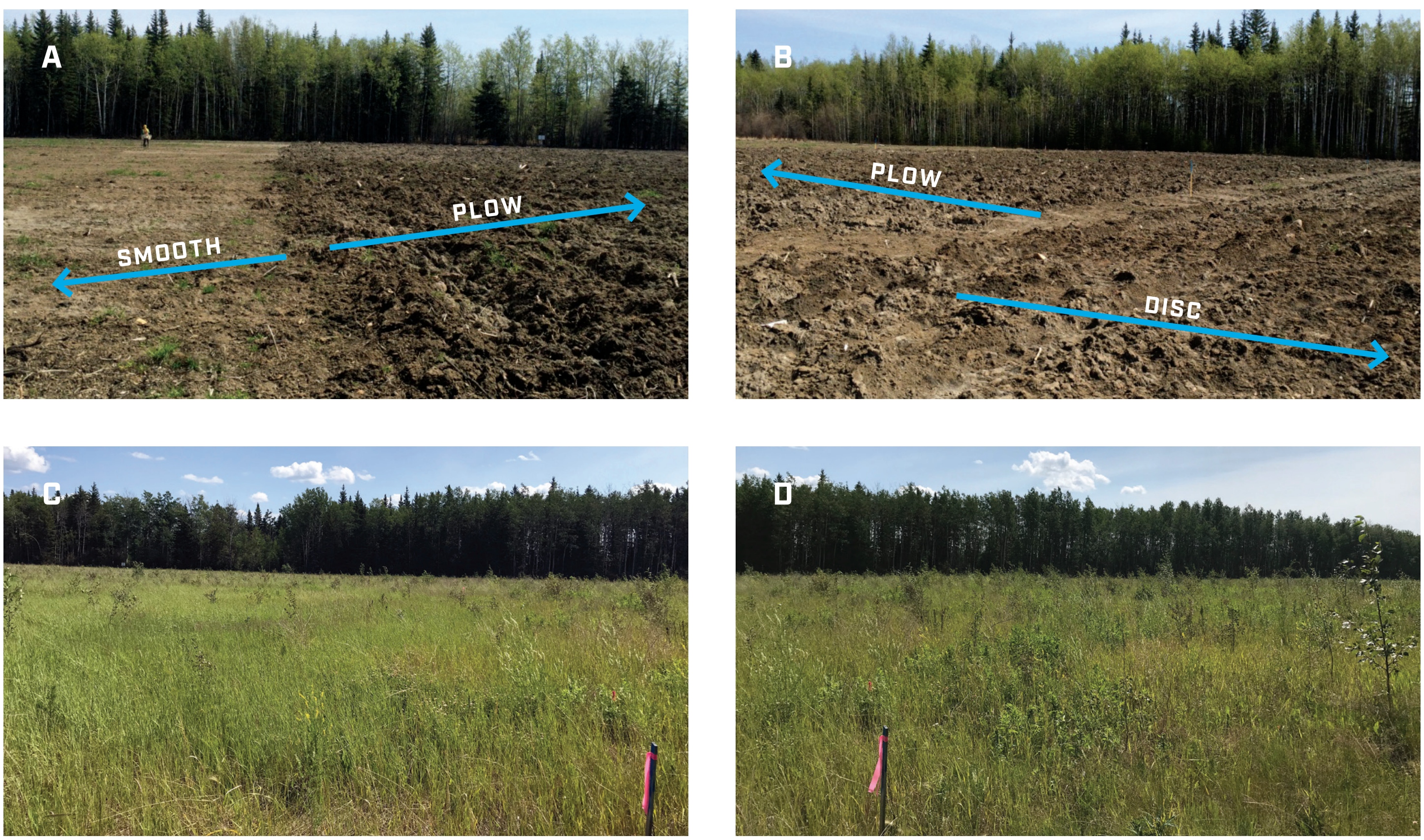


**Figure 2 (below).** Woody plant densities by soil treatment after five years. Blue dotted arrow indicates initial target density established in year 1 with nursery stock or stem cuttings. Black line indicates mean estimate from field trial and rectangle outer boundaries are 95% confidence intervals on the mean estimate.

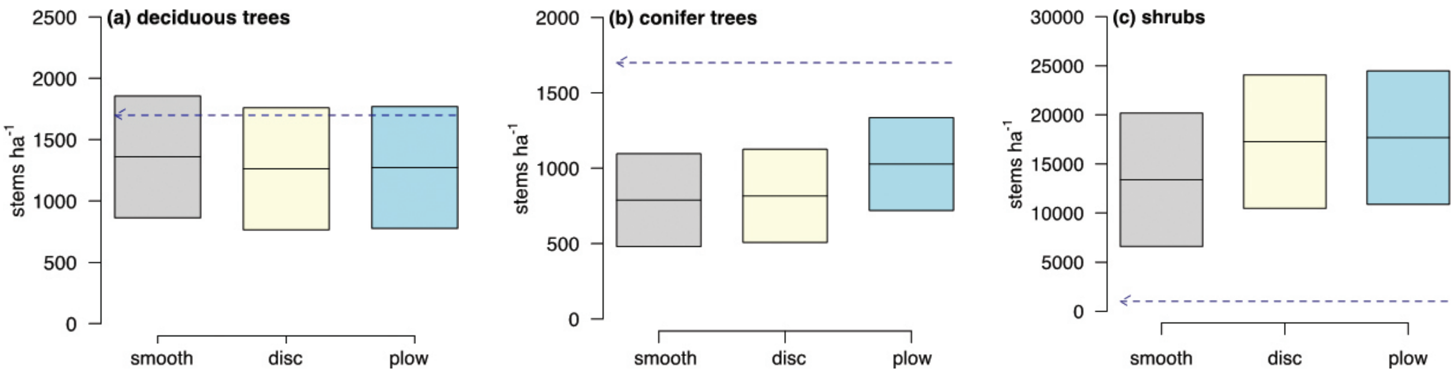
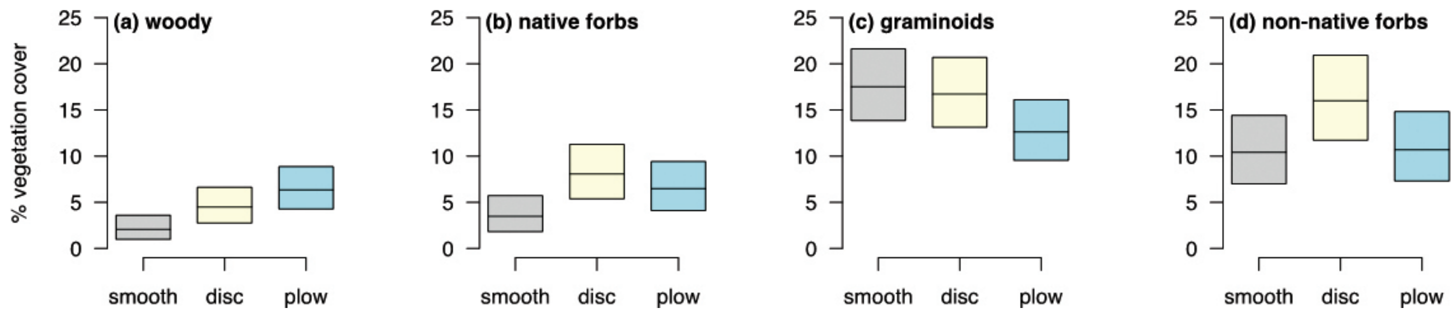



**Figure 3 (below).** Vegetation cover by soil treatment after five years. Black line indicates mean estimate from field trial and rectangle outer boundaries are 95% confidence intervals on the mean estimate.




## PRACTICAL RECOMMENDATIONS

The smooth soil surface versus rough soil surface (plow) have created contrasting conditions for the emergence and growth of forest species, while the disc treatment was a largely intermediate treatment between these extremes. The choice of tool, therefore, should be considered for the final revegetation goal of the site. The strengths and weaknesses, in terms of enhancing particular groups of vegetation of each approach, have been summarized below:

1. **Smooth soil treatment:**
    a. The smooth soil surface enhanced the establishment of wind-dispersed species, predominantly willows, and aspen to a lesser extent. However, this treatment did not enhance seed germination of raspberries and poorer survival outcomes were observed for coniferous trees that were planted; together this led to the lowest total cover of woody vegetation of the three treatments.
    b. Vegetation cover was dominated by graminoid species and had the lowest coverage of native forbs however, non-native forb cover was lower than that observed for disc treatment.

2. **Disc soil treatment:**
    a. The disc treatment resulted in high densities of raspberry emergence (via soil seed bank). This resulted in measurably higher total shrub densities relative to smooth treatment.
    b. Survival of coniferous trees (jack pine and white spruce) was similar to the smooth treatment, but lower than the plow treatment.
    c. Vegetation cover of native forbs and non-native forbs was greatest for this treatment, while woody cover was higher than the smooth treatment but lower than plow, and graminoid cover similar to smooth treatment.
3. **Plow soil treatment:**
    a. Survival of coniferous trees was greatest in this treatment, and white spruce in particular grew tallest.
    b. Similar to discing, the plow treatment resulted in high densities of raspberry emergence, which resulted in measurably higher total shrub densities and the highest total cover in woody vegetation of the three treatments evaluated.
    c. Higher cover of woody vegetation coupled with higher native forb cover have resulted in a vegetation community that was less dominated by grasses after five years.

## COST IMPLICATIONS

The baseline treatment (smooth) does not employ 'additional' cost other than the cost of spreading soil. Discing requires access to both a tractor and disc attachment and can be accomplished at a rate of about 2 hours per hectare. In a large-scale project, the additional cost of mobilizing a tractor and disc attachment is likely feasible but may be impractical for smaller sites (<2 hectares). The conditions created by the plow treatment required a D7 cat as well as RipPlow™ attachments; if this type of dozer is being used for soil replacement and contouring activities, the additional cost would be in the time to plow the site (2-4 hours per hectare) and attachment rental. The same quantity of woody plants were established at this study site, however, survival of coniferous trees was 20% lower in the smooth and disc treatments. Therefore, a greater number of seedlings would have to be planted in order to achieve comparable density results to the plow treatment if coniferous trees were a desirable component of the revegetation plan.

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