Natural Resources Canada
Ressources naturelles Canada

Silviculture knowledge for reclamation of oil and gas disturbances

Soil decompaction

Canada

This publication was co-written by Dr. Amanda Schoonmaker, Northern Alberta Institute of Technology, Boreal Research Institute

Aussi disponible en français sous le titre **:** Décompactage des sols : connaissances en sylviculture pour la réhabilitation de terrains perturbés par des activités pétrolières et gazières

Cat. No. Fo4-65/2016E-PDF (Online)
ISBN 978-0-660-04918-2

Natural Resources Canada
Ressources naturelles Canada

Silviculture knowledge for reclamation of oil and gas disturbances

Soil decompaction

Canada

Background

Silviculture is the practice of controlling the establishment, growth, composition, health and quality of forests at the stand level to meet diverse needs and values. Silvicultural practices can have a strong and beneficial impact on reclaiming areas affected by in situ extraction of oil and gas resources.

Site preparation, forest regeneration and vegetation management are all important phases of silviculture and reclamation. Multiple techniques and practices can optimize the result of reclamation; however, the successful reclamation of in situ sites depends on the physical, chemical and biological properties of the site.

A great wealth of silviculture knowledge has been developed for and traditionally used by the forest industry. Some of this knowledge can be transferred to the oil and gas industry for reclamation through a series of extension products on selected silviculture topics.

This guidebook explains soil decompaction in great detail. It is a silviculture practice that can be used when preparing a site for reclamation. Natural Resources Canada, Canadian Forest Service (NRCan-CFS) and partners developed this guidebook to share their knowledge about how to reclaim disturbed in situ sites. An NRCan guidebook on mounding is also available: *Mounding – Mechanical site preparation*.

Introduction

The impact of industrial operations can affect the sustainability and productivity of forest ecosystems. The activities related to the oil and gas industry, including the temporary removal of top soil and heavy machine traffic, often disturb the soil in ways that are detrimental to re-establishing vegetation and growth. Many of these sites do not regrow native plants through natural regeneration or natural processes because the disturbed sites no longer have the right conditions for seed germination and root growth.

The main soil disturbances that cause productivity losses to the ecosystem include soil compaction and rutting, soil erosion, and removing top soil (e.g. loss of topsoil, seed propagules and organic nutrients). However, the extent and severity of these disturbances will vary depending on the soil type, moisture conditions, the angle of the slope, and the type of equipment used.

Mineral soils rich in silt and clay and moist soils are prone to soil compaction, while organic soils and soils that have a coarser texture are less affected. The type of equipment that was used also has a significant effect on soil compaction. Heavy equipment is more likely to cause damage than light equipment, and wheeled equipment causes greater ground pressure than tracked equipment. Machine traffic has less effect on soil compaction in the winter when the ground is frozen.

Industrial development affects soil by reducing porosity (compaction) and destroying the soil structure, which reduces the hydrologic functions of the soil. Soil compaction that is 10 to 20 centimetres (cm) below the surface does not recover naturally – it requires treatment. And even light machine traffic can damage the hydrologic functions of the soil, which are unlikely to be restored by natural processes, especially in a relatively short period.

An important step in re-establishing a sustainable forest ecosystem is to restore the soil's physical environment by fracturing the soil profile. This process increases soil porosity and aeration so the plant root system can extend and develop.

Figure 1a. A winged subsoiler in the outside pockets of a multi-shank toolbar attached to a bulldozer

Equipment and techniques

Many equipment options are available to restore compacted forest soil. These include a wide range of modifications to the ripper teeth of a crawler tractor or bulldozer. In the accompanying photographs, a bulldozer is used.

► Winged subsoiler technique

Typical usage: The winged subsoiler is from a class of tillage implements developed specifically for deeply plowing compacted soils without inverting the top soil (see figures 1a and 1b). These implements are effective for a wide range of soil moisture regimes and clay content. This treatment creates large voids that allow the freeze and thaw cycle to penetrate deeper into the soil profile and improve the hydrologic function of the soil. Over time, freezing and thawing loosens the soil to considerable depth as the water in the soil changes from frozen to liquid and vice versa.

Figure 1b. A winged subsoiler in the outside pockets of a multi-shank toolbar attached to a bulldozer, lifted above the ground

Operational considerations: The recommended method is to plow in parallel, straight lines with overlapping passes between the furrows to maximize the tillage surface per site (see figures 2a and 2b). The plowing speed should not exceed 3 kilometres per hour.

Figure 2a. First pass of an overlapping pass of a winged subsoiler on a bulldozer

Figure 2b. Second pass of an overlapping pass with a winged subsoiler mounted on a bulldozer

Plowing at depths greater than 70 cm provides the best improvement to the hydrologic function of the soil and the highest decrease in soil bulk density. Shallower plowing depths (<70 cm) create less desirable furrows that comprise a mix of subsoil and top soil (where present). Shallow plowing may also accelerate the closure of adjacent furrows.

When possible, avoid treating soils that have a high moisture content because plowing will form tunnels under the surface but cause little to no real soil fracking. Plowing surface soils that are extremely dry and compacted (e.g. old roads) may require lowering the body of the plow below the strong surface soil to avoid damaging the equipment and to allow the winged subsoiler access to deeper layers. Otherwise, a first treatment that uses ripper shanks (described later) may be necessary to allow the winged subsoiler to access the deeper layers of the soil, which are easier to fracture. Extremely compacted soils may require large and more powerful bulldozers (i.e. larger than a Caterpillar© D7 series bulldozer).

As with all soil decompaction methods, consideration must be given to unwanted establishment of non-native competitive vegetation, which will often readily colonize on recently treated soils. A vegetation management plan that is put into operation concurrent with site adjustment is a necessary feature of all reclamation activities (Figure 3).

Figure 3. Deep sub-soiling that leads to developing undesirable vegetation (Photo: Global Restoration)

Straght ripper shank technique

Typical usage: The straight ripper shank technique is often used in reclamation because it is a readily available tool that can attach to a wide range of bulldozers (see figures 4a and 4b). Ripping is usually carried out with one or two vertically mounted shanks. This technique is most effective when the soil is dry and the clay content is low (see figures 5a and 5b).

Figure 4a. Straight ripper shanks in the outside pocket of a multi-shank toolbar

Figure 4b. Straight ripper shanks in the outside pocket of a multi-shank toolbar attached to a bulldozer

Figure 5a. Bulldozer with two straight ripper attachments on extremely compacted and dry soil

Figure 5b. Measuring the depth of furrows

Figure 6. Standard mounding done with an excavator and bucket

Operational considerations: Where soils are highly compacted, cross-ripping is recommended to further fracture hardened soil clods.

Standard mounding technique

Typical usage: Standard mounding can be achieved with a digging bucket mounted on an excavator. The soil is scooped from the hole and dumped beside the hole.

Operational considerations: This technique can be used in frozen or thawed conditions. Breaking up the scooped soil is recommended to accelerate decompaction (see Figure 6).

Rough and loose mounding technique

Typical usage: Rough and loose mounding is a variation of the standard mounding technique and uses the same equipment. The primary difference is how the scooped soil is handled. The scooped soil is dumped partially in the excavated hole and partially on the adjacent soil surface. The effect is a highly heterogeneous soil surface that is visually more similar to the winged subsoilers technique than the standard mounding technique (see figures 7a and 7b).

Figure 7a. Rough and loose soil treatment with an excavator and bucket

Figure 7b. A highly heterogeneous soil surface

Operational considerations: This technique can be used in frozen or thawed conditions. It is slower than other techniques that use shanks and bulldozers. However, this may be a good option, depending on equipment availability or site accessibility.

Table 1. Treatment options for soil decompaction

Soil conditions			
Tool or technique	Frozen	Not frozen	**Type of operation**
Winged subsoiler	✗[1]	✓	Straight lapping passes
Straight ripper shank	✓[2]	✓	Lapping passes or cross-ripping
Standard mounding	✓[3]	✓	Soil is placed adjacent to the hole
Rough and loose mounding	✓[3]	✓	Soil is placed partially in the hole

Notes:

1 Winged subsoilers are effective in partially frozen conditions (<15 cm of surface frost).

2 Most effective when the soil is dry and with low clay content

3 Operating equipment becomes difficult under wet conditions.

Conclusion

Successfully establishing a sustainable forest ecosystem can be facilitated by applying the soil decompaction techniques described in this guidebook. These techniques will help repair some of the common problems of compacted soils including reduced soil porosity and water retention capacity. Long-term research trials are currently underway to further investigate and compare the effectiveness of these decompaction techniques on soil bulk density and vegetation development.

The information in this guidebook was compiled from previous work conducted by NRCan-CFS and the NAIT Boreal Research Institute in collaboration with Dr. David McNabb (ForestSoil Science Ltd.) and David Polster (Polster Environmental Services Ltd.). The authors want to acknowledge the numerous insightful discussions with Craig Clampitt (NorthWind), Greg Fisher (Shell Canada) and Derek Moore (NorthShore Environmental). These discussions provided valuable content and context for this guidebook. The photographs were provided by Dr. Amanda Schoonmaker (NAIT Boreal Research Institute), unless otherwise indicated.

Reference list

For more information, see the following videos and publications:

VIDEO - How to use a RipPlow in forest reclamation, Northern Alberta Institute of Technology

VIDEO - Using a RipPlow for soil decompaction in forestry reclamation, Northern Alberta Institute of Technology

Corns, I. G. 1988. Compaction by forestry equipment and effects on coniferous seedling growth on four soils in the Alberta Foothills. *Canadian Journal of Forestry Research* 18: 75-84.

McNabb, D. H., Sobze, J.M., and Schoonmaker, A. 2012. *Tilling Compacted Soils with RipPlows: A Disturbed Soil Restoration Technique*. NAIT Boreal Institute Technical Note. p.7.

Polster, D. 2013. *Making Sites Rough and Loose: A Soil Adjustment Technique*. NAIT Boreal Institute Technical Note. p.3.

Sutherland, B. 2003a. Preventing soil compaction and rutting in the Boreal Forest of Western Canada. FERIC, Vancouver. *Advantage Report* Vol. 4, No. 7. p.52.

Tan, X.; Curran, M.; Chang, S.X.; Maynard, D.G. 2009. Early Growth Responses of Lodgepole Pine and Douglas-Fir to Soil Compaction, Organic Matter Removal, and Rehabilitation Treatments in Southeastern British Columbia. *Forest Science* 55(3): 210-220.