SOILS OF SOUTH DAKOTA

Introduction

Soils in South Dakota may be thick or thin, stony or not stony, *saline* or non-*saline*, sandy, *clayey*, or of medium texture, sloping, flat, or in *basins*, and may occur where climates are moist or dry and warm or cool. The unique combinations of soil forming factors in South Dakota give rise to more than 550 different soils. These soils have characteristics that influence their suitability for various uses. It is important to understand how soils form and develop, because many of the characteristics that are critical for land use decisions are determined by soil formation. When a state depends heavily upon agriculture, soil management becomes especially important.

South Dakota is an agricultural state with an area of 77,047 square miles and a population density of 9 persons per square mile. In 1996, cash receipts, excluding government payments, from farming and ranching totaled more than $3.7 billion, with 50% from livestock and livestock product sales and 50% directly from crop sales (S.D. Ag. Stat. Serv., 1997).

In 1996, South Dakota ranked nationally in agricultural production as follows: 1st in oats and all hay; 2nd in rye, flaxseed, alfalfa hay, and sunflowers; 4th in hard red spring wheat; 5th in all wheat and durum wheat; 6th in corn; 7th in all other hay; 9th in soybeans; 10th in grain sorghum; 11th in barley; 17th in

potatoes; and 21st in cash receipts from crops. These crops and their products, along with forage, range, and pasture grown in the state, provide feed for large numbers of livestock. In 1996, South Dakota ranked nationally 3rd in honey and lamb crops; 5th in beef cows that calve and all sheep and lambs; 8th in all cattle and calves; 9th in red meat production; 11th in all pigs and hogs; 26th in milk production; and 17th in cash receipts from livestock (S.D. Ag. Stat. Serv., 1997). This production is possible because South Dakota has large areas of productive soils.

What Are The Major Soil Regions of South Dakota?

Except for the forested Black Hills and scattered areas of trees in *flood plains* and along streams, South Dakota was a vast sea of grass for thousands of years before its soils were cultivated. This grassland environment and its associated climate are the two factors that have most influenced the development of the state's soils.

Climate and vegetation have interacted in South Dakota to produce seven major soil regions (Figure 1). These regions are named: **Cool Moist Forest; Cool, Very Dry Plain; Warm, Very Dry Plain; Cool Dry Plain; Warm Dry Plain; Cool Moist Prairie; and Warm Moist Prairie.**

The Cool Moist Forest Region in the Black Hills is unique in South Dakota because the soils have developed under forested conditions in a cool, humid to subhumid climate. In the other regions, soils have developed under grass vegetation in climates ranging from moist subhumid to semiarid. In Figure 1, arrows indicate the general kind of soil *profile* that has developed on well-drained lands in each region.

In South Dakota, the lines of equal temperature and the lines of equal precipitation cross roughly at right angles (except for Black Hills). Relatively speaking, this makes the southeast warm and moist, the northeast cool and moist, the southwest warm and very dry, and the northwest cool and very dry.

How Do Soils Differ?

Amount of Aeration: Aeration is the exchange of air in the soil with air from the atmosphere. Well-drained (aerated) soils contain air that is similar in composition to that in the atmosphere. Air in poorly-drained soils that have poor aeration tends to have high levels of carbon dioxide and low levels of oxygen.

Amount of Organic Matter and Nitrogen: Native grassland vegetation, which was greatly influenced by climate, has determined the amounts of organic matter in the soils. In general, the more humid eastern portion of the state supported tall grasses that left large amounts of organic matter in the soils. Moving westward, the grass type changed to mid- and finally to short grasses in response to the drier climate. This change in vegetation is reflected in the lower amounts of organic matter in the soils developed under drier climates.

Temperature has also played a part in determining the organic matter content of the soils. In the cooler northern part of the state, more soil organic matter and total organic nitrogen are present than in the southern part under comparable precipitation. This difference is due to slower rates of decay under cooler temperatures.

Organic matter and total organic nitrogen content of most cultivated soils in the state today are substantially lower than when the original prairie sod was broken. These losses are generally about one-third of the original total throughout the state. Therefore, present contents of organic matter and total organic nitrogen in cultivated soils reflect the original amounts, but are one-third less.

Depth of Carbonate Leaching: One way in which the climate is reflected in the soils is in the depth of carbonate (lime) *leaching*. Figure 1 shows that the depth of *leaching* is greater in the humid east than in the drier west and greater in the warmer south than in the cooler north.

Productivity: Not all soils are equally well-suited for plant growth. A soil's ability to sustain plants is referred to as its productivity level. A productive soil is one with chemical, physical, and biological characteristics favorable for the sustainable and economic production of crops suitable for the climate.

Nitrogen Release: Research in South Dakota has shown that nitrogen release to plants is more a function of temperature than of precipitation. Thus the southern and western soils release nitrogen faster than the northern and eastern soils. In southeastern South Dakota, slightly over 2% of the total organic nitrogen usually is released annually to plants. In northeastern South Dakota, slightly less than 2% of the total organic nitrogen of the soils is released annually.

Permeability: Soils differ in their ability to transmit fluids. Soil *permeability* is measured by the number of inches per hour that water moves downward through a saturated sample of soil. Factors such as texture, structure, and amount of organic matter influence a soil's *permeability*. In sandy soils, for example, water flows quickly, while some clayey soils barely let water pass.

pH Level: The pH scale is a numerical measure of acidity or alkalinity ranging from 0 (very acid) to 14 (very alkaline). A soil that tests at a pH of 7 is considered neutral while one at pH 4.5 or lower would be very strongly acid. Soils with a pH of 9.1 or higher are very strongly alkaline.

Salinity: Soils differ in the amounts of soluble salts they contain. If a soil is so high in these salts that plant growth in the soil is impaired, the soil is referred to as *saline*. A *saline* soil has high *electrical conductivity*. A *saline* soil does not contain excess amounts of exchangeable sodium.

Sodium Content: Some salt-affected soils have levels of sodium that are so high that the soil's physical and chemical properties are changed and the soil's ability to support plant growth is adversely affected. Such soils are called *sodic*.

Soil Colors: Soil color correlates well with total amounts of organic matter and organic nitrogen present. Differences are apparent in the surface soil color in the various areas of the state. It is possible to determine soil colors scientifically by comparing them with specially prepared color charts.

The darkest soils are found in northeastern South Dakota, where the climate is cool and moist. These soils have the highest organic matter and total organic nitrogen supplies in the state. The soils of southwestern South Dakota have the lightest color, are browner, and have the least organic matter and total organic nitrogen. The climate there is warm and very dry.

Soil Texture and Particle Size: Soils also differ in their texture, which is the result of the relative amounts of sand, *silt*, and *clay* they contain. *Clay* soils have very fine particles, can have a powdery texture when dry, and be very sticky or slippery when wet. Silty soils feel smooth and silky, like wet talcum powder or flour. Sandy soils have larger, granular particles, are gritty in texture, and are not slippery when wet. *Loam* has a medium texture, the highest *plant-available water holding capacity*, and is usually quite productive. It is about equally influenced by sand, *silt* and *clay*, and also contains a good amount of organic matter.

Soil Layers: Anyone who has looked closely at a recently dug hole or at a roadside cut has noticed that soils contain layers that differ in their appearance. These layers, or *horizons*, occur in a vertical sequence through the soil. The type and depth of these *horizons* create the *soil profile*. In most *soil profiles*, the *horizons* are separated by transitional zones, although some of the profiles have sharply defined boundaries between *horizons*.

Soils vary in the types and number of *horizons* present. Very young soils may have only one or two soil *horizons*. These young soils often have distinct layers in their *profile* due to deposition or geologic events that are not the result of soil formation. As soils develop, the *horizons* become more easily identified until soils become so old that *horizons* begin to fade. The soils in South Dakota are relatively young, and thus, *horizon* development is minimal to moderate.

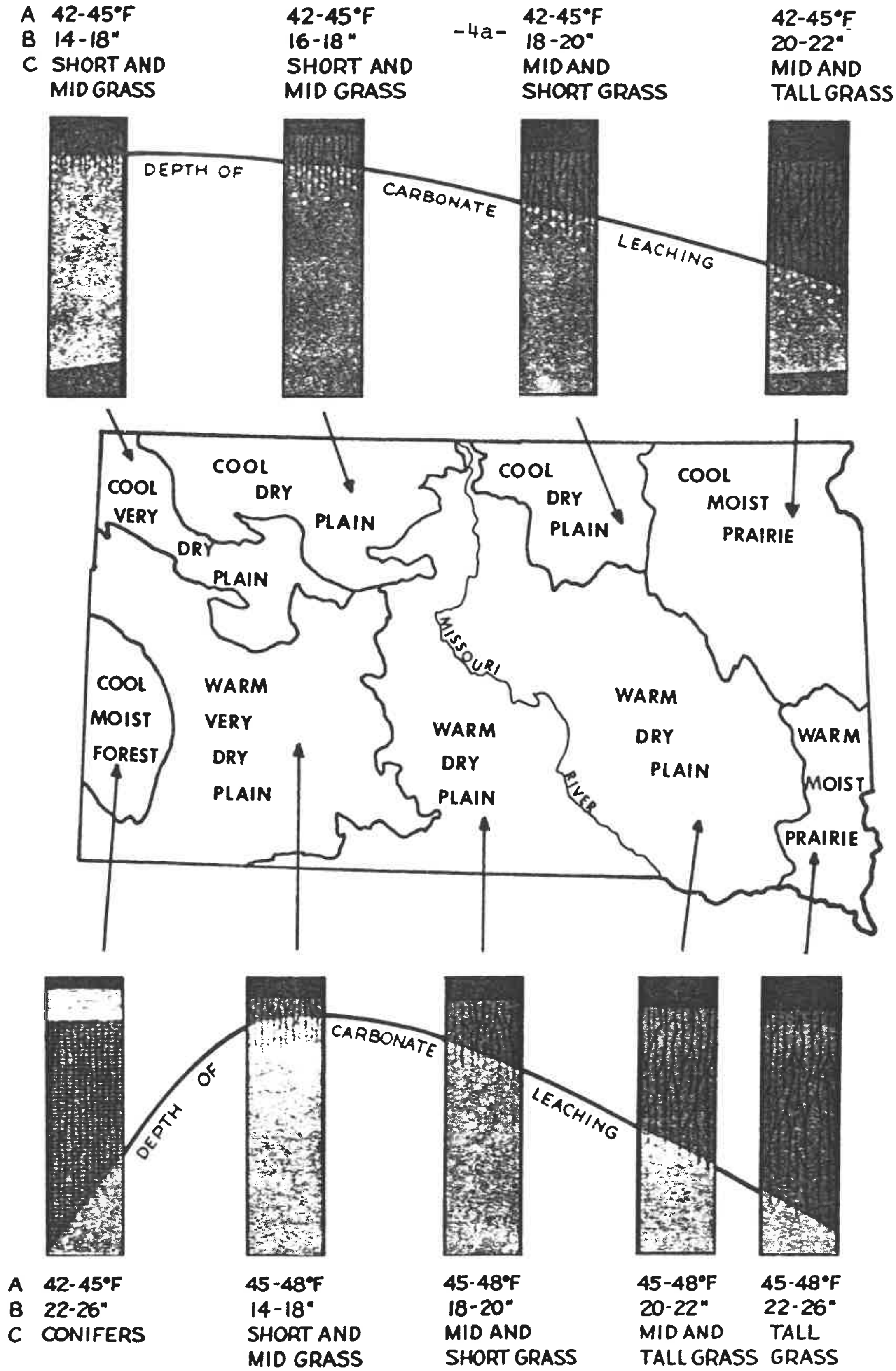

Figure 1. Relationship Among Climate, Vegetation and Soils in South Dakota.
A= Annual Temperature; B = Annual Precipitation; C = Native Vegetation

What Factors Affect Soil Formation?

The kind of soil that develops in any area is the result of the interaction of the five soil forming factors: **climate; plants and soil organisms in the area; parent material; topography**, and **time**.

Climate controls the distribution of plants. Together, climate, plants and soil organisms are called the "active factors" of soil formation. This is because on gently undulating topography, within a certain climatic and vegetative zone, a typical soil will develop, unless *parent material* differences are very great. Thus, the tall and mid-grass prairie soils have developed across a variety of *parent materials*. *Parent material* exerts its influence on soils principally by determining soil texture and mineral composition. Topography determines what drainage a soil will have. Steep slopes have excessively drained, thin soils; flat or depressed topographic areas usually have poorly drained, thick soils. The factor of time can be illustrated by comparing a soil on a *flood plain* that receives annual deposits of *alluvium* with a soil on a stable upland ridge. The *flood plain* soil is without developed *horizons*, although it may have layers of contrasting *alluvium*, while the soil on the stable upland ridge usually has a well-developed soil *profile*.

Climate: South Dakota, because of its inland position, has a continental climate with extremes of summer heat, winter cold, and rapid fluctuations of temperature. Temperatures during the winter months often drop to -20° F (-29° C) or lower, while in the summer readings of 100° F (38° C) or more are common in the state. The average annual temperature is 46° F (8° C) and ranges from 48° F (9° C) in the south to less than 44° F (7° C) in the north.

Annual precipitation ranges from 25 inches (64 cm) in the southeast to less than 14 inches (36 cm) in the northwest. Most precipitation occurs in spring and early summer. Seasonal snowfall averages about 30 to 50 inches (76-127 cm) in the lower elevations of the state to over 100 inches (255 cm) in the Black Hills.

The average depth of frost penetration ranges from 25 inches (64 cm) in southwestern South Dakota to 50 inches (127 cm) in the northeast. Depth of frost depends on the amount of residue cover, soil moisture content, and the amount and timing of snowfalls in relation to temperature extremes. For the area excluding the Black Hills, the average last spring frost ranges from May 5 in the southeast to May 20 in the northwest. Average first fall frosts range from September 15 in the northwest to October 5 in the southeast. Average length of time without killing frost varies from 120 days along the northern part of the state to 160 days in the southeast. The Black Hills area generally has shorter growing seasons than the rest of the state, with average of frost-free days ranging from 110 to 130 days.

During cold seasons winds are from the northwest, while during warm seasons they are from the southeast. Annual average surface wind velocity for the state is 10 to 12 miles (16-19 km) per hour.

Native Vegetation: Except for the Black Hills, which were timbered, and the river valleys where trees grew, the native vegetation of South Dakota was originally grassland. Starting with the eastern border of the state and extending to the eastern edge of the James River Valley, the principal vegetative was tall grass. Big bluestem, sand dropseed, and switchgrass were present along with *forbs*. Moving westward across the James River Valley, the tall grasses gradually become less common, being found only on sandy soils and on cool northern exposures. The medium and short grasses assumed dominance. Important species of the midland area were needleandthread, green needlegrass, western wheatgrass, slender wheatgrass, blue grama, prairie junegrass, and buffalo grass. In western South Dakota, shorter grasses dominated because of decreased rainfall. Important shortgrass species were blue grama, western wheatgrass, needleandthread, prairie junegrass, and little bluestem. Variations in plant associations occurred west of the Missouri River as a result of differences in soil texture. For example, on the Pierre Plain, an area of *clayey* soils, the principal grasses were western wheatgrass, blue grama grass, and buffalograss. In the Sand Hills of southwestern South Dakota, little bluestem, prairie sandreed, and needleandthread were dominant.

Parent material: South Dakota soils have developed from a wide variety of materials (see Figure 2). They include ancient crystalline and *metamorphic* rocks in the Black Hills, *sedimentary* rocks including *shale*, *sandstone*, and *limestone* in western South Dakota, and glacial materials of several ages in the east. Additional *parent materials* include *loess*, *alluvium*, and *colluvial* materials formed from upland deposits.

Crystalline rocks, in the central core of the Black Hills, were formed by cooling of molten magma deep beneath the earth's crust. Over time, these rocks have been thrust upward and exposed by *erosion*. Granite is the dominant crystalline rock type and the resulting soils tend to be gravelly with *loamy* to sandy surface textures. Mocmont is a soil *series* developed from *weathered* granite. Along the edges of the crystalline rocks, *metamorphic* rocks are found, the most common types being schists and slate. The resulting soils tend to be *loamy* with a rock fragment content of at least 15% in surface *horizons*. The rock content increases as soil depth increases until *bedrock* is reached at 40 to 60 inches (102-152 cm). Buska, Pactola, and Virkula are soil *series* developed from *weathered metamorphic* rocks.

Sedimentary rocks were formed by consolidation of loose sediments or by precipitation of carbonates from solution. Much of this took place on the floors of ancient seas. The sands formed *sandstone*, the *silts* and *clays* formed *siltstone* and *shale*, and the basic carbonates formed limestone. Few of these rocks in South Dakota are pure--instead they are *calcareous sandstones*, *sandy limestones*, and so on. The principal *sedimentary* rock *parent materials* include: (1) Pierre *shale* of the central part of the west river area; (2) Upper *Cretaceous sandstones* and sandy shales of northwestern South Dakota; and (3) *Tertiary sandstones* and *siltstones* in the southwest.

The Pierre *shale* area is sometimes called the "gumbo region" because of the plastic *clay* that weathers and forms from the *shale*. Layers of the Pierre *shale* are soft and easily eroded. They generally are not *butte*-formers, rather they weather into soft rounded hills and ridges. Kyle, Lismas, Pierre, Sansarc, and Samsil are soil *series* developed from Pierre *shale*. Some *sedimentary* beds in the Pierre *shale* area (the Pierre, Niobrara, and Morrison formations) occasionally have high amounts of selenium, a chemical element of the sulfur group. These geologic formations are not uniform in their selenium content. High selenium levels in plants grown on these soils may cause harmful effects to livestock and humans.

Upper *Cretaceous sandstones* and sandy *shales* of northwestern South Dakota give rise to many soil textures. The *sandstones* weather to form sandy soils and the *shales*, which primarily contain mixtures *clay* and *silts* (plus small amounts of sand), are *parent materials* for sandy *loams*, *loams*, *clay loams*, silty *clay loams*, silty *clays*, and *clays*. The dominant textures are sandy *loams* and *loams*. Morton, Ralph, and Vebar are soil types in this area. There are significant areas of sodium-affected soils in this region. The Bullock, Daglum, Gerdrum, Hisle, Parchin, and Rhoades series are soils with a severe sodium problem.

Tertiary sandstones and *siltstones* of southwestern and south-central South Dakota form sandy and silty soils. The sandy materials (Valentine and Anselmo soil *series*) on the south are an extension of the Nebraska Sand Hills. Going north the materials progressively have higher *silt* content (Keith, Canyon, and Rosebud soil *series*) and *clay* content (Pierre and Samsil soil *series*). Some of the strata in this area, and also some of those of the Upper *Cretaceous* area in northwestern South Dakota, form benches, plateaus, and *buttes*, because they are more resistant to *erosion* than associated materials.

Pleistocene-age glaciers entered South Dakota from the northeast or north, and flowed south and west, the western margin of glaciation being the Missouri River. As the ice moved over the land, it filled valleys, planed off hills, cut new valleys, piled up ridges, and otherwise changed the topography. The character of the rocks of the pre-glacial surface helped determined the composition of the glacial deposits formed from them. This is because most glacial deposits consist of altered rocks of local origin. Glacial deposits primarily cover the state east of the Missouri River. They are divided into four groups: *till*, *outwash*, glacial lake deposits, and ice contact *stratified* drift.

Till, which is the most abundant, is a mixture of all sized particles, boulders to *clay*. It is thought to have been deposited from under part of the flowing ice. Barnes, Clarno, Ethan, Forman, Houdek, and Poinsett are soil *series* developed from *till*. **Houdek is the state soil for South Dakota.**

Outwash, mostly gravel and sand, was deposited by glacial melt water as it flowed away from the ice. Ordinarily the *outwash* material is covered by *alluvium*, as is the case in Delmont, Enet, and Fordville soils; or *loess*, as is the case of Brandt and Estelline soils.

Glacial lake deposits, called lacustrine materials, consist of parallel-bedded *silt* and *clay* with a small amount of sand sometimes mixed in. They formed in depressions temporarily blocked by *glaciers* and filled with water. The Aberdeen, Beotia, Harmony, and Sinai, are soil *series* developed in these deposits.

Ice contact *stratified* drift accumulated on or against melting *glacier* ice. It occurs as knobs or small hills, usually in rough terrain. The Sioux *series* is an example.

Loess is a non-glacial deposit of wind blown particles of *silt* size. The *loess* in South Dakota came from mixing of *silt* from non-glacial deposits to the west with *silt* blown out from *glacial outwash*. *Loess* deposits are found throughout the state and range from thin layers of less than 12 inches (30 cm) to deposits 30 feet (9 m) or more in thickness. Colby, Keith, Moody, Nora, and Trent are soil *series* developed in these deposits. Strictly speaking, *loess* refers to particles of *silt* size. Sandy and silty *clay* materials, also carried and deposited by the wind are called *eolian* sand and *eolian clay*. They also are important South Dakota soil *parent materials*. Distribution of these wind-deposited sediments is shown in Figure 2.

Alluvial soils form when gravel, sand, *silt*, and/or *clay*, settle out of flowing water. These materials are almost always mixed. Generally, the *alluvium* of west river is *clayey* in texture, while that in the east is mostly *loamy*. Bon, Clamo, Glenberg, Haverson, Havre, LaDelle, Lamo, Lamoure, Lohmiller, Ludden, and Swanboy are soil *series* developed from *alluvium*.

Local alluvium is a water-laid deposit along upland depressions. It is usually sorted and is finer textured than surrounding soils. The texture however, can vary from sand to *clay*. Arnegard, Bonilla, Brookings, Hoven, Kolls, Onita, Parnell, Parshall, Shambo, Tonka, Trent, and Worthing are soil *series* developed in local *alluvium*.

Colluvium is a deposit of rock fragments and unconsolidated earth materials accumulated at the base of slopes as a result of gravity and runoff. It is usually unsorted because gravity can move all sizes. The soils can have textures ranging from sands to extremely bouldery *clay*. Arvada, Davis, Hilger, Rockoa, Sawdust, Slimbutte, and Vanocker are soil *series* developed in colluvial materials.

How Do Soils Form?

Soils develop gradually through a series of changes, beginning with the accumulation of *parent material*, such as rock, *glacial till*, *loess*, or *alluvium*. Weathering processes release simple compounds that serve as food for bacteria, fungi, and other soil organisms. These simple forms of life live and die by the billions. Their bodies decay in the *parent materials* and thus organic matter (humus) begins accumulating. Gradually the developing soil is able to support higher forms of plant and animal life. The present level of humus in our soils is due principally to the activity of higher forms of plant life. As plants grow, upper layers of the loose *parent material* at the surface accumulate humus, *pH* is reduced, and *leaching* takes place. These changes form distinctive soil layers called *horizons*.

The amount of *horizon* development that occurs in a soil is determined by the soil forming factors of time, *parent material*, topography, climate and organisms (Malo, 1996). Climate and organisms (particularly vegetation) cause regional soil differences, as between eastern and western South Dakota. Topography, *parent material*, and age (time soil has been developing) cause local or county differences in soils.

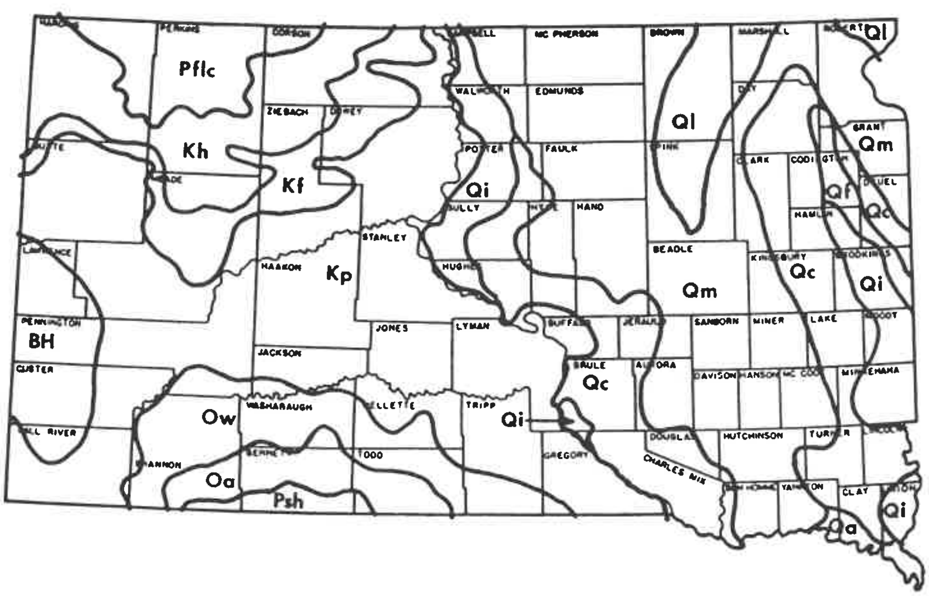

Figure 5. Soil parent materials in South Dakota.

West River
Psh—Sand Hills
Oa—Oligocene-Arickaree—sandstone and siltstone
Ow—White River beds—silts and clays
Pflc—Cannonball, Ludlow, Fort Union, undifferentiated
Kh—Hell Creek—sandy shales
Kf—Fox Hills sandstone
Kp—Pierre shale
BH—Black Hills—undifferentiated crystalline, metamorphic and sedimentary materials

East River
Qa—Alluvium
Ql—Glacial Lake Basin—silts, clays, sands
Qm—Late Wisconsin glacial drift—loam till
Qc—Late Wisconsin glacial drift—loam till, patchy silts (Stagnant ice moraine)
Qt—Early Wisconsin glacial drift—loam till, thin loess
Qi—Early Wisconsin glacial drift—usually thick loess

Figure 2. Soil Parent Materials in South Dakota. From Westin and Malo, 1978.

There are four types of processes involved in *horizon* development. Additions to the soil come from precipitation, organic matter, and solar energy. Losses are processes that often are destructive, such as *erosion*, *leaching* of nutrients, night radiation of energy, nitrogen losses by microbial activity, and water loss through plant *transpiration*. Movement of materials within the soil occur through nutrient cycling by plants and soil mixing by organisms. Lastly, new compounds are formed within soil from *weathered* rocks and minerals.

What Soil Horizons Are Found In South Dakota?

Soil *horizons*, which can be seen on the walls of a fresh road cut, consist of a succession of layers in vertical section down through the soil. *Horizons* in soils are identified by standard symbols (i.e. A, B, k, w, t, and many others). Each symbol shows how the material has been altered, when compared to the original *parent material*. There are three types of symbols used to name soil *horizons*; capital letters, lower case letters, and Arabic numbers. The capital letters are used to describe major layers. Most major soil *horizons* have only one capital letter (i.e. A, B, C, E, O, and R), but some require two (i.e. AB, EB, AC, BC, E/B, and others) if the layer is mixed or composed of two major *horizons*, or is a transitional layer.

An O *horizon* is a layer dominated by organic materials (i.e. leaves, needles, twigs, moss, and other un-decomposed or partially decomposed plant litter). O *horizons* are common in forest-derived and saturated wetland soils. Sometimes O *horizons* are called the "*topsoil* or surface soil" and in some profiles O *horizons* may be found buried under other major layers. Organic matter content in O *horizons* commonly exceeds 35%.

An A *horizon* is a mineral layer that is high in humus (1-10%), or shows the influence of cultivation, grazing, or similar agricultural disturbance. Most of the soils in South Dakota have an A *horizon* that was formed by humus accumulating in the surface soil materials. Usually, the A *horizon* is called "*topsoil*." A *horizons* are usually found at the soil surface, but can be found below an O *horizon*.

A B *horizon* is a mineral layer that forms beneath an A, E, or O *horizon*. In South Dakota, the B *horizon* has one or more of the following: 1) accumulation of *clay*, humus, carbonates, sodium, gypsum, iron/aluminum oxides, other salts; 2) removal of carbonates; 3) formation of soil *structure*; or 4) color change. All B *horizons* represent changes in the *parent material* as a result of soil formation. B *horizons* are sometimes referred to as the "*subsoil*."

A C horizon is usually found beneath O, A, B, or E *horizons*. C *horizons* are soil layers that are little changed. If the *parent material* is just forming (i.e. volcanic area, sand *dunes*), there maybe a C *horizon* at the soil surface. Occasionally, the C *horizon* can have accumulations of various types of salt. Some C *horizons* are composed of soft *bedrock* , such as *shale*, *siltstone*, *weathered sandstone*. The C *horizon* is often called "*parent material*."

The E *horizon* represents a layer where there has been significant loss of *clay*, humus, and iron/aluminum oxides, resulting in a layer that is lighter in color and coarser textured than the layers above or below. E *horizons* occur above B *horizons* and are found at or near the soil surface. They may or may not be beneath O or A *horizons*. E *horizons* are most commonly found in forest-derived, sodium-affected, or depression soils.

The R *horizon* is hard *bedrock*. It is harder than a spade. Examples of hard *bedrock* in South Dakota include granite, *limestone*, and *sandstone*. This *horizon* does not exhibit evidence of soil formation or *weathering*.

Lower case letters are used as suffixes to the major *horizons*. These letters further define the properties of the layer. The most common subhorizons used in South Dakota are: b (buried genetic *horizon*); g (*gleyed* colors, saturated soils); k (lime or carbonate accumulation - both calcium and magnesium); n (sodium affected); p (cultivated or pastured); r (soft/ *weathered bedrock*); ss (high *clay* content soils that significantly shrink and swell); t (*clay* accumulation); w (development of only color and *structure*); y (gypsum accumulation); and z (other salt accumulation).

If a layer needs to be subdivided, then suffix Arabic numbers are used (i.e. Ap1, Ap2; Bt1, Bt2, Bt3; C1, C2). Arabic numbers are used only when the capital and lower case letters are the same.

The principal *horizons* names used in South Dakota for prairie soils are: Ap(if cultivated) or A, AB, Bt or Bw, Bk, and C. The principal *horizons* for forested soils are: O, A, E, Bt, C or R. Sodium affected soils usually have A or Ap (if cultivated), E, Btn, Bkyz, and C *horizons* present. Depressional soils have A1, A2, E, Bt1, Bt2, and C *horizons* present. Many of the young erosional, dunes, or *flood plain* soils have A, AC, C1, and C2 *horizons*. Usually, all the *horizons* and the upper part of the *parent material* occur with a depth of five feet (1.5 m).

All of the *horizons* and sub*horizons* listed above do not occur in every soil. Many soils may have *horizons* other than those discussed. Consult the Soil Survey Manual for a more complete discussion on soil *horizons* (Soil Survey Division Staff, 1993).

Conservation Measures

Protecting the quality of our soils is critical to the welfare of our people and our economy. There are four major concerns in soil conservation: loss of moisture; loss of organic matter and nitrogen; loss of mineral nutrients; and loss of *topsoil* through *erosion*.

Moisture loss occurs through evaporation, *transpiration*, *leaching*, and runoff. Evaporation and runoff are particularly serious when water does not quickly soak into the soil. Soil texture and structure determine how quickly water will be absorbed. Sandy soils will take up water much more quickly than will *clays*. These finer textured soils tend to cause puddling when rain drops splash on the bare soil if soil structure is poor and organic matter levels are low.

One way to increase water uptake and storage by soils is to increase the amount of organic matter in the soil. Organic matter acts like a sponge, thus reducing the puddling problem. Other solutions include leaving *stubble* in the fields, mulching, and increasing the surface roughness.

Moisture loss through weed *transpiration* can be significant. One crop of foxtail grass will remove about 2 *acre-inches* of moisture from soil. Weed reduction can be accomplished through planting weed-free seeds, applying herbicides, and using tillage and crop rotations.

Organic matter and nitrogen loss from soils can seriously reduce crop yields and make soils more susceptible to *erosion*. South Dakota soils have lost about one-third of their organic matter and organic nitrogen as a result of years of cropping. Some farmers and ranchers leave fields *fallow* for a season to renew the soil's productivity. Nitrogen can be returned to the soil through application of natural waste products, commercial organic and inorganic fertilizers, or through the planting of nitrogen-fixing plants, such as alfalfa or clover. Alfalfa and other *legumes* have nodules on their roots that contain bacteria that can transform atmospheric nitrogen to a form usable by legume plants. Building up the organic matter content in the soil is difficult with conventional tillage.

Mineral nutrient losses due to erosion varies from one nutrient to another. Nutrients such as potassium, calcium, and magnesium are usually present in adequate amounts in South Dakota soils. Phosphorus content, however, is low in most soils of the state, and is highest in topsoil, which is lost in erosion. Generally, in soils with high calcium content, phosphorus availability is low because it combines with the calcium to form an insoluble substance. Phosphorus can be returned to the soil by adding waste products and commercial fertilizers.

Soil loss from erosion can be caused by the action of wind and/or water. Soil texture, soil structure, slope of the land, and the amount of plant cover affect the amount of soil *erosion* that can occur.

Wind *erosion* is caused by a problem called "saltation." Erosion is most prevalent in soils with sand-sized grains. These sand-sized grains are blown several feet into the air by the wind and then are driven at high speeds into the ground. The impact sprays more soil, often very fine particles, into the air. These fine soil particles are carried away by the wind. Soil blowing can be reduced through *conservation tillage* that keeps a growing crop or crop residues on the land throughout the year. *No-till* is a *conservation tillage* strategy in which the soil is disturbed only in the immediate area of the planted seed row. If soil blowing begins when the land is bare, it can be reduced by roughing up the soil surface or by tilling ridges perpendicular to the direction of the wind.

One way to reduce wind *erosion* of soil is to plant shelterbelts. These plantings of trees and shrubs to break up large, open tracts of land were first undertaken in the 1930's, in response to the severe drought and soil blowing problems at that time. Shelterbelts also provide valuable wildlife habitat where animals can be sheltered from predators and the harsh climate. Modern shelterbelts are narrower than those planted in the 1930's. The Natural Resources Conservation Service (NRCS - formerly the Soil Conservation Service), the Cooperative Extension Services (CES), and the Agricultural Experiment Station at SDSU will advise land owners on the size and species composition of effective shelterbelts. Maintenance of established shelterbelts is an important task for continued protection of the state's soils.

Water erosion from runoff can be reduced through residue management, *terracing*, *contour* tillage and *contour strip cropping*, all of which lessen the impact of land slope. The key step in water erosion control is stopping the raindrop from directly striking the soil surface. Water erosion on sloping lands is a serious problem in eastern South Dakota. Crop rotation with *legumes* will increase the organic matter in the soil, and make it less prone to erosion.

The NRCS (federal agency) and the CES (county agency), and the Agricultural Experiment Station at SDSU (state agency) work with South Dakotans to implement good soil conservation measures appropriate to the soil type at each location. Addresses and phone numbers for these offices in South Dakota are included in the government pages of your phone book.

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Publication of the *Soils of South Dakota* fact sheet was funded by the Northern State University CUEST Center for Environmental Education, Aberdeen, SD.