# All Uses

## Introduction to Soils

### Soils 101

#### What is soil? (less technical)

Soil is a naturally occurring mixture of mineral and organic ingredients with a definite form, structure, and composition. The exact composition of soil changes from one location to another. The following is the average composition by volume of the major soil ingredients:

- 45% Minerals (clay, silt, sand, gravel, stones).
- 25% Water (the amount varies depending upon precipitation and the water-holding capacity of the soil).
- 25% Air (an essential ingredient for living organisms).
- 5% Organic matter or humus (both living and dead organisms).

A soil is composed primarily of minerals which are produced from parent material that is weathered or broken into small pieces. Beyond occasional stones, gravel, and other rock debris, most of the mineral particles are called sand, silt, or clay. These mineral particles give soil texture. Sand particles range in diameter from 2 mm to 0.05 mm, are easily seen with the unaided eye, and feel gritty. [One millimeter (mm) is about the thickness of a dime.] Silt particles are between 0.05 mm and 0.002 mm and feel like flour. Clay particles are smaller than 0.002 mm and cannot be seen with the unaided eye. Clay particles are the most reactive mineral ingredient in the soil. Wet clay usually feels sticky.

Water and air occupy the pore spaces—the area between the mineral particles. In these small spaces, water and air are available for use by plants. These small pore spaces are essential to the life of soil organisms, to soil productivity, and to plant growth.

The final ingredient of a soil is organic matter. It is comprised of dead plant and animal material and the billions of living organisms that inhabit the soil.

(From "Conserving Soil," NRCS)

#### What is soil? (more technical)

Soil is a natural body which consists of solids (minerals and organic matter), liquid, and gases that occurs on the land surface, occupies space, and is characterized by one or both of the following: (1) horizons, or layers, that are distinguishable from the initial material as a result of additions, losses, transfers, and transformations of energy and matter or (2) the ability to support rooted plants in a natural environment. The upper limit of soil is the boundary between soil and air, shallow water, live plants, or plant materials that have not begun to decompose.

Areas are not considered to have soil if the surface is permanently covered by water too deep (typically more than 2.5 meters) for the growth of rooted plants. The lower boundary that separates soil from the nonsoil underneath is most difficult to define. Soil consists of horizons near the earth's surface that, in contrast to the underlying parent material, have been altered by the interactions of climate, relief, and living organisms over time. Commonly, soil grades at its lower boundary to hard rock or to earthy materials virtually devoid of animals, roots, or other marks of biological activity. For purposes of classification, the lower boundary of soil is arbitrarily set at 2 meters.

(From "Soil Taxonomy," second edition, 1999)

## How does soil form?

Soils develop as a result of the interactions of climate, living organisms, and landscape position as they influence parent material decomposition over time. Differences in climate, parent material, landscape position, and living organisms from one location to another as well as the amount of time the material has been in place all influence the soil-forming process.

The five soil-forming factors are:

- Parent material,
- Climate,
- Living organisms,
- Landscape position, and
- Time.

### Parent Material

Parent material refers to that great variety of unconsolidated organic (such as fresh peat) and mineral material in which soil formation begins. Mineral material includes partially weathered rock, ash from volcanoes, sediments moved and deposited by wind and water, or ground-up rock deposited by glaciers. The material has a strong effect on the type of soil developed as well as the rate at which development takes place. Soil development may take place quicker in materials that are more permeable to water. Dense, massive, clayey materials can be resistant to soil formation processes. In soils developed from sandy parent material, the A horizon may be a little darker than its parent material, but the B horizon tends to have a similar color, texture, and chemical composition.

### Climate

Climate is a major factor in determining the kind of plant and animal life on and in the soil. It determines the amount of water available for weathering minerals and transporting the minerals and elements released. Climate through its influence on soil temperature, determines the rate of chemical weathering.

Warm, moist climates encourage rapid plant growth and thus high organic matter production. The opposite is true for cold, dry climates. Organic matter decomposition is also accelerated in warm, moist climates. Under the control of climate, freezing and thawing or wetting and drying break parent material apart.

Rainfall causes leaching. Rain dissolves some minerals, such as carbonates, and transports them deeper into the soil. Some acid soils have developed from parent materials that originally contained limestone. Rainfall can also be acid, especially downwind from industrial production.

### Living organisms

Plants affect soil development by supplying upper layers with organic matter, recycling nutrients from lower to upper layers, and helping to prevent erosion. In general, deep rooted plants contribute more to soil development than shallow rooted ones because the passages they create allow greater water movement, which in turn aids in leaching. Leaves, twigs, and bark from large plants fall onto the soil and are broken down by fungi, bacteria, insects, earthworms, and burrowing animals. These organisms eat and break down organic matter releasing plant nutrients. Some change certain elements, such as sulfur and nitrogen, into usable forms for plants.

Microscopic organisms and the humus they produce also act as a kind of glue to hold soil particles together in aggregates. Well-aggregated soil is ideal for providing the right combination of air and water to plant roots.

### Landscape position

Landscape position causes localized changes in moisture and temperature. When rain falls on a landscape, water begins to move downward by the force of gravity, either through the soil or across the surface to a lower elevation. Even though the landscape has the same soil-forming factors of climate, organisms, parent material, and time, drier soils at higher elevations may be quite different from the wetter soils where water accumulates. Wetter areas may have reducing conditions that will inhibit proper root growth for plants that require a balance of soil oxygen, water, and nutrients.

Steepness, shape, and length of slope are important because they influence the rate at which water flows into or off the soil. If unprotected, soils on slopes may erode leaving a thinner surface layer. Eroded soils tend to be less fertile and have less available water than uneroded soils of the same series.

Aspect affects soil temperature. Generally, for most of the continental United States, soils on north-facing slopes tend to be cooler and wetter than soils on south-facing slopes. Soils on north-facing slopes tend to have thicker A and B horizons and tend to be less droughty.

### Time

Time is required for horizon formation. The longer a soil surface has been exposed to soil-forming agents like rain and growing plants, the greater the development of the soil profile. Soils in recent alluvial or windblown materials, or soils on steep slopes where erosion, has been active may show very little horizon development.

Soils on older, stable surfaces generally have well-defined horizons because the rate of soil formation has exceeded the rate of geologic erosion or deposition. As soils age, many original minerals are destroyed. Many new ones are formed. Soils become more leached, more acid, and more clayey. In many well drained soils, the B horizons tend to become redder in color with time.

(Found in "From the Surface Down," NRCS)

### What are soil horizons?

Soils are deposited in or developed into layers. These layers, called horizons, can be seen where roads have been cut through hills, where streams have scoured through valleys, or in other areas where the soil is exposed.

Where soil-forming factors are favorable, five or six master horizons may be in a mineral soil profile. Each master horizon is subdivided into specific layers that have a unique identity. The thickness of each layer varies with location. Under disturbed conditions, such as intensive agriculture, or where erosion is severe, not all horizons will be present. Young soils have fewer major horizons.

The uppermost layer generally is an organic horizon, or O horizon. It consists of fresh and decaying plant residue from such sources as leaves, needles, twigs, moss, lichens, and other organic material accumulations. Some organic materials were deposited under water. The subdivisions Oa, Oe, and Oi are used to identify levels of decomposition. The O horizon is dark because decomposition is producing humus.

Below the O horizon is the A horizon. The A horizon is mainly mineral material. It is generally darker than the lower horizons because of the varying amounts of humified organic matter. This horizon is where most root activity occurs and is usually the most productive layer of soil. It may be referred to as a surface layer in a soil survey. An A horizon that has been buried beneath more recent deposits is designated as Ab.

The E horizon generally is bleached or whitish in appearance. As water moves down through this horizon, soluble minerals and nutrients dissolve and some dissolved materials are washed (leached) out. The main feature of this horizon is the loss of silicate clay, iron, aluminum, humus, or some combination of these, leaving a concentration of sand and silt particles.

Below the A or E horizon is the B horizon, or subsoil. The B horizon is usually lighter colored, denser, and lower in organic matter than the A horizon. It commonly is the zone where leached materials accumulate. The B horizon is further defined by the materials that make up the accumulation, such as the letter t in the designation Bt, which identifies that clay has accumulated. Other illuvial concentrations or accumulations include iron, aluminum, humus, carbonates, gypsum, or silica. Soil not having recognizable concentrations within B horizons but showing a color or structural difference from adjacent horizons is designated Bw.

Still deeper is the C horizon or substratum. The C horizon may consist of less clay, or other less weathered sediments. Partially disintegrated parent material and mineral particles are in this horizon. Some soils have a soft bedrock horizon that is given the designation Cr. C horizons described as 2C consist of different material, usually of an older age than horizons which overlie it.

The lowest horizon, the R horizon, is bedrock. Bedrock can be within a few inches of the surface or many feet below the surface. Where bedrock is very deep and below normal depths of observation, an R horizon is not described.

(Found in "From the Surface Down," NRCS)

**What is a soil scientist?**

A soil scientist studies the upper few meters of the earth's crust in terms of its physical and chemical properties; distribution, genesis and morphology; and biological components. A soil scientist needs a strong background in the physical and biological sciences and mathematics.

(From "Careers in Soil Science" http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/edu/?cid=nrcs142p2_054277 )

**What is a soil survey?**

One of the main tools available to help land users determine the potentials and limitations of soils is a soil survey. Soil surveys are available through the USDA, Natural Resources Conservation Service (NRCS). The surveys are made by NRCS in cooperation with other Federal, State, and local agencies. Our offices can provide this information, but more and more soil surveys are also available on the Internet. Web Soil Survey allows you to produce a customized soil survey for your own area of interest.

A soil survey generally contains soils data for one county, parish, or other geographic area, such as a major land resource area. During a soil survey, soil scientists walk over the landscapes, bore holes with soil augers, and examine cross sections of soil profiles. They determine the texture, color, structure, and reaction of the soil and the relationship and thickness of the different soil horizons. Some soils are sampled and tested at soil survey laboratories for certain soil property determinations, such as cation-exchange capacity and bulk density.

Like any tool, a soil survey is helpful only if you know what it can and can't do, and if you use it accordingly. The survey does not replace careful onsite investigation or analysis by a soil scientist

(Found in "From the Surface Down," NRCS)

**Who uses a soil survey?**

Soil surveys available from the Natural Resources Conservation Service are intended for many different users. They can help homebuyers or developers determine soil-related hazards or limitations that affect homesites. They can help land use planners determine the suitability of areas for housing or onsite sewage disposal systems. They can help farmers estimate the potential crop or forage production of his land. They can be used to determine the suitability and limitations of soils for pipelines, buildings, landfills, recreation areas, and many other uses.

Many people assume that soils are all more or less alike. They are unaware that great differences in soil properties can occur within even short distances. Soils may be seasonally wet or subject to flooding. They may be shallow to bedrock. They may be too unstable to be used as a foundation for buildings or roads. Very clayey or wet soils are poorly suited to septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

These soil properties and many others that affect land use are given in soil surveys. Each soil survey describes the properties of soils in the county or area surveyed and shows the location of each kind of soil on detailed maps.

**What is a map unit?**

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. The contrasting components are mentioned in the map unit descriptions. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

#### What is a consociation, complex, association, undifferentiated group, or miscellaneous area?

A *consociation* is a kind of map unit that consists of one major soil or miscellaneous area plus any components of minor extent. The major component is identified in the map unit name. "Consociation" is a coined term.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them.

*Miscellaneous areas* have little or no soil material and support little or no vegetation.

#### What is an Official Series Description?

The Official Soil Series Descriptions (OSD) is a national collection of more than 20,000 detailed soil series descriptions, covering the United States, Territories, Commonwealths, and Island Nations served by USDA-NRCS. The descriptions, in a text format, serve as a national standard.

The soil series is the lowest category of the national soil classification system. The name of a soil series is the common reference term, used to name soil map units. Soil series are the most homogenous classes in the system of taxonomy. "Official Soil Series Descriptions" define specific soil series in the United States, Territories, Commonwealths, and Island Nations served by USDA-NRCS. They are descriptions of the taxa in the series category of the national system of soil classification. They serve mainly as specification for identifying and classifying soils. The descriptions contain soil properties that define the soil series, distinguish it from other soil series, serve as the basis for the placement of that soil series in the soil family, and provide a record of soil properties needed to prepare soil interpretations.

(From "OSD Fact Sheet" http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/home/?cid=nrcs142p2_053586 )

### Information for Land Users

#### Homebuyers

The foundation supports the walls, the walls support the roof, and the soil holds them all. But how can you tell if the soil will be a good "home" for your house? You need to answer some important questions:

- Is the soil stable, or does it have properties that can cause the foundation or walls to crack?
- Is the soil in an area subject to flooding?
- Will storm runoff drain safely away from the house and lot? Or will it turn your yard, or basement, into a pond?
- Does the soil have a seasonal high water table that can cause a basement to flood or a septic system to fail?
- Is the soil deep enough for a basement to be dug economically? For garden and landscape plants to take root and thrive?
- Is the soil so steep that erosion may be severe?

A soil survey can help you answer these and many other questions about the soil.

**Land Use Planners**

Soil surveys can help planners make and substantiate the decisions that local government officials translate into zoning ordinances, building permits, authorizations for sewer extension, and other regulations that mold a growing community. Information about soil limitations for given uses helps prevent major mistakes in land use and unnecessary costs to individuals and the community.

Soil surveys help in determining the extent of floodprone areas, and they rate the hazards that affect use of soils in such areas. In many states soil surveys are used to guide municipal and other government agencies in restricting the use of flood plains for housing, septic tank absorption fields, and other forms of intensive development.

Zoning areas for housing, recreation, commercial, and other kinds of development should take account of the suitability and limitations of soils for such uses. Soil surveys describe soil properties in detail and can help planners establish general patterns of soil suitability and limitations for various land uses.

Erosion and sedimentation may increase where land is being developed. Sediment has become a major pollutant, and communities throughout the Nation spend millions of dollars every year just to remove sediment from drinking water.

Planners and other authorities can use soil maps and soil data to identify sources of sediment and to develop plans for controlling erosion and sedimentation.

Septic tank absorption fields do not work in wet or impermeable soils. Soil surveys provide detailed descriptions of soil properties that can be used to determine the suitability of areas for absorption fields. They indicate soil hazards that affect absorption fields, such as slow permeability caused by high clay content, the presence of a high water table, or excessive permeability that may allow effluent to pollute ground water. In many parts of the United States soil surveys are used as a basis for ordinances that regulate use of land for septic tank absorption fields.

Through use of soil surveys, roads and highways can be routed to avoid major soil hazards, and sources of borrow material needed in constructing highways can be located. Contractors can bid for work more accurately and can consider soil suitability and limitations in planning and designing specific structures.

Recreation uses of land should be based on suitability of soils. Soil surveys can help in identifying areas suitable for campsites, golf courses, manmade fishponds, and many other recreation facilities. They also can help in planning the construction and layout of large recreation areas that have restrooms, parking areas, outbuildings, and other structures.

Prime farmland can be identified through use of soil surveys. Other areas suited to development and not so well suited to farming may be selected for development instead.

In planning uses for specific areas, an onsite investigation by a trained professional can determine if there are any soil hazards or limitations, and whether these can be overcome by corrective measures.

### Appraisers

In appraising the income potential of farmland it is essential to distinguish between income differences caused by soil properties and those caused by management. If two farms are managed in much the same way and still show differences in income, it is likely that the soils differ in inherent productivity. Likewise, two farms that have identical soil resources have the same potential productivity even if they are now managed differently.

Soil surveys available from the Natural Resources Conservation Service can help bankers, loan companies, tax assessors, farmers, and others who need to know about the productivity of farmland obtain reliable estimates of the potential productivity of soils in their area.

### Developers and Builders

As a developer or builder, you probably know of construction projects on which time and money were lost because of unforeseen soil hazards. Soil surveys available from the Natural Resources Conservation Service (NRCS) can help you anticipate soil hazards at proposed construction areas, plan optimum development, and ensure adequate conservation during and after construction.

Soil surveys can help you determine whether tracts are suitable for development and avoid cost overruns caused by unforeseen soil hazards. By studying soil maps and supporting data in soil surveys, you can determine the soil conditions in areas where you plan to build and decide what additional investigations, if any, are needed. Soil surveys can help you avoid the unnecessary complications that attend failure of foundations, soil slippage, flooded basements, and other structural breakdowns caused by adverse soil properties. Special foundations, walls, and floor drains can be planned if soil hazards indicate that buildings of standard design would likely fail. Soil surveys describe soil properties in detail so that you can anticipate such problems and prepare alternative designs or select other areas for development.

### Waste Disposal Entities

Whether you are a homeowner, land use planner, board of health official, county sanitarian, or land developer, waste management concerns you. Soil surveys available from the Natural Resources Conservation Service can help in planning the disposal of liquid and solid wastes through septic tank absorption fields, sewage lagoons, and sanitary landfills.

#### Septic tank absorption fields

Because of rapid suburban expansion, the number of homes that do not have access to a public sewage disposal system has increased greatly. The most common system for individual homes is one in which the sewer line from the house leads to an underground septic tank in the yard. Overflow from the tank disperses into the soil through a system of underground drains or perforated pipes.

To design a system that will work, you need to know the capacity of the soil to absorb effluent. Movement of effluent through soil is determined mainly by the porosity of the soil, the size of the soil particles, and by the kind of clay in the soil. Effluent moves faster through sandy and gravelly soils than through clayey soils. Soils high in clay content have limited pore space for holding effluent. Some kinds of clay expand when wet and close the pores entirely. Such soils are unsuitable for absorption fields. If the soil is not porous, the effluent simply builds up and seeps to the surface.

Soils that have a high water table may be saturated part of the year. A saturated soil cannot absorb additional liquid, and the unfiltered septic tank effluent discharged into the drains may seep to the surface. If there is a seasonal high water table, the septic tank absorption field may work in dry seasons but fail in wet seasons.

Soil that is shallow to rock or soil that has a cemented layer just below the bottom of the trench in which drains are laid lacks space for the effluent to be absorbed. About 4 feet of soil material between the bottom of the trench and any rock formation is necessary for absorption, filtration, and purification of septic tank effluent. More than 4 feet may be required if the underlying rock is limestone that contains water used for domestic use.

Steep slopes—15 percent or steeper—make it difficult to control the distribution of effluent. Effluent distributed into soil on a steep slope may seep onto the ground surface at a lower level. Digging drain trenches on the contour insures that the effluent flows slowly through the drains and disperses throughout the absorption field.

Soils that are subject to flooding should not be used for absorption fields. Flooding destroys the effectiveness of the field and allows unfiltered effluent to pollute the stream.

Before a septic tank absorption field or onsite sewage facility is designed for a specific area, an onsite investigation by a trained professional can determine if there are any soil hazards or limitations and whether these can be overcome by corrective measures.

### Sewage lagoons

Sewage lagoons are shallow manmade ponds used to hold sewage for the time required for bacterial decomposition, after which the clarified water is released from the lagoon.

The lagoon must be capable of holding water with a minimum of seepage. The soil material in the bottom of the lagoon and in the embankment should be free of stones and boulders that interfere with compaction. Porous soils have severe limitations for sewage lagoons because water moves through the soil too rapidly.

The soil also should be low in organic-matter content to reduce the potential growth of aquatic plants. There should be no hazard of flooding, and the depth to water table should be at least 40 inches. Slope should be no more than about 7 percent.

### Sanitary landfills

Sanitary landfill is one way to dispose of garbage, boxes, plastic and metal containers, and other solid wastes. Refuse is spread, compacted, and covered with soil material daily.

Landfill cannot be placed just anywhere. The properties of the soil and the kind of management determine the success of a sanitary landfill.

Soils used for landfill should not be subject to flooding or have a high water table. Flooding the landfill causes pollution of offsite areas. If the water table is seasonally high, leachate from the landfill may contaminate ground water.

Steep slopes cause an erosion hazard. More care is needed on sloping to steep soils to dispose of runoff water, including that from adjacent higher elevations. More grading is required for the roads that lead to and from a landfill on sloping to steep soils than on nearly level soils. Soils used for landfill should be easy to excavate and should hold up under heavy vehicular traffic in all kinds of weather. Most fine-textured (high clay content) soils are plastic and sticky when wet and are difficult to excavate, grade, and compact.

Water movement through the soil should be moderate to slow to retard the movement of leachate from the landfill into underlying layers where it may pollute ground water.

Cover material must be easy to dig, move, and spread over the refuse during both wet and dry periods. It must be easy to compact to reduce the rate of water intake. The area from which the cover material is taken should be suitable for revegetating in order to prevent erosion in the borrow area. Soil used for the final cover layer should be well suited to the growth of plants.

### Disposing of other kinds of waste

Research is being conducted on the disposal of many kinds of wastes into soils. Such wastes include animal wastes from feedlots; residues from vegetable, meat, poultry, and dairy processing plants; chemicals used for fertilizers, pesticides, and herbicides; and effluent and sludge from municipal sewage plants.

Basic factors to consider in disposing of these wastes into the soil are the ability of the soil to assimilate wastes safely, the quality of the waste, particularly its content of nutrients and heavy metals, and the ability of vegetation grown in the disposal areas to utilize the nutrients in the waste. Soil properties that affect use for landfills also affect use of soils for disposing of other kinds of wastes.

## Park Boards and Recreation Area Planners

More ski resorts, dude ranches, camps, parks, picnic areas, and other private and public recreation areas are needed to meet the growing demand for recreation. But just because recreation is for fun does not mean the selection and layout of areas can be haphazard. Soil suitability and limitations should be considered in planning recreation areas.

This Web site tells how soil surveys available from the Natural Resources Conservation Service can help you select tracts suitable for recreation development and plan adequate conservation to ensure that the areas remain attractive and usable.

### Why soil data are needed

It cannot be assumed that just any piece of land can be used for recreation. Some soils are as unsuitable for recreation as they are for supporting buildings or for growing oranges. Among the soil properties that affect recreation uses are the following.

Flood hazard severely limits use of soils for camps and recreation buildings, but such soils are suitable for hiking and nature study and other less intensive uses.

High water tables impose severe limitations on use of soils for campsites, roads and trails, playgrounds, and picnic areas.

Droughtiness makes it difficult to grow grass needed to prevent erosion, and droughty soils may require irrigation to maintain vegetation.

Some clayey soils swell when wet and shrink when dry. This shrinking and swelling may damage floors and foundations of recreation buildings. Such soils may fail to support roads and other structures unless special design is used.

Steep slopes limit the use of soils for playgrounds, campsites, buildings, roads, and trails, but are appropriate for hiking areas.

If bedrock is at shallow depth, it is difficult to level soils for playgrounds and campsites, to construct roads and trails, and to establish vegetation. Shallow soils are poorly suited for uses that require extensive grading.

A clayey or sandy surface layer makes some soils undesirable for playgrounds, campsites, or other uses that require heavy foot traffic.

Soils high in clay content are sticky when wet and remain wet for long periods after rains. Loose sandy soils are unstable and dusty when dry. Sandy loam and loam soils are the most suitable for recreation uses that require heavy foot traffic.

Stones, gravel, and rocks impose moderate to severe limitations on use of soils for campsites, playgrounds, trails, and other uses that require heavy foot traffic.

The absorptive capacity of soils determines whether a septic tank absorption field will work. The soil should be deep and permeable, there should be no seasonal high water table, the slope should not be steep, and there should be no danger of flooding.

Suitability for impounding water determines whether the soil can be used for manmade fishponds. Ponds are desirable for other recreation uses, such as shooting preserves, dude ranches, vacation farms, and wildlife and nature study areas. Soils suited to manmade ponds generally are deep, have low permeability when compacted, are not steep, and have a low susceptibility to piping.

### Selecting recreation areas

Soil surveys can help you select areas suitable for a wide range of recreation uses, including the following:

- wetland refuges for waterfowl
- wildlife management
- open space or nature study areas
- parks
- athletic fields
- ski areas
- golf courses
- campsites, hiking trails, and picnic areas
- dude ranches
- woodlands
- hunting reserves
- manmade ponds

### Maintaining recreation areas

For the manager of a ski resort, dude ranch, camp, park, picnic area, playground, or other private or public recreation area, a soil survey can provide information necessary for planning a conservation program to protect the area against erosion and other kinds of site damage. A soil survey can guide you in selecting a use for each area, based on the suitability of the soil. For example, soils that are susceptible to erosion can be planted to trees, shrubs, and grasses and used in a nonintensive way, such as for nature study. Loamy, well-drained soils can be used for play areas and other uses that require heavy foot traffic.

A soil survey also helps in determining the kind of conservation measures needed to protect the soils while in use. Soil information, which for many years has helped farmers and ranchers prepare conservation plans, can also be used by a camp operator or manager of any recreation area. Vegetation adapted to the soil can be selected and planted to protect the soil from erosion. Dams, terraces, diversions, waterways, and other mechanical measures to control water runoff can be installed in critical areas. In wet areas, if the soil and topography permit and if outlets are available, drains can be installed.

An onsite investigation of a specific site by a trained professional can determine if there are any soil hazards or limitations, and whether these can be overcome by corrective measures.

### Construction Engineers

On many construction projects a major soil hazard is discovered only after the site has been selected and construction is underway. The unforeseen hazard generally leads to delays in construction and to cost overruns.

If soil hazards are known before construction begins, special compensating designs can be prepared in advance or alternate sites can be selected. Although nearly any site can be made suitable for most uses if enough money is spent, avoiding poor sites where possible helps keep construction and maintenance costs to a minimum.

Soil surveys available from the Natural Resources Conservation Service (NRCS) can help engineers anticipate soil-related hazards that affect construction of buildings, highways, pipelines, transmission lines, and similar installations.

#### Determining soil hazards

Soil surveys show the location of and describe each kind of soil in the county or area and describe the soil properties. These data can help engineers anticipate soil-related problems and plan onsite inspection. Failure to investigate adequately may lead to expensive delays in construction or eventual structural breakdown.

#### How soil surveys can help engineers

Construction engineers are particularly interested in soil properties that may require special structural measures to overcome or special maintenance once construction is completed. Soil surveys describe important soil properties that affect construction, including the following:

Shrink-swell potential: Certain kinds of clay soils expand when wet and shrink when dry, and special foundations are required to compensate for this movement. Soil surveys identify soils that have large shrink-swell potential.

Wetness: Soil surveys provide data on natural soil drainage, permeability, depth to seasonal water table, and suitability for winter grading for various kinds of soils. They can help engineers anticipate seasonal limitations on the use of heavy machinery for earthmoving and compacting and estimate the hazard of flooding or damage to underground structures caused by soil wetness.

Depth to bedrock: Soil surveys show areas where bedrock is at a depth of less than 5 or 6 feet and indicate the kind of bedrock.

Erodibility: Soil surveys provide information on how susceptible each soil is to erosion. Slope is only one factor contributing to erodibility. Other soil properties are also important, especially those properties that determine the cohesiveness of soil particles. These properties commonly vary within different layers of the same soil and cause different degrees of erodibility in different soil layers.

Flood hazard: The hazards of flooding and ponding are rated in soil surveys, and flood-prone areas are shown on soil maps. Such information does not take the place of hydrologic studies to determine the severest flood expected once in 10, 25, 50, or 100 years, but it does provide reliable estimates of areas where floods are most likely.

Slope: Slope gradient is a determining factor in establishing the final grade of a construction site and the amount of cut and fill needed to achieve the final grade. Ranges in slope are recorded in soil surveys, and areas where cuts and fills may be needed can be identified by studying soil maps. Slope particularly affects the installation of underground conduits and the construction of roads and highways.

Bearing capacity: Soil surveys give estimates of the particle size and plasticity of soils, and each soil layer is classified according to the Unified and the AASTHO systems. These classifications help in evaluating soils for shallow foundations and determining ease of compaction, ease of winter grading, trafficability, density, moisture relationships, susceptibility to frost action, and other properties.

Corrosion potential: Standard concrete deteriorates rapidly in very acid soils, and steel corrodes in soils that are highly saline or acid. The corrosion potential of each kind of soil is rated in soil surveys.

Organic layers: Muck and peat are very soft and unstable, and if drained, they subside. Areas of organic soils are shown in soil surveys, and the thickness of organic layers is indicated.

Ease of excavation: Excavating friable soils may cost half as much as excavating soils that are hard and compact. Sticky, clayey soils are difficult to spread in thin layers. Some soils are very susceptible to sloughing in trenches; others are stable. All these properties may differ from layer to layer in the same soil. Data presented in soil surveys can be used by engineers to anticipate earthmoving problems and to prepare more accurate bids for earth-moving.

Soil surveys also provide interpretations of the effect of soil properties on many kinds of land use. These interpretations and other data can be used to determine soil suitability as a source of topsoil, sand and gravel, roadfill for highway subgrade, and impermeable material. The interpretations also show the degree and kind of limitations of soils if used for septic tank absorption fields, foundations for low buildings, underground utility lines, pipelines, highways, roads, streets, and parking lots.

### Farmers and Ranchers

As farmer or rancher you don't have time or capital to spend on elaborate agricultural research and experiments or on mapping and studying soils. But you are interested in the results of such studies if they can help you to manage more profitably.

Soil surveys contain detailed maps and descriptions of soils in your area. This information can contribute to the management of your farm or ranch. For specific sites and uses, an onsite investigation of the soils by a trained professional can determine if there are any soil hazards or limitations, and whether these can be overcome by corrective measures.

### How soil surveys can help farmers

To stay in business, farmers have to evaluate important developments in agricultural management. A soil survey can play a major part in this aspect of managing a farm.

Management practices: Farm production depends largely on fitting soil management practices to the soil properties as accurately as possible. It is the right combination of a number of practices that gets optimum results. Researchers try various combinations of fertilizers, tillage methods, water management, and conservation measures. Combinations that produce the greatest yields at the least cost on soils at experiment stations can be expected to give equally good results on similar soils elsewhere. Soil descriptions presented in the soil survey of your area can help you evaluate prospective changes in management of your soils.

New practices also are constantly on trial at state and other agricultural experiment stations. By comparing soils at such stations with those described in the soil survey of your area, you can estimate the likely success of new practices on your farm.

Special crops: You may want to know if new or special crops will work for you. The soil survey of your area describes soil properties that affect crop growth and provides information that could save you costly experiments in determining the best way to manage your land for unfamiliar crops.

Crop yields: Estimated yields of major crops under a high level of management are included in published soil surveys. The estimated yields can help you calculate approximately what returns to expect on your soils and determine whether a high level of management would increase yields enough to pay the extra cost.

Conservation plan: A soil survey can help you determine how intensively you can use your soils without damage. It also helps in determining what conservation measures are needed to control erosion and maintain or increase the productivity of your farm.

Reclaiming land: Some severely eroded soils respond readily to soil treatments, such as fertilizer, lime, and green manure, but other soils respond very poorly. A soil survey can help you decide whether added treatment to reclaim soils is likely to succeed.

Waste disposal: Feedlots, poultry and broiler plants, and dairy farms dispose of manure and other wastes into soils. A soil survey helps in determining how much waste the soils can absorb and in what form.

Recreation: A soil survey can help in selecting areas suitable for manmade ponds. It also can help in planning development of land for fee fishing, hunting, camping, and other recreation facilities used to supplement income.

### How soil surveys can help ranchers

As a rancher, you want the greatest amount of high-quality forage from your range. Because forage yields depend in large part on soil properties, detailed knowledge of the soils on your ranch can help you manage your range more effectively.

Range potential: A soil survey provides detailed soil descriptions that can help you relate the kinds of soil on your ranch to the distinctive kind and amount of vegetation each soil can support. Soil texture, depth, wetness, available water, slope, and topographic position are among the important soil properties that affect range potential. Deep loamy soils on bottom lands may produce the most desirable range plants. On uplands where rainfall is moderate, medium-textured soils that take in water readily may produce desirable plants if grazing is controlled. In some dry areas sandy soils are more productive than clayey soils. Grouping the soils on your range according to their potential productivity helps you plan the kind of management needed to increase forage yields.

Range management: A soil survey can help you estimate the likely benefits of management practices. For example, the soil in an area of brush or mesquite may have such low potential productivity that the cost of chaining or chemical removal may not be worth the ultimate yield in forage. On the other hand, there may be rocky areas or hillsides where the soils are capable of producing more forage if properly managed. A soil survey can help you determine such natural differences in productivity.

Grazing management: If range is overgrazed, desirable plants decrease and less desirable plants may take over the site. A soil survey can help you identify soils that are producing at less than their potential. Each soil survey names the main species of desirable and undesirable range plants that grow on the soils and provide estimates of forage yields than can be expected under favorable and unfavorable conditions.

Pasture, hay, and silage: You may need to grow more winter feed or establish more pasture. A soil survey rates soil suitability for hay and pasture plants so that you can determine which areas will be most productive for this use.

Wildlife and recreation: To supplement income, many ranchers use their land for fee hunting or other kinds of recreation. A soil survey provides information that can help you manage your land for wildlife habitat or identify areas suitable for recreation development.

Conservation plan: A soil survey can help you plan conservation management of your range. Soil maps and soil descriptions help you identify problem areas, select suitable areas for stock ponds, and establish schedules for grazing and proper use of the soils on your range.

**What soil data are available?**

Soil surveys contain detailed maps and descriptions of soils and they provide interpretations of soil properties for farming and ranching where such land use is practiced. Among the soil properties that affect use of soils for farming and ranching are the content of sand, silt, and clay, acidity and alkalinity, flood hazard, depth to water table, natural drainage, erodibility, organic-matter content, and fertility. These and many other properties described in soil surveys provide basic information for managing soils on a farm or ranch.

To determine whether a soil survey of your area is available, call the local office of the Natural Resources Conservation Service. The soil conservationist or soil scientist will welcome an opportunity to discuss conservation management of your soils with you.

## Cropland

Cropland is defined as a land cover or land use category that includes areas used for the production of adapted crops for harvest. Two subcategories of cropland are recognized: cultivated and noncultivated. Cultivated cropland is land that is used for either row crops or close-grown crops. Hayland or pastureland that is in a rotation with row crops or close-grown crops also is considered cultivated cropland. Noncultivated cropland includes permanent hayland and horticultural cropland.

Reference:
"2001 Annual NRI Glossary of Key Terms," National Resources Inventory, USDA, NRCS

### Land capability classification

Determinations of land capability involve consideration of the risks of land damage from erosion and other causes and the difficulties in land use resulting from physical land characteristics and from climate. Land capability, as used in the USA, is an expression of the effect of physical land characteristics and climate on the suitability of soils for crops that require regular tillage, for grazing, for woodland, and for wildlife habitat.

Land capability classification shows, in a general way, the suitability of soils for most kinds of field crops. Crops that require special management are excluded. The soils are grouped according to their limitations for field crops, the risk of damage if they are used for crops, and the way they respond to management. The criteria used in grouping the soils do not include major and generally expensive landforming that would change slope, depth, or other characteristics of the soils, nor do they include possible but unlikely major reclamation projects. Capability classification is not a substitute for interpretations designed to show suitability and limitations of groups of soils for rangeland, forestland, or engineering purposes.

In the capability system, soils are generally grouped at three levels: capability class, subclass, and unit.

**Capability classes**, the broadest groups, are designated by the numbers 1 through 8. Capability classes are determined for both irrigated and nonirrigated land. The numbers indicate progressively greater limitations and narrower choices for practical use. The classes are defined as follows:

**Class 1** soils have slight limitations that restrict their use.

**Class 2** soils have moderate limitations that restrict the choice of plants or require moderate conservation practices.

**Class 3** soils have severe limitations that restrict the choice of plants or require special conservation practices, or both.

**Class 4** soils have very severe limitations that restrict the choice of plants or require very careful management, or both.

**Class 5** soils are subject to little or no erosion but have other limitations, impractical to remove, that restrict their use mainly to pasture, rangeland, forestland, or wildlife habitat.

**Class 6** soils have severe limitations that make them generally unsuitable for cultivation and that restrict their use mainly to pasture, rangeland, forestland, or wildlife habitat.

**Class 7** soils have very severe limitations that make them unsuitable for cultivation and that restrict their use mainly to pasture, rangeland, forestland, or wildlife habitat.

**Class 8** soils and miscellaneous areas have limitations that preclude commercial plant production and that restrict their use to recreational purposes, wildlife habitat, watershed, or esthetic purposes.

**Capability subclasses** are soil groups within one class. They are designated by adding a small letter, *e*, *w*, *s*, or *c*, to the class numeral, for example, 2e. In class 1 there are no subclasses because the soils of this class have few limitations. Class 5 contains only the subclasses indicated by *w*, *s*, or *c* because the soils in class 5 are subject to little or no erosion. These soils have other limitations that restrict their use to pasture, rangeland, forestland, wildlife habitat, or recreation. The significance of each subclass letter is described as follows:

**Subclass letter e** shows that the main problem is the hazard of erosion unless close-growing plant cover is maintained. The susceptibility to erosion and past erosion damage are the major soil-related factors affecting the soils that are assigned this subclass letter.

**Subclass letter w** shows that water in or on the soil interferes with plant growth or cultivation. In some soils the wetness can be partly corrected by artificial drainage. Ponding, a high water table, and/or flooding affect the soils that are assigned this subclass letter.

**Subclass letter s** shows that the soil has limitations within the root zone, such as shallowness of the root zone, a high content of stones, a low available water capacity, low fertility, and excessive salinity or sodicity. Overcoming these limitations is difficult.

**Subclass letter c** shows that the chief hazard or limitation is climate that is very cold or very dry. This subclass letter is used only in some parts of the United States.

**Capability units** are soil groups within a subclass. The soils in a capability unit are enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity. Capability units are generally designated by adding an Arabic numeral to the subclass symbol, for example, 2e-4 and 3e-6. The use of this category of the land capability classification is a state option. This category of the system is not stored in the soil survey database. For information about capability units, please contact the local NRCS State Soil Scientist. For locations of the offices of the State Soil Scientists, click on the State Contacts link in the upper portion of this window.

Reference:
"National Soil Survey Handbook," Part 622 (00-Exhibit 1), USDA, NRCS

### Soil erosion and crop production

Soil erosion has long been considered detrimental to soil productivity. It is the basis for soil loss tolerance values. Considerable loss in productivity is likely to occur on most soils if they are eroded for several centuries at present soil loss tolerance levels. The cost of annual erosion-caused losses in productivity on cropland and pastureland in the United States approaches $27 billion. There is an additional cost of $17 billion for off-site environmental damage. Worldwide costs for erosion-caused losses and off-site environmental damage are estimated at $400 billion per year.

Soil erosion can significantly reduce crop yields, especially in years when weather conditions are unfavorable. As soil erosion continues, the soil is further degraded. Poor soil quality is reflected in decreases in the content of organic matter, aggregate stability, phosphorus levels, and the potential for providing plant-available water. The net result is a decrease in soil productivity.

Soil erosion occurs through either water or wind action. Erosion by water includes sheet, rill, ephemeral gully, classical gully, and streambank erosion. Each succeeding type is associated with the progressive concentration of runoff water into channels as it moves downslope.

**Sheet erosion**, sometimes referred to as "interrill erosion," is the detachment of soil particles by the impact of raindrops and the removal of thin layers of soil from the land surface by the action of rainfall and runoff.

Severe sheet and rill erosion on highly erodible soils in northwest Iowa after heavy rains. The spring rains fell on the surface when the soils were not protected against erosion. (NRCS Photo Gallery NRCSIA99126)

**Rill erosion** is the formation of small, generally parallel channels caused by runoff water. It usually does not recur in the same place.

Rill erosion on highly erodible soils in Cass County, Iowa, after heavy rains. The field was not protected against erosion. (NRCS Photo Gallery NRCSIA99128)

**Ephemeral gully erosion** is the formation of shallow, concentrated flow channels in areas where rills converge. The channels are filled with soil by tillage and form again through subsequent runoff in the same general location.

A central Iowa field where ephemeral gully erosion has washed young corn plants from the ground and has removed topsoil and plant nutrients. (NRCS Photo Gallery NRCSIA99140)

**Classical gully erosion** is the formation of permanent, well defined, incised, concentrated flow channels in areas where rills converge. The gullies cannot be crossed by ordinary farm equipment.

Gully erosion caused by uncontrolled runoff in an area in Kansas. (NRCS Photo Gallery NRCSKS02008)

**Streambank erosion** is the removal of soil from streambanks by the direct action of streamflow. It typically occurs during periods of high streamflow.

The greatest deterrent to soil erosion by water is a vegetative cover, living or dead, on the surface. Supplemental erosion-control practices include contour farming, contour stripcropping, and terraces or diversions.

**Wind erosion** is generally the most common form of soil erosion on the Great Plains. Other major regions that are subject to damaging wind erosion are the Columbia River plains; some parts of the Southwest and the Colorado Basin; areas of muck and sandy soils in the Great Lakes region; and areas of sand on the Gulf, Pacific, and Atlantic seaboards. Wherever the soil surface is loose and dry, vegetation is sparse or does not occur, and the wind is sufficiently strong, wind erosion will occur unless erosion-control measures are applied.

Wind is an erosive agent. It detaches and transports soil particles, sorts the finer from the coarser particles, and deposits the particles unevenly. Loss of the fertile topsoil in eroded areas reduces the rooting depth and, in many places, reduces crop yields. Abrasion by airborne soil particles damages plants and manmade structures. Drifting soil also causes extensive damage. Sand and dust in the air can harm animals, humans, and equipment.

A "black roller" moving across the plains, carrying soil blown from unprotected farmland during the Dust Bowl. (NRCS Photo Gallery NRCSDC01019)

Wind erosion in an area of unprotected fields in north-central Iowa. (NRCS Photo Gallery NRCSIA99158)

Wind erosion in an unprotected cultivated field near Manhattan, Kansas. (NRCS Photo Gallery NRCSKS02050)

References:
1957 Yearbook of Agriculture, USDA, NRCS.
"National Agronomy Handbook," USDA, NRCS, 2002
Natural Resources Conservation Service Photo Gallery, USDA, NRCS
"Soil Quality-Agronomy Technical Note 7," Soil Quality Institute, USDA, NRCS, 1998

**Cropland management**

Because of the impacts of both wind and water erosion on yields and soil quality, good cropland management is necessary to conserve and protect our soil, water, and air. Following is a discussion of several different kinds of cropland management practices. Generally, cropland management involves crop rotation, tillage or planting techniques, crop residue management, nutrient management, and pest management. Additional practices or treatments, where applicable, include irrigation water management (IWM), surface and subsurface water management, contour farming, buffer strips, filter strips, cover crops, cross wind strips, subsoiling, terraces and water- and sediment-control basins, and grassed waterways.

### Crop rotation

**How this practice works:** A planned sequence of two or more different crops grown on the same land in successive years or seasons helps to replenish the soil; reduces the damaging effects of insects, weeds, and disease; and provides adequate feed for livestock. Crop rotations add diversity to an operation and often reduce economic and environmental risks. They are low-cost practices that often form the basis for other conservation practices. Crop rotations are common on sloping soils because of their potential for conserving soil. They can reduce the need for fertilizer when legumes, such as alfalfa or soybeans, replace some of the nitrogen that corn and other grain crops remove.

**The major benefits of crop rotations include:**

1. Reduced runoff and erosion
2. Increased content of organic matter
3. Improved soil tilth
4. Improved pest management
5. Better moisture efficiency
6. Higher yields
7. Improved esthetics and wildlife habitat

An effective crop rotation has three components:

1. The crop rotation must consist of two or more "unlike" crops planted on the same land in successive years or seasons, i.e., a corn-soybean rotation in which corn is planted on a field one year and soybeans planted in the same field the following year. In dryland situations, a crop rotation must have a subsequent crop of sufficient intensity to ensure maximum use of the effective precipitation.
2. The crop rotation must be diverse. Crop diversity promotes effective nutrient cycling and expanded disease- and weed-control strategies.
3. The crop rotation that has sufficient intensity and diversity must be managed properly. Proper management includes tillage and planting methods that reduce the extent of surface disturbance. It also includes dependence on cultural practices that minimize the need for costly technology.

**How this practice helps:**

**Pest management:** Crop rotations naturally reduce the incidence and severity of weeds, insects, and diseases in a cropping system, thereby reducing pesticide costs. When a different crop is grown each year, there is a different host crop that is usually not compatible with the pests that may have carried over from the previous year. As a result, different pest-management strategies can be used.

**Erosion control:** Rotations consisting of continuous row crops and excessive tillage have a higher potential for wind erosion or water erosion than rotations that include closely spaced row crops or perennial crops.

**Surface residue:** Surface residue is one of the most effective erosion-control measures available. If crops that produce high amounts of residue follow crops that produce low amounts of residue in the cropping sequence, higher levels of crop residue are maintained on the surface. Residue management practices, such as mulch tillage and no-till, can help to maximize the amount of crop residue on the surface during critical erosion periods.

**Soil quality:** Cropping sequences that include hay or pasture crops result in greater soil aggregate stability than rotations of continuous grain crops. Under all grain rotations, greater aggregate stability occurs with crops that produce higher amounts of residue. For example, a corn-soybean rotation results in greater organic carbon levels than a rotation of continuous soybeans.

**Nutrient management:** Rotations in which forage legumes or legume cover crops precede grain crops can reduce the need for nitrogen (N) fertilizer when the grain crops are grown.

**Water management:** Dryland rotations can take advantage of stored soil moisture by alternating shallow-rooted crops, such as winter wheat, and deep-rooted crops, such as safflowers.

**Livestock feed production:** For livestock operations, rotations that include hay and/or pasture can provide a major portion or, in some cases, all of the livestock forage and feed. Including hay or pasture in the rotation dramatically reduces the hazard of soil erosion and helps to protect water quality by keeping excess nutrients or chemicals from entering surface water.

Crop rotation (Farmland Protection Program NEPA Documents, Appendix B FPP Practice Effects: Practice Photos, Descriptions and Network Diagrams, USDA, NRCS)

References:
"Core4 Conservation Practices Training Guide," USDA, NRCS, 1999
"National Agronomy Handbook," USDA, NRCS, 2002

**Crop residue management**

**Definition:** Any tillage and planting system that uses no-till, ridge-till, mulch-till, or other systems designed to retain all or a portion of the previous crop's residue on the soil surface. The amount required depends on other conservation practices applied to the field and the farmer's objectives.

**How this practice works:** Leaving last year's crop residue on the surface before and during planting operations provides cover for the soil at a critical time of the year. The residue is left on the surface by reducing the number of tillage operations and the extent of tillage. Pieces of crop residue shield soil particles from rain and wind until plants can produce a protective canopy.

**How this practice helps:**

**Soil temperature:** Crop residue insulates the soil surface from the sun's energy. This insulation may be good or bad, depending on weather conditions at planting time. Cooler soil temperatures may delay planting and/or lead to poorer germination. Where cooler temperatures are a concern, planter attachments may be used to remove crop residue from the row area. Later in the growing season, the cooler soil temperature may improve crop growth and yields.

**Allelopathy:** This term refers to the toxic effects on a crop resulting from decaying residue from the same crop or a closely related crop. A proper crop rotation and use of planter attachments that remove the residue from the row area can eliminate this problem.

**Moisture:** When left on the soil surface, crop residue reduces the rate of water evaporation and increases the rate of water infiltration. Although it may be a disadvantage during planting in some areas, the extra soil moisture may increase yields if a dry period is encountered later in the growing season. Compared to conventional systems, no-till systems often result in more soil moisture later in the growing season and thus may increase yields.

**Organic matter:** Organic matter in soil tends to stabilize at a certain level for a specific tillage and cropping system. Each tillage pass aerates the soil, resulting in the breakdown of crop residue and organic matter. Crop residues left on the soil surface in no-till or ridge-till systems decompose slowly, thus increasing the content of organic matter in the upper few inches of the soil.

**Soil density:** All tillage systems have some effect on soil density. Systems that disturb the plow layer by inversion tillage or mixing and stirring temporarily decrease soil density. After the soil is loosened by tillage, however, the density gradually increases because of wetting and drying, wheel traffic, and secondary tillage operations. By harvest, the soil density has returned to almost the same density as before tillage operations started. Cropping systems that include several tillage operations can create a compacted layer at the bottom of the plow layer. If compaction is excessive, drainage is impeded, plant root growth is restricted, soil aeration is reduced, herbicide injury may increase, and nutrient uptake may be restricted. No-till systems result in a higher soil density at planting time than other systems because the plow layer is not disturbed when a seedbed is formed. This higher density seldom has any effect on germination, emergence, and subsequent crop growth. Many times, the crop benefits from the higher density because the soils retain more available moisture.

**Stand establishment:** Regardless of the tillage system, a uniform planting depth, good seed-to-soil contact, and proper seed coverage are needed for a good stand. Coulter and/or row cleaners may be needed to remove crop residue from the row area and thus ensure a good stand in areas where a no-till system is applied.

**Fertilizer placement:** Starter fertilizer (nitrogen and phosphorus) is generally recommended to help overcome the effects of lower soil temperatures at planting time. If fertility levels (P, K, and pH) are properly maintained before the tillage system is switched to a conservation tillage system, fertility should not be a problem. In a no-till system, surface application of phosphorus and lime will result in stratification of these nutrients, but this has not been shown to affect crop yields. For a no-till system, it is generally recommended that nitrogen be knifed into the soil or that a nitrogen stabilizer be used. Nitrogen that is applied on the surface may volatilize and be lost if a rain does not move the nitrogen into the soil profile shortly after application.

**Weed control:** Controlling weeds is essential for profitable production systems. With less tillage, herbicides and crop rotations become more important in obtaining adequate weed control. Weed identification, herbicide selection, application rates, and timing are important. A burn-down may be needed in no-till and ridge-till systems. A change in weed species can be expected in no-till and ridge-till systems. Perennials may become more evident but usually can be controlled with good management. The combination of post-applied herbicides and bioengineered crops has made weed control much easier, even in a no-till system.

**Insect management:** Regardless of the tillage system, effective insect-management guidelines and tactics are available. Different tillage systems may affect potential insect pressure, but management addresses this pressure.

**Disease control:** Crop residue on the soil surface can result in increased disease problems, but many disease-control strategies are available. Crop rotation or the selection of disease-resistant hybrids may nullify these potential problems.

**Crop yields:** Crop yields are more affected by weather than by the tillage system. Yields generally are higher when a crop rotation is used, especially in areas where a no-till system is applied.

**Production costs:** All of the costs associated with various tillage systems must be analyzed in an evaluation of profitability.

**Machinery and labor costs:** The total cost for machinery and labor per acre usually decreases as the amount of tillage is reduced. If the size of the power units can be decreased (in a no-till system), the savings can be even more dramatic. No-till equipment (planters, drills, and nutrient-injection equipment) may be more expensive than the conventional equipment. Because of increased efficiency, producers who use no-till systems have been able to farm more acres without additional labor than producers who use conventional tillage systems.

No-till planting (NRCS Photo Gallery NRCSIA99096)

Large no-till planters used in Washington's Palouse region (NRCS Photo Gallery NRCSWA84002)

Ridge-till soybeans in corn residue (NRCS Photo Gallery NRCSIA99306)

References:
"Core4 Conservation Practices Training Guide," USDA, NRCS, 1999
"National Agronomy Handbook," USDA, NRCS, 2002
NRCS Photo Gallery, USDA, NRCS

### Nutrient management

**Definition:** Management of the amount, source, placement, and form of plant nutrients and soil amendments applied to soils to obtain optimum yields and minimize the risk of surface- and ground-water pollution. This management also includes the timing of application.

**Comprehensive Nutrient Management Plan (CNMP):** A CNMP is a conservation plan that is unique to an animal-feeding operation (AFO). It is a group of conservation practices and management activities that, when implemented as part of a conservation system, will help to ensure that both production and natural resource protection goals are met. A CNMP incorporates practices that use animal manure and organic by-products as beneficial resources. It addresses the impacts that soil erosion, manure, and organic by-products may have on water quality. These impacts may derive from an AFO. A CNMP is developed to assist an AFO owner or operator in addressing all applicable local, tribal, State, and Federal water-quality goals or regulations. For nutrient-impaired stream segments or water bodies, additional management activities or conservation practices may be required to address these goals or regulations.

**How this practice works:** Soil samples are taken on a 2.5-acre grid and analyzed for nitrogen (N), phosphorus (P), potassium (K), and other micronutrients and pH. Realistic crop yield goals and the nutrient requirements for the crop rotation are set. Credits for contributions from the previous year's crop, animal waste, and biosolid applications are subtracted to determine the amount of nutrients and/or soil amendments to be applied. Nutrients are then applied at the proper time and by the proper method. Nutrient sources include animal manure, biosolids, and commercial fertilizers. Good nutrient management reduces the potential for nutrients to go unused and wash or infiltrate into water supplies.

**CNMP** development includes the documentation of:

- *Manure and wastewater handling and storage:* This element addresses the components and activities associated with the production facility, feedlot, and manure and wastewater storage and treatment structures and areas, including areas used to facilitate the transfer of manure and wastewater.
- *Land treatment practices:* This element addresses the evaluation and implementation of appropriate conservation practices on sites proposed for land application of manure and organic by-products from an AFO. On fields where manure and organic by-products are applied as beneficial nutrients, measures that minimize runoff and soil erosion are essential if plant uptake of the nutrients is to occur.
- *Nutrient management:* This element addresses the requirements for land application of all nutrients and organic by-products. Manure and organic by-products are commonly applied to the surface because of their content of nutrients and organic matter. Land application must be planned and implemented in a way that minimizes potential adverse impacts on the environment and on public health.
- *Record keeping:* This element documents implementation of activities associated with CNMPs. Documentation of implementation and management activities provides valuable benchmark information that the AFO can use to adjust the CNMP to meet production and natural resource conservation objectives.
- *Feed management:* This element may be used to reduce the nutrient content of manure. It may result in less land being required to effectively utilize the manure. Specific feed management activities that address nutrient reduction in manure may include phase feeding, amino acid supplemented low crude protein diets, or the use of low phytin phosphorus grain and enzymes, such as phytase or other additives.
- *Other utilization activities:* This element includes environmentally safe alternatives to land application of manure and organic by-products that could be part of the CNMP. These alternatives are needed where the nutrient supply exceeds the nutrient requirements of the crops and/or where land application would cause significant environmental risk. Examples are using manure for energy production, such as burning, methane generation, and conversion to other fuels. Reducing the weight or volume or changing the form can reduce transportation costs or create more valuable products.

**How this practice helps:** Sound nutrient management reduces input costs and protects water quality by preventing excessive application of commercial fertilizer and animal manure. Correct applications of manure and biosolids on all fields can improve soil tilth and increase the content of organic matter. Proper waste-storage facilities allow timely application of nutrients while protecting surface water and ground water.

Application of anhydrous ammonia fertilizer at planting time in Cedar County, Iowa (NRCS Photo Gallery NRCSIA99245)

Fertilizer applied directly into an irrigation lateral for flood application near Yuma, Arizona (NRCS Photo Gallery NRCSAZ02084)

A manure storage tank (part of a conservation plan) on a dairy farm in Lancaster County, Pennsylvania (NRCS Photo Gallery NRCSPA00020)

State-of-the-art lagoon waste management system for a 900-head hog farm. The facility is completely automated and temperature controlled (NRCS Photo Gallery NRCSGA02035)

References:
"Core4 Conservation Practices Training Guide," USDA, NRCS, 1999
"National Agronomy Handbook," USDA, NRCS, 2002
NRCS Photo Gallery, USDA, NRCS

**Pest management**

**Definition:** Use of environmentally sensitive prevention, avoidance, monitoring, and suppression strategies to manage weeds, insects, diseases, animals, and other organisms (including invasive and noninvasive species) that directly or indirectly cause damage or annoyance.

**How this practice works:** Crop rotations naturally reduce the incidence and severity of weeds, insects, and diseases in a cropping system, thereby reducing pesticide costs. The key components for pest management are:

1. Use integrated pest management principles to ensure that the techniques are environmentally sound.
2. Use crop rotations to break up pest cycles.
3. Use hand weeding or spot treatment when appropriate.
4. Use biological control and beneficial insects.
5. Scout fields, and apply chemicals at the correct time and dosage rate.
6. Consider the effects of repetitive use of the same chemicals on pesticide resistance.
7. Apply erosion-control measures to reduce runoff and associated pollution.
8. Use field borders and buffer strips to reduce the potential for pollution from runoff.
9. Become familiar with common pests, including their life cycles, and learn alternative control techniques.
10. Use chemicals safely.
11. Always follow label instructions.
12. Use extreme care in preparing tank mixes and rinsing chemicals from tanks.
13. Ensure that farm workers are properly trained in safety precautions.

**Weeds**

**Weed shift:**Changing tillage systems may result in a "weed shift" as new weed species appear because of a lack of tillage and a change in the mode of action for herbicides being used with no-till. Winter annuals may increase in extent, and small-seed weeds, which usually germinate at the surface of the soil, may become more dominant. Large-seed weeds, which generally germinate deeper in the soil, decrease in extent with no-till. Perennial weeds, including trees and shrubs in some areas, may also increase in extent under no-till.

**Weed control:**In a no-till system, a burn-down generally is needed to control existing weeds before planting. The perception exists that more herbicides are used in a no-till system. With the new chemicals available, however, about the same application rates are used. Mulch-till and no-till systems may involve one product or a combination of early preplant, preemergent, and post application products. Regardless of the tillage system, rotating modes of action help to prevent herbicide resistance in weeds.

**Diseases**

Four key factors are involved in disease management:

- A susceptible host crop
- A pathogen (disease-causing agent)
- An environment that favors the pathogen
- Adequate time for economic damage to occur

Integrated pest management is used as a preventative tool as well as a corrective action. In some areas lack of rotation causes increased disease pressure. Diseases have not been a major factor in the adoption of high-residue systems when a good crop rotation is used.

**Insects**

Insect problems and controls generally are no different for no-till than for other tillage systems. The exception is that early weed growth may attract some insects. Appropriate scouting and integrated pest management techniques can reduce the risk of insect damage.

**How this practice helps:** The importance of crop rotation for successful no-till or mulch-till implementation cannot be overemphasized. Generally, rotating a grass with a legume provides the most consistent results. Breaking the green bridge between living roots of older host plants that cause disease problems and the newly planted crops is critical in the rotation from one crop to the next.

**Allelopathic crop effects**

Some plants produce toxic material during the breakdown of residue. These chemicals may inhibit the germination or vigor of other plants. This effect can be detrimental or beneficial. For example, corn planted into corn residue, wheat into wheat residue, or alfalfa into an alfalfa stand may result in poor stand establishment because of autotoxicity, a specific type of allelopathy. Some varieties of these crops are more sensitive than others. On the other hand, soybeans planted into a rye cover crop may have little weed pressure because of the allelopathic effect produced by decaying rye residue on germinating weed seeds.

Crop consultant scouts field for pests as part of an integrated crop management system in northeast Iowa (NRCS Photo Gallery NRCSIA99289)


A stopwatch used to calibrate a sprayer prior to an application of herbicide (NRCS Photo Gallery NRCSMD91001)

Mixing herbicide prior to application. The farmer is careful to wear complete protection while using the chemicals (NRCS Photo Gallery NRCSMD91009)

Using Global Positioning System equipment for precision application of pesticides and herbicides on a farm in northern Louisiana (NRCS Photo Gallery NRCSLA00010)

References:
"Core4 Conservation Practices Training Guide," USDA, NRCS, 1999
Farmland Protection Program NEPA Documents, Appendix B FPP Practice Effects: Practice Photos, Descriptions and Network Diagrams, USDA, NRCS
"National Agronomy Handbook," USDA, NRCS, 2002
NRCS Photo Gallery, USDA, NRCS

### Irrigation water management (IWM)

**Definition:** IWM is the process of determining and controlling the amount of irrigation water and the timing and rate of its application so that crop moisture requirements are met at the same time that water losses and soil erosion are minimized.

**How this practice works:** IWM matches irrigation water application to the needs of the crop and the infiltration rate of the soil and thus helps to reduce surface runoff during irrigation and prevent excessive soil erosion and loss of nutrients. Properly timing the water application maximizes the beneficial effects of pesticides and yet reduces the chance of loss from leaching or runoff. Properly designed and managed irrigation and drainage systems remove runoff and leachate efficiently, control deep percolation, minimize the erosion caused by the applied water, and reduce adverse impacts on surface water and ground water.

The volume of irrigation water applied and the frequency of irrigation should be determined by crop needs and soil characteristics. Soil moisture should be monitored to determine when application is needed to prevent crop stress and limit deep percolation. The volume of irrigation water applied should match the water-holding capacity of the soil in the root zone of the crop. The application rate should not greatly exceed the absorption or infiltration rate of the soil. When fertigation or chemigation is used, wells must be equipped with check valves and anti-siphon devices to prevent well contamination, which can lead to contamination of the aquifer.

**Pollution process:** Pollution is the result of a series of factors. These can be categorized as availability, detachment, and transport. Water pollution is a hazard only when a pollutant is available in some form in the field, becomes detached, and is transported beyond the edge of the field, below the root zone, or above the crop canopy and toward a receiving water body.

**Availability:** A potentially polluting substance is available in some amount and in some place. The potential pollutant could be sediment from a highly erosive soil since soil is always available. Chemical compounds vary not only in quantity but also in the degree of their availability for movement. The amount available at the time of runoff or deep percolation is important. Nutrients from fertilizer in or on the soil or from mineralized crop residue, pesticides applied to the field, bacteria carried with an application of animal manure, or some other potentially harmful material have different forms and times of availability for movement.

**Detachment:** The potential pollutant or its environment is modified so that the substance can be moved from where it should be to where it should not be. The detachment process is either physical or chemical. Chemical pollutants can be grouped into three categories on the basis of their adsorption characteristics: (1) strongly adsorbed, (2) moderately adsorbed, and (3) nonadsorbed.

Detachment is dependent on:

- The type of compound and concentration
- The strength of bonding to the soil particles
- Quality and quantity of irrigation water
- The chemical, physical, and biological characteristics of the soil (pH, content of organic matter, porosity, and electrical conductivity)
- Climatic conditions (wind, temperature, and water movement)
- The properties of the chemical compound

Highly soluble compounds are easily detached when they dissolve into both surface runoff and percolating water. Strongly adsorbed compounds are sometimes not detached but are carried by soil particles that have been separated by water drop splash or surface runoff shear.

**Transport:** Transport is the movement of material from its natural or applied position. Agricultural pollutants are typically transported in water during periods of surface runoff or deep percolation, or they can be moved through wind drift and volatilization. The particular pathway by which a pollutant leaves the field depends on the soil type, the hydrology of the field, the type of irrigation system and its operational techniques, the timing and rate of nutrient and pesticide application, and the interaction of the compounds with water and soil as affected by management practices. Pollutants are generally transported to receiving water bodies by surface runoff and/or through deep percolation. Excess irrigation water application provides an opportunity for transport.

**How this practice helps:** IWM helps to effectively use available irrigation water as it manages and controls the moisture environment of crops and other vegetation. IWM minimizes soil erosion and the loss of plant nutrients and protects both the quantity and quality of water resources.

**IWM basics**

1. Determine when to apply water according to the rate of use by the plants at the various stages of crop or forage growth.
2. Measure or estimate the amount of water required for each irrigation run.
3. Determine the time needed for the soil to absorb the required amount of water.
4. Detect changes in the water intake rate.
5. Determine how and when to adjust the stream size, the application rate, and the time of irrigation to compensate for changes in the soil or topography that affect the water intake rate.
6. Recognize the erosion caused by irrigation.
7. Evaluate the uniformity of water application.

**Source reduction:** Maintain a surface cover to prevent excessive erosion and entrap potential pollutants. Provide the kind of conservation tillage, vegetative cover, and water management practices needed to reduce irrigation-induced soil erosion and runoff and thus reduce the amount of time that water is in contact with the potential contaminant. Nutrients, especially fertilizers, should be applied so that their availability matches the uptake needs of the plants as closely as possible. Matching application to plant requirements can reduce the amount of pollutants available for detachment and transport.

**Reduction of availability:** Optimize nutrient availability by managing the rate, timing, source, and method of application. Soil and plant testing monitors the buildup of available nutrients in the root zone of the crop. Incorporation of chemicals reduces their contact time with irrigation water. Improving the chemical, physical, and biological condition of the soil can help retain and degrade many of the chemical compounds in the root zone.

**Reduction in detachment:** For those nutrients that are strongly adsorbed to soil particles, detachment and transport off the field are major avenues of loss. For example, phosphorus is tightly bound to soil particles by aluminum, iron, and calcium minerals. Thus, it is readily transported only when soil becomes detached.

**Reduction in transport:** Because many nutrients and salts are strongly adsorbed to soil particles, the amount of these materials lost from the field is directly related to the amount of sediment carried from the field. Chemicals that dissolve readily are easily transported with excess irrigation water either from the edge of the field or from the bottom of the root zone. Applying the proper amount of irrigation water at the proper time is essential in reducing the potential for the transport of pollutants.

**Salt:** All irrigation water contains dissolved salts, which are added to the soil during each irrigation run. Fertilizer and animal manure also contain salts. Salts may stay in solution and move below the root zone, or they may precipitate within the root zone. Excessive or imbalanced dissolved salts can cause four types of production problems in irrigated areas:

- General yield declines
- Structure problems
- Toxicity
- Corrosion

**General yield declines:** Dissolved salts create an osmotic force that makes water unavailable for plant uptake. Excessive dissolved salts reduce the amount of plant-available water in the soil. The reduced amount of water can cause crop stress.

**Structure problems:** The total amount of dissolved salts in the soil may not be as important as the relative ratio of the different salts. If salt types are out of proportion, soil structure problems can result. The most significant salt imbalance occurs if there is too much sodium in relation to magnesium and calcium in the soil water. This problem usually leads to restricted permeability in the soil. As infiltration is reduced, the soil becomes hard, making root penetration difficult.

**Toxicity:** Some nutrient salts, while essential for plant growth in small amounts, are toxic in excessive amounts. Boron, for example, is toxic to plants and starts to restrict plant growth when irrigation water exceeds 1-ppm boron levels.

**Corrosion:** Salts can cause corrosion of irrigation equipment. Water must be handled and treated carefully because of the need to prevent disruption of water distribution, especially when drip irrigation systems are used.

### Drainage and runoff

The removal of excess soil water by drainage systems has greatly increased agricultural production. These systems not only remove the gravitational water from the soil but also allow freer exchange of soil air with atmospheric air. Changing the water and air status of the soil impacts the fate and transport of agrochemical compounds. Foremost, drainage water carries with it any dissolved materials from the soil. Soluble carbon, nitrates, potassium, phosphorus, and pesticides move with drainage water. This water is transported to subsurface drain outlets, seeps and springs, open channels, and fissures in bedrock and can become part of the surface water. Some of the drainage water moves downward through the soil, does not resurface, and becomes part of the ground water.

Some irrigation water must pass through the root zone of the crop if soil salinity is to be maintained at a desirable level. Deep percolation is required to remove salts from the root zone. The key questions are: *How much deep percolation is required?* and *Where does it go?* Leaching should be done when residual soil nitrate levels are at the lowest.

If insufficient drainage occurs, as is the case when impermeable rock or clay is relatively near the soil surface, percolating water backs up and creates a saturated zone in the soil. Under these conditions, natural drainage cannot remove the excess water fast enough and plant roots are adversely affected by a lack of oxygen in the soil. Artificial drainage systems are needed to carry away the excess soil water. These systems generally consist of perforated, polyethylene tubes buried at various depths and intervals at or near the bottom of the root zone of the crop. Soil water enters the perforations and is carried by gravity to a surface outlet or is pumped to the surface for disposal.

### Water level control

Water level control is the manipulation of soil moisture to create a suitable soil and plant environment for control of vegetative growth, reduction of such compounds as nitrate nitrogen, or promotion of soil micro and mesa fauna. This control is accomplished by changing the aeration or water status of the soil pores. Such crops as rice respond favorably to saturated soil conditions and can grow better than other vegetation under these conditions.

### Water management planning accounts

Two types of water management planning accounts are available. A "water budget" is a projected accounting of the water supply in the soil for a general area and a general period of time. It indicates where the water comes from and where it goes. A "water balance" is the daily accounting of the water supply for a specific field (soil and crop type) during a specific time.

**Methods of controlling irrigation-induced soil erosion**

In-field soil erosion in areas of furrow irrigation systems can be controlled by:

- Using proper inflow streams
- Reducing irrigation grades
- Maintaining crop residue on the soil surface
- Using a soil-stabilizing compound, such as polyacrylamide (PAM)
- Using crop rotation

Off-field sediment movement can be controlled by:

- Establishing vegetative filters at the lower edge of the field
- Controlling runoff, thereby reducing water velocity
- Installing sediment-detention basins
- Collecting and redistributing tailwater

Fertilizer applied directly into an irrigation lateral in an area near Yuma, Arizona (NRCS Photo Gallery NRCSAZ02084)

Siphon tubes used for furrow irrigation in an area of romaine lettuce near Yuma, Arizona (NRCS Photo Gallery NRCSAZ02010)

A handline sprinkler irrigation system (NRCS Photo Gallery NRCSID00003)

An area in the Colorado River Basin, where salinity is a challenge for landowners and resource professionals (NRCS Photo Gallery NRCSUT03052)

(NRCS Photo Gallery NRCSUT03053)

District Conservationist Edward Romero demonstrates the use of a moisture meter as an aid in scheduling irrigation runs for grapes. The system is based on gypsum blocks placed in the soil profile to monitor moisture content. Arriba County, New Mexico (NRCS Photo Gallery NRCSNM02029)

A tailwater recovery ditch near a rice field in northern California (NRCS Photo Gallery NRCSCA02115)

References:
"Core4 Conservation Practices Training Guide," USDA, NRCS, 1999
Farmland Protection Program NEPA Documents, Appendix B FPP Practice Effects: Practice Photos, Descriptions and Network Diagrams, USDA, NRCS
NRCS Photo Gallery, USDA, NRCS

**Contour farming**

**Definition:** Tilling and planting across the slope, following the contour of the land, as opposed to farming up and down hills.

**How this practice works:** Farming on the contour creates small ridges that slow runoff water, and it increases the rate of water infiltration, reduces the hazard of erosion, and redirects runoff from a path directly downslope to a path around the hillslope. Farming on the contour rather than up and down the slope reduces fuel consumption and is easier on equipment.

- Contour farming is often used in combination with other practices, such as terraces, water- and sediment-control basins, and stripcropping.
- Longer, steeper slopes may require stripcropping rather than just contour farming, which is less effective in preventing excessive erosion on the steeper or longer slopes.
- Irregular slopes may require more than one key contour line. Some fields may be too steep and/or irregularly shaped for contour farming.
- Strips of row crops should be roughly the same width as strips of hay or small grain crops. The desirable acreage of row crops should be considered. Hay strips will rotate to row crops over time. The width of the strip depends on slope, equipment, and management.
- A hand level or contour gauge can be used to establish a key line around the hill.
- All tillage and planting operations should be parallel to the key contour line.
- Rotating strips from corn to legumes allows corn to use the nitrogen added to the soil by the legumes.
- Herbicide carryover may be a problem.
- Replacing end rows with grasses or legumes reduces the hazard of erosion and makes turning equipment easier.
- Grassed waterways are needed where runoff concentrates.
- The grade of the contour key line generally should not exceed 2 percent. Within 100 feet of an outlet (i.e., a waterway), however, the grade can be 3 percent.
- Where curves in contour lines are too sharp for farm equipment, grass strips may serve as sites where the equipment can turn.

**How this practice helps:** Contour farming can reduce soil erosion by as much as 50 percent compared to farming up and down hills. It promotes better water quality by controlling sedimentation and runoff and increasing the rate of water infiltration.

Contour farming in northeast Iowa
(NRCS Photo Gallery NRCSIA99176)

References:
"Core4 Conservation Practices Training Guide," USDA, NRCS, 1999
"Contour Farming and Stripcropping," USDA, NRCS, Wisconsin
http://www.nrcs.usda.gov/wps/portal/nrcs/detail/wi/technical/?cid=nrcs142p2_020785
NRCS Photo Gallery, USDA, NRCS

### Contour stripcropping

**How this practice works:** Contour stripcropping is used with contour farming. Crops are arranged so that a strip of meadow or small grain is alternated with a strip of row crops. Not more than half of a field can be planted to row crops. Meadow slows runoff, increases the rate of water infiltration, traps sediment, and provides surface cover. Ridges formed by contoured rows slow waterflow and reduce the hazard of erosion. Rotating the strips from corn to legumes allows nutrient-needy crops to benefit from the nitrogen added to the soil by the legumes. Contour stripcropping combines the beneficial effects of contouring and crop rotation. It may be combined with terraces to provide additional erosion control and stormwater management.

**How this practice helps:** Contour stripcropping can reduce soil erosion by as much as 50 percent compared to farming up and down hills. The cost of fertilizer can be reduced if legumes, such as alfalfa or clover, are planted in the meadows. Contour stripcropping improves water quality by controlling sedimentation and runoff and increasing the rate of water infiltration.

Alternating strips of alfalfa and corn grown on the contour in northeast Iowa (NRCS Photo Gallery NRCSIA99355)

Aerial view of contour stripcropping in central Wisconsin (NRCS Photo Gallery NRCSUT03035)

Contour stripcropping

Reference:
Farmland Protection Program NEPA Documents, Appendix B FPP Practice Effects: Practice Photos, Descriptions and Network Diagrams, USDA, NRCS

**Cover crops**

**Definition:**Growing a crop of grass, small grain, or legumes primarily for seasonal protection and soil improvement.

**How this practice works:**Cover and green manure crops, including cereal rye, oats, clover, hairy vetch, and winter wheat, are grown on cropland and in orchards, vineyards, and certain recreation and wildlife areas to temporarily protect the ground from wind erosion and water erosion during times when the land is not adequately protected. These crops are usually plowed under or desiccated to accommodate the primary crop being produced on the site.

**How this practice helps:**Cover crops are used to control erosion, improve fertility by adding organic matter to the soil, trap nutrients, improve soil tilth, improve water infiltration and aeration in the soil, and control weed competition. These crops also are designed to increase bee populations for pollination purposes. They have beneficial effects on water quantity and quality. Cover crops also filter sediment, pathogens, and dissolved and sediment-attached pollutants.

A cover crop in an orchard (NRCS Photo Gallery NRCSCA01010)

A cover crop in a field in Black Hawk County, Iowa (NRCS Photo Gallery NRCSIA99177)

References:
"Core4 Conservation Practices Training Guide," USDA, NRCS, 1999
Farmland Protection Program NEPA Documents, Appendix B FPP Practice Effects: Practice Photos, Descriptions and Network Diagrams, USDA, NRCS
NRCS Photo Gallery, USDA, NRCS

### Grassed waterways

**Definition:**A grassed waterway is a natural or constructed channel that is shaped or graded to carry surface water at a nonerosive velocity to a stable outlet. The required dimensions are those needed for the waterway to convey runoff from the design storm, generally the 10-year, 24-hour storm. The grassed waterway is designed to ensure that the velocity of runoff water is not excessive.

**How this practice works:** The primary purpose of a grassed waterway is to convey runoff from terraces, diversions, or other areas of water concentration without causing erosion or flooding. Another purpose is to improve water quality. Grassed waterways are natural drainageways that are graded and shaped to form a smooth, bowl-shaped channel. They are seeded to sod-forming grasses. Runoff water that flows down the drainageway flows across the grass rather than tearing away soil and forming a larger gully. An outlet is commonly installed at the base of the drainageway to stabilize the waterway and to keep a new gully from forming.

The most critical time for successful installation of a grassed waterway is immediately following construction, when the channel is bare and unprotected from runoff. Waterways are generally planted to perennial grass and then mulched with straw. In some areas silt fences or straw bales in the waterway reduce the velocity of the runoff, thereby reducing the risk of gully formation in the new waterway.

**How this practice helps:** A grassed waterway provides a vegetative strip that benefits the environment in several ways in addition to the primary benefit of providing a nonerosive waterway. These additional benefits include diversity of wildlife habitat, corridor connections, vegetative diversity, noncultivated strips of vegetation, and improved esthetics. An additional grassed width on each side of the grassed waterway allows the waterway to better serve as a conservation buffer.

**Functions:** The primary function of a grassed waterway is to transport water and sediment. Nearly all grassed waterways are located topographically so that runoff enters the waterways either as sheet or concentrated flow. Because of high water velocities, little or no sediment deposition occurs within the waterway. Therefore, suspended sediment entering the grassed waterway will most likely exit the waterway at its outlet to the possible detriment of the receiving water body. The function of a grassed waterway is not to reduce sediment loading in runoff. Providing enough additional grassed width on each side of the waterway to serve as filter strips, however, reduces the sediment load entering the waterway and thus enhances the quality of water bodies.

A grassed waterway in Fayette County, Iowa (NRCS Photo Gallery NRCSIA99447)

Grassed waterways in a corn field in northeast Iowa (NRCS Photo Gallery NRCSIA99509)

Rock checks installed to reduce runoff velocity in a waterway in St. Clair County, Illinois (Office photo StC1000)

A seeded and mulched grassed waterway in St. Clair County, Illinois (Office photo StC1001)

References:
"Core4 Conservation Practices Training Guide," USDA, NRCS, 1999
Farmland Protection Program NEPA Documents, Appendix B FPP Practice Effects: Practice Photos, Descriptions and Network Diagrams, USDA, NRCS
NRCS Photo Gallery, USDA, NRCS

**Terraces**

**How this practice works:** Terraces break long slopes into shorter ones. They generally follow the contour. As water makes its way down a hill, terraces serve as small dams that intercept and guide the water to an outlet. There are two basic types of terraces: storage terraces and gradient terraces. Storage terraces collect water and store it until it can infiltrate into the ground or be released through a stable outlet. Gradient terraces are designed as a channel to slow runoff water and carry it to a stable outlet, such as a grassed waterway.

**How this practice helps:** Terraces improve both water quality and soil quality. Terraces with grassed frontslopes or backslopes can provide nesting habitat and other cover for wildlife.

Grassed-back terrace in Iowa (NRCS Photo Gallery NRCSIA03005)

Contour terraces in Kansas (NRCS Photo Gallery NRCSKS02026)

Reference:
NRCS Photo Gallery, USDA, NRCS

### Buffer strips

**How this practice works:** Conservation buffers are areas or strips of land where a permanent cover of vegetation is maintained to help control pollutants and manage other environmental problems. Buffer vegetation may produce alternative commodities to diversify farm income. These include lumber, fuel wood, fiber, hay, seeds, and ornamental, medicinal, and food products.

**How this practice helps:** Buffers are strategically located on the landscape to accomplish many objectives. They reduce the hazard of erosion by slowing the velocity of water or wind, trap sediment or other pollutants, and may provide wildlife habitat. Following is a description of 10 different kinds of buffers.

#### Alley cropping

Alley cropping is the planting of trees or shrubs in two or more sets of single or multiple rows with agronomic, horticultural, or forage crops cultivated in the alleys between the rows of woody plants. Alley cropping is used to enhance or diversify farm products, control surface runoff and wind and water erosion, improve the utilization of nutrients, improve crop production by modifying the microclimate, increase the diversity of wildlife habitat, and enhance the beauty of the area.

#### Contour buffer strips

Contour buffer strips are strips of perennial vegetation alternated with wider cultivated strips that are farmed on the contour. Contour buffer strips slow runoff and trap sediment.

The amount of sediment, nutrients, pesticides, and other contaminants in runoff is reduced as the runoff passes through the buffer strips.

Grassed contour buffer strips in Iowa (NRCS Photo Gallery NRCSIA00031)

### Cross wind trap strips

Cross wind trap strips are areas of herbaceous plants that are resistant to wind erosion and as nearly as possible are grown perpendicular to the prevailing wind direction. These strips catch wind-borne sediment and other pollutants, such as nutrients and pesticides, from the eroded material before it reaches water bodies or other sensitive areas. They filter the wind-borne material.

### Field borders

Field borders are bands or strips of perennial vegetation established on the edge of a cropland field. They help to control sheet, rill, and gully erosion at the edge of fields; trap sediment, chemicals, and other pollutants; are turning areas for farm equipment; and provide habitat for wildlife.

A field border in Iowa (NRCS Photo Gallery NRCSIA99192)

**Filter strips**

Filter strips are areas of grass or other permanently established vegetation used to reduce the amount of sediment, organic material, nutrients, pesticides, and other contaminants from runoff and to maintain or improve water quality. They slow the velocity of water, filter suspended soil particles, and increase infiltration of runoff and soluble pollutants and adsorption of pollutants on soil and plant surfaces.

Conservation filter strips in Illinois (NRCS Photo Gallery NRCSIL00018)

### Grassed waterway/vegetated filter

A grassed waterway/vegetated filter system is a natural or constructed vegetated channel that is shaped and graded to carry surface water at a nonerosive velocity to a stable outlet. It spreads the flow of water before the water enters a vegetated filter.

### Herbaceous wind barriers

Herbaceous wind barriers consist of tall grasses and other nonwoody plants established in one- to two-row, narrow strips spaced across the field, perpendicular to the normal wind direction. These barriers reduce wind velocity across the field and intercept wind-borne soil particles.

### Riparian forest buffers

Riparian forest buffers are areas of trees and shrubs adjacent to streams, lakes, ponds, and wetlands. They intercept contaminants from surface runoff and shallow subsurface waterflow.

Buffers along a stream in an area of rangeland in California (NRCS Photo Gallery NRCSCA00026)

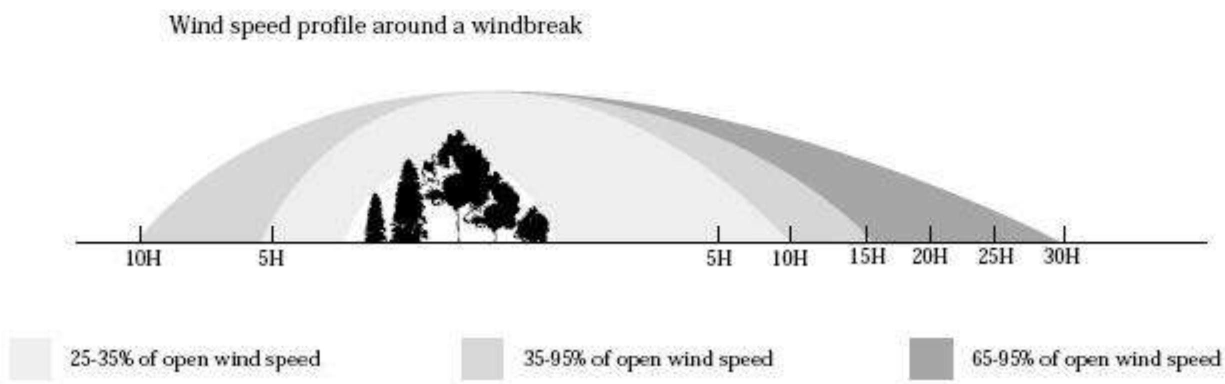
### Vegetated barriers

Vegetated barriers are areas of narrow, permanent strips of stiff-stemmed, erect, tall, dense perennial plants established in parallel rows and perpendicular to the dominant slope of the field. These barriers provide help to control water erosion on cropland and offer an alternative to terraces where the soil might be degraded by terrace construction.

### Windbreaks or shelterbelts

Windbreak or shelterbelts consist of a single row or multiple rows of trees or shrubs that protect the soil from wind erosion, protect sensitive plants, manage snow, improve irrigation efficiency, protect livestock and structures, and create or enhance wildlife habitat.

Field windbreaks in North Dakota (NRCS Photo Gallery NRCSND99001)




Wind speed profile around a windbreak

References:

"Core4 Conservation Practices Training Guide," USDA, NRCS, 1999
NRCS Photo Gallery, USDA, NRCS


## Forestland

Forestland traditionally provides a diverse range of commodity and non-commodity products and values, including wood products, grazing for wildlife and livestock, high quality water, wildlife and fish habitat, recreational opportunities, and aesthetic and spiritual values. Forestland is often closely associated with or inseparable from other land resources, such as rangeland, pastureland, riparian areas, cropland, and urban-forest interfaces.

### Grazed Forestland

Over 600 million acres of privately owned and managed forestlands in the United States produce understory vegetation that is used for the production of livestock. Forestland that naturally has widely spaced trees, such as ponderosa pine and some southern pines, normally produces a crop of forage each year. These forested areas are defined and described as grazed forestlands.

Forestlands produce a large share of the Nation's timber, provide habitat for wildlife, are important watersheds, provide forage for livestock, and provide recreational opportunities for millions of people.

Reference: "National Range and Pasture Handbook," USDA-NRCS

### Forest Canopy

The forest canopy is the more or less continuous cover of branches and foliage formed collectively by adjacent tree crowns. Canopy is measured as the vertical projection downward of the aerial portion of the tree’s vegetation, usually expressed as a percent of the ground so occupied.

### Forest Overstory

The forest overstory is the layer of foliage in a forest canopy consisting of the crowns of dominant, codominant, and intermediate trees that rise above the shorter understory foliage.

### Forest Understory

In the context of forestland ecological sites, understory refers to plants growing beneath the forest canopy.

### Forest Productivity

The productivity of a particular soil is obtained for one or more species of trees by determining the site index of those species growing on that soil. Site index curves have been developed for several base ages. The 100-year and 50-year curves are most commonly used for natural and planted stands of trees.

#### Site Index

Site index is a measure of the quality of a site based on the height of dominant trees at a specified age.

### Forestland Ecological Sites

Forestland landscapes are divided into ecological sites for the purposes of inventory, evaluation, and management. An ecological site is a distinctive kind of land with specific physical characteristics that differs from other kinds of land in its ability to produce a distinctive kind and amount of vegetation.

Ecological sites evolve with a characteristic fire regime. Fire frequency and intensity contribute to the characteristic plant community of the sites.

#### Succession and Retrogression

Succession is the process of soil and plant community development on an ecological site. Retrogression is the change in vegetation away from the historic climax plant community due to mismanagement or severe natural climatic events.

#### Historic Climax Plant Community

The historic climax plant community is the plant community that was best adapted to the unique combination of factors associated with the ecological site. It was in a natural dynamic equilibrium with the historic biotic, abiotic, and climatic factors on its ecological site in North America at the time of European immigration and settlement.

#### Naturalized Plant Community

A naturalized plant community is a plant community composed entirely of non-native species that have become adapted to a particular site. It is capable of perpetuating itself without cultural treatment.

### Forestland Management

The management of trees begins with an understanding of the soil on which they grow or are to be grown. Some soils are very suitable for growing wood crops; others barely support tree cover. Different tree species may vary in production on the same soil. The probability of seedling survival, the relative danger of erosion when cover is removed, the resistance of trees to windthrow, and problems in equipment use are some of the management items that can be inferred from soils information.

Reference: "National Forestry Manual," USDA-NRCS.

### Agroforestry

Agroforestry combines agriculture and forestry technologies to create more integrated, diverse, productive, profitable, healthy, and sustainable land-use systems. Agroforestry practices include:

#### Alley Cropping

In alley cropping, an agricultural crop is grown simultaneously with a long-term tree crop to provide annual income while the tree crop matures. Fine hardwoods like walnut, oak, ash, and pecan are favored species in alley cropping systems and can potentially provide high value lumber or veneer logs. Nut crops can be another intermediate product.

#### Forest Farming

In forest farming, high-value specialty crops are cultivated under the protection of a forest canopy that has been modified to provide the correct shade level. Crops like ginseng, shiitake mushrooms, and decorative ferns are sold for medicinal, culinary, and ornamental uses. Forest farming provides income while high-quality trees are being grown for wood products.

#### Riparian Forest Buffers

Riparian forest buffers are natural or re-established streamside forests made up of tree, shrub, and grass plantings. They buffer non-point source pollution of waterways from adjacent land, reduce bank erosion, protect aquatic environments, enhance wildlife, and increase biodiversity.

#### Silvopasture

Silvopasture combines trees with forage and livestock production. The trees are managed for high-value sawlogs and at the same time provide shade and shelter for livestock and forage, reducing stress and sometimes increasing forage production. In plantations of conifers or hardwoods for timber or Christmas trees, managed grazing provides added products and income. Some nut and fruit orchards may also be grazed.

#### Windbreaks

Windbreaks are planned and managed as part of a crop and/or livestock operation to enhance production, protect livestock, and control soil erosion. Field windbreaks protect a variety of wind-sensitive row, cereal, vegetable, orchard, and vine crops, control wind erosion, and increase bee pollination and pesticide effectiveness. Livestock windbreaks reduce animal stress and mortality, feed consumption, and visual impacts and odors. Living snowfences keep roads clean of drifting snow and increase driving safety. They can also spread snow evenly across a field, increasing the content of moisture in the soil in spring.

#### Special Applications

Tree and shrub plantings may be used to help solve special farm concerns, such as disposal of animal wastes and filtering irrigation tailwater, while producing a short- or long-rotation woody crop. Special multi-row "timberbelts" can be managed both to protect crops or livestock and to produce hardwood timber or a short-rotation woody crop for fuel or fiber. All of the agroforestry practices can be enhanced to provide wildlife habitat. Plantings of trees, shrubs, grasses, and feed grains provide havens for wildlife.

Agroforestry is a "social forestry." Its purpose is sustainable development. Practices are focused on meeting the economic, environmental, and social needs of people on their private lands.

At the farm level, agroforestry is a set of practices that provide strong economic and conservation incentives for landowner adoption.

Incorporated into watersheds and landscapes, agroforestry practices help to attain community/society goals for more diverse, healthy and sustainable land-use systems.

#### Where Does Agroforestry Apply?

Agroforestry applies to private agricultural and forestlands and communities. These are highly disturbed, human-dominated land-use systems. Targets include lands that are highly-erodible, flood-prone, economically marginal, and environmentally sensitive.

The typical situation is agricultural, where trees are added to create desired benefits. Our goal is to restore essential processes needed for ecosystem health and sustainability, rather than to restore natural ecosystems. Agroforestry provides strong incentives for adoption of conservation practices and alternative land uses and supports a collaborative watershed analysis approach to management of landscapes containing mixed ownerships, vegetation types, and land uses.

Reference: National Agroforestry Center, USDA Forest Service, Lincoln, NE

### Pastureland and Hayland

Pastureland, often called improved pasture, or tame pasture, is defined as grazing land permanently producing introduced or domesticated native forage species receiving varying degrees of periodic cultural treatment to enhance forage quality and yields. It is primarily harvested by grazing animals. Permanent pastureland in this context means the present operator has no desire to change the land use or rotate crops in the field.

Pastureland may be machine harvested when and where the need arises, site conditions permit, and the forage type is of sufficient stature, quantity, and quality to permit efficient machine harvest preserving. If part of the annual growth is machine harvested, but regrowth is available and used for grazing during the majority of the growing season, the primary land use is pasture. If the machine harvesting schedule results in little or no appreciable regrowth for grazing, the primary land use is then cropland or hayland.

#### Forage

Forage can be defined as the edible parts of plants, other than separated grain, that can provide standing feed for grazing animals or be harvested for feeding. Crops that are sometimes classified as grain crops are also forages, such as corn and sorghum grown for silage. Small grains may also be stored in a silo or baled. Examples include alfalfa and bermudagrass.

#### Forage Suitability Groups

Forage suitability groups (FSG's) are composed of one or more individual soil map units having similar potentials and limitations for forage production. Soils within a forage production suitability group are sufficiently uniform to:

- Support the same adapted forage plants under the same management,
- Require similar conservation treatment and management to produce the forages selected in the quality and quantity desired, and
- Have comparable potential productivity

Reference: "Range and Pasture Handbook," USDA-NRCS

### Pastureland Condition

Pastureland condition is the status of the plant community and the soil in a pasture in relation to its highest possible condition under "ideal" management. The land user selects and establishes the desired plant community unless a preexisting one is acceptable or can be developed from the existing site. The desired plant community should be selected on the basis of the adaptability to the existing soils and climate at the site. Livestock production goals and livestock forage preferences should also be considered.

Where "ideal" pastureland management is applied, grazing pressure and agronomic inputs are managed in a manner that keeps the desired plant community reasonably stable at the species proportions desired for the livestock type and class. Over time, permanent pastures tend to naturalize. Other unintended plants invade and become part of the plant community. Some of these are acceptable forage species; others are not. Shifts in plant species composition, if allowed to proceed without intervention, usually result in a plant community that does not meet the goals of the land user. This plant community often produces lower quality forage than the established pasture plant community, sometimes yields less forage, and may not respond as well to agronomic inputs.

Reference: "Pastureland Soil Quality Information Sheet 1," Soil Quality Institute, USDA-NRCS, 2003

## Horticulture

Horticulture is the science and art of growing fruit, vegetables, flowers, shrubs, and trees. These plants may be used for erosion control, esthetic or environmental purposes, and food production. Plants chosen should be suitable for the site and the climate. Important considerations for the plants include the form, mature size, color, growth habits, maintenance needs, and placement on the landscape. Just as important are the type of soil and the fertility and water requirements. The soil survey provides information on soil properties and characteristics that can help the property owner make decisions about what to plant.

### Nutrient Management

*Apply only the nutrients plants can use.*

#### In Your Backyard

Twenty nutrients have been identified that are required by plants. Of these, nitrogen, phosphorus, and potassium are required in relatively large amounts. Nitrogen is associated with lush vegetative growth, adequate phosphorus is required for flowering and fruiting, and potassium is necessary for durability and disease resistance. Calcium, sulfur, and magnesium are also required in comparatively large quantities. These six nutrients are referred to as macronutrients.

The other nutrients, referred to as micronutrients, are required in very small amounts. These include such elements as copper, zinc, iron, and boron. While both macro and micronutrients are required for good plant growth, over-application can be as detrimental as a deficiency. Over-application of plant nutrients not only may impair plant growth, but also may contaminate groundwater by leaching through the soil or may pollute surface waters by washing away.

### Soil Testing

Testing your soil for nutrients and pH is important for providing your plants with the proper balance of nutrients while avoiding over-application. If you are establishing a new lawn or landscaping, a soil test is strongly recommended. The cost of soil testing is minor in comparison to the cost of plant materials and labor. Correcting a problem before planting is much simpler and cheaper than afterwards.

Once your yard is established, continue to take periodic soil samples. Many people routinely lime their lawns, but doing so can result in raising the pH too high. Since many fertilizers tend to lower the pH, however, the pH may drop below desirable levels after several years, depending on fertilization and other soil factors.

Home tests for pH, nitrogen, phosphorus, and potassium are available from garden centers. While these may give you a general idea of the nutrients in your soil, they are not as reliable as tests performed by the Cooperative Extension Service at land grant universities. University and other commercial testing services provide more detail, and you can request special tests for micronutrients if you suspect a problem. In addition to the analysis of nutrients in your soil, these services often provide recommendations for the application of nutrients or on adjusting the pH.

The test for soil pH is very simple—pH is a measure of how acidic or alkaline your soil is. A pH of 7 is considered neutral. Below 7 is acidic and above 7 is alkaline. Since pH greatly influences plant nutrients, adjusting the pH can often correct a nutrient problem. At a high pH, several of the micronutrients become less available for plant uptake. Iron deficiency is a common problem, even at a neutral pH, on such plants as rhododendrons and blueberries. At a very low pH, other micronutrients may be too available, resulting in plant toxicity.

Phosphorus and potassium are tested regularly by commercial testing labs. There are soil tests for nitrogen, but these tests may be less reliable than those for phosphorus and potassium. Nitrogen is present in the soil in several forms, and the forms can change rapidly: therefore, a precise analysis of nitrogen is more difficult to obtain. Most university soil test labs do not routinely test for nitrogen. Home testing kits often contain a test for nitrogen which may give you a general idea of the presence of nitrogen; because of the various transformations of nitrogen, however, the reading may not be reliable.

Organic matter is often part of a soil test. Soil organic matter is highly desirable. Organic matter has a large influence on soil structure. Good soil structure improves aeration and water movement and retention and thus encourages increased microbial activity and root growth, both of which influence the availability of nutrients for plant growth. Soil organic matter also affects the availability of plant nutrients and how pesticides react in the soil. Soils that have a high content of organic matter tend to have a greater supply of plant nutrients than many soils that have a low content of organic matter. Organic matter tends to bind up some soil pesticides, reducing their effectiveness.

Tests for micronutrients are usually not performed unless there is reason to suspect a problem. Certain plants have greater requirements for specific micronutrients and may show deficiency symptoms. Iron deficiency is common on blueberries, rhododendrons, and pin oaks unless the soil is quite acidic. On these plants, the younger leaves will usually show signs of the deficiency first. The areas between the veins will be yellowish, while the veins remain green. Other plants growing in the same soil will show no signs of a deficiency. In this case, altering the pH will often correct the problem.

### Taking a Soil Test

1. If you intend to send your sample to the land grant university in your state, contact the local Cooperative Extension Service for information and sample bags. If you intend to send your sample to a private testing lab, contact them for specific details about submitting a sample.
2. Follow the directions carefully for submitting the sample. The following are general guidelines for taking a soil sample.
    1. Sample when the soil is moist but not wet.
    2. For each acre of land to be tested, 10 to 15 sub-samples are recommended. Areas that appear different or that have been used differently should be sampled separately. For example, a separate sample should be submitted for an area that has been in a garden and one that has been lawn.
    3. Obtain a clean pail or similar container.
    4. Clear away the surface litter or grass.
    5. With a spade or soil auger, dig a small amount of soil to a depth of 6 inches.
    6. Place the soil in the clean pail.
    7. Repeat steps d through f until the required number of samples have been collected.
    8. Mix the samples together thoroughly.
    9. From the mixture, take the sample that will be sent for analysis.
    10. Send immediately. Do not dry before sending.
3. If you are using a home soil testing kit, follow the above steps for taking your sample. Follow the directions in the test kit carefully.

### Fertilizers and Soil Amendments

Once you have the results of the soil test, you can add nutrients or soil amendments, such as lime, as needed. If you need to raise the pH, use lime. Lime is most effective when it is mixed into the soil; therefore, it is best to apply it before planting. For large areas, rototilling is most effective. For small areas or around plants, working the lime into the soil with a spade or cultivator is preferable. When working around plants, be careful not to dig too deeply or so roughly that you damage plant roots. Depending on the form of lime and the soil conditions, the change in pH may be gradual. It may take several months before a significant change is noted. Soils high in organic matter and clay tend to take larger amounts of lime to change the pH than do sandy soils.

If you need to lower the pH significantly, especially for such plants as rhododendrons, you can use aluminum sulfate. Other commercially available fertilizers can also lower the pH. In all cases, follow the soil test or manufacturer's recommended rates of application. Again, mixing well into the soil is recommended.

There are numerous choices for providing nitrogen, phosphorus, and potassium. If your soil is of adequate fertility, applying compost may be the best method of applying additional nutrients. Although compost is relatively low in nutrients compared to commercial fertilizers, it is especially beneficial in improving the condition of the soil. By keeping the soil loose, compost allows plant roots to grow well throughout the soil and thus allows them to extract nutrients from a larger area. A loose soil enriched with compost is also an excellent habitat for earthworms and other beneficial soil microorganisms that are essential for releasing nutrients for plant use. Also, the nutrients from compost are released slowly, so there is no concern for "burning" the plant with an over-application.

Manure is also an excellent source of plant nutrients and organic matter. Manure should be composted before applying. Fresh manure may be too strong and can injure plants. Be careful when composting manure. If left in the open, exposed to rain, nutrients may leach out of the manure and the runoff can contaminate waterways. Make sure the manure is stored in a location away from wells and any waterways and that any runoff is confined or slowly released into a vegetated area. Improperly applied manure also can be a source of pollution. For best results, work composted manure into the soil.

When a bed is prepared before planting, compost and manure may be worked into the soil to a depth of 8 to 12 inches. If compost and manure are being added to existing plants, work carefully around the plants.

Green manures are another source of organic matter and plant nutrients. Green manures are crops that are grown and then tilled into the soil. As the crops break down, nitrogen and other plant nutrients become available. Green manures can also help to prevent soil erosion. Green manures, such as rye and oats, are often planted in the fall after the crops have been harvested. In the spring, the green manures are tilled under before planting.

With all organic sources of nitrogen, whether compost or manure, the nitrogen must be changed to an inorganic form before the plants can use it. Therefore, it is important to have well drained, aerated soils that provide the favorable habitat for the soil microorganisms responsible for these conversions.

There are numerous sources of commercial fertilizers that supply nitrogen, phosphorus, and potassium. The first number on the fertilizer analysis is the percentage of nitrogen, the second number is phosphorus, and the third number is the potassium content. A 10-20-10 fertilizer has twice as much of each of the nutrients as a 5-10-5. How much of each nutrient you need depends on your soil test results and the plants you are fertilizing. Nitrogen stimulates vegetative growth, and phosphorus stimulates flowering. Too much nitrogen can inhibit flowering and fruit production. For many flowers and vegetables, a fertilizer higher in phosphorus than nitrogen is preferred, such as a 5-10-5. For lawns, nitrogen is usually required in greater amounts, so a fertilizer with a greater amount of nitrogen is beneficial.

### Fertilizer Application

Commercial fertilizers are normally applied as a dry granular material or mixed with water and watered onto the garden. If you are using granular materials, avoid spilling on sidewalks and driveways. These materials are water soluble and can cause pollution problems if rinsed into storm sewers. Granular fertilizers are a type of salt, and if applied too heavily on plants, they can burn the plants. If you are using a liquid fertilizer, apply directly to or around the base of the plant.

For the most efficient use and to decrease the potential for pollution, fertilizer should be applied when the plants have the greatest need for the nutrients. Plants that are not actively growing do not have a high requirement for nutrients. Therefore, applications of nutrients to dormant plants or to plants growing slowly due to cool temperatures are more likely to be wasted. Light applications of nitrogen may be recommended for lawns in the fall but nitrogen fertilizers generally should not be applied to most plants in the fall in regions of the country that experience cold winters. Since nitrogen encourages vegetative growth, applying it in the fall it may reduce the plant's ability to harden properly for winter.

In some gardens, applying the fertilizer around the individual plants rather than broadcasting across the entire garden can reduce the amount of fertilizer needed. In the case of phosphorus, much of the fertilizer phosphorus becomes unavailable to the plants once it is spread on the soil. For better plant uptake, apply the fertilizer in a band near the plant. Do not apply directly to the plant or in contact with the roots.

## Pest Management

*Early detection and treatment of pests means a healthier growing environment..*

### In Your Backyard

Pest management can be one of the greatest challenges to the home gardener. Yard pests include weeds, insects, diseases, and some species of wildlife. Weeds are plants that are growing out of place. Insect pests include an enormous number of species from tiny thrips, which are nearly invisible to the naked eye, to the large larvae of the tomato hornworm. Diseases are caused by fungi, bacteria, viruses, and other organisms, some of which are only now being classified. Poor plant nutrition and misuse of pesticides also can cause injury to plants. Slugs, mites, and many species of wildlife, such as rabbits, deer, and crows, can be extremely destructive.

### Identify the Problem

Careful identification of the problem is essential before control practices can be used. Some insect damage may appear to be a disease, especially if no visible insects are present. Nutrient problems may also mimic diseases. Herbicide damage resulting from misapplication of chemicals also can be mistaken for other problems.

### What to Look For

#### Insects and mites

All insects have six legs, but other than that they are extremely variable. Insects include such organisms as beetles, flies, bees, ants, moths, and butterflies. Mites and spiders have eight legs—they are not insects. But for the purposes of this tip sheet, they will be considered as insects.

Insects damage plants in several ways. The most visible damage is chewed plant leaves and flowers. Many pests are visible and can be readily identified, including the Japanese beetle, Colorado potato beetle, and numerous species of caterpillars, such as tent caterpillars and tomato hornworms. Other chewing insects, however, such as cutworms (which are caterpillars) come out at night to eat and burrow into the soil during the day. These are much harder to identify but should be considered if young plants seem to disappear overnight or are found cut off at ground level.

Sucking insects are extremely common and can be very damaging. These insects insert their mouth parts into the plant tissues and suck out the plant juices. They also may carry diseases that they spread from plant to plant as they move about the yard. You may suspect that these insects are present if you notice misshapen plant leaves or flower petals. Often the younger leaves will appear curled or puckered. Flowers developing from the buds may only partially develop. Look on the underside of the leaves, as that is where many species tend to gather. Common sucking insects include leafhoppers, aphids, mealy bugs, thrips, and mites.

Other insects cause damage by boring into stems, fruits, and leaves. They may disrupt the plant's ability to transport water. They also create opportunities for disease organisms to attack the plants. You may suspect the presence of boring insects if you see small accumulations of sawdust-like material on plant stems or fruits. Common examples of boring insects include squash vine borers and corn borers.

### Diseases

Plant disease identification is extremely difficult. In some cases, only laboratory analysis can conclusively identify some diseases. Disease organisms injure plants in several ways. Some attack leaf surfaces and limit the plant's ability to carry on photosynthesis. Other organisms produce substances that clog plant tissues that transport water and nutrients. Other disease organisms produce toxins that kill the plant or replace plant tissue with their own.

Symptoms associated with plant diseases may include the presence of mushroom-like growths on trunks of trees; leaves with a grayish mildewy appearance; spots on leaves, flowers, and fruits; sudden wilting or death of a plant or branch; sap exuding from branches or trunks of trees; and stunted growth.

Misapplication of pesticides and nutrients, air pollutants, and other environmental conditions, such as flooding and freezing, can also mimic some disease problems. Yellowing or reddening of leaves and stunted growth may indicate a nutritional problem. At first glance, blossom end rot of tomato, in which the bottom of the tomato turns black, might appear to be a disease caused by some pathogen. It is actually caused by the plant's inability to take up calcium quickly enough during periods of rapid growth. Prevent this problem with adequate moisture—adding more calcium is of no benefit! Leaf curling or misshapen growth may be a result of herbicide application.

### Pest management practices

Preventing pests should be your first goal, although it is unlikely that you will be able to avoid all pest problems because some plant seeds and disease organisms may lie dormant in the soil for years.

Diseases need three elements to become established: the disease organism, a susceptible species, and the proper environmental conditions. Some disease organisms can live in the soil for years; other organisms are carried in infected plant material that falls to the ground. Some disease organisms are carried by insects. Good sanitation will help to minimize some problems. Planting resistant varieties of plants prevents many diseases. Rotating annual crops in a garden also prevents some diseases.

You will likely have the most opportunity to alter the environment in favor of the plant and not the disease. Healthy, vigorous lawn and garden plants have a higher resistance to pests. Plants that have adequate, but not excessive, nutrients are better able to resist attacks from both diseases and insects. Excessive rates of nitrogen often result in extremely succulent vegetative growth and can make plants more susceptible to insect and disease problems. They can also decrease the winter hardiness of the plants. Proper watering and spacing of plants can limit the spread of some diseases. Some disease species require free-standing water in which to spread, while other species just need high humidity. Proper spacing provides good aeration around plants. A trickle irrigation system, in which water is applied to the soil and not to the plant leaves, may be helpful.

Barriers may be effective in excluding some pests. Mulching is effective against weeds. Fences can limit damage from rabbits. Row covers may prevent insect damage on young vegetable plants. Netting can be applied to small fruit trees and berries to limit damage from birds.

### Integrated Pest Management (IPM)

It is difficult, if not impossible, to prevent all pest problems every year. If your best prevention efforts have not been entirely successful, you may need to use some control methods. Integrated Pest Management (IPM) relies on several techniques to keep pests at acceptable population levels without excessive use of chemical controls. The basic principles of IPM include monitoring (scouting), determining tolerable injury levels (thresholds), and applying appropriate strategies and tactics. Unlike other methods of pest control in which pesticides are applied on a rigid schedule, IPM applies only those controls that are needed, when they are needed, to control pests that will cause more than a tolerable level of damage to the plant.

Monitoring is essential for a successful IPM program. Check your plants regularly. Look for signs of damage from insects and diseases as well as indications of adequate fertility and moisture. Early identification of potential problems is essential.

There are thousands of insects in the garden, many of which are harmless or even beneficial. Proper identification is needed before control strategies can be adopted. It is important to recognize the different stages of insect development for several reasons. The caterpillar eating your plants may be the larva of the butterfly you were trying to attract. The small larva with six spots on its back is probably the young of the ladybug, a very beneficial insect. Some control practices are most effective on young insects. Also, different stages may also be more damaging than others.

It is not necessary to kill every insect, weed, or disease organism to have a healthy yard. This is where the concept of thresholds comes in. The economic threshold is the point where the damage caused by the pest exceeds the cost of control. In a home garden, this can be difficult to determine. What you are growing and how you intend to use it will determine how much damage you are willing to tolerate. Remember that larger plants, especially those close to harvest, can tolerate more damage than a tiny seedling. A few flea beetles on a radish seedling may warrant control, whereas numerous Japanese beetles eating the leaves of beans close to harvest may not.

If the threshold level for control has been exceeded, you may need to employ control strategies. Strategies can be discussed with the Cooperative Extension Service, garden centers, or nurseries.

## Control Strategies

### Mechanical/physical controls

#### Insects

Many insects can be removed by hand. This method is preferable if a few large insects are causing the problem. Simply remove the insect from the plant and drop it into a container of soapy water or vegetable oil. Caution: some insects have spines or excrete oily substances that can cause injury to humans. Use caution when handling unfamiliar insects. Wear gloves, or remove insects with tweezers.

Many insects can be removed from plants by spraying water from a hose or sprayer. Small vacuums can be used to suck up insects. Traps can be used effectively for some insects. These come in a variety of styles, depending on the insect to be caught. Many traps rely on the use of pheromones—naturally occurring chemicals produced by the insects and used to attract the opposite sex during mating. They are extremely specific for each species and, therefore, will not harm beneficial species. One caution with traps is that they may actually draw more insects into your yard. You should not place them directly in the garden. Other traps are more generic and will attract numerous species. These include such things as yellow and blue sticky cards. Different insects are attracted to different colors. Sticky cards also can be used effectively to monitor insect pests.

**Weeds**

Hoeing, pulling, and mulching are the most effective physical control methods for weeds. Weeding is most important while plants are small. Well established plants often can tolerate competition from weeds.

**Other pests**

Fences, netting, and tree trunk guards can be extremely successful in limiting damage from small mammals and birds. Numerous traps also are available to catch or kill some animals. Caution: In many states it is illegal to move wildlife, including squirrels. Traps may also catch animals other than the ones targeted. Check local regulations before trapping.

Diatomaceous earth, a powder-like dust made of tiny marine organisms called diatoms, can be used to reduce damage from soft-bodied insects and slugs. Spread this material on the soil—it is sharp and cuts or irritates these soft organisms. It is harmless to other organisms. Shallow dishes of beer can be used to trap slugs.

**Biological controls**

Biological controls are nature's way of regulating populations. Biological controls rely on predators and parasites to keep organisms under control. Many of our present pest problems result from the loss of predator species.

| Beneficial Insect | Controls |
|---|---|
| Green lacewings | aphids, mealy bugs, thrips, spider mites |
| Ladybugs | aphids, Colorado potato beetle |
| Praying mantis | almost any insect |
| Ground beetles | caterpillars that attack trees and shrubs |
| Parasitic nematodes (tiny worm-like organisms) | grubs, beetles, cutworms, army worms |
| Trichogramma wasp (extremely small, non-stinging wasps) | corn borer, cabbage looper, other worms |
| Seedhead weevils and other beetles | weeds |

Other biological controls include birds and bats that eat insects. A single bat can eat up to 600 mosquitoes an hour. Many bird species eat insect pests on trees and in the garden. Bacillus thuringiensis (Bt) is a bacteria that specifically attacks larvae of some insect pests, including white grubs in the lawn and Japanese beetles. This bacteria is harmless to desirable species.

### Chemical controls

When using biological controls, be very careful with pesticides. Most common pesticides are broad spectrum, which means that they kill a wide variety of organisms. Spray applications of insecticides are likely to kill numerous beneficial insects as well as the pests. Herbicides applied to weed species may drift in the wind or vaporize in the heat of the day and injure nontargeted plants. Runoff of pesticides can pollute water. Many pesticides are toxic to humans as well as pets and small animals that may enter your yard.

Some common, nontoxic household substances are as effective as many more toxic compounds. A few drops of dishwashing detergent mixed with water and sprayed on plants is extremely effective in controlling many soft-bodied insects, such as aphids and whiteflies. Crushed garlic mixed with water may control certain insects. A baking soda solution has been shown to help control some fungal diseases on roses.

When using pesticides, follow label directions carefully. Altering the rate of application or increasing the frequency of application can injure desirable plant and animal species. Spot applications of the pesticide to the targeted pest can reduce the amount used and help reduce the risk of injury to nontargeted species. Do not apply on windy days. Read the label for information on other environmental conditions, such as temperature and rain, that may influence the pesticide's effectiveness. Be aware that many so-called "organic" pesticides may be just as toxic as the synthetic chemical products.

### Alternatives to pesticides and chemicals

When used incorrectly, pesticides can pollute water. They also kill beneficial insects as well as harmful ones. Natural alternatives prevent both of these events from occurring and save you money. Consider using natural alternatives for chemical pesticides: Nondetergent insecticidal soaps, garlic, hot pepper sprays, 1 teaspoon of liquid soap in a gallon of water, used dishwater, or a forceful stream of water to dislodge insects.

Also consider using plants that naturally repel insects. These plants have their own chemical defense systems; when planted among flowers and vegetables, they help to keep unwanted insects away. The table below contains a partial list of nature's alternatives.

| Pest | Plant Repellent |
|---|---|
| Ant | mint, tansy, pennyroyal |
| Aphids | mint, garlic, chives, coriander, anise |
| Bean leaf beetle | potato, onion, turnip |
| Codling moth | common oleander |
| Colorado potato bug | green beans, coriander, nasturtium |
| Cucumber beetle | radish, tansy |
| Flea beetle | garlic, onion, mint |
| Imported cabbage worm | mint, sage, rosemary, hyssop |

| | |
|---|---|
| Japanese beetle | garlic, larkspur, tansy, rue, geranium |
| Leaf hopper | geranium, petunia |
| Mexican bean beetle | potato, onion, garlic, radish, petunia, marigolds |
| Mice | onion |
| Root knot nematodes | french marigolds |
| Slugs | prostrate rosemary, wormwood |
| Spider mites | onion, garlic, cloves, chives |
| Squash bug | radish, marigolds, tansy, nasturtium |
| Stink bug | radish |
| Thrips | marigolds |
| Tomato hornworm | marigolds, sage, borage |
| Whitefly | marigolds, nasturtium |

**Native Plants**

When planning your next landscape project, consider using native species. Native plants tend to grow better than introduced species because they have evolved under local growing conditions. Native plants are less prone to disease and, once established, require less watering and fertilizer than non-native species. Also, they can reduce the amount of lawn you need to mow.

Design choices are as diverse with native plants as with introduced species. There are trees, shrubs, grasses, and wildflowers to choose from. Native plants come in a vast array of colors—blooming and adding interest to your landscape throughout the year. Many native plants have colorful, decorative leaves in a variety of shapes.

If you want a formal-looking yard, group similar plants and colors together with spacing wide enough to allow plant distinction. If you prefer a more natural look, scatter a variety of plants at random. Then allow the plants to grow into each other, providing a free-flowing form. Whatever your design, the soft pastels of delicate wildflowers are a welcome sign of spring. In winter, tall grasses and silhouettes of leafless shrubs add a texture to the landscape that a mowed lawn will never offer.

If you are enhancing an established yard, inventory your yard and work with the features you have. With the aid of field guides, you may locate hidden treasures in the form of wildflowers you were unaware of. Perhaps a stump, fallen log, or large rock could be a focal point for your garden. And it can be exciting to build your new landscape design around a mature native tree.

Native plants can attract native animals, such as butterflies and birds by providing food and shelter. Fruits, such as acorns or berries, are vitally important, but other benefits can be less noticeable. Many animals are host dependent—that is, they need a specific type of plant to survive. Butterfly larvae may chew on some new plants you have worked hard to establish, but that could be a small price to pay if you will be rewarded with magnificent butterflies in a few short weeks.

Since the settlement of this country, there has been a rapid decline of native plant and animal species. Some introduced plants have become invasive, taking over where wild plants once thrived. Planting native plants in your backyard is a step towards preserving your own natural heritage.

Be aware that many localities have laws or ordinances against digging up native plants for transplanting. Native species should be obtained from reputable nurseries and garden centers that offer a selection of plants indigenous to the area. Most states have a native plant society, and contacts can be found on the Internet. Local bookstores have books dedicated to plants and animals of the region. By asking a few questions, you can get the information you need to "go native" in your backyard.

**Selecting the Right Tree**

Summertime brings hot weather. It is the time of year when we appreciate the shade of a big, beautiful tree. Trees provide other benefits, too. They can block the wind, help clean the air, provide fruit and nuts, and create a hospitable habitat for wildlife. And trees make a great hideaway where children can play. Once you decide to add a tree to your backyard, do you know how to select the right tree-one that will live a long time?

When looking for that perfect tree for your yard, pick one with good form. Most trees should have one main leader (trunk) and a balanced number of side branches. They should look healthy and free from insect damage—and show evidence of growth. Be sure to get your tree from a reputable nursery that has inspected and certified stock. Select a tree grown in your area, because trees raised under local growing conditions are more likely to thrive in your yard.

Container-grown trees spend at least part of their life in a pot. These trees transplant well from early spring into fall. Be sure the tree is not simply potted bare rootstock. The root mass will come out of the pot intact if it is a container-grown tree. There should be plenty of feeder roots—those thin, hair-like roots—but not so many roots that the tree has become pot-bound. Also, check the roots for damage. Rodent damage is easy to spot-you will see evidence of chewing and, possibly, tunnels or holes. Avoid any tree with a rotten odor coming from the root area-it probably is suffering from disease.

Balled and burlapped trees usually transplant well. The tree's root system is contained within the ball of soil; the soil remains firm around the root system to minimize transplant shock. You do not want a tree that has been allowed to dry out. Make sure your tree's root ball is kept moist prior to planting.

Bare root trees are usually extremely small plants. Most of these trees are best planted in winter if the ground is not frozen or in early spring before the leaves come out. The roots are exposed, so the trees must be stored in a cool, humid place and the roots kept covered with a moist material until planting time.

Knowing what to look for when tree shopping will help you select the right tree. A healthy tree will last a long time and provide many backyard benefits.

**How to Plant a Tree**

Selecting the right tree for the right place is a good first step in any landscape design, but proper planting also is important for getting your tree off to a good start. Trees are like all living creatures. They require more attention in the beginning to promote a long, healthy life.

Carefully choose the planting site. Trees are difficult to move once they are established. Check with local authorities for regulations on placement of trees. Some communities have ordinances restricting placement of trees within a specified distance of a street, sidewalk, streetlight, or other utilities. BEFORE DIGGING, make sure that all underground utilities are clearly marked. You wouldn't want to cut off the electric power to your community or risk injury.

Carefully follow the planting instructions that come with your tree. If specific instructions are not available, follow these tips:

Dig a hole about twice the size of the tree's root ball, or about 1 foot wider than the root system. The hole should be slightly shallower than the root ball. If the soil is especially heavy or wet, consider planting the tree slightly higher.

Remove all materials from the root mass. This includes wires, string, burlap, and biodegradable containers. Neglecting this step will hinder proper root growth. Gently place the tree in the center of the hole and position it to grow straight. If the tree has a prettier side, place that side in the direction most frequently viewed. If planting a bare root tree, carefully spread the roots. Crumble the soil removed from the hole and cover the roots with it. As you add soil to fill in around the tree, lightly tamp the soil to collapse air pockets, or add water to help settle the soil. Air pockets around the roots can be devastating to a newly planted tree.

Add about four inches of mulch—wood chips, shredded bark, or grass clippings—around the base of the tree, extending out to the tips of the outermost branches. A circle of mulch 3 feet in diameter is common. Mulching will retain moisture, reduce weeds, maintain a more even soil temperature, and eliminate mowing next to the delicate bark. Be sure to pull the mulch away from the tree trunk because decomposing mulch can cause rot problems.

Finally, give the tree a thorough watering. If the root ball is extremely dry, allow water to trickle into the soil by placing the hose at the trunk of the tree. Young trees need protection against rodents, frost cracks, sunscald, lawnmowers, and weed whackers. Plastic guards are an inexpensive and easy control method. Light-colored tree wraps can be used to protect the trunk from sunscald. Usually, staking trees is not necessary unless you live in an area with high winds.

A properly planted and maintained tree will grow much faster and live much longer than one that is incorrectly planted. Trees can be planted almost any time of the year as long as the soil is not frozen. However, early fall is the optimum time to plant trees. For the first year or two, especially after a week or so of extremely hot or dry weather, watch your tree closely for signs of moisture stress. If you see leaf wilting or hard, caked soil, water the tree well and slowly enough so the water soaks in rather than runs off.

Take the time to give your tree a good start on life. You and the next generation will enjoy the benefits of your backyard tree for years to come.

### Attracting Butterflies

Making your yard more attractive to butterflies does not have to be an expensive, major undertaking. A few choice plants, a basking site, and a source of water may be all that is needed to entice these colorful insects into your yard.

Before selecting plants for butterflies, find out what species are common in your area. Many species, such as the well-known monarch, are found across most of the United States, but other species are native to specific parts of the country. Knowing what types of butterflies are common in your area will help you select proper plants for the larvae.

Butterfly larvae—or caterpillars—have specific food requirements. Most species can only survive on a few types of plants. Monarch larvae feed only on milkweed plants, while the similar looking viceroy larvae feed on willow and poplar leaves. The black swallowtail larvae feed on such plants as carrots, dill, and parsley. Many species feed on native plants, including those often called weeds such as nettle and thistle.

Adult butterflies require a source of nectar or other liquid from sap or over-ripe fruits. Their long mouthparts are able to reach deep into flowers to obtain this nectar. Butterfly weed, phlox, clover, zinnias, goldenrod, lantana, liatris, asters, and numerous other species will provide the colorful adults with their needed food.

Here are some suggestions to make your yard more desirable for butterflies:

Avoid using insecticides. Butterflies are insects; therefore, most insect sprays will kill butterflies.

Learn to recognize the larvae of butterflies. Those caterpillars eating your parsley may be the larvae of the swallowtail butterfly.

Plant a variety of flowers that bloom from spring until fall. They will provide a continuous source of nectar for the adult butterflies.

Include native plant species in your garden.

While adults are attracted to a wide variety of flowers, many have a preference for red, yellow, orange, and purple flowers. Single flowers are easier for butterflies to get nectar from than the fuller double blossoms.

Locate your garden in full sun. Butterflies are most active on warm sunny days.

Provide a source of water such as a shallow saucer of water or a birdbath. Butterflies do drink.

Place several flat rocks in full sun in the garden. Butterflies need to warm up in the morning before they are capable of active flight. Rocks provide a basking site for butterflies to raise their body temperature.

Be patient! It may take time for butterflies to find your yard, especially if you are the only one in the neighborhood providing desirable habitat. Even if you don't attract the desired species at first, keep trying and enjoy the beauty of the plants!

### Ground Covers for Steep Slopes

Steep slopes present both challenges and wonderful opportunities for landscaping. Steep banks can be difficult and dangerous to mow. Erosion can be a serious problem if vegetation is not established. South-facing slopes may warm up and dry out quicker than other areas, while north-facing slopes may be cooler than surrounding areas. So, what are your options if you have a steep incline in your yard that presents maintenance problems?

First, determine the existing conditions. Which direction does the bank face? Is it shady or sunny? Then, decide if you want a formal, manicured look or a more natural look.

If you prefer a well-maintained look, plant low-growing groundcovers other than grass. Numerous plants are available that will blanket the ground, protecting it from erosion and remaining neat throughout the year with little or no maintenance. Low-growing species of juniper (prostrate juniper) will do well in many sunny, drier locations. These plants spread rapidly and have a variety of textures and colors (ranging from blues to greens). In shady spots, the non-native pachysandra commonly does well. This plant remains green throughout the winter and spreads easily. Wintercreeper is another non-native but hardy plant that grows in sun and partial shade. Varieties are available that have white or gold variegated leaves. Yet another possibility is periwinkle, actually a Vinca species, known for its blue or white flowers. Check with a local nursery for species that are best suited to your area.

When planting groundcovers on slopes, try to avoid planting into bare soil. This may not be possible in areas of new construction. In this case, mulch around the plants with an organic mulch to help retain water and prevent erosion. If you have existing sod, it is preferable to kill the sod and plant into it. This practice limits the potential for serious erosion before the new groundcover becomes established. You may want to mulch around the plants so the area looks neat. Providing extra water while the plants are being established greatly enhances success during dry periods.

If you prefer a more natural look, plant wildflowers and native grasses on slopes. Once established, these natural plantings can provide season-long color, food, and shelter for birds and butterflies. Periodic mowing may be needed to control growth and keep woody shrubs and trees from becoming established. Check on local ordinances dealing with unmowed areas.

Terraces provide another option for steep slopes. Terraces provide architectural interest as well as opportunities for extensive gardens. They can vary considerably in cost, depending on the materials used and the area to be terraced. Terraces must be installed properly to ensure the stability of the slope. Check on local ordinances and building codes if you are considering a terrace. When contracting for the work, use a reliable, competent professional.

## Terracing

*Use terraces to make flower and vegetable gardening possible on steep slopes or simply to add interest to your landscape.*

### In Your Backyard

Terraces can create several mini-gardens in your backyard. On steep slopes, terracing can make planting a garden possible. Terraces prevent erosion by shortening the long slope into a series of shorter, more level steps. This allows heavy rains to soak into the soil rather than run off and cause erosion.

### Materials for Terraces

Numerous materials are available for building terraces. Treated wood is commonly used because of several advantages: it is easy to work with, blends well with plants, and is often less expensive than other materials. There are many types of treated wood on the market from railroad ties to landscaping timbers. These materials will last for years. While there has been some concern about using these treated materials around plants, studies by Texas A&M University and the Southwest Research Institute concluded that these materials are not harmful to gardens or people when used as recommended. Other materials for terraces include bricks, rocks, concrete blocks, and similar masonry materials. Some masonry materials are made specifically for walls and terraces and can be more easily installed by a homeowner than other materials, such as field stone and brick. Most stone or masonry products tend to be more expensive than wood.

### Height of Walls

The steepness of the slope often dictates wall height. Make the terraces in your yard high enough so the land between them is fairly level. Be sure the terrace material is strong enough and anchored well enough to stay in place through freezing and thawing and heavy rainstorms. Do not underestimate the pressure of water-logged soil behind a wall. It can be enormous and can cause improperly constructed walls to bulge or collapse. Many communities have building codes for walls and terraces. For large projects, the expertise of a professional is needed to make sure the walls can stand up to water pressure in the soil. Large terraces also need to be built with proper drainage and to be tied back into the slope properly. Because of the expertise and equipment required to do this correctly, you will probably want to restrict terraces you build yourself to no more than a foot or two high.

### Building a Terrace

The safest way to build a terrace is probably the cut and fill method. With this method, little soil is disturbed, giving you protection from erosion should a sudden storm occur while the work is in progress. This method will also require little, if any, additional soil.

1. Contact your utility companies to identify the location of any buried utilities before starting to excavate.

2. Determine the rise and run of your slope. The rise is the vertical distance from the bottom of the slope to the top. The run is the horizontal distance between the top and bottom. This will help you determine how many terraces you need. For example, if your run is 20 feet and the rise is 8 feet and you want each bed to be 5 feet wide, you will need four beds. The rise of each bed will be 2 feet.

3. Start building beds at the bottom of your slope. You will need to dig a trench in which to place your first tier. The depth and width of the trench will vary, depending on how tall the terrace will be and the specific building materials you are using. Follow the manufacturer's instructions carefully when using masonry products. Many of these have limits to the number of tiers or the height that can be safely built. If using landscape timbers and your terrace is low (less than 2 feet), you only need to bury the timber to about half its thickness or less. The width of the trench should be slightly wider than your timber. Make sure the bottom of the trench is firmly packed and completely level. Place your timbers in the trench.

4. For the sides of your terrace, dig a trench into the slope. The bottom of this trench must be level with the bottom of the first trench. When the depth of the trench is 1 inch greater than the thickness of your timber, you have reached the back of the terrace and can stop digging.

5. Cut a timber to the correct length and place it in the trench.

6. Drill holes through your timbers, and pound long spikes or pipes through the holes and into the ground. A minimum of 18 inches pipe length is recommended; longer pipes may be needed for stability for higher terraces.

7. Place the next tier of timbers on top of the first, overlapping corners and joints. Spike these together.

8. Move soil from the back of the bed to the front of the bed until the surface is level. Add another tier as needed.

9. Repeat, starting with step 2. In continuously connected terrace systems, the first timber of the second tier will also be the back wall of your first terrace.

10. The back wall of the last bed will be level with the front wall of that bed.

11. When finished, plant and mulch.

### Plants for Dry Conditions

Even in regions where rainfall normally is abundant, plants can suffer from lack of moisture. When root growth is limited by concrete or asphalt or when plants are grown in containers or in excessively well drained, sandy soil, moisture stress can be a constant problem.

In some cases, the soil may be improved by adding organic material, such as peat moss or compost, that will help retain moisture in the soil. Also, mulching will help by reducing evaporation of water from the soil surface and keeping weeds in check. However, if plants seem to constantly dry out, in spite of your best efforts, you may want to consider growing plants that can withstand dry conditions. Using drought-resistant plants can help reduce your water bill and the amount of time you spend working in the garden!

Characteristics of plants that normally are adapted to dry conditions include thick fleshy leaves; very narrow leaves (such as those of many evergreen species); and hairy, spiny, or waxy leaves. All of these features are adaptations that help to minimize the amount of water lost from the leaves. Many drought-tolerant plants also have very deep root systems. Plants that originate in dry environments also will have greater drought resistance.

Don't worry that your only choice will be cactus plants. For most landscaping situations, many plants are available that tolerate dry conditions. Perennial flowering plants that tolerate dry conditions include numerous herb species, such as lavender, artemisia, sage, and yarrow. Many varieties of these plants have attractive, fragrant, silvery foliage in addition to colorful flowers that are attractive to hummingbirds and butterflies. Sedum and species of coneflower, liatris, and sunflowers do well in sunny dry locations.

Colorful annuals that thrive in sunny dry conditions include portulaca—a low-growing plant that reseeds itself and produces masses of flowers in nearly all colors. Vinca, which has shiny leaves and flowers of white to pink to lavender, works well as a border plant along hot sunny walkways. The brightly colored California poppy also grows in dry soils.

Many grasses adapted to prairie conditions do well in dry locations and provide habitat for birds. They serve as a landscaping focal point and can be mixed with perennial flowers for contrast.

Shrubs that tolerate dry conditions include many species of junipers, some species of cotoneaster, pyracantha, potentilla, and caragena. Many of these shrubs have berries that are attractive and provide food for wildlife.

A local nursery can recommend plants for dry sites in your area. There are many locally adapted native plants that will withstand dry conditions and enhance your landscape for wildlife.

### Patio Plants for Birds and Butterflies

Whether you have a large yard or not, you may want to encourage birds and butterflies to come to your doorstep. Flower pots and hanging baskets can encourage a variety of species to perch on your patio for close-up observation. While native plants may be preferable for natural areas, especially in regions with cold winters, patio plantings allow you to grow exotic tropical species that can be interesting to friends and wildlife.

*Some considerations when planning your patio garden:*

**Containers.** Numerous materials and styles are available. Plastic pots are lightweight, inexpensive, and durable. Drain holes in the bottom are essential because plastic pots retain moisture better than pots made from porous materials, such as unglazed clay or wood. Ceramic pots tend to be more expensive and are often quite heavy compared to plastic. Large planters can be made from rot-resistant wood. Even in outdoor locations, it is advisable to put saucers under the pots to catch drain water that can stain decks and patios.

Consider what you want to plant before selecting a planter. Choose a planter large enough to accommodate the plant. Inadequately sized pots will require frequent watering and will look out of proportion with large plants.

**Potting soil.** Planters should be filled with a potting mix that is well drained but that will hold some water. Because of the limited rooting area provided by the pot, ordinary garden soil generally is not suitable—it tends to be too heavy and does not drain or retain moisture as well as organic potting soils.

**Light.** The amount of sun that your pots will receive should help you determine what to plant. If your planters will be in sunlight most of the day, make sure the plants you select require full sun. If you have a shady patio, select plants, such as impatiens or snapdragons, that require or at least tolerate less direct light.

**Watering.** Depending on the size of the pot and weather conditions, plants may need to be watered daily. Check frequently and water as needed. If frequent watering is necessary and your time is limited, you can purchase automatic watering devices for pots.

**Choice of plants.** The choice of plants is boundless. Vegetables, flowers, and even vines grown on supports will do well in pots. Nasturtiums, petunias, and impatiens are attractive to hummingbirds and grow well in pots. The pendulous fuchsia is a favorite for hanging baskets and also attracts hummingbirds. Pots planted with herbs, such as parsley and dill, can provide fresh herbs for personal use and food for swallowtail caterpillars. Monarch butterflies and other species are attracted to lantana, cosmos, and zinnias. Other butterfly plants suitable for pots include verbena, marigolds, hibiscus, and asters. Vines suitable for larger pots and attractive to butterflies include bougainvillea and morning glory.

Be creative, and have fun. Even if the plants you choose are not the favorites of any birds or butterflies, enjoy them yourself!

From the Natural Resources Conservation Service, National Association of Conservation Districts, and Wildlife Habitat Council.

## Rangeland

### What is rangeland?

Rangeland is a kind of land on which the historic climax vegetation was predominantly grasses, grasslike plants, forbs, or shrubs. Rangeland includes land revegetated naturally or artificially to provide a plant cover that is managed like native vegetation. Rangelands include natural grasslands, savannas, most deserts, tundra, alpine plant communities, coastal and freshwater marshes, and wet meadows.

Rangelands provide numerous products and have many values and uses. Rangelands are a primary source of forage for domestic livestock and for wildlife. Rangelands provide water for urban, rural, domestic, industrial, and agricultural use. They provide wildlife habitat, areas for natural recycling, purification of the air, and carbon sequestration. Rangelands have aesthetic value, provide open space, and act as buffers for urban areas. They are a vital link in the enhancement of rural social stability and economic vigor.

Reference: "Range and Pasture Handbook," Section 600.0202(a) page 2-2

### What is range management?

Range management is the art and science founded on ecological principles and dealing with the use of rangelands and range resources for a variety of purposes. These purposes include use as watersheds, wildlife habitat, grazing by livestock, recreation, and aesthetics.

### What is an ecological site?

An ecological site is a distinctive kind of land with specific physical characteristics that differs from other kinds of land in its ability to produce a distinctive kind and amount of vegetation. Landscapes are divided into ecological sites for the purposes of inventory, evaluation, and management.

An ecological site is the product of all the environmental factors responsible for its development, and it has a set of key characteristics that are included in the ecological site description. Ecological sites have characteristic soils and hydrology that have developed over time throughout the soil development process. The factors of soil development are parent material, climate, living organisms, topography or landscape position, and time. These factors lead to soil development or degradation through the processes of loss, addition, translocation, and transformation.

Most ecological sites evolved with a characteristic kind of herbivory (kinds and numbers of herbivores, seasons of use, and intensity of use). Herbivory directly influences the vegetation and soil, both of which influence the hydrology.

Ecological sites evolve with a characteristic fire regime. Fire frequency and intensity contribute to the characteristic plant community of the sites.

Reference: "Range and Pasture Handbook," Section 600.0300 (a) page 3.1-1

### What is an ecological site description?

An ecological site description is prepared for each ecological site. These descriptions contain information regarding the physiographic features, climate, soils, water features, and plant communities associated with each ecological site. Plant community dynamics, annual production estimates, growth curves, associated wildlife communities, and interpretations for use and management of the site are also included in each site description.

Ecological site descriptions provide the foundation information to assist land managers in making timely, well informed resource management decisions.

Example: "National Range and Pasture Handbook," Exhibit 3.1-3 page 3.1 ex-3

### What is a historic climax plant community?

The historic climax plant community for a site in North America is the plant community that existed at the time of European immigration and settlement. It is the plant community that was best adapted to natural disturbances, such as drought, fire, grazing of native fauna, and insects. The historic climax plant community was in dynamic equilibrium with its environment.

The historic climax plant community of an ecological site is not a precise assemblage of species for which the proportions are the same from place to place or from year to year. In all plant communities, variability is apparent in productivity and occurrence of individual species. Boundaries of the plant communities can be recognized by characteristic patterns of species composition, association, and community structure.

Reference: "National Range and Pasture Handbook," Section 600.0301 pages 3.1-2

### What is a similarity index?

Similarity index is the comparison of the present plant community on an ecological site to any other plant communities that may exist on the site.

The purpose for determining similarity index is to provide a benchmark for future comparisons evaluating the extent and direction of changes that have occurred in the plant community because of a specific treatment or management.

Reference: "National Range and Pasture Handbook," Section 600.0402(b) page 4-17

**How is similarity index calculated?**

To determine the present plant community's similarity index to a specific plant community, the specific plant community must be adequately described in the ecological site description. The specific plant community must be described by species and the expected range of production by weight by species or by groups of species as well as the expected normal total annual production. This range of production becomes the allowable production to be counted when determining similarity index.

The existing plant community must be inventoried by recording the actual weight, in pounds, of each species present. The annual production by species of the existing plant community is then compared to the production of individual species in the desired plant community. All allowable production is then totaled. It is important to remember that if the similarity index is calculated when plants are still growing, then the plant productions should be reconstructed to reflect the total production for the year.

The relative similarity index to the desired plant community is calculated by dividing this total weight of allowable production by the total annual production in the desired plant community. This evaluation expresses the percentage of the desired plant community present on the site. For example, if the current inventory reflects only 65% of the allowable plants compared to the desired plant community, then the current plant community has a 65% similarity index to the desired plant community.

Reference: "National Range and Pasture Handbook," Section 600.0402(b)(2) page 4-17

**What is trend?**

Trend is a rating of the direction of plant community changes that may be occurring on a site. The plant community and the associated components of the ecosystem may be either moving toward or away from the historic climax plant community or some other desired plant community. At times, it can be difficult to determine the direction of change. Usually trend is determined by two evaluations over time.

Trend provides information necessary for the operational level of management to ensure that the direction of change meets the objectives of the manager. The present plant community is a result of a sustained trend over a period of time.

Trend is an important and required part of a rangeland resource inventory. It is significant when planning the use, management, and treatment needed to affect desired change in the rangeland resource.

Reference: "National Range and Pasture Handbook," Section 600.0402(a) page 4-14

**How is range trend determined?**

The plant community and the associated components of the ecosystem may be either moving toward or away from the historic climax plant community or some other desired plant community (rangeland trend or planned trend). The kind of trend (rangeland trend or planned trend) being evaluated must be determined.

Rangeland trend is defined as the direction of change in an existing plant community relative to the historic climax plant community. It is described as:

- *Toward:* Moving towards the historic climax plant community.
- *Not apparent:* No change detectable.
- *Away from:* Moving away from the historic climax plant community.

Planned trend is defined as the change in plant composition within an ecological site from one plant community type to the desired plant community. It is described as:

- *Positive:* Moving towards the desired plant community.
- *Not apparent:* No change detectable.
- *Negative:* Moving away from the desired plant community.

Most ecological sites evolved with a characteristic kind of herbivory (kinds and numbers of herbivores, seasons of use, and intensity of use). Herbivory directly influences the vegetation and soil, both of which influence the hydrology.

Trend is determined by evaluating changes in plant composition, abundance of seedlings and young plants, plant residue, plant vigor, and condition of the soil surface.

Reference: "National Range and Pasture Handbook," Section 600.0402(a) page 4-14

**What is rangeland health?**

The rangeland health assessment is an attempt to look at how the ecological processes on an ecological site are functioning. Ecological processes include the water cycle (the capture, storage, and redistribution of precipitation), energy flow (conversion of sunlight to plant and animal matter), and nutrient cycle (the cycle of nutrients, such as nitrogen and phosphorus, through the physical and biotic components of the environment).

Qualitative assessments of rangeland health provide land managers with information that can be used to identify areas that are potentially at risk of degradation and provide early warnings of resource problems on upland rangelands.

This procedure has been developed for use by experienced, knowledgeable land managers. It is not intended that this assessment procedure be used by individuals who do not have experience or knowledge of the rangeland ecological sites they are evaluating. This approach requires a good understanding of ecological processes, vegetation, and soils for each of the ecological sites to which it is applied.

Reference: "National Range and Pasture Handbook," Section 600.0402(c) pages 4-23

**How is rangeland health evaluated?**

Ecological processes functioning within a normal range of variation support specific plant and animal communities. Direct measures of site integrity and status of ecological processes are difficult or expensive to measure because of the complexity of the processes and their interrelationships. Therefore, biological and physical attributes are often used as indicators of the functional status of ecological processes and site integrity.

Three closely interrelated attributes are evaluated:

- *Soil/site stability:* The capacity of the site to limit redistribution and loss of soil resources (including nutrients and organic matter) by wind and water.
- *Hydrologic function:* The capacity of the site to capture, store, and safely release water from rainfall, run-on, and snowmelt (where relevant) to resist a reduction in this capacity and to recover this capacity following degradation.
- *Integrity of the biotic community:* Capacity of a site to support characteristic functional and structural communities in the context of normal variability, to

resist loss of this function and structure because of a disturbance, and to recover following such disturbance.

Reference: "National Range and Pasture Handbook," Section 600.0402(c)(2) pages 4-24

## Recreation

Soil surveys available from the Natural Resources Conservation Service can help in the selection of tracts suitable for recreational development and in the planning of adequate conservation to ensure that the areas remain attractive and usable.

More ski resorts, dude ranches, camps, parks, picnic areas, and other private and public recreation areas are needed to meet the growing demand for recreation. But just because recreation is for fun does not mean the selection and layout of areas can be haphazard. Soil suitability and limitations should be considered in planning recreational areas.

### Why Soil Data Are Needed

It cannot be assumed that just any piece of land can be used for recreation. Some soils are as unsuitable for recreation as they are for supporting buildings or for growing oranges. The following items are among the soil properties that affect recreational uses:

- A hazard of flooding can severely limit the use of soils for camps and recreation buildings, but such soils are suitable for hiking, nature study, and other less intensive uses.
- High water tables impose severe limitations on the use of soils for campsites, roads, trails, playgrounds, and picnic areas.
- Droughtiness makes it difficult to grow the grass needed to prevent erosion, and droughty soils may require irrigation to maintain vegetation.
- Some clayey soils swell when wet and shrink when dry. This shrinking and swelling may damage floors and foundations of recreation buildings. Such soils may fail to support roads and other structures unless special design is used.
- Steep slopes limit the use of soils for playgrounds, campsites, buildings, roads, and trails, but are appropriate for hiking areas.
- If bedrock is at a shallow depth, it is difficult to level soils for playgrounds and campsites, to construct roads and trails, and to establish vegetation. Shallow soils are poorly suited for uses that require extensive grading.
- A clayey or sandy surface layer makes some soils undesirable for playgrounds, campsites, or other uses that require heavy foot traffic.
- Soils that have a high in content of clay are sticky when wet and remain wet for long periods after rains. Loose, sandy soils are unstable and dusty when dry. Soils that have a texture of sandy loam or loam are the most suitable for recreational uses that require heavy foot traffic.
- Stones, gravel, and rocks impose moderate to severe limitations on the use of soils for campsites, playgrounds, trails, and other uses that require heavy foot traffic.
- The absorptive capacity of soils determines whether a septic tank absorption field will work. The soil should be deep and permeable, there should be no seasonal high water table, the slope should not be steep, and there should be no danger of flooding.

- Suitability for impounding water determines whether a soil can be used for constructing fishponds. Ponds are desirable for other recreation uses, such as shooting preserves, dude ranches, vacation farms, and wildlife and nature study areas. Soils suited to constructed ponds generally are deep, have slow permeability when compacted, are not steep, and have a low susceptibility to piping.

### Selecting Recreational Areas

Soil surveys can help you select areas suitable for a wide range of recreational uses, including:

- Wetland refuges for waterfowl
- Wildlife management
- Open space or nature study areas
- Parks
- Athletic fields
- Ski areas
- Golf courses
- Campsites
- Hiking trails
- Picnic areas
- Dude ranches
- Woodlands
- Hunting reserves
- Constructed ponds

### Maintaining Recreational Areas

For the manager of a ski resort, dude ranch, camp, park, picnic area, playground, or other private or public recreational area, a soil survey can provide information necessary for planning a conservation program to protect the area against erosion and other kinds of site damage.

A soil survey can guide you in selecting a use for each area, based on the suitability of the soil. For example, soils that are susceptible to erosion can be planted to trees, shrubs, and grasses and used in a nonintensive way, such as for nature study. Loamy, well-drained soils can be used for play areas and other uses that require heavy foot traffic.

A soil survey can also help in determining the kind of conservation measures needed to protect the soils while in use. Soil information, which for many years has helped farmers and ranchers prepare conservation plans, can also be used by a camp operator or a manager of any recreational area. Vegetation adapted to the soil can be selected and planted to protect the soil from erosion. Dams, terraces, diversions, waterways, and other mechanical measures to control water runoff can be installed in critical areas. In wet areas, if the soil and topography permit and if outlets are available, drains can be installed.

### Recreational Uses and Interpretations

Soil Surveys include a number of interpretations specifying the suitability and limitations of soils for various uses. The following paragraphs describe a number of these interpretations.

**Camp areas** are tracts of land used intensively for tents, trailers, and campers, and the accompanying activities of outdoor living. Also to be considered are placement of sanitary facilities and utility lines. Camp areas are subject to heavy foot traffic and some vehicular traffic.

**Picnic areas** are natural or landscaped tracts used primarily for preparing meals and eating outdoors. These areas are subject to heavy foot traffic. Most vehicular traffic is confined to access roads and parking areas.

**Playgrounds** are areas used intensively for such games as baseball, football, and soccer, and for restrooms, parking areas, and outbuildings. Playgrounds require nearly level soils that are free of stones and that can withstand heavy foot traffic while maintaining adequate vegetation.

**Paths and trails** are areas used for walking, horseback riding, and other uses. They require little cutting and filling for slope modification.

**Off-road motorcycle trails** are primarily used for recreational use with trail-type, all-terrain vehicles or motorcycles. Little or no trail preparation is done and the surface is not usually vegetated or surfaced.

**Snowmobile trails** are available in certain states.

**Golf Fairways** are areas that support turf for lawns, golf fairways, and ornamental trees and shrubs for landscaping.

## Urban Uses

Soils used for urban purposes are in areas of developed and developing land. These uses are described in this section.

### Soils information helps people make many different decisions

A wide range of decisions can be based, directly or indirectly, on soils information. Examples include decisions about where to put a garden, park, or road. People in urban areas who use soils information include:

- Homeowners with small sites
- County planners, local planning boards, builders, or developers with large sites
- Students exploring careers in soils or educators planning outdoor classrooms
- Scientists or researchers
- Renters or property managers interested in ongoing maintenance or expanded use of existing soils

#### Urban areas include developed and developing land

The management of soils on developed and developing land is complex. Information is needed from many agencies to be applied across a variety of land uses. Contact information for other agencies on flood maps (FEMA), environmental education (EPA), and other issues is listed under the heading "References and resources" at the end of this introduction. Most of the information presented for other land uses in Web Soil Survey also can be adapted and used to learn more about urban areas of developed and developing land. Therefore, it may be helpful for you to understand a few basic definitions showing the relationship of developed and developing land to other land uses, such as cropland, forestland, and rangeland. Horticulture and recreation are special focus areas that can occur in areas of any land use.

The following definitions, with the exception of that for developing land, are from the National Resources Inventory program (NRI-97) of the U.S. Department of Agriculture, Natural Resources Conservation Service.

#### Developed land

A combination of land cover/use categories including urban and built-up areas and rural transportation land.

#### Rural transportation land

A land cover/use category consisting of all highways, roads, railroads, and associated rights-of-way outside urban and built-up areas; including private roads to farmsteads or ranch headquarters, logging roads, and other private roads, except field lanes.

#### Urban and built-up areas

A land cover/use category consisting of residential, industrial, commercial, and institutional land; construction sites; public administrative sites; railroad yards; cemeteries; airports; golf courses; sanitary landfills; sewage treatment plants; water control structures and spillways; other land used for such purposes; small parks within urban and built-up areas; and highways, railroads, and other transportation facilities if they are surrounded by urban areas.

#### Developing land

As defined for Web Soil Survey, developing land is a broad category that includes transitional areas of cropland, forestland, or rangeland that may be developed in the near future.

### Common questions about soils on developed and developing land

Listed below are common categories of uses related to developed and developing land. For each category, a set of common questions is listed along with the soil suitability ratings and soil properties available in Web Soil Survey that may provide answers to the questions. For an explanation of soil suitability ratings as they relate to soils in developed areas, see the section in this introduction titled “Understanding the suitability and limitations ratings.”

Note: The headings "Soil suitability and limitation ratings" and "Soil property and quality ratings" refer to tab labels in Web Soil Survey.

#### Roads, buildings, and other structures

##### Is my property on a flood plain?

Web Soil Survey only provides information about the susceptibility to and frequency of flooding. Consult flood maps from FEMA (see the "References and resources" section).

##### Is my property in an area where overland or stream flooding may cause damage?

- *Soil suitability and limitation ratings:* Playgrounds; Shallow Excavations
- *Soil property and quality ratings:* Flooding Frequency Class; Representative Slope

**Is my property in an area where water may rise from below and cause damage?**

- *Soil suitability and limitation ratings:* Excavated Ponds (Aquifer-fed)
- *Soil property and quality ratings:* Depth to Water Table; Representative Slope; Map Unit Hydric Rating

**Why has my house settled unevenly, resulting in cracks in the walls?**

- *Soil suitability and limitation ratings:* Dwellings with Basements
- *Soil property and quality ratings:* Percent Clay; Organic Matter; Flooding Frequency

**Will a septic tank absorption field work on this site?**

- *Soil suitability and limitation ratings:* Septic Tank Absorption Fields
- *Soil property and quality ratings:* Depth to Water Table; Representative Slope; Depth to Soil Restrictive Layer

**Is construction on this land limited by erosion and sedimentation?**

- *Soil suitability and limitation ratings:* Potential Erosion Hazard (Roads, Trails)
- *Soil property and quality ratings:* K Factor; Representative Slope; Hydrologic Group; Percent Clay

**Our roads buckle and have many potholes. Are there other options for the soil bed or paving?**

- *Soil suitability and limitation ratings:* Local Roads and Streets
- *Soil property and quality ratings:* Percent Clay; Saturated Hydraulic Conductivity (Ksat)

**Is my house in danger of slipping down the slope or over the cliff?**

- *Soil suitability and limitation ratings:* Shallow Excavations; Potential Erosion Hazard (Roads, Trails)
- *Soil property and quality ratings:* Depth to Soil Restrictive Layer; Saturated Hydraulic Conductivity (Ksat)

### Vegetation

**Should I be concerned about contaminated soils on my property?**

Web Soil Survey provides information about the soil properties primarily related to plant growth and structural support. Consult your local health or environmental department for evaluations of risk from contamination, or contact the U.S. Environmental Protection Agency (see the "References and resources" section).

**Is the soil in our park suitable for vegetation that can withstand heavy foot traffic?**

- *Soil suitability and limitation ratings:* Lawns, Landscaping, and Fairways

- *Soil property and quality ratings:* Percent Clay; Bulk Density; Depth to Soil Restrictive Layer

**Is our problem with poor vegetation growth due to soil compaction?**

- *Soil suitability and limitation ratings:* Crop Productivity Index; Potential Seedling Mortality; Lawns, Landscaping, and Golf Fairways
- *Soil property and quality ratings:* Percent Clay; Bulk Density; Depth to Soil Restrictive Layer

**We received a notice to remove noxious weeds, but how can we recognize them?**

Contact your local Weed Board as listed in the notice. Information about and pictures of specific plants are available in the PLANTS database (see the "References and resources" section).

**Are automatic lawn sprinklers suitable for my soil, or will they result in excessive wetness?**

- *Soil suitability and limitation ratings:* Water Management; Irrigation Suitability; Lawns, Landscaping, and Golf Fairways
- *Soil property and quality ratings:* Available Water Capacity; Percent Clay; Drainage Class; Map Unit Hydric Rating; Flooding Frequency Class; Ponding Frequency Class

**What native plants will grow in my soil but won't invade my neighbor's lawn?**

- *Soil suitability and limitation ratings:* Ecological Site (Rangeland); Nonirrigated Crop Yield
- *Soil property and quality ratings:* Available Water Capacity; Percent Clay; Depth to Soil Restrictive Layer

### Water management

**How can we find the best location for our park and avoid being limited to a few weeks' use because of standing water?**

- *Soil suitability and limitation ratings:* Water Management; Picnic Areas; Playgrounds; Camp Areas; Building Site Development
- *Soil property and quality ratings:* Percent Clay; Flooding Frequency Class; Ponding Frequency Class; Drainage Class; Map Unit Hydric Rating; Depth to Soil Restrictive Layer

**How can I find a suitable location for a small urban pond? I want to include vegetation that would attract wildlife.**

- *Soil suitability and limitation ratings:* Water Management; Embankments, Dikes, and Levees; Excavated Ponds (Aquifer-fed)
- *Soil property and quality ratings:* Percent Clay; Drainage Class; Map Unit Hydric Rating; Flooding Frequency Class; Ponding Frequency Class

**Can I do anything about the muddy water in the ditch near a construction site?**

- *Soil suitability and limitation ratings:* Potential Erosion Hazard; contact local planning department
- *Soil property and quality ratings:* Percent Clay; see also RUSLE2-Related Attributes (Soil Reports tab)

### A brief guide to soils in urban areas

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. 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 impervious cover, such as pavement, driveways, and buildings. Collectively, nonsoil areas are classified as miscellaneous areas.

Some general information about map unit components and the kinds of map units (for example, "complex") in a soil survey is provided under the heading "Components and kinds of map units".

#### Understanding the suitability and limitations ratings

- Generally, there are no data recorded for map units or components called "urban land".
- If the urban land occurs as part of a complex, it is possible to view the soil information for the other components in the complex by using the advanced options for aggregation methods.
- When urban land makes up the largest percentage of the map unit, using the "dominant condition" aggregation method may obscure the information for nearby developing land and undisturbed soils. Adjusting the aggregation method to "least limiting" and leaving the component percent box unchecked (thereby opening up all components for ratings) can help to overcome this problem.
- Udorthents are an example of a more general classification category of soils. The data available for these soils commonly are limited or are displayed in the form of wide ranges. Ratings for specific uses generally are not available. Disturbed land is commonly mapped as Udorthents.
- Developing land generally was mapped as the undisturbed soil map unit or component. Because data or ratings for the map units of urban land and more general classifications typically are not available, it may be useful to look at the other soils in an urban land complex or at the soils in adjacent map units for clues to soil suitability or soil properties.
- As soil surveys are updated, more developed land may be captured as map units and the soil properties in some larger areas may be consistent enough to be rated for suitability.

#### Urban land map units

- Urban land consists of paved areas or areas of highly disturbed land. This land may still have some of the characteristics of the soil components that existed in the area before it was disturbed. The soil survey generally describes the top 5 feet of the soil.
- In some rapidly developing areas, the soil has been disturbed since the soil survey mapping was completed. Differences between the earlier mapping and the current conditions may be noticeable at the surface or when sequences of

layers repeat below the surface. Typically, these areas are mapped as urban land or as a complex of urban land with an undisturbed soil.

- Soil properties in urban areas can vary considerably over distances too small to be captured on soil survey maps. Therefore, onsite investigations are needed before specific practices are designed.
- The following photos illustrate the variety of urban soils.


Lack of distinct horizons in a filled area

Loamy fill over natural sand (note the abrupt color change)

Fill material over wet soil

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area.

### Components and kinds of map units

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

### Minor components

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

### Kinds of map units

Soils that have profiles that are almost alike make up a "soil series". Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into "soil phases." Most of the areas shown on detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A "complex" consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An "association" is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An "undifferentiated group" is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include "miscellaneous areas." Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Additional information about map units is available elsewhere in Web Soil Survey (see the "Soil Reports" tab). Some reports display properties of the soils, and others list limitations, capabilities, and potentials for many uses. Many of the terms used in describing map units and components of map units are defined in the narrative descriptions that accompany these reports.

### References and resources

Earth Team (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/partnership/?cid=nrcs142p2_053402)

FEMA flood plain maps (http://gis1.msc.fema.gov) or FEMA Map Service Center at 1-800-358-9616). If you would like to examine the maps and speak with someone knowledgeable about your local circumstances, you may also contact your local map repository, an office that keeps the FEMA maps for public reference and use. This office is generally in your local planning, engineering, or public works department.

Scheyer, J.M., and K.W. Hipple. 2005. Urban Soil Primer. United States Department of Agriculture, Natural Resources Conservation Service (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/use/urban/?cid=nrcs142p2_053993)

Soil Risks and Hazards (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/use/?cid=nrcs142p2_053956)

United States Department of Agriculture, Natural Resources Conservation Service. Field Office Technical Guide (eFOTG) (http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/technical/fotg/)

United States Department of Agriculture, Natural Resources Conservation Service. PLANTS database. National Plant Data Center (http://plants.usda.gov/)

United States Environmental Protection Agency (EPA) (http://www.epa.gov)