NRCS's Guide to Urban Soil Types

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Urban Soil Primer

For homeowners and renters, local planning boards, property managers, students, and educators

Contents

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Cover: Urban scenes and soil profiles from across the United States.

Preface

The *Urban Soil Primer* is intended to give planning officials and people who live in urban areas an introduction to soils. It provides information important in planning and managing land resources in a manner that helps to prevent or mitigate problems associated with sedimentation, contamination, runoff, and structural failure. In nontechnical language, this publication describes the basic processes and functions common to all soils. Much of the complexity of soil science is simplified, and many sensitive issues are discussed only in passing.

This primer lists many affordable resources available to people seeking information about soils in urban areas. These resources include government agencies, such as the Environmental Protection Agency (www.epa.gov), which provides information about contamination, and the Natural Resources Conservation Service (www.nrcs.usda.gov), which provides assistance with conservation planning and implementation through local field offices. The Natural Resources Conservation Service (NRCS) provides leadership in a partnership effort to help people conserve, maintain, and improve our natural resources and environment. Other resources include universities, private consultants, and nonprofit groups experienced with soils in urban areas.

This primer provides the basic vocabulary and key concepts needed for further explorations in urban soil survey and for the development of interpretive guidelines for specific local uses by soil type. Many of the terms used in this publication are defined in the Glossary. The primer was produced by staff at the NRCS National Soil Survey Center with assistance from a cadre of NRCS field soil scientists. It is available as a printed booklet and as a compact disc (CD), or it may be downloaded from the NRCS Web site (http://soils.usda.gov/use).

Contact your State or local office of the Natural Resources Conservation Service for more information. Visit http://offices.usda.gov/scripts/ndCGI.exe/oip_public/USA_map to find the NRCS field office near you.

Welcome to the fascinating field of urban soils.

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Chapter 1: Introduction

Soil is an amazing, mostly natural material that covers nearly all of the land surface of the earth. Soil, along with water and air, provides the basis for human existence. It is the interface between the earth's atmosphere and bedrock or ground water. It has either formed in place or has been transported to its present location by wind, water, ice, gravity, or humans. Soils may have been deposited thousands or millions of years ago by volcanoes, glaciers, floods, or other processes or were delivered to the site by truck or other mechanical device an hour ago, a week ago, or several months ago. These facts illustrate why soils are very complex. Soil functions, as part of a natural ecosystem, are also very complex and diverse. Basic knowledge about soil allows us to use it wisely.

The primary goal of this publication is to help people who live in cities understand soil and to help them know where and how to get information about soil. Knowing about soil and its potentials and limitations helps urban planners and those living in urban areas to make good decisions about using their soil as a basic and valuable resource. Soil is the basic raw material and common link to all projects whether one wants to build a park, a street, a golf course, or a large building, landscape a yard, or just plant a backyard garden. Soil lies beneath each activity!

Figure 1.1: Urban garden.

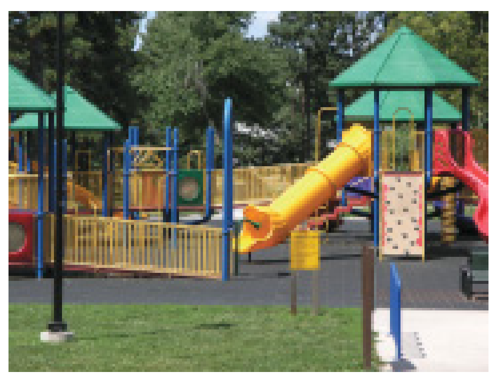

Figure 1.2: Playground.

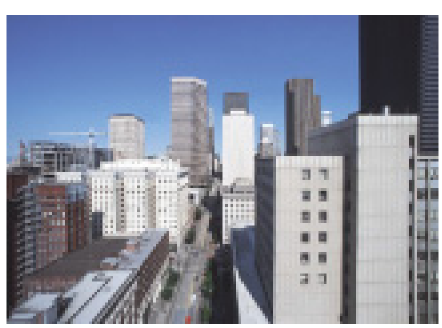

Figure 1.3: City skyline.

Urban project managers and homeowners can predict a soil's behavior under similar situations when they know how soil responds to the same use in other locations. Similar kinds of soil tend to behave in the same ways. There are more than 22,000 different soils identified and mapped in the United States. Some States recognize more than 1,000 different kinds of soil. Knowing soil responses to specific uses allows engineers and others to design projects that will not require high maintenance costs, will last a long time, will not harm individuals, society, or ecosystems, and will not fail and/or require expensive repair and/or removal costs.

Figure 1.4: Urban development.

Growth Trends in Urban Areas

Figure 1.5 demonstrates that urban areas are expanding at a rapid rate within the United States. Urbanization is also a worldwide issue. Soils that are best suited to other uses, such as providing food and fiber for our Nation, are commonly the easiest to use as sites for homes and cities. Urban areas often expand into surrounding forestland, rangeland, or agricultural land areas because these areas are adjacent to existing urban areas. Prime farmland is vanishing at a alarming rate in certain regions of the United States because of urban expansion and development (figure 1.6). We must balance the increasing size of urban areas with our need for food and fiber.

Urban areas occur all across the USA, from coastal areas to areas high in the mountains, and soils occur in such areas as parks, playgrounds, lawns, and gardens. These soils are similar in some ways to soils in rural areas, but in other ways they are very different. A basic understanding of urban soils will help you learn more about this valuable resource. As urban areas grow and change, so must the management of natural resources surrounding and within those areas.

We invite you to continue to explore the complex, fascinating, and fun science of urban soils.

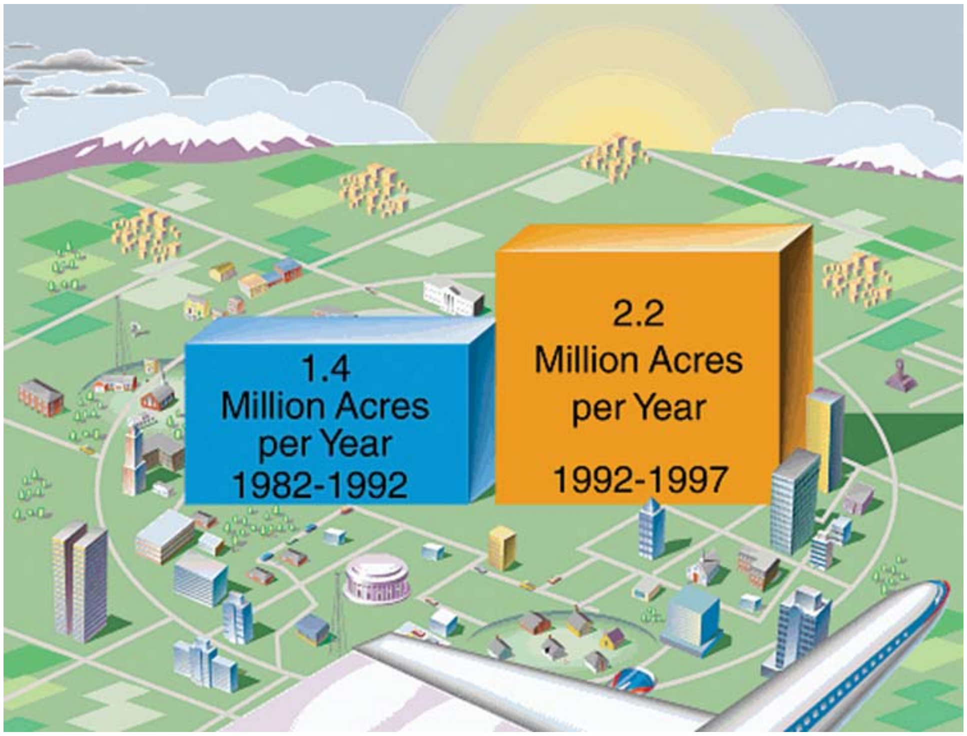

Figure 1.5: Land converted to urban development from 1982 through 1997 (NRCS, NRI).

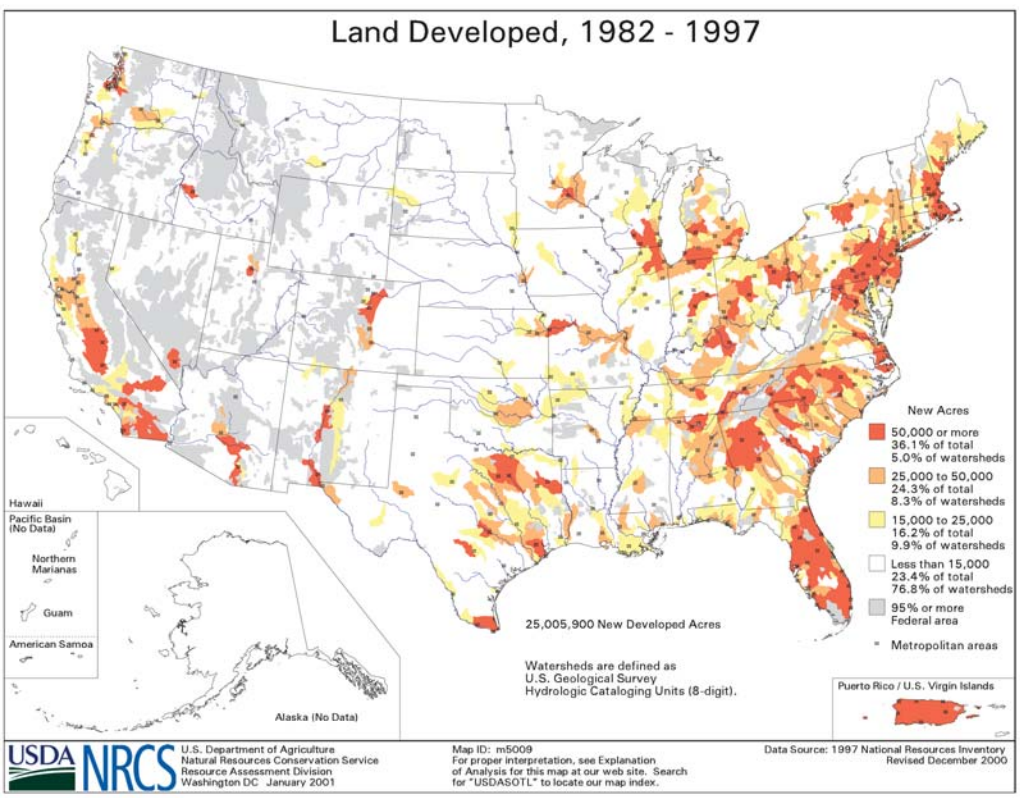

Figure 1.6: Annual rate of urban development from 1982 through 1997 (NRCS, NRI).

Chapter 2: Basic Soil Properties

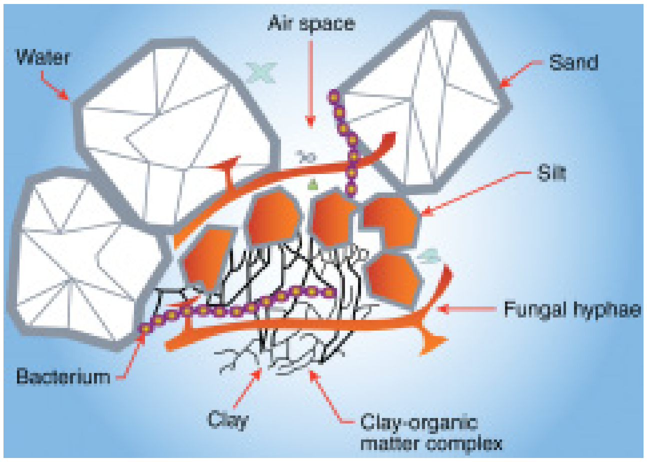

Figure 2.1

Soils in an urban area may share some properties with soils in forests, pastures, cotton fields, or even other urban areas. There are large differences in soils as they naturally occur in forests, farmed fields, and grazing land areas, and these differences are changed when an area is converted to an urban area. Soil scientists have developed conventions and language to communicate among themselves. It is important that we share scientific information with everyone, not just other scientists and professionals. Soil properties, such as soil texture and structure, particle-size distribution, soil reaction, and bulk density, help us to understand and predict how soils react and respond to different uses. Construction activities, compaction, and surface sealing dramatically change soil properties and can sometimes result in a reduced ability to perform the critical functions or activities of natural soil.

Topics in this chapter:

- **Soil variation**
- **Soil components**
- **Soil-forming processes**
- **Soil horizons**
- **Measuring and monitoring soil properties**

Soil Variation

What is soil and why is soil important to each of us? Traditionally, soil is defined as a dynamic natural body that is made up solids, liquids, and gases, occurs on the earth's surface, contains living matter, and supports or is capable of supporting plants. Bockheim (1974) defines urban soil as "soil material having a non-agricultural, man-made surface layer more than 50 cm (20 inches) thick that has been produced by mixing, filling, or by contamination of land surface in urban and suburban areas." In some important ways, soils of urban areas differ from soils of other areas.

Differences in urban soils have been observed and recorded by scientists, engineers, equipment operators, and construction workers for a long time. Even within urban areas, there is a multiplicity of soil conditions, ranging from "natural" soils that are relatively undisturbed to soils in which the natural materials have been mixed or truncated, to soils that formed in added materials, or fill, of varying thickness. Each of these areas, in turn, can be subject to different types of use and management, which can further affect their soil properties. Soils in urban areas can be divided into two general types: *natural* soils, which formed in material naturally deposited by water, wind, or ice or in material weathered from the underlying bedrock, and *anthropogenic* soils, which formed in human-deposited material, or fill (table 2.1). Anthropogenic soils are almost anywhere in the urban environment. The purpose of adding fill to an area may be to alleviate undesirable soil properties or to modify the urban landscape for specific activities.

Table 2.1: Examples of Fill Material in Urban Soils

- Natural soil materials that have been moved around by humans
- Construction debris
- Materials dredged from waterways
- Coal ash
- Municipal solid waste
- A combination of any or all of the above

Characteristics of soil in any urban area depend on many things. They depend on how deep the site has been excavated during construction and if new materials were brought in and mixed with the original soil materials. They depend on the properties of the original natural soil and the past uses of the site. Many times topsoil is removed from the site prior to construction and may or may not be returned to the site. After excavation, subsoil may be placed as fill over topsoil. Changing the order of the soil layers or mixing the topsoil and subsoil can alter soil properties. These variables make predicting soil behavior difficult in urban areas.

Soil Components

All soil is made up of air, water, numerous kinds of living and/or dead organisms (organic matter), and mineral matter (sand, silt, and clay). In the urban arena, it includes many manmade materials. The amount of each of these soil components varies from one place to another in the world or from one kind of soil to another. Soil components can vary dramatically within distances of only a few feet on the same landscape.

Soil composition can be dramatically changed by pedestrian or vehicular traffic, especially when the soil is wet. The soil components most easily changed are the amounts of soil air and water. Imagine the change in soil composition at construction sites after large trucks and heavy construction equipment drive over a soil and compact it. Imagine people walking and playing on wet soils in city parks and recreation areas or yards. Note the differences in percent of soil air and soil water in figures 2.2 and 2.3. Figure 2.2 illustrates the general composition of a natural soil. Figure 2.3 illustrates the general composition of a soil that has been compacted by heavy traffic. As soil particles are squeezed together, pores for air and water are reduced in size and number (figure 2.4). The reduced pore space changes the way a soil handles water intake and water movement throughout its layers, or horizons.

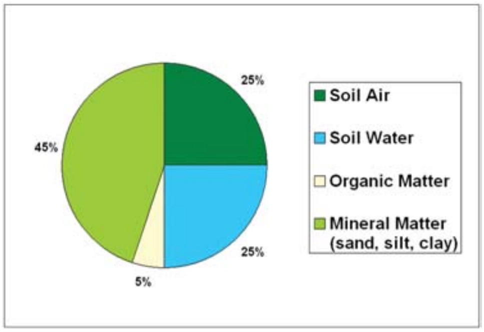

Figure 2.2: Composition of a natural soil, by weight.

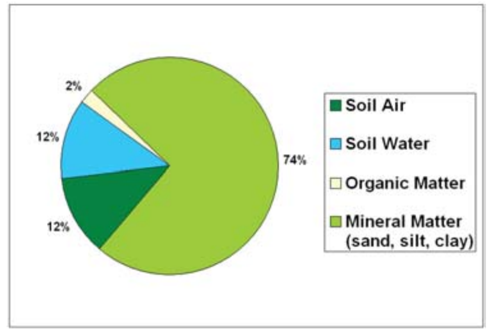

Figure 2.3: Composition of a compacted soil, by weight.

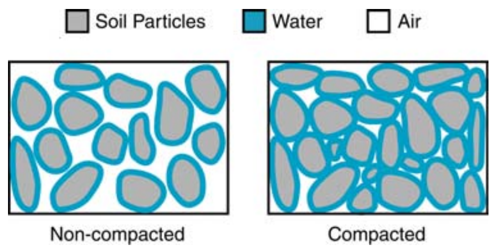

Figure 2.4: Soil pore space.

Soil-Forming Processes

Soils form through a group of processes no matter where they are located or what they are used for. All soils form because of four processes operating along with five basic soil-forming factors. The four processes that operate on soil material are additions, transformations, translocations, and losses (figure 2.5). We are able to map, classify, and interpret soil because a given set of environmental factors produces a predictable kind of soil.

The soil-forming factors are parent material, climate, living and dead organisms, time, and landscape position. When all soil-forming factors are similar, a similar soil is produced. If we change one or more of the soil-forming factors significantly, then a different soil is produced.

Additions to soil generally include organic matter, fertilizer, pollutants, and deposits of soil material. All of the additions change a soil and how it functions. In urban areas new soil material is sometimes added on top of an existing soil. If thick enough, the new layer or layers can change the way the soil develops. When a layer of concrete or asphalt is added to the top of a soil in areas where streets, parking lots, or driveways are built, additions to the soil are suddenly altered, restricted, or even stopped.

Transformations are changes that take place within a soil. In figure 2.5, transformations are illustrated by the letters x and y and the arrows that connect them. During transformation processes, material does not leave the soil but is simply changed from one form to another or from one compound to another. Micro-organisms and earthworms play an important role in soil transformations. Earthworms eat soil and plant materials and transform them into organic material that provides food for plants and other organisms. Chemical weathering changes parent material, such as rocks and sand grains, and creates new minerals and/or smaller particles. Rocks are transformed into sand grains, and sand grains are transformed into silt and clay particles over time. As iron particles change form, they change soil colors from gray to brown or to red and yellow. Applying too much fertilizer of certain kinds can transform a soil into one that is too acidic for plants to grow.

Translocations are movements of soil components from one place to another in the soil. Translocations can move materials from one soil layer to another and can even move the materials completely out of a soil. Water moves through a soil profile and carries clay particles, soluble salts, organic matter, and chemical compounds downward into the soil. Translocations can also be upward or horizontal. As soil dries and water evaporates from the soil surface, minerals and salts may move back toward the soil surface. In dry areas translocations are restricted because there is less water to carry compounds and materials deep into the soil. Compounds and minerals can move only as deep as water moves into a soil. Concentrations of soluble material generally are closer to the surface in dry areas than in other areas. Windthrow and the activity of animals (i.e., ants, termites, groundhogs, and worms) also can move soil components upward.

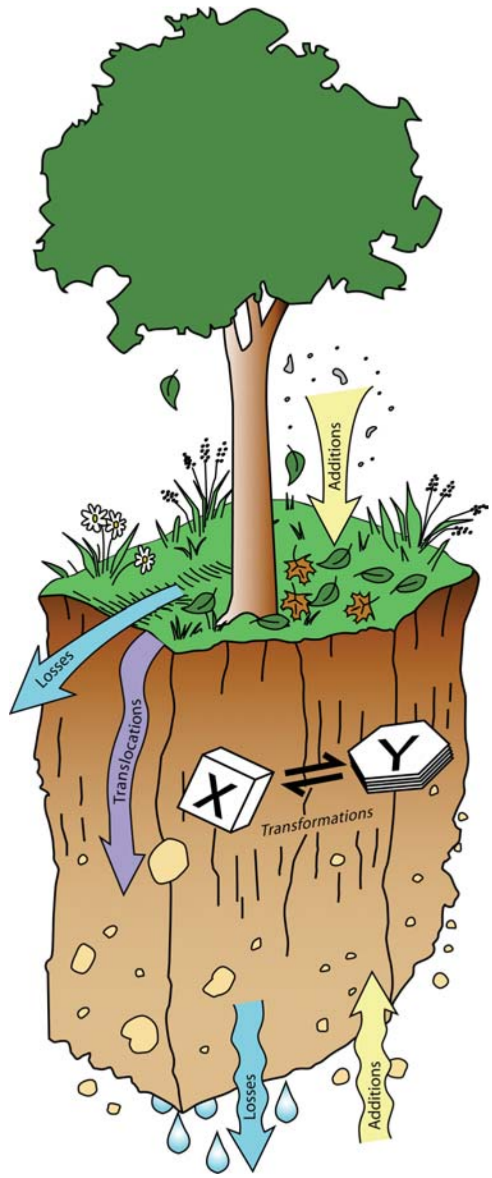

Figure 2.5: Soil-forming processes.

Losses occur when water moves material through and out of a soil profile. If enough water is available, soluble materials, such as sodium and calcium, are removed early in the process of soil formation. Lawn and garden fertilizers are relatively soluble and may be removed from a soil when too much water is applied. Ground-water pollution can occur if too much water is added to a soil that contains contaminates. Erosion by wind or water removes the soil particles and compounds needed for plant growth. Topsoil removed through water erosion in a given area can improve the soil in the area where the sediments are deposited.

Soil Horizons

Soils are made up of soil horizons, or layers, that form as the result of five soil-forming factors. The six major kinds of soil horizons are designated as O, A, E, B, C, and R (figure 2.6). All six of these horizons are not always evident in every soil profile.

For example, most agricultural soils do not have an O horizon because organic horizons are usually mixed with A horizons during tillage. Also, a soil has an R horizon only if bedrock is close to the surface.

O horizons are generally the uppermost layers and form on top of mineral horizons where they occur. They are formed by the accumulation of fresh and decaying plant parts, such as leaves, grass, needles, and twigs. O horizons are dark colored (mainly black or brown) because decomposing plant and animal materials produce humus. They are generally in forested or wet areas.

A horizons are below O horizons and are made up mostly of mineral material. They are characterized by the loss of iron, clay, and aluminum and the addition of organic matter by soil organisms. Hence, they are dark colored in most areas, except for extremely dry areas. A horizons are commonly referred to as topsoil.

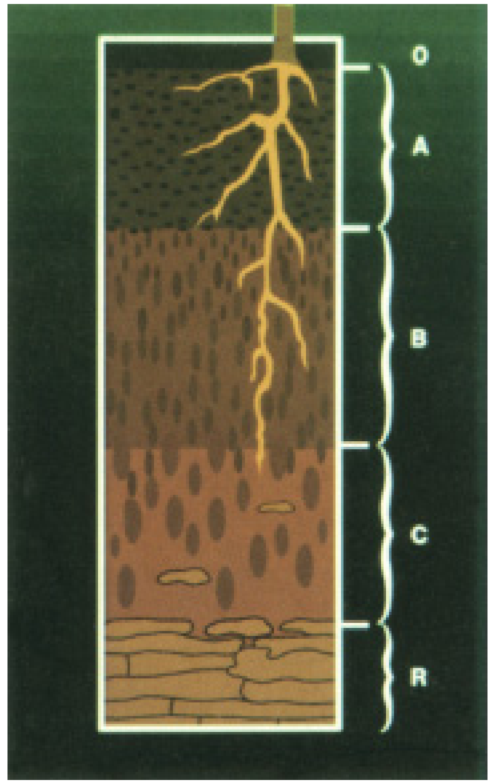

Figure 2.6:Natural soil profile with major horizons.

E horizon*s* are commonly in forested areas. The “E” stands for eluvial, which means that clay, iron, organic matter, and other minerals have been removed from this horizon. E horizons commonly appear white or lighter in color than the horizons above and below them.

B horizons are below A or E horizons and are characterized by the accumulation of iron, clay, aluminum, and other compounds. B horizons are commonly referred to as subsoil.

C horizons are below B horizons and are commonly referred to as the substratum. They are made up mainly of partially weathered or disintegrated parent material, but soft bedrock can also occur. Because C horizons are deeper in the profile, the effects of the soil-forming factors are less pronounced than the effects in the overlying A and B horizons.

R horizons are made up of bedrock. The bedrock can be far below or just a few inches below the surface.

Horizons in urban soils may not be fully related to the natural soil-forming factors but instead may be manmade layers formed by the deposition of dredge, fill, and/or mixed materials. Human artifacts, such as bricks, bottles, pieces of concrete, plastics, glass, pesticides, petroleum products, pollutants, garbage, and disposable diapers, are often components of urban soils. Manmade materials may be added to raise a landscape to a higher level, backfill ditches or foundation walls, or construct berms. In urban areas, human activity is often the predominant activity in making soil instead of the action of the natural agents of wind, water, ice, gravity, and heat.

Urban soils differ from natural soils because they have been altered to some degree. They have been excavated, compacted, disturbed, and mixed and may no longer possess their natural soil properties and features. Many highly disturbed soils in urban areas or on construction sites have not been in place long enough for soil-forming factors to significantly change them and to form soil horizons. In areas where

Figure 2.7: Urban soil profile.

fill materials have been in place for a considerable time (e.g., 50 years or so), the formation of A horizons and sometimes weakly expressed B horizons has been documented. Figures 2.7 and 2.8 show soil horizons in urban and natural soil profiles.

Measuring and Monitoring Soil Properties

Soil properties are measured at specific sites or sampled for laboratory analysis. The properties that can be described in the field include horizonation and layering, color, texture, structure, consistence, depth to bedrock, and drainage class. The properties that generally are measured in the laboratory include content of organic matter, particle-size distribution, clay mineralogy, reaction, exchangeable cations, and concentrations of contaminants. The soil characteristics that are estimated or calculated from the measured properties include engineering classification and erodibility.

Physical Soil Properties

Soil is a mixture of mineral matter, organic material, air, and water. The texture of a mineral soil is based on the amounts of sand, silt, and clay in the soil. Sand, silt, and clay are defined on the basis of the size of each individual soil particle. These size

A horizon

B horizon

C horizon

Figure 2.8: Natural soil profile.

relationships can be demonstrated by imagining that a sand particle is the size of a basketball, a silt particle is the size of a baseball, and a clay is the size of an aspirin tablet (figure 2.9).

Soil texture and other soil properties vary significantly within short distances on urban or natural landscapes. This variation is caused by the movement and mixing of soil materials during construction activities or changes in any of the soil-forming

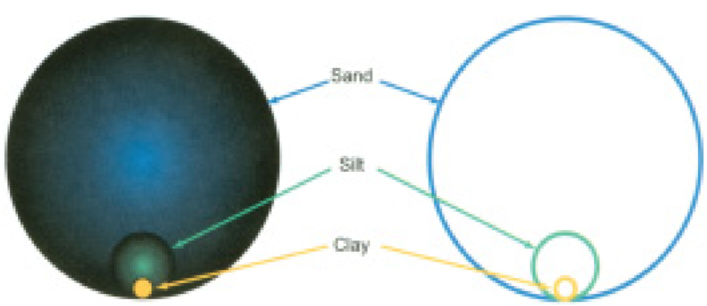

Figure 2.9: Relative sizes of sand, silt, and clay particles.

factors**.** The combinations of different textures may improve or limit the soil for a specific use.

Soil texture affects water and air movement through the soil as particles of different sizes pack together and thus determine the size and spacing of pores and channels. Sand particles have the largest pore spaces and allow water to drain through the pores most freely. Silt particles have smaller pore spaces, so water moves through them more slowly. Clay particles have very small pores, and so they tend to adsorb and hold more water. The mixture of particle sizes affects water, nutrient, and contaminant absorption. The specific type of mineral influences engineering properties, such as shrink-swell potential and excavation difficulty, especially in expanding clays (smectite), which behave like plastics.

The soil textural triangle (figure 2.10) can be used to determine soil texture from the relative amounts of particles of any two sizes. For example, a clay percentage of 15 with a silt percentage of 70 gives a soil texture of silt loam.

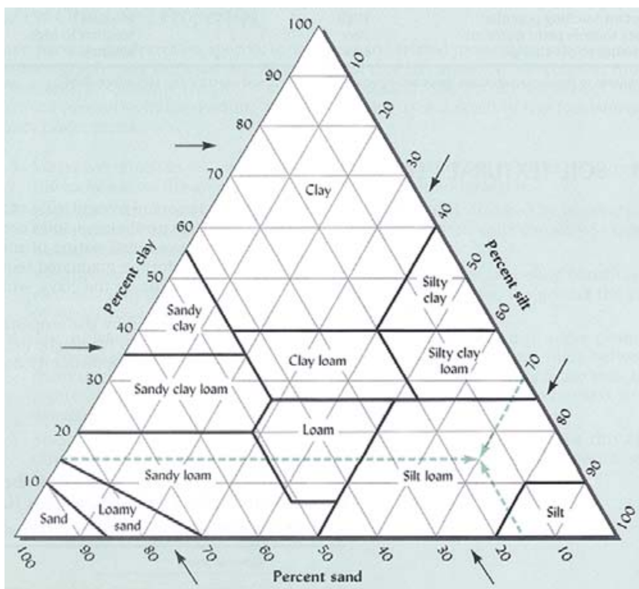

Figure 2.10: Soil textural triangle.

Measures of Water Movement

Water movement in urban soils is described in three ways (figure 2.11):

- infiltration into the soil surface, especially from rainfall
- percolation within the soil drain lines from septic systems, which is especially important in the soil below the drain line and above a restrictive layer
- permeability within the soil from the surface to a restrictive layer

Key terms in understanding water movement in soils are “restrictive layer” and “water table.” Restrictive layers have high density (high weight in a given volume of soil) and low porosity (limited space between particles), so that water cannot flow into or through them. Restrictive layers at the surface can cause surface sealing and limit

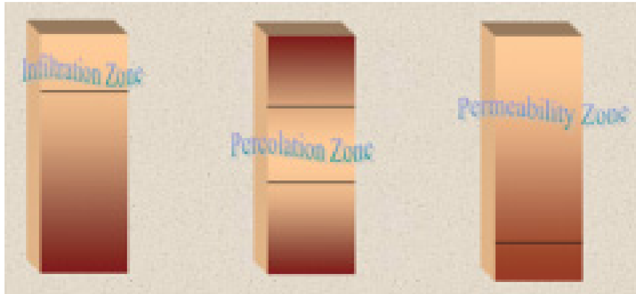

Figure 2.11: Comparison of descriptive terms for water movement in soils.

infiltration of water into the soil. Restrictive layers within the percolation zone reduce the drainage rate of fluids in septic drain lines and can cause septic systems to back up and fail. Compaction of soil materials can occur if heavy weight is on the surface when the soil is wet, resulting in dense restrictive layers below the surface.

A “perched” water table occurs when a restrictive layer anywhere in the soil limits waterflow deeper into the soil. Water drains down from the soil surface and builds up, or “perches,” above the restrictive layer and above the expected water table depth. An “apparent” water table is fed from below by ground water, streamflow, or subsurface lateral flow as water moves across a restrictive layer below the soil surface.

Soil Color

Soil color differences in a profile reflect soil-forming processes and can be an indicator of soil wetness. These differences help to distinguish fill from natural soil. Important coloring agents in soil include parent (geologic) material, soil wetness, extent of leaching, content of organic matter, and the chemical form and content of iron.

Organic matter darkens the soil to a degree, depending on the content and the extent of decomposition. *Iron* gives soil a brown, yellow, or red color. Shades of blue or green may also appear, depending on iron amount, oxidation state, and hydration state. When soil is saturated, iron can become soluble and can be removed, leaving the soil with “mottled” brown and gray colors or completely gray colors, depending on the extent of the wetness.

Soil Structure

Soil structure is the combination or arrangement of primary soil particles into secondary units or aggregates. Organic materials and clay are important binding agents. Wetting and drying cycles are important in creating structure. Soil structure influences pore space and water movement in soils.

The principal forms of soil structure are—*granular* (roughly spherical)*; platy* (laminated); *angular or subangular blocky* (roughly cube shaped, with more-or-less flat surfaces); *prismatic* (vertical axis of aggregates longer than horizontal); and *columnar* (prisms with rounded tops). See figures 2.12 to 2.15.

Structureless soils are either *single grained* (each grain by itself, as in dune sand) or *massive* (the particles adhering without any regular cleavage, as in many hardpans).

Figure 2.12: Granular structure.

Figure 2.13: Blocky structure.

Figure 2.14: Prismatic structure.

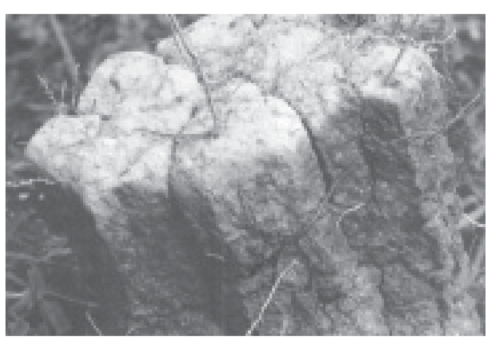

Figure 2.15: Columnar structure.

Chapter 3: Soils Regulate, Partition, and Filter Air and Water

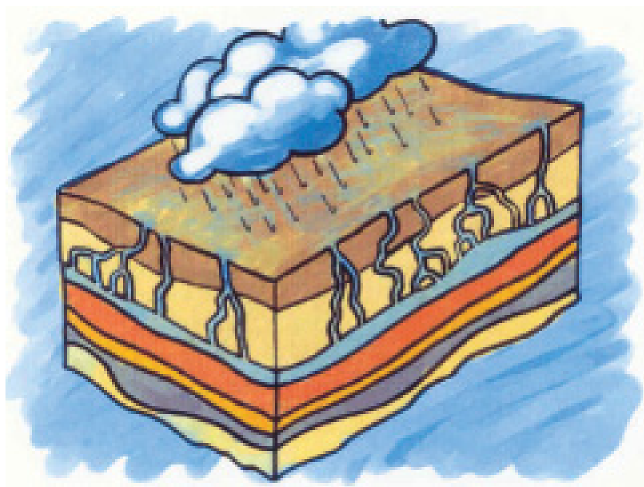

Figure 3.1

Soils play a very important role in storing, regulating, and filtering both air and water resources. As rainwater falls onto the soil surface, it may percolate into the soil or run off the surface, depending on soil properties. Soil particles may hold chemicals and nutrients, making them available for plant roots and keeping them from moving into lakes and streams or entering the ground water. Soil pores that hold and transmit air and water play an important role in the health of the soil environment. All living organisms need both air and water. If all soil pores are filled with water or compacted, then less air is available to plant roots. After site preparation or manipulation, the properties of urban soils differ from those of natural soils and the soil air and water react much differently.

Topics in this chapter:

- **Soil functions**
- **Urban landscapes**
- **Soil and water interactions**
- **Soil temperature**
- **Stream corridors**
- **Storm water management**
- **Urban wind erosion**

Soil Functions

The kinds of activities that soils perform are called soil functions. Soil functions help us sort the extremely complex soil system into smaller parts that can be studied and understood. We depend on soil for more than just producing food. Other soil functions include a) providing building materials and support for structures; b) preserving natural and cultural history; c) regulating, partitioning, and filtering air and water; d) sustaining biological diversity and productivity; e) trapping pollutants; and f) providing sites for recreation. Soils perform specific critical functions no matter where they are located, and they perform more than one function at a time (table 3.1).

Table 3.1: Five Concurrent Soil Functions

- Soils act like *sponges,* soaking up rainwater and limiting runoff. Soils also impact ground-water recharge and flood-control potentials in urban areas.
- Soils act like *faucets,* storing and releasing water and air for plants and animals to use.
- Soils act like *supermarkets,* providing valuable nutrients and air and water to plants and animals. Soils also store carbon and prevent its loss into the atmosphere**.**
- Soils act like *strainers or filters,* filtering and purifying water and air that flow through them.
- Soils buffer, degrade, immobilize, detoxify, and *trap* pollutants, such as oil, pesticides, herbicides, and heavy metals, and keep them from entering ground-water supplies. Soils also store nutrients for future use by plants and animals above ground and by microbes within the soils.

Soil functions occur in spite of the land use. Rainwater must be dispersed or regulated in urban areas, and landscaping plant roots must have air available for growth. When areas are paved over, plans must be in place to handle rainwater. Buildings constructed on fill material must still be supported by the materials on the site. Soils perform the same or similar functions in all areas, including urban ones.

An important task is convincing people living in the urban environment to consider soil information and data before urban projects begin. This information must be part of the planning process for all urban projects. As soil properties change because of construction or other disturbances, major changes occur in the capacity of a soil to function, as predicted by engineering properties. The ability of a soil to support buildings and other structures changes when the soil is disturbed and/or mixed with other materials. Soil materials placed on top of garbage cannot support large buildings and certain other structures. Thus, it is important to know ahead of time what functional changes are expected to result from soil disturbance. Soil maps and soil profile descriptions can help us to understand how the soil at the building site will respond to project management.

Urban Landscapes

Landscapes in urban areas are controlled by underlying geologic landforms; by human activities, such as excavation or other disturbances and removal of water, oil, or minerals; and by microrelief in small areas. Soil movement can result from hazards, such as the formation of sinkholes, soil settling, decomposition of buried trees or landfills, and landslides. Some of these hazards are natural in the environment, and others are caused by human activities, such as excavation and filling for building. These impacts are secondary to the intended soil use. Old geologic formations, such as lava flows and lava tubes, collapse and unexpectedly create large holes. Knowing the underlying geologic formations before building can eliminate the need for costly repairs.

Urban planning for landscape changes requires consideration of fill consistency, soil porosity, internal water movement, surface drainage, and the increased water retention as organic matter is added to the soil. Knowledge of landforms helps us to understand water movement and storage whether the landforms were created by geologic forces or human construction. Some human-constructed soil layers dramatically impact water movement in soils. Geologic landforms lie beneath areas of urban development and may not be visible on the landscape (figure 3.2).

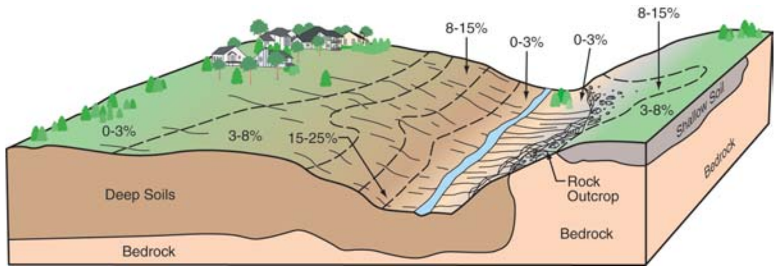

Figure 3.2: Soil slope and underlying geology.

Table 3.2: Summary of Inputs Useful in Identifying Urban Soil-Landscape Units

• Infrastructure	Storm drains, building heights, housing density, and road types
• Soil catenas	Interrelated drainage, soil texture, soil depth, and geologic deposits
• Block diagrams	Geologic material, relief, and spatial patterns of cuts and fills
• Site data	Measured erosion, infiltration, streamflow, and waste filtration
• Soil science	Chemical, physical, and biological interactions and discontinuities
• Vegetation	Seasonal variation, opportunistic species, and adapted physiology

Soil and Water Interactions

Maps with contour lines, called topographic maps, show the direction of waterflow from landforms (figure 3.3). The contour lines are drawn around landforms. Each line represents the same elevation. Contour lines generally show 10- or 20-foot intervals. They run side by side across a slope, and water moves perpendicularly (at a right angle) to the lines to get downhill. The contour lines are closest together where the slope, or downhill gradient, is steepest.

When contour lines form a V shape and elevation increases as you follow the point of the V, the V points upstream. The lines for flat areas or gentle slopes are spaced farther apart than the lines for steeper areas. A closed circle indicates a hilltop or knoll. A closed circle with hatch lines inside indicates a closed depression or sinkhole at the lowest point on a landscape. Map unit symbols on soil survey maps commonly

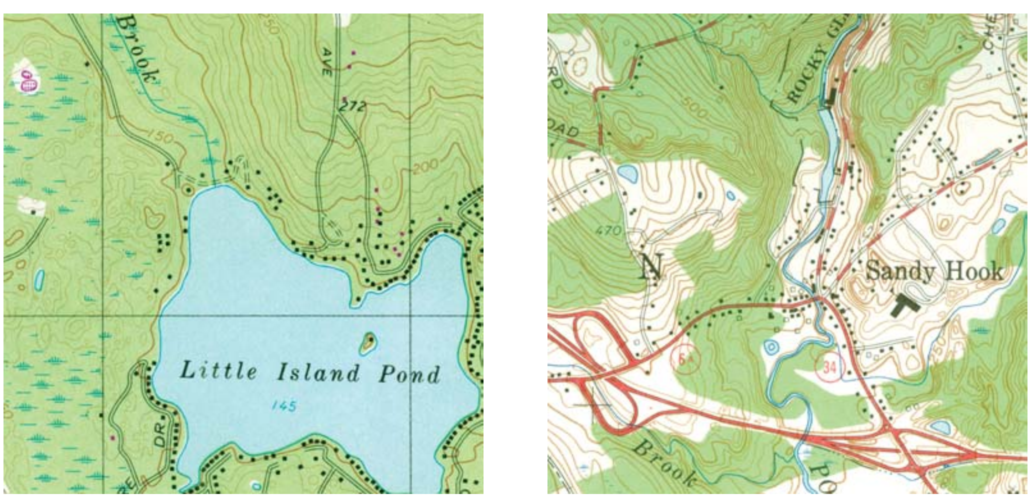

Figure 3.3: Topographic map detail.

indicate the relative steepness of slope. They tie the map unit delineation in soil survey reports to the name of the soil, the texture of its surface layer, and its slope. An example is Ridgebury loam, 3 to 8 percent slopes.

Water tables are underground supplies of water that generally occur closer to the surface during wet periods and are deeper during dry periods. Land use impacts water tables and runoff. An area of wetland may occur where the land surface slopes to an elevation below the water table. Where the underground water does not rise to the surface, it is called an aquifer. Water tables can be identified by observing and recording soil color and soil wetness in urban project excavations or in test holes.

The movement of water into a soil depends heavily on soil texture, soil structure, slope, bulk density, compaction, surface loading, and vegetation. Figures 3.4 and 3.5 demonstrate that more water moves into the soil on natural landscapes than on

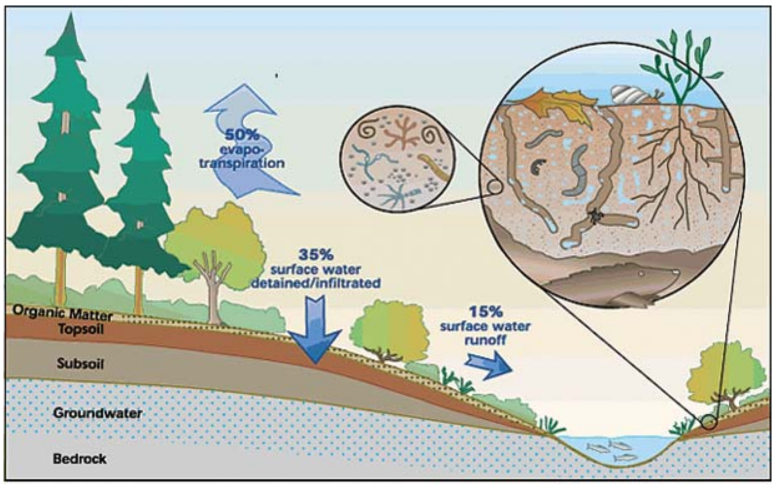

Figure 3.4: Water movement on a natural landscape with a plant cover. This landscape is in a humid area. In the drier regions, the stream level is higher than the surrounding land.

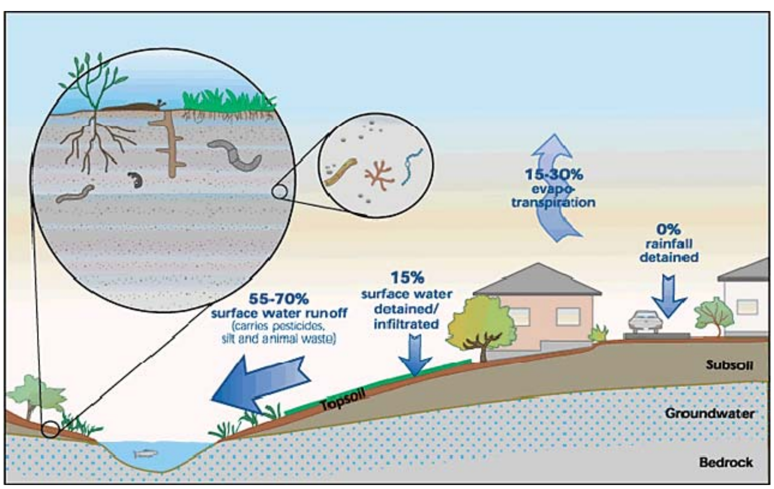

Figure 3.5: Water movement on a disturbed urban landscape with limited vegetation and impervious surfaces. This landscape is in a humid area. In the drier regions, the stream level is higher than the surrounding land.

disturbed landscapes, such as those in urban areas. More water evaporates into the air on natural landscapes than in areas covered by streets, roads, homes, garages, and other buildings. More water runs off urban areas because of the impervious nature of pavement, compacted soil layers, and urban buildings. Water containing sediment clogs lakes and reservoirs. Removing this sediment is costly (figure 3.6).

Figure 3.6: Removing sediment from a flood-control lake. A dam is in the background.

Oil, gas, lawn fertilizer, pesticides, and other pollutants often run off from urban areas and into lakes, streams, or reservoirs and reduce water quality. Some of the fertilizer, pesticides, and herbicides can run through the soil and into ground water, also impacting urban water quality.

Geologic formations, the kinds of rocks that occur below soils, affect water movement in soils and their landscapes. An example of an unstable geologic formation is a shale bed, which is prone to slippage and landslides (figures 3.7 and 3.8). The weight of excess water in the soil can reduce slope and soil stability, especially in urban areas where expensive urban projects are built.

Figure 3.7: A home damaged by slippage of shale beds.

Soil Temperature

Soil temperature may be higher in urban areas than in the surrounding forests and fields. Heat islands form where extensive pavement and large buildings absorb and return heat and restrict airflow within a city. The water supply may be limited in the heat islands as roof runoff and rainwater are piped to storm drains in the streets. Heat stress can occur in plants in excessively dry soils. Soil water and microbial activity within the soil have a significant impact on subsurface soil temperature (figure 3.9).

Figure 3.8: Soil slump on a steep slope below a mall.

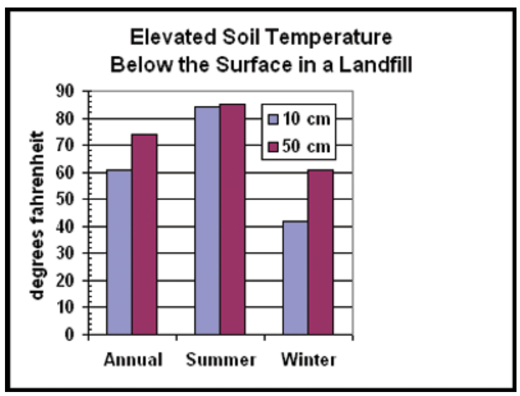

Figure 3.9: Increased microbial activity results in elevated soil temperature in a landfill.

Stream Corridors

Stream corridors provide opportunities for recreational green space, flood control, and wildlife habitat in urban areas. Urban and suburban soil ecosystems are similar to rural ones but have the added dynamics of heat islands, channeled storm water, and transportation systems for urban residents. In some areas, streets interrupt normal surface drainage and ponds or lakes form. Many urban projects restore streams that were piped underground in the past and create riparian stream corridors. These areas may connect with retrofitted parking lots of porous pavement, so that more rainwater eventually returns to the ground water or surface rivers and lakes.

The filtering function of soils is critical in areas within stream corridors and under parking areas. Soils require an active biological community for the chemical reactions that draw toxic materials out of runoff water and hold them in less reactive forms within the soils.

Because of a high population density and the resulting intensive land use, urban soils commonly are disturbed. This disturbance can be small and involve only the soil profile. Examples are mixing of soil horizons, removal of topsoil, and additions of soil material for plant growth. Other disturbances, such as shaping and grading activities, can be more dramatic and can change the shape of the landscape itself. Cutting and filling activities change the surface characteristics that impact water movement into and through soil, site erosion characteristics, and soil fertility. Shaping and grading activities may improve a project site, but they may also change the direction and flow of water, causing problems on adjacent sites. Planning is required prior to construction to minimize the problems in adjacent areas and the impacts on ground water, erosion, and sedimentation. Silt fences can keep sediment from reaching streams and other water bodies (figure 3.10).

Figure 3.10: Silt fences collect sediment and keep it from reaching water bodies near construction sites. Construction is just starting on this site.

Watersheds in urban areas can be defined by the type of boundary between landscape features that forces water to move in a different direction. We can differentiate between an urban watershed, or "sewer shed" (defined by storm drains), and a "natural" watershed, defined by topographic watershed divides.

Landscape disturbance may also have positive effects. It sometimes introduces additional plant and animal species or helps to minimize the effects of the less favorable traits of natural landscapes. Soil reconstruction can take advantage of different soil textures and boundary conditions between soil layers to manage waterflow, structural stability, and nutrient storage.

Storm Water Management

Construction activities can be major contributors to poor water quality from sedimentation and dust in urban areas. Changes in water quality in adjacent streams and wetlands commonly indicate poor management of urban soils. For example, a lower abundance of organisms, such as crayfish and dragonflies, in streams can be an indicator of poorly managed urban soils nearby.

Runoff is water that cannot infiltrate the soil and flows across the land surface, picking up soil particles and any other objects that can be moved as sediment during rainstorms and periods of flooding (figure 3.11). Sediment can clog streets and storm drains with mud, and floodwater can carry excess phosphorus, nitrogen, and other contaminants to streams or lakes. Excess nutrients, attached to soil particles in sediment, may cause algae blooms and poor underwater visibility. Algae blooms are sometimes health hazards and impact swimming and fishing. Algae blooms and sedimentation also decrease water quality, usually by reducing the oxygen content.

Figure 3.11: Street flooding submerges cars.

Erosion- and sediment-control plans are used where large land areas are to be disturbed or where activity is expected to last through a number of rainfall or windstorm events. Two major components of these plans are control of runoff and windblown dust and maintenance of the flow rate and amount of water (hydrology) at preconstruction levels. Preventative measures that slow the flow of sediment to waterways include silt fences staked on contours across hillsides and hay bales anchored at intervals within runoff ditches.

Some urban areas have rapid soil infiltration rates of approximately 2.5 inches per hour. A negative effect of the high infiltration rate is that if fertilizer is applied immediately before a severe thunderstorm, then a great deal of the fertilizer may be leached through the soil into ground water or washed directly into the storm drains. Soil scientists have called these nutrient-rich storm drains human-made wormholes. Wormholes in the soil fulfill a similar function of carrying nutrients rapidly to distant places in the soil.

More often, storm water management in highly developed areas is needed to prevent flooding and emergency discharge of untreated sewage into rivers (figure 3.12). The amount and flow of storm water depend on how much rainfall can infiltrate into the soil. The amount of rainfall varies greatly in urban areas across the Nation. Construction practices that disturb the soil may differ from one State to another because of local and State ordinances. Increased runoff resulting from decreased water infiltration (from compaction or land shaping) is a high priority in urban planning.

"Urban Hydrology for Small Watersheds" (Technical Release 55, USDA, NRCS, 1986) is still widely used as a tool for planning and monitoring water movement, especially in urban areas where soils have been disturbed. Water infiltration plays a critical role in the calculation of the amount of water that will flow from a site in a certain amount of time. Relative infiltration rates for different housing densities and varying degrees of lawn vigor are expressed as runoff curve numbers (RCN) in TR-55 (table 3.3). The hydrologic soil group (HSG), which is an indicator of infiltration, is predetermined for each soil. The letter A indicates rapid infiltration, and the letter D indicates that rainwater generally runs off the surface. Soil management in urban areas can focus on decreasing runoff (RCN) by increasing the area of "good" open lawn, where more than 75 percent of the surface is covered with grass. Each addition of pavement will increase the amount and speed of water leaving the site.

Figure 3.12: A flooded parking lot and street.

Table 3.3: TR-55 Runoff Curve Numbers by Housing Density and Vigor of Cover

Cover type	Increasing runoff (RCN) by decreasing infiltration (HSG)				Soil condition
	A	B	C	D	
Paved driveway	98	98	98	98	impervious
Commercial district	89	92	94	95	85% impervious
Newly graded area	77	86	91	94	no vegetation
Housing lot <1/8 acre	77	85	90	92	65% impervious
Housing lot 1/4 acre	61	75	83	87	38% impervious
Housing lot 1/2 acre	54	70	80	85	25% impervious
Housing lot 2 acres	46	65	77	82	12% impervious
“Poor” open lawn	68	79	86	89	<50% grassed
“Good” open lawn	39	61	74	80	>75% grassed

Excerpt from table 2.2a in TR-55, “Urban Hydrology for Small Watersheds.” RCN is the runoff curve number (30-98). The number 30 indicates the least runoff. HSG is hydrologic soil group (A-D). Group A consists of soils characterized by rapid infiltration.

Urban Wind Erosion

Wind erosion is the movement of soil particles by wind. It occurs when land surfaces lack vegetation and the soil dries out. Windspeeds must reach a certain velocity (in most cases more than 12 miles per hour at 1 foot above the land surface) to move soil particles, depending on the size of the particles. The smaller soil particles (silt and clay) require lower windspeeds, and individual particles of organic matter move most easily and with the lowest windspeeds because of their low weight. “PM-2.5” dust refers to soil particles less than 2.5 microns in size. It can enter human lungs and cause respiratory problems. These small particles form when construction vehicles pulverize soil under dry and windy conditions. There is a high potential for dust blowing on large construction sites and in other disturbed areas (figures 3.13 and 3.14).

Figure 3.13: A cut on a construction site. This site is subject to wnd erosion.

Figure 3.14: A dust cloud along a highway. Windblown particles are measured by the meter in the foreground.

There are three kinds of wind erosion based on particle size and weight (figure 3.15). “Soil creep” occurs when very high wind moves coarse sand particles by rolling them along the soil surface. “Saltation” occurs when wind moves soil particles by bouncing them along the soil surface. Medium-sized sand particles usually are moved by this process. A “dust storm” occurs when wind detaches small soil particles from the land surface and suspends them in the air. Wind erosion is most visible during the suspension stage of dust storms.

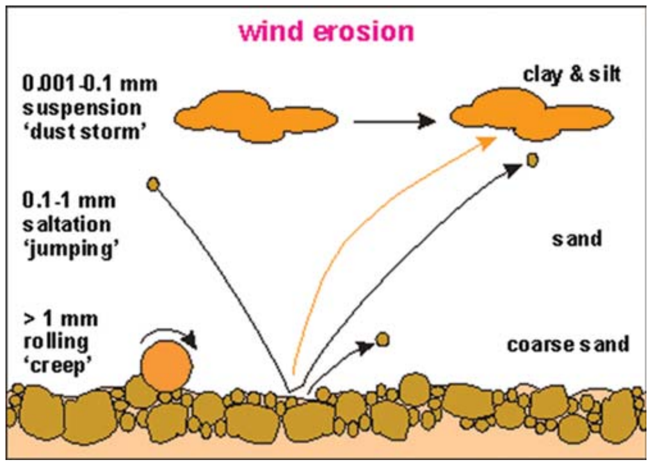

Figure 3.15: Process of wind erosion.

Flat areas in dry climates are likely to have serious wind erosion problems. Certain areas of the United States are more prone to high-velocity winds than others. Construction activities usually disturb the land surface by removing plants and pulverizing soil aggregates, making the site more likely to dry out. Reducing traffic over the land surface, keeping the surface rough by maintaining soil clods or aggregates, watering construction site surfaces, applying mulch to disturbed sites, and maintaining windbreaks or barriers reduce the risk of urban wind erosion. Establishing grasses and other plants as soon as possible after construction is completed also helps to control wind erosion.

Chapter 4: Soils Sustain Plant and Animal Diversity and Productivity

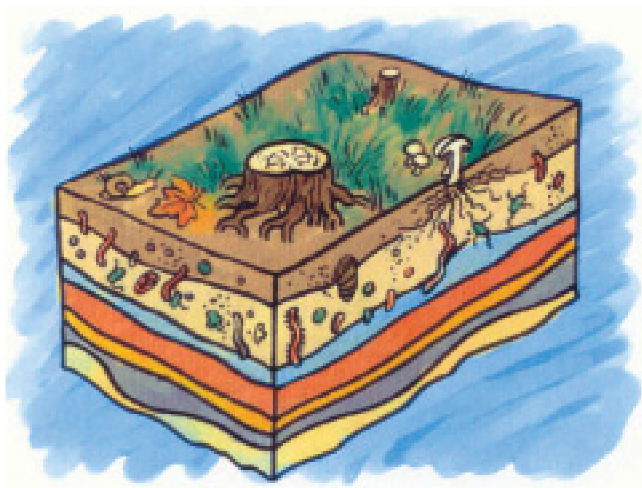

Figure 4.1

Whether they are in urban or natural areas, soils provide living space and supply air, water, and nutrients for micro-organisms, plants, animals, and humans. In most areas, soil properties determine which plants and animals can live in and on the soil. Urban soils that have been disturbed and mixed may no longer possess the natural characteristics needed to support life. Soil amendments may be required to reestablish plants. In many urban areas, the remaining soil materials must be modified before they can support plant and animal life.

Topics in this chapter:

- **Soil fertility and plant nutrition**
- **Soil acidity**
- **Soil organisms and biochemistry**
- **Soil as a filter and buffer for waste**
- **Identifying problem sites from historical records**
- **Identifying problem sites by visual clues**
- **Precautions for community gardens, playgrounds, and parks**
- **Historical tidbits on waste management**

Soil Fertility and Plant Nutrition

Management of urban soils for productive gardens requires a basic understanding of physical and chemical soil properties. Local sampling and testing can help gardeners to determine the suitability of urban soils for certain plants and the need for fertilizer, or plant food (table 4.1).

Table 4.1: Examples of the Factors That May Affect the Productivity of Urban Soil

- Little or no addition of organic matter
- Artifacts that disrupt water movement
- Elevated salt content
- Interrupted nutrient cycling and modified activity of micro-organisms
- High soil temperatures that increase the rate of chemical reactions
- Generally higher pH values resulting from additions of cement, plaster, and road salts
- Lateral (sideways) subsurface waterflow resulting from compacted layers

Meeting the nutritional needs of urban plants requires consideration of soil moisture and temperature as well as the chemicals and biological organisms needed to convert fertilizers into useful nutrients. Plant selection may vary according to the grower's nutritional needs, cultural traditions, soil conditions, and the space available. Plants common in different ethnic diets can be successfully grown in urban areas (figures 4.2 and 4.3). Attention must be paid to different plant tolerances for metals and to drainage, the growing season, and weed control.

Figure 4.2: Produce from a Vietnamese home garden.

Figure 4.3: Intensive Vietnamese home garden in an urban area.

Plant growth and nutrition are closely linked to soil properties. The ability of soil particles to hold and release nutrients for plants and micro-organisms to use is called the cation-exchange capacity (CEC). This capacity determines which nutrients stay in solution and are available for uptake by plant roots and which nutrients are moved through the soil and thus are not available for plant and microbe use. Cations in the soil are positively charged nutrients, such as nitrogen, sodium, calcium, and potassium. Different plants and microbes require different kinds and amounts of nutrients. Trace metals also are nutrients in the soil. They generally are used in very small amounts. Such trace metals as iron and manganese are necessary for plant growth. Also, they help plants to fight diseases. Metal mobility and potential toxicity in soil occur at the lower pH levels and depend on metal binding through cation exchange.

Various kinds of clay in the soil attract and hold cations onto negatively charged parts of their surfaces. Certain clays internally bind some chemicals very tightly. As a result, it is difficult for plants to obtain the necessary nutrients from the soil solution. In areas of these highly active clays, we often add lime (calcium carbonate) to reduce the acidity of the soils and facilitate release of the nutrients from the clays into soil solution.

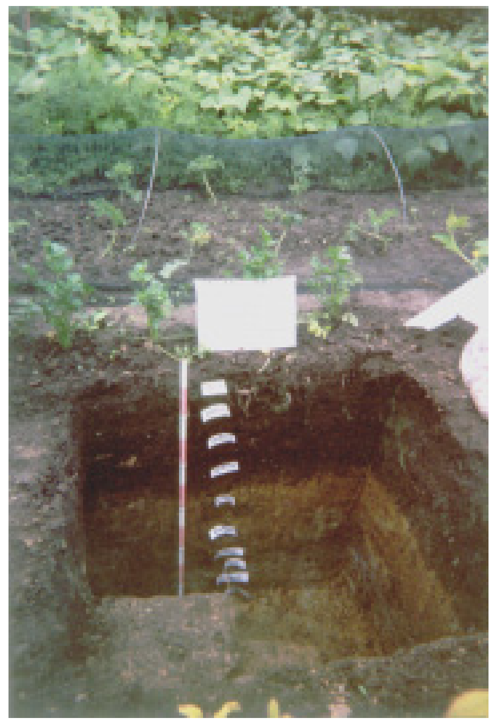

Figure 4.4 Soil profile in a long-term garden.

Organic matter has many active sites that bind chemicals in a manner similar to the way clay particles bind the chemicals in the soil. Organic matter is often visible in a thick, dark surface layer, in which plants begin to grow and take up nutrients. Clays and other soil materials are mixed with the organic matter in each soil layer to form a chemical system. Intensive vegetable gardening over many years during which unused plant materials and organic waste are returned to the soil can produce a thick, dark surface layer of organic matter. The color of the resulting dark surface layer may contrast with the color of the underlying soil, as is shown in figure 4.4, which pictures a 100-year-old continuous vegetable garden.

Soil Acidity

An acid is a substance that has a positive charge and usually yields hydrogen ions when dissolved in water. Hydrogen ions are positively charged. The stronger the acid, the better it dissolves in water. The pH scale (1-14) is a common measure of soil reaction. The lower the number, the greater the acidity. The midpoint of the pH scale is neutral (7.0), a good level for the growth of most plants.

Changes in soil reaction, as measured by pH, have significant effects on metals in soil. Metal toxicity to plants and animals increases in strongly acid soils with a low pH (3.5). Metals in these soils are released from negative sites back into soil solution. At a higher pH (8.5), the metals often are sequestered in the soil. The term “sequestered” indicates that the positively charged metal ions are bound tightly to negatively charged sites in the soil. These sites may be on clays, mineral compounds, or organic matter, including the surfaces of some micro-organisms. These strong, tight bonds restrict the availability of metals for plant uptake and reduce the risk of animal consumption or human skin contact.

Soil Organisms and Biochemistry

Soil is made up of mineral particles and organic matter, the decomposed remains of living things. Bacteria, fungi, and other micro-organisms are largely responsible for breaking down dead plants and animals in the soil. Small organisms (microbes) have negatively charged sites where soil nutrients and metals can bind to form soil aggregates and compounds. Earthworms and larger animals eat and digest organic materials and minerals, transform them into soil aggregates, and deposit them as waste. Soil aggregates are loose groupings of many different soil components in a structure allowing water and air movement as well as biochemical reactions for energy production and nutrient cycling (figure 4.5).

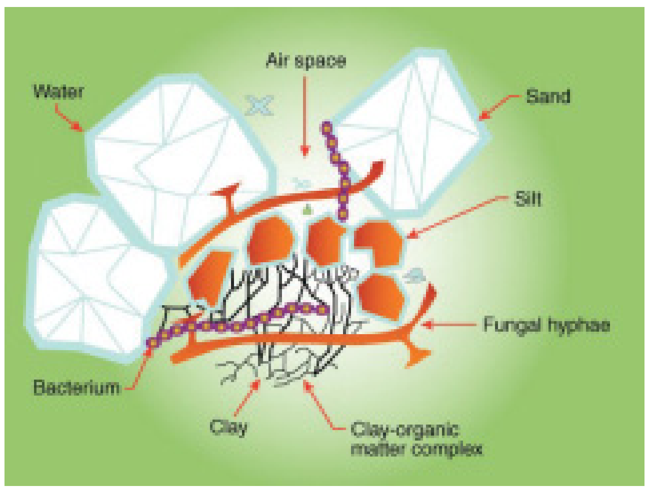

Figure 4.5 : Soil components at a microbial scale.

Soil as a Filter and Buffer for Waste

Managing compost and organic waste is important for plant nutrition and for the biological degradation and conversion of contaminants into inactive forms in the soil. Two key ways to manage waste are filtering and buffering. Waste is filtered when it flows through the soil and is slowly trapped and bound to soil particles. Soil buffering traps waste particles and transforms them into inactive forms.

Composting and using septic systems are examples of waste management in urban soils. Organic materials are needed to hold water and nutrients in the soil for plant growth. In urban parks and community gardens, as well as suburban home gardens and yards, composting can recycle most of the leaves and grass clippings (figure 4.6). This management alternative provides inexpensive soil conditioner that increases porosity and improves the rooting environment for plants.

The major considerations in applying yard and garden waste after composting are plant nutritional needs and the potential of the compost to contain weed seeds or contaminants. Existing resources from the Cooperative Extension Service provide guidelines for managing compost in a manner that maximizes the nutrient content and minimizes the transfer of diseases or contaminants. The same practices work for

Figure 4.6: Composting barrels or traditional fenced piles fit different management intensities in home gardens.

organic waste whether from urban or agricultural sources, and the economic benefits of recycling apply to both.

Understanding the role of soils in septic systems helps residents of small towns or remote housing developments to manage the return of some nutrients to the soil. The liquid septic effluent can provide nitrogen and phosphorus for use by the roots of lawn grasses. Lawn areas receiving liquid drainage from poorly designed or failing septic systems may appear darker green and have thicker grass than surrounding lawn areas. Lakes surrounded by intensive development using septic systems may have water-quality problems, such as algae blooms or high phosphorus levels, if the systems become overloaded.

Conversion of summer cottages to year-round homes may lead to septic system failure or excessive drainage of nutrient-rich septic effluent to lakes or streams. Upgrades, cleanouts, and enlargements of septic systems are needed to accommodate the amount of human waste produced and to make sure that the waste does not pollute surface water or the ground-water supply for wells. Soil properties affecting septic system design and installation include slope, depth to bedrock, permeability, depth to the water table, plasticity of the soil (possible expansion when the soil is wetted and then dried), soil texture and structure, and potential for corrosion of steel or concrete pipe.

Identifying Problem Sites From Historical Records

Metals in soils come from various sources. They may have been present in the geologic rock, or they may occur as atmospheric additions of copper, mercury, lead, and zinc. Metals also may have been deposited by past industrial activities, such as battery production, brass and steel manufacturing, mining, and many different processes involving nickel, cadmium, copper, and lead. Lead is especially evident near roadways because of automobile emissions before the availability of unleaded gasoline, and automobile demolition areas may contain a variety of metals that were commonly used in older cars. As lead paints and some window blinds and soldered pipes used in houses before 1978 wear out and deteriorate, they add lead to nearby soils.

Other ongoing sources of metals and organic waste material are landfills and dump areas that are poorly maintained or unregulated. Landfill materials eventually decompose and form a highly variable type of urban soil. The volunteer vegetation may be dominated by phragmites, as is shown in figure 4.7. These sites can be reclaimed for limited recreational or industrial use.

Figure 4.7: An older landfill with phragmites.

Areas affected by city fires may have concentrated metals buried in the soils. These concentrations are discovered only by referring to historical records or by digging into the soils (figure 4.8). Major fires may leave surface residue high in contaminants. A variety of plants may still grow well, but careful evaluation of each site is needed to determine the risk to human health.

Marine sediments may be dredged and used as fill in low-lying urban areas. Contaminants in the dredged material may be moved onto a site. Other problems with water movement and root resistance may result from compaction of a subsurface layer of very fine sand.

Figure 4.8: Soil profile with a buried layer of ash and refuse. This site was burned by a city fire.

Identifying Problem Sites by Visual Clues

Metal contamination on a site may be evidenced by plant growth, animal behavior, or paint flecks containing lead from older buildings. Many plants simply cannot grow where the level of certain metals is high. Other plants grow well in contaminated soil but fail to set seed or do not grow as well as expected. Absence of any plant growth is a warning sign that a site may be severely contaminated. Caution during sampling is needed.

Metals may be present at a site but not be a high risk for gardening or recreation, depending on the soil properties, drainage, and vegetation at the site. A human health risk from mosquitoes can occur not only in areas of standing water but also in any areas near homes or on city streets with stagnant water. Compaction is often the main problem causing water to pool on the surface without infiltrating into the soil. Mixing the soil when it is just a little moist can increase the porosity (air space between particles) and allow water to soak in. Other options are to divert the water away from low spots and to create channels for storm water to flow around the site or in specific streams or ditches across the site.

Precautions for Community Gardens, Playgrounds, and Parks

Outdoor recreation and gardening are popular activities on urban soils. The risk to human health varies among the sites used for these activities and even between the soils on the same site. A careful study of the area and consideration of key soil properties are needed (table 4.2)

Community and home gardens on contaminated soils may not be a health risk if the garden vegetables supply a very small proportion of the vegetables in the overall human diet. Caution is advised, however, when produce grown in contaminated soils is eaten. Often, the garden supplements the produce bought at grocery stores and for most of the year the nutritional needs of the growers are met elsewhere. Buying vegetables at farmer's markets or school fundraising gardens is another way to dilute the dietary intake of contaminated plants by any one person

Caution is needed in areas of bare ground or leaking water near past industrial sites, dumps, or older homes. Gloves should be worn during soil sampling. Dust from contaminated sites may be dangerous if inhaled by humans or animals. Extended skin contact or hand-to-mouth activities may allow metals to enter children's bodies and interfere with growth and mental development. Pets may collect contaminated dust or mud and carry it into the home.

Prolonged skin contact with contaminated gardens can endanger young children. Raised bed gardens built with a liner on the soil surface and carefully selected fill materials provide a relatively safe and productive alternative. For many residents of urban areas, a community garden is a desirable opportunity for physical exercise, visiting with neighbors, supplementing vegetables, and relaxation.

Table 4.2: Human Health Risks

potential health risks
- **dust inhaled**
- **soluble lead for plant intake**
- **mud puddles that attract children and increase skin contact**

soil chemical properties influencing relative risks
- **strongly bound and insoluble forms of contaminants**
- **prevalence of active clay surfaces for binding**
- **organic carbon in various active forms for binding**
- **other cations, electrical conductivity, pH, and salts**

soil physical properties influencing relative risk
- **drainage**
- **infiltration and permeability**
- **erosion potential for runoff and sediment loss**
- **particle sizes and water in soil pore space**

Historical Tidbits on Waste Management

Night soil was a traditional material in monasteries and in urban areas without sewer systems. Human waste was recycled into gardens and agricultural areas as fertilizer. It was usually emptied from storage pots each morning. Thus, it was called "night soil."

Kitchen gardens were located near cooking areas to provide vegetables and herbs convenient for food preparation. These often were fertilized with night soil. Many historical discard areas are uncovered by the efforts of archaeology and give us insight into the foods people ate, the cooking vessels they used, and the ways they recycled waste materials.

Chapter 5: Soils as Building Material and Structural Support

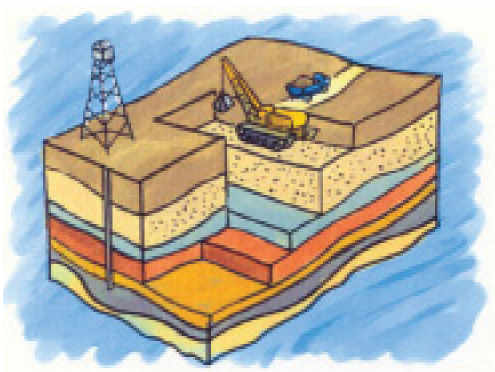

Figure 5.1a

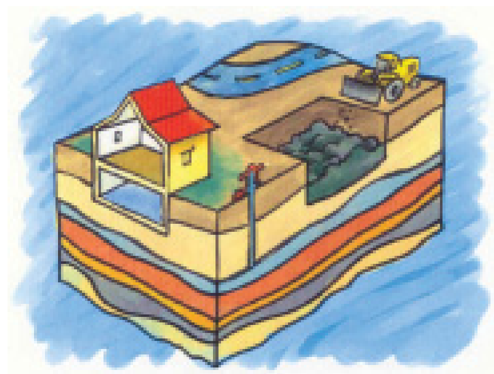

Figure 5.1b

Soil is used as raw material in urban construction activities. Sand, gravel, and clay are mined and used as important materials for many purposes, such as constructing foundations and roadbeds, leveling and filling building sites, and lining ponds and lakes where porous materials require sealing. Soil provides structural support for the houses, schools, shopping malls, churches, industrial parks, and parks and recreation fields that are part of urban areas. Not all kinds of soil are suitable for the many urban uses that are required. Sandy soils are better drained than clayey soils, and some soil layers that are exposed during construction have low strength and are easily compacted. When exposed, bedrock and hardpans are difficult to manage. Knowledge of the soils on the site is needed prior to construction.

Topics in this chapter:

- **Site preparation**
- **What happens when soil is disturbed?**
- **Management after disturbance**
- **Special care of plants in islands within paved areas**
- **Sinkholes**
- **Artificial landscapes**
- **Building material**
- **Materials that allow water to infiltrate**
- **Open space in planned developments**
- **Reclaiming contaminated sites and vacant lots**

Site Preparation

One goal of construction activities in urban areas is to provide material that supports buildings, streets and roads, ballfields, tennis courts, golf courses, parks, and gardens. Another goal is to use soil and other land resources wisely. Each construction site has different needs from the standpoint of supporting structures to be built and then providing materials for landscaping the site after construction is completed. Some sites are left in their natural condition, but many are leveled, drained, shaped, and compacted. These activities help to overcome the engineering and construction limitations affecting building foundations or concrete slabs for building floors, parking lots, athletic fields, or other uses. Soil or even bedrock must be moved or removed when a construction site is leveled or graded. When bedrock or hardpans are involved, drilling and blasting may be needed to loosen the materials. Large machinery, such as an earthmover (figure 5.2), is used to move soil material from one place to another on the site.

Figure 5.2: An example of construction machinery.

Soil materials that are moved from one construction site to another or to a different location on the same site must be compacted if they are to support the weight of buildings. Machinery is used to reduce the number and size of soil pores and increase soil strength (figure 5.3). When soils are not compacted or when sites are unstable, project failures occur. Figure 5.4 shows a house foundation that is unstable. The electric meter was torn from the house as the soil next to the foundation settled. In figure 5.5 settling around a house has torn the outside step away from the patio doors. The red line on the foundation is the original level of the patio. Figure 5.6 shows damage to a road built on an unstable soil.

Soil compaction often occurs in areas where sidewalks were not built along the preferred footpaths (figure 5.7). This compaction is unintentionally caused by people after construction is completed. Because of soil sealing at the surface, vegetation cannot grow in compacted areas. Compaction below the surface may be evidenced by puddles on the surface or trees that are blown over by heavy winds because of shallow root systems. Compaction often is caused by the heavy machinery used by builders and contractors (figure 5.8). The use of large machinery to move materials around on a building site when the soil is wet compacts surface and subsurface horizons in the soil. These compacted horizons, which are characterized by reduced pore space and increased density, alter soil drainage, root penetration, and even microbial communities on the site.

Unintentional soil compaction is a symptom of soil mismanagement and can be a cause of excessive runoff, with or without sedimentation. Compaction occurs when soil particles are packed tightly together as heavy forces (including vehicles, foot traffic, or even glaciers) are applied to wet soils. Compaction is reflected in decreased

Figure 5.3: Sheepsfoot rollers compact soil.

Figure 5.4: An electrical service box torn from a home because of soil settling.

Figure 5.5: A home damaged by soil settling.

Figure 5.6: A road constructed on an unstable soil.

Figure 5.7: Compaction in a footpath.

Figure 5.8: Compaction caused by the use of heavy machinery during wet periods.

water infiltration, limited internal water movement, and the inability of plant roots to grow through a restrictive soil layer.

After soils are modified and used for urban projects, the landscape must still function as a natural system. In other words, the soils must still regulate, partition, and filter air and water; sustain biological diversity and productivity; and support structures. This is the challenge. Soils in densely populated urban areas are dramatically different from soils naturally occurring in forests, on rangeland, in agricultural areas, or at the urban fringe. The functions of urban soils often are modified (figure 5.9), sometimes in a positive way and sometimes in a negative way.

Urban soils range from slightly disturbed to completely manmade. Natural soils can occur in urban areas where site preparation has not been extensive. Urban soils present unique challenges to landscape architects, horticulturalists, engineers, and urban planners. The general types of soil disturbance in urban areas include intentional cutting and filling; vehicular or foot traffic, which can cause compaction; introduction of manufactured soils for raised bed gardens and containerized plantings; and special preparation of sites for parks, gardens (figure 5.10), athletic fields, and golf courses (figure 5.11). Large-scale soil disturbance includes leveling through cutting

Figure 5.9: A modified urban landscape.

Figure 5.10: A garden near a home foundation.

Figure 5.11: Golf course.

and filling or through grading in certain areas, such as sites for buildings or athletic fields; filling of wet areas or areas that have undesirable soil characteristics; and filling of unused or abandoned areas in preparation for waste disposal.

Disturbed soils differ from soils in natural areas because their horizons have been mixed, destroyed, or removed; natural soil structure has been destroyed; compaction has occurred because of heavy machinery use; water transmission rates have probably been reduced because of soil compaction and loss of soil structure; and runoff and soil erosion rates typically have been increased.

What Happens When Soil is Disturbed?

Humans are probably the most important organisms of the soil-forming factors in urban areas. Urban soils have been disturbed by human activity in some manner and to some degree. This disturbance has changed the properties of the soils, and the soils should now be managed in a different manner. Mixing different parts of more than one soil can result in a new soil that may be better suited to a certain use than the original soils. Some soils have to be altered before they are suitable for certain uses. An example is a soil in an area where preparing a roadbed requires mixing and deliberately compacting soil material. Topsoil commonly is piled up and then spread on top of the altered soil after construction. In some strongly sloping areas, soil may be moved from one area to another to fill low-lying areas and level the site for construction. In some areas soil material is created on the site by mixing manmade and/or natural materials from various sources. The materials may be mixed as they are moved by heavy construction equipment.

Soils in urban areas are used for many purposes even if they are compacted and/or contaminated. Contaminated soil material is sometimes buried because of the need to protect those who work or play on the site. This contaminated material may be exposed during construction activities. Old dump sites for petroleum and chemicals are now being exposed as urban redevelopment occurs in many cities. The buried materials have leached into other soil layers or even into the ground water, and cleanup coasts are extremely high. In some areas cleanup may be impossible. Some soils are unintentionally compacted prior to their use. This compaction causes problems after construction. Soils that have been compacted or contaminated create special problems for certain uses or for the people who live or work on them. A soil scientist and specialists in other disciplines can provide valuable information to help people use soils properly and to address existing problems in urban areas. It is important to get advice and help from soil scientists before projects are started.

These facts help us begin to understand that urban soils are very different from soils in natural areas. Even in undisturbed areas, no two soils are exactly alike. Thus, it is important to know all one can about a soil before it is used for any purpose, including urban projects. Most soil-related limitations can be overcome if enough money is available to correctly design, install, and maintain a project. Costs to overcome project errors are often higher than the original project costs.

Management After Disturbance

After disturbance, the surface layer of urban soils should have the characteristics needed for good plant growth. Management includes overcoming physical and chemical root restrictions, providing nutrients by managing soil fertility and acidity (pH), and reducing the likelihood of contamination or disease problems. In areas where the climate is dry, a water supply for the site also is needed.

Special Care of Plants in Islands Within Paved Areas

Urban plants may grow on small islands within disturbed or paved areas. Overland waterflow to the vegetation is limited on these islands. Large soil pores that connect to the surface are critical if water is to move to the deep roots of the plants. The soil in the island of vegetation should extend below the pavement and should provide enough volume for root growth in proportion to the above-ground height of the trees and shrubs. Trees and flowerbeds along streets may require more frequent applications of fertilizer and water than backyards or gardens.

Sinkholes

Sinkholes severely limit urban uses. They form where water has been pumped from underlying geologic formations, leaving the surface soil without support; where limestone bedrock is dissolved in water and removed below the soil during geologic weathering; and where underground volcanic lava tubes collapse after geologic weathering (figure 5.12).

Figure 5.12: A sinkhole where a lava tube has collapsed.

Artificial Landscapes

Many urban parks were once deep ravines. These ravines were filled with construction materials and refuse during the process of land leveling. Examining a pit dug into the soil under the vegetation helps soil scientists to determine the soil properties controlling the way water moves through the soil and the way nutrients are released to plants (figure 5.13).

Figure 5.13: Soil scientists examining urban soils.

Building Material

Soils in urban areas are more often the recipients of excavated and dredged materials than the source of those materials. Some areas do have large deposits of sand or gravel that can easily mined and transported to other areas. The pits left behind when quarries in urban areas are closed are sometimes used for water-based recreation or are refilled with other material, such as garbage or road debris.

Fill material can be natural soil (derived locally or moved onsite), waste (e.g., coal ash, dredged spoil, and construction debris), or a mixture of both (figure 5.14). Soils in urban areas may have cultural artifacts (garbage), construction debris, and various waste products.

Figure 5.14: A filled area excavated for a home foundation.

Soil material is sometimes made on a site by mixing manufactured materials with natural materials from various sources as both of the materials are moved around by heavy construction equipment. This process may result in hardpans or compacted layers that impede foundation drainage under extensive fill material added for home construction. The potential problems associated with disturbed urban soils include a scarcity of organic material for plant nutrition and biological soil-building reactions, the presence of artifacts that damage construction equipment or release contaminants, and significant variability between soil layers. The variability between the soil layers affects water movement and the stability of the soil under weight.

Materials That Allow Water To Infiltrate

Urban renewal may include removing old culverts and pipes and thus restoring a natural stream, as in a park with trees and picnic areas. Restoration of stream corridors for recreation, flood control, and wildlife may require rebuilding of streambanks with such material as rock or gabions (rock baskets, as shown in figure 5.15) that can withstand the erosive force of floodwater (FISRWG, 1998). Pavement may be removed from parking lots near the reconstructed stream so that more water can infiltrate into the soil and thus raise the stream level. Porous building materials may be added to the surface of streets (figure 5.16), parking lots, or sloping areas that require greater stability. The porous materials permit water to move into the soil instead of running off the site. Also, plants growing through the materials help to control erosion (figure 5.17).

Figure 5.15: Rock baskets.

Figure 5.16: Brick street in an historic district.

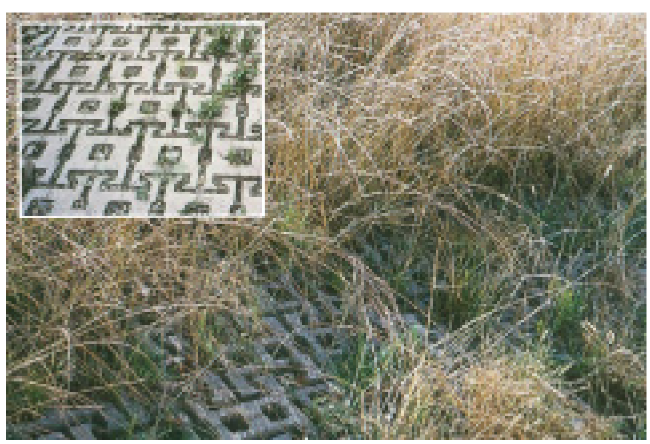

Figure 5.17: Soil surfaces may be covered with products that provide strength for slope stability and still allow water to infiltrate and plants to grow.

Open Space in Planned Developments

Planting beds may be constructed in parking lots, around playgrounds, and near nature trails to allow a wider variety of plants to flourish with frequent watering and intensive fertilizing. Urban planning can combine housing and open space needs for a community through consideration of the soil resources of the larger urban area (figures 5.18 and 5.19).

Figure 5.18: Aerial view of planned development.

Figure 5.19: A subdivision.

Building suburban houses on slight or moderate slopes and establishing lawns minimize erosion. The houses generally have gutters that channel runoff from roofs into storm drains. Very little space is left between houses, but larger lawn areas are in the backyards, where mowing and fertilizing can be coordinated among suburban owners. The soils around the houses should be characterized by good infiltration. They should slope away from the foundation, so that basements are not flooded. A level soil with moderate infiltration and good drainage is desirable in areas near swimming pools and play structures.

Reclaiming Contaminated Sites and Vacant Lots

In the more densely populated urban areas, a vacant lot may be the only site available for recreation and gardening. This restriction forces residents to use soils that may be compacted and contaminated or filled with unknown materials. Reclaimed mine areas provide land for urban housing and recreation after soil reconstruction measures are applied for water movement, structural stability, and plant growth. Raised bed gardens built with composted leaves and grass provide a plant rooting space of minimal risk to children and adults in many urban areas (figure 5.20).

Figure 5.20: A raised bed garden.

Chapter 6: Soils Preserve Natural and Cultural History

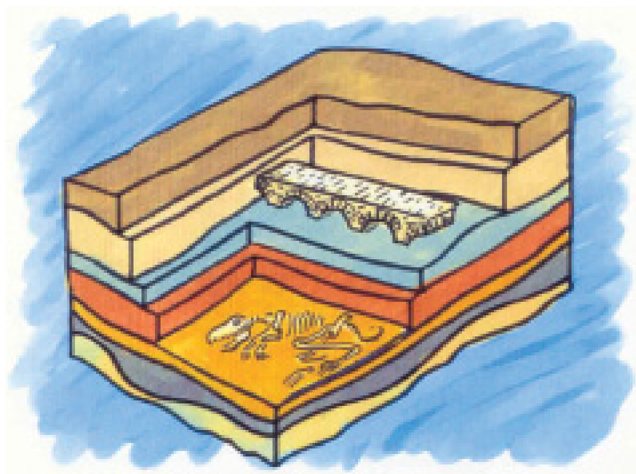

Figure 6.1

Soils can tell us much about our past. They are derived from a variety of parent materials and are transported by wind, water, ice, gravity, or humans. Soil material has been transported to its present location over very long to very short periods of time. What occurs in or under a soil can indicate how old a buried soil layer is and even how it got to its present location. For example, glaciers from the Canadian ice sheets moved down into the northern part of the United States about 12,000 to 15,000 years ago. Rocks otherwise found only in Canada are within the soils impacted by these glacial events. Soils can be dated by the plant pollen or artifacts within them. Layers of garbage or dredge material also can indicate the age of the soils. In addition, they help to preserve artifacts of culture and history.

Topics in this chapter:

- **Urban site preparation**
- **Intentional burial**
- **Catastrophic events**

Urban Site Preparation

When most sites for urban projects are prepared, soil excavation is required to allow the construction of building foundations, roads, and streets and to shape the lot for construction activities. Excavations vary in depth and size, depending on the building project. Very deep excavations are required when skyscrapers or other large buildings are constructed or when roads and streets are built on strongly sloping land. As soil material is removed by excavation, objects that have been buried, either by natural processes or by humans, are sometimes uncovered and must be dealt with before construction begins.

The objects that are discovered in the soils during excavation may have been accidentally lost, intentionally discarded or buried, or buried by catastrophic events. Coins and jewelry are examples of the buried items that are discovered. Old dumps, hazardous materials, fossils, or artifacts of past civilizations also may be exposed during site preparation.

Intentional Burial

Landfills and garbage dumps are examples of intentional burial sites (figure 6.2). Construction debris, garbage, and other items are often placed in dumps or low-lying areas and then covered by soil or dredge materials. Operators of most landfills are required to cover each layer of garbage with a layer of soil on a daily basis. When old landfills are discovered during project excavations, the content may appear to be a stack of debris and soil in layers. In the past, old dumpsites and burial areas were not marked on maps. Radioactive materials or carcinogens may have been buried in some areas before landfill regulations were in place. These areas can be avoided if their location is known, but the location is not always known. The buried materials can be very dangerous when exposed during construction activities. If areas such as these are discovered on a homesite or building lot, the discovery should be reported to the proper authorities.

Figure 6.2: Bulldozers working in a landfill.

Liquid materials, such as oil and oil products, pesticides, and other pollutants also have been placed in landfills and garbage dumps. These materials are in various kinds of containers that eventually corrode, degrade, and begin to leak (figure 6.3). The pollutants may leak into the ground water or out onto the surface in areas downslope from the landfill or dumpsite. In our Nation's past, dumpsites in many rural areas were unregulated. Toxic or hazardous waste material was deposited on these sites along with household garbage. As towns and cities grow and expand, these sites are often uncovered and must be cleaned up before use.

Small towns or a few buildings are sometimes intentionally covered by water impounded by large dams. Over time, sediment that settles out of the water buries the buildings and streets. The dam may be filled with sediment and abandoned. If the site is later used for another purpose, the buildings and debris material may be exposed during site preparation.

Figure 6.3: Barrels containing hazardous material.

Current technology helps us to design safe dumps and landfills. Liners made of impervious materials are now used under garbage and waste materials in dumps to contain the waste materials and keep the by-products of decomposition from leaving the site and leaking into ground water. Cover material placed on top of the garbage can keep odors and hazardous gases from escaping into the atmosphere. Most dumps now require permits. Strict monitoring helps to ensure that hazardous material is not deposited in the dumps. When dumps and landfills are closed, monitoring plans require that the sites be checked on a regular basis.

Catastrophic Events

Figure 6.4: Human artifacts buried by windblown dust.

Catastrophic events, such as earthquakes, volcanoes, landslides, dust storms, and large floods, bury objects unintentionally (figures 6.4, 6.5, and 6.6). An object discovered during urban development is sometimes a surprise. The exposed objects may be skeletons of prehistoric plants and animals, old buildings, human artifacts from earlier civilizations, footprints, leaf imprints, or even pollutants and contaminants that were buried during past disposal activities. Some project sites must be altered when pollutants or contaminants are exposed during excavation. On other sites, changes in project and/or construction plans are needed because of artifacts or hazardous materials uncovered during construction.

Soil horizons are important time markers and are used to help date items discovered when sites for urban projects are excavated. Newspaper articles tell of human and animal bones that were disturbed during excavations in urban areas. In some areas excavation is stopped until the bones can be identified so that the remains of members of ancient civilizations are not disturbed prior to study and cataloging. When the conditions and soil properties are right, buried artifacts and remains are well preserved for long periods of time. Not all kinds of soil, however, preserve artifacts and plant and animal remains. Some soils are so acid that they dissolve the buried materials. In some areas of wet soils, organisms living in the water consume the buried materials as food.

Figure 6.5: Animal skeletons buried by volcanic ash.

Figure 6.6: 1994 landslide (USGS photo).

Locating existing information about a site before site preparation begins can save the owner a great deal of time and expense. Soil survey reports commonly provide information about historic sites and past land use activities as well as information about soils. Soil survey information regarding slope stability, restrictive layers in the soils, and water transmission rates can help builders and landowners to avoid problems and save money. The costs of repairing, rebuilding, or relocating structures can be avoided, and the life expectancy of projects can be enhanced.

Chapter 7: Soil Management for Recreation and Renewal

Many cities and towns maintain botanical gardens or arboretums for use by their citizens and visitors. Some of these gardens and arboretums are very well known and draw people from all over the United States and the world. Some are used for large gatherings of people celebrating special community or holiday events. Unmanaged use of parks, gardens, and arboretums can cause damage to plants and severe soil compaction, which restricts the movement of water into the soil. The result is increased soil erosion, poor plant vigor and growth, increased runoff and offsite sedimentation, and renovation costs.

The most common kinds of urban parks and gardens are meditation gardens, rooftop gardens, rain gardens, butterfly gardens, outdoor classrooms, desert gardens, kitchen gardens, victory gardens, pocket parks, riverfront parks, green space, open space, medicine circles, labyrinths, and peace parks (figures 7.1, 7.2, 7.3, 7.4, and 7.5). The kinds of plants in these areas vary because of differences in soil properties. Additions of special types of nutrients (plant foods or soil conditioners) to the soil or containers in which the plants can grow may be needed.

Figure 7.1: Butterfly garden at an elementary school.

Schoolyards are ideal spots for building butterfly gardens and outdoor classrooms. These areas can also serve as small neighborhood parks. The soil and site history in the areas can show whether contamination is likely and whether protective measures are needed to minimize exposure. Soil testing is needed before the projects begin.

Applications of basic environmental science in urban areas can quickly become complicated and may require special contributions from scientists in many fields. A garden site surrounded by buildings may be hotter and drier than expected because rainwater is channeled in roof gutters and street drains away from the site, nearby concrete walls and streets stay hot longer, and the buildings cut off breezes. In some parts of the country, the added heat can extend the short growing season for

Figure 7.2: An urban pocket park under development.

Figure 7.3: A developed urban pocket park.

Figure 7.4: An urban riverfront park.

Figure 7.5: Intensively managed ballfields after soil reconstruction.

vegetables, but in the warmer regions, it can make a garden site undesirable for some plants.

Careful planning of lawns and picnic areas is needed because of the possibility of heavy foot traffic during wet periods. Urban parks commonly have a combination of paved areas and manufactured soils that can withstand trampling.

Conversion of a vacant lot into a ballfield or picnic area may be delayed if the site was used in the past as a garbage dump. Soil contamination, bad smells, uneven ground surfaces, and other problems may be caused by buried garbage that is slowly decomposing. Some former landfills provide space for parks and ballfields, but they must be carefully planned and managed for intensive use by many people in variable weather.

A few basic soil management practices can help to maintain existing parks or reclaimed recreation areas over time. A soil-based site management plan might include ways to balance water content and movement. Compost leaves and grass add organic materials and thus increase the supply of plant nutrients. Also, they help to maintain soil porosity and thus reduce the likelihood of compaction. In general, gardens and parks in urban areas require careful initial site selection followed by intensive maintenance of the vegetation in lawns and landscaped areas. A soil scientist may need to dig a pit so that the soil properties that affect management can be investigated (figures 7.6 and 7.7).

Figure 7.6: A backhoe used for digging a soil pit.

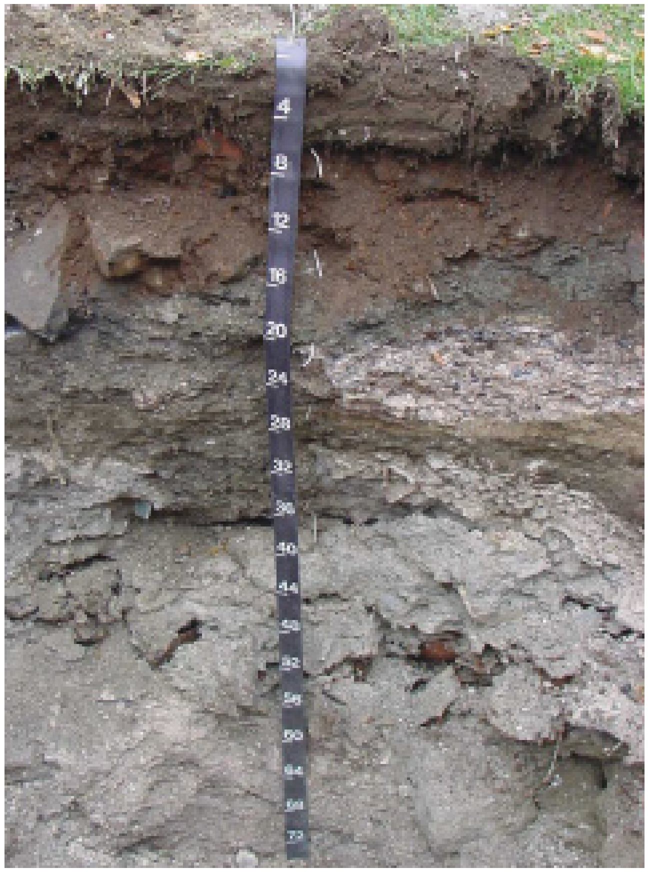

Figure 7.7: Human artifacts buried in a soil pit.

Schools, parks and recreation departments, and garden centers often employ people with training in soils and landscaping. Many recreation areas and parks are heavily used for more than one purpose throughout the year (figure 7.8). Maintenance plans are needed in these areas. These plans can be used as templates for planning smaller pocket parks and gardens that comply with local regulations.

Figure 7.8: High school playing fields are used for sports and for band and music competitions or performances.

Chapter 8: Help Is Nearby

Many of the conservation practices used in agricultural and forested areas can be adapted to work in urban areas or small towns. The Backyard Conservation Program of the Natural Resources Conservation Service (NRCS) helps urban people to plan, establish, and maintain simple waterways and plantings around homes, schools, and small parks. Team-building skills across disciplines, among generations, and among cultural groups are essential for successful urban conservation programs. These skills have been combined with the science behind NRCS field-office conservation planning. The Backyard Conservation Program has improved the ability of NRCS to serve customers using ecosystem concepts in urban areas.

Topics in this chapter:

- **Soil surveys in urban areas**
- **Naming soil series and soil map units**
- **Help in evaluating your soil and urban site**

Soil Surveys in Urban Areas

The program responsible for mapping all soils in the United States is called the National Cooperative Soil Survey (NCSS). It has been ongoing for more than 100 years. The NCSS is a partnership that combines the resources of Federal agencies, including the Natural Resources Conservation Service (NRCS), the U.S. Forest Service (USFS), the National Park Service (NPS), and the Bureau of Land Management (BLM), and the resources of State and local agencies and universities. In the earliest years of the soil survey program, soil surveys were focused on lands that were or could be important for agriculture. At that time, urban areas were broadly mapped or sometimes even ignored as soil surveys were completed.

The NCSS program has nearly completed the initial mapping of all nonurban land within the Nation and is now turning its attention to updating and maintaining existing soil survey data, to mapping lands managed by certain Federal and State agencies, and to mapping urban areas. Some urban areas have already been mapped, while others are just beginning soil surveys. Table 8.1 lists several completed and published

Table 8.1: Examples of Soil Surveys in Urban Areas

Soil Survey of the San Diego Area, California, 1973
Soil Survey of Suffolk County (Long Island), New York, 1975
Soil Survey of Washington, District of Columbia, 1976
Soil Survey of St. Louis County and St. Louis City, Missouri, 1982
Soil Survey of Charlotte County, Florida, 1984
Soil Survey of Cumberland and Hoke Counties, North Carolina, 1984
Soil Survey of Montgomery County, Maryland, 1985
Soil Survey of Nassau County (Long Island), New York, 1987
Soil Survey of South LaTourette Park, Staten Island, New York,1997
Soil Survey of Baltimore City, Maryland, 1998

soil surveys of urban areas. Soil survey activities currently are either planned or underway in several other urban areas.

Mapping urban areas can be difficult because the present land use restricts the access to sites needed for observation of soil profiles and because land use can quickly change. Observing the soils in these areas is difficult because impervious layers of concrete and asphalt are commonly on the surface and because most people do not want holes dug in their yards or gardens.

An urban soil classification scheme based mostly on the use or intended use of the soils could be developed. Urban soils can be investigated for commercial, residential, industrial, and greenbelt uses. For a satisfactory design of each use, there are key soil properties that must be known and understood. The NCSS program maps and classifies soils according to National standards and collects soil property data to be used in developing soil interpretations helpful in wise land use planning.

The emphasis on mapping urban areas results from the increasing size and density of the urban areas, a more environmentally aware clientele, the fact that nearly all rural areas have already been mapped once, and the need for more and better land resource data within and adjacent to urban areas.

NCSS soil survey information is useful for general planning activities. Because of the map scale, however, this information is not adequate for most site-specific activities. Most activities in urban areas are site specific, apply to areas of land smaller than those generally shown on soil maps, and involve highly intensive uses. Site-specific examinations are needed to provide the accurate and detailed data needed for most urban projects.

Naming Soil Series and Soil Map Units

Table 8.2 lists some soil series in urban areas and the type of material in the upper part of the soils and in the underlying substratum. Each soil that is mapped in the NCSS program is given a name that distinguishes it from other soils. Each has a set of chemical and physical soil properties that are different from those of other soils. Groups of soils having profiles that are almost alike, except for differences in the

Table 8.2: Examples of Urban Soil Series

Series	Survey area	Depth and type of surface fill	Substratum
Harvester	St. Louis, MO	12-40" fill or reworked loess	< 20% glass, brick
Fishpot	St. Louis, MO	up to 48" fill or reworked loess	< 20% glass, brick
Matlacha	Charlotte Co., FL	35" dredge spoil	natural sand
St. Augustine	Charlotte Co., FL	30" dredge spoil	natural sand
Bragg	Cumberland and Hoke Cos., NC	20-81" sandy clay loam fill	buried loamy sand
Greatkills	Staten Island, NY	7-24" mod. coarse texture	garbage
Canarsie	Staten Island, NY	10-39" mod. coarse texture	dense glacial till
Foresthills	Staten Island, NY	10-39" mod. coarse texture	buried soil
Greenbelt	Staten Island, NY	40-80" mod. coarse texture	same fill
Centralpark	Staten Island, NY	40-80" very gravelly material	same fill

texture of the surface layer, are called soil series. For example, the soils of one series may have bedrock or a layer of garbage at a depth of 24 inches, while the soils of another series may have bedrock or a layer of garbage at a depth of 75 inches. Other soil series are separated on the basis of chemical properties or, more often, on the basis of a combination of physical and chemical properties. Soils usually are named by the soil scientists who map them. Most are named after landmarks, geographic areas, rivers, mountain peaks, cities, or towns. Examples are the Centralpark series (named after Central Park in New York City) and the Seattle series (named after Seattle, Washington). In a few instances, the names are simply made up.

Urban soils form in different types of human-deposited material, including a) loamy fill over natural sand, b) dredged spoil, c) coal ash, and d) construction debris (figures 8.1a, 8.1b, 8.1c, and 8.1d).

Nonsoil areas are given such names as Rock outcrop, Urban land, Dumps, Water, and Rubble land. Urban land is defined as areas with a specific percentage of pavement, driveways, and buildings (impervious cover). Collectively, nonsoil areas are classified as miscellaneous areas.

Soils are mapped either as a single soil series or a group of soil series and/or miscellaneous areas. For example, one group could be mapped as "Urban land-Charlton complex, 2 to 8 percent slopes." A single soil map unit could be mapped as "Seattle loam, 1 to 3 percent slopes." The end of this soil name ("2 to 8 percent slopes") is an example of additional information called "soil phase" criteria. Soil phase criteria may be related to such characteristics as slope, texture of the surface layer (e.g., loam), and flooding.

Figure 8.1a: Profile of a Verrazano soil, which formed in loamy fill over natural sand.

Figure 8.1b: Profile of a Big Apple soil, which formed in dredged spoil.

Figure 8.1c: Profile of a Riker soil, which formed in coal ash.

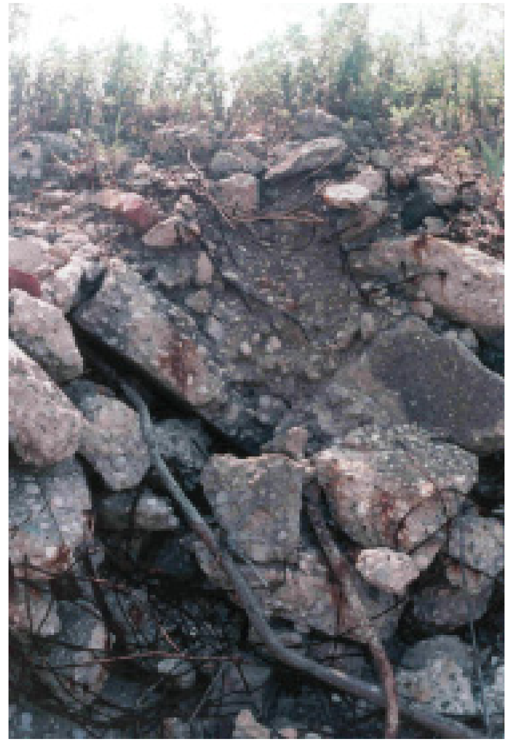

Figure 8.1d: Profile of an Inwood soil, which formed in construction debris.

Soil maps are usually made with aerial photographs as the background. Figure 8.2 is an example of a soil map of a dominantly urban area. By carefully examining the background aerial photograph, one can observe the streets and buildings of the urban area. The light blue areas are lakes or reservoirs. The soils delineated on the map have been separated from one another by black lines. Every delineation on the map has a set of letters that identifies the map unit. Examples of these map symbols are Ur, Urb, UpC, and CrC. The list of map unit symbols and map unit names is called a legend. The legend is very important because it can be used as a link to information or data about the map units. Those who need soil information must have the soil map, the legend, and the soil data or interpretations to make effective use of the soil information in planning onsite investigations for specific projects at the proper scale.

Help Evaluating in Your Soil and Urban Site

Local resource information can be obtained from soil scientists, professional gardeners or garden clubs, science teachers, city planners and planning boards, Master Gardeners, landscape contractors, private soil consultants, and local people with expertise gained through work on schools, outdoor worship areas, and parks. A field tour that involves a combination of these experts can be an effective learning experience (figure 8.3).

Local resource specialists can better assist you when you know some of the vocabulary that applies to urban soils, such as the terms used in this primer. Questions about site planning, landscaping, composting, and urban waste management may lead to a search of city laws and regulations including scientific terms. Management intended to reduce the risk to human health may require micro-engineering for urban sites and selection of certain plants that can grow well on the sites.

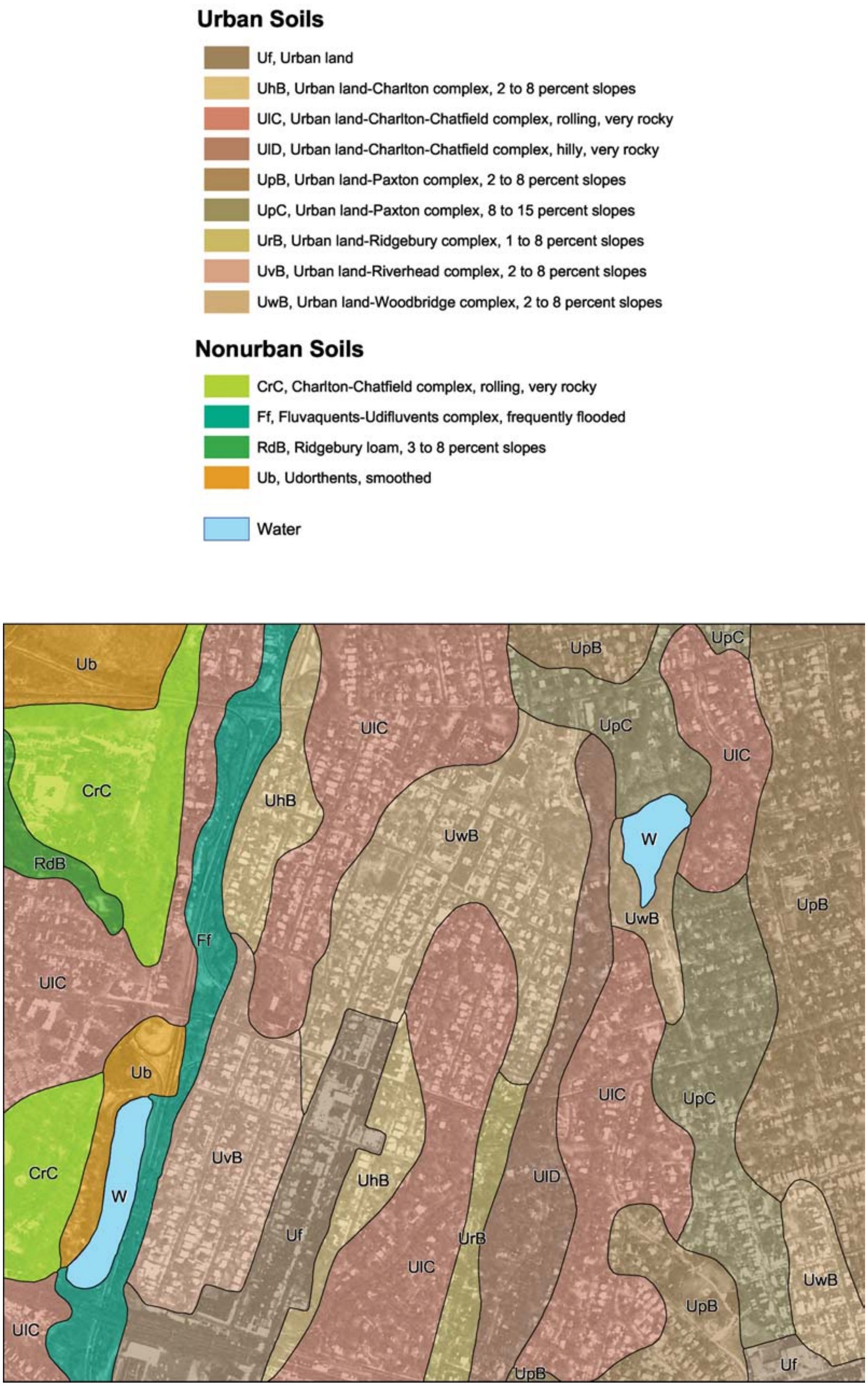

Figure 8.2: A map of dominantly urban soils.

Figure 8.3: A stop on a field tour of soils in Central Park, New York City.

The local Cooperative Extension Service provides brochures explaining how you can collect samples for soil testing and can help you to locate the nearest public university offering soil fertility tests at a low cost. The Cooperative Extension Service also trains Master Gardeners, local volunteers who can help you to manage garden plants and related insects and diseases (figure 8.4).

Figure 8.4: Adult working in a community garden plot.

The Urban Soil Quality Card includes some basic soil tests that you can perform before you plant a garden or vegetation in a park. The card was developed in Connecticut by local community groups with assistance from NRCS soil scientists and community planners. It is designed to be printed and used as written or with changes that you make to help you evaluate your specific site. It is available on the Internet (http://soils.usda.gov/sqi/soil_quality/assessment/cardguide.html).

Other sources of local soil expertise and assistance are youth program leaders and handbooks from organizations, such as Girl Scouts, Boy Scouts, 4H Clubs, Envirothon teams, the Science Bowl, school science fairs, the National Science Teacher's Association, the Future Farmers of America, and Vocational Agriculture Curriculum (figures 8.5, 8.6, and 8.7). Many of these resources are listed under the heading "References and Resources" in this primer.

Figure 8.5: A boy with a soil color book.

Figure 8.6: Boys and girls testing soil.

Figure 8.7: Preliminary examination of soil in a backyard.

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Glossary

Aggregate, soil. Many fine particles held in a single mass or cluster. Natural soil aggregates, such as granules, blocks, or prisms, are called peds. Clods are aggregates produced by tillage or logging.

Bedrock. The solid rock that underlies the soil and other unconsolidated material or that is exposed at the surface.

Catena. A sequence, or "chain," of soils on a landscape that formed in similar kinds of parent material but have different characteristics as a result of differences in relief and drainage.

Cation. An ion carrying a positive charge of electricity. The common soil cations are calcium, potassium, magnesium, sodium, and hydrogen.

Cation-exchange capacity. The total amount of exchangeable cations that can be held by the soil, expressed in terms of milliequivalents per 100 grams of soil at neutrality (pH 7.0) or at some other stated pH value.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Compaction. Creation of dense soil layers when the soil is subject to the heavy weight of machinery or foot traffic, especially during wet periods.

Composting. Managing the decomposition of organic materials, such as leaves, grass, and garden waste.

Container gardens. Gardens planted in pots, concrete boxes, brick or stone basins, or other isolated rooting areas within paved areas.

Contaminated soil. A soil that has high concentrations of trace metals or organic waste that is toxic or a high risk to people or animals.

Drainage class (natural). Refers to the frequency and duration of wet periods under conditions similar to those under which the soil formed. Alterations of the water regime by human activities are not a consideration unless they have significantly changed the morphology of the soil. Seven classes of natural soil drainage are recognized—*excessively drained, somewhat excessively drained, well drained, moderately well drained, somewhat poorly drained, poorly drained,* and *very poorly drained*.

Drainage, surface. Runoff, or surface flow of water, from an area.

Erosion. The wearing away of the land surface by water, wind, ice, or other geologic agents and by such processes as gravitational creep.

Erosion (geologic). Erosion caused by geologic processes acting over long geologic periods and resulting in the wearing away of mountains and the building up of such landscape features as flood plains and coastal plains. Synonym: natural erosion.

Erosion (accelerated). Erosion much more rapid than geologic erosion, mainly as a result of human or animal activities or of a catastrophe in nature, such as a fire, that exposes the surface.

Fertility, soil. The quality that enables a soil to provide plant nutrients, in adequate amounts and in proper balance, for the growth of specified plants when light, moisture, temperature, tilth, and other growth factors are favorable.

Gravel. Rounded or angular fragments of rock as much as 3 inches (2 millimeters to 7.6 centimeters) in diameter. An individual piece is a pebble.

Hard bedrock. Bedrock that cannot be excavated except by blasting or by the use of special equipment that is not commonly used in construction.

Heat islands. Small areas of artificially drained urban soils surrounded by tall buildings that change soil temperature and moisture patterns. May also refer to an entire city with an artificial microclimate.

Horizon, soil. A layer of soil, approximately parallel to the surface, having distinct characteristics produced by soil-forming processes. In the identification of soil horizons, an uppercase letter represents the major horizons. Numbers or lowercase letters that follow represent subdivisions of the major horizons. The major horizons of mineral soil are as follows:

O horizon.—An organic layer of fresh and decaying plant residue.

A horizon.—The mineral horizon at or near the surface in which an accumulation of humified organic matter is mixed with the mineral material. Also, a plowed surface horizon, most of which was originally part of a B horizon.

E horizon.—The mineral horizon in which the main feature is loss of silicate clay, iron, aluminum, or some combination of these.

B horizon.—The mineral horizon below an A horizon. The B horizon is in part a layer of transition from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics, such as (1) accumulation of clay, sesquioxides, humus, or a combination of these; (2) prismatic or blocky structure; (3) redder or browner colors than those in the A horizon; or (4) a combination of these.

C horizon.—The mineral horizon or layer, excluding indurated bedrock, that is little affected by soil-forming processes and does not have the properties typical of the overlying soil material. The material of a C horizon may be either like or unlike that in which the solum formed. If the material is known to differ from that in the solum, an Arabic numeral, commonly a 2, precedes the letter C.

Cr horizon.—Soft, consolidated bedrock beneath the soil.

R layer.—Consolidated bedrock beneath the soil. The bedrock commonly underlies a C horizon, but it can be directly below an A or a B horizon.

Humus. The well decomposed, more or less stable part of the organic matter in mineral soils.

Hydrologic soil groups. Refers to soils grouped according to their runoff potential. The soil properties that influence this potential are those that affect the minimum rate of water infiltration on a bare soil during periods after prolonged wetting when the soil is not frozen. These properties are depth to a seasonal high water table, the infiltration rate and permeability after prolonged wetting, and depth to a very slowly permeable layer. The slope and the kind of plant cover are not considered but are separate factors in predicting runoff.

Hydrologic unit or watershed. In urban areas, a catchment area with an outlet in or affecting a densely populated area.

Impervious soil. A soil through which water, air, or roots penetrate slowly or not at all. No soil is absolutely impervious to air and water all the time.

Infiltration. The downward entry of water into the immediate surface of soil or other material, as contrasted with percolation, which is movement of water through soil layers or material.

Landslide. The rapid downhill movement of a mass of soil and loose rock, generally when wet or saturated. The speed and distance of movement, as well as the amount of soil and rock material, vary greatly.

Leaching. The removal of soluble material from soil or other material by percolating water.

Loam. Soil material that is 7 to 27 percent clay particles, 28 to 50 percent silt particles, and less than 52 percent sand particles.

Low strength. The soil is not strong enough to support loads.
Nutrient, plant. Any element taken in by a plant essential to its growth. Plant nutrients are mainly nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, manganese, copper, boron, and zinc obtained from the soil and carbon, hydrogen, and oxygen obtained from the air and water.
Organic matter. Plant and animal residue in the soil in various stages of decomposition.
Parent material. The unconsolidated organic and mineral material in which soil forms.
Percolation. The movement of water through the soil.
Permeability. The quality of the soil that enables water or air to move downward through the profile. The rate at which a saturated soil transmits water is accepted as a measure of this quality. In soil physics, the rate is referred to as "saturated hydraulic conductivity."
pH value. A numerical designation of acidity and alkalinity in soil. (See Reaction, soil.)
Pocket park. A relatively small area reserved for recreation or gardening and surrounded by streets or buildings.
Profile, soil. A vertical section of the soil extending through all its horizons and into the parent material.
Raised bed gardens. Gardens that are planted in boxes made of wood or other materials and have the rooting area above the ground surface. The boxes may be filled with composted materials mixed with uncontaminated soil.
Reaction, soil. A measure of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is described as precisely neutral in reaction because it is neither acid nor alkaline.
Relief. The elevations or inequalities of a land surface, considered collectively.
Restrictive layer. A compact, dense layer in a soil that impedes the movement of water and the growth of roots.
Runoff. The precipitation discharged into stream channels from an area. The water that flows off the surface of the land without sinking into the soil is called surface runoff. Water that enters the soil before reaching surface streams is called ground-water runoff or seepage flow from ground water.
Sand. As a soil separate, individual rock or mineral fragments from 0.05 millimeter to 2.0 millimeters in diameter. Most sand grains consist of quartz. As a soil textural class, a soil that is 85 percent or more sand and not more than 10 percent clay.
Sealed soil. Soil that is covered with buildings, pavement, asphalt, or other material. Water and air do not enter the soil from the surface.
Series, soil. A group of soils that have profiles that are almost alike, except for differences in texture of the surface layer. All the soils of a series have horizons that are similar in composition, thickness, and arrangement.
Shale. Sedimentary rock formed by the hardening of a clay deposit.
Shrink-swell potential. The potential for volume change in a soil with a loss or gain in moisture. Volume change occurs mainly because of the interaction of clay minerals with water and varies with the amount and type of clay minerals in the soil. The size of the load on the soil and the magnitude of the change in soil moisture content influence the amount of swelling of soils in place. Shrinking and swelling can damage roads, dams, building foundations, and other structures. It can also damage plant roots.
Silt. As a soil separate, individual mineral particles that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). As a soil textural class, soil that is 80 percent or more silt and less than 12 percent clay.
Sinkhole. A depression in the landscape where limestone has been dissolved or lava tubes have collapsed.

Slope. The inclination of the land surface from the horizontal. Percentage of slope is the vertical distance divided by horizontal distance, then multiplied by 100. Thus, a slope of 20 percent is a drop of 20 feet in 100 feet of horizontal distance.

Soft bedrock. Bedrock that can be excavated with trenching machines, backhoes, small rippers, and other equipment commonly used in construction.

Soil-forming factors. Five factors responsible for the formation of the soil from the unconsolidated parent material. The factors are time, climate, parent material, living organisms (including humans), and relief.

Structure, soil. The arrangement of primary soil particles into compound particles or aggregates. The principal forms of soil structure are platy, prismatic, columnar, blocky, and granular. Structureless soils are either single grained or massive.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are *sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay,* and *clay*. The sand, loamy sand, and sandy loam classes may be further divided by specifying “coarse,” “fine,” or “very fine.”

Topographic maps (USGS). Maps that show terrain, ridges, waterways, contours, elevations, and geographic locations. Also may show roads and buildings.

Trace elements. Chemical elements, for example, zinc, cobalt, manganese, copper, and iron, in soils in extremely small amounts. They are essential to plant growth.

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