HOUDEK

South Dakota State Soil

SOIL SCIENCE SOCIETY OF AMERICA

Photo Soil Monolith: Chip Clark/Smithsonian Institution

Introduction

What do the Chinese ring-necked pheasant, Black Hills spruce, Pasque flower, rose quartz, triceratops, and the Houdek loam have in common? They are all state symbols for South Dakota. The Chinese ring-necked pheasant is the state bird, Black Hills spruce is the state tree, Pasque is the state flower (**Figure 1**), rose quartz is the state mineral, triceratops is the state fossil, and the Houdek loam is the state soil. Let's explore how the Houdek is important to South Dakota.

History and Commemoration

South Dakota has a large acreage of productive, prairie derived soils on glacial till (material deposited by glaciers). Most of these soils are medium textured and have high natural fertility. Houdek is a native soil of South Dakota and does not occur in any other state. The Houdek soil was chosen because of its large extent and its importance to agriculture.

The Professional Soil Scientists Association of South Dakota and the South Dakota chapter of the Soil and Water Conservation Society worked together to commemorate the importance of soil to South Dakota. It is fitting that Houdek loam, a typical prairie derived glacial till soil, was adopted as the state soil to acknowledge the importance soil has played in our State's most important industry, agriculture.

The Houdek series was established in 1955 in Spink County, South Dakota. The series was separated from the Barnes series which was established in 1914. In 1990, the late Governor George Mickelson signed a House Bill into law, making the Houdek loam South Dakota's Official State Soil.

What is Houdek Soil?

Soil material is separated into three different size fractions called *sand*, *silt*, and *clay*, which make up the *soil texture*. They are present in all soils in different proportions and say a lot about the character of the soil. In addition, soils may be thick to thin, stony to not stony; saline to not saline; sandy, silty, loamy, or clayey; sloping, flat, or in depressions; and may occur where climates are moist to dry and warm to cool.

Each soil series is uniquely defined by the different colors, *organic matter* levels, textures, layers or horizons, *parent materials*, and other *morphological* (structure), chemical, and physical properties.

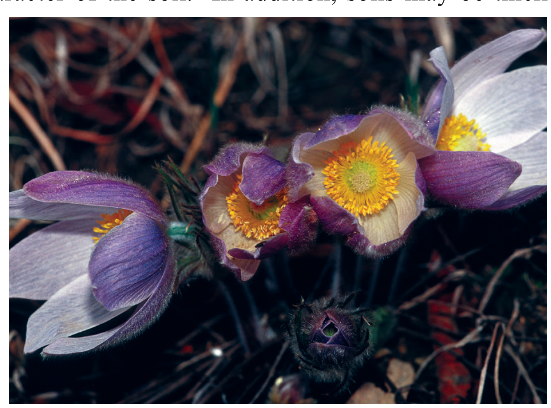

Fig. 1 South Dakota State flower (Pasque flower). Credit: USDA-NRCS photo gallery. 2015a

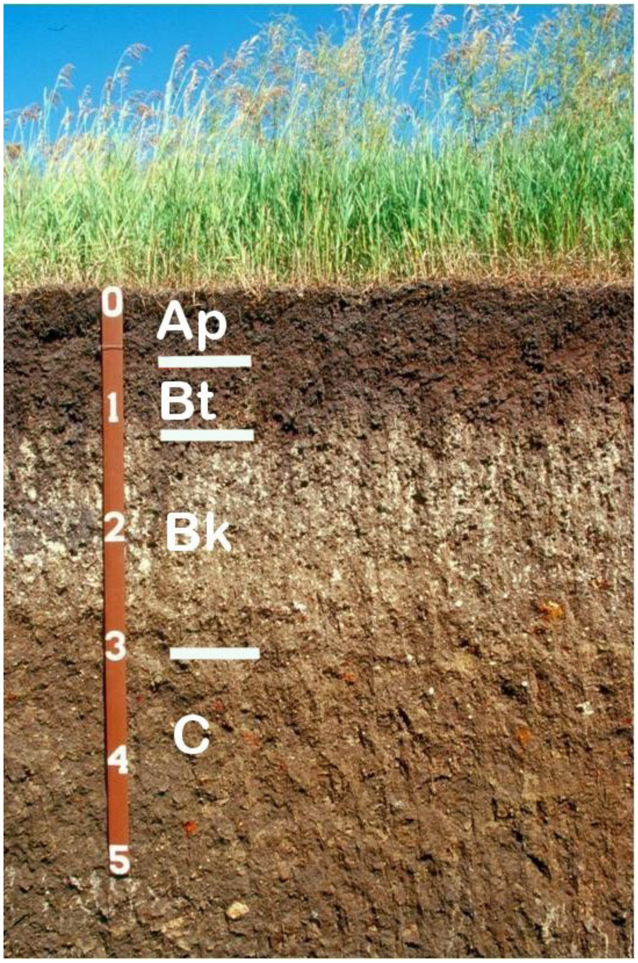

Fig. 2. (Left) Houdek Soil Profile. Source: http://pssasd.drivehq.com/Houdek/index.html

Fig. 3. (Above) Location of Houdek soils in South Dakota, Credit: Smithsonian Institution's Forces of Change exhibit.

The Houdek profile (**Figure 2**) is composed of *topsoil* formed from the weathering of *glacial till* and the decomposition of grass residues causing the deep dark color (Ap) with 2-4 % organic matter (Figure 3). This 6-8 inch layer is *friable* (easily crumbles) and has a neutral *soil pH (6-7.3)*.

The subsoil of the Houdek soil is divided into two parts: 1) a layer of clay accumulation (Bt); and 2) a layer of lime accumulation (Bk). As the Houdek soils weathered and formed, water from the soil surface carried lime and clay downward. These materials were deposited deeper, forming the two subsoil layers. The Bt layer is 10-15 inches deep, is friable, and has a neutral pH. The Bk layer is 15-30 inches deep, friable, and moderately alkaline. The C layer is 20+ inches deep, is friable, and moderately alkaline.

The last layer in the Houdek soil is the parent material (C). This layer represents the materials from which the Houdek soil has developed with time. It represents what the glacier originally left at the soil surface.

The Bk and C layers are also *calcareous*, meaning they contain enough calcium carbonate ($CaCO_3$) to effervesce (fizz) when treated with hydrochloric acid (HCl)!

Climate factors and vegetation/soil organisms have weathered the glacial parent materials to form the present day Houdek soil. Because soils are complex, variable, and occur as a mosaic on the land, it is difficult for one to learn them all. However, if one learns the properties of the state soil, Houdek, then other soils can be compared to it.

> ***"Out of all the long list of nature's gifts to humans, none is perhaps so utterly essential to human life as soil."*** —H.H. Bennett

Where to dig a Houdek

Yes you can dig a soil. It is called a soil pit and it shows you the *soil profile*. The different horizontal layers of the soil are called soil horizons. There are more than 2 million acres of Houdek and closely related soils in the central part of the state (**Figure 3**). It is one of the most extensive soils in the state. In South Dakota there are more than 550 different kinds of soils called "soil series."

Importance of Soils

Soils are not an unlimited natural resource. Soils take thousands of years to form and it only takes a few years to destroy their *productivity* as a result of erosion and other types of improper management. Soils are used to produce crops, range, timber, and for recreation. They are used for engineering purposes and are an integral part of the water cycle. Soils are nature's waste disposal medium and they serve as habitats for many varied kinds of plants, birds, animals, and microorganisms. Soils are basic to our survival. We cannot live without them. Socially, economically, and environmentally soils are crucial to society's growth and development.

Fig. 4. (Above) Houdek soil landscape. Credit: USDA-NRCS

Fig. 5. (Right) No-till planting. Credit: USDA-NRCS

Soil and Agriculture's Importance to South Dakota

When a state depends heavily upon agriculture for its livelihood, soil quality becomes an especially important matter. Stewardship of the land depends upon one's knowledge of soil characteristics and qualities.

South Dakota is an agricultural state with an area of 77,047 square miles and a population density of nine persons per square mile. Cash receipts from farming and ranching normally exceeds $9 billion each year with an economic impact of $21 billion (USDA-NASS 2013; Decision Innovation Solutions, 2014).

On the average, South Dakota ranks nationally in the top ten for corn, soybeans, spring wheat, winter wheat, oats, alfalfa hay, all hay, grain sorghum, sunflower seed, barley, rye, millet, and flaxseed production. These crops and their products, along with forage, range, and pasture grown in the state, provide feed for large numbers of livestock. On the average, South Dakota ranks nationally in the top ten for beef, sheep, hog, bison, and honey production (USDA-NASS, 2013).

This production is possible because South Dakota has large areas of productive soils. One of these productive soils is the Houdek loam, our state soil. Soils are the foundation of life and the economic base for South Dakota. They have properties and characteristics which influence their suitabilities for various uses. It is critical for society to understand how soils form and develop. Houdek loam is a symbol which one can use to help increase public awareness of South Dakota's soil resources.

Management and Limitations for Use

Houdek soils are used extensively for cropland, hayland, and rangeland (**Figure 4**). Small grains, corn, sunflowers, and soybeans are commonly grown crops. Alfalfa and alfalfa-grass mixtures provide hay and pasture for grazing livestock. Large areas of Houdek soils are in native range. Crops and grasses grown on the Houdek soil provide habitat to wildlife. Soil erosion (wind and water) control, soil productivity, soil organic carbon levels, and soil moisture conservation are major concerns of land managers in this geographic

When a soil cannot be used for one or more of the described functions, it is referred to as a limitation. Soil experts, called *Soil Scientists*, studied Houdek soil and identified that it should be carefully managed (*conservation tillage*, *no-till*, and *cover crops*) to prevent wind and water *erosion* (**Figure 5**). Houdek soils with slopes greater than 9 % should not be cultivated and be left in permanent grass vegetation with careful grazing practiced to protect the soil resource from soil erosion and degradation.

Houdek Soil Formation

Before there was soil there were rocks and in between, CLORPT. Without CLORPT, there would be no soil. So what is CLORPT? They are the five major factors that are responsible for forming a soil like Houdek. The kind of soil that develops in any area is the result of the interaction of the five soil forming factors; **CL**imate, **O**rganisms (vegetation and soil biota), **R**elief (topography), **P**arent material, and **T**ime. As a result, the properties of the Houdek soil and all other soils are determined by CLORPT factors. *Weathering* takes place when environmental processes such as rainfall, freezing, and thawing act on rocks and parent materials causing them to dissolve, fracture, and break into pieces. CLORPT then acts on the rock pieces, glacial sediments, and vegetative materials to form soils.

Climate – Temperature and precipitation influence the rate at which parent materials weather and dead plants and animals decompose. They affect the chemical, physical, and biological relationships in the soil. The Houdek soils developed in a subhumid climate with a mean annual precipitation of 20 to 22 inches and an average annual temperature of 45 to 47 ^{O}F. The influence of the two have resulted in the downward movement of lime and clay form the Bk and Bt horizons, respectively, in the Houdek soils.

Organisms – This refers to plants and animal life. In the soil, plant roots spread through, animals burrow in, and bacteria eat plant and animal tissue. These and other soil organisms (e.g., fungi and bacteria) speed up the breakdown of large soil particles into smaller ones. Plants and animals also influence the formation and differentiation of soil horizons (e.g., Ap, Bt, and Bk). Plants determine the kinds and amounts of organic

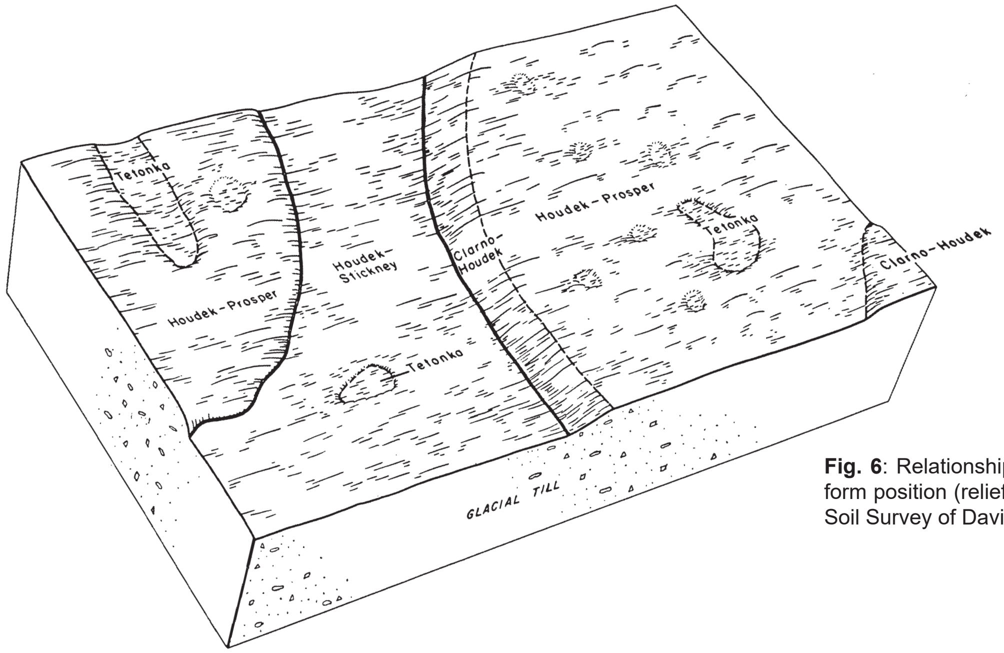

Fig. 6: Relationship of Houdek soils to associated soils, landform position (relief) and parent material. Credit: USDA-NRCS, Soil Survey of Davidson County, SD

matter that are added to a soil under normal conditions. Animals breakdown complex compounds into small ones and in so doing add organic matter to the soil. Houdek soils developed under mid-grass prairie vegetation which deposits organic matter in the soil through plant root additions and decomposition. Houdek soils have significant accumulations of humus (organic matter).

Relief – Landform position or relief describes the shape of the land (hills, valleys, and plains), and the direction it faces makes a difference in how much sunlight the soil receives and how much water it keeps. Deeper soils form at the bottom of the hill rather than at the top of a hill because gravity and water move soil particles downhill. Soils of the Houdek series are very deep (>60 inches to bedrock), well drained and are located on stable uplands (**Figure 6**). The slopes can range from 0 to 25 % with most Houdek soils having slopes of 0 to 6%.

Parent material – Just like people inherit characteristics from their parents, every soil inherits some traits from the material from which it forms. Some parent materials are transported and deposited by glaciers, wind, water, or gravity. The factor of parent material exerts its influence on soils principally by determining soil texture, water holding capacity, and to a great extent their mineralogical composition. Houdek soils have developed from glacial till.

Time – All the factors of soil formation act together over a period of time to produce soils. As a result, soils vary in age. The length of time that soil material has been exposed to the soil-forming processes makes older soil different from younger soils. Generally, older soils have better defined soil horizons and greater depth of *leaching* when compared to younger soils. Less time is needed for a soil profile to develop in a humid and warm area with dense vegetative cover where the Houdek soil is than in a cold or dry area with sparse vegetation.

Ecoregions, Soils, and Land Use in South Dakota

According to the Environmental Protection Agency (EPA), ecoregions are areas where ecosystems (and the type, quality, and quantity of environmental resources) are generally similar. Houdek soils are primarily found in Ecoregions 46n (James River Lowlands) and 42e (Southern Missouri Coteau) in east central South Dakota (**Figure 7**). Winter wheat, corn, hay, and soybeans are most prevalent in this ecoregion. The Southern Missouri Coteau (42e) is located on the southern fringe of continental glaciation, with a topography of gentle undulations, smaller and less dense wetland areas, and more stream erosion. Soybeans, winter wheat, hay, and corn are the dominant crops planted on the soils in this ecoregion.

The elevation ranges in this area from 1300 to 1900 feet and most of the area is nearly level to undulating till plains with prairie potholes and moraines. The average annual precipitation ranges from 20 to 25 inches with an average of 22 inches per year. The majority of the rainfall (>70%) occurs as high-intensity thunderstorms during the growing season. Snowfall averages about 36 inches/year. The average annual temperature is 47^{O}F with a 165-day growing season (32^{O}F basis). The dominant soil order in ecoregions 46n and 42e are Mollisols (from the Latin *mollis* – soft), prairie or grassland soils that have a dark-colored surface horizon. They are highly fertile and rich in chemical "bases" such as calcium and magnesium. The dark surface horizon comes from the yearly addition of organic matter to the soil from the deep roots of prairie plants.

The native prairie vegetation in this ecoregion includes western wheatgrass, green needlegrass, needleandthread, and porcupine grass. In areas that receive overflow water the dominant grass is big bluestem. In very wet, poorly drained soils the dominant vegetation is prairie cordgrass, reed canarygrass, and western wheatgrass are the major grasses present.

In these two ecoregions about 60% of the land is used for dry cropland, 35% for grassland (native range or tame pasture), 3% for urban land, and 2% for other land uses. Nearly, all the land is farms or ranchland. The major crops are corn, soybeans, grain sorghum, small grains, and alfalfa. Native range or tame pasture grows on 33% of the land in this ecoregion.

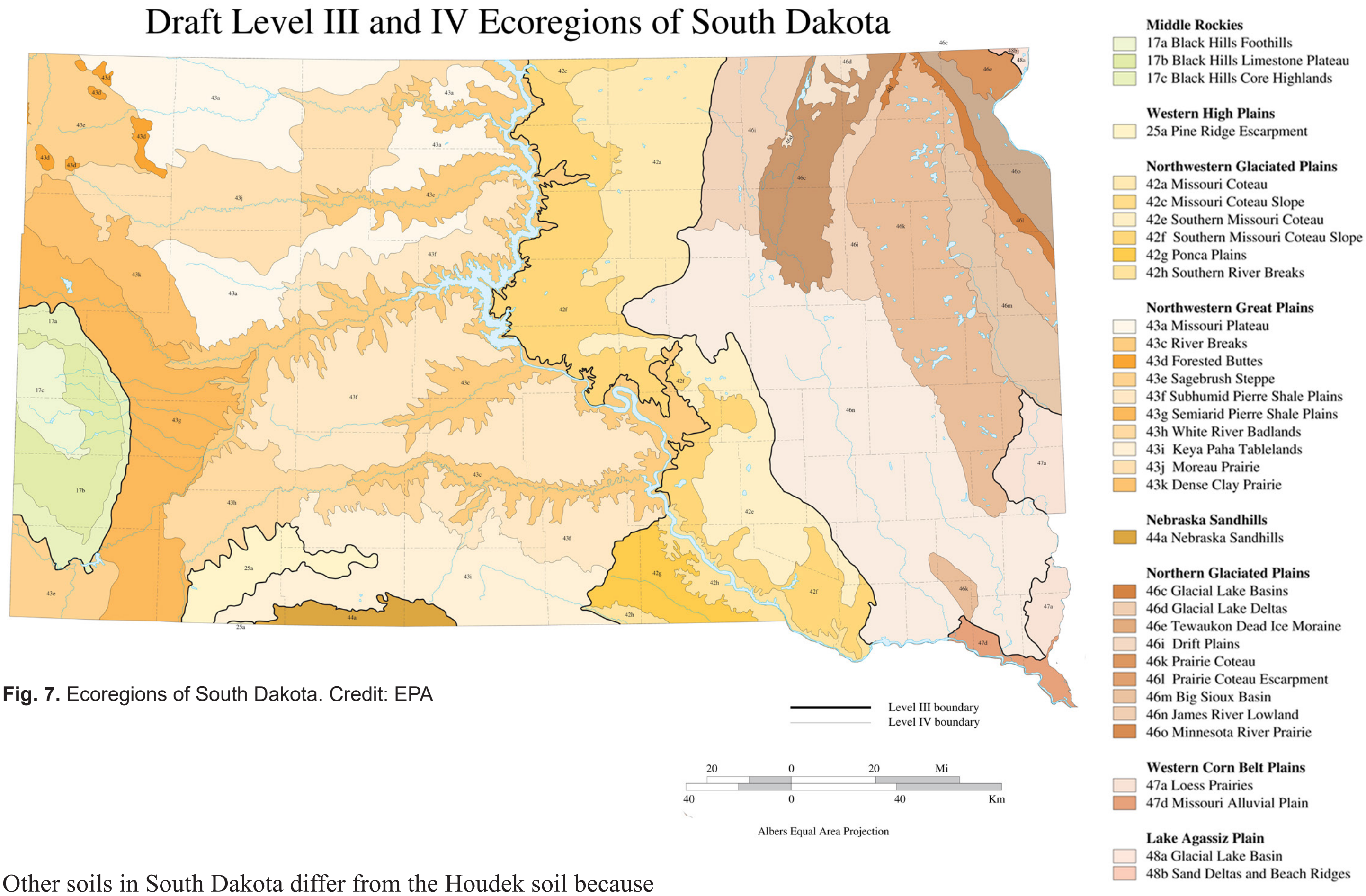

Fig. 7. Ecoregions of South Dakota. Credit: EPA

Other soils in South Dakota differ from the Houdek soil because they have different characteristics and properties, much like a collie dog is different from other breeds of dogs. Soil boundaries due to changes in soil parent material or topography generally are distinct while boundaries due to climate and vegetation differences are gradual over a geographic area.

Soils east of the Houdek series formed in similar parent materials or loess and are used more intensively for row crop (corn and soybean) production when compared to the Houdek soils. The northeastern South Dakota soils (46e, 46k, 46m, 46l, 46o) developed in a cool, moist subhumid climate with about 23 inches of average annual precipitation and an average annual temperature of 43 ^{O}F. The southeastern soils (46k, 46m, 47a, 47d) developed in a warm, moist subhumid climate with about 24 inches of average annual precipitation and an average annual temperature of 47 ^{O}F. Soils in these two areas formed under tall-grass prairie vegetation and have higher soil organic matter contents, are darker colored, are more moist, are leached of carbonates more deeply, have thicker A horizons and profiles, have less strongly developed prismatic B horizons, and there is less tendency for clay accumulation in the B horizons when compared to the Houdek soils found in soil zone 5.

Soils north (42f, 42g, 46c, 46i) of the Houdek series have similar parent materials and are used for small grains, soybeans, corn, and sunflower production. These soils developed in a cool, dry subhumid climate with about 18 to 20 inches of average annual precipitation and an average annual temperature of 43 ^{O}F. Soils in this region formed under mid-grasses and the soils have higher soil organic matter contents, are darker colored, have thicker A horizons and profiles, are more moist, are leached of carbonates to a greater depth, and are cooler than the Houdek soils.

Soils west (excluding the Black Hills, ecoregions 17a, 17b, and 17c; see Figure 7) of the Houdek series tend to be drier and have formed in different parent materials (west of the Missouri River sedimentary bedrock [shale, sandstone, and siltstone; ecoregions (25a, 42g, 42h, 43a, 43c-43k, and 44a)] are the dominant parent materials when compared to the Houdek soil, The soils in the northwestern SD ecoregions have developed in a cool, semiarid climate with about 13 -16 inches of average annual precipitation and an average annual temperature of 42 -44 ^{O}F. The soils in the southwestern SD ecoregions developed in a warm semiarid climate with about 15 inches of average annual precipitation and an average annual temperature of 45 ^{O}F. The soils in western SD ecoregions formed under short- and mid-grass prairies and are used mostly for range with small areas of small grain (winter wheat, spring wheat, oats), grain sorghum, alfalfa hay, other hay, and sunflower production. Soils in the western regions of SD tend to be lighter colored, have lower organic matter contents, have thinner A horizons and profiles, less leaching of carbonates, and have smaller and more developed prismatic structure in the B horizons when compared to the Houdek soils.

In the far western part of SD we find the Black Hills (171, 17b, 17c), an undulating to mountainous area where soils are derived from igneous, metamorphic, and sedimentary rocks and the dominant vegetation is mixed forest (pine, spruce, aspen) with a sub-humid climate conditions and are used for timber, grazing, and recreation. The soils formed under a humid climate with an average annual precipitation of 23 inches and an average annual temperature of 40 ^{O}F. Soils in this zone tend to have O horizons, E horizons with platy structure, and developed Bt horizons with strong angular blocky structure. The A horizons are thin, profiles are leached to greater depths and the profiles are deeper than the Houdek soil.

Glossary

Calcareous Soil: A soil containing enough calcium carbonate (commonly combined with magnesium carbonate) to effervesce visibly when treated with cold, dilute hydrochloric acid.

Clay: A soil particle that is less than 0.002 mm in diameter. Clay particles are so fine they have more surface area for reaction. They hold a lot of nutrients and water in the soil. A clay soil is a soil that has more than 40% clay, less than 45% sand and less than 40% silt.

Conservation Tillage: Any tillage sequence that reduces loss of soil or water relative to conventional tillage, including the following systems:

Minimum tillage. The minimum soil manipulation necessary for crop production or meeting tillage requirements under the existing soil and climatic conditions.

Mulch tillage. Tillage or preparation of the soil in such a way that plant residues or other materials are left to cover the surface; also called *mulch farming, trash farming, stubble mulch tillage,* and *plowless farming*.

No-tillage system. A procedure whereby a crop is planted directly into a seedbed not tilled since harvest of the previous crop; also called *zero tillage*.

Plow-planting. The plowing and planting of land in a single trip over the field by drawing both plowing and planting tools with the same power source.

Ridge till. Planting on ridges formed by cultivation during the previous growing period.

Sod planting. A method of planting in sod with little or no tillage.

Strip till. Planting is done in a narrow strip that has been tilled and mixed, leaving the remainder of the soil surface undisturbed.

Subsurface tillage. Tillage with a special sweep-like plow or blade that is drawn beneath the surface, cutting plant roots and loosening the soil without inverting it or without incorporating residues of the surface cover.

Wheel-track planting. A practice of planting in which the seed is planted in tracks formed by wheels rolling immediately ahead of the planter.

Cover Crop: Close-growing crop, that provides soil protection, seeding protection, and soil improvement between periods of normal crop production, or between trees in orchards and vines in vineyards.

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

Fertility, Soil: The relative ability of a soil to supply the nutrients essential to plant growth.

Friable: A soil consistency term pertaining to soils that crumble with ease.

Glacial Till: Dominantly unsorted and unstratified earth material, generally unconsolidated, and deposited directly by a glacier without substantial reworking by meltwater, which consists of a heterogenous mixture of clay, silt, sand, gravel, stones, and boulders in any proportion; rock fragments of various lithologies imbedded within a finer matrix that can range from clay to sandy loam.

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

Organic Matter: The organic fraction of the soil exclusive of undecayed plant and animal residues. See also humus.

Parent material: The unconsolidated organic and mineral material in which soil forms.

Productivity: A measure of the soil's ability to produce one particular crop/plant or a series of crops/plants, including range, and timber, under a specific management system.

Sand: A soil particle between 0.05 and 2.0 mm in diameter. Sand is also used to describe soil texture according to the soil textural triangle, for example, loamy sand.

Silt: A soil particle between 0.002 and 0.05 mm diameter. It is also used to describe a soil textural class.

Slope: The inclination of the land surface from the horizontal. Percent slope is the vertical distance divided by the horizontal distance multiplied by 100.

Soil Horizon: A layer of soil with properties that differ from the layers above or below it.

Soil Morphology: The physical constitution, particularly the structural properties, of a soil profile as exhibited by the kinds, thicknesses, and arrangement of the horizons in the profile, and by the texture, structure, consistence, and porosity of each horizon.

Soil pH: Soil pH is a measure of the acidity or basicity (alkalinity) of a soil.

Soil Profile: The sequence of natural layers, or horizons, in a soil. It extends from the surface downward to unconsolidated material. Most soils have three major horizons, called the surface horizon, the subsoil, and the substratum.

Soil Quality: The capacity of a specific kind of soil to function, within natural or managed ecosystem boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and support human health and habitation.

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.

Soil Texture: The relative proportions of sand, silt, and clay particles that make up a soil. Sand particles are the largest and clay particles the smallest. Learn more about soil texture at www.soils4teachers.org/physical-properties The basic textural classes, in order of increasing proportion of fine particles, are *sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay,* and *clay.* The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse, fine," or "very fine" for the sand size.

Topsoil: The upper part of the soil, which is the most favorable material for plant growth. Topsoil is ordinarily rich in organic matter and is used to topdress road banks, lawns, and land affected by mining.

Weathering: All physical disintegration, chemical decomposition, and biologically induced changes in rocks or other deposits at or near the earth's surface by atmospheric or biologic agents or circulating surface waters with essentially no transport of the altered material. These changes result in disintegration and decomposition of the material.

Additional Information

Persons interested in learning more about soils and/or the specific soils of a county or area in South Dakota should contact the United States Department of Agriculture (Natural Resources Conservation Service), South Dakota State University (Agricultural Experiment Station or the Cooperative Extension Service), or the South Dakota Department of Agriculture.

All counties in South Dakota have published, modern detailed soil survey reports. These soil survey reports are available at the local (county) USDA-Natural Resources Conservation Service or the SDSU Cooperative Extension Service offices. Real time soil survey information for South Dakota can be accessed online through the Web Soil Survey at https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm

Additional Resources

Soil! Get the Inside Scoop. David Lindbo and others. Soil Science Society of America, Madison, WI.

Know Soil, Know Life. David L. Lindbo, Deb A. Kozlowski, and Clay Robinson, editors. Soil Science Society of America, Madison, WI.

Web Resources

Soils for Teachers—www.soils4teachers.org

Soils for Kids—http://www.soils4kids.org/

Have Questions? Ask a Soil Scientist—https://www.soils.org/ask

Soil Science Society of America—https://www.soils.org/

Smithsonian Soils Exhibit—http://forces.si.edu/soils/

National Association of Conservation Districts—www.nacdnet.org/education

USDA-NRCS Educational Resources—http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/edu/

USDA-NRCS Soils—http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/soils/

USDA-NRCS South Dakota Homepage—http://www.nrcs.usda.gov/wps/portal/nrcs/site/sd/home/

Professional Soil Scientists Association of SD—http://www.pssasd.org/

Soilweb (iPhone, Android, Google Maps, Google Earth)—http://casoilresource.lawr.ucdavis.edu/soilweb/

South Dakota Agricultural Experiment Station, South Dakota State University—http://www.sdstate.edu/aes/index.cfm

South Dakota Association of Conservation Districts—http://www.sdconservation.org/

South Dakota Chapter of the Soil and Water Conservation Society—http://www.sdswcs.org/

South Dakota Department of Agriculture— https://sdda.sd.gov/

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www.epa.gov/eco-research/ecoregions.

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