Dealing with Damaged Suburban Soils

PART 2

Before you plant, know what you're working with: The best design and the healthiest plants won't survive in compacted, compromised soil. In Part 1 of this two-part article (June 2011), you learned about soil basics. Here, you'll learn how to improve the suburban soil you encounter.

BY JOE BOGGS AND JIM CHATFIELD

How do we deal with damaged soils? The first step is to develop an understanding of soil basics; you must know exactly what has been damaged in order to undo the damage. This is the second part of a two-part series on soil basics.

In Part I, we introduced the three soil properties that are used to describe the general characteristics of soil: the **physical properties**, such as soil texture; the **chemical properties**, such as pH and Cationic Exchange Capacity (CEC); and the **biological properties**, such as soil microorganisms. We closely examined the physical and chemical properties and explained how they affect our ability to grow healthy plants.

In this article, we will dig deeper into the biological properties. Understanding how the biological properties affect soil structure is key to understanding how we can repair damaged suburban soils. (For a brief review of soil structure, see sidebar below.)

How soil is put together

We introduced "soil texture" in Part I. This is a physical property that is determined by measuring the percent of sand, silt and clay in the soil; these are the "mineral components." Soil texture is like the basic construction materials used to build a house. Sand, silt and clay are like the nails, lumber, brick and cement that are eventually put together to form a recognizable structure—a Cape Cod revival home, a Neo-Victorian or perhaps even a McMansion. A pile of sand, silt and clay is no more recognizable or functional as soil as a pile of construction materials is functional as a home.

"Soil consistency" is a term used to describe the general organization of the soil, with the soil being placed in one of the following descriptive categories: loose, friable, firm and extremely firm. Soil consistency is usually a temporary condition. For example, soil that is rototilled will become loose, or friable. However, once the soil is watered—or stepped on during planting—the soil collapses and could even become firm. Soil consistency is much like a house in the very early stages of construction: It does not have a final form, and it could fall apart.

"Soil structure" describes how the soil is put together in its final form. The concept is very different from the basic building blocks represented by soil texture, or the loosely organized particles found in soil consistency. Soil structure is like the end product of home construction: The home is solid, and the style is clearly recognizable.

Biological properties and soil structure

"If a healthy soil is full of death, it is also full of life: worms, fungi, microorganisms of all kinds ... Given only the health of the soil, nothing that dies is dead for very long."—Wendell Berry, *The Unsettling of America*.

Healthy soils are home to a staggering number of micro- and macroorganisms. For example, research by Serita Frey of the University of New Hampshire has shown that a healthy cup of forest soil contains: 50,000 arthropods; 100,000 nematodes; 20 million protozoa; 200 billion bacteria; and 60 miles of fungal hyphae. These organisms play a vital role in the development of soils with good structure to support healthy plants.

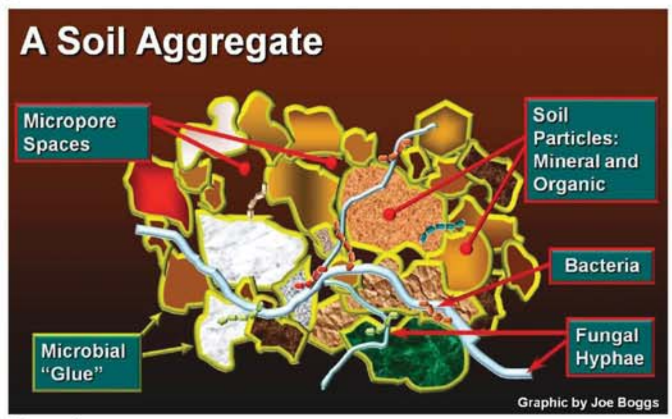

Figure 1

Soil organisms exude a range of sticky substances into the soil; most of the substances are waste products. These sticky substances cause soil particles to stick together, so the substances are called "microbial glue." A small collection of soil particles that are stuck together by microbial glue is called a "soil aggregate," and soil that contains a large collection of aggregates is called "aggregated soil." Soil aggregates include both mineral particles (sand, silt, and clay) as well as organic particles. Keep in mind that microbial glue is not Super Glue®; the aggregates are easily broken apart by compaction or even tilling.

Note in Figure 1 that within the soil aggregates are tiny spaces called "micropores." While water and air can exist within the micropores, their extremely small size limits their effectiveness in allowing water to move through the soil, as well as their ability to hold sufficient oxygen to support healthy plant roots. However, these tiny pore spaces are important for nutrient retention and exchange, particularly in clay soils. Between the aggregates are large spaces called "macropores" (Figure 2). These large pore spaces allow water to easily move

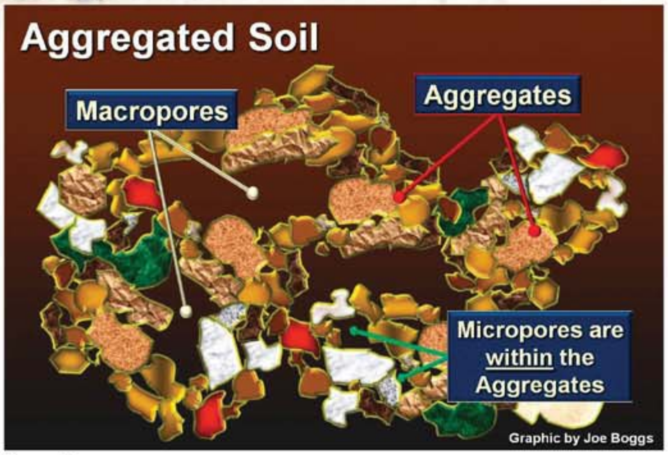

Figure 2

through the soil, and the pores hold large amounts of air—the oxygen required to support the growth and health of plant roots. Thus, aggregates endow soil with a good structure for plant growth. Check out the sidebar, "Soil aggregation, soil moisture and soil fertility" below for more.

Dealing with damaged soil

The first step in dealing with damaged soil is to diagnose exactly what happened to the soil; in essence, you need to learn the history of the soil. Was the topsoil compacted during construction, or was it removed? Do not make a diagnosis based on "face value"; compacted soil often mimics subsoil! Diagnosing the problem may require some investigation.

Compaction is generally viewed by landscapers as the ultimate offense. However, the total loss of topsoil is a far greater crime, because there is only one quick fix and it is usually very expensive. Topsoil is a precious natural resource. It arrived by the action of glaciers, wind or water, or it evolved through the weathering of rocks in the subsoil (Horizon "B"). The time required for subsoil to naturally evolve into topsoil is measured in tens of hundreds, perhaps even thousands, of years. No amount of organic matter applied to the site, or magical incantations spoken over the subsoil, will hasten the process.

Put simply, the most effective way to deal with loss of topsoil is to return topsoil to the site. Ideally, topsoil that is

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Figure 5 - Although compaction causes serious damage to the soil, it leaves behind all of the preexisting soil horizons; the organic layer and topsoil have just been squeezed down.

Soil aggregation, soil moisture, and soil fertility

Figure 3 is a classic graphic showing the relationship between soil texture and soil moisture. We introduced this graphic in Part I and noted it clearly shows that clay holds on to more water compared to sand. We explained that clay particles hold on to water because of their high surface-to-volume ratio compared to sand and because the positive side of bipolar water molecules will attach to the negative sites on clay particles; just like opposite ends of bar magnets attach to one another. However, the graph is solely based on soil texture; the data behind the graph were collected from non-aggregated soil.

Soil aggregation changes everything. Figure 4 illustrates what happens when a clay soil is aggregated. Notice that water easily moves through the soil profile by flowing through the macropores between the aggregates. In fact, research has shown that aggregated clay soil may drain as quickly as sandy soil.

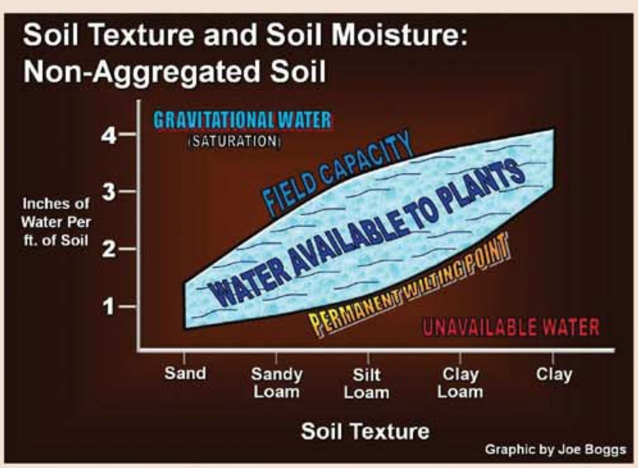

Figure 3

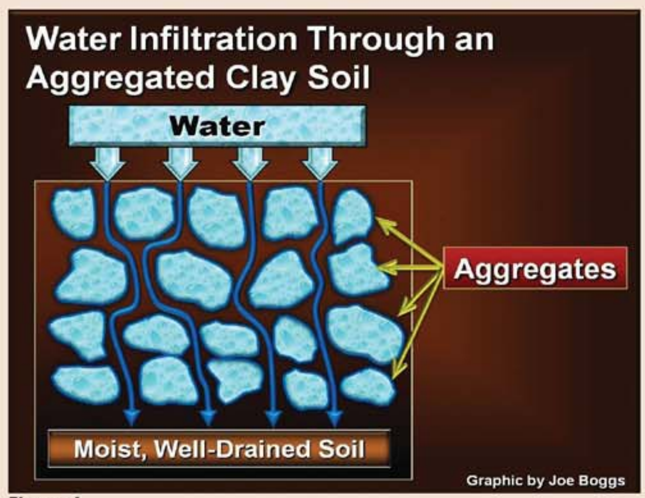

Figure 4

The clay particles within the soil aggregates still retain the textural characteristics illustrated in Figure 3. The particles will still hold on to water to be released over time to support plant growth; the "water available to plants" continues to hold true in aggregated soil. Thus, through soil aggregation, even clay soil can be made to achieve the sought-after condition of a "moist, well-drained soil."

Additionally, as we learned in Part 1, clay has a very high CEC. The clay particles in aggregated clay soil will hold on to plant nutrients rather than allowing them to wash through the soil as with sandy soils. The high nutrient and water holding capacity of clay means that enhancing aggregation in clay soil to improve drainage is much more effective relative to supporting plant growth compared to replacing soil with sand to improve water drainage.

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removed during building construction should be stockpiled and returned whence it came. Unfortunately, it is a common practice for developers and contractors to sell some or even all of the topsoil. Thus, new topsoil may need to be purchased. How much is needed? Take a look around the area to determine the depth of the native topsoil. The new topsoil should match the depth of the topsoil that was removed—thus the expense!

The new topsoil should be assessed to make certain it is of good quality and compatible with the subsoil. For example, if the subsoil is composed of sand-based material, topsoil that is high in clay will produce a soil incompatibility problem. The new topsoil should also contain organic matter. As we shall see, organic matter is essential to supporting organisms that will ultimately produce good soil structure.

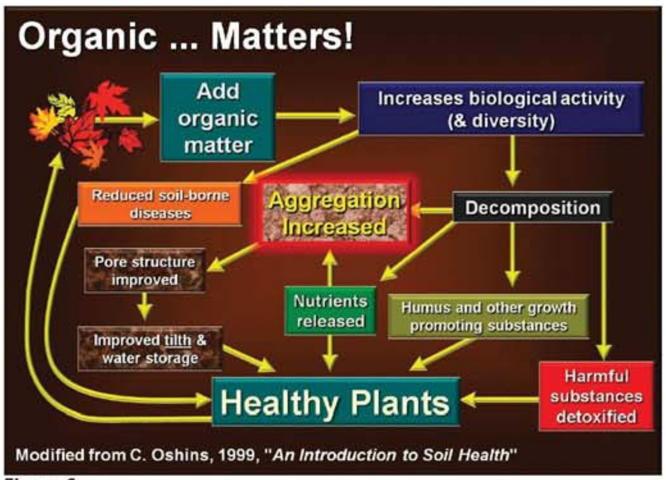

Figure 6

Although compaction causes serious damage to the soil, it leaves behind all of the preexisting soil horizons; the organic layer and topsoil have just been squeezed down. While the aggregates have been broken apart and the macropores eliminated, all of the soil particles that were once arranged into a structural home to healthy plant roots remain in place; the house has just been knocked down.

It is often said that once soil structure has been destroyed, it can never be recovered. This is only partially true. While the original soil structure cannot be recovered, good soil structure can be revived with a little time and attention focused on supporting the soil organisms that produce the microbial glue that bonds soil particles into aggregates. In fact, there is nothing magical about the aggregation process; it's natural.

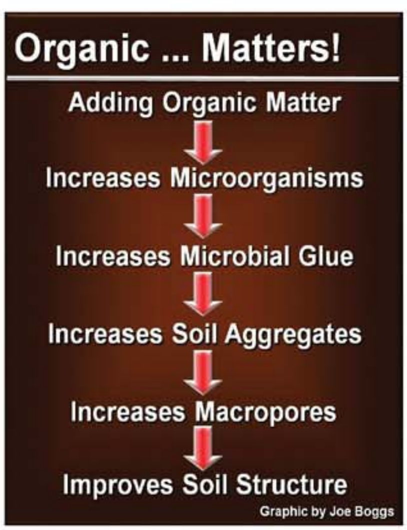

Figure 7

Carbon : Nitrogen Ratios

Material	C:N Ratio
Newspaper	600 : 1
Fresh Sawdust	400 : 1
Oak Leaves	90 : 1
Wheat, Oat, or Rye Straw	80 : 1
Horse Manure	50 : 1
Alfalfa Hay	20 : 1
Dairy Manure	25 : 1
Poultry Manure	18 : 1
Compost	15 : 1
Clover and Alfalfa (early)	13 : 1

A ratio above 30:1 may cause problems with soil nitrogen deficiency

Graphic by Joe Boggs

Figure 8

Putting the good stuff back

Horace said: "Naturam expellas furca, tamen usque recurret." Translation? "You can drive nature out with a pitchfork, but she always comes back."

Figure 6 illustrates the substantial benefits of adding organic matter to the soil. The organic matter increases biological activity, which in turn increases soil aggregation. Indeed, soil aggregation is a central theme; note the central location of the box labeled "Aggregation Increased." The box labeled "Pore structure improved" refers to an increase in the number of macropores in the soil. Remember that macropores only exist in aggregated soil. Once aggregation occurs, there is improved soil "tilth"; this term refers to soil structure. Improved tilth means improved soil structure.

Figure 7 illustrates exactly how adding organic matter improves soil structure. However, improving soil tilth takes time. That's because the entire process is connected to the amount of microbial glue generated by soil organisms. How can we enhance the process? We can make the process more efficient by enhancing biological diversity in the soil.

The organic matter we add to the soil is used by soil organisms as food; we refer to their feeding activity as "decomposition." There are multiple steps in the decomposition process with each step involving different groups of organisms converting larger pieces of organic matter into smaller pieces. It is important to keep in mind that biological diversity in the soil is directly linked to the diversity of the organic matter that is added to the soil.

All organic matter is not equal. Figure 8 shows the carbon to nitrogen (C:N) ratios for several forms of organic matter. Note that a C:N ratio above 30:1 may cause the soil to become too deficient in nitrogen to support healthy plants. Consider the role of meat and potatoes in our own diet: The meat provides us with nitrogen; the potatoes provide carbon. If the C:N ratio of the organic matter in the soil is above 30:1, there is not enough nitrogen (meat) for the microorganisms to have a balanced diet when they utilize all of the carbon (potatoes). So, the microorganisms draw nitrogen from the soil at the expense of plants; they steal meat off the plant's plate.

Using different forms of organic matter increases microbial diversity in the soil by providing a varied diet for microorganisms. You would probably attract a very select group of friends if you only served meat and potatoes in your home. Using a wide range of organic matter in the soil will support wide-ranging groups of microorganisms; each group is associated with a particular step in the decomposition process.

The fix is in the soil

So, how do we "fix" damaged suburban soil? Obviously, we must add organic matter back into the soil. One method is to simply spread organic mulches over the soil surface. Organic mulches begin to decay almost as soon as they are applied; some mulches decay faster than others. As large pieces of mulch become smaller pieces, the smaller particles work their way into the soil by frost/freeze action or by water washing the particles into the soil. Of course, this takes time. Organic mulches are best used to maintain a constant infusion of organic matter into the soil rather than to introduce organic matter into damaged soil.

> The best way to deal with damaged suburban soil is to prevent it from happening in the first place.

The most effective way to add organic matter into compacted soil is to use a rototiller. Although rototillers will destroy soil structure by grinding up soil aggregates, a tiller is an essential tool for correcting damage caused by soil compaction. A rototiller will mix organic matter deep into compacted soils, while at the same time loosening the soil (improving soil consistency) and introducing oxygen to support aerobic decomposition of the organic matter. Once the soil has been mixed and plants installed, tilling should be avoided to allow soil aggregation to occur. Organic mulches will provide a constant infusion of organic matter into the soil. Mulches also reduce the loss of organic matter from the soil by oxidation.

Effectively improving soils beneath landscape trees and shrubs has long been a problem. However, the challenge has been lessened with the introduction in recent years of tools such as an Air-Spade® or a Supersonic Air

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Knife®. These devices use accelerated air to remove soil without damaging roots. For example, soil problems can be corrected beneath planted trees by using one of these devices to remove and replace the soil, usually within the dripline. The technique is generally reserved for small trees due to the risk of making larger trees unstable.

Larger, established trees can benefit from "radial trenching," where an Air-Spade or a Supersonic Air Knife is used to dig trenches away from the trunk of the tree in a radial pattern, like spokes on a wheel with the trunk being the hub. Remember that the accelerated air does not damage roots. The same technique can also be used to improve soil conditions when planting a new tree. Research has shown that backfilling the trenches with improved or amended topsoil (e.g. mixed with organic matter) enhances root growth and development.

Figure 9 - The most effective way to add organic matter into compacted soil is to use a rototiller. Although rototillers will destroy soil structure by grinding up soil aggregates, a tiller is an essential tool for correcting damage caused by soil compaction.

Figure 10 - An air knife removes soil from a tree root zone without damaging the roots. The technique is generally reserved for small trees due to the risk of making larger trees unstable.

Figure 11 - Larger, established trees can benefit from "radial trenching," where an Air-Spade or a Supersonic Air Knife is used to dig trenches away from the trunk of the tree in a radial pattern.

Figure 12 - A CRZ—critical root zone—should be created around mature trees to keep construction equipment from compacting the soil near established roots.

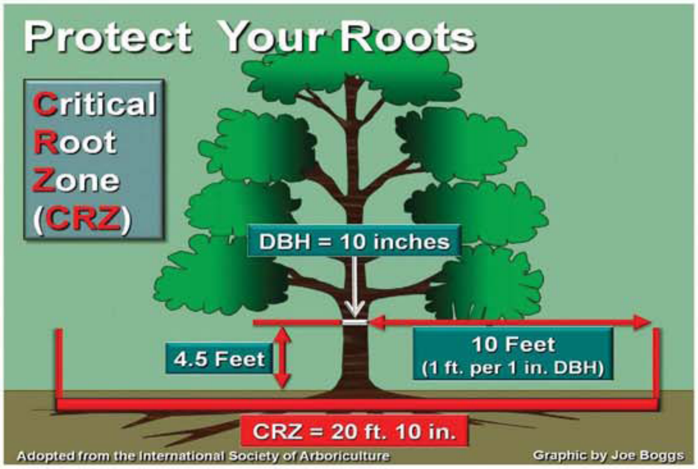

Figure 13

Prevention is the best policy

Finally, the best way to deal with damaged suburban soil is to prevent it from happening in the first place. We should shift our efforts from wringing our hands over soil that was damaged during construction to working with developers and contractors to prevent damage to the soil. This may not be easy, or always possible. However, an ounce of prevention is worth pounds of cure—in topsoil, organic matter, money and so on.

If construction is occurring near established trees, "keep out" zones can be created to prevent soil compaction and root damage. These protected zones carry a number of designations including Tree Protection Zones (TPZ), Protected Root Zones (PRZ) or Critical Root Zones (CRZ). Protected zones are usually cordoned off with temporary fencing or ropes.

Unfortunately, there is no agreement among researchers and practitioners regarding the best method to calculate the total area that should be protected. However, some protection is better than none. Figure 13 illustrates how to calculate the CRZ recommended by the International Society of Arboriculture (ISA). The ISA's CRZ is defined as an area equal to an increase of 1 foot in radius from the trunk for each 1 inch of the tree's diameter at breast height (DBH), which is measured 4.5 feet above the grade. For example, the tree in our CRZ illustration has a DBH of 10 inches, so the radius of the CRZ would be 10 feet.

Regardless of the name given to the protection zone, or the method used to calculate the area, the goal remains the same: to prevent damage to the soil and plant roots. Why is it so important to protect our soil?

William Butler Yeats said it best: "All that we did, all that we said or sang / Must come from contact with the soil ... ."

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