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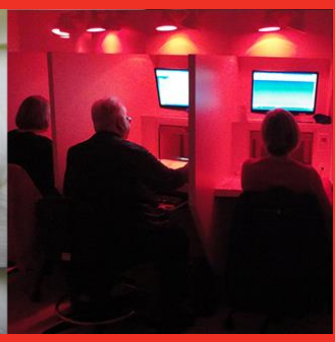

Soil Restoration Protocol

Prepared by:

Dr. Darby McGrath
Jason Henry
Ryan Munroe

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Introduction

Urban soils are mechanically engineered to be highly compacted and contain a low amount of organic matter. This drastic alteration of the soil profile usually results in poor establishment and growth of associated vegetation, including trees, shrubs and ground vegetation. Although there are several different techniques used to assess soil compaction, soil bulk density is a useful measure to consider when implementing soil restoration.

Soil bulk density is the dry weight of soil contained within a known volume (g/cm^3 or mg/m^3). Measuring soil bulk density is important given that many studies have been conducted on the density of soil and how it influences or even restricts root growth. Bulk density can be used as a benchmark for soil restoration by identifying the ideal soil bulk density for tree growth and working to replicate those conditions in urban plantings.

Research on Ontario Ministry of Transportation and Alberta Transportation right-of-way sites demonstrated that soil bulk density is typically higher (compacted) across highway roadside plantings than what is ideal for tree growth (< 1.40 g cm^3). Of the 11 research sites in Alberta and Ontario evaluated, the majority of soils were found to have bulk densities greater than 1.55 g/cm^3 that were restricting of root growth. Research findings suggest that tree establishment and survival is strongly correlated to bulk density.

To improve the physical structure of soil, it is recommend that the organic matter content of high density soils be increased to alleviate compaction. Addition of organic matter has been shown to lower soil bulk density more effectively and with longer lasting effects than mechanical de-compaction alone. Incorporation of organic matter has also been shown to improve soil structure, water holding capacity, biological activity and nutrient concentrations in amended soils.

Site preparation is comprised of three stages, namely (1) Subsoiling, (2) Selecting an Organic Amendment and (3) Applying an Organic Amendment. The following sections provide additional information on key concepts and considerations relevant to each of these stages.

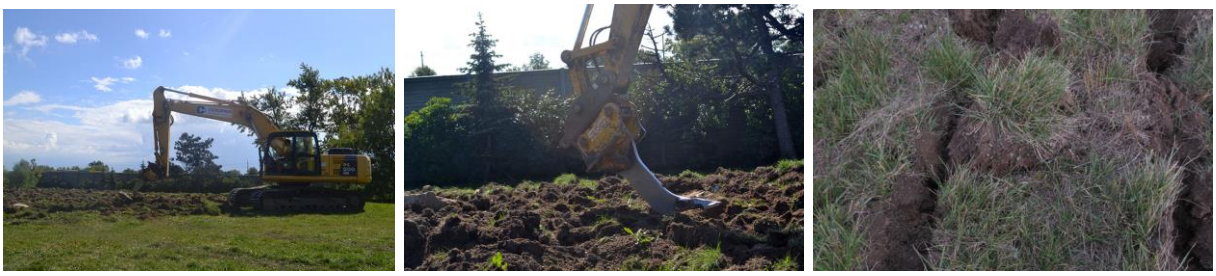
Stage 1: Subsoiling

Subsoiling begins by laying out the designated planting polygon or trench. We recommend using planting beds rather than pits, given that trees in planting bed treatments performed significantly better than that of back-filled planting pits.

Before carrying out any soil restoration work, acquire locates on your site to ensure you know the whereabouts of any belowground infrastructure. Use a single tine bucket-mounted excavating ripper for the entire planting area.

Key Considerations:

- Tine width is usually 10 - 25 cm
- Deep ripping to a depth of 90 cm/36 inches is recommended. Make sure to assess total soil depth before you undertake any subsoiling.
- Spacing between tine ripping lines should be approximately 30 – 60 cm
- Soils should be ripped perpendicular to the road and/or in line with the slope of the site

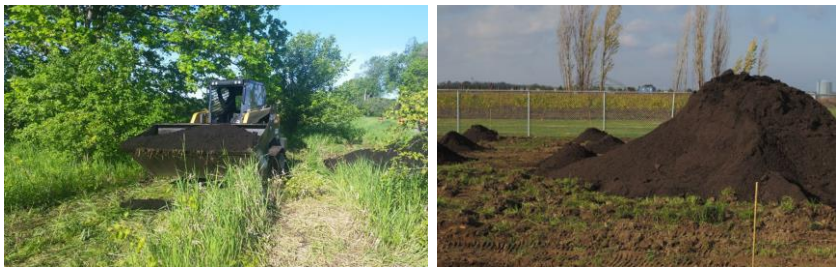


Stage 2: Selecting an Organic Amendment

There are several types of organic amendment that can be used to help restore soil function, including composts and mulches. Key considerations when sourcing compost include maturity, soluble salts, organic matter content, pH, nutrient content and carbon:nitrogen ratio (C:N). Trace metal content, sharps and presence of soil-borne pathogens are also worth considering when selecting an organic amendment. We typically use and have the most experience with municipal compost as it is widely available, its production is regulated and it tends to be cost-effective.

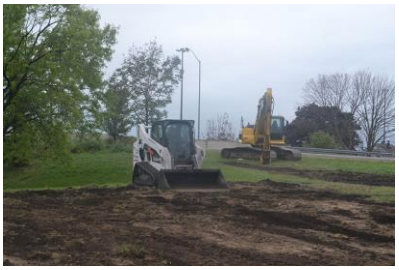
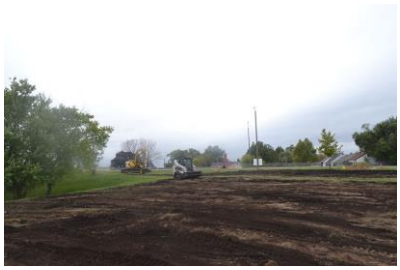
Below are important qualities to consider when selecting compost for soil restoration:

- Mature compost (assessed based on respiration levels)
- Moisture content between 40% - 50%
- Organic matter content (based on Loss-on-Ignition test) should be a minimum of 30%
- Carbon to Nitrogen ratio should be between 10:1 and 25:1
- Soluble salts (of a saturated paste) should be less than 4 mS/cm



Stage 3: Applying Organic Amendment

Typically, the selected organic amendment is applied using a skid-steer or front-mounted bucket on a tractor. Once the amendment is placed onto the planting bed and is level, a PTO driven rotary soil spader or rototiller can be used to incorporate the amendment to a depth of 20-30 cm. Skid-steer operators may need to back-blade the amendment to level it out before rototilling or spading can take place. It may take several passes to ensure the organic amendment is sufficiently incorporated.


Vineland Research and Innovation Centre
4890 Victoria Avenue North, Box 4000
Vineland Station, ON L0R 2E0

tel: 905.562.0320

vinelandresearch.com

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