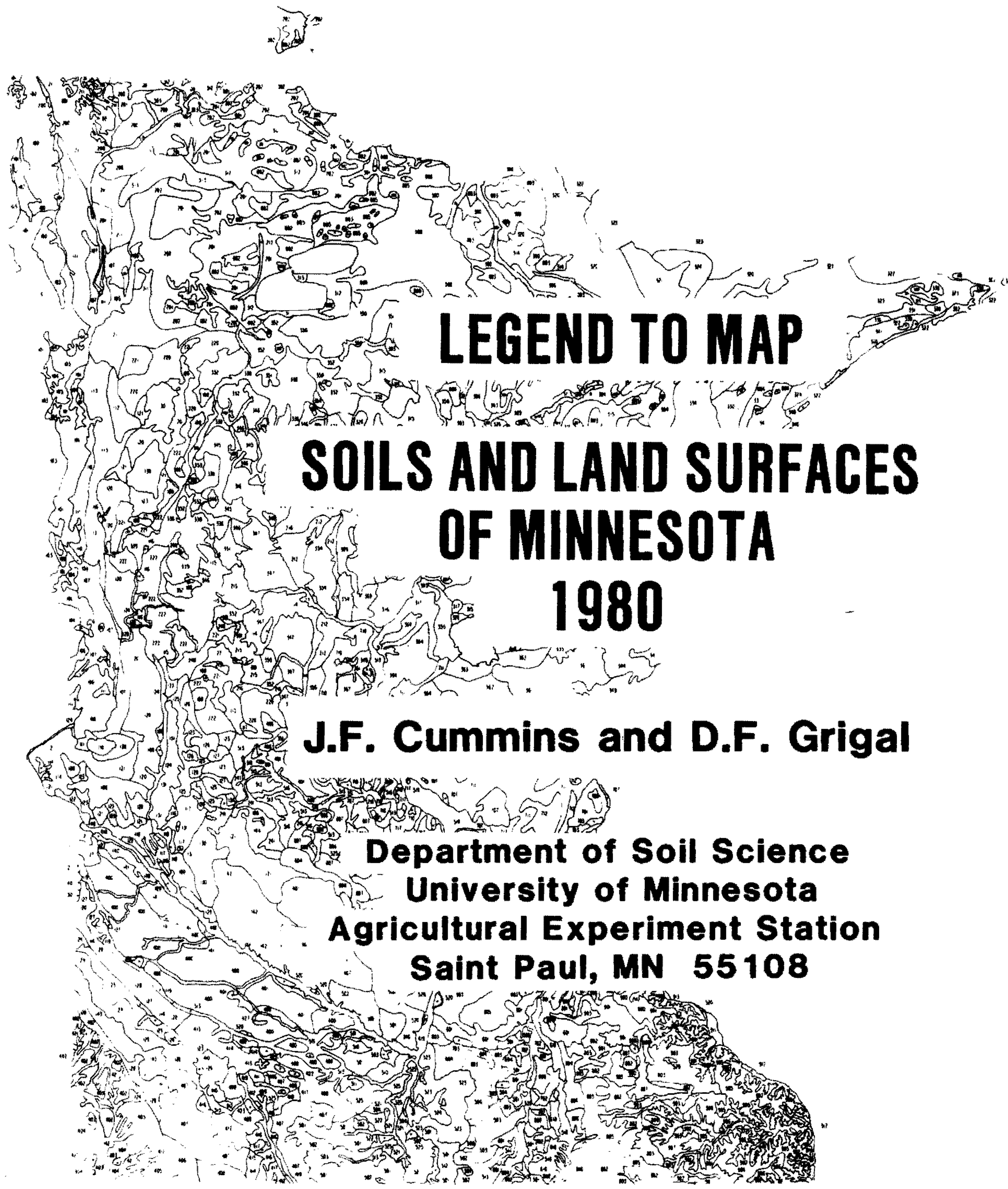

LEGEND TO MAP

SOILS AND LAND SURFACES OF MINNESOTA 1980

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INTRODUCTION

Soils lay in a complex mosaic across Minnesota. This mosaic is not random, but is the result of the blending of the effects of five major environmental elements. The five elements that lead to the pattern of soils that we observe are the geologic material from which the soil originally formed (the parent material); the climate in the area in which the material is found; properties of the landscape upon which that material lay, such as its slope and aspect (relief); the plants and animals (organisms) that can potentially live on or in the material; and the length of time during which the previous four elements have interacted.

A unique combination of the five elements will produce a soil. At any location in the state, that combination of elements may be unique, and produce a unique soil; or a given combination may recur at many locations, producing similar soils at those locations. The relative uniqueness partly depends on the scale or broadness of our vision. For example, viewed from a global perspective, Minnesota is considered to have a temperate climate. Yet Minnesotans know that International Falls is colder in winter than is most of the remainder of the state, and that the Red River Valley is drier in summer than is most of the remainder of the state. Thus a uniform climate at one scale (global) becomes heterogenous at another scale (statewide). The same consideration of scale comes to the fore when we consider any of the five elements that help form the soil mosaic.

The attached legend and map consider the state from a certain perspective or scale, and the result is as shown. It would be equally valid to consider the state from some other perspective, yielding a mosaic with a different order of complexity.

In addition to a description of each unit on the map, this legend also includes a discussion of soils and their properties, how the five elements shape the soil mosaic, and the system that is currently used to classify soils in Minnesota and in the remainder of the United States.

SOIL PROPERTIES

First, we need a better definition of soil. Soils cover a large proportion of the surface of the Earth. They differ from rocks in that they are composed of layers, called horizons, which are roughly parallel to the land surface on which the soils have formed. Horizons differ from each other and from the underlying rocks as a result of the alteration and/or movement of material from one horizon to another.

All soils consist of solid materials, both organic and mineral, and pores. The organic portion of the soil includes living plants and animals and their remains in various stages of decay. The soil mineral matter consists of particles of various sizes that have formed through the physical and chemical breakdown of rocks and minerals. Soil pores occur between individual soil particles or between and within their aggregates. The soil pores contain the gas (air) and liquid (water) phases of the soil. The three phases—solid, liquid, and gas—are present in all soils. However, the amount, kind, and size of organic matter, mineral particles, and pore space for air and water are not uniform in all soils or even within a soil.

Each soil layer, or horizon, has individual characteristics resulting from the influence of living organisms, climatic factors, and the mineral matter from which the horizon has developed. The horizons of a soil occur in sequence from the surface, and may extend down to a depth of several feet. Each horizon differs from those above or below it in one or more properties. Examples of these properties are thickness, color, texture (relative proportion of different sizes of mineral particles), structure (arrangement of mineral particles into aggregates or *peds*) and consistence (the mutual attraction of soil particles which is expressed as resistance to change in shape by crushing).

Most Minnesota soils have three major horizons. These are designated with the letters A, B, and C, from the surface downward. The major horizons may be further subdivided, designated with the major horizon letter plus an arabic numeral—for example, A1, A2, A3, B1, B2 and B3.

The A horizon is commonly referred to as the *surface soil or topsoil.* If a soil occurs under prairie vegetation, this horizon is dark-colored from the organic matter added to it by prairie plants and animals. If under forest, this horizon is often very light in color. Water moving through it, into deeper soil horizons, has carried away material such as reddish-colored iron oxides and/or clay.

The B horizon is commonly called the *subsoil.* It is usually found 9 to 20 inches below the surface and is commonly 15 to 30 inches thick, although the range is 0 to 36 inches or more. The materials removed from the A horizons in solution and suspension may accumulate in the B horizon.

The C horizon is a soil layer that either may consist of material from which the A and B horizons developed, or it may be of different material. This second case occurs in soil profiles containing two or more geologic materials that are layered. Biological activity—plant and animal life—is low in the C, and the materials in the C horizon have changed less through weathering than have those in the A and B horizons. The C horizon is often lighter in color than is the A or B horizon.

One of the most important soil properties, and one which affects many other properties, is the soil texture, or size distribution of soil particles. Soils usually have particles of three general sizes: sand, silt and clay. Sand particles can be easily seen and feel gritty. Silt particles can be seen with a magnifying lens or under a microscope. When dry they feel like flour, and when wet they have a smooth, floury feel with little evidence of stickiness. Clay particles are very fine and can be observed only with an electron microscope. Clay is sticky and plastic when wet and can be molded; it will dry into a hard mass. Few soils contain only one particle size. Nearly all soils have a certain proportion of sand, silt and clay.

Texture is a permanent soil property that greatly influences productivity. Soils with a high proportion of coarse particles (sandy soils) commonly have rather low productivity. Likewise, soils with a high proportion of fine particles (high clay soils) are often inherently low in productivity. Sandy soils do not hold enough water for good plant growth and they are poor storehouses for plant nutrients. They must receive frequent additions of water and nutrients to be productive. The main problem with soils high in clay is the large number of very small pores that occur within them, creating slow permeability and poor internal drainage. This means that high clay soils will often be so wet that root development is hindered. Removing excess water by tiling or some other method of draining often increases their productivity.

The most productive soils are usually medium to moderately fine in texture. Examples are loams, silt loams and silty clay loams. Such soils are good storehouses for plant nutrients and are capable of storing a high proportion of water available to plants. Conditions are generally very favorable for root growth.

SOIL FORMATION

We can now discuss the five elements, or soil-forming factors, and how they influence the soils that we find in Minnesota.

Parent Material

The landscape of Minnesota was shaped by the Ice Age, when a series of glaciers spread over most of the state, molding the land. The debris remaining after the glaciers melted provided the material from which most Minnesota soils have formed. There are various kinds of debris, depending on the kind of glacier-associated activity.

Glacial drift is a general term for rock material transported by glacial ice, whether deposited by the ice itself or deposited by meltwaters flowing from the ice. *Glacial till* more specifically is the unsorted mixture of clay, silt, sand, gravel and boulders which was deposited by the ice sheet. It was usually deposited in *moraines*, whose topography may range from level plains to rather high hills.

In some cases, especially at the terminus of a glacial advance, the debris buried and insulated large remnants of glacial ice. This ice melted very slowly, and as it did the surface of the debris continually shifted. Basins were raised and hills lowered as the underlying ice melted. The result is a very irregular topographic feature called a *dead-ice moraine.*

Glacial outwash resulted when, as the ice melted during warm seasons, melt water flowed from the margins of the ice sheet and was redeposited as a partly sorted mixture of gravel, sand, and silt. Stratification of these materials into layers is common, although one material usually predominates. Glacial outwash often occurs in old melt-water channels, many of which are now streams. If outwash was deposited in direct contact with glacial ice, most of the fine material was washed out of the deposit. In addition, as the ice melted, *ice-contact slopes* formed where the ice had once been.

Waters flowing from a melting glacier were often blocked by ice or glacial debris to form lakes and ponds. These waters were laden with fine-grained material which settled out as the flow ceased, forming *lacustrine deposits.* Most of these deposits are silts or clays, but sand commonly occur on the margin of former lake basins.

Loess is a wind-deposited material consisting almost entirely of silt, but perhaps including small amounts of very fine sand or clay. Loess deposits originated from materials carried away from the melting ice sheet during warm seasons. During cool seasons, melting and therefore water flow ceased and the materials were deposited in broad, flat areas such as bottomlands. After drying, they were picked up by wind and redeposited many miles from the source.

There are also minor amounts of other kinds of parent material in the state. *Alluvium* is material which was deposited by water in floodplains along streams, usually after the glacial period. Alluvium-derived soils are frequently stratified with layers of gravel, sand, silt, and clay. *Colluvium* is material deposited at the bottom of slopes by gravity, soil creep, or local wash. Silty and loamy colluvial materials are most common, although rock fragments are common below slopes with rock outcrops. *Residuum* is the residue from the weathering in place of sedimentary rocks such as limestone, sandstone, and shale. These residue may be subsequently moved by water or gravity.

The location and variety of these various types of deposits in the state depends on the glacial history, and on post-glacial events. For example, the mosaic of soils in Minnesota is complex because not one, but many glacial lobes flowed across the state. These lobes came from different source areas, and they brought with them materials of different physical and chemical properties. The Wadena Lobe came from the northwest corner of the state, bringing a gray sandy loam till with lime; the Rainy Lobe came from the northeast, bringing a brown till with even more sand and rock fragments and no lime; the Superior Lobe flowed out of the Lake Superior basin, bringing a red, sandy loam, lime-free till; and the Des Moines Lobe came from the west northwest, and with its two sub-lobes, the St. Louis and Grantsburg Sublobes, carried gray lime-rich loam till. To complicate matters even further, lobes were often overridden by one another so that mixing of tills occurred. Lobes also passed over former glacial lakes, incorporating those clayey sediments into their till. Outwash material often flowed from more than one lobe, and mixed sediments were deposited.

Details of the glacial history, and the resulting physiography of the state, are too complex to discuss here. However, each of the major physiographic areas of the state is dominated by one kind of material, such as the sandy till in the Toimi Drumlin Area, and the lacustrine silts and clays in the Glacial Lake Agassiz basin (Fig. 1). Greater detail may be found in the article in which Fig. 1 originally appeared (Wright, 1972a), and in an accompanying article (Wright, 1972b).

A variety of soils results from the variety of parent materials in Minnesota. For example, soils formed from lacustrine clays are different from those formed from outwash gravels, even if the other four soil-forming factors are similar.

Climate

Climate is a second important factor affecting soil formation. Temperature and moisture, both as averages and as extremes, affect chemical and physical changes that occur in the original parent material. Minnesota has a relatively wide climatic range for a non-mountainous state. The mean monthly temperature and normal precipitation for four stations located in roughly the four corners of the state indicate that wide range (Fig. 2). The mean annual temperature in the state ranges from about 35°F near the Canadian border to about 45°F at the Iowa

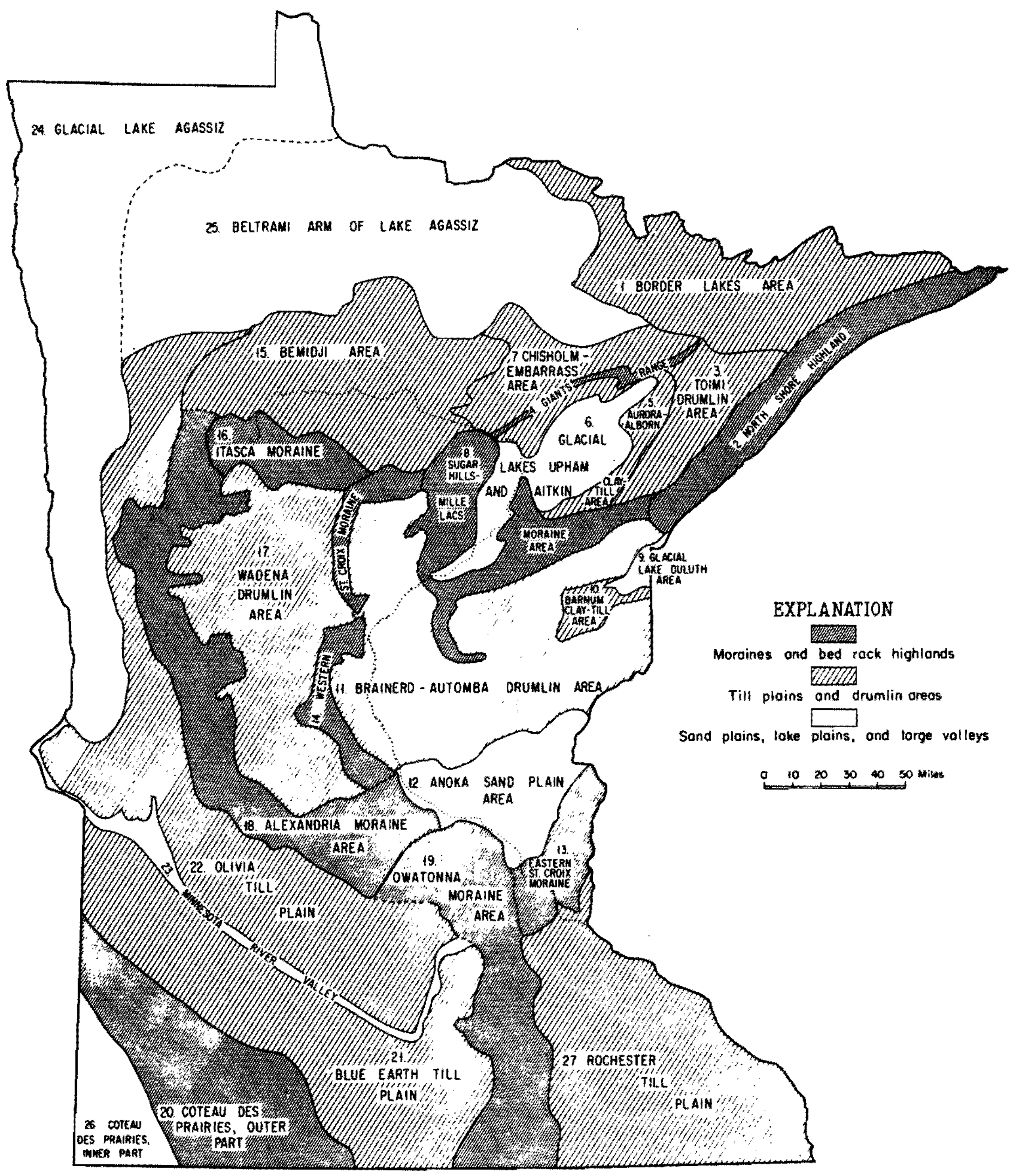

Fig. 1. Map of physiographic areas in Minnesota (Wright, 1972a).

border (Fig. 3). Temperature tends to increase relatively uniformly from north to south in the state (Fig. 3). Although the influence of Lake Superior may be expected to affect state temperatures, because of prevailing westerly winds and the steep upland along the North Shore, the lake's influence only extends a short distance inland (Fig. 3).

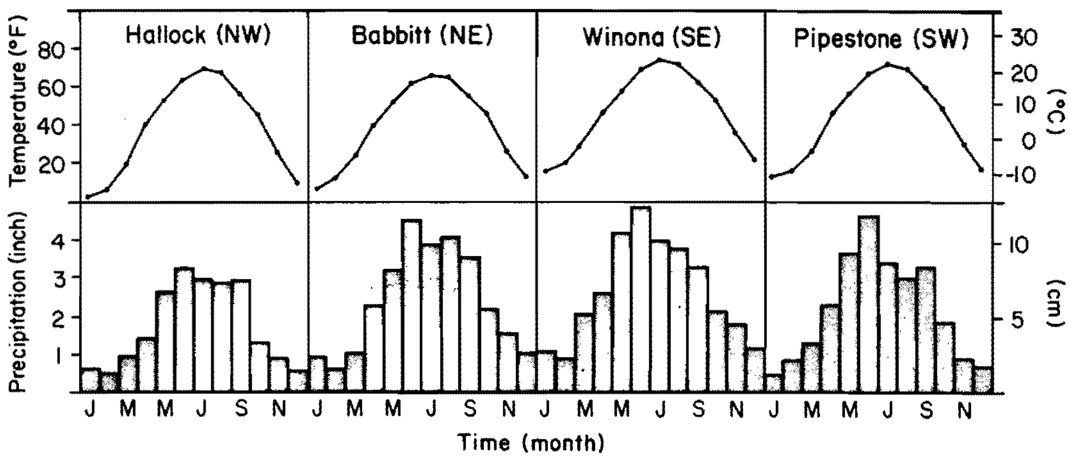

Fig. 2. Mean monthly temperature and normal precipitation, 1941-1970, for stations representing major areas of Minnesota (U.S. Dept. Commerce, 1973).

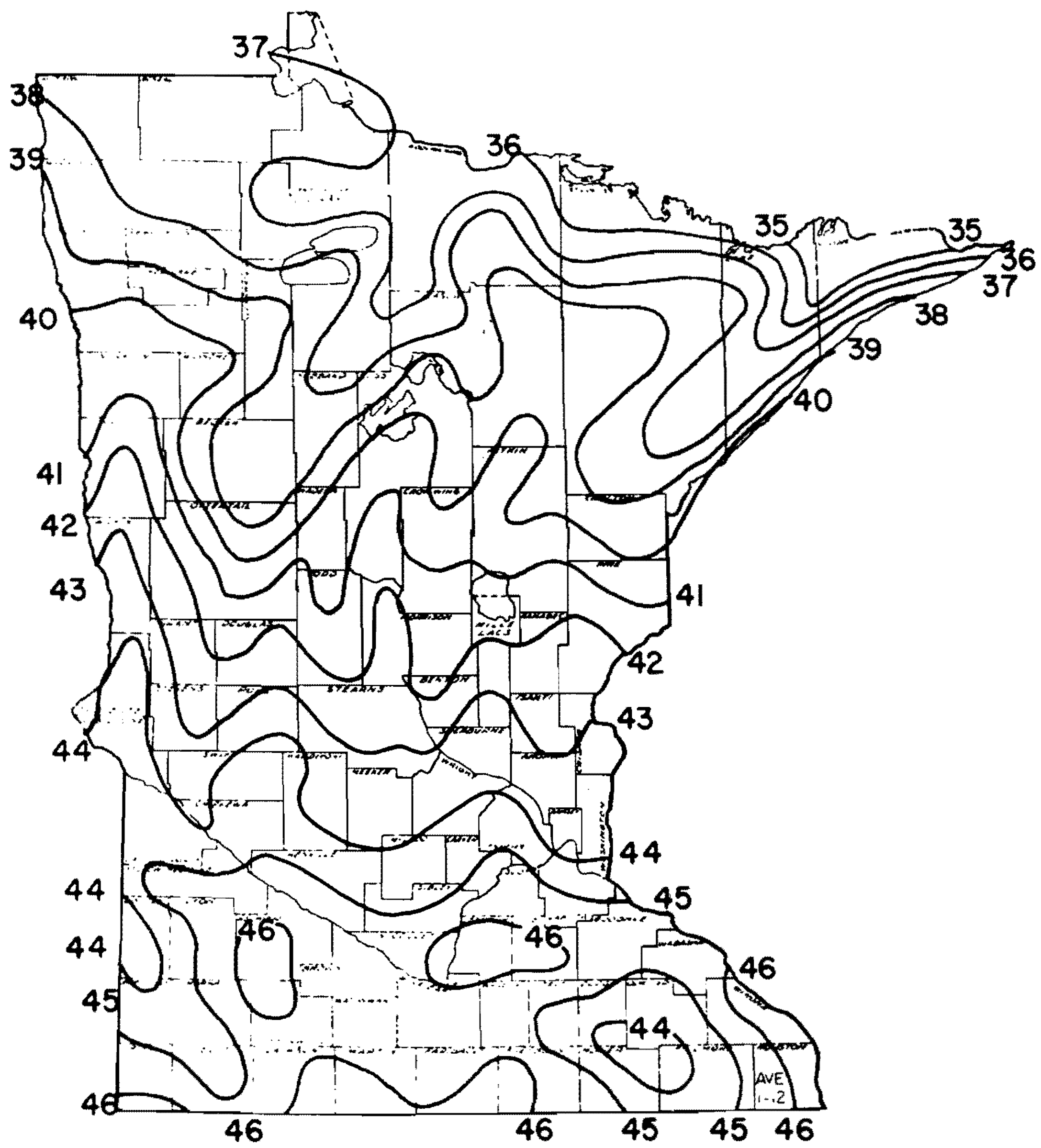

Fig. 3. Minnesota annual normal temperature (Baker and Strub, 1965).

Chemical and biological processes generally proceed at a more rapid rate as the temperature increases. Thus the extent and intensity of many processes involved in soil formation are directly related to the magnitude and duration of soil temperatures above freezing. For example, the weathering or breakdown of soil minerals occurs more rapidly with warmer temperatures.

The mean annual temperature may not be the best measure of the amount of heat available for soil processes. Little weathering or other processes occur in winter, and yet winter temperatures strongly affect the mean annual temperature. Another measure of heat effect that is used is the heat sum or growing degree days (GDD), an expression of the total number of days that the temperature exceeds a certain value, multiplied by that excess. In Fig. 4, the annual total GDD are shown, based on temperatures in excess of 40°F.

The range of this heat sum in the state is nearly two-fold, from less than 2600 in the northeast to over 5000 in the southeast (Fig. 4). This heat is available for

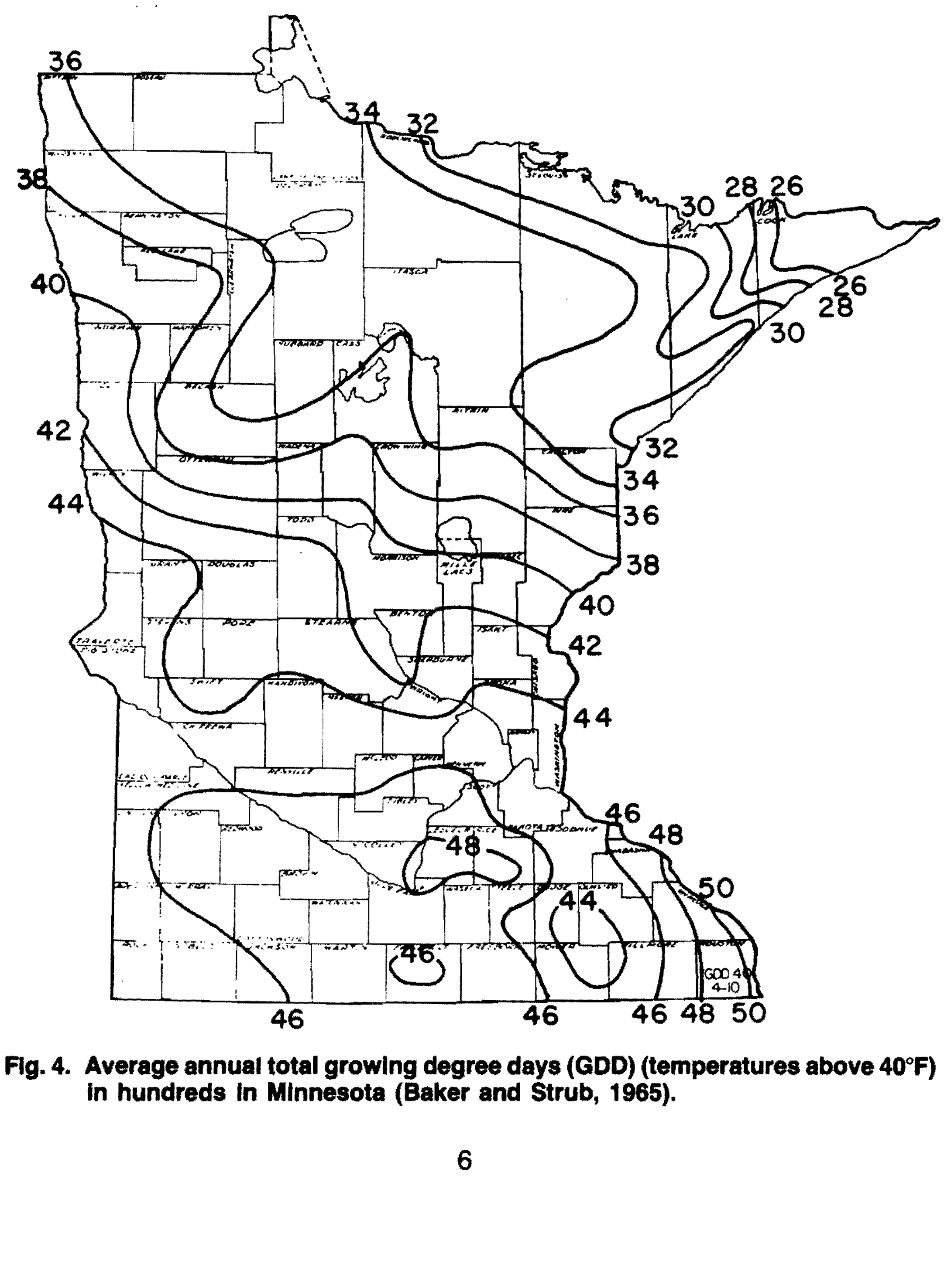

Fig. 4. Average annual total growing degree days (GDD) (temperatures above 40°F) in hundreds in Minnesota (Baker and Strub, 1965).

soil processes. All other factors being equal, we would expect to find soils with more development in the south than in the north, and this is generally the case. However, it is difficult to find situations in which all other factors are equal. Not only does temperature or heat vary across the state, but precipitation also varies.

Precipitation falling on an area is important in determining the supply of moisture at the soil surface. The local distribution of moisture may vary appreciably because of topography, vegetative cover, or permeability of the surficial materials, but the overall supply of moisture is primarily related to the quantity of rainfall and snowfall. Such processes as runoff, erosion, infiltration, and leaching are related to the quantity of rainfall, the rate at which it reaches the soil surface, and its seasonal distribution.

In contrast to temperature, the normal annual precipitation in the state increases from west to east (Fig. 5). Areas along the Dakota border receive about 20 inches of rain per year, and those along the Wisconsin border receive about 30 inches per year (Fig. 5).

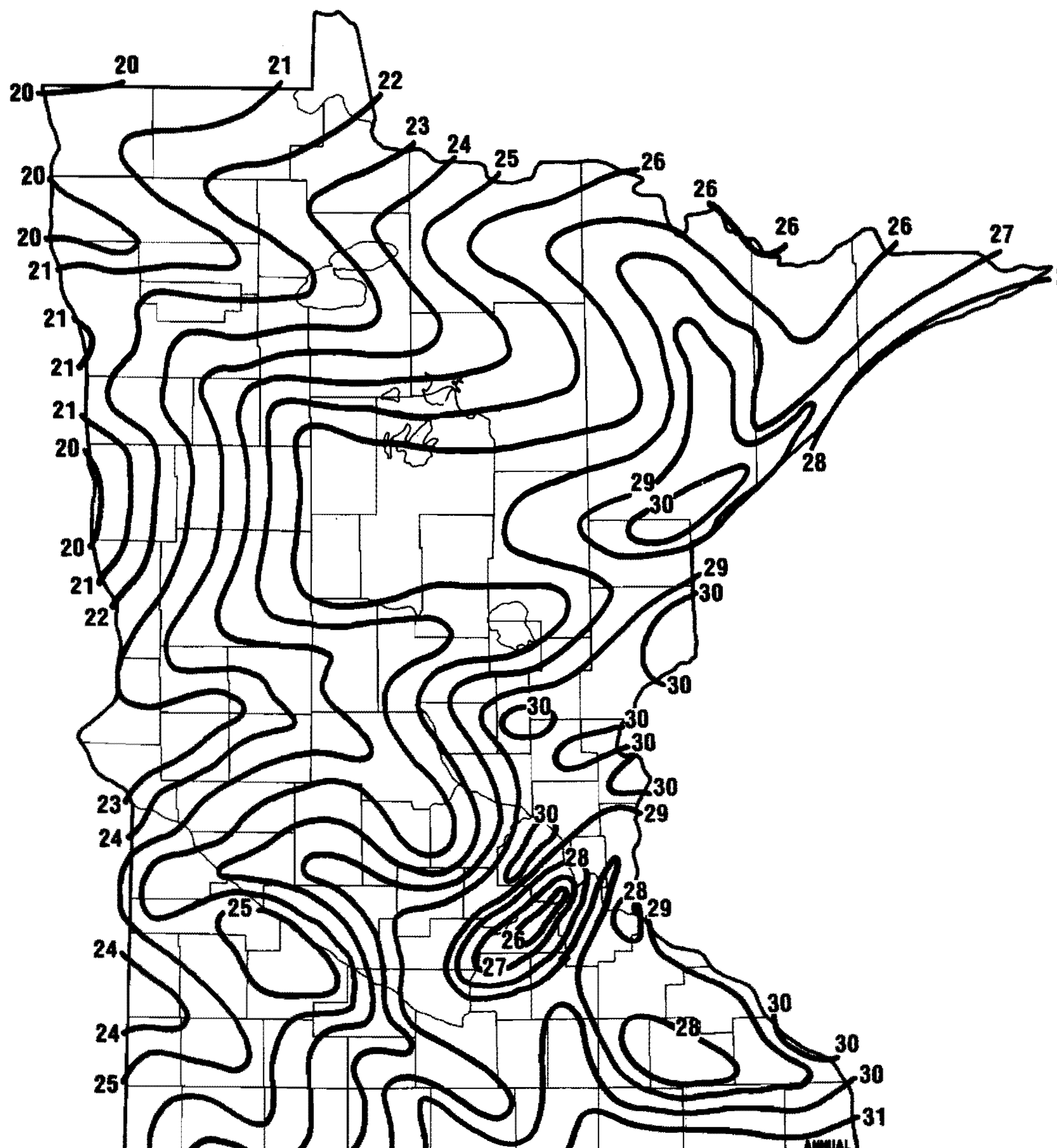

Fig. 5. Minnesota normal annual total precipitation in inches (Baker and Kuehnast, 1978).

However, normal precipitation may be as deceiving as mean annual temperature. Warmer temperatures usually lead to more evaporation of precipitation to the atmosphere, so that less is available to interact with the soil. For example, Fig. 6 shows the average annual runoff for Minnesota in inches. This is a rough index of the amount of water which has been retained, however briefly, in the soil. In the western parts of the state, less than 10% of the incoming precipitation runs off, while in the northeast about 50% of precipitation becomes runoff. This fact, combined with the lower total precipitation in the west, means much less water is available for soil processes in western Minnesota than in the east. Soils in southwestern and western Minnesota, for example, retain the high lime concentrations in the A and B horizons that they inherited from the parent material. In the same parent material further east, lime has been removed by leaching.

Finally, one other climatic factor must be considered. Because soil development proceeds relatively slowly, soil properties may reflect a previous climate, or paleoclimate. Because climate has changed appreciably since the end of the Ice Age, we may find soils whose properties show a poor relationship to present climate.

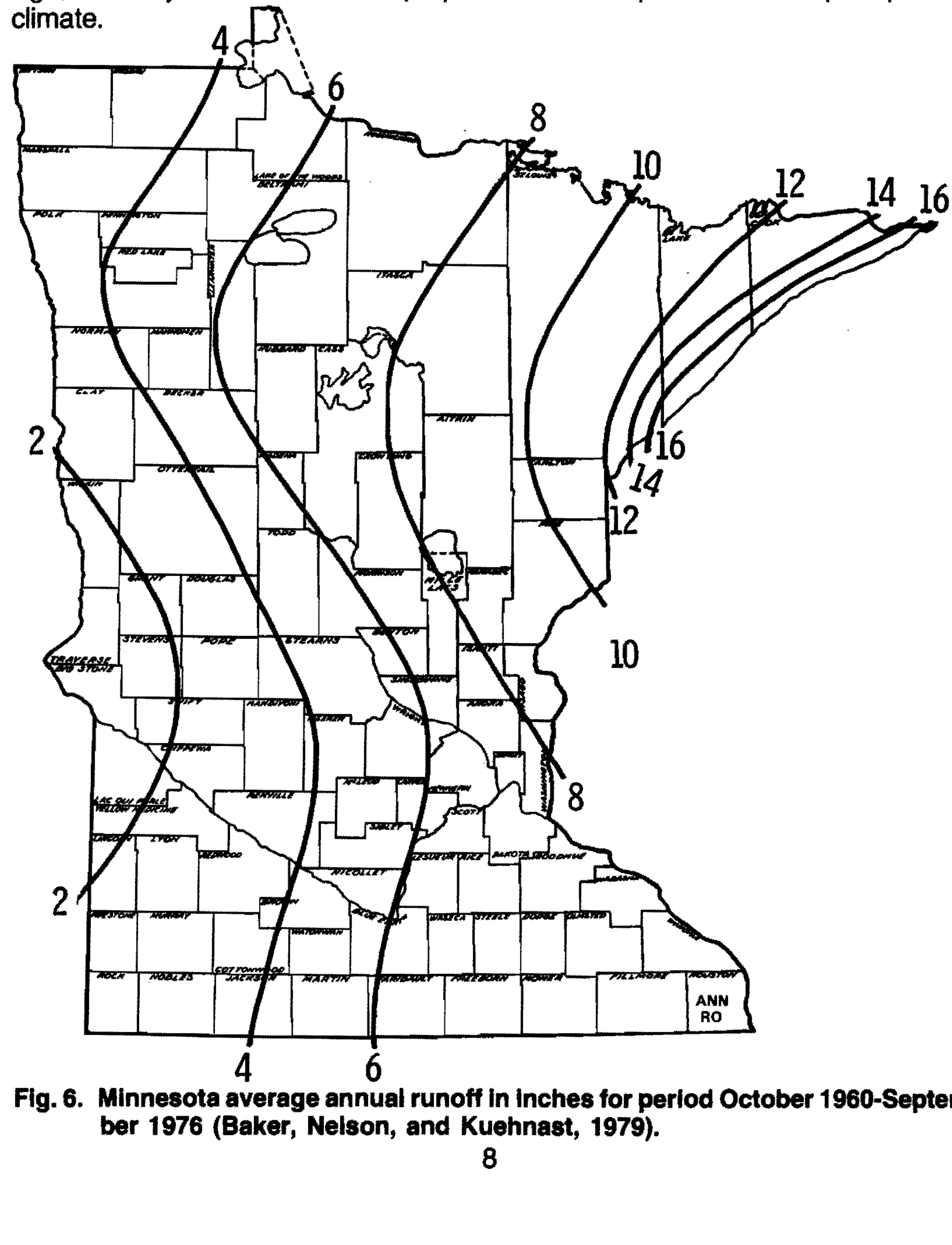

Fig. 6. Minnesota average annual runoff in inches for period October 1960-September 1976 (Baker, Nelson, and Kuehnast, 1979).

Relief

Relief, or the lay of the land, is another factor of soil formation. It affects both the soil climate and the movement of material. Local relief affects drainage, runoff, and erosion, in turn affecting the formation and distribution of soils. Steeper slopes contribute to greater runoff, as well as to greater translocation of surficial materials downslope through surface erosion and movement of the soil mass. Furthermore, ridges or hilltops are more exposed to air currents and hence are susceptible to comparatively greater evaporation losses of moisture. These influences of relief are reflected in the less-developed and often shallower soils characteristic of rolling or hilly sites. The runoff and erosion processes are less pronounced on undulating to gently rolling topography, and the environment is relatively more moist and so is more favorable for biological activity and chemical alteration. Periods of excessive soil moisture are usually rare or are of short duration that generally favorable aeration prevails most of the time. Such sites are occupied by well-drained soils showing appreciable development.

Appreciably more moist conditions occur more frequently and for longer periods on very gently sloping or nearly level terrain. This is due in part to greater intake of precipitation because of further reduction in runoff, and in part to additions of runoff from higher land. Frequently, such surfaces are also associated with lower-lying topographic positions so that removal of excessive soil moisture is often restricted. This more moist environment is conducive not only to a greater rate of weathering, but in addition, with processes associated with wet conditions and restricted aeration. The most humid soil environment in a local landscape is likely to be found in depressed or concave-shaped positions, particularly those with high water tables. Not only will the precipitation reaching the surface be detained where it falls, but additional moisture will be contributed as runoff from adjoining areas. Furthermore, instead of loss of soil material by erosion, these areas are in a position to gain new materials from inwash. Wet conditions and very much restricted aeration are likely to prevail for considerable periods. Such conditions are conducive to development of gray soil colors and appreciable accumulations of soil organic matter.

In addition, wet soils are often colder than dry soils. The water in the soil requires considerable heat to raise its temperature and that of the surrounding soil matrix. This relationship is particularly important in spring, when plants need heat for germinating and/or initiating growth.

Variation in local relief, and the direction in which a slope faces, or its aspect, can also affect local soil climate. A south-facing slope is warmer and dryer than is a north-facing slope in the same locality, because it receives more solar radiation. As the steepness of the slope increases, this effect becomes more important. In areas in Minnesota on the border between forest and prairie vegetation, we can often find forest vegetation and associated forest soil on the north-facing slopes, and prairie vegetation and prairie soils on the south-facing slopes. In areas of steep topography, changes in soil properties associated with local climatic variation may occur over distances of less than one hundred yards.

As mentioned earlier, ridges and hilltops are more exposed to drying winds than are sheltered areas. Any low spot, from a valley to a minor depression, is also subject to the downslope movement of cold air, and a pool of colder air collects there. As a result, temperatures are often lower in depressions. This effect is most pronounced in areas of hilly topography.

One such area of hilly topography is the southeastern part of the state, or roughly the area known as the Rochester Till Plain (Fig. 1). Although this area does not have particularly high elevations above sea level (Fig. 7), the deeply incised river valleys lead to a hilly topography, with resulting aspect and altitudinal differences in soil climate. The highest altitudes in the state occur in the northeast and in the southwest (Fig. 7), and surrounding areas may be subject to cold air drainage. Other areas of the state, such as the beds of the former glacial lakes, have extremely level topography. The bed of Glacial Lake Agassiz, now called the Red River Valley, is an excellent example (Fig. 1, Fig. 7). Smaller areas of level topography, for example areas of glacial outwash, also occur throughout the state. A unique kind of topography occurs in some areas in the southeast part of the state. In some spots in those areas, the limestone bedrock has dissolved, leaving pockets or sinkholes (karst topography) that affect the pattern of the stream network.

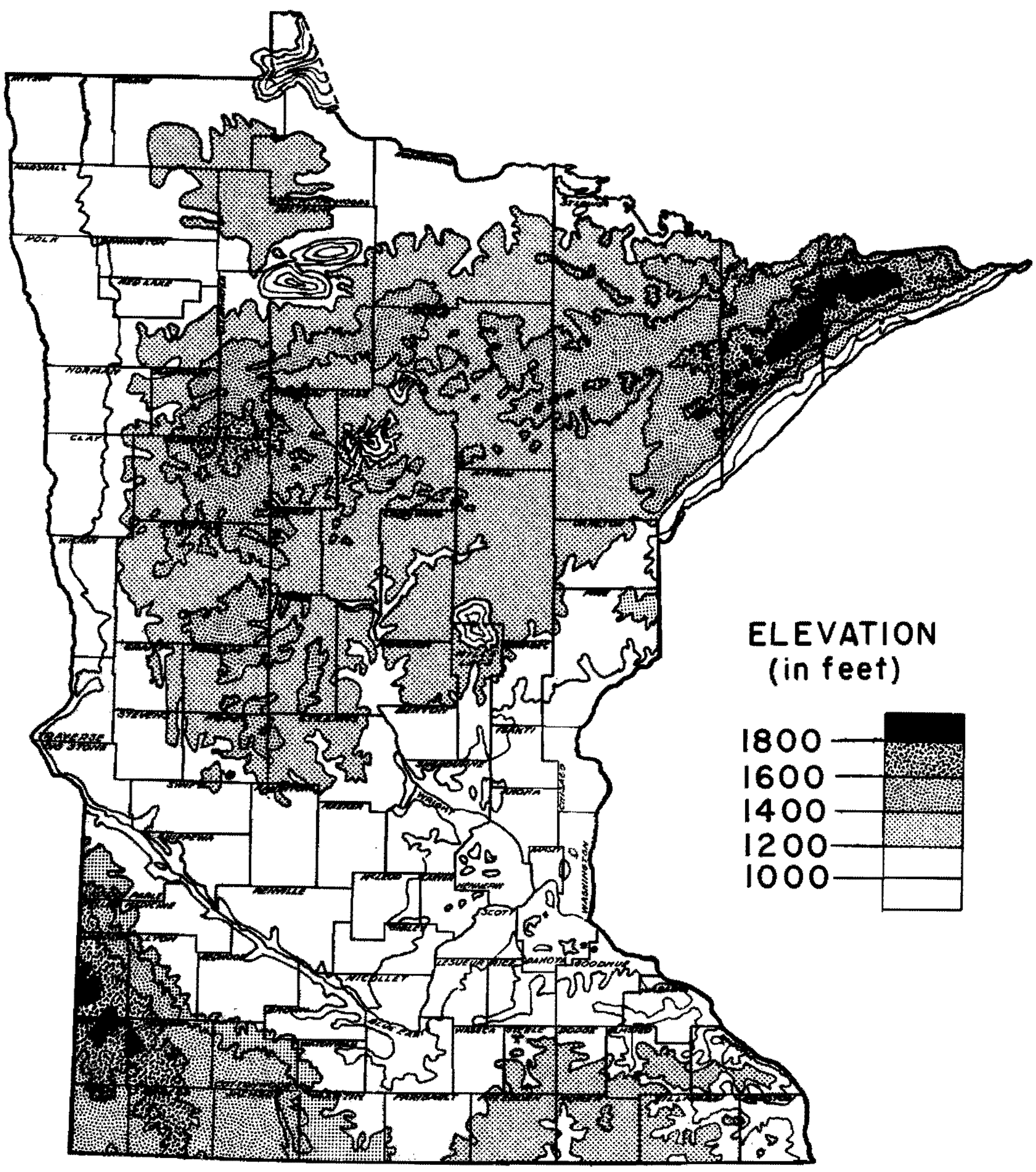

Fig. 7. Topographic map of Minnesota (Baker and Strub, 1963).

Relief is important in determining the pattern of occurrence of soils within different areas of the state. This pattern is closely related to relief because of its influences on drainage, erosion, climate, and plant growth.

Organisms

Plants, animals, bacteria and other organisms are active in soil formation. They aid in the breakdown of parent materials and in the formation and decomposition of organic matter in the soil. Vegetation affects soil formation by depositing organic materials in the soil and by transferring plant nutrients from the subsurface to the surface.

Plants that are common in prairies typically have fibrous roots that die and decay each year and provide the surface soil with a good supply of organic matter. This imparts a dark color to the surface. Prairie plants and animals also tend to slow the leaching of bases out of the surface soil by keeping those elements in the rooting zone, so that under prairie the soil surface usually is only weakly acid or even alkaline. The drier climate found in prairies also reduces leaching.

Plant roots are not as concentrated near the surface in forests as in prairies, and so the surface soil under forests is usually lighter in color than under prairie. Forests also produce large quantities of leaf and branch litter, which falls and often decays on the surface. Some of the products of this decay are organic acids, which enhance the leaching of bases from the surface soil and make it relatively acid. Conifer litter generally produces more acid than does litter from deciduous trees.

Soil animals can have very strong effects on soil formation. Earthworms can mix and incorporate plant material into the soil, producing dark surfaces even under forest. Prairie dogs, gophers, and other small mammals are well-known for their ability to burrow into and thus mix the soil. In some areas, the burrowing of such diverse animals as crayfish and toads has mixed soils.

Soil microorganisms, especially bacteria and fungi, play major roles in soil formation. Without them, organic matter would not break down and ecosystems ultimately could not function. As organic matter is broken down, nutrients that it contains are released and made available for plant growth. Microorganisms also form compounds that help to keep the soil stable, maintaining good pore space while at the same time resisting movement by running water.

Although all organisms affect soil formation, differences in vegetation usually leads to differences in associated animals and microorganisms. Vegetation patterns, therefore, reflect patterns of most organisms. The pattern of vegetation in presettlement Minnesota was very distinctive, and for the most part this pattern has roughly continued to the present. The north-south temperature pattern and the east-west precipitation pattern across the state have led to a northwest-southeast vegetation pattern (Fig. 8).

Boreal conifer forests, typically found throughout central Canada, occur in the northeastern part of the state. Mesic hardwood forests typical of a large part of the central United States occur in the southeast. Vegetation in the southwest reflects that of nearby dry South Dakota, and finally the prairies in the northwest extend hundreds of miles north and west into Canada.

Between these distinctively different vegetation types exist transition zones or ecotones. These ecotones may be occupied by an intermediate mixed vegetation, or the transition from one vegetation type to another may be relatively abrupt. In addition, the position of these ecotones historically has shifted with climatic change, with the prairie "moving" east with warmer/drier conditions, and the forest "moving" west in cooler/moister periods.

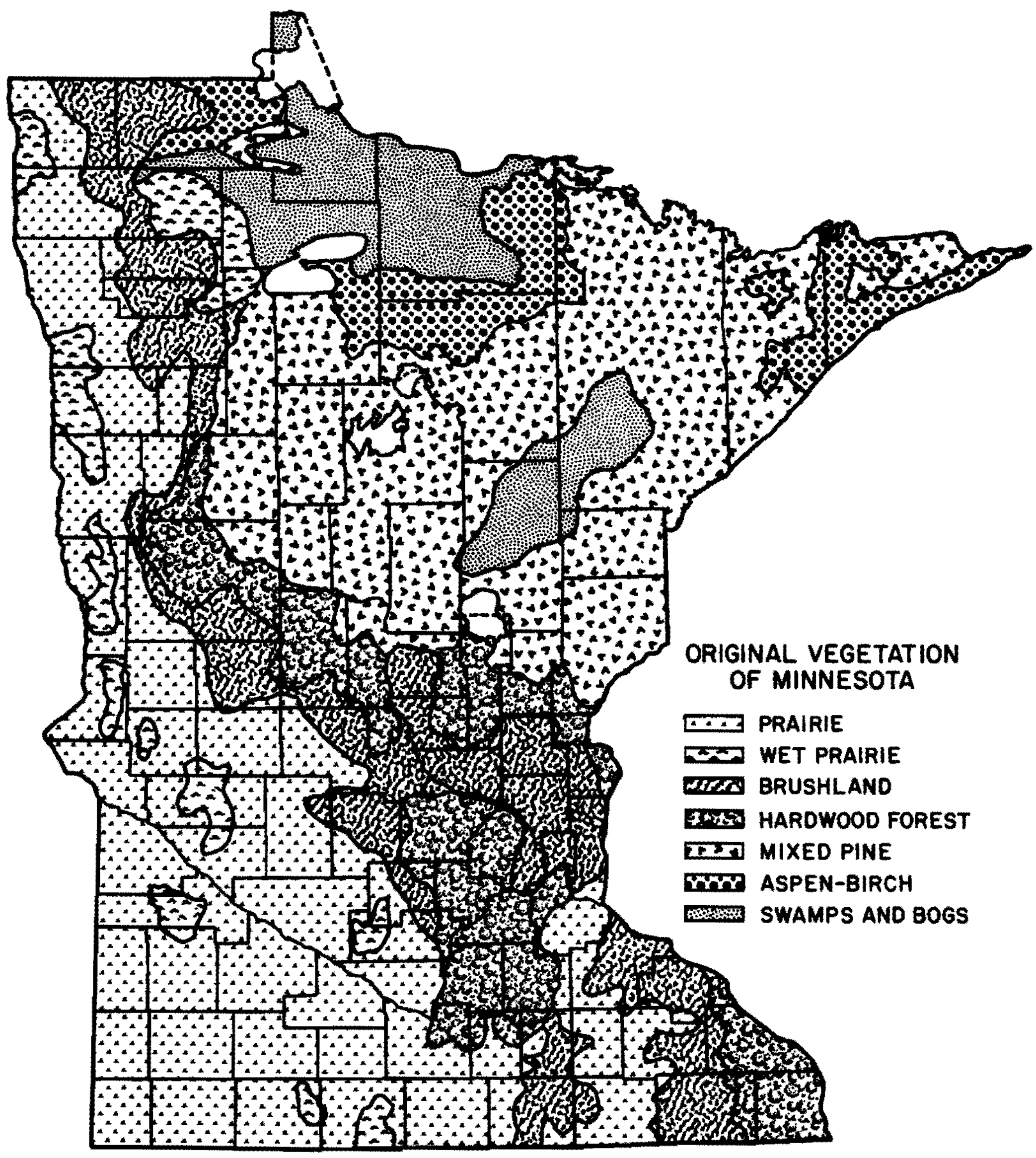

Fig. 8. Original vegetation of Minnesota, abstracted from Marschner (Heinselman, 1974).

Because soils closely reflect the vegetation growing on them (and vice versa), then, for example, distinctively different soils occur in the northeast compared to the southwest. In addition, the transition zone contains a mix of soils depending on the location of the continually shifting ecotone. In these areas, small climatic differences due to relief often lead to vegetation differences that in turn lead to markedly different soils in juxtaposition.

Time

The final element or factor affecting soil formation is the length of time during which the other factors have operated. Soil on a recently exposed landscape, such as a mine dump, is very similar to its parent material because soil-forming processes have not had sufficient time to significantly alter that material. On the other hand, soils that are formed in materials that are many hundreds of thousands of years old, such as those found in the southeastern parts of the United States, are termed "highly-developed" and often have properties that bear little resemblance to those of the underlying material. The soil-forming processes have had sufficient time to strongly influence the soil. Other events, such as periods of severe erosion, may disrupt the normal pace of soil formation.

As discussed earlier, Minnesota is covered with debris associated with glaciation. Nearly all the most recent glaciers occurred in the state less than 20,000 years ago, and in some cases less than 12,000 years ago. Even the areas that may not have been covered by glacers within that period (the far southeast) were covered by loess associated with the glaciers. As a result, most of the soils in Minnesota are approximately the same age, and so time has not had a differential effect on their formation. In a larger context, Minnesota soils are considered to be relatively youthful.

Although on the whole, Minnesota soils are about the same age, there are areas that are exceptions to this statement. Steep slopes may continually erode, exposing additional fresh material and removing weathered material, keeping the soils on those slopes more youthful. Soils on river floodplains receive regular inputs of sediments and thus are continually renewed. In some areas of the state, such as the Anoka Sand Plain and parts of the Bemidji Area (Fig. 1), sand dunes were active during warm/dry periods, reshaping the landscape and setting the time clock back to zero. As stated earlier, however, the soils of Minnesota are considered to be relatively youthful.

Organic soils

Although variation in the five soil-forming factors can be used to explain the properties of mineral soils throughout the state, a significant area in the state (about 7,000,000 acres) is covered by organic soils, or the remains of plant material. The formation of organic deposits, whether deep or shallow, is not easily explained by the five soil-forming factors. We can, however, attempt to fit organic soils into the five-factor scheme. The parent material is really the vegetation that has grown on the surface of these soils. This vegetation, upon dying, accumulates to form the soil. This accumulation generally occurs because the substrate is saturated with water, inhibiting microorganism activity.

In order for excess water to be present, a unique combination of climate and relief is necessary. First, adequate precipitation and restricted evaporation are necessary to provide water. Secondly, the relief and the mineral substrate must be such that the water accumulates. Organic deposits usually occur in former lake basins or on very level plains with a very slowly permeable mineral substrate.

The organisms, and especially the vegetation, that grow on organic soils are often unique to those wet locations. As stated above, they also serve indirectly as the parent material of the soil. Finally, the time of accumulation of organic material is important. Although some deposits began to accumulate at the bottom of lakes as those lakes were formed following melting of glacial ice, other organic deposits did not begin to accumulate until about 3,500 to 4,000 years ago, when the state's climate became cooler and more moist.

SOIL CLASSIFICATION

Soils have a diverse array of properties, each of which varies over a wide range. Soils are arranged into groups based on the similarity of some subset of those properties, or in other words, soils are classified. The classification system used in the United States arranges all soils into one of ten major units, or soil orders. These orders are further broken down into suborders, great groups, subgroups, families, and series. The legend for this map presents the classification of the dominant great groups within a mapped unit, part of the soil family name (the texture), and examples of representative soil series.

The properties used to differentiate among soil orders are generally those that give broad climatic groupings of soils. However, some orders span more than one climatic zone. Orders are in turn divided into suborders that narrow the broad climatic ranges, often by criteria based on moisture status. Great groups then subdivide suborders, based on the uniformity of kinds and sequences of major soil horizons.

Criteria for separation at the family level are properties important to plant growth. Texture is one of the major criteria used to separate soil families. Finally, when soil scientists talk about the soils on a small area of land, such as a farm, they most often speak of soil series. Each series has distinctive properties, and is named for a geographic location near where a representative of that soil occurs. Minnetonka, Menahga, Nicollet, and Toivola are examples of common Minnesota soil series.

Before soil orders, suborders, and great groups can be described, some further information about the classification system is necessary. The system is hierarchical, and the name of each soil category provides direct information about both its properties and its level in the hierarchy. Names of soil units at categories below the order contain a part of the order name as a suffix. Prefixes added to this suffix provide additional information about soil properties. An example may help to explain the concept. The names of all levels in the soil order Mo*ll*isols end with the suffix *oll*. The suborder of wet Mollisols is Aqu*oll*s. A great group of the Aquolls, the Calci*aquoll*s, contain an accumulation of calcium carbonate. Similar kinds of name construction are used in all parts of the classification system.

Listed below are the major soil orders, suborders, and great groups that occur in Minnesota, along with a very brief description of some of their distinctive properties. The soils are listed alphabetically by order.

Alfisols— soils with evidence of strong development of distinctive properties, including a fine-textured subsoil relatively high in nutrients, usually formed under forest vegetation.

- Aqualfs— wet Alfisols
  - Albaqualfs— Aqualfs with an abrupt change in soil texture between the surface and the subsoil.
  - Fragiaqualfs— Aqualfs with a zone located in the subsoil that is brittle when moist and hard when dry.

- Glossaqualfs— Aqualfs in which the surface properties extend like "tongues" into the subsoil.
- Ochraqualfs— Aqualfs without distinctive properties.

Boralfs— Alfisols of northern areas, or cool Alfisols.

- Eutroboralfs— Boralfs relatively high in nutrients.
- Fragiboralfs— Boralfs with a zone located in the subsoil that is brittle when moist and hard when dry.
- Glossoboralfs— Boralfs that are moist all years or are relatively low in nutrients.

Udalfs— Alfisols of moderate temperatures.

- Hapludalfs— Udalfs without distinctive properties.
- Paleudalfs— Udalfs with a thick, reddish subsoil, usually the product of a long period of soil formation.

Entisols— soils with little or no evidence of formation of distinctive properties.

Aquents— wet Entisols.

- Haplaquents— Aquents without any distinctive properties.
- Fluvaquents— Aquents found along rivers in floodplains.
- Psammaquents— sandy Aquents.

Fluvents— Entisols found along stream and river channels, but not as wet as Aquents.

- Udifluvents— Moist fluvents with moderate temperatures.

Orthents— Loamy and clayey Entisols with decreasing organic matter with depth.

- Udorthents— moist Orthents with moderate temperatures.
- Ustorthents— usually moist Orthents, but subject to annual periods of dryness.

Psamments—sandy Entisols.

- Udipsamments— moist Psamments with medium temperatures.

Histosols— soils formed from accumulation of plant material, most often in wet environments (peatland soils).

Fibrists— primarily poorly decomposed organic material.

- Sphagnofibrists—sphagnum moss fibers are dominant.

Hemists— organic material is moderately decomposed.

- Borohemists— cool Hemists.
- Medihemists— Hemists with moderate temperatures.

Saprists— organic material is well decomposed

- Borosaprists— cool Saprists.
- Medisaprists— Saprists with moderate temperatures.

Inceptisols—soils showing evidence of the beginning of formation of distinctive properties.

- Aquepts— wet Inceptisols.
  - Haplaquepts— Aquepts without distinctive properties.
  - Humaquepts— Aquepts whose surface is high in organic matter.
- Ochrepts— Inceptisols without any distinctive properties.
  - Dystrochrepts— Ochrepts relatively low in nutrients.
  - Eutrochrepts— Ochrepts relatively high in nutrients.
  - Fragiochrepts— Ochrepts with a zone located in the subsoil that is brittle when moist and hard when dry.

Mollisols— soils with a deep, dark, fertile topsoil, usually formed under prairie vegetation.

- Albolls— Mollisols in which the dark topsoil is underlain by a bleached (white) layer.
  - Argialbolls— Albolls with clay accumulation in the subsurface.
- Aquolls— wet Mollisols.
  - Calciaquolls— Aquolls with large amounts of accumulated lime.
  - Haplaquolls— Aquolls without any distinctive properties.
- Borolls— Mollisols of northern areas, or cool Mollisols.
  - Argiborolls— Borolls with clay accumulation in the subsurface.
  - Haploborolls— Borolls without distinctive subsurface properties.
  - Vermiborolls— Borolls with much earthworm activity.
- Udolls— moist Mollisols of moderate temperatures.
  - Arguidolls— Udolls with clay accumulation in the subsurface.
  - Hapludolls— Udolls without distinctive subsurface properties.
- Ustolls— drier Mollisols, generally of semi-arid areas.
  - Haplustolls— Ustolls without distinctive subsurface properties.

Spodosols—soils with accumulations of organic matter and iron and aluminum in the subsoil, usually formed under coniferous vegetation.

- Orthods— Spodosols without distinctive properties.
  - Haplorthods— Orthods without distinctive properties.
  - Fragiorthods— Orthods with a zone located in the subsoil that is brittle when moist and hard when dry.

THE LEGEND AND MAP

Introduction

The map, as the title states, is a delineation of soils and land surfaces of Minnesota. We have attempted to separate areas that differ in surface characteristics, especially relief. If these differences are then overlaid on the varying parent materials, climate, and vegetation across the state, the result is a complex pattern of soils.

Because of the scale at which this map is reproduced (1:1,000,000), we cannot show every breakdown of soil/land surface. A small unit, only one-quarter inch on a side, represents about 16 square miles, or almost half a township. Within delineated units, therefore, soil areas may occur that are not described in the legend. A good example of this problem are small peat bogs that are interspersed over many landscapes, yet are often less than a square mile in area. These kinds of differing soils will not appear on this map.

In addition, to reduce the complexity of the map and the legend, we sometimes combined two contiguous units which varied somewhat in a property, or we assigned the same number to units that were geographically separated but bore many similarities. As a result, any detailed consideration of soils at a specific location needs more detailed maps or on-site investigations.

The Legend

With the numbering system in the legend (the symbol), we have placed soil units into broad categories primarily related to their temperature and vegetation. Soil scientists use 47°F soil temperature, corresponding to an average air temperature of about 45°F, to separate soils in their classification system. Vegetation was considered, because as explained earlier, it has a strong influence on soil properties and development. Major changes in the numbering sequence are explained where they occur in the legend.

The soil great groups that dominate in a unit are identified in the legend. A general description of each named great group can be found in the preceding section dealing with soil classification. Soils at the great group level are separated into broad climatic zones; which in turn are more narrowly divided, often based on moisture conditions; and then subdivided based on the kinds and sequences of soil horizons.

Simply the great group name conveys considerable information about the properties of the soils. For example, soils with the sequence ..*aqu*.. in the great group name are wet during most years. Soils with the named ending...*oll* have dark, deep, relatively fertile surfaces. Names beginning with *Fragi*...have a subsurface horizon that is poorly penetrated by water or plant roots, leading to very wet soils in spring and the possibility of tree throw during windstorms. The preceding section dealing with soil classification, along with the great group name, will provide considerable information about the soils within a delineation on the map.

The next column in the legend is the texture of the soil family. In a previous section, we discussed the term soil texture and its importance as a soil property, because of its strong influence on soil fertility and moisture. The family texture column provides information about soil textures within a delineation. The sequence of soil textures in approximate order of increasing fineness or clay are: sandy, coarse-loamy, fine-loamy, coarse-silty, fine-silty, fine (clayey), and very-fine (also clayey). In some mineral soils, materials of two widely different textures occur, usually as a result of geologic deposition. In those cases, the textural family name is also stratified, such as sandy over loamy (sandy/loamy).

Because organic soils contain only very limited amounts of mineral material, under the column dealing with family texture we have noted the dominant kind of organic material in the soil, ranging from poorly broken down (raw) fibric material through hemic material to the most decomposed or disintegrated sapric material.

The family texture also provides considerable information about the soil. As stated earlier, sandy soils are commonly droughty and of low fertility. Clayey soils often have limited air and water movement, and loamy or silty soils most frequently provide the best environment for plant growth. Other properties of soil, such as susceptibility to erosion, are also related to texture.

The column dealing with landform attempts to describe the landscape of the soil mapping unit. Landscapes in Minnesota may range from level glacial lake plains through rolling moraines to areas such as the southeast with deeply incised valleys. The glossary in the back may provide further explanations of the terms dealing with landform.

Landform also affects the soil and its uses. A landscape with strong relief may not lend itself well to row-cropping, whereas a lake plain or a moraine with less than 10 feet of local relief may be very well suited for such use.

The parent material is that from which the soil has formed. It varies both in texture and in color as it relates to the glacial lobe from which it originated, and the mode of deposition. Deposition by the ice itself, by standing water, or by running water all produced differing kinds of parent material.

Parent material provides further detail on the soil unit, and hence, further information that can be used to determine suitable uses. For example, materials that originated from the Des Moines Lobe of glacial ice, and less so from the Wadena Lobe, contain lime. Soils formed in those materials may be better suited for some plants than are the more acid soils commonly formed in materials from the other lobes. Lakes in areas with limy till are less acid, and generally more productive, than are those in till areas without lime.

The original vegetation column presents our estimate of the original vegetation, at about the time of settlement, with which the soil formed. This is based on the best evidence, both in the soil and in old records, that is available. In many areas, however, examples of original vegetation are very limited in extent, and so this column may vary in accuracy.

Finally, a column deals with representative soil series that can be found in each mapping unit. Soil series are the lowest level in the classification system. The range of properties within any given soil series is rather small, and quite specific statements can be made about uses of such soils. Information about series are catalogued by the USDA Soil Conservation Service and by the University of Minnesota Agricultural Experiment Station. These agencies can be contacted for information about specific series.

Terms that are not explained elsewhere in this booklet can be found in the glossary.

DETAILED LEGEND

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES

UNITS 001 TO 008 ARE DOMINATED BY ORGANIC SOILS, OR SOILS FORMED FROM PLANT TISSUE. DEGREE OF FIBER DECOMPOSITION REPLACES MINERAL TEXTURE IN THESE UNITS.

001	Borosaprists Borosaprists Borohemists	Sapric Sapric Hemic	Lake plains, nearly level, <5 ft. local relief	--------	Fen and swamp conifers	Seelyeville Cathro Mooselake

Remarks: Include small islands of mineral soils. Raised bogs are more common in the larger delineations. Burned peat areas are common. Areas along the Canadian border have large areas of fibric material.

002	Borohemists Borosaprists Borosaprists	Hemic Sapric Sapric	Lake plains, nearly level, <5 ft. local relief	--------	Swamp conifers and fen	Mooselake Seelyeville Cathro

Remarks: Mineral islands are few to common. Burned peat areas common. Large bog north of Red Lakes has few mineral islands and large raised bogs.

003	Borohemists Borohemists	Hemic Hemic	Lake plains and former lake basins,nearly level, <5 ft. local relief	--------	Swamp conifers, especially spruce	Greenwood Rifle

Remarks: Raised bogs are common; mineral islands are uncommon.

004	Borohemists	Hemic	Former lake basins and floodplains, <5 ft. local relief	--------	Swamp conifers	Mooselake
005	Sphagnofibrists Sphagnofibrists	Fibric Fibric	Lake plains, nearly level, <5 ft. local relief	--------	Black spruce and sphagnum moss	Waskish Lobo

Remarks: These are raised bogs and occur predominantly near center of other large areas of organic soils. They are low domes, slightly higher than surrounding surfaces.

006	Borohemists Borosaprists	Hemic Sapric	Lake plains and former lake basins, nearly level, <5 ft. local relief	--------	Swamp conifers	Mooselake Lupton

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
008	Borohemists Borohemists Udipsamments Haplaquents	Hemic Hemic Sandy Sandy/loamy	Lake plains, nearly level, <5 ft. local relief	--------	Swamp conifers and fen	Mooselake Seelyeville Hiwood Grygla

Remarks: A till plain whose relief was further subdued by wave action. Unit also contains beaches, spits, strands, and other associated lake features. Raised bogs are common. Greenwood and Waskish are also common Histosols.

UNITS 100 TO 144 ARE DOMINATED BY PRAIRIE SOILS WITH MEAN TEMPERATURES COOLER THAN 47° F.

Units 100 to 109 include soils formed on 5 to 10 ft. or more of clayey sediments, either within the basin of Glacial Lake Agassiz or on moraines.

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
100	Haplaquolls Calciaquolls Udifluvents	Very-fine Fine Fine	Lake plain and alluvium, nearly level, <5 ft. local relief	Gray lacustrine sediments	Tall grass prairie	Northcote Hegne Cashel

Remarks: Saline soils are common. Willows and cottonwood occur along streams on Udifluvents.

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
101	Calciaquolls Haplaquolls Udifluvents	Fine-silty Fine Fine	Lake plain and alluvium, nearly level, <5 ft. local relief	Gray lacustrine sediments	Tall grass prairie	Bearden-Colvin Fargo Cashel

Remarks: Saline soils are common. Willows and cottonwood occur along streams on Udifluvents.

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
102	Calciaquolls Haplaquolls Haplaquolls	Fine Fine Very-fine	Lake plain, nearly level, <5 ft. local relief	Gray lacustrine sediments	Tall grass prairie	Hegne Fargo Northcote

Remarks: A complex of low ridges (<18 inch) and swales with highly calcareous soils on the ridges and deeply leached soils on the swales. The dryer ridges may have supported mid-height prairie grasses.

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
103	Haplaquolls Calciaquolls	Fine Fine	Lake plain, nearly level, <5 ft. local relief	Gray lacustrine sediments	Tall grass prairie	Fargo Hegne

Remarks: Four- to twelve-inch microrelief, with Calciaquolls on ridges. Mid-height prairie grasses may have occurred on ridges. The Haplaquolls are dominant in this unit.

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
104	Calciaquolls Haplaquolls	Fine Fine	Lake plain, nearly level, <5 ft. local relief	Gray lacustrine sediments	Tall grass prairie	Hegne Fargo

Remarks: Six- to 24-inch microrelief, with Calciaquolls on ridges. Mid-height prairie grasses may have occurred on ridges. This unit contains a more intimate mixture of Calciaquolls and Haplaquolls than does 103.

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
105	Haplaquolls	Very-fine	Lake plain,	Gray	Tall and	Viking
	Calciaquolls	Fine	nearly level,	lacustrine	mid grass	Hegne
	Haplaquolls	Fine-loamy	<5 ft. local	sediments	prairie	Roliss
			relief	and till		
Remarks:	A till plain whose relief was further subdued by wave action. Cobbles are common. Six-to 24-inch microrelief.					
106	Haplaquolls	Very-fine	Lake plain,	Gray	Tall and	Viking
	Haplaquolls	Fine	nearly level,	lacustrine	mid grass	Fargo
	Calciaquolls	Fine	<5 ft. local	sediments	prairie	Hegne
			relief	and till		
Remarks:	Similar to unit 105 in landform and parent materials.					
107	Haplaquolls	Fine-loamy	Lake plain,	Gray till	Tall and	Roliss
	Calciaquolls	Fine-loamy	nearly level,		mid grass	Vallers
			<5 ft. local		prairie	
			relief			
Remarks:	Six- to 24-inch microrelief. Although a lake plain, relatively little lacustrine sediments were deposited and the relief was subdued by wave action. The shallow drainageways are occupied by a soil with weak argillic properties. The 107 unit in Pennington and Polk Counties includes some beach ridges and some thick sandy mantles.					
108	Haploborolls	Fine ,	Isolated lake	Gray	Tall grass	Nutley
	Haploborolls	Fine	plains, nearly	lacustrine	prairie	Sinai
	Haplaquolls	Fine	level to	sediments	with sedges	Fulda
			sloping,			
			10-50 ft local			
			relief			
Remarks:	These delineations include isolated glacial lakes, usually in moraines. In the large delineations in Stevens and Big Stone Counties, relief is from ice block depressions in a level till plain. The units in Douglas, Becker and Mahnomen Counties have up to 50 ft. local relief and have a common elliptical shape.					
109	Calciaquolls	Fine-silty	Lake plain,	Gray	Tall grass	Colvin
	Haplaquolls	Fine-silty	nearly level,	lacustrine	prairie with	Perella
	Calciaquolls	Fine-silty	<5 ft. local	sediments	sedges	Bearden
			relief			
Remarks:	Six- to 24-inch microrelief. McIntosh and Winger soils are dominant in some areas. The delination west of Montevideo includes steep scarp slopes.					

Units 110 to 119 include soils formed in coarse-silty, coarse-loamy, or sandy sediments over sediments that are finer in texture. These sediments occur as either glacial outwash or as sediments from streams flowing into glacial lakes.

110	Calciaquolls	Coarse-silty	Lake plain,	Gray	Tall and	Glyndon
	Calciaquolls	Coarse-silty/	nearly level,	lacustrine	mid	Wheatville
		clayey	<5 ft. local	sediments	grass	
	Calciaquolls	Coarse-silty	relief		prairie	Borup
Remarks:	Six- to 24-inch microrelief. Wave action re-deposited fluvial sediments over lacustrine silts and clays.					

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
111	Calciaquolls Calciaquolls Calciaquolls	Sandy Sandy/loamy Coarse-loamy	Lake plain, nearly level, <5 ft. local relief	Gray lacustrine sediments	Tall and mid grass prairie	Ulen Grimstad Rockwell

Remarks: Six- to 24-inch microrelief. Wave action re-deposited fluvial sediments over finer lacustrine sediments or till.

112	Haploborolls Haplaquolls Udipsamments	Sandy Sandy Sandy	Lake plain, 1-20 ft. local relief	Gray lacustrine sediments	Tall grass prairie, hazel shrubland, aspen	Flaming Hamar Poppleton

Remarks: The sediments were predominantly deltaic deposits in Glacial Lake Agassiz, which were subsequently re-deposited by wave action in the lake. The unit includes dune fields where the Buffalo and Sandhill Rivers entered the lake. The aspen occurred on the eastern part of the unit.

113	Haploborolls Calciaquolls Calciaquolls	Sandy-skeletal Sandy Coarse-loamy	Beach ridges and lake plain, 1-10 ft. local relief	Gray lacustrine sediments	Tall and mid grass prairie	Sioux Syrene Rockwell

Remarks: The beach ridges, formed by wave action on surrounding uplands, contain significant gravel deposits.

114	Haploborolls Haploborolls Haploborolls	Sandy Sandy Sandy	Pitted outwash plain, 1-5 ft. local relief	Gray outwash	Tall and mid grass prairie	Hubbard Arvilla Lohnes

Remarks: Unit includes ice block pits, ridges and braided swales. Dorset, Osakis, Sverdrup and Forada soils are common in some areas.

115	Haploborolls Haploborolls Haploborolls	Sandy Sandy Sandy	Pitted outwash, rolling, 2-20 ft. local relief	Gray outwash	Tall and mid grass prairie with hazel shrubland	Arvilla Hubbard Lohnes

Remarks: Unit includes ice block pits, ridges, braided swales, and collapsed alluvium. Some pits are ponded; others include peat. Forada and Osakis soils are extensive in some areas; Sverdrup soils are also found.

116	Haploborolls Haploborolls Haploborolls	Sandy Sandy Sandy	Deeply pitted or collapsed outwash, 5-45 ft. local relief	Gray outwash	Tall and mid grass prairie, aspen, and oak	Lohnes Arvilla Hubbard

Remarks: Udorthents are on the steeper knolls, and deeper pits are ponded or filled with peat.

117	Calciaquolls Calciaquolls Haploborolls	Coarse-loamy Fine-loamy/sandy Sandy	Outwash plain, 1-5 ft. local relief	Gray outwash	Tall and mid grass prairie	Arveson Marysland Hecla

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
118	Haploborolls Argiborolls Argiborolls	Sandy Coarse-loamy Coarse-silty	Level to gently rolling deltaic deposits, 5-15 ft. local relief	Gray outwash	Tall grass prairie	Maddock Shible Edison
119	Calciaquolls Calciaquolls Haplaquolls	Fine-silty Fine-loamy/sandy Fine-silty	Deltaic and valley train deposits, 1 to 5 ft. local relief	Gray outwash	Tall grass prairie	Colvin Marysland Lamoure

Units 120 to 129 include soils formed exclusively in loamy glacial till or in till overlain by silty or clayey sediments.

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
120	Haploborolls Haploborolls Calciaquolls	Fine-loamy Fine-loamy Fine-loamy	Ground moraine, 5-15 ft. local relief	Gray till	Tall and mid grass prairie	Aazdahl Formdale Vallers
121	Calciaquolls Calciaquolls Haplaquolls	Fine-loamy Fine-loamy Fine-silty	Ground moraine, <5 ft. local relief	Gray till	Tall and mid grass prairie with sedge	Hamerly Vallers Quam
122	Haploborolls Haploborolls Haplaquolls	Fine-loamy Fine-loamy Fine-loamy	Ground moraine, 5-15 ft. local relief	Gray till	Tall grass prairie	Buse Barnes Flom

Remarks: Includes eroded and stony moraine terraces along the Minnesota River in Lac Qui Parle and Swift Counties.

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
123	Udorthents Haploborolls Haploborolls	Fine-loamy Fine-loamy Fine-loamy	Rolling terminal moraine, 15-30 ft. local relief	Gray till	Tall and mid grass prairie	Langhei Buse Barnes

Remarks: Quam soils are common in depressions.

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
124	Udorthents Haploborolls Haplaquolls	Fine-loamy Fine-loamy/sandy Fine-silty	Tunnel valley, 5-20 ft. local relief	Gray till and outwash	Tall and mid grass prairie	Langhei Renshaw Quam

Remarks: Unit includes outwash terraces and recent alluvium. Local relief is 30-45 ft. + on steep slopes into the valleys.

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
125	Udorthents Haploborolls Borosaprists	Fine-loamy Fine-loamy Sapric	Steep terminal moraine, 30-45 ft. + irregular local relief	Gray till	Tall and mid grass prairie, reeds and sedges	Langhei Buse Cathro

Remarks: Unit includes outwash sediments in valley trains and terraces, and recent alluvium. Haplaquolls and Borosaprists are common in depressions and swales.

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
126	Haploborolls Haploborolls Haplaquolls	Fine-loamy Fine-loamy Fine-silty	Dead-ice moraine, 30-45 ft. local relief	Gray till	Tall grass prairie	Barnes Svea Quam

Remarks: The landform in this unit has a relatively level top with steep but simple side slopes.

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
127	Haploborolls Haploborolls Haploborolls	Sandy Fine-loamy Sandy-skeletal	Ice contact feature, 30-45 ft. + local relief	Gray till and outwash	Tall and mid grass prairie	Arvilla Buse Sioux
128	Argiborolls Haploborolls Haplaquolls	Fine-loamy Fine-loamy Fine-loamy	Terminal moraine, 5-15 ft. local relief	Gray till	Tall and mid grass prairie	Forman Aastad Flom

Remarks: Predominantly on slope of Coteau des Prairie, with 300 to 500 ft. rise and northeast aspect of the Coteau slope.

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
129	Haploborolls Haploborolls Haploborolls	Fine-loamy Fine-silty Fine-silty	Terminal moraine, 5-45 ft. local relief	Silt over gray till	Tall and mid grass prairie	Barnes Waubay Poinsett

Remarks: This unit includes large elliptical land forms with undulating tops and steep, simple side-slopes.

Units 130 to 144 include soils formed in silty materials deposited by wind or water on silty or loamy glacial till.

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
130	Calciaquolls Calciaquolls Calciaquolls	Fine-silty Fine-silty Fine-loamy	Ground moraine, <5 ft. local relief	Lacustrine silt over gray till	Tall and mid grass prairie with sedges	McIntosh Winger Hamerly
131	Haploborolls Udorthents Calciaquolls	Fine-silty Fine-loamy Fine-loamy	Ground moraine, 5-15 ft. local relief	Gray till with partial silt mantle	Tall grass prairie	Tara Langhei Vallers
140	Haploborolls Haploborolls Haploborolls	Coarse-silty Fine-loamy Fine-silty	Ground moraine, 15-30 ft local	Silt over gray till	Tall and mid grass prairie	Rothsay Doland Tara
141	Haploborolls Haplustolls Haplaquolls	Fine-loamy Fine-loamy Fine-loamy	Ground moraine, 5-15 ft local relief	Lacustrine silt over gray till	Tall and mid grass prairie	Doland Ves Canisteo

Remarks: The Haplaquolls are high in carbonates and gypsum.

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
142	Haploborolls Haploborolls Calciaquolls	Fine-silty Fine-loamy Fine-loamy	Ground moraine, 5-15 ft local relief	Gray till	Tall and mid grass prairie	Tara Buse Vallers

Remarks: The till is predominantly loamy, but silty areas occur. The unit includes areas of Barnes, Doland, Winger, Canisteo, and McIntosh soils.

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
143	Vermiborolls Vermiborolls Haplaquolls	Fine-loamy Fine-loamy Fine-loamy	Ground moraine, 5-15 ft. local relief	Silt over gray till	Tall and mid grass prairie	Oak Lake Singsass Flom

Remarks: The areas of worm activity are larger than this unit, and are common throughout the Coteau.

144	Udorthents Hapludolls Haplaquolls	Coarse-loamy Coarse-loamy Fine-loamy	Ground moraine, 15-30 ft. local relief	Gray till	Tall and mid grass prairie	Sunberg Wadenill Delft

Remarks: The parent material is a mixture of tills from the Des Moines and Wadena glacial lobes.

UNITS 200 TO 241 ARE DOMINATED BY SOILS OF THE FOREST-PRAIRIE TRANSITION WITH MEAN TEMPERATURES COOLER THAN 47° F.

Units 200 through 211 include soils formed in loamy and sandy sediments whose relief has been subdued by wave action, or on beaches and strands of Glacial Lake Agassiz.

200	Calciaquolls Calciaquolls Borosaprists	Coarse-loamy Coarse-loamy Loamy	Lake plain, nearly level, <5 ft. local relief	Gray lacustrine sediments over gray till	Tall grasses with reeds and sedges, willow shrubs, aspen	Fram Percy Cathro
201	Ochraqualfs Humaquepts Borosaprists	Fine-loamy Coarse-loamy Sapric	Lake plain, nearly level <5 ft. local relief	Gray till	Willow shrubs, reed-sedge, aspen	Chilgren Haug Cathro

Remarks: A till plain whose relief was further subdued by wave action. The unit often has deposits of large and numerous boulders that significantly affect land use. In places, the till and boulders are mantled wholly or in part by lacustrine silts and clays, with considerable interstratification of sands and gravel. Basins in the unit often contain or contained peat (in some cases, eliminated by burning).

202	Ochraqualfs Haplaquolls Borosaprists	Fine-loamy Fine-loamy Sapric	Lake plain, nearly level, <5 ft. local relief	Gray till	Aspen, reed-sedge, willow shrubs	Chilgren Roliss Cathro

Remarks: This unit is similar to 201 in terms of the boulder content. The parent material in this unit is less sandy than in 202, and somewhat less peat burning appears to have occurred.

211	Udipsamments Udipsamments Psammaquents	Sandy Sandy Sandy	Lake plain and beach complex, 2-15 ft. local relief	Gray lacustrine sediments	Reed-sedge, tall grasses, aspen	Poppleton Redby Cormant

Remarks: The sandy sediments were reworked and the relief subdued by wave action. Cobbles and boulders are common, especially in the swales.

Units 212 to 217 include soils formed in sandy and gravelly outwash and on ice-contact features.

212	Udipsamments Udipsamments Psammaquents	Sandy Sandy Sandy	Pitted outwash plain, 5-15 ft. local relief	Gray outwash	Jack and red pine	Menahga Meehan Newson

Remarks: Chetek and Warman series also occur in this unit. Rifle is a common Histosol.

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
213	Eutroboralfs	Loamy-skeletal	Beach ridge, 5-15 ft local relief	Gray sands and gravels	Oak, aspen, tall grass, pines to east	Marquette
	Haploborolls	Sandy				Lohnes
	Haplaquolls	Coarse-loamy				Hangaard
215	Eutroboralfs	Coarse-loamy	Outwash plain, <5 ft. local relief	Gray outwash	Mixed hardwoods and pine	Dorset
	Eutroboralfs	Loamy-skeletal				Marquette
	Haplaquolls	Coarse-loamy				Forada

Remarks: Unit also contains recent alluvium along streams. Sverdrup and Osakis are also common soils.

216	Udipsamments	Sandy	Drumlins mantled by outwash, 5-15 ft. local relief	Outwash sands	Jack and red pine, some oak	Menahga
	Eutroboralfs	Coarse-loamy				Dorset
	Eutroboralfs	Loamy-skeletal				Marquette

Remarks: The outwash material is a mixture of both red and gray sources.

217	Eutroboralfs	Coarse-loamy	Outwash,. 15-30 ft. local relief	Outwash sands	Oak openings	Dorset
	Eutroboralfs	Loamy-skeletal				Marquette
	Haplaquolls	Coarse-loamy				Forada

Remarks: The outwash material is a mixture of both red and gray sources.

Units 220 to 222 include soils formed in calcareous loamy gray till.

220	Argiborolls	Fine-loamy	Terminal moraine, 5-15 ft. local relief	Gray till	Oak openings, mixed hardwoods, shrubs	Gonvick
	Eutroboralfs	Fine-loamy				Waukon
	Haplaquolls	Fine-silty				Quam

Remarks: Beltrami and Shooker soils are commonly associated in Polk, Norman, and Mahnomen Counties.

221	Eutroboralfs	Fine-loamy	Terminal moraine, 15-30 ft. local relief	Gray till	Oak openings, shrubs, mixed hardwoods	Waukon
	Argiborolls	Fine-loamy				Gonvick
	Haplaquolls	Fine-silty				Quam
222	Eutroboralfs	Fine-loamy	Terminal moraine, 30-45 ft. local relief	Gray till	Oak openings, shrubs	Waukon
	Argiborolls	Fine-loamy				Gonvick
	Borosaprists	Sapric				Cathro

Units 240 and 241 include soils formed from till and outwash on dead-ice moraines.

240	Eutroboralfs	Fine-loamy	Dead-ice moraine, 30-45 ft. + local relief	Gray till and outwash	Mixed hardwoods, oak openings	Waukon
	Eutroboralfs	Loamy-skeletal				Marquette
	Borosaprists	Sapric				Markey

Remarks: This unit shows ice-disintegration features. Coarse-textured soils in this unit will vary from sandy to gravelly, and may or may not be Mollisols. The Borosaprists vary in properties.

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
241	Eutroboralfs Haploborolls Borosaprists	Fine-loamy Sandy-skeletal Sapric	Dead-ice, moraine, 30-45 ft. + local relief	Gray till and outwash	Tall grass prairie, oak openings, mixed hardwoods	Waukon Sioux Cathro

UNITS 300 to 369 ARE DOMINATED BY FOREST SOILS WITH MEAN TEMPERATURES COOLER THAN 47° F.

Units 300 to 305 include soils formed in gray, brown, or red clayey sediments.

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
300	Eutroboralfs Ochraqualfs Borohemists	Very-fine Very-fine Hemic	Lake plain, nearly level, 0-15 ft. local relief	Gray lacustrine sediments	Aspen-birch with understory of black ash, conifers including white cedar	Taylor Indus Mooselake
301	Eutroboralfs Udifluvents	Very-fine Loamy	Lake plain, 0-30 ft. local relief	Gray lacustrine sediments	Aspen-birch	Taylor Udifluvent

Remarks: This unit is a lake plain incised by major rivers, and therefore includes the steep slopes and alluvial areas along the rivers.

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
302	Eutroboralfs Haplaquepts Glossoboralfs	Very-fine Very-fine Fine-silty	Lake plain, nearly level, 0-10 ft. local relief	Red lacustrine sediments	White pine, spruce, fir, aspen-birch	Ontonagon Bergland Campia

Remarks: The red sediments overlie gray sediments in parts of Carlton County. This unit is crossed by deeply incised streams and ravines.

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
303	Eutroboralfs Ochraqualfs Borosaprists	Fine-silty Fine-silty Sapric	Lake plain, nearly level, 0-10 ft. local relief	Gray lacustrine sediments	Aspen-birch, swamp conifers	Baudette Spooner Cathro
304	Glossoboralfs Glossaqualfs Borohemists	Fine-loamy Fine-loamy Hemic	Ground moraine and drumlin, 2 to 15 ft. local relief	Brown and gray till	White pine, aspen-birch	Nashwauk Keewatin Greenwood

Remarks: The surface till was lacustrine sediments that were re-worked and re-deposited by the St. Louis Sublobe of the Des Moines Lobe.

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
305	Glossoboralfs Glossaqualfs Borohemists	Fine-loamy Fine-loamy Hemic	Terminal moraine, 0 to 30 ft. local relief	Brown and gray till	White pine, aspen birch	Nashwauk Keewatin Greenwood

Remarks: This moraine has broken topography indicating direct ice contact and melting.

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES

Units 311 to 318 include soils formed in sandy sediments deposited in an early (Koochiching) phase of Glacial Lake Agassiz, in Glacial Lakes Aitkin and Upham, and in outwash derived from the Des Moines Lobe and its St. Louis Sublobe, and from the Wadena Lobe.

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
311	Udipsamments Udipsamments Psammaquents	Sandy Sandy Sandy	Lake plain, nearly level, 0-10 ft. local relief	Gray lacustrine sediments	Jack pine, aspen, oak, balsam poplar	Hiwood Redby Cormant

Remarks: The sands, after being deposited in a lake, were re-worked by wind. They overlie a bouldery till from 4 to 15 feet below. These soils are analogues of those in units 111 and 211. Here, however, the units include finer textures, organic soils, and rock.

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
312	Haplaquents Psammaquents Borofibrists	Sandy/loamy Sandy Fibric	Lake plain, 2-20 ft. local relief	Gray lacustrine sediments and till	Aspen, jack pine, swamp conifers	Grygla Cormant Borofibrist

Remarks: A till plain whose relief was further subdued by wave action. Unit also contains beaches, spits, strands, and other associated lake features.

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
313	Udipsamments Psammaquents Eutroboralfs	Sandy Sandy Loamy--skeletal	Beach ridges and associated lake plain, 2-20 ft. local relief	Gray lacustrine sediments	Aspen, balsam poplar, swamp conifers	Hiwood Redby Marquette

Remarks: Bouldery till occurs 4 to 15 ft. below the surface materials.

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
314	Udipsamments Udipsamments Borohemists	Sandy Sandy Hemic	Outwash, 0-30 ft. local relief	Predominantly gray outwash	Aspen-birch, jack pine	Menahga Graycalm Mooselake

Remarks: These outwash areas include materials from the Des Moines, Wadena, Rainy, and in some cases Superior Lobes, either as distinct strata or intermixed. A few bedrock outcrops occur in this unit.

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
315	Psammaquents Udipsamments Borohemists	Sandy Sandy Hemic	Lake plain, nearly level, 0-10 ft. local relief	Gray lacustrine sediments	Aspen, swamp conifers, jack pine	Cormant Shawano Mooselake

Remarks: Some of these deposits were reworked by wind to form dunes, now fully stabilized. In places, local relief is >20 ft.

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
316	Udipsamments Udipsamments Psammaquents	Sandy Sandy Sandy	Pitted outwash, 5-15 ft. local relief	Gray outwash	Jack pine	Menahga Meehan Newson
317	Udipsamments Glossoboralfs Borohemists	Sandy Coarse-loamy Hemic	Outwash, 5-15 ft. local relief	Mixed red and gray outwash	Jack pine, white and, red pine	Menahga Chetek Mooselake

Remarks: This outwash was deposited on glacial ice which subsequently melted, "collapsing" the outwash.

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
318	Udipsamments Psammaquents Udipsamments	Sandy Sandy Sandy	Lake plain, nearly level, 0-10 ft. local relief	Red lacustrine deposits	Spruce-fir, white pine	Nemadji Newson Omega

Remarks: This unit is crossed by deeply incised streams and ravines.

Units 320 to 324 include soils formed in thin till over bedrock.

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
320	Fragiochrepts Dystrochrepts Eutroboralfs	Coarse-loamy Loamy Very-fine	Ground moraine over bedrock, 20-75 ft. local relief	Brown till with gray lacustrine deposits	White and red pine, aspen-birch	Conic Insula Taylor

Remarks: The landscape is dominated by the bedrock hills with thin mantles of till. The lower elevations contain lacustrine deposits.

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
321	Fragiochrepts Dystrochrepts Borohemists	Coarse-loamy Loamy Hemic	Ground moraine over bedrock, 20-75 ft. local relief	Brown till	Jack pine, white and red pine	Conic Insula Mooselake

Remarks: Peat bogs occupy former lake basins and drainageways below bedrock hills.

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
322	Udorthents Dystrochrepts Dystrochrepts	Loamy Loamy Coarse-loamy	Ground moraine over bedrock, 15-150 ft. local relief	Brown till or red till	White pine, aspen-birch	Quetico Insula Mesaba

Remarks: The steep bedrock ridges trend east-west along the Canadian border.

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
323	Fragiochrepts Dystrochrepts Udorthents	Coarse-loamy Loamy Loamy	Ground moraine over bedrock, 20-75 ft. local relief	Brown till	Jack pine, white and red pine, aspen-birch	Conic Insula Quetico
324	Dystrochrepts Dystrochrepts Udorthents Eutroboralf	Loamy Coarse-loamy Sandy-skeletal Very-fine	Ground moraine over bedrock, 20-75 ft. local relief	Brown till and outwash and gray lacustrine deposits	Jack pine, aspen-birch, white and red pine	Insula Mesaba Toivola Taylor

Remarks: Outwash and till both mantle the bedrock. Lacustrine sediments occur at lower elevations.

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
325	Fragiochrepts Udorthents Borohemists	Coarse-loamy Sandy-skeletal Hemic	Terminal moraine and outwash, 40-150 ft. local relief	Brown stony till	White pine, aspen-birch, northern hardwoods	Ahmeek Toivola Mooselake

Remarks: These units include some drumlins and flutes (grooves in bedrock formed by glacial ice). Soils that are over bedrock; such as the Quetico, Insula, and Mesaba; and bedrock outcrops are common. These units are the Highland Moraine.

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES

Units 326 to 329 include soils formed in loamy gray and brown till.

326	Eutroboralfs Glossaqualfs Borohemists	Fine-loamy Fine-loamy Hemic	Dead-ice moraine, 2-20 ft. local relief	Mixed gray and brown till	White pine, aspen-birch	Warba Stuntz Mooselake

Remarks: The broken topography of this unit indicates direct ice contact, and melting of ice beneath the till with subsequent readjustment of the landscape. Some drumlins occur in the unit.

327	Eutroboralfs Eutroboralfs Borohemists	Fine-loamy Coarse-loamy Hemic	Dead-ice moraine, 30-45 ft. local relief	Mixed gray and brown till	White pine, northern hardwoods	Warba Heyder Mooselake

Remarks: Broken topography indicates both ice contact and melting of ice beneath the till, with subsequent landscape readjustments.

328	Eutroboralfs Eutroboralfs Ochraqualfs	Fine-loamy Fine-loamy Fine-loamy	Terminal moraine, 5-15 ft. local relief	Gray till with brown inclusions	White pine, aspen-birch	Alstad Cushing Ochraqualf

Remarks: Mooselake is the dominant organic soil in this unit.

329	Eutroboralfs Eutroboralfs Borohemists	Fine-loamy Fine-loamy Hemic	Ground moraine, 15-30 ft. local relief	Gray till with brown inclusions	White pine, aspen-birch	Cushing Alstad Mooselake

Remarks: Some drumlins occur in this unit.

Units 330 to 339 include soils formed in gray and brown sandy and gravelly sediments.

330	Fragiorthods Fragiochrepts Borohemists	Coarse-loamy Coarse-loamy Hemic	Ground moraine over bedrock, 5-25 ft. local relief	Brown till	White pine, aspen-birch	Iron River Ahmeek Greenwood

Remarks: The shape of the bedrock controls the landscape form in this unit.

331	Udorthents Haplorthods Dystrochrepts	Sandy-skeletal Coarse-loamy/sandy Coarse-loamy/sandy	Outwash, 20-50 ft. local relief	Stony brown and some red outwash	Red and white pine, aspen-birch, spruce-fir	Toivola Amasa Cloquet

Remarks: The unit includes the NW-SE trending Vermilion moraine across north St. Louis County.

332	Udipsamments Udipsamments Eutroboralfs	Sandy Sandy Sandy-skeletal	Outwash, 0-30 ft. local relief	Gray outwash	Jack and red pine, aspen-birch	Menahga Graycalm Marquette

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
333	Udipsamments Udipsamments Eutroboralfs	Sandy Sandy Sandy-skeletal	Outwash, 20-100 ft. local relief	Gray outwash	Red and white pine, aspen-birch, spruce-fir	Menahga Graycalm Marquette
Remarks: This outwash was originally deposited on glacial ice which subsequently melted, collapsing the outwash and resulting in substantial relief.						
334	Fragiochrepts Haplaquepts Borohemists	Coarse-loamy Coarse-loamy Hemic	Rolling to steep drumlins, 30-45 ft. + local relief	Brown stony till	Aspen-birch, spruce-fir	Newfound Haplaquept Mooselake
Remarks: This unit includes most of the Toimi Drumlins						
335	Udipsamments Dystrochrepts Dystrochrepts	Sandy Coarse-loamy/ sandy Sandy	Outwash, 5-40 ft. local relief	Predominantly red with some brown stony outwash	Jack pine, white and red pine, aspen-birch	Omega Cloquet Cromwell
Remarks: This outwash was deposited on glacial ice which subsequently melted, collapsing the outwash and leading to substantial relief.						
336	Fragiochrepts Borohemists Haplaquents	Coarse-loamy Hemic Coarse-loamy	Rolling drumlins, 15-35 ft. local relief	Brown till with gray intermixed	Aspen-birch spruce-fir, white pine	Newfound Mooselake Haplaquent
Remarks: The St. Louis Sublobe overrode Toimi Drumlins in the delineated area. The bogs areas are elongated between the drumlins. The northwest part of the unit was affected by Glacial Lake Upham.						
337	Eutroboralfs Borohemists	Coarse-loamy Hemic	Dead-ice moraine, 15-50 ft. local relief	Brown and gray till and outwash	Aspen-birch, northern hardwoods, white pine	Itasca Mooselake
Remarks: Areas may be where St. Louis Sublobe overrode earlier Rainy or Wadena Lobe material. Unit includes both collapsed outwash and till features.						
338	Eutroboralfs Eutroboralfs Haplaquolls	Coarse-loamy Loamy-skeletal Coarse-loamy	Outwash, nearly level, 0-10 ft. local relief	Gray outwash	Jack pine, red pine, aspen-birch	Dorset Marquette Forada
Remarks: Unit includes Menahga and related soils, and stream alluvium. Many flood plains along streams have peat soils.						
339	Eutroboralfs Eutroboralfs Haplaquolls	Coarse-loamy Loamy-skeletal Coarse-loamy	Rolling pitted outwash, 30-45 ft. + local relief	Gray outwash	Northern hardwoods, white pine	Dorset Marquette Forada
Remarks: Outwash probably from both Des Moines and Wadena Lobes.						

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES

Units 340 to 349 include soils formed in sediments from the St. Louis Sublobe, or mixed sediments from the Rainy, Superior, and Wadena Lobes.

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
340	Eutroboralfs Glossaqualfs Borohemists	Fine-loamy Fine-loamy Hemic	Ground moraine, 5-15 ft. local relief	Red stony till	Aspen-birch	Duluth Dusler Mooselake
Remarks: These units contain poorly expressed drumlins.						
341	Fragiochrepts Fragiaqualfs Borohemists	Coarse-loamy Coarse-loamy Hemic	Drumlins, 2-20 ft. local relief	Red stony till	White pine, aspen-birch, northern hardwoods	Ahmeek Ronneby Mooselake
Remarks: These units include the Automba drumlins.						
342	Fragiaqualfs Udorthents Fragiochrepts	Coarse-loamy Sandy-skeletal Coarse-loamy	Terminal moraine, 30-45 ft. + local relief	Red stony till and outwash	Aspen-birch, spruce-fir, white pine	Ronneby Toivola Ahmeek
Remarks: This unit shows ice-contact features.						
343	Eutroboralfs Udipsamments Borohemists	Fine-loamy Sandy Hemic	Dead-ice moraine, 10-35 ft. local relief	Mixed gray and brown till and outwash	White and red pine, aspen-birch	Nashwauk Menahga Mooselake
Remarks: The broken topography of this unit is associated with deposition on or in contact with glacial ice and subsequent melting of that ice.						
344	Fragiboralfs Humaquepts Borohemists	Coarse-loamy Coarse-loamy Hemic	Ground moraine, 5-15 ft. local relief	Red stony till	Spruce-fir, aspen-birch, northern hardwoods	Mora Twig Mooselake
345	Fragiboralfs Fragiboralfs Borohemists	Coarse-loamy Coarse-loamy Hemic	Dead-ice moraine, 15-30 ft. local relief	Gray stony till	White and red pine, northern hardwoods	Rockwood Fragiboralf Mooselake
Remarks: Gray till is of Wadena Lobe origin.						
346	Fragiboralfs Fragiboralfs Borohemists	Coarse-loamy Coarse-loamy Hemic	Dead-ice moraine, 30-45 ft. + local relief	Gray stony till	White and red pine, aspen-birch	Rockwood Fragiboralf Mooselake
Remarks: Gray till is of Wadena Lobe origin.						
347	Fragiboralfs Fragiboralfs Fragiaqualfs	Coarse-loamy Coarse-loamy Coarse-loamy	Drumlins, 15-30 ft. local relief	Gray till	Northern hardwoods	Rockwood Blowers Paddock
Remarks: The Wadena Drumlins. Bogs are common between drumlins and on river flood plains. Rifle is a common Histosol.						

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
348	Eutroboralfs Fragiaqualfs Borohemists	Coarse-loamy Coarse-loamy Hemic	Ground moraine, nearly level, 0-10 ft. local relief	Red stony till	Spruce-fir, aspen-birch	Automba Ronneby Mooselake
349	Glossoboralfs Glossoboralfs Humaquepts	Fine-loamy/sandy Fine-loamy/sandy Coarse-loamy/sandy	Outwash plain, 5-15 ft. local relief	Red stony outwash	White and red pine, aspen-birch, northern hardwoods	Onamia Halder Warman

Units 350 to 353 include soils formed in medium-textured gray till and associated outwash.

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
350	Eutroboralfs Ochraqualfs Eutroboralfs	Fine-loamy Fine-loamy Fine-loamy	Terminal moraine, 5-15 ft. local relief	Gray till	Aspen-birch, northern hardwoods	Beltrami Shooker Nebish

Remarks: Quam and Mooselake soils are common in depressions. In Beltrami County, some soils in the unit have silty and clayey surfaces.

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
351	Eutroboralfs Eutroboralfs Ochraqualfs	Fine-loamy Fine-loamy Fine-loamy	Terminal moraine, 15-30 ft. local relief	Gray till	Aspen-birch, northern hardwoods	Beltrami Nebish Shooker

Remarks: Quam and Mooselake soils are common in depressions. In Beltrami County, some soils in the unit have silty and clayey surfaces.

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
352	Eutroboralfs Eutroboralfs Ochraqualfs	Fine-loamy Fine-loamy Fine-loamy	Terminal moraine, 30 ft. + local relief	Gray till	White and red pine, spruce-fir, northern hardwoods	Nebish Beltrami Shooker

Remarks: Quam and Mooselake soils are common in depressions. In Beltrami County, some soils in the unit have silty and clayey surfaces.

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
353	Eutroboralfs Eutroboralfs Borohemists	Fine-loamy Loamy-skeletal Hemic	Dead-ice moraine, 30-45 ft. local relief	Gray till and outwash	Hardwoods, oak openings	Nebish Marquette Mooselake

Units 354 to 356 include soils formed in outwash, dead-ice moraines, and in material that was directly in contact with melting ice.

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
354	Fragiboralfs Psammaquents Borohemists	Coarse-loamy Sandy Hemic	Drumlins with sandy mantle, 5-15 ft. local relief	Mixed stony brown and gray till and outwash	Jack pine, red pine, aspen-birch, sedge	Rockwood Newson Rifle

Remarks: Sandy mantles on some of the Wadena Drumlins. Histosols (Rifle series) are common between drumlins and along streams.

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
355	Eutroboralfs Glossoboralfs Borohemists	Fine Coarse-loamy Hemic	Dead-ice moraine, 30-45 ft. + local relief	Mixed red and gray till and outwash	White pine, northern hardwoods, aspen-birch	Hibbing Chetek Borohemist
Remarks: Areas in Pine and Carlton Counties contain red till and outwash.						
356	Fragiboralfs Fragiboralfs Udipsamments	Coarse-loamy Coarse-loamy Sandy	Drumlins, 30-45 ft+ local relief	Gray and some red till and outwash	Hardwoods, oak openings	Rockwood Blowers Mahtomedi
Remarks: Primarily till from the Wadena Lobe, with mixing from both the Des Moines and Superior Lobes in some areas.						
Units 361 to 369 include soils formed on moraines, including dead-ice moraines, and drumlins, in brown and red till with some modification of gray till from the Wadena Lobe.						
361	Haplaquolls Fragiaqualfs Haplaquolls	Coarse-loamy Coarse-loamy Coarse-loamy	Irregular ground moraine, 5-15 ft. local relief	Red stony till	White and red pine, northern hardwoods, aspen-birch	Parent Ronneby Prebish
362	Haplaquolls Haplaquolls Borohemists	Coarse-loamy Coarse-loamy Hemic	Low drumlins, <5 ft. local relief	Red stony till	Northern hardwoods, aspen-birch, white pine	Parent Prebish Greenwood
Remarks: Very low-relief Pierz Drumlins, bounded by bogs.						
363	Fragiochrepts Fragiaqualfs Haplaquolls	Coarse-loamy Coarse-loamy Coarse-loamy	Irregular terminal moraine; 15-30 ft. local relief	Red stony till	Northern hardwoods, white pine	Milaca Ronneby Prebish
364	Fragiochrepts Fragiaqualfs Haplaquolls	Coarse-loamy Coarse-loamy Coarse-loamy	Drumlins, 15-30 ft. local relief	Red stony till	Northern hardwoods, white and red pine, oak	Brainerd Nokay Prebish
Remarks: Pierz Drumlins.						
365	Fragiochrepts Fragiaqualfs Haplaquolls	Coarse-loamy Coarse-loamy Coarse-loamy	Drumlins, 30-45 ft. + local relief	Brown stony till	White and red pine, northern hardwoods, aspen-birch	Milaca Ronneby Prebish
Remarks: Pine River Drumlins.						
366	Fragiochrepts Fragiaqualfs Haplaquolls	Coarse-loamy Coarse-loamy Coarse-loamy	Dead-ice moraine, 30-45 ft. + local relief	Brown stony till	White pine, northern hardwoods	Milaca Ronneby Prebish

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
367	Fragiboralfs Eutroboralfs Fragiaqualfs	Coarse-loamy Coarse-loamy Coarse-loamy	Drumlins, long slopes, 40-50 ft. local relief	Brown till over gray	Hardwoods, oak	Holdingford Opole Upsula

Remarks: Darling Drumlins.

369	Fragiochrepts Glossoboralfs Borohemists	Coarse-loamy Coarse-loamy Hemic	Dead-ice moraine, 30-45 ft. local relief	Brown till and outwash	White and red pine, aspen-birch	Brainerd Chetek Mooselake

Remarks: The units include material that was in contact with melting ice.

UNITS 400 TO 427 ARE DOMINATED BY THE DRY PRAIRIE SOILS OF SOUTHWEST MINNESOTA. GYPSUM IS COMMON IN THE WET SOILS. SOIL THICKNESS VARIES SHARPLY WITH TOPOGRAPHY.

400	Haplustolls Haplustolls Haplaquolls	Fine-loamy Fine-loamy Fine-loamy	Ground moraine, 5-15 ft. local relief	Gray till	Tall and mid grass prairie	Normania Ves Canisteo
401	Haplustolls Haplaquolls Haplaquolls	Fine-loamy Fine-loamy Fine	Low relief ground moraine, <5 ft. local relief	Gray till	Tall and mid grass prairie	Normania Canisteo Okoboji
402	Haploborolls Haploborolls Haplaquolls	Fine-loamy Fine-silty Fine-silty	Dissected ground moraine, 5-15 ft. local relief	Loess over dense gray till	Tall and mid grass prairie	Vienna Brookings Hidewood
403	Haploborolls Haplaquolls Haplaquolls	Fine-silty Fine-silty Fine-silty	Level till plain, <5 ft. local relief	Loess over gray till	Tall and mid grass prairie	Brookings Hidewood Marcus
404	Haplustolls Haplustolls Haplaquolls	Fine-silty Fine-silty Fine-silty	Eroded till plain, 15-30 ft. local relief	Loess over gray till	Tall and mid grass prairie	Moody Trent Whitewood
405	Hapludolls Haplaquolls Hapludolls	Fine-loamy Fine-loamy Fine-loamy	Eroded till plain, 15-30 ft. local relief	Loess over gray till	Mid and tall grass prairie	Wilmonton Letri Everly
406	Udorthents Hapludolls Haplaquolls	Fine-loamy Fine-loamy Fine-loamy	Eroded till plain, 15-30 ft. local relief	Gray till	Mid and short grass prairie	Storden Clarion Glencoe

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
407	Haplaquolls Hapludolls Hapludolls	Fine-loamy Fine-loamy Fine-silty	Ground moraine, <5 ft. local relief	Gray till and lacustrine sediments	Tall grass prairie	Webster Nicollet Ransom

Remarks: Waldorf and Collinwood are also common soil series.

408	Hapludolls Haplaquolls Hapludolls	Fine Fine-loamy Fine-loamy	Ground moraine, 15-40 ft. local relief	Gray till	Tall grass prairie	Collinwood Webster Nicollet

Remarks: Landforms in this unit are circular, level-topped hills with simple side-slopes, bounded by broad nearly level and depressional areas.

409	Hapludolls Hapludolls Haplaquolls	Fine-loamy Fine-loamy Fine-loamy	Irregular ground moraine, 5-20 ft. local relief	Gray till	Tall grass prairie	Swanlake Clarion Webster
410	Hapludolls Haplaquolls Hapludolls	Fine-loamy Fine-loamy Fine-loamy	Irregular ground moraine, 15-40 ft.+ local relief	Gray till	Tall grass prairie	Nicollet Canisteo Swanlake

Remarks: Landforms in this unit are circular, level-topped hills with simple side slopes bounded by broad nearly level and depressional areas.

411	Haplaquolls Hapludolls Haplaquolls	Fine-loamy Fine-loamy Fine-loamy	Irregular ground moraine, <5 ft. local relief	Gray till	Tall and mid grass prairie	Canisteo Crippen Jeffers

Remarks: Many soils in this unit contain gypsum crystals.

412	Hapludolls Hapludolls Haplaquolls	Fine Fine-silty Fine	Level ground moraine, <5 ft. local relief	Gray till	Tall and mid grass prairie	Collinwood Ransom Waldorf

Remarks: In Cottonwood County, this unit contains many gypsum crystals. Rushmore and Marna are also common soil series in some areas.

413	Hapludolls Hapludolls Haplaquolls	Fine-loamy Fine-loamy Fine-loamy	Terminal moraine, 5-15 ft. local relief	Gray till	Mid and tall grass prairie	Everly Wilmonton Letri

Remarks: This unit is the northeast-facing slope of the Coteau des Prairie. The regional slope rises 300 to 500 ft. in 2 to 6 miles.

414	Udorthents Hapludolls Hapludolls	Fine-loamy Coarse-loamy/sandy Fine-loamy	Ice contact feature, irregular 30-45 ft.+ local relief	Gray till	Tall grass prairie	Storden Estherville Swanlake

Remarks: The parent material in this unit was directly in contact with melting glacial ice.

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
415	Hapludolls Hapludolls Haplaquolls	Fine-loamy Coarse-loamy Fine-loamy	Dead-ice moraine, 15-30 ft. local relief	Gray till	Tall grass prairie	Nicollet Dickinson Canisteo

Remarks: Similar to unit 512, which is further to the east. The unit has many features associated with melting of underlying ice.

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
416	Hapludolls Hapludolls Haplaquolls	Fine-loamy Fine-loamy Fine-loamy	Irregular ground moraine, 15-30 ft. local relief	Gray till	Mid and tall grass prairie	Swanlake Clarion Delft
417	Hapludolls Haplaquolls Hapludolls	Fine-loamy Fine-loamy Fine-loamy	Irregular ground moraine, 5-15 ft. local relief	Gray till	Mid and tall grass prairie	Nicollet Canisteo Swanlake

Remarks: The Haplaquolls in this unit contain many gypsum crystals.

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
418	Udorthents Haploborolls Haploborolls	Fine-loamy Fine-loamy Fine-loamy	Steep slopes down to river floodplain	Gray till	Mid and tall grass prairie, hardwood forest, riverbottom forest	Langhei Buse Darnen

Remarks: The vegetation varies with the aspect. The river floodplain lies up to 200 ft. below the upland.

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
419	Udorthents Hapludolls Hapludolls	Fine-loamy Fine-loamy Fine-loamy	Steep slopes down to river terraces and floodplains	Gray till	Mid and tall grass prairie, hardwood forest, riverbottom forest	Storden Swanlake Terril

Remarks: The vegetation varies with the aspect. The river floodplain lies up to 250 ft. below the upland. Chaska is a dominant floodplain soil series.

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
420	Ustorthents Haplustolls Haplustolls	Fine-silty Fine-silty Fine-silty	Eroded till plain, 100-150 ft. local relief	Loess	Short, mid, and tall grass prairie	Crofton Nora Alcester
421	Haploborolls Haplaquolls Udifluvents	Fine-silty/ sandy Fine-silty Mixed	Terraces and floodplains, <10 ft. local relief	Gray outwash and till	Tall grass prairie with sedges	Estelline Lamoure Udifluvent
422	Haplustolls Haplustolls	Fine-silty Fine-loamy	Ground moraine and loess over bedrock, 15-30 ft. local relief	Loess or gray till	Short, mid, and tall grass prairie	Ihlen Germantown

Remarks: The bedrock in this unit, Sioux quartzite, is near the surface.

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
423	Udorthents Hapludolls Hapludolls	Fine-loamy Fine-loamy Sandy-skeletal	Ice-contact feature, 30-45 ft. + local relief	Gray till	Mid and tall grass prairie	Storden Swanlake Salida
Remarks: This unit is known as the "blue mounds."						
427	Hapludolls Hapludolls Haplaquolls	Coarse-loamy/sandy Sandy-skeletal Fine-loamy	Valley-trains and floodplains, 5-30 ft. local relief	Gray outwash	Tall grass prairie	Estherville Salida Comfrey

UNITS 500 TO 526 ARE DOMINATED BY MOIST PRAIRIE SOILS WITH MEAN TEMPERATURES WARMER THAN 47° F.

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
500	Haplaquolls Hapludolls Haplaquolls	Fine-loamy Fine-loamy Fine-loamy	Level ground moraine, <5 ft. local relief	Gray till	Tall grass prairie	Webster Nicollet Glencoe
Remarks: In some areas, Canisteo soils are more prevalent than Webster, Okaboji more prevalent than Glencoe, or Cordova more prevalent than Webster. The northeasternmost units supported hardwood forest.						
501	Hapludolls Haplaquolls Hapludolls	Fine-loamy Fine-loamy Fine-loamy	Irregular ground moraine, 5-15 ft. local relief	Gray till	Tall grass prairie	Nicollet Canisteo Swanlake
Remarks: The northeasternmost units supported hardwood and oak forests. These units are crossed by deeply cut stream channels. In some areas, Webster soils are more prevalent than Canisteo.						
502	Hapludolls Hapludolls Haplaquolls	Fine-loamy Fine-loamy Fine-loamy	Irregular rolling to steep terminal moraine, 15-30 ft. local relief	Gray till	Tall grass prairie	Swanlake Clarion Glencoe
503	Hapludolls Haplaquolls Hapludolls	Fine-loamy Fine-loamy Fine-loamy	Irregular ground moraine, 15-30 ft. local relief	Gray till	Tall grass prairie	Nicollet Webster Clarion
Remarks: Landforms in this unit are elliptical hills with simple side slopes bounded by broad level areas. Storden soils are common but of limited area.						
504	Udorthents Hapludolls Hapludolls	Fine-loamy Coarse-loamy/sandy Fine-loamy	Ice-contact feature, 15-30 ft. local relief	Gray till	Mid and tall grass prairie	Storden Estherville Swanlake

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
510	Haplaquolls Haplaquolls Haplaquolls	Coarse-loamy Coarse-loamy Coarse-loamy	Deltaic deposits, 5-15 ft. local relief	Gray lacustrine sediments	Tall grass prairie	Darfur Dassel Fieldon
Remarks: In some places, small knobs of Nicollet soils rise above the sandy areas. Small sand dunes developed in some places.						
511	Hapludolls Hapludolls Haplaquolls	Sandy Coarse-silty Coarse-loamy	Deltaic deposits, 5-15 ft. local relief	Gray lacustrine sediments	Tall grass prairie	Litchfield Grogan Darfur
512	Hapludolls Hapludolls Haplaquolls	Fine-loamy Coarse-loamy Fine-loamy	Dead-ice moraine, 15-30 ft. local relief	Gray till	Tall grass prairie	Nicollet Dickinson Canisteo
Remarks: Similar to unit 415 which is further west. The unit has many features associated with melting of underlying ice.						
513	Hapludolls Hapludolls Haplaquolls	Coarse-sandy Coarse-loamy Fine-loamy/sandy	Outwash and valley train, <5 ft. local relief	Gray outwash	Tall grass prairie and oak openings	Estherville Linder Biscay
514	Hapludolls Hapludolls Argiudolls	Coarse-loamy/sandy Sandy Fine-loamy/sandy	Outwash, 10-40 ft local relief	Gray outwash	Tall grass prairie and oak openings	Estherville Dickman Dakota
Remarks: This outwash was deposited on glacial ice which subsequently melted, "collapsing" the outwash.						
515	Haploborolls Haplaquolls Haploborolls	Sandy Sandy Sandy	Outwash over till, 5-15 ft. local relief	Gray outwash	Hardwoods and tall grass prairie	Hubbard Isan Duelm
516	Haplaquolls Haploborolls Haplaquolls	Fine-loamy/sandy Sandy Fine-silty	Level valley train and floodplain, <5 ft. local relief	Gray outwash	Tall grass prairie	Regal Osakis Colo
Remarks: Hardwoods occur on the northernmost units.						
518	Haplaquolls Ochraqualfs Hapludalfs	Fine-loamy/sandy Fine-loamy/sandy Fine-loamy/sandy	Nearly level outwash and valley train, 0-10 ft. local relief	Gray outwash	Tall grass prairie and oak openings	Marshan Udolpho Hayfield
Remarks: Includes Histosols (Palms, Muskego, and Blue Earth) and some areas of lacustrine sediments.						

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
519	Haploborolls	Sandy	Valley trains,	Gray	Tall grass	Hubbard
	Udipsamments	Sandy	terraces,	outwash and	prairie and	Nymore
	Haplaquolls	Fine-loamy	and flood plains,	alluvium	oak	Comfrey
			<5 ft. local		openings	
			relief			
Remarks: Braided channels are a prominent feature.						
520	Argiudolls	Fine-loamy/	Level outwash	Mixed gray	Oak openings	Dakota
		sandy	with deep	and red	and tall	
	Hapludolls	Fine-loamy/	pits, <10 ft.	outwash	grass prairie	Fairhaven
		sandy	local relief			
	Hapludolls	Coarse-				Estherville
		loamy/sandy				
Remarks: Evidence of braided channels occur in this unit. In some areas silty sediments are dominant, such as the Prairie Creek outwash in Rice County and the Whitewater delta near Elgin in Wabasha County.						
521	Hapludolls	Fine	Lake plain,	Gray	Tall grass	Collinwood
	Haplaquolls	Fine	<5 ft. local	lacustrine	prairie	Waldorf
	Haplaquolls	Fine	relief	sediments		Lura
Remarks: Barbert soils are common in the depressions. The unit includes some deep ice block depressions and sharply incised stream channels.						
522	Haplaquolls	Fine	Lake plain,	Gray	Tall grass	Marna
	Hapludolls	Fine	nearly level,	lacustrine	prairie	Guckeen
	Haplaquolls	Fine	<5 ft. local	sediments		Lura
			relief			
Remarks: The unit includes some deep ice-block depressions and sharply incised stream channels.						
523	Haplaquolls	Fine	Lake plain,	Gray	Tall grass	Marna
	Hapludolls	Fine	nearly level,	lacustrine	prairie with	Guckeen
	Argiaquolls	Fine	<5 ft. local	sediments	sedges	Minnetonka
			relief			
Remarks: Hardwood forests occur on the northern part of the unit. In places up to 10% of the surface is occupied by the Barbert soil in shallow depressions. Cordova soils are also common. The unit includes some deep ice-block depressions and sharply incised stream channels.						
524	Haplaquolls	Very-fine	Lake plain,	Gray	Tall grass	Beauford
	Haplaquolls	Fine	nearly level,	lacustrine	prairie	Lura
	Argiudolls	Fine	<5 ft. local	sediments	with	Shorewood
			relief		sedges	
Remarks: Low rises are often occupied by the Baroda soils. In some places, up to 10% of the surface is occupied by the Barbert soils. The unit includes some deep ice-block depressions and sharply incised stream channels.						
525	Hapludolls	Fine-silty	Lake plain,	Gray	Tall grass	Truman
	Haplaquolls	Fine-silty	<5 ft. local	lacustrine	prairie	Madelia
	Hapludolls	Fine-silty	relief	sediments		Kingston
Remarks: The unit includes some deep ice-block depressions and sharply incised stream channels.						

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
526	Argiaquolls Argiudolls Argiaquolls	Fine Fine Fine-loamy	Lake plain, <5 ft. local relief	Gray lacustrine sediments	Tall grass prairie and oak openings	Minnetonka Shorewood Cordova

Remarks: Hardwood forests occurred in the northern part of this unit. The unit includes some deep ice-block depressions and sharply incised stream channels.

UNITS 600 TO 610 ARE DOMINATED BY SOILS OF THE PRAIRIE-FOREST TRANSITION WITH MEAN TEMPERATURES WARMER THAN 47°F.

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
600	Hapludalfs Argiudolls Haplaquolls	Fine-loamy Fine-loamy Fine-loamy	Terminal moraine, irregular, 5-15 ft. local relief	Gray till	Hardwoods	Lester LeSueur Glencoe
601	Hapludalfs Argiudolls Medisaprists	Fine-loamy Fine-loamy Sapric	Terminal moraine, irregular, 15-30 ft. local relief	Gray till	Hardwoods	Lester LeSueur Palms

Remarks: Cordova is a common soil on the broader summits.

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
602	Hapludalfs Hapludalfs Haplaquolls	Fine-loamy Fine Fine-loamy	Ground moraine, 15-30 ft. local relief	Gray till	Oak openings and tall grass prairie	Lester Kilkenny Webster
603	Argiudolls Argiaquolls Hapludalfs	Fine-loamy Fine-loamy Fine-loamy	Irregular ground moraine, <10 ft. local relief	Gray till	Hardwoods	LeSueur Cordova Lester

Remarks: The landforms of this unit include circular hills with 15-30 ft. relief simple side slopes. Most of the unit is associated with the "Big Woods".

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
604	Hapludalfs Ochraqualfs Argiaquolls	Fine Fine Fine	Terminal moraine, 15-40 ft. local relief	Gray till	Tall grass prairie, hardwoods	Kilkenny Lerdal Minnetonka

Remarks: Hardwoods occur in the eastern units, prairie on the west. The till, high in shale, is mantled with clayey sediments. The majority of the landform has gently undulating hilltops with simple side-slopes. Hills are bounded by broad level areas where large bogs and lakes are common.

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
605	Hapludalfs Ochraqualfs Medihemists	Fine Fine Hemic	Irregular terminal moraine, 15-40 ft. local relief	Gray till	Hardwoods	Erin Lerdal Caron

Remarks: The till high in shale, is mantled with clayey sediments. Most of this unit is associated with the "Big Woods". The majority of the landform has gently undulating hilltops with simple side slopes. Hills are bounded by broad level areas where large bogs and lakes are common.

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
606	Hapludalfs Argiudolls Haplaquolls	Fine-loamy Fine-loamy Fine-loamy	Irregular terminal moraine, 5-15 ft. local relief	Gray till	Tall grass prairie	Koronis Marcellon Glencoe
Remarks:	The gray till is predominantly of Des Moines Lobe origin, but has some admixture of Wadena and Superior Lobe material.					
607	Hapludalfs Argiudolls Medisaprists	Fine-loamy Fine-loamy Sapric	Irregular terminal moraine, 15-30 ft. local relief	Gray till	Hardwoods, tall grass prairie	Koronis Marcellon Palms
Remarks:	The gray till is predominantly of Des Moines Lobe origin, but has some admixture of Wadena and Superior Lobe material. The hardwoods occur on the northern parts of this unit; the prairie to the south.					
608	Hapludalfs Argiudolls Borosaprists	Fine-loamy Fine-loamy Sapric	Irregular terminal moraine, 15-30 ft. local relief	Gray till	Hardwoods, oak openings	Lester LeSueur Cathro
Remarks:	The till is predominantly from the Des Moines Lobe, but contains an admixture of material from the Wadena and Superior Lobes.					
610	Haplaquolls Hapludolls Hapludalfs	Fine-silty Fine-loamy Fine-loamy	Ground moraine, 5-15 ft. local relief	Gray till	Tall grass prairie, oak openings	Maxcreek Merton Blooming
Remarks:	This unit commonly has a silty or a loamy upper mantle. A stoneline separates the mantle from the till below.					

UNITS 700 TO 720 ARE DOMINATED BY FOREST SOILS OF EAST-CENTRAL MINNESOTA.

700	Ochraqualfs Hapludalfs Argiaquolls	Fine-loamy Fine-loamy Fine-loamy	Irregular ground moraine, <5 ft. local relief	Gray till	Hardwoods	Dundas Nessel Cordova
Remarks:	Although predominantly gray till from the Grantsburg Sublobe of the Des Moines Lobe, there is some mixing with material from the Wadena and Superior Lobes.					
701	Hapludalfs Hapludalfs Ochraqualfs	Fine-loamy Fine-loamy Fine-loamy	Irregular ground moraine, 5-15 ft. local relief	Gray till	Hardwoods	Hayden Nessel Dundas
Remarks:	Predominantly Des Moines Lobe till, but with some mixing with material from the Wadena and Superior Lobes. Barbert and Rolfe soils occur in some depressions.					

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
702	Hapludalfs Argiaquolls Medihemists	Fine-loamy Fine-loamy Hemic	Irregular terminal moraine, 15-30 ft. local relief	Gray till	Hardwoods, oak openings	Hayden Hamel Caron
Remarks: Predominantly Des Moines Lobe till, but with some mixing with material from the Wadena and Superior Lobes.						
703	Hapludalfs Argiaquolls Medihemists	Fine-loamy Fine-loamy Hemic	Irregular terminal moraine, 30-45 ft. + local relief	Gray till	Hardwoods, oak openings	Hayden Hamel Caron
Remarks: Sandy, gravelly, and stony features associated with melting ice are common in Elysian moraine. The material is predominantly from the Des Moines Lobe, but in places material from the Wadena and Superior Lobes is intermixed.						
704	Hapludalfs Eutroboralfs Hapludalfs	Fine-loamy Coarse-loamy Fine-loamy	Irregular terminal moraine, 5-15 ft. local relief	Gray till	Northern hardwoods	Hayden Heyder Nessel
Remarks: The material is predominantly from the Des Moines Lobe, but will contain material from the Wadena and Superior Lobes.						
705	Hapludalfs Hapludalfs Medihemists	Fine-loamy Coarse-loamy Hemic	Irregular terminal moraine, 15-30 ft. local relief	Gray till	Hardwoods, oak openings	Hayden Kingsley Caron
Remarks: The material is predominantly from the Des Moines Lobe, but may contain some material from the Wadena and Superior Lobes.						
706	Eutroboralfs Hapludalfs Hapludalfs	Coarse-loamy Coarse-loamy Fine-loamy	Terminal moraine, 15-30 ft. local relief	Gray till	Oak openings, hardwoods	Heyder Burnsville Hayden
Remarks: The material is predominantly from the Des Moines Lobe, but may contain some material from the Wadena and Superior Lobes.						
707	Eutroboralfs Hapludolls Udorthents	Coarse-loamy Sandy Sandy-skeletal	Dead-ice moraine, 30-45 ft. + local relief	Gray till and outwash	Oak openings, hardwoods	Heyder Hawick Emmert
Remarks: The unit contains outwash that has "collapsed" following melting of ice from beneath it, and material with evidence of having been in contact with melting ice. Some units contain steep bedrock slopes. Some mixing of material from the Wadena and Superior Lobes into Des Moines Lobe material has occurred. In central Meeker County, the unit has 15-30 ft. local relief and is underlain by till.						

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
708	Hapludalfs Udipsamments Glossoboralfs	Coarse-loamy Sandy Fine-loamy	Dead-ice moraine, 15-30 ft. local relief	Brown and red till and outwash	Oak openings, hardwoods	Kingsley Mahtomedi Santiago

Remarks: Minor inclusions of gray parent material also occur in this unit.

709	Hapludalfs Udipsamments Udorthents	Coarse-loamy Sandy Sandy-skeletal	Dead-ice moraine, 30-45 ft. + local relief	Brown and red till and outwash	Hardwoods, oak openings	Kingsley Mahtomedi Emmert

Remarks: Near Newport this unit contains steep bedrock slopes.

710	Eutroboralfs Eutroboralfs Udipsamments	Fine-loamy Sandy Sandy	Dead-ice moraine, 30-45 ft. + local relief	Brown till and outwash	Hardwoods	Collegeville DeMontreville Mahtomedi
711	Udipsamments Udipsamments Borohemists	Sandy Sandy Hemic	Undulating outwash plain, 5-15 ft. local relief	Gray outwash	Oak openings, shrubland	Zimmerman Sartell Rifle

Remarks: Most of this unit is a major part of the Anoka Sand Plain.

712	Borohemists Haplaquolls Udipsamments	Hemic Sandy Sandy	Outwash plain, 0-15 ft. local relief	Gray outwash	Oak openings, fen, willow shrubs	Rifle Isanti Lino

Remarks: A major unit of the Anoka Sand Plain. The outwash plain in this unit contains peat-filled depressions that were formed by melting blocks of ice or were channels for outwash streams.

713	Glossoboralfs Glossoboralfs Udipsamments	Fine-silty/sandy Coarse-loamy Sandy	Outwash, 15-30 ft. local relief with extremes of 5 to 50 ft.	Gray and red outwash	Oak openings, hardwoods	Antigo Chetek Mahtomedi

Remarks: This outwash was deposited on glacial ice, which then melted, "collapsing" the outwash.

714	Glossoboralfs Glossoboralfs Glossoboralfs	Fine-silty/sandy Fine-silty Coarse-loamy	Outwash plain, 0-20 ft. local relief	Gray silt over outwash	Oak openings, hardwoods	Antigo Comstock Anoka

Remarks: This unit has a silty or sandy mantle of aeolian or lacustrine origin. Circular hills with level tops and simple sideslopes occur in this unit.

716	Eutroboralfs, Glossoboralfs Glossoboralfs	Sandy Coarse-loamy Coarse-loamy	Outwash plain, 5-15 ft. local relief	Brown and gray outwash	Oak openings, hardwoods	DeMontreville Chetek Rosholt

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
717	Udipsamments	Sandy	Outwash plain	Gray outwash	Hardwoods,	Nymore
	Hapludalfs	Coarse-loamy	and valley train,		oak openings	Burnsville
	Hapludolls	Coarse-loamy/sandy	5-15 ft. local relief to 30 ft. in some areas			Estherville

Remarks: Hardwoods are more common on the westernmost part of this unit. Local areas may have inclusions of coarse-loamy till. Underlying bedrock controls the landforms in the St. Cloud area.

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
718	Hapludalfs	Coarse-loamy	Outwash plain,	Gray	Oak	Burnsville
	Hapludolls	Sandy	5-15 ft. local	outwash	openings	Hawick
	Udipsamments	Sandy	relief			Nymore
720	Eutroboralfs	Fine	Lake plain,	Gray	Northern	Dalbo
	Ochraqualfs	Fine	<10 ft. local	lacustrine	hardwoods,	Brickton
	Borohemists	Hemic	relief	sediments	aspen-birch	Mooselake

Remarks: Glacial Lake Grantsburg.

UNITS 800 TO 913 ARE SOILS OF SOUTHEAST MINNESOTA.

Units 800 through 807 include soils formed in a silty or loamy mantle over an eroded till, residuum, or bedrock surface. The area has mature relief. The eroded surface (lag) under the mantle is sandy and gravelly with cobbles and boulders. A few very large boulders occur on the landscape. Evidence of soil displacement due to ice (ice wedges) are common, and some paleosols occur.

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
800	Hapludolls	Fine-loamy	Eroded	Loess or loamy	Tall grass	Ostrander
	Hapludolls	Fine-silty/sandy	till plain, 20-40 ft.	sediment over gray and/or	prairie, oak openings,	Waukegan
	Hapludolls	Fine-silty/sandy	local relief	red till and bedrock	hazel brushland	Baytown

Remarks: The till plains have eroded surfaces and are mantled with varying thicknesses of erosional debris (stony material). The unit also includes bedrock exposures. Ripon, Channahon, Gale and Etter series occur as soils shallow to bedrock. The drainage system is integrated.

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
801	Hapludolls	Fine-loamy	Eroded till	Loess or	Tall grass	Ostrander
	Hapludolls	Fine-silty	plain, 20-40	loamy	prairie	Klinger
	Haplaquolls	Fine-silty	ft. local relief	sediments over dense gray till		Maxfield

Remarks: There is varying thicknesses of erosional sediments between the loess or sediment and the underlying till. The integrated drainage system is not incised upslope from major drainways.

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
802	Hapludalfs	Fine-loamy	Eroded till	Loess or	Tall grass	Kasson
	Haplaquolls	Fine-silty	plain,	loamy	prairie,	Maxfield
	Hapludalfs	Fine-loamy	20-40 ft. local relief	sediments over dense gray till	oak openings, hazel shrubland	Dowagiac

Remarks: The till plain shows some dead-ice features, such as kames. An integrated, unincised drainage system has developed. Leached lacustrine silts and clays occur below the stone line in many areas of upper drainageways. Paleosols occur randomly in the unit.

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
803	Hapludalfs Haplaquolls Hapludalfs	Fine-loamy Fine-silty Fine-loamy	Eroded till plain, 20-40 ft. local relief	Loess or loamy sediments and erosional lag over dense gray till	Oak openings, tall grass prairie, hazel brushland	Kasson Maxfield Dowagiac

Remarks: The till plain shows dead-ice features, such as kames. Some areas have limestone within 40 inches. Karsts are common in Fillmore County. The drainage system is integrated, but is modified in places by karst topography.

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
804	Haplaquolls Ochraqualfs Hapludalfs	Fine-silty Fine-loamy Fine-loamy	Level till plain, <5 ft. local relief	Loess or loamy sediments and erosionsal lag over dense gray till	Tall grass prairie, oak openings, hazel brushland	Maxfield Skyberg Kasson

Remarks: The integrated drainage system is not incised upslope from major drainways.

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
805	Haplaquolls Hapludalfs Ochraqualfs	Fine-silty Fine-loamy Fine-loamy	Eroded till plain, 20-40 ft local relief	Loess or loamy sediments and erosionsal lag over dense gray till	Tall grass prairie, hazel brushland	Maxfield Kasson Skyberg

Remarks: Leached lacustrine silts and clays occur below the stone line in many areas of upper drainageways. The integrated drainage system is not incised upslope from major drainways.

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
806	Ochraqualfs Glossaqualfs Hapludalfs	Fine-loamy Fine-loamy Fine-loamy	Eroded till plain, 5-15 ft local relief	Loess or loamy sediments over dense gray till	Oak openings, hazel shrubland, tall grass prairie	Skyberg Sargeant Vlasaty

Remarks: The integrated drainage system is not incised upslope from major drainways. The erosional lag is more sandy with more variable thickness than in other units. Paleosols are a common subsoil in some areas. Soils shallow to bedrock or residuum are near some streams.

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
807	Argiudolls Argiudolls Hapludolls	Loamy Fine-loamy Sandy	Level ground moraine over bedrock, 1-10 ft, local relief	Gray till and outwash and residuum	Oak openings, tall and mid grass prairie, hardwoods	Channahon Atkinson Sparta

Remarks: Karsts are weakly developed in this unit. Some bedrock slopes are steep. Unit also includes floodplain and terrace soils. The integrated drainage system is modified by karst topography in some areas.

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES

Units 900 through 913 include upland soils formed on mature relief in loess, or in loess over bedrock, residuum, or glacial till. The units also include soils on valley walls, terraces, and floodplains.

900	Hapludolls Eutrochrepts Udorthents	Fine-silty Coarse-silty Coarse-silty	Loess mantled bedrock or ground moraine over bedrock, local relief is 5-10 ft on crests, 20-40 ft on ridge flanks.	Loess	Tall grass prairie, oak openings, hardwoods	Port Byron Timula Bold

Remarks: This unit is a loess-mantled eroded till plain with Udorthents on points of ridges. Units in Olmsted County have rolling, irregular relief. Mt. Carroll and Port Byron soils occur in association. The drainage system is integrated.

901	Hapludalfs Hapludolls Hapludalfs	Fine-silty Fine-silty Fine-silty	Loess mantled bedrock or ground moraine over bedrock, local relief is 10-20 ft on crests, 30-60 ft on ridge flanks.	Loess	Oak openings, hardwoods, tall grass prairie	Seaton Joy Dubuque

Remarks: Residual material or pedisediments from the Galena formation usually have more angular fragments and are thinner than those from the Oneota dolomite. The drainage system is integrated.

902	Hapludolls Hapludolls Hapludolls	Fine-loamy Loamy-skeletal Fine-loamy/sandy	Unglaciated or lightly glaciated upland slopes, glacial terraces and floodplains.	Gray colluvium and outwash	Hardwoods, short and mid grass prairie	Frontenac Brodale Waukee

Remarks: Local relief is 0-10 ft on terraces and floodplains, 40-100 ft on foot and toe slopes, and 100-300 ft on valley wall slopes. Some terraces are separated by steep scarp slopes. Arenzville and Spillville series are common on the floodplain. The drainage system is integrated.

903	Hapludalfs Haplaquolls Hapludolls	Fine-silty Fine-silty Fine-silty	Eroded till plain and bedrock, 10-20 ft. local relief on crest, 30-60 ft. on ridge flanks.	Loess and loess over gray till	Tall grass prairie, and hardwoods	Mt. Carroll Garwin Port Byron

Remarks: Seaton soils fringe the steep slopes and ravines. Bedrock is near the surface at points of ridges. The drainage system is integrated.

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
904	Hapludalfs Hapludalfs Hapludolls	Fine-silty Fine-loamy Sandy	Eroded till plain and bedrock, 30-50 ft. local relief.	Loess, gray till, sandstone and limestone residuum.	Oak openings, tall grass prairie	Seaton Renova Bellechester

Remarks: The Boone and Hixton soils are common on the sandstone knolls. Wet drainways contain Garwin and Clyde soils; Floyd soils occur on some lower convex slopes. Lilah soils are on kames. Red till is exposed in some roadcuts. The drainage system is integrated.

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
905	Hapludalfs Hapludalfs Paleudalfs	Fine-silty Fine-silty Fine-silty	Unglaciated or lightly glaciated uplands, 10-20 ft. local relief on crests, 30-60 ft. on ridge flanks.	Loess or loess over residuum or thick pedisediments	Hardwoods	Mt. Carroll Newhouse Valton

Remarks: A mature integrated drainage system has developed. The underlying bedrock is Oneota dolomite. The Seaton soil is dominant in some areas. Texture of the residuum ranges from clay to sand and becomes more intermixed downslope. In western Winona County, patches of gray till underlie the loess.

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
906	Hapludalfs Hapludalfs Paleudalfs	Fine-silty Fine-silty Fine-silty/ clayey	Unglaciated or lightly glaciated uplands, 10-20 ft. local relief on crests, 30-60 ft. on ridge flanks.	Loess and residuum	Hardwoods, oak openings, hazel shrubland, tall grass prairie	Seaton Blackhammer Southridge

Remarks: Palsgrove and New Glarus soils fringe the upper edges of steep slopes. Port Byron, Mt. Carroll and associated soils occur in areas of former prairie or oak openings. A mature integrated drainage system has developed. The underlying bedrock is Oneota dolomite. Inlier mesas of Galena formation are bounded by nearly vertical St. Peter sandstone scarps and loamy footslopes. Mt. Carroll, Frankville, and Massbach soils occur on the mesa summits.

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
907	Hapludalfs Hapludalfs Hapludalfs	Fine-silty Fine-silty Loamy	Lightly glaciated uplands	Loess and loamy pedisediments	Hardwoods, oak openings	Seaton Dubuque Channahon

Remarks: The drainage system is integrated but modified by karst topography

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
908	Hapludalfs Argiudolls Hapludalfs	Fine-silty Fine-loamy Fine-loamy	Unglaciated or lightly glaciated uplands, 10-20 ft. local relief on crests, 30-60 ft. on ridge flanks.	Loess, gray till	Oak openings, short, mid, and tall grass prairie, hardwoods	Mt. Carroll Atkinson Racine

Remarks: The unit is a mixture of thick loess, thin loess over limestone or sandstone, and isolated patches of loamy sediment over gray till. The landscape is crossed in places by deeply incised streams and ravines. Bedrock is the transition from eroded Prairie du Chien to the St. Peter-Platteville complex. The drainage system is integrated.

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
911	Udipsamments Hapludolls Humaquepts	Sandy Coarse-loamy Sandy	Level outwash, 0-10 ft. local relief	Gray outwash	Tall grass prairie, oak openings	Plainfield Minnieska Newton
912	Fluvaquents Udifluvents Hapludolls	Fine-silty Fine-silty Coarse-loamy	Terraces and floodplains, <5 ft local relief	Gray outwash and alluvium	Tall grass prairie	Mound Prairie Rawles Minnieska

Remarks: Includes clayey and sandy terraces, and medium-textured colluvium. Steep scarp slopes separate some terraces.

MAP SYM-BOL	DOMINANT GREAT GROUPS	FAMILY TEXTURE	LANDFORM	PARENT MATERIAL	ORIGINAL VEGETATION	REPRE-SENTATIVE SERIES
913	Udifluvents Fluvaquents Haplaquolls	Sandy Coarse-silty Fine-loamy	Floodplains, <5 ft. local relief	Alluvium	Sedges, willows	Arenzville Newalbin Comfrey

Remarks: This unit also includes unclassified material in the Mississippi River backwater, dam pools, dredge spoil, and point bars.

INTERPRETATIONS

Interpretations are evaluations of the usefulness of a specific soil for an intended purpose. At the broad level of this state map, specific on-site interpretations are not possible. However, general statements about some soil uses can be made. For example, in the explanation of the legend, some interpretive statements were made, such as the presence of a subsurface horizon poorly penetrated by water and roots in soils whose great group names begin with *Fragi* . . .

Increasingly more detailed interpretations for soils in the state can be found by referring to the Soil Atlas Series, maps of the state at 1:250,000 scale, with accompanying text. The University of Minnesota, Department of Soil Science, should be contacted about maps in this series. The most detailed soil maps, and those from which the most detailed interpretations can be made, are found in soil survey reports for specific counties. Many counties in the state are already mapped, and mapping is currently underway in many more. Information on the availability of county soil surveys can be obtained from either the University of Minnesota or the USDA Soil Conservation Service.

Although they must be considered only very general statements, Table 1 presents the interpretations for soil groups to be found on the map. The table is first arranged alphabetically by soil great group, as found in the legend. The next division is texture, which aggregates the texture categories from the legend into three broad groups, coarse, or the sandy textural class; medium, including coarse and fine-loamy and coarse and fine-silty; and fine, including both fine and very-fine.

The general supplying capacity of the soil for water and nutrients to growing plants is listed next. The water-supplying capacity includes the categories wet, high, medium, and low. The wet category infers the presence of a water table, or saturated zone, at the soil surface during wet seasons. The other three categories are relative amounts of water that the soil can store for plants within the normal depth of rooting.

Nutrient-supplying capacity to plants is indicated in three categories of high, medium, and low. Both the water and nutrient supplying capacities infer soils in the native state, without management such as drainage, irrigation, or addition of fertilizers.

The permeability of the soil relates to its ability to conduct water. This permeability is related to the texture of the soil and the presence of impermeable horizons. The term in this column; high, moderate, or low; is exclusive of the influence of a seasonal water table, although in many cases permeability may affect presence and duration of saturated zones.

The column termed "roadfill" relates to the suitability of the soil material for excavation in one place and use in road embankments in another place. These ratings are based on the texture of the material, the ease of excavation as affected by high water table or other factors, and on observed performance.

One of the key characteristics of a soil that affects many of its uses is its landscape position. Because of the many possible combinations of great group, texture, and landscape, the effect of landscape could not be briefly summarized in a table. The interpretations in Table 1 are general, and must be adjusted for specific sites.

Table 1. General Interpretations for Soils on Map "Soils and Land Surfaces of Minnesota"

		Supplying Capacity[2]			
Great Group	**Texture[1]**	**Water[3]**	**Nutrients**	**Permeability[4]**	**Road-fill[5]**
Albaqualf	fine	wet	high	low	poor
Argialboll	fine	wet	high	low	poor
Argiboroll	medium	high	high	moderate	fair
Argiudoll	medium	high	high	moderate	fair
	fine	medium	high	low	poor
Borohemist	hemic	wet	medium	low	poor
Borosaprist	sapric	wet	medium	low	poor
Calciaquoll	coarse	wet	medium	high	fair
	medium	wet	high	moderate	fair
	fine	wet	high	low	poor
Dystrochrept	coarse	low	low	moderate	good
	medium	high	low	moderate	fair
Eutroboralf	medium	high	high	moderate	fair
	fine	medium	high	low	poor
Eutrochrept	medium	high	high	moderate	fair
Fluvaquent	medium	wet	medium	moderate	poor
Fragiaqualf	medium	wet	medium	low	fair
Fragiboralf	medium	high	medium	low	fair
Fragiochrept	coarse	low	low	low	good
	medium	high	medium	low	fair
Fragiorthod	coarse	medium	low	low	good
	medium	high	medium	low	fair
Glossaqualf	medium	wet	low	moderate	poor
Glossoboralf	medium	high	low	moderate	fair
Haplaquent	coarse	wet	low	moderate	poor
Haplaquept	medium	wet	medium	moderate	poor
	fine	wet	high	low	poor
Haplaquoll	coarse	wet	medium	high	fair
	medium	wet	high	moderate	poor
	fine	wet	high	low	poor
Haploboroll	coarse	low	medium	high	good
	medium	high	high	moderate	poor
	fine	medium	high	low	poor
Haplorthod	coarse	medium	low	moderate	good
	medium	high	medium	moderate	fair
Hapludalf	medium	high	medium	moderate	fair
	fine	medium	low	low	poor
Hapludoll	coarse	low	medium	high	good
	medium	high	high	moderate	fair
	fine	medium	high	low	poor
Haplustoll	medium	medium	high	moderate	poor

Great Group	Texture[1]	Supplying Capacity[2] Water[3]	Supplying Capacity[2] Nutrients	Permeability[4]	Road-fill[5]
Humaquept	coarse	wet	low	moderate	poor
	medium	wet	medium	moderate	poor
	fine	wet	high	low	poor
Medihemist	hemic	wet	medium	low	poor
Medisaprist	sapric	wet	high	low	poor
Ochraqualf	medium	wet	medium	moderate	poor
	fine	wet	high	low	poor
Psammaquent	coarse	wet	low	high	fair
Sphagnofibrist	fibric	wet	low	high	poor
Udifluvent	medium	high	medium	moderate	fair
	fine	medium	high	low	poor
Udipsamment	coarse	low	low	high	good
Udorthent	medium	high	medium	moderate	fair
Ustorthent	medium	medium	medium	moderate	poor
Vermiboroll	medium	high	high	moderate	poor

[1]coarse = sandy; medium = loamy and silty; fine = clayey
[2]supplying capacity, within rooting zone, to growing plants
[3]wet infers saturated zone at the soil surface during wet seasons
[4]exclusive of influence of saturated zone
[5]suitability for fill, road beds, and similar uses

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Minnesota soils

The map described here presents information on soils and land surfaces of Minnesota at a scale of 1:1,000,000. An even more general approach to soils of Minnesota can be found in an earlier map that is out of print, but may be available in libraries:

Arneman, H. F. 1963. Soils of Minnesota. 1:2,000,000 map and text. Univ. Minn. Agric. Ext. Bull. 278. 8p.

A considerably more detailed series of maps of Minnesota soils, with explanatory text, are the Soil Atlas Series, published by the University of Minnesota Agricultural Experiment Station.These maps, at four times the detail of our general map (1:250,000), cover the state in eleven sheets. Information concerning their availability can be obtained from the University of Minnesota, Department of Soil Science, 1529 Gortner Avenue, St. Paul, MN 55108.

Even more detail is available from soil maps of individual counties, which range in scale from four inches per mile (1:15,840) to about three inches per mile (1:24,000). Unfortunately, not all counties in the state have been mapped. Details on the mapping status, and on availability of county soil maps, are available from either the Department of Soil Science, address above, or from the USDA Soil Conservation Service, 316 South Robert, St. Paul, MN 55101.

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GLOSSARY

Acid soil is specifically a soil with a pH below 7.0 but for most practical purposes, a soil with a pH below 6.6.

Aggregates are masses or clusters of individual soil particles, either produced naturally (peds) or by tillage operations (clods).

Alluvium is material, such as sand, silt, or clay, deposited on land by streams. In the context of this map, it refers to material deposited during the post-glacial period.

Alkaline soil is specifically a soil that has a pH > 7.0, but for most practical purposes, a soil with a pH > 7.4.

Argillic horizon is a subsurface horizon formed by the illuviation of crystalline clay.

Aspect is the compass direction which a slope faces.

Bases in soil are usually considered to be calcium, magnesium, potassium, and sodium ions.

Beach ridges are elevated gravelly landforms that once were beaches of glacial lakes.

Bedrock is the solid rock that underlies the soil or that is exposed at the surface.

Bog is a peatland dominated by mosses, especially Sphagnum.

Braided channels or streams are systems of streams that subdivide and detour, in a complex pattern, around low alluvial islands such as sand and gravel bars.

Brown drift is glacial drift whose origin was from ice flowing from north-northeast of Minnesota. The most recent lobe from that direction was the Rainy Lobe.

Brushland refers to a vegetation type dominated by tall shrubs such as hazel and willow, with interspersed grasses and forbs.

Clay is a soil separate with the mineral soil particles less than 0.002 millimeter in diameter.

Coarse-textured (light-textured) soil contains large quantities of sand particles.

Cobbles are rounded or partly rounded fragments of rock 3 to 10 inches in diameter.

Collapsed outwash is outwash that was deposited atop glacial ice. After the ice melted, the outwash "collapsed" into a broken topography.

Colluvium is soil material, rock fragments, or both moved by creep, slide, or local wash and deposited at the bases of steep slopes.

Coteau des Prairies is a topographic high extending northwest to southeast across the southwest corner of Minnesota. It diverted glaciers during their advance.

Dead-ice moraine is a moraine formed by glacial debris deposited atop glacial ice. The ice core of the moraine melted very slowly, so that landscape features such as streams and lakes were formed on the surface and persisted for thousands of years. As the ice core melted, the surface topography was altered and disrupted, leading to an irregular surface with a variety of materials.

Deltaic deposits are related to deposition as a delta. In the context of this map, deposition usually occurred in glacial lakes.

Drift is all mineral material—clay, sand, gravel, boulders—transported and deposited by a glacier or its meltwater.

Drumlins are low, elongated mounds of till, shaped by the flow of the ice sheet above them.

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

Erosional lag is a layer of coarse fragments, such as sand and gravel, remaining on the surface after fine particles have been removed by erosion. This layer may be subsequently buried by deposition of other material.

Esker is a long, low, steep-sided, winding ridge of partially sorted till, deposited on the bed of a stream in a tunnel under stagnant ice.

Fen is a peatland dominated by sedges, reeds, and grasses. It may contain some shrubs such as willow and alder.

Fibric soil material is the least decomposed of all organic soil material. It contains a large amount of well-preserved fiber that is readily identifiable according to botanical origin.

Fine-textured (heavy-textured) soil contains large quantities of the fine soil particles, silt and clay.

First bottom is the normal flood plain of a stream, subject to frequent or occasional flooding.

Flood plain is a nearly level alluvial plain that borders a stream and is subject to flooding unless protected artificially.

Fluvial is associated with flowing waters. In the context of this map, it usually refers to glaciofluvial deposits, or deposits from water flowing from melting glaciers.

Foot slope is the inclined surface at the base of a hill.

Formation is an assemblage of rocks with some character in common, used for convenience in description and mapping.

Galena formation is a thick (approximately 175 ft.) formation of shales and limestone, exposed in southeastern Minnesota. It was deposited about 450 million years ago, and lies above the Platteville formation.

Glacial lake is a lake formed during glaciation, usually because drainways were blocked by glacial ice.

Ground moraine is glacial debris, consisting chiefly of unsorted material, that is widely distributed and has a gently irregular surface. The debris is deposited underneath and at the margin of a glacier.

Gypsum is $CaSO_4$, and crystals are found in locations in southern and western Minnesota where subsurface water is "wicked up" to dry on the soil surface, usually on the fringe of low areas.

Hardwoods in the context of this map refer to a vegetation type dominated by mesic hardwoods typical of the central United States, with tree species such as sugar maple, basswood, hickory, elm and white oak.

Hemic soil material is organic soil material intermediate in degree of decomposition between the less decomposed fibric and the more decomposed sapric material.

Ice-contact feature is an area in which outwash was directly in contact with glacial ice. After the ice melted the outwash slumped, resulting in irregular topography. In the context of this map, it is related to but smaller in area than a dead-ice moraine.

Ice wedges are wedge-shaped masses of ice that form in soil under freezing conditions, often near glaciers. After the ice melts, the resulting cavity is filled by soil materials.

Illuviation is the process of deposition of material moved from an upper to a lower soil horizon.

Incised drainways are stream networks that are deeply cut into the underlying bedrock or unconsolidated material.

Infiltration is the downward entry of water into the soil.

Integrated drainage is a unified network of streams with regular courses, often controlled by the structure of the underlying bedrock, with many tributaries and few swamps. It develops in older mature landscapes.

Kame is a rise of poorly sorted drift deposited at the edge of melting glacial ice.

Karst-terrain is a topography formed over limestone or dolomite with caves, sinkholes, and underground drainage.

Lacustrine deposits are materials ranging from fine clay to sand derived from glaciers and deposited in glacial lakes, mainly by glacial melt water. Many deposits are interbedded or laminated.

Lake plain is a level area which was once the bed of a glacial lake.

Leaching is the removal of materials in solution by water percolating through the soil.

Lime refers to the presence of calcium carbonate in the soil. Soil horizons with lime are alkaline.

Loam is mineral soil material that has an intermediate mixture of sand, silt, and clay particles.

Local relief is the relative difference in landscape elevation that can be found within approximately 160 acres. It generally applies to about 80% of the mapped area.

Loess is fine windblown dust (dominantly silt) transported from outwash or alluvial plains.

Mantle is usually a surface layer of material of different texture than the underlying material.

Microorganisms include fungi, bacteria, and actinomycetes in soil.

Microrelief is small-scale elevation differences, usually measured in inches.

Moraine is unconsolidated rock and mineral debris deposited by glacial ice.

Northern hardwoods in the context of this map refer to a vegetation type typically found in the northern United States and southern Canada, with tree species such as sugar maple, basswood, yellow birch, and red oak.

Oneota dolomite is a relatively thick (approximately 100 ft.) drab to buff-colored medium-grained dolomite exposed in southeastern Minnesota. It is the lower member of the Prairie du Chien group, laid down about 500 million years ago.

Outcrop is an exposure of a part of the continuous solid rock of the earth's crust.

Outwash is stratified sand and gravel produced by glaciers and carried, sorted, and deposited by glacial meltwater.

Outwash plain is a plain formed by deposition of sorted and stratified material by glacial meltwaters.

Paleosol is a soil formed on a landscape in the geologic past; hence its properties may not reflect current conditions.

Peatland is a general term that includes all peat-covered terrain.

Peat is an organic soil consisting largely of undecomposed or only slightly decomposed organic matter accumulated under conditions of excessive moisture.

Pedisediment is a layer of sediment, usually alluvium, that mantles a former erosion surface at the foot of a slope.

Permeability is the quality of the soil that enables water to move downward through it.

pH, soil is the degree of acidity or alkalinity expressed by the negative logarithm of the hydrogen-ion activity of a soil.

Pitted outwash plain is a plain composed of glacial sand and gravel and containing small pits left by the melting of enclosed ice blocks.

Platteville formation is a thin (approximately 30 ft.) formation of alternating beds of dolomitic limestone and shale, exposed in southeastern Minnesota. It lies above the St. Peter sandstone.

Prairie du Chien group is a formation of predominantly dolomitic rocks exposed in southeastern Minnesota. Laid down about 500 million years ago, it includes the Oneota dolomite and underlies the St. Peter sandstone.

Red drift is glacial drift whose origin was from ice flowing from northeast of Minnesota, and probably the Lake Superior basin. The most recent lobe from that direction was the Superior Lobe.

Residuum is unconsolidated, weathered, or partly weathered mineral material that accumulates over disintegrating rock.

Riverbottom forest is forest commonly found on river floodplains, and includes species such as silver maple, willow, cottonwood and elm.

Runoff is the precipitation discharged into stream channels from an area.

St. Peter sandstone is a relatively thick (approximately 120 ft.), light-yellow to white, uniform quartz sandstone exposed in southeastern Minnesota. It was deposited about 450 million years ago, and lies above the Prairie du Chien group and below the Platteville formation.

Sand is a soil separate with individual rock or mineral fragments from 0.05 millimeter to 2.0 millimeters in diameter.

Sapric soil material is the most highly decomposed of all organic soil material.

Scarp is a steep slope or cliff; same as escarpment.

Silt is a soil separate with individual mineral particles that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter).

Skeletal soils are those with over 35% volume of stones.

Slope is the inclination of the land surface from the horizontal.

Stone line is a concentration of coarse fragments in a soil. Generally it is indicative of an old weathered surface. In a cross section, the line may be one fragment or more thick. It generally overlies material that weathered in place and is overlain by recent sediment of variable thickness.

Swamp conifers include northern white cedar, balsam fir, tamarack, and black spruce.

Terminal moraine is a moraine formed at the edge of ice at its position of greatest advance.

Terrace is a level, usually narrow, plain bordering a river, lake, or the sea. Rivers sometimes are bordered by terraces at different levels.

Texture, soil, is the relative proportions of sand, silt, and clay particles in a mass of soil.

Till is unstratified glacial drift deposited directly by the ice and consisting of clay, sand, gravel, and boulders intermingled in any proportion.

Till plain is an extensive flat to undulating area underlain by glacial till.

Toe slope is the outermost inclined surface at the base of a hill; part of a foot slope.

Tree throw is the uprooting and tipping of trees by wind.

Tunnel valley is a valley formed under stagnant ice by high pressure flow of water trapped under the ice; associated with eskers.

Valley train is a long, narrow outwash plain along a valley far beyond the edge of glacial ice.

Water table is the upper limit of the soil or geologic material that is wholly saturated with water.

Weathering is all physical and chemical changes produced in rocks or other materials, at or near the earth's surface, by atmospheric agents.