# The Role of Soil Management in Minimizing Water and Nutrient Losses from the Urban Landscape[1]

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This publication is part of a series developed to assist Florida homeowners with managing their landscapes to reduce environmental impacts. This is a joint publication of multiple departments and programs in UF/IFAS, including the Florida-Friendly Landscaping™ program, the Department of Soil and Water Science, the Environmental Horticulture Department, and the Center for Landscape Conservation and Ecology. This fact sheet was produced with support from the Florida Turfgrass Association through a Florida Department of Agriculture and Consumer Services Specialty Crops Block Grant.

For the rest of this series, visit http://edis.ifas.ufl.edu/topic_series_environmental_landscape_management.

## Introduction

Soil is the most important building block of a healthy, attractive landscape, serving many important physical, chemical, and biological functions. Soil provides a physical substrate for plant support and holds nutrients and water for plant use. It also facilitates groundwater recharge (water moving from surface water to groundwater) and provides long-term storage for organic matter. Soil also provides a habitat for microorganisms that aid in the transformation and availability of nutrients. Soil is an integral part of any ecosystem, but urbanization often changes soils in ways that negatively affect plant development. Soils in urban areas may have reduced water infiltration, resulting in increased runoff and increased potential for nutrient losses. Homeowners in urban areas often overcompensate for poor planting conditions by applying inappropriate amounts of fertilizer and water. These practices eventually lead to nutrient losses through stormwater runoff or soil leaching, and these lost nutrients negatively impact groundwater and ecosystems in nearby springs, streams, and water bodies.

Ideal soil conditions for planting a new landscape include the following:

- Loamy texture (i.e., mixture of sand, silt, and clay) for holding nutrients and water
- Well drained to avoid standing water around plants and to provide groundwater recharge
- Slightly acidic to neutral pH
- Adequate organic matter to hold water between rain and irrigation events and to provide nutrients for plants
- Little to no compaction so that roots can easily penetrate the soil and oxygen and water can reach the roots
- Low soluble salt content

These conditions are rarely present in home landscape soil, especially soon after construction of a new home. During

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construction, home sites undergo numerous changes that disrupt the soil and do not leave landscapes in an ideal condition for planting.

## What Are the Challenges Associated with Urban Soils?

Before your neighborhood was developed, the soil was most likely naturally formed, consisting of air, water, microorganisms, organic matter, some nutrients, and minerals. The soil may have been part of a natural, forested ecosystem or an agricultural soil. When your home was built, common construction and development practices changed these natural soils to a more challenging environment for growing plants.

## Characteristics of Urban Soils

The disturbance of soils after construction occurs in many ways—there is no such thing as a typical post-construction urban soil. However, urban soils share several common characteristics responsible for the challenges in establishing and maintaining landscape plants and turfgrass:

- Variable soil characteristics and texture
- Compacted soil conditions
- Poor soil structure and low organic matter content
- High variability in fertility and pH levels
- Low biological activity

### Variable Soil Characteristics and Texture

Often, fill material (sand) from nearby areas is brought to the construction site. This sand is spread on top of the native soil, burying the topsoil layer (Figure 1). The fill sand serves as the base for placing the concrete slab for the home foundation. The fill material is also spread around the site on areas that will become the lawn and landscape. The fill sand has low organic matter and nitrogen content. It also can have a wide range of phosphorus and other nutrient content, and typically has low water-holding capacity. During the final development process, additional sand or topsoil may be imported and added over the sandy fill material. Moving the soil and mixing the soil profile create highly variable physical and chemical characteristics (Figure 2) and can result in considerable compaction in urban soils.

In some locations of Florida, dredged material from stormwater retention ponds is brought on site. This material may have a high clay content, which leads to challenges in establishing new landscapes. Clay soils do not drain well and can be easily compacted (Figure 3). Soils with high amounts of clay can lead to poor root development (Figure 4) and are susceptible to standing water during much of the year. This leads to waterlogging of the soil and root rot. Prior to landscape installation, a thin layer of topsoil is commonly applied on top of the fill material to aid in plant establishment, but the underlying soil problems remain.

Figure 1. Fill sand is often piled on construction sites to serve as a base for the home's foundation.
Credits: George Hochmuth


Figure 2. Fill sand is typically added to a construction site to raise the elevation, resulting in the burial of the native soil profile. In this picture, note that various fill materials were applied in layers to establish the final grade.
Credits: Don Rainey

Figure 3. Clay soils do not drain well, causing standing water.
Credits: Don Rainey

Figure 4. Stormwater pond dredging is often used as a fill on home construction sites. These heavy clay soils cause poor root development.
Credits: Don Rainey

Finally, the soil at the home site may contain other construction debris such as wire, wood, nails, asphalt paper, and concrete shards. These materials can restrict plant root development for newly established landscape plants.

## Soil Compaction

The construction of a residential home involves human and mechanical traffic, often resulting in soil compaction (Figure 5). Compaction of urban soils reduces air availability to plant roots and decreases the amount of rainwater that can percolate into the soil. The water running off these landscapes can carry soil and nutrients from the site and possibly deposit them in local waterways. Compacted soils can be especially problematic in sloped home sites, leading to more rapid runoff and soil erosion.

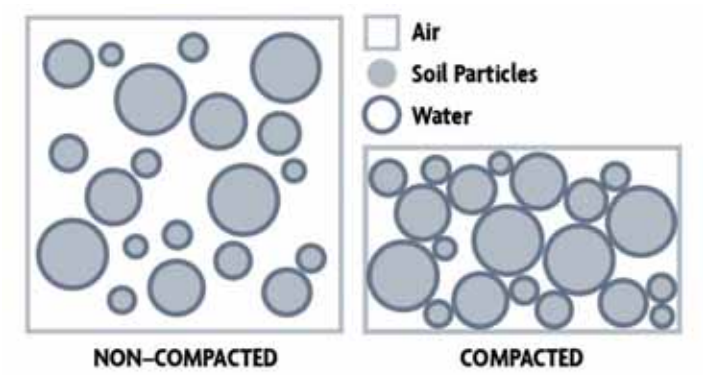


Figure 5. Illustration of soil compaction. Note the reduced proportion of air space in the compacted soil (University of Minnesota Extension 2001).
Credits: Stacey Jones, UF/IFAS

## Low Organic Matter Content

Organic matter improves soil structure by increasing soil aggregation (the ability of the soil to form clumps) and by improving soil aeration and water-holding capacity. Organic matter in high-quality soil is a major source of plant nutrients such as nitrogen and phosphorus. Organic matter is also the food source for many beneficial soil microbes such as bacteria and fungi that help regulate nutrient availability in the soil. It also supports other animals such as earthworms that help to aerate the soil. Native soil often contains organic matter, but during construction and development, this layer is often buried under several feet of fill sand that has little or no organic matter content. The low organic matter content in urban soils may lead homeowners to apply higher levels of fertilizer and water to compensate for the lost organic matter. This leads to an increased use of water and the potential for nutrient leaching or runoff.

## Variability in Nutrient Content and pH Level

Urban soils often contain considerable debris left behind from construction. For example, the pH level in landscape soil can be directly impacted by concrete waste. Soil pH is generally elevated near masonry walls and foundations due to the lime and concrete residues from construction. Concrete debris may also be buried in other areas of the landscape, resulting in pockets of soil where elevated pH makes it difficult to establish landscape plants that need an acidic pH. Plants growing in these high pH soils may exhibit micronutrient deficiency symptoms, such as yellowing of upper leaves similar to an iron deficiency. In addition to the concrete waste, irrigation water typically has high pH levels, which gradually increase the pH of landscape soils over time. Depending on fill material source, there can also

be a dramatic difference in the pH and nutrient availability of native soils and fill material (Figure 6).


Figure 6. Comparison between native soil and fill material pH and Mehlich-1 extractable phosphorus. The insert image shows samples collected from the upper six inches of the two areas to illustrate the dramatic difference in organic matter content.
Credits: M. Clark

## Low Biological Activity

Healthy soils are critical to build a strong ecosystem and to support wildlife in the landscape (Figure 7). Soils in most new construction sites contain low populations of soil microorganisms. A healthy soil contains a rich mixture of plant (flora) and animal life (fauna). These organisms help decompose organic matter, cycle nutrients in the soil, and retain nutrients for plant uptake. An active soil ecosystem can help reduce the amount of fertilizers required in the landscape. As organic matter and plant materials decompose, they provide food for nematodes, fungi, and bacteria that form the base of the food web.

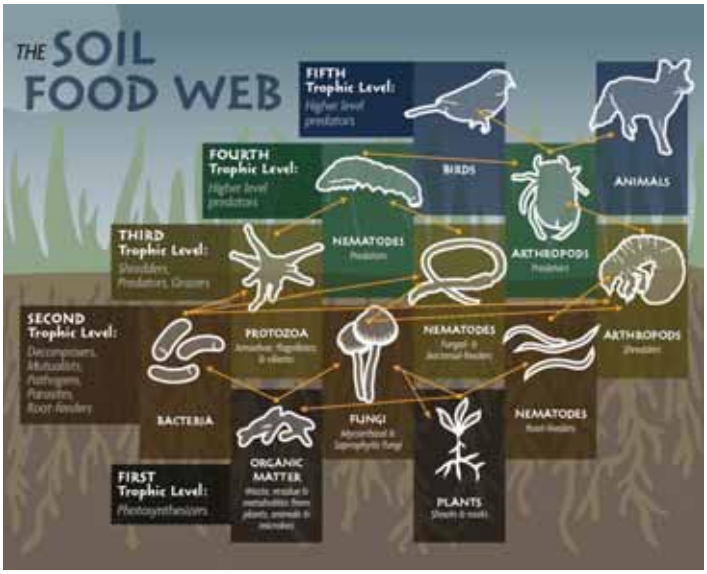


Figure 7. Components of the soil food web (Ingham 2000).
Credits: Stacey Jones, UF/IFAS

# Ways to Improve Urban Soils and Make Your Landscape Environmentally Friendly

Managing a landscape planted in disturbed urban soils can be challenging. The homeowner should recognize that these soils may create opportunities for pollution from lawn and landscape fertilization. Ideally, a new home buyer can have some control over the landscape soil development before landscape plants are installed. If confronted with poor urban soils, the homeowner has options to improve the health of the landscape plants and reduce the environmental impacts of landscape management. Soil compaction, high pH levels, and lack of organic matter are major factors in urban soil that lead to water and nutrient management challenges. The homeowner can have an impact on these soil characteristics.

## Soil Compaction

The first step a homeowner should take is to assess the soil for compaction. Detailed soil tests can be done to make this determination. These tests include measuring soil bulk density and penetration resistance with a penetrometer. These tests are not always easily available so the homeowner is advised to check with the local UF/IFAS Extension office (http://solutionsforyourlife.ufl.edu/map/) about the availability of soil compaction tests or for names of available services. Alternatively, the homeowner can observe the landscape for standing water or conduct a simple test of soil compaction with a shovel or soil probe. Compacted soil makes it difficult to push a shovel, hollow tube, or metal rod into the ground more than a few inches.

## High Variability in Nutrient Content and pH Level

Next, a soil sample should be taken from several areas in the landscape and analyzed separately to determine soil nutrient levels and soil pH. Your local county UF/IFAS Extension office has more information about testing the soil in your landscape. The soil test results can guide you to proper decisions about pH management and fertilizer needs of plants to be installed. Also, during soil sampling you can observe any areas of compacted soil. Please refer to *Soil Testing and Sampling for the Home Landscape or Vegetable Garden* by Amy L. Shober and Rao S. Mylavarapu at http://edis.ifas.ufl.edu/ss494. More information and guidelines on the physical and chemical assessment of the soil at the site is presented by Shober, Weise, and Toor (2013) (http://edis.ifas.ufl.edu/ss534).

Modifying the soil pH, especially high soil pH, is challenging. This is made especially difficult where we irrigate with basic (high pH) well or municipal water. Landscaping with plants tolerant of high soil pH conditions is a good approach. Chemically reducing soil pH with sulfur additions may help, and using "acid-forming" ammonium or urea-based nitrogen fertilizers is beneficial but usually the effect is temporary. Relying on rainfall or harvested rainwater as much as possible also helps to minimize additions of high-pH irrigation water. Organic matter should be added to the soil when replacing plants in the landscape. Shober, Wiese, and Denny (2011) provide guidelines for reducing the soil pH in the landscape. These approaches help to improve plant growth, increase the efficiency of fertilizer and water use in the landscape, and reduce the likelihood of nutrient losses from the landscape.

## Poor Soil Structure and Low Organic Matter

The ideal composition of organic matter in the soil consists of currently living and recently living organisms and fresh, decomposing, and stabilized (fully decomposed) organic matter (Figure 8). As the organic matter degrades, it increases the soil's nutrient- and water-holding capacities. The process of incorporating organic matter into the soil breaks up compacted soil areas. Organic matter improves soil structure, reduces compaction, and helps moderate soil pH increases.

The best course of action for soil improvement is to build organic matter in the landscape over time to achieve the desired proportions of the various organic matter components. Depending on where it is used, organic matter can be

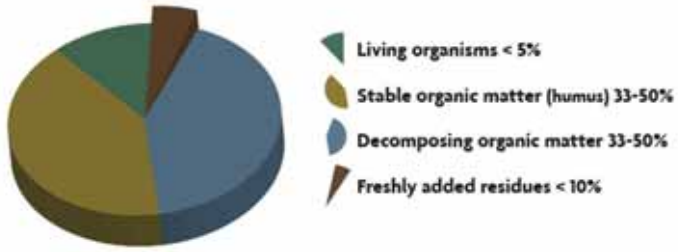


Figure 8. Ideal mixture of soil organic matter components (Ingham 2000).
Credits: Stacey Jones

applied by several methods.

For established plant beds, the easiest method is to use compost made from grass clippings and other organic materials. Turfgrass clippings should be put on the lawn where they can decompose and return organic matter and nutrients. Compost can be applied as mulch or topdressing to landscape beds, but use fully composted materials for incorporation into the soil. As a rule of thumb, compost should not have any recognizable pieces of organic matter (e.g., sticks, leaves, wood chips, etc.).

To prepare a new plant bed, compost can be mixed into the root zone before planting. This mixing can be done with a shovel; use a rototiller for larger areas. However, a tiller should not be used in areas that contain established trees or woody shrubs. The root systems of these plants extend well outside the canopy, and a tiller can cause serious root damage. Use the free service "Dial 811" to determine where electrical and data/phone wires are located.

Increasing soil organic matter has positive effects on nutrient and water management in the landscape. Organic matter helps hold water and nutrients in the soil, likely reducing the amounts of fertilizer and irrigation required. Improving soil quality with organic matter reduces the potential for nutrient losses from the landscape, making your home site more environmentally friendly. As improvements are made and the landscape matures, some of these problems such as compaction and lack of microbial biological activity will be resolved.

When attempting to improve soil quality, patience is important, because conditions may take years to improve.

## Plant Selection

Choosing the right plant for the right place in your landscape is an important part of creating a Florida-Friendly landscape. Sometimes there is little you can do to drastically change the soil in the landscape. Selecting plants that tolerate or thrive in poor soil conditions may be the most effective and least expensive approach. To learn which plants can tolerate high soil pH conditions, see *The Florida-Friendly Landscaping™ Guide to Plant Selection & Landscape Design* at http://fyn.ifas.ufl.edu/pdf/FYN_Plant_Selection_Guide_v090110.pdf.

# Summary

Soil is the basic building block of any landscape, but home construction practices can result in challenging management issues for soils in the home landscape.

Disturbed urban soils can result in poor plant growth, increased water and fertilizer requirements, and increased susceptibility to pests and disease. Elevated pH levels and high soil compaction can lead to serious water quality

issues if homeowners do not take the right steps to improve soil quality. The best course of action for homeowners is to start with a soil assessment and soil tests, and then to build organic matter in the landscape over time. The addition of organic matter content increases nutrient- and water-holding capacities and makes the soil easier to till for planting. Correcting soil quality problems in the landscape development stage results in a more Florida-Friendly landscape with reduced water pollution and nutrient loss.

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