Million Trees NYC Plantings
Examining Soil Conditions

Richard K Shaw
USDA-NRCS

A diverse geological setting and several hundred years of anthropogenic disturbance have resulted in a wide variety of soil conditions in New York City. Some small pockets of minimally disturbed soils formed in naturally-deposited materials can still be found among the soils formed in human-transported materials, or fill. Soils in urban areas can pose several formidable challenges for successful plant growth. Some of the general characteristics of urban soils listed by Craul (1992) include:

- High degree of vertical and spatial variability;
- Restricted aeration and drainage;
- Presence of artifactual materials (brick, concrete, asphalt, etc.) and contaminants;
- Modified soil reaction, usually elevated;
- Modified soil temperature regimes.

This section describes the evaluation of a few soil properties to help in proper plant selection for long term success: particle size distribution; depth to water table; depth to a physically restrictive layer; and soil reaction. The first two are difficult to change without great expense and must be worked with. The last two, in many cases, can be corrected.

First, site characteristics are important, and generally affect soil conditions. Take note of the following:

i. Vegetation
ii. Slope
iii. Aspect (direction that the slope faces, looking downslope)
iv. Landscape position or landform (ridgetop, sideslope, footslope, floodplain, till or fill plain, etc.).

Also take note of any bedrock outcrop or surface stoniness, and the micro-topography.

As larger areas can vary in the above characteristics, soil conditions may vary accordingly, and multiple soil investigations (and accompanying soil samplings) may be necessary.
Select a site which is representative of the planting area as a whole (in the above characteristics) and dig a small pit to about 18 to 24" for examining the soil properties. If you can't dig to 18" note the reason why. It may be due to an excess of large fragments (see 1a, below), a physically restrictive zone (see 3 below), or both.

Characterize the following soil properties in the surface and subsurface, if appropriate:

- particle size distribution;
- depth to water table, or any morphologic (soil color) indicators of wetness;
- depth to physically restrictive (to roots or water) zone.

In addition, soil samples should be taken for pH and nutrient analyses.

1. <u>Particle size distribution</u>

a) Estimate the % volume taken up by coarse fragments (>2mm): are they rocks or human-made artifacts?

Excessive amounts of coarse fragments (>35% of the volume) can take up a substantial part of the water and nutrient holding volume. They can also provide information on the origin of the material, and some clues on the properties of the fine earth fraction. An excessive amount of artifacts can be accompanied by chemical problems, such as contamination or high alkalinity.

b) Fine earth: is it organic material (plant decomposition residues) or mineral material (derived from rocks)?

If it is organic material, measure the thickness. A buildup of considerable organic materials at the surface (>8 inches thick) is generally an indicator of saturation.
For mineral material, is it sandy, loamy, or clayey? See the text box below on *Estimating General Soil Texture*. Texture determines water and nutrient holding capacity, and affects air and water movement through the soil.

Estimating General Soil Texture
Wet about 25g of soil and knead into a ball, until it is plastic and moldable, like moist putty.
Place the ball between the thumb and forefinger, and squeeze upward into a ribbon. Allow the ribbon to emerge and extend over the forefinger, breaking from its own weight. The length of the ribbon reflects the clay content.

Does not hold together for a ribbon	*sandy*
Forms a ribbon < 1 inch long	*loamy*
Forms a ribbon > 1 inch long	*clayey*

2. <u>Depth to seasonal high water table</u>
   Is there a water table present? At what depth? The water table in soil usually fluctuates seasonally, generally highest in the winter and lowest in the summer. If there is no water table present, do the soil colors suggest wetness? See the text box below on *Soil Color and Wetness*. Identifying the depth to seasonal high water table with soil morphology can be tricky, especially with filled or disturbed soils. Look at other site characteristics for supporting evidence. First, is it a low-lying area? As with wetland delineation, it is best to check the vegetation and the hydrology indicators (water marks, drift lines, sediment deposits, etc.) as well, which should concur with signs of soil wetness.

Soil Color and Wetness
Prolonged saturation during the growing season results in a depletion of oxygen by plants and microorganisms in the soil. This lack of oxygen restricts aerobic root respiration and aerobic microbial reactions, and promotes the following biogeochemical processes: 1) a transformation of several elements from oxidized to reduced chemical forms; and 2) an accumulation of organic matter. After the oxygen is gone, nitrates, manganese oxides, iron oxides, sulfates, and carbon dioxide in soil are reduced in that specific order. Iron is one of the most important coloring agents in soil. Oxidized, or ferric (Fe^{+3}), iron compounds are responsible for the brown, yellow, and red colors in soil. When iron is reduced to the ferrous (Fe^{+2}) form, it becomes mobile, and can be removed from certain areas of the soil. When the iron is removed, a gray color remains, or the reduced iron color persists in shades of green or blue. Upon aeration, reduced iron can be re-oxidized and re-deposited, sometimes in the same horizon, resulting in a variegated or mottled color pattern. These soil color patterns resulting from saturation, or ***redoximorphic features****, can indicate the duration of the anaerobic state, ranging from brown with a few pale mottles, to complete gray in wetter conditions. The depth to gray color is generally interpreted as depth to seasonal high water table. Soils that are dominantly gray with brown or yellow mottles immediately below the surface horizon are usually hydric.*

3. <u>Depth to soil compaction or restrictive layer</u>
   Is there a dense, physically restrictive layer present? At what depth? Can it be broken up mechanically? Soils can become physically dense from both anthropogenic and natural processes. Soil structure, or aggregation into secondary units, can reflect compaction or high bulk density. See the *Soil Structure* text box below. Healthy, non-compacted soils are characterized by granular structure in the surface and subangular blocky in the subsurface; compacted or dense soil is generally platy or massive.

Soil Structure

Granular – roughly spherical; good surface structure 

Subangular blocky – good subsurface structure 

Platy – flat, horizontal; indicative of compaction 

Massive – coherent but structureless

Single grain – sandy and structureless

Consistence is the ease with which a lump of soil can be crushed by the fingers. It is related to bulk density, and it can also describe the difficulty of excavating the soil. It is highly dependent on soil moisture content. Terms commonly used to describe consistence in <u>moist</u> soil appear in the *Soil Consistence* text box below. They can be used to express the relative density of soil material.

Soil Consistence

Loose – non-coherent, does not hold together in a mass

Friable – holds together but crushes easily under gentle pressure between fingers

Firm – crushes under moderate pressure between fingers

Very Firm – needs considerable pressure to crush between fingers

Other soil properties can reflect the presence of a restrictive layer: an absence of roots, or evidence of a zone of saturation above an excessively dense horizon.
Some soils (Bronx, Manhattan, Staten Island) are shallow to bedrock. This is difficult to change.

Lastly, take soil samples for pH and nutrient analysis. Take a thin slice (~ 1” wide) of soil material from the side of the hole to a 12”depth. Repeat this procedure at 3 to 5 sites within the sampling area, mix the subsamples together in a bucket, and submit a portion of the mixture for analyses.

Existing NRCS NYC Soil Survey Maps and information may be helpful, especially for the larger open spaces. This can be found at: http://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm

Reference: Craul, PJ. 1992. Urban soil in landscape design. John Wiley and Sons, Inc. New York.