AREA Forum

METHODS TO EVALUATE SOIL COMPACTION

To continue the discussion from January, we asked three more researchers involved in the study of soil compaction in urban environments to express their thoughts about different methods for evaluating compaction. If you would like to participate in this discussion, you may send your response to the *Journal* Editor (see inside cover) or to me at ach@hp9000a1.uam.mx or ach@hp.fciencias.unam.mx. We invite additional comments and suggestions to be submitted for inclusion in future issues.

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Measurement and evaluation of soil compactness must balance time, accuracy, and cost. That balance varies by method, application, and site. Expense does not necessarily equal accuracy, nor does accuracy in technique necessarily translate into a representative measurement of the site or problem in question. Many choose to report bulk density as an indicator of relative compactness.

The clod method, when appropriate, is practical; however, there is always the problem of having the requisite materials on site when you need them. I like the results of a technique we tried at Cornell University using a freeze-dry method with shrink-wrapping. You can get the exact weight and volume of the shrink-wrap by submerging the wrap in water. I am concerned about overestimation of the volume due to insufficient shrinkage or folds in the wrapping material. For ease of handling and efficiency of field data collection, it would be great to have the clod in a sealed, stable condition at the sampling moisture content moments after collection.

Soil volume-by-replacement methods can be very accurate, but they can also be very time consuming to collect. In this method, a sample of material is collected by digging a small hole, and weighing the soil. The volume of the hole is measured by filling the hole either with liquid-filled balloons or density sand. Individual technique is important because aggressive digging can artificially enlarge the hole volume with compaction of the soil at the sides. Measurement accuracy is problematic in poorly graded gravel soils because sand can enter the pores at the sides of the hole. This underestimates the density of the material by overestimating the hole volume. The minimum representative sample per test increases with effective grain size of the soil due to the individual aggregates' influence on the weight of the sample (1 stone can influence the measured density of a small sample more than 1 grain of sand in the same sample). The extra effort to maximize the collection sample is warranted to minimize the impact of the error, so the hole should be made as large as possible. There is also a good deal of equipment calibration required for such a basic test.

Nuclear densimeters benefit from immediately available data and sampling times of minutes per observation. Definition of relative density within a site with a valid sampling is much easier; however, the benefit of replication comes with a loss in accuracy of the individual observation. The tools are expensive, calibration can be difficult, and the whole business of radioactive tool management is a limitation. Contracting the project out to an operator is a cost-effective alternative, even at US$75 per hour, for large sites or high replication.

I like the process of testing for homogeneity with the nuclear densimeter and immediately testing several sites to pair the densimeter data with balloon or sand-cone readings to aid in interpretation of the results. If you have the sand and cone calibrations in place, and if you are organized; you can spend 2 partial days in preparation, complete up to 2 sand-cone readings per hour (with no complications), and have the data ready after the soil has dried to your protocol specifications. You can easily capture 12 measurement sites per hour with a Troxler densimeter at surface and

20-cm (8-in.) levels with data immediately available for relative density and moisture content analysis. You either have to trust the operator's calibration, have calibration samples on site to test, or follow with paired sand-cone/balloon tests.

Relative compactness, measured by bulk density, can be used to predict soil material behavior and some plant response trends, given knowledge of other soil physical parameters. Bulk density is more useful if used relative to a plant response threshold, within that particular soil or soil type. Tables listing maximum densities by soil classification often are based on other soil parameters evaluated by varied plant responses, not always with density and trees over a meaningful time frame.

Plant-soil interactions within a range of pore size distributions are at issue for horticultural management, while density measurements communicate solids (by weight) per unit volume. The pores are the important factor, so density can be used as a hint at best. The pore size distribution will influence water and air balance within the soil and root penetration ability. It takes considerable effort to evaluate individual soil systems for living plant responses, moisture release characteristic curves, and penetration data over the ranges of density and moisture content expected on a site—longer than most can wait to make a decision in the field. We can use previous research to streamline the process, but only as an estimate. Density measurement as a diagnostic tool relates plant response to a limiting soil density based on observed soil physical properties, biotic activity in the soil, and some negative observation in plant growth. It justifies expectations of a problem after heavy compaction, but does little in predicting plant response.

To make much sense, penetrometer data must similarly be tied into a series of parameters that affect frictional properties of the soil. Penetrometer data are influenced by the type and shape of the penetrometer, soil type, moisture content, density of the soil, the speed at which the needle or piston is driven into the soil, the size of the needle or piston in relation to the particle size distribution of the soil, and the interactions of these variables. Penetrometer data can be developed and translated into part of a larger field diagnostic method for landscape soil evaluation. Field penetrometers can quickly and easily detect relative differences within a site and can find layer differences. We have work to do in protocol and interpretation if we want the tool to yield data for decision-making criteria for the variety of situations in which we are called to offer professional advice. After all, penetrometer data communicate strength and frictional properties of the solids (and moisture) relative to a metal shaft, but we are still concerned with pores.

I would like to know if anyone has experience with the piezoelectric compaction meters, or if anyone is looking at them for arboricultural research with a similarly opportunist view.

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Soil compaction is a complex topic. I began to study it 6 years ago when I participated in the design of a decompacting machine. Much has been spoken on the issue of compaction and on the ways to reduce it. I have often seen large investments in decompacting areas without positive results. Soil compaction not only affects the physical component of the soil but also its chemical and biological components. To solve the problem, is necessary to know the intensity of the compaction, to analyze the type of soil, and to identify the causes.

The methods that we use to evaluate soil compaction are as follows.

1. Visual evaluation in trenches to the depth considered important. It can vary from 50 to 150 cm (20 to 60 in.). In this phase, we can observe the different soil horizons. In most compacted soils, we observe various superposed caps of artificial horizons.
2. Biological analysis. We look for the presence of mycorrhizae and evaluate the distribution of the radical system.
3. Chemical analysis. We determine the quantities of nitrogen, phosphorus, and potassium, and the percentage of organic matter.
4. Physical analysis. We measure the reduction of water infiltration, mechanical resistance to root

development, water retention capacity, and gas diffusion decrease rate. Part of this analysis must be accomplished in the laboratory. The soil must be analyzed at various depths and the results are compared to those from similar noncompacted soils. Information about soil texture is an important prerequisite because texture is a passive factor that determines in many cases the degree of compaction. Infiltration can be measured with an infiltrometer, and mechanical resistance to penetration with a penetrometer. For gas diffusion, the concentration of CO_2 and O_2 can be analyzed and diffusion speed measured.

All of these evaluations can be used to measure compaction, but in many cases a visual inspection of a trench in the soil is sufficient. Trenches do not require use of expensive instruments but can be difficult to accomplish due to the presence of pavements, possible damage to the root system, and presence of other infrastructures.

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Compaction is a common process in urban soils. Typically, to build stable infrastructure, soils are compressed purposefully until they have been compacted to more than 90% or 95% of a standard. Urban horticulture relies on this compacted material for the rooting space of trees, shrubs, and other plants. Urban foresters and arborists often are asked to alleviate, reduce, or even remove compaction from soil. Compaction is generally difficult to alleviate and perhaps even more difficult to measure. Without effective methods for measuring soil compaction, it is difficult to assess how compacted a soil is or whether a treatment has reversed any of the compaction in a soil.

Bulk density (weight per unit volume) is the most common measure of compaction. There are several methods for measuring the bulk density of a soil sample, which is actually a surrogate measure of compaction. The cylinder method involves driving a 2- or 3-in. (5- or 7.5-cm) diameter cylinder into the soil and extracting a soil core of known volume, finding its weight (both moist and dry), and then calculating the bulk density. The “clod method” is somewhat more precise because it uses a single soil aggregate from the soil profile to measure the density. Both of these measures are coarse estimates of a soil’s density, and when compared to reference samples of similar soil texture, they allow an estimation of compaction. Factors that affect bulk density include moisture conditions at sampling, which may compress soil materials, the particle density (real density) of the individual soil particles, the mineralogy of the soil, and the soil’s texture.

When we assess compaction, we often are concerned about the ability of roots to penetrate the soil material. Compaction is often evaluated with another surrogate measure, penetration resistance. With this technique, a steel rod of a given diameter with a specific angle tip is driven at a consistent speed into the soil. Pressure change is measured as the instrument is driven into the ground. The penetrometer, as it is aptly named, comes in a variety of shapes and sizes. Because it measures pressure change in a very small area as the rod is driven, multiple samples must be taken and averaged to give a reasonable estimate. Additionally, this method requires the use of a control area of similar soil properties because it is a comparative technique. The are many studies in which penetration resistance has been compared across dissimilar materials. The problem with this approach is that the person performing the test cannot tell if the change is due to changes in soil properties or to compaction of soil materials. New techniques with penetrometers include video logging, which places a fiber-optic probe at the tip of the instrument to record the actual encounter with soil features as the pressure is recorded. Commercial instruments with this technology are just beginning to appear on the market. The value in this addition to the technique is the ability to use soil micromorphology to help explain variation in penetration resistance.

Several common soil physics calculations are also of use in evaluating compaction. porosity (void volume/total volume) as calculated from bulk density is a useful tool when making multiple comparisons within the same material. Void ratio (volume voids/solid volume) is a useful tool when comparing materials that are dissimilar.

Direct density tests including proctor density are widely used in construction of infrastructure. Density measured by neutron activation (a radioactive technique) is common in engineering work but is effective only to a depth of 6 to 12 in. (15 to 30 cm). It requires destructive sampling for calibration, and the instrument must be recalibrated each time soil properties change. Most of the direct methods for evaluating compaction involve compressing a previously uncompacted sample and are of little value for most urban soil and arboricultural studies.

Surrogate measures of soil density will continue to be the norm for evaluating compaction. Scientists and arboricultural professionals should include thorough soil assessments along with any soil testing that is performed, including density analyses. Evaluation of such factors as water table depths and aeration status are important when evaluating rhizosphere conditions. Compaction is frequently not the sole cause of poor plant health. Usually, multiple soil conditions are responsible for poor plant performance in urban soils.

ISA NEWS & NOTES

OHIO CHAPTER TO HOST FERTILIZATION CONFERENCE

Recent concerns about current tree and shrub fertilization practices prompted the Ohio Chapter of ISA to host a two-day conference on the subject, to be held in Akron, Ohio, May 17 and 18, 2000.

The purpose of the conference is to find the common ground in the research, literature, and practices and make practical scientific recommendations; and to identify the gaps in the body of research knowledge and make recommendations for the future direction of fertilizer research.

Opportunities to support the industry and help further our common knowledge are available at several levels. For more information about sponsorship opportunities, contact me (see information below) or Bal Rao at (330) 673-9511 ext. 351 or brao@davey.com

Mark your calendars now. A limited number of seats are available to listen to the leading researchers and practitioners present their findings. Participants are invited to a cocktail reception Wednesday evening to meet and talk with the researchers. All participants will receive a complimentary copy of the abstract. On Thursday, participants will have a chance to submit questions to the panel of researchers.

Registration for the conference, including lunches, breakfasts, and breaks is only US$250. Contact Alan Siewert (see information above).

Do you have questions about fertilizing? As practitioners, what questions do you face when you fertilize? Email or fax them to me. We will use your input to guide the discussion and program.

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CHANGES FROM THE 8TH TO THE 9TH EDITION OF THE GUIDE FOR PLANT APPRAISAL

Replacement Cost and Trunk Formula Methods

In the 9th edition of the Guide for Plant Appraisal, the most significant procedural change is that in both methods, the costs of the replacement tree and its installation are adjusted by the Species rating. The rationale for this is that the costs of an installed replacement tree are based on its cost of production and its cost of installation. These costs do not necessarily reflect the quality of the species when mature; therefore, they also are adjusted by the Species rating.

The individual steps in the written directions and in the appraisal worksheets are similarly numbered in both the Replacement Cost Method and the Trunk

Formula Method so that there is less chance for confusion. Within each, the steps are divided into 1) Field Observations, 2) Regional Plant Appraisal Committee and/or Appraiser-Developed or -Modified Information, and 3) Calculations by Appraiser Using Field and/or Regional Information.

Palms are to be appraised by the Replacement Cost Method as determined regionally.

Condition

Tree structure is given more emphasis in the Condition rating. Structure and health are each rated (1–4) for roots, trunk, and scaffold branches. Twigs and foliage are rated only as to health.

Location

The rating of a Site is to consider its relative real-estate value on a percentage basis, not strictly monetarily, in relation to the city, area, and/or region in which it is located, as well as its visual and functional values.

The Income and Market approaches to appraisal are discussed in more detail so they might better be used by themselves or as reasonableness tests for the cost approaches (Replacement, Trunk Formula, Repair, or Cure).

Easements and Rights of Way

Plant appraisal needs to consider the extent of the owner's rights on easements and rights of way. An owner may be limited on how trees are pruned within an easement or right of way on his or her property. The actual rights granted to the person or company holding the easement or right of way may need to be ascertained.

A More Proactive Approach

Appraising the value of plants before they are lost or damaged is recommended, especially on high value properties and prior to construction around existing trees.

Editor's Note: The 9th Guide for Plant Appraisal will be available from ISA in late March.