SOIL SURVEY

Powder River Area

Montana

SOIL CONSERVATION SERVICE

UNITED STATES DEPARTMENT OF AGRICULTURE
Soil Conservation Service
and Forest Service

UNITED STATES DEPARTMENT OF THE INTERIOR
Bureau of Land Management
in cooperation with

MONTANA AGRICULTURAL EXPERIMENT STATION

Major fieldwork for this soil survey was done in the period 1960 to 1964. Soil names and descriptions were approved in 1967. Unless otherwise indicated, statements in this publication refer to conditions in the county in 1964.

This survey was made cooperatively by the Department of Agriculture Soil Conservation Service and Forest Service, Department of the Interior, Bureau of Land Management, and the Montana Agricultural Experiment Station. It is part of the technical assistance furnished to the Powder River Soil and Water Conservation District.

Either enlarged or reduced copies of the soil map in this publication can be made by commercial photographers, or they can be purchased on individual order from the Cartographic Division, Soil Conservation Service, USDA, Washington, D.C. 20250

HOW TO USE THIS SOIL SURVEY

THIS SOIL SURVEY contains information that can be applied in managing farms and ranches, in selecting sites for roads, ponds, buildings, and other structures; and in judging the suitability of tracts of land for agriculture, industry, and recreation.

Locating Soils

All the soils of the Powder River Area are shown on the detailed map at the back of this publication. This map consists of many sheets made from aerial photographs. Each sheet is numbered to correspond with a number on the Index to Map Sheets.

On each sheet of the detailed map, soil areas are outlined and are identified by symbols. All areas marked with the same symbol are the same kind of soil. The soil symbol is inside the area if there is enough room; otherwise, it is outside and a pointer shows where the symbol belongs.

Finding and Using Information

The "Guide to Mapping Units" can be used to find information. This guide lists all the soils of the county in alphabetic order by map symbol and gives the capability classification of each. It also shows the page where each soil is described and the page for the capability unit, windbreak suitability group, and range-soil group in which the soil has been placed.

Individual colored maps showing the relative suitability or degree of limitation of soils for many specific purposes can be developed by using the soil map and the information in the text. Translucent material can be used as an overlay over the soil map and colored to show soils that have the same limitation or suitability. For example, soils that have a slight limitation for a given use can be colored green, those with a moderate limitation can be colored yellow, and those with a severe limitation can be colored red.

Farmers and those who work with farmers can learn about use and management of the soils from the soil descriptions and from the discussions of the range-soil groups and windbreak suitability groups.

Ranchers and others can find, under "Range Management," groupings of the soils according to their suitability for range, and also the names of many of the plants that grow on each range site.

Engineers and builders can find, under "Engineering Uses of the Soils," tables that contain test data, estimates of soil properties, and information about soil features that affect engineering practices.

Scientists and others can read about how the soils formed and how they are classified in the section "Formation and Classification of the Soils."

Newcomers in the area will be especially interested in the section "General Soil Map," where broad patterns of soils are described. They may also be interested in the information about the county given at the beginning of the publication and in the section "General Nature of the Area."

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SOIL SURVEY OF POWDER RIVER AREA, MONTANA

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UNITED STATES DEPARTMENTS OF AGRICULTURE AND THE INTERIOR IN COOPERATION WITH THE MONTANA AGRICULTURAL EXPERIMENT STATION

THE POWDER RIVER AREA, in the southeastern corner of Montana, consists of Powder River County and part of Rosebud County, (fig. 1). It has a land area of 2,305,760 acres, or almost 3,603 square miles. The survey area extends 54 miles from north to south and 70 miles from east to west. Broadus, the county, seat is the only town in the survey area.

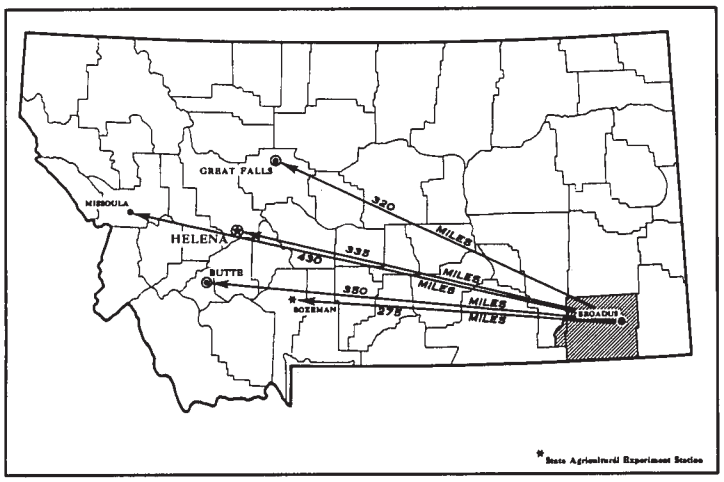

Figure 1.--Location of Powder River Area in Montana.

The survey area consists of gently rolling to steep uplands and mountainous areas in the valleys of the Powder and Little Powder Rivers and of Mizpah, Pumpkin, and Otter Creeks. The climate is continental in which winters are cold and summers are warm, and the seasonal precipitation varies markedly. About 90 percent of the survey area is rangeland, and 10 percent is used for crops. Although livestock is the main source of income, the survey area also has some wheat, barley, oats, corn, and alfalfa grown for seed and hay.

The 437,773 acres of Federal land in Custer National Forest is administered by the Forest Service. Another 251,772 acres of Federal land scattered throughout the survey area is administered by the Bureau of Land Management, and 165,027 acres of State land is administered by the State Land Board of Commissioners. The remaining 1,451,168 acres are privately owned.

In 1954, farmers and ranchers of part of the survey area began organizing the Powder River District. During 1956 all remaining land in the area was included in the District. In 1962, the name of this District was changed to Powder River Soil and Water Conservation District. The District organization helps farmers and ranchers get technical assistance from the United States Department of Agriculture. This soil survey is part of that assistance.

HOW THIS SURVEY WAS MADE

Soil scientists made this survey to learn what kinds of soils are in the Powder River Area, where they are located, and how they can be used. The soil scientists went into the survey area knowing they likely would find many soils they had already seen and perhaps some they had not. As they traveled over the survey area, they observed the steepness, length, and shape of slopes, the size and speed of streams, the kinds of native plants or crops, the kinds of rock, and many facts about the soils. They dug many holes to expose soil profiles. A profile is the sequence of natural layers, or horizons, in a soil; it extends from the surface down into the parent material that has not been changed much by leaching or by the action of plant roots.

The soil scientists made comparisons among the profiles they studied, and they compared these profiles with those in counties nearby and in places more distant. They classified and named the soils according to nationwide, uniform procedures. The soil series and the soil phase are the categories of soil classification most used in a local survey (*3*)[1]

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

[1] Italicized numbers in parentheses refer to Literature Cited, p.

arrangement, and other important characteristics. Each soil series is named for a town or other geographic feature near the place where a soil of that series was first observed and mapped. Hesper and Farland, for example are the names of two soil series. All the soils in the United States having the same series name are essentially alike in those characteristics that affect their behavior in the undisturbed landscape.

Soils of one series can differ in texture of the surface soil and in slope, stoniness, or some other characteristics that affects use of the soils by man. On the basis of such differences, a soil series is divided into phases. The name of a soil phase indicates a feature that affects management. For example, Farland silt loam, 2 to 4 percent slopes, is one of several phases within the Farland series.

After a guide for classifying and naming the soils had been worked out, the soil scientists drew the boundaries of the individual soils on aerial photographs. These photographs show buldings, field borders, trees, and other details that help in drawing boundaries accurately. The soil map in the back of this publication was prepared from the aerial photographs.

The areas shown on a soil map are called mapping units. On most maps detailed enough to be useful in planning the management of farms and fields, a mapping unit is nearly equivalent to a soil phase. It is not exactly equivalent, because it is not practical to show on such a map all the scattered bits of soil of some other kind that have been seen within an area that is dominantly of a recognized soil phase.

Some mapping units are made up of soils of different series, or of different phases within one series. Three such kinds of mapping units are shown on the soil map of the Powder River Area: soil complexes, soil associations, and undifferentiated soil groups.

A soil complex consists of areas of two or more soils, so intermingled or so small in size that they cannot be shown separately on the soil map. Each area of a complex contains some of each of the two or more dominant soils, and the pattern and relative proportions are about the same in all areas. The name of a soil complex consists of the names of the dominant soils, joined by a hyphen.

A soil association is made up of adjacent soils that occur as areas large enough to be shown individually on the soil map but are shown as one unit because the time and effort of delineating them separately cannot be justified. There is a considerable degree of uniformity in pattern and relative extent of the dominant soils, but the soils may differ greatly one from another. The name of an association consists of the names of the dominant soils, joined by a hyphen. Farland-Cabba association, 4 to 8 percent slopes, is an example.

An undifferentiated soil group is made up of two or more soils that could be delineated individually but are shown as one unit because, for the purpose of the soil survey, there is little value in separating them. The pattern and proportion of soils are not uniform. An area shown on the map may be made up of only one of the dominant soils, or of two or more. The name of an undifferentiated group consists of the names of the dominant soils, joined by "and." Farland and Havrelon soils, 4 to 8 percent slopes, is an example.

In most areas surveyed there are places where the soil material is so rocky, so shallow, or so severely eroded that it cannot be classified by soil series. These places are shown on the soil map and are described in the survey, but they are called land types and are given descriptive names. Shale outcrop is a land type in the Powder River Area.

While a soil survey is in progress, samples of soils are taken, as needed, for laboratory measurements and for engineering tests. Laboratory data from the same kinds of soils in other places are assembled. Data on yields of crops under defined practices are assembled from farm records and from field or plot experiments on the same kinds of soils. Yields under defined management are estimated for all the soils.

But only part of a soil survey is done when the soils have been named, described, and delineated on the map, and the laboratory data and yield data have been assembled. The mass of detailed information then needs to be organized in such a way as to be readily useful to different groups of users, among them farmers, managers of woodland and rangeland, and engineers.

On the basis of yield and practice tables and other data, the soil scientists set up trail groups. They test these groups by further study and by consultation with farmers, agronomists, engineers, and others, then adjust the groups according to the results of their studies and consultation. Thus, the groups that are finally evolved reflect up-to-date knowledge of the soils and their behavior under present methods of use and management.

GENERAL SOIL MAP

The general soil map at the back of this survey shows, in color, the soil associations in the Powder River Area. A soil association is a landscape that has a distinctive proportional pattern of soils. It normally consists of one or more major soils and at least one minor soil, and it is named for the major soils. The soils in one association may occur in another, but in a different pattern.

A map showing soil associations is useful to people who want a general idea of the soils in a survey area, who want to compare different parts of this area, or who want to know the location of large tracts that are suitable for a certain kind of land use. Such a map is a useful general guide in managing a watershed, a wooded tract, or a wildlife area, or in planning engineering works and recreational facilities. It is not a suitable map for planning the management of a farm or field, or for selecting the exact location of a road or similar structure, because the soils in any one association ordinarily differ in slope, depth, stoniness, drainage, and other characteristics that affect their management.

The soil associations in Powder River Area are discussed in the following pages.

1. Elso-Remmit-Ocean Lake Association

Gently sloping to steep; shallow silt loams and fine sandy loams underlain by shale and sandstone, and deep soils that have a fine sandy loam subsoil; on uplands

This association is in the eastern part of the Powder River Area. It consists of smooth rounded hills, tabular divides with long side slopes, and some buttes with steep side slopes. The Buttes have areas of exposed shale and eroded drainageways. Gently sloping terraces and coalescing alluvial fans border the sides of stream valleys that are 1/4 to 1 mile wide. The association is drained by a system of branching drainageways. In these drainageways the gullying action of the headwaters of streams cuts back toward the tabular divides (fig. 2, top). The vegetation of the association is mid and short grasses.

The soils of this association are at an elevation of 3,000 to 3,550 feet. The mean annual precipitation is between 10 and 15 inches. The weather is cold in winter and warm in summer. The mean annual soil temperature is 47 to 49° F., and the frost-free period ranges from 110 to 120 days a year.

This association occupies about 12 percent of the Powder River Area. It is about 40 percent Elso soils, 20 percent Remmit soils, 20 percent Ocean Lake soils, and the rest is minor soils.

Elso soils occupy the smooth foot slopes, ridges, and tabular divides. They are shallow, light-colored medium-textured soils that are underlain by soft beds of silty and sandy shale.

Remmit soils occupy the smooth rounded hills and gentle to steep foot slopes and terraces. These soils are light colored and moderately coarse textured. They developed from beds of soft sandy shale.

Ocean Lake soils occupy the ridges, knobs, and tabular divides. They are loamy soils over soft cross-bedded sandstone.

Among the minor soils in this association are the gently sloping to strongly sloping Cushman, Fort Collins, McRae, Heldt, and Hesper soils on smooth uplands and the nearly level to gently sloping Haverson, Hydro, and Glenberg soils on flood plains and stream terraces.

Shallow soils on hilly uplands are dominant in this association. These soils are used mainly for range, on which herds of cattle and flocks of sheep are grazed during spring, summer, and fall. In some places the smooth, nearly level to strongly sloping soils are used for growing crops.

Wildlife is plentiful. Deer and antelope are the big game in the association. Sage hen and sharptail grouse are the principal upland game birds.

2. Elso-Midway-Thurlow Association

Nearly level to steep; silt loams and clay loams that are shallow over stratified sandy, silty, and clayey shale, and deep soils that are dominantly silty clay loam throughout; on uplands

This association is a rough, broken, deeply dissected upland plain. One large part, separated by a narrow belt of soil association 3, is in the eastern half of the survey area, extending from the southern boundary of the survey area almost to the northern boundary. Smaller areas are in the western part. The association consists of steep buttes that have shale exposed, broken slopes with walled drainageways, tabular divides, ridges, and knobs. It is drained by branching drainageways that are gullied at the headwaters. The main trunk streams meander and rework the flood plains. The stream valleys are 1/2 to 1 mile wide. Here the soils are nearly level on narrow stream terraces and are nearly level to strongly sloping on short fan terraces, foot slopes, and swales (fig. 2, bottom). The vegetation is short and mid grasses.

The association is at an elevation of about 3,000 to 3,500 feet. It occurs in a 10- to 15-inch rainfall belt. The weather is cold in winter and warm in summer, and the frost-free season ranges from 115 to 120 days a year. The average annual soil temperature ranges from 47 to 49° F.

This association occupies about 28 percent of the survey area. It is about 40 percent Elso soils, 20 percent Midway soils, 20 percent Thurlow soils, and the rest is minor soils.

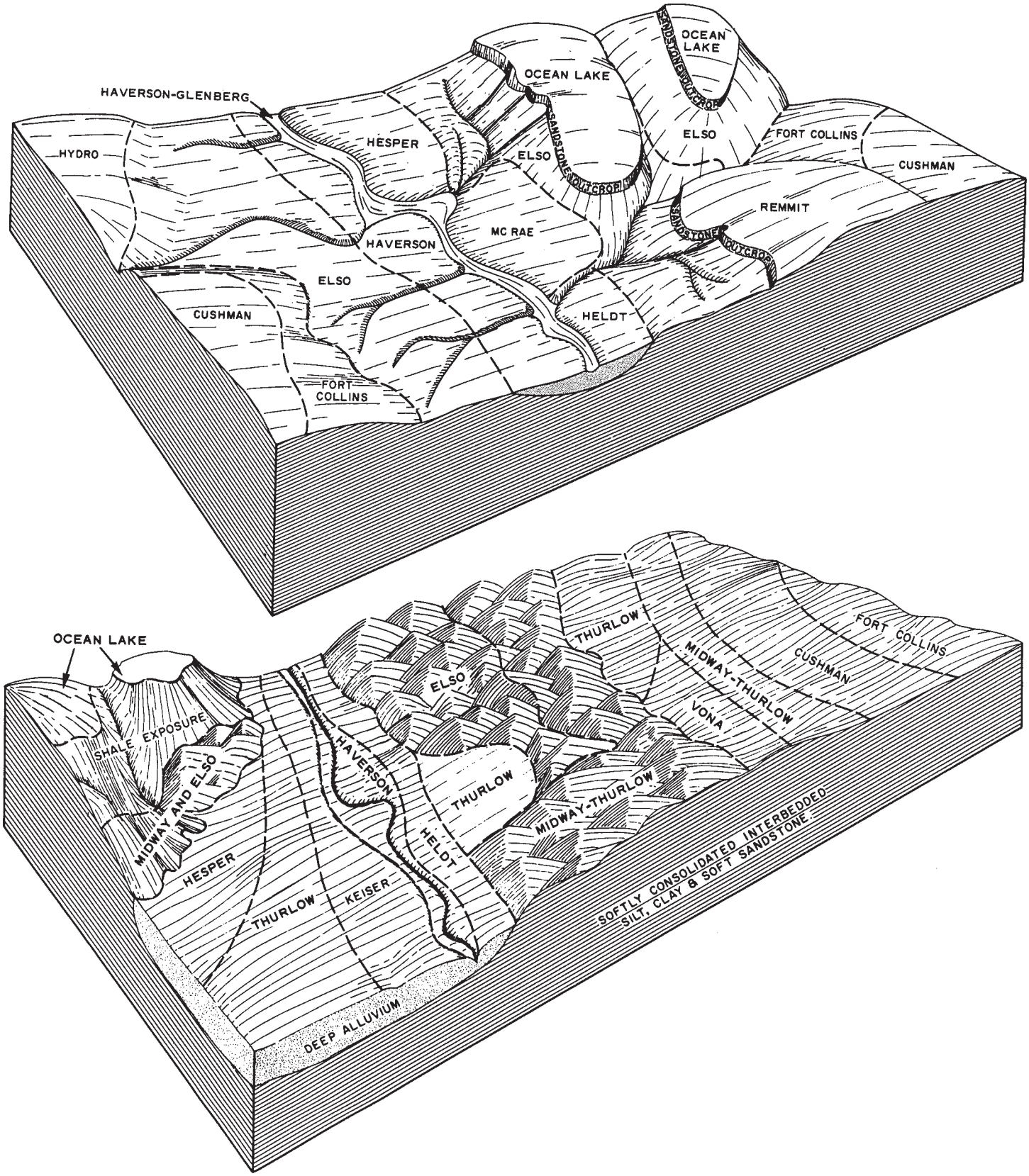

Figure 2.--Top: Relationship of soils in the Elso-Remmit-Ocean Lake association to topography. Bottom: Relationship of soils in the Elso-Midway-Thurlow association to topography and underlying material.

Elso soils are dominant in this association. Their slopes are smooth, grass covered, and of medium length. These soils are strongly sloping and occupy foothills, ridges, and divides. They are light colored, medium textured, and underlain by beds of softly consolidated silty, clayey, and sandy shale.

The Midway soils surround the nearly barren shale that crops out from the steep sides of gullies, the narrow tabular divides, and the ridge points. They are shallow, light-colored soils that are moderately fine textured and calcareous. They developed over beds of clayey shale.

Thurlow soils occupy smooth foot slopes and remnants of alluvial fans between gullies. They are deep, light-colored, and moderately fine textured soils that developed on beds of clayey shale.

The nearly level to strongly sloping minor Cushman, Fort Collins, Heldt, Hesper, Keiser, and Vona soils occupy the short alluvial fans, terraces, foot slopes, and swales. These soils are deep and well drained. Campspass and Barvon soils are strongly sloping to steep and occupy tree-covered northerly slopes of the association.

Ninety percent of the association is grazed by livestock, for the soils are steep, broken, rough, and dissected. The soils on smooth terraces, fans, and foot slopes are planted to hay and small grains. These cultivated areas generally are along the wider drainageways, on the wider flood plains, or on the stream terraces along the valley sides.

Wildlife is plentiful in this association. The big game is deer and antelope, and the principal upland game birds are sage hen, sharptail grouse, and wild turkey.

3. Haverson-Glenberg Association

Nearly level to gently sloping; deep silt loams and fine sandy loams underlain dominantly by strata of fine sandy loam to silty clay loam; mainly on flood plains, terraces, and fans

This association occupies the flood plains, stream terraces, short smooth valley slopes, and fans along the Powder River, the Little Powder River, and Mizpah, Pilgrim, Ranch, Pumpkin, Crow, East Fort, and Otter Creeks. These valleys range from 1/4 mile to 2 miles in width. The association is a continually changing river plain. Material worn away from the hills in the higher river basin is swept along by the streams and deposited in more level areas. The streams and rivers meander from one side of the valley to the other. They deposit material that gradually raises the level of the beds, and they cut the valley walls back toward the divides (fig. 3, top). The vegetation is mid and short grasses.

This association is at an elevation of 2,700 to 3,500 feet in a 10- to 15-inch rainfall belt. The winters are cold and summers are warm. The average growing season ranges from 115 to 120 days, and the mean annual soil temperature ranges from 47 to 49° F.

This association occupies about 4 percent of the Powder River Area. It is about 60 percent Haverson soils, 20 percent Glenberg soils, and minor soils make up the rest.

Haverson soils occupy flood plains, low stream terraces, alluvial fans, and foot slopes. These soils are deep, light colored, and medium textured. They were formed in loamy alluvium.

Glenberg soils occupy flood plains and low terraces of rivers and streams. They are light colored, moderately coarse textured soils that developed in alluvium.

Among the minor soils on valley bottoms are Bankard and Fort Collins. These are light colored, deep, well-drained soils. They developed in silty, clayey, and sandy alluvium. A few minor soils, such as Midway and Thurlow, occupy high stream terraces and alluvial fans.

This association generally is used for growing hay, small grains, corn, and alfalfa. Most of these crops are used as a supplement for feeding livestock raised in the survey area. Grazing is limited. Brush and cottonwood trees commonly grow in this association and shelter livestock during winter. Where it is irrigated, this association is well suited to the crops commonly grown in the survey area.

Wildlife is plentiful. Common animals and birds are deer, rabbits, fox, racoon, pheasants, sharptail grouse, and songbirds.

4. Ringling-Cabba-Midway Association

Sloping to steep or hilly; shallow slaty loams to clay loams underlain by shale; on uplands

This association occurs mainly in the western, southwestern, and central parts of the survey area. It occupies high narrow divides, steep southerly slopes that have exposures of shale, rounded red-capped buttes, mesa remnants, and slopes covered with grass or trees. The red caps of the buttes are red shale beds of former burned-over coalfields (fig. 3, bottom). The association is drained by a branching pattern of U-shaped valleys, swales, and drainageways. The main streams in this pattern are Otter and Pumpkin Creeks and the Tongue and the Powder Rivers. All trunk streams flow in a northerly direction, and secondary streams flow from west to east to meet them.

This association occurs at elevations of 3,000 to 4,000 feet in the 15- to 19-inch rainfall belt. Winters are cold, summers are warm, and the growing season is 100 to 115 days. The mean annual soil temperature is 45 to 47° F.

This association occupies about 45 percent of the Powder River Area. It is about 40 percent Ringling soils, 25 percent Cabba soils, 20 percent Midway soils, and the rest is minor soils.

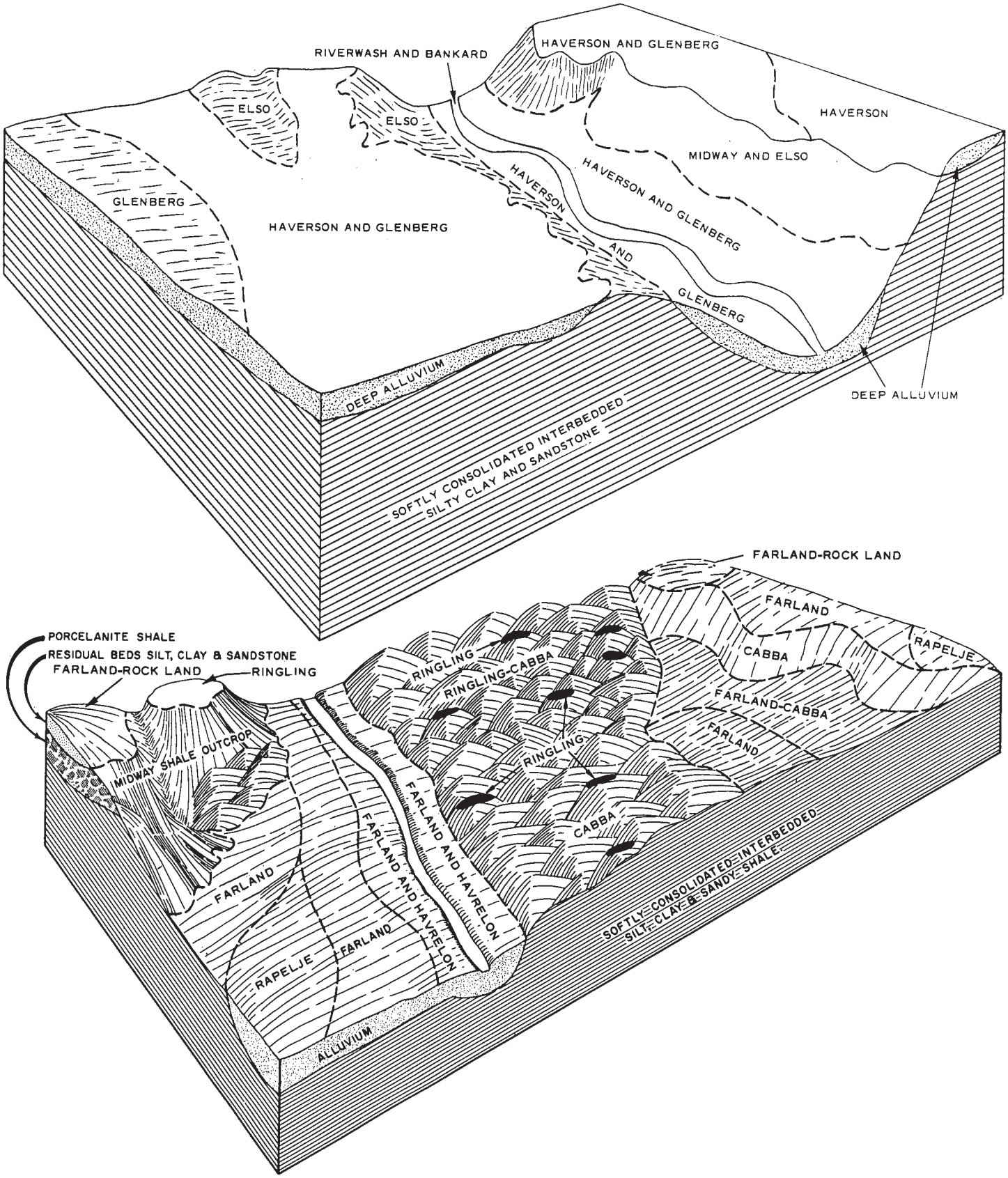

Figure 3.--Relationship of soils to topography and underlying material. Top: Haverson-Glenberg association; bottom: Ringling-Cabba-Midway association.

Ringling soils are steep and hilly and occur on uplands. They are shallow, medium-textured, and well-drained soils that developed from red porcelanite shale.

Cabba soils are steep and occupy convex divides and buttes. They are medium textured and well drained.

Midway soils are steep and occur on tabular divides, ridge points, and narrow foot slopes. They are moderately fine textured, calcareous, and shallow. Underlying layers are clayey, silty, and sandy shale.

Farland, Haverson, and Rapelje are among the minor soils on foot slopes and high terraces. They are deep, well-drained soils. Campspass and Barvon are steep minor soils that occupy the north-facing forested slopes.

This association is mainly range, and the raising of cattle and sheep is the main enterprise. Crops are grown along the larger drainageways and on some of the high wide terraces. Hay and small grains are the principal crops. Although many coal mines and coal veins occur in the association, few mines are in operation. At the time of the survey, coal was not in demand for heating or industrial use.

Wildlife is plentiful. Deer and antelope are the big game in the association, and the upland game birds are sage hen, sharptail grouse, and turkeys. Coyotes, racoons, and foxes inhabit the association, as do many songbirds.

5. Kyle-Midway-Cabba Association

Undulating to steep and hilly; deep soils that are clayey throughout, and shallow clay loams and silt loams underlain by clayey, silty, and sandy shale; on uplands

This association ojcurs in the southwestern corner of the survey area. The landscape has smooth, rounded, steep and hilly relief in which U-shaped drainageways join ridges on the sides of narrow gullies that have shale exposed. Along the drainageways, the soils on alluvial fans are undulating to strongly sloping. The association has a branching drainage pattern in which smooth U-shaped bottom lands merge with smooth rounded valley sides and rounded hills. (fig. 4, top). The vegetation is mid and short grasses.

The association occupies elevations of 3,500 to 4,500 feet. Winters are cold and summers are warm. The average annual precipitation is 12 to 16 inches and the mean annual soil temperature is 46 to 48° F. The frost-free season ranges from 100 to 115 days.

This association occupies about 4 percent of the survey area. It is about 40 percent Kyle soils, 30 percent Midway soils, 20 percent Cabba soils, and the rest is minor soils.

Kyle soils are strongly sloping to steep and occur on uplands. They are deep, dark colored, fine textured, and well drained.

Midway soils are steep and occur on tabular divides, ridge points, and narrow foot slopes. They are moderately fine textured, calcareous, and shallow soils that are underlain by clayey, silty, and sandy shale.

The steep Cabba soils are on convex divides and buttes. They are shallow, medium textured, and well drained.

The Thurlow, Haverson, Hydro, and McRae soils are among the minor soils that occupy foot slopes, smooth swales, valley bottoms, and U-shaped drainageways. The Arvada and Bone soils are in small areas of less than 5 acres on alluvial fans.

This association is over 95 percent rangeland. Some areas are used for growing alfalfa and small grains for livestock feed.

Wildlife is plentiful in the association. Deer and antelope are the big game animals, and sage hen and sharptail grouse are the principal game birds. Songbirds are abundant.

6. Ringling-Fergus-Relan Association

Strongly sloping to steep; shallow soils that are underlain by weathered shale, and deep soils that have a clay loam to loam subsoil; on uplands, fans, and foot slopes

This association is located in the southwestern part of Custer National Forest. It consists of smooth, sloping to steep, high upland terraces and narrow divides, U-shaped grassed swales, basins, and foot slopes. The area is drained by a branching pattern of mostly smooth and grassed drainageways. The vegetation is mid and short grasses.

The association is at elevations of 3,000 to 4,000 feet. The winters are cold and the summers are warm, and the frost-free season is about 100 days. Annual precipitation is about 16 inches, and the mean annual soil temperature is 45 to 47° F.

The association occupies about 2 percent of the Powder River Area. It is about 50 percent Ringling soils, 25 percent Fergus soils, 15 percent Relan soils, and minor soils make up the remaining 10 percent (fig. 4, bottom).

Ringling soils are steep and hilly and occur on uplands. They are shallow, medium textured, and well drained. They developed from red porcelanite shale.

Fergus soils occur on swales, foot slopes, and fans. These dark-colored, medium-textured, gently to moderately sloping soils are deep and well drained.

Relan soils are gently sloping and occur in swales and on foot slopes. They are deep, well drained, and medium textured.

Small areas of Farland, Midway, and Cabba soils are common in the Ringling soil areas.

More than 95 percent of this association is used for grazing.

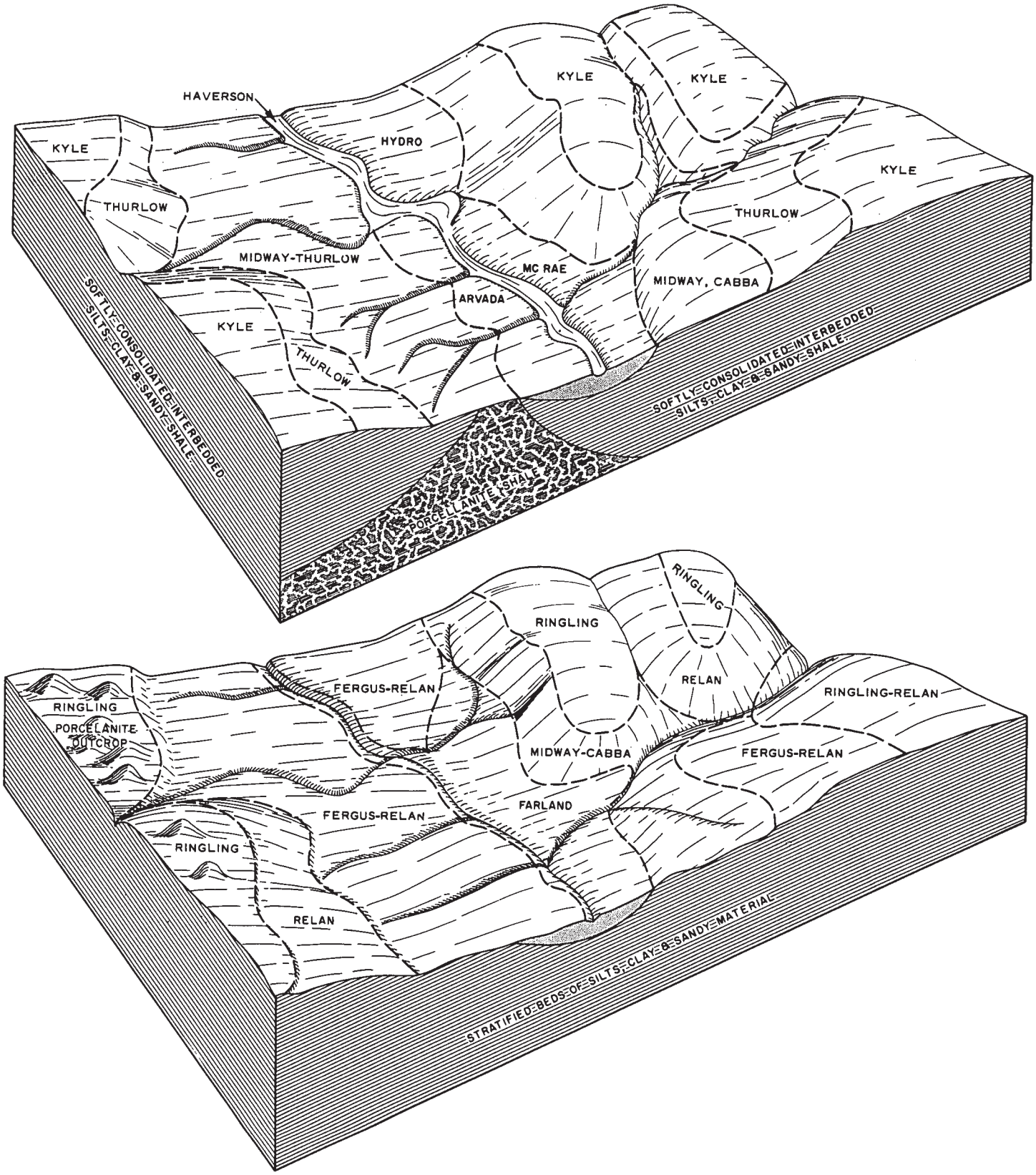

Figure 4.--Relationship of soils to topography and underlying material. Top: Kyle-Midway-Cabba association; bottom: Ringling-Fergus-Relan association.

7. Farland-Cabba Association

Nearly level to steep or hilly; deep soils that have a silty clay loam and silt loam subsoil, and shallow silt loams; on uplands

This association is in the western part of the Powder River Area. The landscape is one of moderately sloping to strongly sloping, high upland terraces, foot slopes, and smooth tabular divides. The steep soils on divides, knobs, ridges, and between the high terraces and foot slopes are generally shallow. The association has a branching drainage pattern.

Elevations are 3,000 to 4,000 feet. In this association winters are cold and summers are warm. The frost-free season is about 100 days. Annual precipitation is about 16 inches, and the mean annual soil temperature is less than 47° F.

This association occupies about 1 percent of the Powder River Area. It is about 70 percent Farland soils, 20 percent Cabba soils, and the rest is minor soils (fig. 5, top).

Farland soils are deep, well drained, and medium textured. They are nearly level to strongly sloping and occur on terrace remnants and foot slopes. The strongly sloping to steep Cabba soils are shallow, medium textured, and well drained. They occur on ridges.

Among the minor soils in this association are Campspass and Barvon soils on north-facing, heavily wooded areas, Relan and Fergus soils on smooth foot slopes and high terraces, Kyle soils along the drainageways, Midway and Remmit soils on foot slopes, and Ringling soils on knobs and ridges.

About 80 percent of the association is used for grazing livestock. Runoff from steep barren areas of Midway and Cabba soils creates a major hazard on the lower footslopes, for stock trails or roads generally gully when the snow thaws in spring. Soils along the drainageways are used for growing hay and small grain.

Wildlife is plentiful in the association. Deer and antelope are the principal big game, and sage hen, sharptail grouse, and wild turkey are the upland game birds. Because there are no permanent perennial streams in the area, recreation facilities are limited. Although there is some dude ranching, it is not a major item in the economy.

8. Campspass-Barvon Association

Strongly sloping to steep; deep soils that have a loam to silty clay loam subsoil, and deep loams that are underlain by dominantly clay loam; on uplands

This association is in the northeastern part of the Custer National Forest, generally on the heavily wooded northerly slopes. This is the only extensive forest in the Powder River Area, and soil development shows the influence of the overstory of conifers. The vegetation is ponderosa pine.

This association occurs at elevations above 3,500 feet. Winters are cold and summers are warm. The frost-free season is about 100 days. The average annual precipitation is more than 16 inches, and the mean annual soil temperature is 45 to 47° F.

This association occupies less than 1 percent of the survey area. It is about 50 percent Campspass soils, 45 percent Barvon soils, and the rest is minor soils (fig. 5, bottom).

The Campspass soils are deep, steep, and medium textured. They occupy sparsely forested slopes that face north and northwest.

The Barvon soils are deep, medium textured, and dark colored. They are on forested slopes that face northwest.

The Ringling, Cabba, Relan, Midway, and Farland soils are the minor soils in this association. They normally occupy open park areas, swales, and valley bottom land.

The Campspass and Barvon soils produce the only marketable timber in this association. When the timber is cut, there is an erosion hazard on trails and skid roads and gullying occurs on downhill trails. The trails and roads need good surface drains that are located properly to drain off water in spring floods and when the snow melts. Timber production is moderate.

The association provides limited grazing on the small parklike areas 15 to 20 acres in size. Recreational facilities are good. Wildlife is plentiful, and hunting is good. Deer is the principal big game animal, and the number of sagehen and sharptail grouse is small. Wild turkeys are increasing rapidly and provide good hunting.

9. Midway-Thurlow Association

Rolling to strongly sloping and steep; shallow clay loams that are underlain by clayey, silty, and sandy shale, and deep soils that are dominantly silty clay loam throughout; on uplands

This association is on uplands in the southwestern part of the Custer National Forest. It consists of shallow and deep soils that are rolling to strongly sloping and steep. The association has a branching pattern of usually smooth and U-shaped drainageways. The vegetation is short and mid grasses.

Elevation is 3,500 to 4,000 feet. Winters are cold and summers are warm. The frost-free season is about 100 days. The annual precipitation is about 16 inches, and the mean annual soil temperature is 47 to 49° F.

This association occupies about 4 percent of the survey area. It is about 45 percent Midway soils, 35 percent Thurlow soils, and the rest is minor soils (fig. 6).

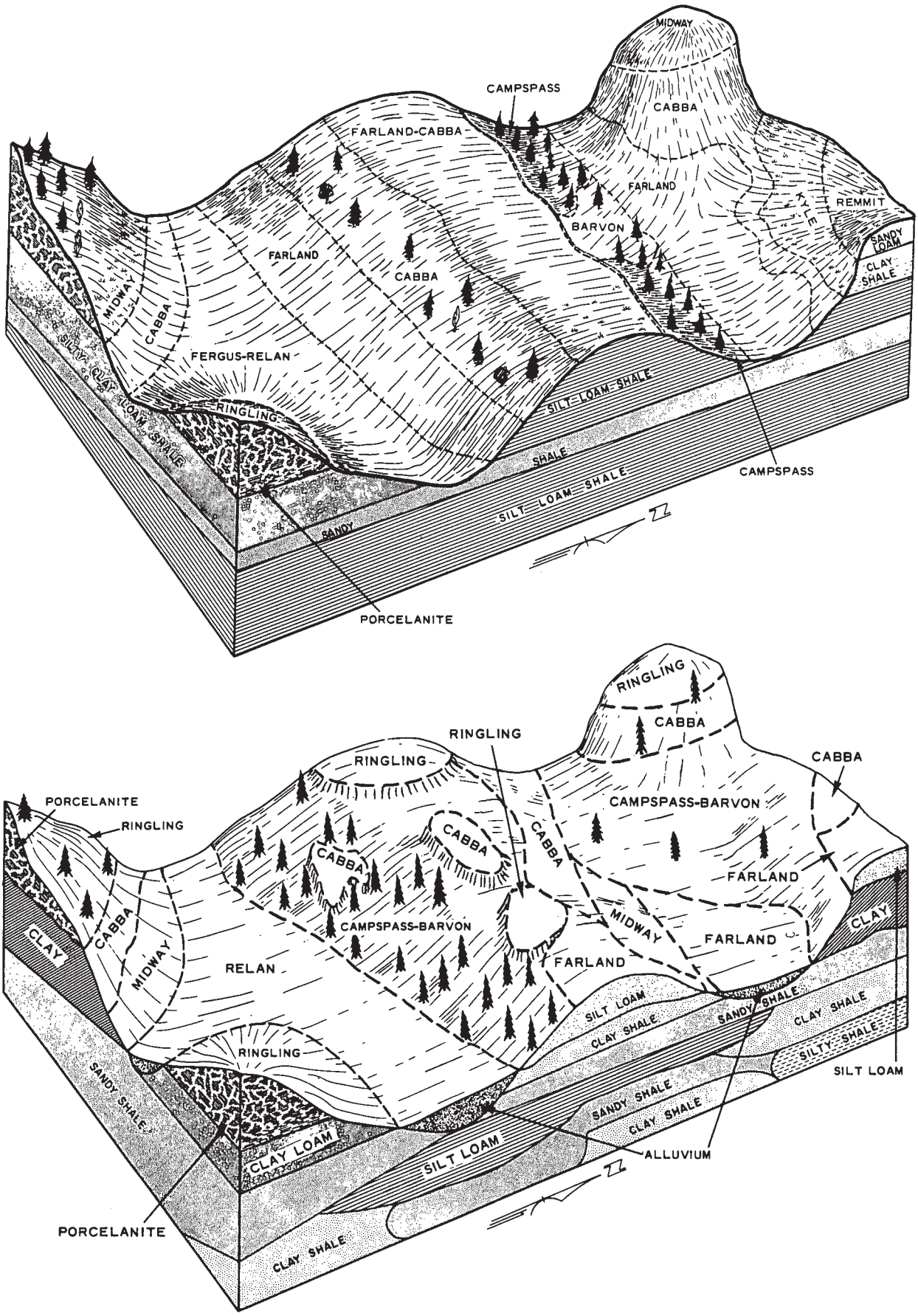

Figure 5.—Relationship of soils to topography and underlying material. Top: Farland-Cabba association; bottom: Campspass-Barvon association.

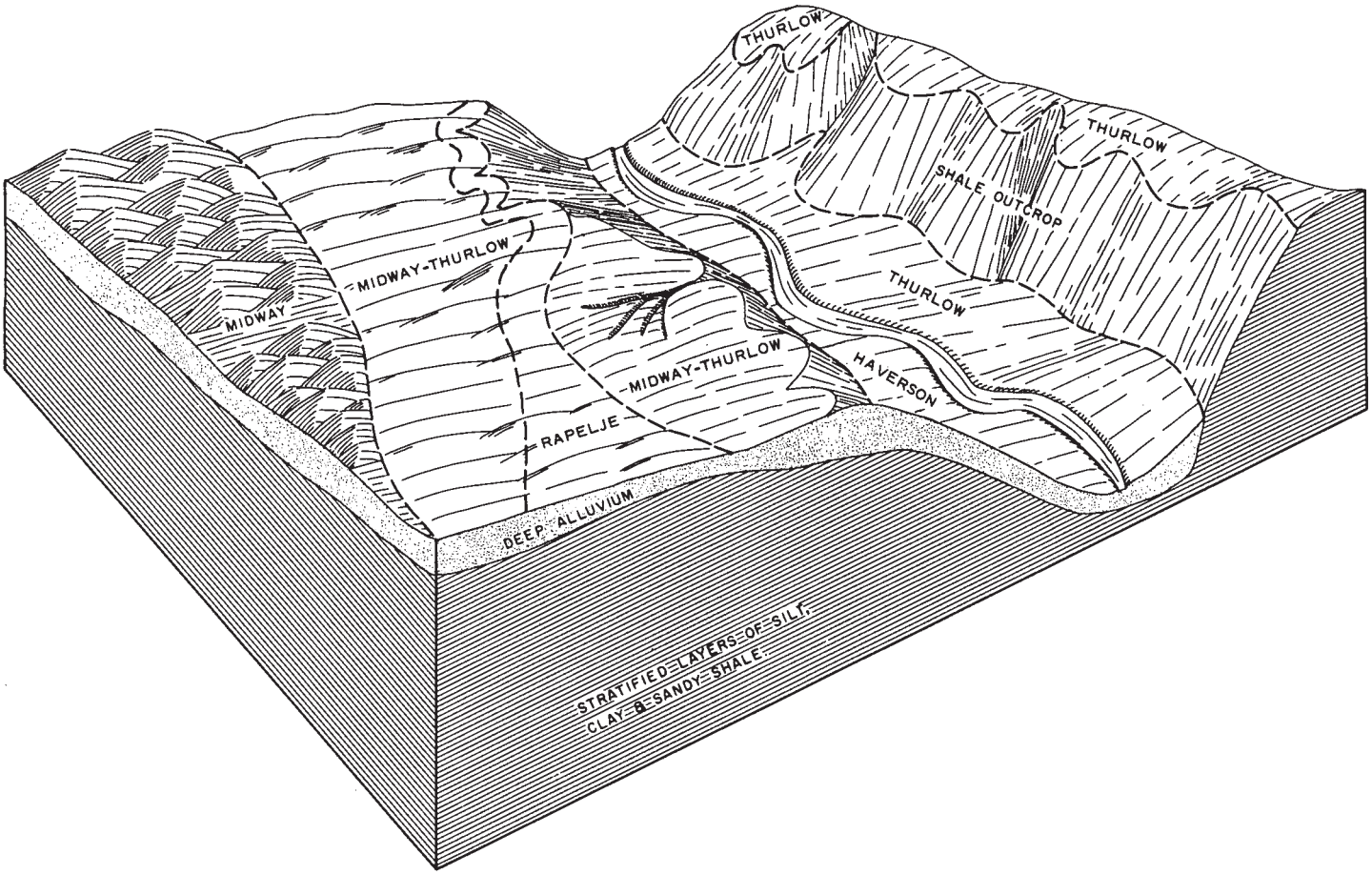

Figure 6.--Relationship of soils in the Midway-Thurlow association to topography and underlying material.

Midway soils are moderately fine textured and calcareous. They are shallow over clayey, silty, and sandy shale. Midway soils occupy ridges, tabular divides, and steep southern exposures.

Thurlow soils are deep, light-colored, moderately fine textured soils that formed on clay shale. They occupy smooth, long foot slopes, ridgetops, and divides.

Among the minor soils are Elso soils on the ridges, Kyle soils on the foot slopes, and small areas of Rapelje and Galata soils in basins and swales on the broad ridges.

This association is used primarily for forage. Numerous small fields are cultivated along the large drainageways and the long, smooth foot slopes or broad divides.

Although recreation possibilities of the association are limited, wildlife is plentiful. Deer and antelope are the principal big game animals.

The Powder River Area is used mainly for range and for crops and pasture. This section tells how the soils are used and managed for those purposes, and also for trees and shrubs in windbreaks and for building roads, farm ponds, and other engineering uses.

Crops and Pasture

In the following pages, the system of capability classification used by the Soil Conservation Service is explained, capability units, or groups of similar soils, are described, and management suitable for these groups is discussed. In addition, average yields of principal crops are predicted for the soils in the survey area that are commonly used for dryland farming.

Capability Grouping

Capability grouping shows, in a general way, the suitability of soils for most kinds of field crops. The groups are made according to the limitations of the soils when used for field crops, the risk of damage when they are used, and the way they respond to treatment. The grouping does not take into account major and generally expensive landforming that would change slope, depth, or other characteristics of the soils; does not take into consideration possible but unlikely major reclamation projects; and does not apply to rice, cranberries, horticultural crops, or other crops requiring special management.

Those familiar with the capability classification can infer from it much about the behavior of soils when used for other purposes, but this classification is not a substitute for interpretations designed to show suitability and limitations of groups of soils for range, for forest trees, or engineering.

In the capability system, all kinds of soils are grouped at three levels, the capability class, subclass, and unit. These are discussed in the following paragraphs.

CAPABILITY CLASSES, the broadest groups, are designated by Roman numerals I through VIII. The numerals indicate progressively greater limitations and narrower choices for practical use, defined as follows:

Class I soils have few limitations that restrict their use. (None in the Powder River Area)

Class II soils have moderate limitations that reduce the choice of plants or that require moderate conservation practices.

Class III soils have severe limitations that reduce the choice of plants, require special conservation practices, or both.

Class IV soils have very severe limitations that reduce the choice of plants, require very careful management, or both.

Class V soils are not likely to erode but have other limitations, impractical to remove, that limit their use largely to pasture, range, woodland, or wildlife. (None in the Powder River Area)

Class VI soils have severe limitations that make them generally unsuited to cultivation and limit their use largely to pasture or range, woodland, or wildlife.

Class VII soils have very severe limitations that make them unsuited to cultivation and that restrict their use largely to pasture or range, woodland, or wildlife.

Class VIII soils and landforms have limitations that preclude their use for commercial plants and restrict their use to recreation, wildlife, or water supply, or to esthetic purposes.

CAPABILITY SUBCLASSES are soil groups within one class; they are designated by adding a small letter, e, w, s, or c, to the class numeral, for example, IIe. The letter e shows that the main limitation is risk of erosion unless close-growing plant cover is maintained; w shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); s shows that the soil is limited mainly because it is shallow, droughty, or stony; and c, used in only some parts of the United States, shows that the chief limitation is climate that is too cold or too dry.

In class I there are no subclasses, because the soils of this class have few limitations. Class V can contain, at the most, only the subclasses indicated by w, s, and c, because the soils in class V are subject to little or no erosion, though they have other limitations that restrict their use largely to pasture, range, woodland, wildlife, or recreation.

CAPABILITY UNITS are soil groups within the subclasses. The soils in one capability unit are enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity and other responses to management. Thus, the capability unit is a convenient grouping for making many statements about management of soils. Capability units are generally designated by adding an Arabic numeral to the subclass symbol, for example, IIe-1 or IIIe-4. Thus, in one symbol, the Roman numeral designates the capability class, or degree of limitation; the small letter indicates the subclass, or kind of limitation, as defined in the foregoing paragraph; and the Arabic numeral specifically identifies the capability unit within each subclass.

The grouping of soils for dryland farming differs from that for irrigated farming. The description of the classes, subclasses, and units that follow are for dryland. The term "dryland" appears only in the name of the capability units in classes II, III, and IV, because the units in classes VI, VII, and VIII are not cultivated.

In the following pages the capability units in the Powder River Area are described and suggestions for the use and management of the soils are given. To identify the capability unit in which any soil has been placed, refer to the "Guide to Mapping Units" at the back of this survey.

Capability unit IIe-1, Dryland

In this unit are deep, level to sloping, medium-textured soils that are well drained and moderately permeable. These soils occur on fans, terraces, and uplands. Natural fertility and organic-matter content are high. Plants root deeply in these soils. The available water capacity is 8 to 10 inches for a 5-foot depth. Runoff is slow, and on cultivated fields the hazard of water erosion or soil blowing is slight.

The soils of this unit warm early in spring and have a frost-free season of 100 to 120 days. The average annual precipitation is 16 to 19 inches.

These soils are well suited to dry-farmed crops. Wheat and barley are commonly grown in a crop-fallow system, but they can be grown annually without fallow. Alfalfa for hay and seed and safflower and corn for silage are also grown on these soils. Stands of native grass are used for range. Native grasses produce a large amount of forage.

Crop stubble should be left on the soil to hold snow cover and to increase water intake during heavy rains. Nitrogen fertilizer is beneficial in spring if the available moisture is above average. Alfalfa benefits from phosphorus added after the second year of growth.

Capability unit IIIe-1, Dryland

This unit consists of deep and moderately deep, gently sloping to strongly sloping soils that are medium-textured and moderately fine textured. These soils are well drained and moderate to moderately slow in permeability. Root development in these soils is not restricted. They occur on stream terraces, fans, foot slopes, and undulating uplands. They are low to high in fertility and low to medium ir organic-matter content. The available water capacity is 6 to 10 inches. Not much rain falls on these soils, but bare fields are subject to water erosion and soil blowing.

These soils warm early in spring. The frost-free season is 100 to 120 days, and the average annual precipitation is about 12 inches.

The soils in this unit are suited to dryfarmed crops and as range. Small grains are grown in a crop-fallow system. Suitable grass crops are crested wheatgrass, Siberian wheatgrass, and pebescent wheatgrass.

These soils are easy to till. Maintaining organic-matter content by returning crop residues to the soil improves tilth and reduces the hazard of erosion. Field stripcropping, contour stripcropping, and leaving crop residues on the soils, control erosion and soil blowing. In some places soils on valley sides need diversion terraces to intercept runoff from the soils above. The main watercourses should be left in sod permanently. Crops respond to nitrogen and phosphorus fertilizers when annual precipitation is above normal.

Capability unit IIIe-2, Dryland

This unit consists of fine-textured, level to gently sloping soils on stream terraces, fans, and foot slopes. These soils are deep, well drained, and slowly permeable. Plants root deeply in these soils. The available water capacity is 10 to 13 inches for a 5-foot depth of soil. Natural fertility is high, but organic-matter content is low. Water intake is moderately slow, and the hazard of erosion is moderate. Because these soils have a granular surface layer, unprotected fields are subject to soil blowing.

These soils have a frost-free season of 100 to 120 days. The average annual precipitation is about 12 inches.

These soils are suited to dryfarmed crops, hay and pasture, and range. Small grains are grown in a crop-fallow system. Crested wheatgrass, Siberian wheatgrass, and western wheatgrass are grown for hay and pasture. Stands of native grass are used for range.

These soils are difficult to till, and the cost of power to cultivate them is high. The surface layer becomes cloddy if the soils are tilled when wet. Tilth and permeability can be improved by returning crop residues to the soil. This practice also helps to control soil blowing.

Capability unit IIIe-3, Dryland

In this unit are deep, well-drained, moderately permeable soils that are moderately sloping and medium-textured and moderately fine textured. These soils occur on stream terraces, fans, and foot slopes in the uplands. Fertility is high, and organic-matter content is medium to high. Plants root deeply. The available water capacity is 8 to 10 inches for a 5-foot depth. Water intake is moderately rapid, and runoff is slow. The hazard of erosion is slight to moderate on cultivated fields.

These soils warm moderately early in spring. The frost-free season is 100 to 120 days, and the average annual precipitation is 15 to 19 inches.

The main crop is small grains, which are grown in a crop-fallow system. Crested wheatgrass, intermediate wheatgrass, and alfalfa are grown for hay

and pasture. Stands of native grass are used for range.

Contour and field stripcropping and leaving crop residues on the soil surface help to control erosion and soil blowing. Diversion terraces are needed to control erosion on cultivated soils located on long, steep valley sides. Crops respond well to nitrogen and phosphorus fertilizers if the soil is moist to a depth of 36 inches or more at seeding time.

Capability Unit IIIe-4, Dryland

This unit consists of moderately coarse textured, nearly level to gently sloping soils on upland stream terraces, fans, and foot slopes. These soils are deep, well drained, and moderately rapid in permeability. Plants root deeply. Fertility is moderate and organic-matter content is low. The available water capacity is 6 to 8 inches for a 5-foot depth of soil. Because of the rapid intake of water, runoff is slow and the hazard of erosion is slight. Soil blowing is the major hazard.

These soils warm early in spring. The frost-free season is 100 to 120 days, and the average annual precipitation is about 12 inches.

These soils are suited to dryfarmed crops. Small grains are grown in a crop-fallow system. Crested wheatgrass, Siberian wheatgrass, pebescent wheatgrass, and alfalfa are grown for hay and pasture. Stands of native grass are used for range.

These soils need protection from soil blowing, and diversion terraces are required to control erosion on the long, steep valley sides. Returning all crop residues to the soil helps maintain organic-matter content and control soil blowing. Stripcropping that has narrow strips and the use of windbreaks also control soil blowing. Crops respond well to nitrogen fertilizer if the soil is moist to a depth of 36 inches or more at seeding time.

Capability Unit IIIs-1, Dryland

This unit consists of fine-textured and medium-textured, nearly level soils on fans, terraces, and foot slopes in the uplands. These soils are deep, well drained, and moderately slow in permeability. Plants root deeply. Fertility is high, but organic-matter content is low. The available water capacity is 10 to 13 inches for a 5-foot depth. Runoff is moderately slow and the hazard of erosion is slight. The hazard of slow blowing is moderate.

The soils in this unit warm early in spring. The frost-free season is 100 to 120 days, and average annual precipitation is about 12 inches.

These soils are suited to dryfarmed crops, hay and pasture, and range. Small grains are grown in a crop-fallow system. Suitable grasses for hay and pasture are crested wheatgrass, Siberian wheatgrass, and western wheatgrass. Stands of native grass are used for range.

These soils are difficult to till, and the cost of power to cultivate them is high. The surface layer becomes cloddy if these soils are tilled when wet. Tilth and permeability can be improved by returning all crop residues to the soil. This practice also helps to control soil blowing.

Capability unit IIIc-1, Dryland

This unit consists of medium-textured and moderately fine textured, nearly level soils on stream terraces, fans, and foot slopes. These soils are deep and moderately deep, well drained, and moderately slow in permeability. Root development is not restricted. Fertility is low to high, and organic-matter content is low to medium. The available water capacity is 6 to 10 inches. Runoff is slow, but unprotected fields are moderately susceptible to soil blowing and water erosion.

These soils warm early in spring and are easily tilled. The frost-free season is 100 to 120 days, and average annual precipitation is about 12 inches.

These soils are suited to dryfarmed crops, irrigated crops, and range. Small grains are grown in a crop-fallow system. Where irrigation water is available, alfalfa is grown for hay and seed. Suitable grasses are crested wheatgrass, Siberian wheatgrass, and pebescent wheatgrass.

Returning crop residues to the surface layer helps to maintain organic-matter content, improve tilth, and control water erosion and soil blowing. Also effective in controlling water erosion and soil blowing are field and contour stripcropping, particularly if crop residue is left near the surface. In some places diversion terraces are needed on valley side slopes to intercept runoff from the soils above. Water courses need to be permanently sodded to prevent gullying. Crops respond to nitrogen and phosphate fertilizers when annual precipitation is above normal.

Capability Unit IVe-1, Dryland

This unit consists of medium-textured and moderately fine textured, strongly sloping and hilly soils on terraces and uplands. These soils are deep and moderately deep, well drained, and moderate and moderately slow in permeability. Plants root deeply. Organic-matter content is low to medium. The available water capacity ranges from 6 to 10 inches. The water intake rate is medium, and runoff generally is moderately slow. The soils are moderately erodible. Severe gullying is likely where runoff collects in drainageways in cultivated fields. In bare areas these soils blow readily during dry periods.

The soils of this unit tend to warm early in spring. The frost-free season is 100 to 120 days, and the average annual precipitation is about 12 inches.

These soils are suited to dryfarmed crops, hay and pasture, and range. Small grains are grown in a crop-fallow system.

Erosion can be controlled by contour stripcropping that has permanent grass buffers, provided a small grain and fallow are alternated and crop residues are kept on or near the surface. Light applications of nitrogen fertilizer benefit grass seedings on eroded areas.

Capability Unit IVe-2, Dryland

This unit consists of medium-textured and moderately fine textured, gently rolling to sloping soils on uplands. These soils are shallow and well drained. Fertility is low to high, and organic-matter content is low to medium. Available water capacity is 6 to 10 inches. The shale substratum lies at a depth of 20 inches and restricts the penetration of water and roots. Runoff is rapid, and water that concentrates in drainageways causes gully erosion.

These soils warm early in spring. The frost-free season is 100 to 120 days, and the average annual precipitation is 12 to 15 inches.

These soils are mainly used for range. A small acreage is used for growing small grains in a crop-fallow rotation. Crested wheatgrass, Siberian wheatgrass, and western wheatgrass are grown for hay and pasture. Alfalfa is grown for hay and seed. Contour stripcropping and returning crop residues to the surface help to control erosion on cultivated areas.

Capability unit IVe-3, Dryland

This unit consists of sloping and strongly sloping, fine-textured and moderately fine textured soils on upland foot slopes and fan terraces. These soils are deep, well drained, and slowly permeable. Plants root deeply. Organic-matter content is low, and fertility is moderate to high. The available water capacity is 10 to 13 inches for a 5-foot depth of soil. Runoff is medium to rapid. In the most sloping areas runoff concentrates in drainageways and swales and causes gully erosion. Because of the granular structure, these soils blow easily. The frost-free season is 100 to 120 days, and the average annual precipitation is about 12 inches.

The soils of this unit are used mostly for range. Small grains are dryfarmed in a few areas.

These soils are difficult to till when wet or dry. The cost of power to cultivated them is high. The soils are clayey and are strongly sloping in some places. Contour stripcropping and returning crop residues to the soil help to control erosion.

Capability unit IVe-4, Dryland

This unit consists of moderately coarse textured, gently sloping soils on terraces and strongly sloping soils on uplands. These soils are deep, well drained, and moderately rapid in permeability. Plants root deeply. The organic-matter content is low, and fertility is moderate. The available water capacity is 6 to 8 inches for a 5-foot depth, and the rate of water intake is high. These soils blow easily if left unprotected during dry periods. Water erosion generally is not a serious hazard, but runoff water that concentrates on the strong slopes may cause gully erosion in drainageways.

These soils warm rapidly in spring. The frost-free season is 100 to 120 days, and the average annual precipitation is 12 to 14 inches.

These soils are used mostly for range. They are also used for dryfarmed small grains and alfalfa, for which they are suited.

Cultivated areas can be protected from soil blowing by tree windbreaks and stripcropping if the strips are narrow and crop residues are left on the soil surface. Crop residues returned to the soil lessen the loss of organic matter, as does minimum tillage. Crops on these soils respond well to nitrogen fertilizer.

Capability Unit VIe-1

In this unit are medium-textured, strongly sloping to steep and hilly soils on uplands. These soils are deep and moderately deep, well drained, and moderate to moderately slow in permeability. Plants root deeply in these soils. The available water capacity is 4 to 10 inches, and runoff is slow. The erosion hazard is slight because the soils are covered with forest litter.

These soils warm slowly in spring. The frost-free season is about 90 to 100 days, and the average annual precipitation is 16 to 19 inches.

These soils are not suitable for cultivation. They have a 30 to 80 percent crown cover of ponderosa pine. Areas of open parks are grazed. Protection from fire and overgrazing is needed if timber stands and grass cover are to be maintained.

Capability Unit VIe-2

This unit consists of shallow, medium-textured and moderately fine textured soils and deep, loamy and clayey soils on uplands. These soils are well drained and mainly strongly sloping to hilly. Organic-matter content and fertility are low to medium. The available water capacity is 4 to 10 inches. Runoff is medium to rapid, and permeability is moderate to slow. Plant roots penetrate only through the fractures in the shale beds. These soils are susceptible to water erosion and soil blowing.

The soils in this unit warm early in spring. The frost-free season is 100 to 120 days, and the average annual precipitation is about 12 inches.

These soils are used mainly for range. Crested wheatgrass and Siberian wheatgrass can be grown for hay and pasture on the less sloping soils. New seedings must be protected from soil blowing until they are well established.

Capability Unit VIe-3

This unit consists of shallow and deep, well-drained, moderately coarse textured soils and deep, very gravelly, loamy soils that are underlain by softly consolidated sandstone and sandy shale. These soils occur on uplands and are strongly sloping to steep and hilly. They are low to medium in organic-matter content and fertility. The available water capacity is 2 to 7 inches. Permeability is moderately rapid, and runoff is very slow. Roots penetrate the shale only through fractures. These soils blow easily where plant cover is removed.

The soils in this unit warm early in spring. The frost-free season is 100 to 120 days, and the average annual precipitation is about 12 inches.

Most of the acreage of this unit is used for range. A permanent, well-managed grass cover is effective in controlling soil blowing.

Capability Unit VIs-1

This unit consists of fine-textured, gently sloping soils on stream terraces, fans, and foot slopes. These soils are deep, well drained, and slowly permeable. They are low in fertility and organic-matter content. The available water capacity is about 7 to 10 inches for a 5-foot depth. The water intake rate is slow, and runoff is medium. These soils are strongly alkaline and have a crusted surface and a high shrink-swell potential.

The soils of this unit warm moderately early in spring. The frost-free season is 100 to 120 days, and the average annual precipitation is about 12 inches.

The primary use of these soils is range.

Capability Unit VIw-1

In this unit are nearly level to sloping loamy soils on stream terraces and flood plains and strongly saline soils on flood plains. These soils are deep and are deeply penetrated by roots. Permeability is moderate to moderately rapid. Runoff is received from the surrounding foot slopes. These soils are seasonally flooded and are subirrigated part of the year. The available water capacity is 4 to 9 inches for a 5-foot depth. Organic-matter content and natural fertility are low to medium.

The frost-free season is 100 to 120 days, and the average annual precipitation is 12 to 16 inches.

The soils of this unit are used primarily for meadow hay and grass. They are not suitable for cultivation unless they are drained.

Capability Unit VIIe-1

In this unit are shallow, well-drained medium-textured and moderately fine textured soils that occur on uplands and are steep to very steep. Also in this unit are deep, steep loamy soils on terrace escarpments. Natural fertility and organic-matter content are low to medium in the soils of this unit. The available water-holding capacity is about 4 inches in the shallow soils and about 10 inches in the deep soils. Runoff from the steep and hilly slopes is medium to rapid. In concentrates in low swales and depressions and causes gully erosion in the drainageways. Permeability to roots and to water and air is moderate in the upper 20 inches of the shallow soils.

The soils in this unit warm early in spring and have a frost-free season of 100 to 120 days. The average annual precipitation ranges from 12 to 16 inches.

These soils are used only for range. Deferred grazing is needed to control erosion, conserve moisture, and maintain a plant cover.

Capability Unit VIIe-2

In this unit are very steep and hilly slaty loam soils on uplands. These soils are excessively drained and moderately rapid in permeability. They are directly underlain by porcelanite shale beds at a depth of less than 20 inches. Fertility and organic-matter content are low to high. The available water capacity is 2 to 9 inches. Water intake is moderately rapid, and runoff is slow to medium.

These soils warm early in spring. The frost-free season is about 100 days, and the average annual precipitation is about 12 to 16 inches.

All of the acreage of these soils is used for range.

Capability Unit VIIe-3

This unit consists of shallow, steep and hilly sandy loam soils that are underlain by sandstone. These soils occur on uplands. They are well drained and moderately rapid in permeability. Fertility and organic-matter content are low. The available water capacity ranges from 2 to 9 inches, and runoff is slow to medium.

The soils of this unit warm early in spring. The frost-free season is 100 to 120 days, and the average annual precipitation is about 12 inches.

These soils are used only for range.

Capability Unit VIIs-1

Epsie clay, 4 to 15 percent slopes, is the only soil in this unit. This soil is fine textured, well drained, and slowly permeable. It is shallow soil over shale and is strongly alkaline. Organic-matter content and fertility are low, and the available water capacity is 2.5 to 4 inches. Runoff is moderately rapid.

This soil warms rapidly in spring. The frost-free season is about 100 to 120 days.

This soil is used as range.

Capability Unit VIIIw-1

Only Riverwash is in this unit. This land type consists of deep, well-drained, permeable sand and

gravel that were recently deposited on river flood plains. It is flooded during the spring thaw, but it dries quickly when the floodwater recedes. The organic-matter content and fertility are very low. Available water capacity is about 2 inches for a 5-foot depth. Soil blowing and water erosion are severe hazards. The frost-free season is 100 to 120 days.

This land is not suited to grazing or cultivation. It generally is bare of vegetation.

Capability Unit VIIIs-2

This unit consists of steep and hilly shale and sandstone outcrops on uplands. Runoff is rapid. These areas are not suited to cultivation. Their main value is use as watersheds.

Predicted Yields of Dryland Crops

Table 1 lists, for those soils commonly cultivated, predicted average yields of the principal dryland crops grown in Powder River Area. The yield figures given are estimated long-time averages expected under a high level of management. In estimating these yields, crop failures were considered. The estimates are based on interviews with farmers and records of the Montana Agricultural Experiment Station. The management needed to obtain the yields in table 1 are: (1) proper use of crop residue in summer fallow, (2) contour or wind stripcripping, contour tillage, terracing, and planting field shelterbelts, (3) using proper seeding rates and proper dates of planting, and (4) applying fertilizers in amounts indicated by soil tests and crop requirements.

Range Management[2]

Approximately 2,075,214 acres, or 90 percent of the Powder River Area, is range, or land on which the climax vegetation is suited to and mainly used for grazing. The economy of the survey area largely depends on the sale of livestock products. The soils also are important as wildlife habitats and for use as watersheds.

The soils of this survey are classified by range-soil group. A range-soil group consists of soils that have similar surface texture, depth, and subsoil permeability and that occur under similar conditions of rainfall and other elements of climate. In its original or climax condition, each range-soil group has a distinct kind and amount of vegetation, measurably different from the kind and amount on other range-soil groups.

For proper management, a rancher should know the different kinds of range-soil groups in his holdings and the plants best suited to each. Management can then favor the growth of the best forage plants on each group.

The total yield of forage varies from year to year with precipitation (4). Yields are above average in years of high rainfall and below average in years of lower rainfall. The safest basis for determining how many animals to graze in any given year is the forage production during that year.

Range Condition

Range condition is the present state of the vegetation of a range-soil group in relations to its climax vegetation. A range is in excellent condition if 76 to 100 percent of the plant cover, by weight, is similar to the original or climax plant community; it is in good condition if 51 to 75 percent of the vegetation is similar to the original; in fair condition if 25 to 50 percent of the plants are similar to the original; and in poor condition if less than 25 percent of the present vegetation is the original kind.

The native plant community may be altered, both as to kind and amount of plants, by grazing animals. Livestock constantly seek the more palatable, nutritious, and readily available forage plants. Plants are classified as decreasers, increasers, and invaders, according to their response to grazing pressures.

Species of plants that decrease in relative abundance with continued moderately heavy to heavy grazing are called decreasers. They are the plants most relished by grazing animals and are, therefore, the first to decline with overuse. Less palatable plants that increase to fill the voids left by the more desirable plants, are called increasers. These short grasses and less desirable plants, in turn may be weakened by continued close grazing and decline in abundance. The site is then taken over by invaders--unpalatable plants, weedy type plants, or exotics that make up less than 2 1/2 percent of the total production in the climax vegetation. They fill the voids that develop as more desirable plants are weakened or killed by overgrazing or other disturbances.

General Management

Proper use of range, deferred grazing, and distribution of grazing through stockwater development, salting, fencing, and herding are all good management practices. Where applied, these practices improve the growth of plants and conserve soil, water, and plants. One of the objects of good range management is to keep the vegetation in excellent or good condition. Proper use of range as well as periodic rests from grazing during the growing

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[2] Phillip E. Van Cleave, range conservationist, Soil Conservation Service, helped prepare this section.

TABLE 1.--PREDICTED AVERAGE YIELDS PER ACRE OF CROPS UNDER A HIGH LEVEL OF DRYLAND MANAGEMENT

[Absence of figure indicates that crop is not commonly grown on the soil]

Soil	Winter wheat	Barley	Oats	Alfalfa
	Bushels	Bushels	Bushels	Tons
Bew silty clay, 0 to 2 percent slopes	24	30	---	1.5
Bew silty clay, 2 to 4 percent slopes	24	30	---	1.5
Bew silty clay, 4 to 8 percent slopes	24	30	---	1.5
Cushman-Elso silt loams, 4 to 8 percent slopes	18	34	---	.9
Cushman-Elso silt loams, 8 to 15 percent slopes	14	18	---	.9
Farland silt loam, 0 to 2 percent slopes	26	34	80	1.5
Farland silt loam, 2 to 4 percent slopes	26	34	80	1.5
Farland silt loam, 4 to 8 percent slopes	26	30	80	1.5
Farland-Cabba association, 4 to 8 percent slopes	19	30	80	1.5
Farland and Havrelon soils, 4 to 8 percent slopes	19	30	80	1.5
Fergus-Relan association, 2 to 8 percent slopes	19	30	80	1.5
Fort Collins silt loam, 0 to 2 percent slopes	21	32	---	1.2
Fort Collins silt loam, 2 to 4 percent slopes	21	32	---	1.2
Fort Collins silt loam, 4 to 8 percent slopes	16	24	---	1.2
Galata silty clay, 4 to 8 percent slopes	15	20	---	1.2
Gilt Edge silt loam, 0 to 2 percent slopes	18	25	---	1.5
Gilt Edge silt loam, 2 to 6 percent slopes	18	25	---	1.5
Glenberg fine sandy loam, 0 to 2 percent slopes	15	18	---	1.2
Haverson loam	18	25	---	1.5
Haverson silty clay	18	25	---	1.5
Haverson silty clay loam	18	25	---	1.5
Haverson silt loam	18	25	---	1.5
Heldt silty clay loam, 0 to 2 percent slopes	25	30	70	1.5
Heldt silty clay loam, 2 to 4 percent slopes	25	30	70	1.5
Heldt silty clay loam, 4 to 8 percent slopes	25	30	70	1.5
Hesper silty clay loam, 0 to 2 percent slopes	20	24	---	1.5
Hesper silty clay loam, 2 to 4 percent slopes	20	24	---	1.5
Hesper silty clay loam, 4 to 8 percent slopes	20	24	---	1.5
Hesper silty clay loam, 8 to 15 percent slopes	20	24	---	1.5
Hopley-Relan loams, 4 to 8 percent slopes	15	22	---	1.2
Hydro silty clay loam, 0 to 2 percent slopes	15	24	---	1.2
Hydro silty clay loam, 2 to 4 percent slopes	15	24	---	1.2
Hydro silty clay loam, 4 to 8 percent slopes	15	24	---	1.2
Hydro-Arvada complex, 2 to 8 percent slopes	15	20	---	1.2
Hydro-Fort Collins silt loams, 0 to 2 percent slopes	16	24	---	1.2
Keiser silty clay loam, 0 to 2 percent slopes	20	24	---	1.2
Keiser silty clay loam, 2 to 4 percent slopes	20	24	---	1.2
Keiser silty clay loam, 4 to 8 percent slopes	20	24	---	1.2
Kyle clay, 2 to 4 percent slopes	18	25	---	1.5
Kyle clay, 4 to 8 percent slopes	18	25	---	1.5
McRae silt loam, 0 to 2 percent slopes	20	22	---	1.5
McRae silt loam, 2 to 4 percent slopes	20	22	---	1.5
McRae silt loam, 4 to 8 percent slopes	20	22	---	1.5
Rapelje silt loam, 0 to 2 percent slopes	15	24	---	1.5
Rapelje silt loam, 2 to 8 percent slopes	15	24	---	1.5
Relan loam, 4 to 8 percent slopes	20	30	50	1.5
Remmit fine sandy loam, 2 to 4 percent slopes	14	25	70	1.2
Remmit fine sandy loam, 4 to 8 percent slopes	14	25	70	1.2
Thurlow silty clay loam, 0 to 2 percent slopes	20	30	70	1.2
Thurlow silty clay loam, 2 to 4 percent slopes	20	30	70	1.2
Thurlow silty clay loam, 4 to 8 percent slopes	20	30	70	1.2
Thurlow silty clay loam, 8 to 15 percent slopes	20	30	70	1.2
Vona fine sandy loam, 2 to 4 percent slopes	25	25	---	1.4
Vona-Remmit fine sandy loam, 4 to 8 percent slopes	25	25	---	1.4

season, permits vegetation in poor and fair condition to improve and maintains vegetation in good and excellent condition.

Knowledge of range management and condition classes helps the rancher to evaluate his range and plan ways to maintain and improve it. To identify the range-soil group in which any soil in the Powder River Area has been placed, refer to the "Guide to Mapping Units" at the back of this survey.

Description of Range-Soil Groups

Each of the 13 range-soil groups that occur in significant amounts in the survey area is described in the following paragraphs. Given for each group are plants that generally grow on the soils and practices that improve the range.

Range-Soil Group 1

Only the mapping unit Haverson soils, saline, is in this group. These soils are nearly level to gently sloping, poorly drained, and loamy. They occupy alluvial valleys in the 10- to 14-inch precipitation zone. These soils receive runoff and seepage water from higher soils on uplands. They are near streams and have a high water table. The content of soluble salts is high.

Where the range is in excellent condition, alkali sacaton, western wheatgrass, and other mid grasses make up about 60 percent of the total plant cover. The rest is made up of increasers, such as inland saltgrass, greasewood, Baltic rush, Gardner saltbush, and sedges. Where the range is in poor condition, there is a high percentage of inland saltgrass, mat muhly, foxtail barley, curlycup gumweed, and annuals. These soils are smooth and can be reseeded and interseeded.

Where the range is in excellent condition, the total annual air-dry yield when moisture is average is about 2,100 pounds of herbage per acre. In a dry year the yield is as low as 1,200 pounds of herbage per acre.

Range-Soil Group 2

This group consists of deep, nearly level to strongly sloping fine sandy loam soils. They occur on valley bottoms and upland foot slopes in the 10- to 14-inch precipitation zone. Runoff is slow and permeability is moderately rapid.

Where the range is in excellent condition, the dominant plants are prairie sandreed, sand bluestem, little bluestem, Indian ricegrass, needle-and-thread, western wheatgrass, and small amounts of yucca and green sagewort. A small percentage is short grasses and shrubs, and forbs make up less than 5 percent of the total cover. Where the range is in poor condition, blue grama, threadleaf sedge, green sagewort, broom snakeweed, yucca, annuals, and other weedy plants are dominant.

Soils without plant cover blow easily. The soils can be reseeded or interseeded to establish grass cover.

Where the range is in excellent condition, the total annual air-dry yield when moisture is average is about 1,400 pounds of herbage per acre. In a dry year the yield is as low as 1,100 pounds of herbage per acre.

Range-Soil Group 3

This group consists of well-drained, gently sloping to steep and hilly silt loam and gravelly loam soils that are moderate to moderately slow in permeability. These soils occur on uplands in the 15- to 19-inch precipitation zone. They have a silty clay loam or gravelly loam subsoil and calcareous substratum, and are underlain by shale at depths of 40 inches or more.

Where the range is in excellent condition, the range vegetation is dominantly mid grasses. A small percentage is short grasses and shrubs, and 15 percent is forbs. The dominant plants are green needlegrass, Idaho fescue, bluebunch wheatgrass, western wheatgrass, needle-and-thread, and lesser amounts of big and silver sagebrush, winterfat, fringed sagewort, plains pricklypear, and broom snakeweed. Where the range is in poor condition, there is a high percentage of blue grama, Sandberg bluegrass, needleleaf sedge, annuals, broom snakeweed, and other weedy plants. These soils can be seeded.

Where the range is in excellent condition, the total annual air-dry yield when moisture is average is about 2,000 pounds of herbage per acre. In a dry year the yield is as low as 1,400 pounds of herbage per acre.

Range-Soil Group 4

This group consists of nearly level to rolling silt loam and loam soils in the 10- to 14-inch precipitation zone. These soils are well drained and moderate to slow in permeability. The subsoil ranges from silt loam to clay, and the substratum is calcareous silt loam or clay loam or a bed of platy shale that can be penetrated by grass roots.

Where the range is in excellent condition, the dominant plants are green needlegrass, western wheatgrass, needle-and-thread and there are small amounts of silver sagebrush, winterfat, fringed sagewort, and forbs. Where the range is in poor condition, the dominant plants are blue grama, Sandberg bluegrass, threadleaf sedge, cactus, fringed sagewort, broom snakeweed, sagebrush, annuals, and weedy forbs. These soils can be seeded.

Where the range is in excellent condition, the total annual air-dry yield when moisture is average is about 1,400 pounds of herbage per acre. In

a dry year the yield is as low as 1,100 pounds of herbage per acre.

Range-Soil Group 5

This group consists of deep, well-drained clay loam or granular clay soils that have a calcareous subsoil and substratum, and granular clay soils that are underlain by shale at a depth of 20 inches or less. These soils are moderately slow and slow in permeability. They are nearly level to sloping and gently rolling and occur in the 10- to 14-inch precipitation zone.

Where the range is in excellent condition, the range vegetation is dominantly mid grasses. A small percentage is short grasses and shrubs, and 10 percent is forbs. The dominant plants are green needlegrass and western wheatgrass, and there are smaller amounts of prairie junegrass, plains reedgrass, forbs, and big and silver sagebrush. Where the range is in poor condition, the dominant plants are short grasses, annuals, sagebrush, fringed sagewort, broom snakeweed, curlycup gumweed, eriogonum, biscuitroot, and other weedy forbs. These soils can be seeded.

Where the range is in excellent condition, the total annual air-dry yield when moisture is average is about 1,400 pounds of herbage per acre. In a dry year the yield is as low as 1,100 pounds of herbage per acre.

Range-Soil Group 6

This group consists of steep fine sandy loam soils that are underlain by fractured platy sandy shale at a depth of less than 20 inches. These soils occupy upland slopes in the 10- to 14-inch precipitation zone. The soils are well drained and moderately rapid in permeability. Plant roots penetrate deep into the fractures in the shale beds and between layers of shale. These soils absorb moisture readily, but the available water capacity is low. Because of their sandy texture, they are subject to soil blowing.

Where the range is in excellent condition, the dominant plants are western wheatgrass, little bluestem, needle-and-thread, prairie sandreed, Indian ricegrass, and side-oats grama, and there are smaller amounts of blue grama, threadleaf sedge, yucca, prairie rose, and skunkbush sumac. Where the range is in poor condition, the dominant plants are threadleaf sedge, blue grama, cactus, broom snakeweed, green sagewort, and annuals.

Because these soils are steep and erodible, the use of machinery for improving plant cover is restricted.

Where the range is in excellent condition, the total annual air-dry yield when moisture is average, is about 1,000 pounds of herbage per acre. In a dry year the yield is as low as 600 pounds of herbage per acre.

Range-Soil Group 7

This group consists of steep and hilly silt loam and loam soils that are underlain by soft shale at a depth of less than 20 inches. Porcelanite shale fragments are scattered throughout the profile in places. These soils are well drained and moderately slow in permeability. Because these soils are steep, water is lost in rapid runoff and is not available for plants.

Where the range is in excellent condition, the dominant plants are western wheatgrass, bluebunch wheatgrass, little bluestem, green needlegrass, prairie sandreed, needle-and-thread, and winterfat. Increaser plants are fringed sagewort, skunkbush sumac, common juniper, and yucca. Where the range is in poor condition, the dominant plants are blue grama, prairie junegrass, threadleaf sedge, sagewort, broom snakeweed, common juniper, and annuals.

Steep slopes restrict the use of machinery for improving plant cover.

Where the range is in excellent condition, the total annual air-dry yield when moisture is average is about 1,000 pounds of herbage per acre. In a dry year the yield is as low as 600 pounds of herbage per acre.

Range-Soil Group 8

This group consists of steep and hilly, calcareous clay loam and granular clay soils that are underlain by platy shale at a depth of less than 20 inches. These soils occur in the 10- to 14-inch precipitation zone.

Where the range is in excellent condition, the dominant plants are western wheatgrass, green needlegrass, bluebunch wheatgrass, little bluestem, and side-oats grama. Plains muhly, prairie junegrass, and blue grama grow in smaller amounts. Where the range is in poor condition, dominant plants are blue grama, prairie junegrass, Sandberg bluegrass, curlycup gumweed, broom snakeweed, and annuals.

Steep slopes, shale outcrops, and deep drainageways restrict the use of machinery for improving plant cover.

Where the range is in excellent condition, the total annual air-dry yield when moisture is average is about 1,000 pounds of herbage per acre. In a dry year the yield is as low as 600 pounds of herbage per acre.

Range-Soil Group 9

Only Bankard fine sandy loam is in this group. This soil has a loose sand and gravel subsoil and substratum. It occupies flood plains and terraces in the 10- to 14-inch precipitation zone. It is rapidly permeable, is somewhat excessively drained, and has a low available water capacity.

Where the range is in excellent condition, the dominant plants are little bluestem, needle-and-thread, prairie sandreed, western wheatgrass, and there are smaller amounts of blue grama, prairie junegrass, threadleaf sedge, cactus, and creeping juniper. Where the range is in poor condition, the dominant plants are blue grama, threadleaf sedge, fringed sagewort, creeping juniper, Sandberg bluegrass, and annuals. These soils can be reseeded.

Where the range is in excellent condition, the total annual air-dry yield when moisture is average is about 900 pounds of herbage per acre. In a dry year the yield is as low as 500 pounds of herbage per acre.

Range-Soil Group 10

This group consists of deep nearly level and gently sloping soils. These soils are on stream terraces, fans, and uplands in the 10- to 14-inch precipitation zone. The dense clay subsoil is within a few inches of the surface, and it is exposed on the surface of shallow depressions in more than 20 percent of the area. The substratum contains salt or gypsum. These soils are moderately well drained. Permeability and runoff are slow. The available moisture capacity is high, but these soils yield moisture to plants very slowly.

Where the range is in excellent condition, the dominant plants are western wheatgrass, green needlegrass, Gardner saltbush, and there are smaller amounts of needle-and-thread, blue grama, and Sandberg bluegrass. Where the range is in poor condition, the dominant plants are blue grama, Sandberg bluegrass, bottlebrush squirreltail, inland saltgrass, greasewood, broom snakeweed, cactus, and annual weeds. Many areas are bare. These soils can be reseeded with adapted species of grass.

Where the range is in excellent condition, the total annual air-dry yield when moisture is average is about 900 pounds of herbage per acre. In a dry year the yield is as low as 600 pounds of herbage per acre.

Range-Soil Group 11

This group consists of gently sloping to strongly sloping, dense clay soils on uplands in the 10- to 14-inch precipitation zone. The surface layer is crusty clay loam that is underlain by dense clay or clay shale. These soils are well drained. Permeability is very slow, and the dense clay substratum restricts the movement of water.

Where the range is in excellent condition, the dominant plants are western wheatgrass and green needlegrass and smaller amounts of silver sagebrush, Gardner saltbush, prairie junegrass, plains reedgrass, and forbs. Where the soils are in poor condition, the dominant plants are buffalograss, bottlebrush squirreltail, cactus, curlycup gumweed, broom snakeweed, and annuals. These soils can be reseeded.

Where the range is in excellent condition, the total annual air-dry yield when moisture is average is about 800 pounds of herbage per acre. In a dry year the yield is as low as 500 pounds of herbage per acre.

Range-Soil Group 12

Midway and Elso rocky soils, 35 to 75 percent slopes, are the only soils in this group. These soils occur on sandstone ledges and breaks in the 10- to 14-inch precipitation zone. Gully erosion is severe.

Where the range is in excellent condition, the dominant plants are western wheatgrass, bluebunch wheatgrass, little bluestem, and plains muhly, and there are smaller amounts of silver sagebrush, juniper, winterfat, and skunkbush sumac. Where the range is in poor condition, the dominant plants are rubber rabbitbrush, creeping juniper, snowberry, sagebrush, blue grama, annuals, and weedy forbs. Proper range use and regulation of grazing are the only management practices applicable to this group of soils.

Where the range is in excellent condition, the total annual air-dry yield when moisture is average is about 700 pounds of herbage per acre. In a dry year the yield is as low as 300 pounds of herbage per acre.

Range-Soil Group 13

This group consists of very steep and hilly loam or silt loam soils that are underlain by platy, hard, porcelanite shale within a depth of 20 inches. These soils occur in uplands in the 15- to 19-inch precipitation zone. They are well drained and moderately permeable.

Where the range is in excellent condition, the dominant plants are bluebunch wheatgrass, western wheatgrass, side-oats grama, little bluestem, green needlegrass, and Idaho fescue, and there are smaller amounts of needle-and-thread, plains muhly, threadleaf sedge, forbs, and ponderosa pine and juniper trees. Where the range is in poor condition, the dominant plants are annuals, weedy forbs, needle-and-thread, threadleaf sedge, fringed sagewort, prairie junegrass, and ponderosa pine and juniper trees. Proper range use and regulation of grazing are the only management practices applicable to this group of soils.

When the range is in excellent condition, the total annual air-dry yield when moisture is average is about 500 pounds of herbage per acre. In a dry year the yield is as low as 200 pounds of herbage per acre.

Windbreaks

Tree windbreaks help to reduce the impact of the wind on farms and ranches. They protect farmsteads against drifting snow and soil blowing. They also provide shelter for livestock and food and cover for birds and other wildlife.

The selection of trees and shrubs that grow best on a specific kind of soil insures survival and rapid growth. This selection is most important in dryland plantings. Proper soil preparation, moisture conservation, timely planting, and weed control are necessary for the successful establishment of a windbreak. Windbreaks provide maximum benefits when planted at right angles to the prevailing winds. They should be wide enough to protect the area that needs protection. Plantings on sandy soils normally need to be protected against soil blowing until the trees become established.

The broad-leaved trees and shrubs used for windbreak plantings include American elm, green ash, Siberian elm, golden willow, cottonwood, Russian-olive, boxelder, chokecherry, skunkbush sumac, American plum, buffaloberry, and caragana. Evergreen trees include ponderosa pine, Rocky Mountain juniper, and Colorado blue spruce. The most hardy species are caragana, Russian-olive, Siberian elm, green ash, ponderosa pine, and Rocky Mountain juniper. Willows and cottonwoods do best where soils are moist throughout the year. Species that tolerate slight to moderate salinity or alkalinity are Russian-olive, buffaloberry, cottonwood, golden willow, Siberian elm, and Rocky Mountain juniper.

Windbreak Suitability Groups

Soil properties that are important in rating the suitability of a soil for windbreak plantings are the amount and depth to lime in the soil profile, depth to bedrock, available moisture capacity, content of coarse rock fragments, permeability, degree of wetness, and the presence or absence of alkali and salts.

The soils of the Powder River Area are placed in five windbreak suitability groups. The soils in each group need similar management for successful plantings. Each windbreak suitability group is described in the following paragraphs, and species of trees and shrubs most suited to the group are listed. To identify the soils in a windbreak suitability group, refer to the "Guide to Mapping Units" at the back of this soil survey. The soils not placed in one of the five windbreak groups are not suitable for windbreak plantings.

Windbreak Suitability Group 1

This group consists of dark-brown to black sandy loam, silt loam, and loam soils that are more than 36 inches deep. In places these soils are mildly calcareous and have lime accumulations at a depth of more than 24 inches. Where soils are under grass, slopes are less than 8 percent; where soils are forested, slopes are 15 to 50 percent. In this group are the best soils for windbreak plantings in the survey area. All trees and shrubs listed in the introduction to the subsection "Windbreaks" are suitable except golden willow, cottonwood, and American elm.

Windbreak Suitability Group 2

This group consists of well-drained, light-colored clay loams and loams that are moderate and moderately slow in permeability, are more than 20 inches deep, and have slopes of 0 to 15 percent. Plantings on these soils should have the maximum spacing between rows. The growth rate for trees and shrubs grown on these soils is slower than for group 1 because precipitation is less.

Species suitable for planting on the soils of this group are caragana, honeysuckle, lilac, chokecherry, American plum, skunkbush sumac, buffaloberry, sand cherry, Nanking cherry, Russian-olive, Siberian elm, green ash, ponderosa pine, juniper, Colorado spruce, and hawthorn.

Windbreak Suitability Group 3

This group consists of well-drained, slowly permeable clay soils and soils that have limy substrata. Slopes are 0 to 15 percent. These soils are less suitable for windbreak plantings than soils in groups 1 and 2. They have a high shrink-swell potential. Because root penetration is slow and roots are compressed, the loss of seedlings is high. Except where soils are irrigated, the choice of plants is limited to the most hardy species. The growth rate is slow and maximum height is less than on the more favorable soils. The spacing between rows should be at least 20 feet.

On this group species suitable for both dryland and irrigated sites include caragana, honeysuckle, lilac, chokecherry, skunkbush sumac, Russian-olive, Siberian elm, Rocky Mountain juniper, green ash, and ponderosa pine.

Windbreak Suitability Group 4

This group consists of deep, well-drained silty clay loam and silt loam soils. These soils have a moderately slowly permeable clay loam or silty clay subsoil that contains crystals of salt or gypsum at a depth of more than 4 feet. Slopes are 0 to 15 percent. The choice of plants is limited to the most hardy and salt-tolerant species. Plantings should be spaced at least 20 feet apart.

On this group species suitable for planting on both dryland and irrigated sites are caragana, Russian-olive, Siberian elm, lilac, chokecherry, Rocky Mountain juniper, and skunkbush sumac.

Windbreak Suitability Group 5

The soils of this group are moderately saline to alkaline. They generally have a silt loam surface layer, a dense clay subsoil, and a salt-saturated substratum. The subsoil has more moisture than average and is slowly permeable to plant roots and water. Slopes are less than 4 percent.

Species suitable for planting on both dryland and irrigated sites are very limited. The species most likely to survive are Russian-olive, white willow, golden willow, purple willow, buffaloberry, cottonwood, and Rocky Mountain juniper.

Engineering Uses of Soils

Soil properties that are of special interest to engineers are those that affect the construction and maintenance of engineering structures, such as roads, airports, pipelines, building foundations, water storage facilities, erosion control structures, drainage systems, and sewage disposal systems. Among the properties most important to the engineer are permeability to water, shear strength, compactibility, texture, plasticity and reaction. Depth of the unconsolidated materials and topography are also important.

With the use of the soil map for identification, the interpretations in this survey can be used for many purposes. It should be emphasized, however, that they do not eliminate the need for onsite sampling and testing for design and construction of specific engineering works involving heavy loads and excavations deeper than the depths of layers here reported. Even in these situations, the soil map is useful in planning more detailed investigations and for suggesting the kinds of problems that may be expected. Engineers can use the information in the survey to:

1. Make soil and land use studies that will aid in selecting and developing industrial, business, residential, and recreational sites.
2. Make preliminary estimates of the engineering properties of soil that will help in the planning of agricultural drainage systems, farm ponds, irrigation systems, terraces, waterways, and spreader dikes.
3. Make preliminary evaluations of soil and ground conditions that will aid in selecting locations for highway, road, and airport and in planning detailed investigations at the selected locations.
4. Locate probable sources of gravel, sand, or other construction materials.
5. Correlate performance of engineering structures with soil mapping units and thus develop information that will be useful in designing and maintaining the structures.
6. Determine the suitability of soils for cross-country movement of vehicles and construction equipment.
7. Supplement information obtained from other published maps, reports, and aerial photographs for the purpose of making maps and reports that will be more useful to engineers.
8. Develop other preliminary estimates for construction purposes pertinent to a particular area.

Tables 2, 3, and 4 provide data useful in soils engineering. Some of the terms used by the agricultural soil scientist may be unfamiliar to the engineer, and some common terms may have a special meaning in soil science. Several of these terms are defined in the Glossary at the back of this survey. Additional information about the soils can be found in other sections of the survey, particularly "Descriptions of the Soils" and "Formation and Classification of Soils."

Engineering Classification Systems

The three systems of classification in table 2--the USDA, the Unified, and the AASHO--require some explanation. Soil scientist and other agricultural workers classify soils according to the system of textural classification used by the Department of Agriculture (USDA). In this system the texture of the soil material made up of particles smaller than 2 millimeters is determined by the percentage of sand, silt, and clay in the soil material.

The other two classifications shown in table 2 are used by engineers. They are the Unified system (7) and the system used by the American Association of State Highway Officials (AASHO) (1).

The Unified system is based on the identification of soils according to their texture and plasticity, as well as their performance when used as material for engineering structures. The eight classes of coarse-grained soils are identified as GW, GP, GM, GC, SW, SP, SM, and SP; six classes of fine-grained soils are identified as ML, CL, OL, MH, CH, and OH; and organic soil is identified by the symbol Pt. The symbol ML is used for inorganic silts, very fine sands, rock flour, silt, clayey fine sands, or for clay and silt that have slight plasticity and a low liquid limit. CL is used for inorganic clays of low to medium plasticity, and for gravelly clays, sandy clays, silty clays, and lean clays that have a low liquid limit. CH is used for inorganic clays of high plasticity and fat clays that have a high liquid limit. OL is used for organic silts and organic clays of low plasticity and low liquid limit.

The AASHO system is based on actual performance of material used as a base for roads and highways. In this system soil materials are classified into seven groups. These groups range from A-1, which consists of gravelly soils of high bearing capacity that are the best soils for subgrades, to A-7, which are clay soils that have low strength when wet and are the poorest soils for subgrades. Within each group the relative engineering value of the soil is indicated by a group index number. In

table 2, this number is shown in parentheses following the group classification. Group index numbers range from 0 for the best material to 20 for the poorest. Where laboratory data are not available, the group index number is not included in engineering estimates.

Estimated Engineering Properties of Soils

Table 3 lists the soil series and the land type Terrace escarpments in the survey area and gives estimates of soil properties that are significant in engineering. These estimates are based on the test data in table 2, on information in other parts of the survey, and on knowledge gained from experience with similar soils in other counties of the State.

Riverwash, Rock land, and Shale outcrop are not included in this table, because their properties are too variable to estimate. Depth to the seasonal high water table also is not given in table 3. Except for Haverson soils, saline, the soils in the survey area have a water table more than 5 feet from the surface. In Haverson soils, saline, the seasonal high water table is less than 3 feet from the surface.

Some columns in table 3 need no explanation; others are explained in the following paragraphs.

Permeability indicates the rate at which water moves downward through undisturbed soil material. The rate depends largely on texture, porosity, and structure of the soil. A rate of less than 0.2 inch is slow; 0.2 to 0.63 inch moderately slow; 0.63 inch to 2 inches, moderate; 2 to 6.3 inches, rapid; and more than 6.3 inches, very rapid.

Available water capacity is the amount of water that, between field capacity and the wilting point, a soil can hold available for plant use after all free water has drained away. When a soil is air dry, this amount of water will wet the soil material to a depth of 1 inch without deeper penetration. Available water capacity is affected by texture, structure, and organic-matter content of the soil.

Reaction, or the degree of acidity or alkalinity, is given in pH values and defined in the Glossary.

The salinity of the soils depends on the content of soluble salts, such as sodium chloride, sodium sulphate, and gypsum. It is estimated according to the electrical conductivity of the soil saturation extract, expressed in millimhos per centimeter at 25° C. The relative terms used to rate salinity are defined as follows: None, less than 2 millimhos per centimeter; low, 2 to 4; moderate, 4 to 8; high, 8 to 15; and very high, more than 15.

In the estimates for corrosivity of untreated steel pipe, the soil properties considered were total acidity, drainage, and texture.

The shrink-swell potential indicates the volume change to be expected with a change in moisture content. The volume change is determined primarily by the amount and kind of clay in the soil. Clay and silty clay soils that are classified A-7 generally have a high shrink-swell potential. Clean sand and gravel and other soils that contain small amounts of nonplastic and slightly plastic fines have a low shrink-swell potential.

A soil that has high frost action, or frost heave, is not suitable for road construction and building sites.

Engineering Interpretations of Soils

In table 4 are interpretations of engineering properties of soils. The first part estimates the suitability of each soil as source material for engineering purposes. The second part lists soil features that affect engineering structures and practices, and the third part rates limitations to use of the soil as sewage disposal fields. Rock land and shale outcrop are not included, because their properties are too variable to be evaluated.

The soils are rated as a source of topsoil because topsoil is needed in establishing vegetation and controlling erosion on embankments and road shoulders. Each soil also is rated as a source for sand, gravel, and road fill. The silt content of sand and gravel in the area is so high that they are unsuitable for concrete unless they are washed.

Features that affect highway location are soil stability, susceptibility to frost action, plasticity, and steep slopes. Bedrock is not a problem, because the unconsolidated stratified shale and sandstone are easily shattered and handled. The red porcelanite shale is moved easily and shatters readily when ripped with heavy machinery. Although there is little sand and gravel in the area, porcelanite shale and clinkers called scoria are crushed and used for road material. The porcelanite shale makes a fair base for subgrades and subbases. It breaks down rapidly and generally lasts 2 to 5 years as a surface material before it needs replacing.

Soil features that affect the reservoir areas of farm ponds are porosity, permeability, and depth to fractured rock. Most of the soils in the survey area are suitable for use as reservoirs. The embankments of farm ponds are affected by stability, shrink-swell potential, permeability, compactibility, erodibility, and shear strength.

Agricultural drainage is affected by permeability, a clayey subsoil, and salinity.

Land leveling is affected by salinity, texture, permeability, and slope.

Irrigation is affected by permeability, salinity texture, and water intake rate.

Building sites are affected by shrink-swell ratio, susceptibility to flooding, steep slopes, stability, and bearing capacity. Specific values should not be given to estimates of bearing capacity.

Also rated in table 4 are limitations to use for sewage disposal fields. Limitations are rated slight, moderate, and severe. Slight limitations can easily be overcome, but moderate limitations indicate that a moderate effort is needed before the soils will function properly as a sewage disposal field. A severe limitation indicates that use for disposal fields may not be practical.

Soil name and location	Parent material	Depth from surface	Helena laboratory No.	Mechanical analyses 2/ Percentage passing sieve-- 3 in.	1 1/2 in.	3/4 in.	No. 4
		Inches					
Elso silt loam: SE¼ of sec. 31, T. 3 S., R. 46 E., Powder River County.	Residuum from soft shale.	0-6	301037	---	---	100	92
		6-26	301038	---	---	---	100
Midway silty clay loam: 2,640 ft. E., 1,580 ft. N. of SW. corner of sec. 18, T. 6 S., R. 45 E., Powder River County.	Residuum from soft shale.	0-12	301040	---	---	100	98
		6/ 12-32	301041	---	---	---	---
Nihill gravelly loam: (Mapped only in association with Elso soils.) 700 ft. S. of N¼ corner of sec. 6, T. 4 S., R. 48 E., Powder River County.	Very gravelly loam alluvium.	0-8	301035	100	96	89	66
		8-35	301036	100	98	83	50

1/ Tests performed by the Montana State Highway Commission in cooperation with the U.S. Department of Commerce, Bureau of Public Roads, in accordance with standard procedures of the American Association of State Highway Officials.

2/ Mechanical analyses according to the American Association of State Highway Officials Designation T 88. Results by this procedure may differ somewhat from results that would have been obtained by the soil survey procedure of the Soil Conservation Service (SCS). In the AASHO procedure, the fine material is analyzed by the hydrometer method and the various grain-size fractions are calculated on the basis of all the material, including that coarser than 2 millimeters in diameter. In the SCS procedure, the fine material is analyzed by the pipette method and material coarser than 2 millimeters in diameter is excluded from calculations of grain-size fractions. The mechanical analyses used in this table are not suitable for use in naming textural classes of soils.

TEST DATA 1/

Mechanical analyses 2/--Continued					Liquid limit	Plasticity index	Maximum density	Optimum moisture	Classification	
Percentage passing sieve--Con.			Percentage smaller than--						AASHO 3/	Unified 4/
No. 10	No. 40	No.200	0.005 mm.	0.002 mm.						
91	90	68	23	16	32	8	102	20	A-4(7)	ML
99	99	65	28	22	39	8	106	18	A-4(6)	ML
97	93	89	64	40	48	15	93	27	A-7-5(12)	ML
---	---	100	88	68	58	10	96	27	A-5(12)	MH
59	51	27	7	5	28	6	105	19	A-2-4(0)	SM-SC
41	34	15	4	2	21	0	109	18	A-1-b(0)	GMd 5/

3/ Based on Standard Specifications for Highway Materials and Methods of Sampling and Testing (Pt. 1, Ed. 7): The Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes, AASHO Designation M 145-49.

4/ Based on the Unified Soil Classification System, Tech. Memo. No. 3-357, v. 1, Waterways Experiment Station, Corps of Engineers, March 1953.

5/ The suffix d is used for roads and airfields only. It is based on Atterburg limits and is used when liquid limit is 28 or less and plasticity index is 6 or less.

6/ Soft shale.

Soil series and map symbol	Depth to hard bedrock	Depth from surface	Classification			Percentage passing sieve--
			Dominant USDA texture	Unified	AASHO	No. 4
	Inches	Inches				
Arvada:						
Ab----------	>60	0-17	Clay and silty clay----------	CH	A-7	100
(For properties of the Bone soil in this mapping unit, refer to the Bone series.)		17-60	Stratified silty clay loam, sandy clay loam, and fine sandy loam.	ML or CL	A-4 or A-6	
Bankard:						
Ba----------	>60	0-11	Fine sandy loam----------	SM	A-4	100
		11-62	Loamy sand and coarse sand---	SP-SM	A-1 or A-2	90-100
Barvon----------	40-60	0-42	Loam and clay loam----------	ML or CL	A-4 or A-6	100
(Mapped only with Campspass soils.)		42	Shale.			
Bew:						
Bc, Be, Bw----------	>60	0-60	Silty clay and clay----------	CH	A-7	100
Bone----------	>60	0-36	Silty clay loam and silty clay.	CL	A-6	100
(Mapped only with Arvada soils.)		36-62	Clay----------	CH	A-7	100
Cabba:						
Ca----------	<20	0-16	Loam and silt loam----------	ML	A-4	100
		16	Siltstone, sandstone, and shale.			
Campspass:						
Cb----------	40-60	2-0	Duff and humus----------	OL	-------	-------
(For properties of the Barvon soil in this mapping unit, refer to the Barvon series.)		0-43	Loam, clay loam, and silty clay loam.	CL	A-6	100
		43	Sandstone, siltstone, or shale.			
Cushman:						
Ce, Ch----------	20-40	0-26	Loam and clay loam----------	CL	A-6	100
(For properties of the Elso soils in these mapping units, refer to the Elso series.)		26	Soft sandstone.			
Elso:						
Ec, El, Eo----------	<20	0-20	Silt loam----------	ML	A-4	100
(For properties of the Ocean Lake soil in mapping unit Eo, refer to the Ocean Lake series.)		20	Shale.			

See footnotes at end of table.

Percentage passing sieve--Continued		Permeability	Available water capacity	Reaction	Salinity	Corrosivity of untreated steel pipes	Shrink-swell potential	Frost-action potential
No. 10	No. 200							
		Inches per hour	Inches per inch of soil	pH value				
100	80-90	0.06-0.2	0.12-0.14	7.9-9.2	Moderate to very high.	High---------	High---------	Moderate.
100	50-70	<0.06	0.12-0.15	7.9-9.2	Moderate to very high.	High---------	Low to moderate.	Moderate to high.
90-100	35-50	6.3-20.0	0.13-0.15	6.6-7.8	None---------	Low----------	Low----------	Moderate.
80-100	5-15	>20.0	0.05-0.07	6.6-7.8	None---------	Low----------	Low----------	Low.
100	60-80	0.63-2.0	0.17-0.19	6.6-8.4	None---------	Low to moderate.	Low to moderate.	Moderate to high.
100	80-90	0.06-0.2	0.15-0.17	7.4-8.4	Low----------	High---------	High---------	Moderate.
100	80-90	0.06-0.2	0.16-0.18	7.4-8.4	High---------	High---------	Moderate-----	High.
100	80-90	<0.06	0.14-0.16	8.5-9.0	High to very high.	High---------	High---------	Moderate.
100	80-90	0.63-2.0	0.19-0.21	7.9-8.4	None---------	Low----------	Low----------	High.
-------	-------	0.63-2.0	0.30-0.40	5.6-6.5	None---------	Low----------	High shrink; low swell.	High.
100	70-80	0.20-0.63	0.18-0.20	6.6-8.4	None---------	Moderate-----	Moderate-----	High.
100	70-80	0.63-2.0	0.18-0.20	6.6-9.0	None to low--	Moderate to high.	Moderate-----	High.
90-100	65-75	0.63-2.0	0.19-0.21	7.9-8.4	None to low--	Moderate to high.	Low----------	High.

Soil series and map symbol	Depth to hard bedrock	Depth from surface	Classification			Percentage passing sieve--
			Dominant USDA texture	Unified	AASHO	No. 4
	Inches	Inches				
Epsie:						
Ep	<20	0-18	Clay	CH	A-7	100
		18	Shale.			
Farland:						
Fa, Fd, Fe, Fh, Fk, Fl, Fm (For properties of the Cabba soils in mapping units Fh and Fk and of the Havrelon soil in mapping unit Fl, refer to their respective series. Rock land in mapping unit Fm is too variable for properties to be estimated.)	>60	0-72	Silt loam, silty clay loam, and fine sandy loam.	ML	A-4	100
Fergus:						
Fn (For properties of the Relan soil in this mapping unit, refer to the Relan series.)	>60	0-5	Silt loam	ML	A-4	90-100
		5-35	Silty clay loam and clay loam	ML or CL	A-6	90-100
		35-60	Channery heavy silt loam	SM	A-2	70-80
Fort Collins:						
Fo, Fr, Fs	>72	0-62	Silty clay loam, silt loam	CL	A-6	100
Galata:						
Ga	>40	0-42	Clay or silty clay	CH	A-7	100
		42	Shale or sandstone.			
Gilt Edge:						
Gd, Ge	>60	0-8	Silt loam	ML	A-4	100
		8-24	Clay	CH	A-7	100
		24-62	Silty clay loam and silt loam	CL	A-6	100
Glenberg:						
Gf	>60	0-36	Fine sandy loam	SM	A-4	100
		36-60	Sand or loamy sand	SM	A-2	100
Haverson:						
Ha, Hc, Hf	>60	0-60	Stratified loam, silt loam, very fine sandy loam, and silty clay loam.	ML or CL	A-4 or A-6	100
Hd, He	>60	0-20	Silty clay loam or silty clay	CL or CH	A-6 or A-7	100
		20-60	Stratified loam, silt loam, and clay loam.	ML or CL	A-4 or A-6	100
Hg	>60	0-60	Stratified silt loam, loam, and fine sandy loam.	ML	A-4	100

See footnotes at end of table.

PROPERTIES OF SOILS--Continued

Percentage passing sieve--Continued		Permeability	Available water capacity	Reaction	Salinity	Corrosivity of untreated steel pipes	Shrink-swell potential	Frost-action potential
No. 10	No. 200							
		Inches per hour	Inches per inch of soil	pH value				
100	80-90	<0.06	0.14-0.16	5.1-8.4	Moderate to high.	High---------	High---------	Moderate.
100	80-90	0.63-2.0	0.18-0.2	7.4-9.0	None---------	Low----------	Low----------	High.
80-100	80-90	0.63-2.0	0.16-0.18	6.6-7.4	None---------	Low----------	Low----------	High.
85-100	70-80	0.2-0.63	0.18-0.20	6.6-8.4	None---------	Moderate-----	Moderate to high.	Moderate to high.
35-75	15-35	0.63-2.0	0.13-0.15	7.9-8.4	None---------	Low----------	Low----------	Moderate.
100	70-80	0.20-0.63	0.18-0.2	6.6-8.4	None---------	Moderate-----	Moderate-----	High.
80-100	80-90	0.06-0.20	0.14-0.16	7.4-9.0	Low to moderate.	High---------	High---------	Moderate.
100	80	0.63-2.0	0.18-0.20	6.6-7.3	None---------	Low----------	Low----------	High.
100	80-90	0.06-0.20	0.14-0.16	7.4-8.4	None---------	High---------	High---------	Moderate.
100	80-90	0.06-0.20	0.18-0.20	8.5-9.0	Low to moderate.	High---------	Moderate-----	High.
95-100	35-50	0.63-2.0	0.13-0.15	6.6-8.4	None to low--	Low to moderate.	Low----------	Moderate to high.
95-100	12-25	6.3-20.0	0.06-0.08	8.5-9.0	None to low--	Low to moderate.	Low----------	Low.
100	60-90	0.63-2.0	0.16-0.18	7.9-9.0	Low to moderate.	High---------	Low----------	High.
100	80-90	0.2-0.63	0.14-0.20	7.9-9.0	Low to moderate.	High---------	Moderate to high.	Moderate to high.
100	60-80	0.63-2.0	0.16-0.18	8.5-9.0	Low to moderate.	High---------	Low to moderate.	High.
100	60-80	0.2-0.63	0.14-0.18	8.5-9.0	Moderate to high.	High---------	Low----------	High.

Soil series and map symbol	Depth to hard bedrock	Depth from surface	Classification			Percentage passing sieve--
			Dominant USDA texture	Unified	AASHO	No. 4
	Inches	Inches				
Havrelon (Mapped only with the Farland soils.)	>60	0-60	Loam, silt loam, and fine sandy loam.	ML	A-4	100
Heldt:						
Hh, Hk, Hm	>60	0-44	Silty clay loam	CL	A-6 or A-7	100
		44-66	Silty clay loam, silt loam stratified.	CL	A-6	100
Hesper:						
Hn, Ho, Hp, Hr	>60	0-60	Silty clay loam and silt loam	CL	A-6	100
Hopley:						
Hs (For properties of the Relan soil in this mapping unit, refer to the Relan series.)	42-60	0-42	Loam	ML	A-4	100
		42	Shale.			
Hydro:						
Ht, Hu, Hv, Hw, Hx, Hy (For properties of the Arvada soil in mapping unit Hw, of Elso soil in mapping unit Hx, and Fort Collins soil in mapping unit Hy, refer to their respective series.)	>60	0-43	Silty clay loam	CL	A-6 or A-7	100
		43-62	Silty clay loam	CL	A-6	100
Keiser:						
Kc, Ke, Kf	>60	0-9	Silty clay loam	CL	A-6	100
		9-60	Silt loam	ML	A-4	100
Kyle:						
Kl, Km, Kn	>40	0-52	Clay	CH	A-7	100
		52	Shale.			
McRae:						
Mc, Md, Me	>60	0-65	Silt loam and silty clay loam	ML	A-4	100
Midway:						
Mf, Mg, Mr, Mt, Mw (For properties of the Elso soils in mapping unit Mg and Mw and of Thurlow soil in mapping unit Mt, refer to their respective series. Rock land in mapping unit Mr is too variable to estimate properties.)	<20	0-7	Clay loam and clay	CL or CH	A-6 or A-7	100
		7	Shale.			

See footnotes at end of table.

Percentage passing sieve--Continued		Permeability	Available water capacity	Reaction	Salinity	Corrosivity of untreated steel pipes	Shrink-swell potential	Frost-action potential
No. 10	No. 200							
		Inches per hour	Inches per inch of soil	pH value				
100	60-90	0.63-2.0	0.14-0.16	7.4-8.4	None---------	Low----------	Low---------	High.
100	85-95	0.06-0.20	0.15-0.17	7.9-8.4	None to low--	Moderate to high.	Moderate----	Moderate to high.
100	80-95	0.06-0.20	0.15-0.17	8.5-9.0	Low to moderate.	Moderate------	Low to moderate.	Moderate to high.
100	80-90	0.2-0.63	0.18-0.2	6.6-9.0	None---------	Moderate------	Moderate----	High.
100	50-70	0.63-2.0	0.16-0.18	6.6-8.4	None---------	Low----------	Low---------	High.
100	80-95	0.2-0.63	0.17-0.19	6.6-9.0	None to low--	High----------	Moderate to high.	Moderate to high.
100	75-95	0.2-0.63	0.16-0.18	7.9-9.0	Low to moderate.	High----------	Moderate----	Moderate to high.
100	80-90	0.2-0.63	0.18-0.20	6.6-7.3	None---------	Moderate------	Moderate----	High.
100	80-90	0.2-0.63	0.18-0.20	8.5-9.0	Low to moderate.	High----------	Low---------	High.
100	80-90	0.06-0.20	0.14-0.16	7.4-8.4	Low to moderate.	High----------	High--------	Moderate.
100	60-75	0.63-2.0	0.18-0.20	6.6-9.0	None to low--	Moderate to high.	Low---------	High.
100	80-90	0.06-0.20	0.16-0.18	7.9-8.4	None to low--	High----------	High--------	Moderate.

Soil series and map symbol	Depth to hard bedrock	Depth from surface	Classification			Percentage passing sieve--
			Dominant USDA texture	Unified	AASHO	No. 4
	Inches	Inches				
Nihill:						
Nh---------- (For properties of the Elso soil in this mapping unit, refer to the Elso series.)	>60	0-60	Very gravelly loam----------	GM	A-1 or A-2	35-55
		60	Shale.			
Ocean Lake:						
Oc---------- (Rock land is too variable to estimate properties.)	<20	0-15	Fine sandy loam and fine sand-	SM	A-2 or A-4	100
		15	Sandstone.			
Rapelje:						
Ra, Rc----------	>60	0-26	Silty clay loam----------	CL	A-6	100
		26-43	Silt loam----------	ML	A-4	100
		43-60	Fine sandy loam----------	SM	A-4	100
Relan:						
Re, Rf, Rh---------- (For properties of the Cabba soil in mapping unit Rh, refer to the Cabba series.)	>60	0-26	Silt loam and loam----------	ML	A-4	90-95
		26-60	Gravelly loam----------	SM	A-2	70-90
Relan variant:						
Rk----------	>60	0-14	Gravelly loam----------	GM	A-4	60-80
		14-60	Very gravelly loam----------	GM	A-2 or A-1	40-60
Remmit:						
Rm, Rn, Ro---------- (For properties of the Ocean Lake soil in mapping unit Ro, refer to the Ocean Lake series.)	>60	0-44	Fine sandy loam----------	SM	A-4	100
		44-62	Silt loam----------	ML	A-4	100
Ringling:						
Rs, Rt, Ru---------- (For properties of the Cabba soil in mapping unit Rt, and Relan soil in mapping unit Ru, refer to their respective series.)	<20	0-16	Slaty and very slaty loam-----	GM or SM	A-2	45-75
		16	Porcelanite or baked shale.			
Terrace escarpments:						
Te----------	>60	0-60	Loam, silt loam, silty clay loam, and fine sandy loam.	ML or CL	A-4 or A-6	100

See footnotes at end of table.

PROPERTIES OF SOILS--Continued

Percentage passing sieve--Continued		Permeability	Available water capacity	Reaction	Salinity	Corrosivity of untreated steel pipes	Shrink-swell potential	Frost-action potential
No. 10	No. 200							
		Inches per hour	Inches per inch of soil	pH value				
20-35	5-25	2.0-6.3	0.07-0.09	7.9-8.4	None---------	Low----------	Low---------	Low.
90-100	30-40	6.3-20.0	0.10-0.12	7.4-7.8	None---------	Low----------	Low---------	Moderate.
100	80-90	0.2-0.63	0.18-0.20	6.6-8.4	None---------	Moderate------	Moderate----	High.
100	80-90	0.63-2.0	0.18-0.20	7.9-8.4	None---------	Low----------	Low---------	High.
100	35-50	2.0-6.3	0.13-0.15	7.9-8.4	Low to moderate.	High----------	Low---------	High.
85-95	50-60	0.63-2.0	0.15-0.17	7.4-8.4	None---------	Low----------	Low---------	High.
35-75	15-35	0.63-2.0	0.11-0.13	8.5-9.0	None---------	Low----------	Low---------	Moderate.
50-75	35-50	6.3-20.0	0.11-0.12	7.4-8.4	None---------	Low----------	Low---------	Moderate.
25-50	12-35	6.3-20.0	0.06-0.08	7.9-9.0	None---------	Low----------	Low---------	Low.
100	35-50	0.20-6.3	0.13-1.5	7.4-8.4	None---------	Low----------	Low---------	High.
100	80-90	0.63-2.0	0.18-0.2	8.5-9.0	None to low--	High----------	Moderate----	High.
40-70	20-30	6.3-20.0	0.08-1.0	7.4-8.4	None---------	Low----------	Low---------	Low.
100	60-90	(1/)	(1/)	8.0-9.2	Low to very high.	Low to high---	Low to moderate.	Moderate to high.

TABLE 3.--ESTIMATED ENGINEERING

Soil series and map symbol	Depth to hard bedrock	Depth from surface	Classification			Per-centage passing sieve--
			Dominant USDA texture	Unified	AASHO	No. 4
	Inches	Inches				
Thurlow: Th, Tm, To, Tr	>60	0-62	Silty clay loam and silty clay.	CL	A-6	100
Vananda: Va	>60	0-60	Clay	CH	A-7	100
Vona: Vo, Vr (For properties of the Remmit soil in mapping unit Vr refer to the Remmit series.)	>60	0-60	Fine sandy loam	SM	A-4	100

1/ Variable.

PROPERTIES OF SOILS--Continued

Percentage passing sieve--Continued		Permeability	Available water capacity	Reaction	Salinity	Corrosivity of untreated steel pipes	Shrink-swell potential	Frost-action potential
No. 10	No. 200							
		Inches per hour	Inches per inch of soil	pH value				
100	80-90	0.2-0.63	0.18-0.2	6.6-9.0	None---------	Moderate-----	Moderate-----	High.
100	80-90	<0.06	0.14-0.16	8.5-9.6	Moderate to high.	High---------	High---------	Moderate.
100	35-50	2.0-6.3	0.13-0.15	7.4-9.0	None---------	Low----------	Low----------	High.

TABLE 4.--INTERPRETATION OF

Soil series and map symbol	Suitability as source of--				Soil features affecting--
	Topsoil	Sand	Gravel	Road fill	Highway location
Arvada: Ab (For properties of the Bone soil in this mapping unit, refer to the Bone series.)	Poor	Unsuitable	Unsuitable	Poor	High shrink-swell potential; high compressibility; very slow permeability.
Bankard: Ba	Poor	Fair; needs washing.	Unsuitable	Good	Some areas subject to flooding.
Barvon: (Mapped only with Campspass soil.)	Good	Unsuitable	Unsuitable	Fair to poor.	Moderate to high frost-action potential, moderately steep to steep slopes.
Bew: Bc, Be, Bw	Poor: clayey texture.	Unsuitable	Unsuitable	Poor	High shrink-swell potential.
Bone (Mapped only with Arvada soils.)	Unsuitable	Unsuitable	Unsuitable	Poor	Moderate to high shrink-swell potential.
Cabba: Ca	Fair	Unsuitable	Unsuitable	Poor	Moderately steep to steep slopes; high frost-action potential.
Campspass: Cb (For properties of Barvon soils in this mapping unit, refer to the Barvon series.)	Fair	Unsuitable	Unsuitable	Poor	Moderately steep to steep slopes; high frost-action potential.
Cushman: Ce, Ch (For properties of the Elso soils in these mapping units, refer to the Elso series.)	Fair	Unsuitable	Unsuitable	Poor	High frost-action potential, sandstone at 20-40 inches.

Soil features affecting--Continued						Limitation to use for sewage disposal fields
Farm ponds		Agricultural drainage	Land leveling	Irrigation	Building sites	
Reservoir area	Embankment					
No unfavorable features.	Poor stability, high shrink-swell potential.	Very slow permeability.	Moderate to very high salinity, clayey texture.	Very slow permeability, moderate to very high salinity.	High shrink-swell potential.	Severe: very slow permeability.
High porosity-	Rapid permeability.	No unfavorable features.	Sandy texture.	Rapid permeability.	Some areas subject to flooding.	Moderate: flooded occasionally.
No unfavorable features.	Fair to good stability, subject to piping.	Steep slopes---	Steep slopes-	Steep slopes---	Moderately steep to steep slopes.	Severe: moderately steep to steep slopes.
No unfavorable features.	Very poor stability.	No unfavorable features.	No unfavorable features.	No unfavorable features.	High shrink-swell potential.	Severe: slow permeability.
No unfavorable features.	Poor stability, moderate to high shrink-swell potential.	Very slow permeability.	Silty clay loam texture, high salinity or alkalinity, slow permeability.	Very slow permeability, clayey textures in substratum, high to very high salinity.	Moderate to high shrink-swell potential.	Severe: very slow permeability.
No unfavorable features.	Poor compactability, fair to poor stability.	Shallow to shale.	Shallow to shale.	Shallow to shale.	Moderately steep to steep slopes.	Severe: moderately steep to steep slopes.
No unfavorable features.	Poor compactability, fair to poor stability.	Steep slopes---	Steep slopes-	Steep slopes---	Moderately steep to steep slopes.	Severe: moderately steep to steep, moderately slow permeability.
No unfavorable features.	Poor compactability, fair to poor stability.	No unfavorable features.	No unfavorable features.	No unfavorable features.	High bearing capacity.	Severe: steep slopes, sandstone at depth of 20 to 40 inches.

TABLE 4.--INTERPRETATION OF ENGINEERING

Soil series and map symbol	Suitability as source of--				Soil features affecting--
	Topsoil	Sand	Gravel	Road fill	Highway location
Elso: Ec, El, Eo (For properties of Ocean Lake soil in mapping unit Eo, refer to the Ocean Lake series.)	Poor	Unsuitable	Unsuitable	Poor	Strongly sloping to steep, high frost-action potential.
Epsie: Ep	Poor: high content of salts.	Unsuitable	Unsuitable	Poor	High shrink-swell potential, moderate frost hazard.
Farland: Fa, Fd, Fe, Fh, Fk, Fl, Fm (For properties of Cabba soils in mapping units Fh and Fk and Havrelon soil in mapping unit Fm, refer to the Cabba and Havrelon series. Rock land in mapping unit Fl too variable for evaluation.)	Good	Unsuitable	Unsuitable	Poor	Fair stability, high frost-action potential.
Fergus: Fn (For properties of the Relan soil in this mapping unit, refer to the Relan series.)	Good	Unsuitable	Unsuitable to fair.	Fair to poor.	Fair stability, moderate to high frost-action potential.
Fort Collins: Fo, Fr, Fs	Good	Unsuitable	Unsuitable	Poor	Fair stability, high frost-action potential.
Galata: Ga	Poor	Unsuitable	Unsuitable	Poor	High plasticity, very poor stability.

Soil features affecting--Continued						Limitation to use for sewage disposal fields
Farm ponds		Agricultural drainage	Land leveling	Irrigation	Building sites	
Reservoir area	Embankment					
No unfavorable features.	Poor compactability, fair to poor stability.	Shallow to shale.	Shallow to shale.	Shallow to shale.	High bearing capacity, strongly sloping to steep.	Severe: strongly sloping to steep, shallow to shale.
No unfavorable features.	High shrink-swell potential, very poor stability, very poor compactability.	High salt content.	High salt content.	High salt content.	High shrink-swell potential.	Severe: slow permeability, less than 20 inches to shale.
No unfavorable features.	Poor stability, high compactability, moderately erodible.	No unfavorable features.	No unfavorable features.	No unfavorable features.	Moderate bearing capacity.	Slight, 0-5 percent slopes; moderate, 5-10 percent slopes; severe, 10-20 percent slopes.
No unfavorable features.	Fair stability, high compactability.	No unfavorable features.	No unfavorable features.	No unfavorable features.	Moderate bearing capacity.	Severe: moderately slow permeability in subsoil.
No unfavorable features.	Fair stability, moderate erodibility, high compactability.	No unfavorable features.	No unfavorable features.	No unfavorable features.	Moderate bearing capacity, high frost-action potential.	Severe: moderately slow permeability.
No unfavorable features.	Very poor stability, high shrink-swell potential, high compactability.	Slow permeability.	Clayey texture of subsoil, slow permeability of subsoil.	Slow permeability.	Low bearing capacity, high shrink-swell potential.	Severe: slow permeability.

TABLE 4.--INTERPRETATION OF ENGINEERING

Soil series and map symbol	Suitability as source of--				Soil features affecting--
	Topsoil	Sand	Gravel	Road fill	Highway location
Gilt Edge: Gd, Ge	Fair for upper 6 inches.	Unsuitable	Unsuitable	Poor	High plasticity, very poor stability.
Glenberg: Gf	Fair: fine sandy loam texture.	Fair: low to high amount of nonplastic fines.	Unsuitable	Fair	Fair stability, moderately rapid permeability.
Haverson: Ha, Hc, Hf	Good	Unsuitable	Unsuitable	Poor	Fair stability, high frost-action potential.
Hd, He	Fair to good.	Unsuitable	Unsuitable	Poor	Poor stability, moderate to high frost-action potential.
Hg	Poor	Unsuitable	Unsuitable	Poor	Poor stability, high to very high frost-action potential.
Havrelon (Mapped only with Farland soils.)	Good	Unsuitable	Unsuitable	Poor	Very poor stability-
Heldt: Hh, Hk, Hm	Good for upper 16 inches.	Unsuitable	Unsuitable	Fair to poor.	Good to fair stability.

Soil features affecting--Continued						Limitation to use for sewage disposal fields
Farm ponds		Agricultural drainage	Land leveling	Irrigation	Building sites	
Reservoir area	Embankment					
No unfavorable features.	Very poor stability, high shrink-swell potential, high compactability.	Slow permeability.	Clayey texture of subsoil, slow permeability of subsoil.	Slow permeability.	Low bearing capacity, high shrink-swell potential.	Severe: slow permeability.
Moderately rapid permeability.	Fair compactability, fair stability.	No unfavorable features.	No unfavorable features.	Moderately rapid water intake rate.	High bearing capacity, moderately rapid permeability.	Slight.
No unfavorable features.	Poor compactability.	No unfavorable features.	No unfavorable.	No unfavorable features.	Moderate bearing capacity.	Moderate: moderate permeability in surface layer.
No unfavorable features.	Poor to fair stability, high compactability.	Clayey subsoil-	Clayey subsoil.	Moderately slow permeability.	Low to very low bearing capacity, poor stability.	Severe: moderately slow permeability.
No unfavorable features.	Poor stability, high compactability.	Moderate to high salinity.	Moderate to high salinity.	Moderate to high salinity, moderately slow permeability.	Low bearing capacity.	Severe: moderate to high salinity, moderately slow permeability.
No unfavorable features.	Moderately erodible, moderately susceptible to piping, poor compactability.	No unfavorable features.	No unfavorable features.	No unfavorable features.	Moderate bearing capacity.	Slight.
No unfavorable features.	Good to fair stability, very poor compactability.	Slow permeability.	No unfavorable features.	Slow permeability.	Moderate bearing capacity.	Severe: slow permeability.

TABLE 4.--INTERPRETATION OF ENGINEERING

Soil series and map symbol	Suitability as source of--				Soil features affecting--
	Topsoil	Sand	Gravel	Road fill	Highway location
Hesper: Hn, Ho, Hp, Hr	Good for upper 12 inches.	Unsuitable--	Unsuitable--	Poor--------	Good to fair stability, high frost-action potential.
Hopley: Hs (For properties of the Relan soil in this mapping unit, see the Relan series.)	Good--------	Unsuitable--	Unsuitable--	Poor--------	Fair stability, high frost-action potential, moderate bearing capacity.
Hydro: Ht, Hu, Hv, Hw, Hx, Hy (For properties of the Arvada soil in mapping unit Hw, Elso soil in mapping unit Hx, and Fort Collins soil in mapping unit Hy, refer to their respective series.)	Fair for upper 10 inches.	Unsuitable--	Unsuitable--	Fair to poor.	Fair stability, moderate to high frost-action potential.
Keiser: Kc, Ke, Kf	Good for upper 9 inches.	Unsuitable--	Unsuitable--	Poor--------	Fair stability, high frost-action potential.
Kyle: Kl, Km, Kn	Poor--------	Unsuitable--	Unsuitable--	Poor--------	Moderate frost-action potential, high shrink-swell potential.
McRae: Mc, Md, Me	Good--------	Unsuitable--	Unsuitable--	Poor--------	Poor stability, high frost-action potential.

PROPERTIES OF SOILS--Continued

Soil features affecting--Continued						Limitation to use for sewage disposal fields
Farm ponds		Agricultural drainage	Land leveling	Irrigation	Building sites	
Reservoir area	Embankment					
No unfavorable features.	Good to fair stability, high compactability.	Moderately slow permeability.	No unfavorable features.	Moderately slow permeability.	Moderate bearing capacity, moderate shrink-swell potential.	Severe: moderately slow permeability.
No unfavorable features.	Fair stability, high compactability.	No unfavorable features.	No unfavorable ffeatures.	No unfavorable features.	Moderate bearing capacity, fair stability.	Moderate: hard shale below a depth of 40 inches, 4-8 percent slopes.
No unfavorable features.	Very poor stability, very poor compactability.	Moderately slow permeability.	Silty clay loam subsoil.	Moderately slow permeability.	Very poor stability.	Severe: moderately slow permeability.
No unfavorable features.	Fair stability, high compactability.	Moderately slow permeability.	No unfavorable features.	Moderately slow permeability.	Low bearing capacity.	Severe: moderately slow permeability.
No unfavorable features.	High shrink-swell potential, very high compactability, fair to poor stability.	Slow permeability.	Clay subsoil, some salts in subsoil.	Slow permeability.	Low bearing capacity.	Severe: slow permeability.
No unfavorable features.	Poor stability, poor compactability.	No unfavorable features.	No unfavorable features.	No unfavorable features.	Poor stability, moderate bearing capacity.	Slight, 0-5 percent slopes; moderate, 5-8 percent slopes.

TABLE 4.--INTERPRETATION OF ENGINEERING

Soil series and map symbol	Suitability as source of--				Soil features affecting--
	Topsoil	Sand	Gravel	Road fill	Highway location
Midway: Mf, Mg, Mr, Mt, Mw (For properties of Elso soils in mapping units Mg and Mw and Thurlow soil in mapping unit Mt, refer to their respective series. Rock land in mapping unit Mr too variable for evaluation.)	Poor: shallow depth.	Unsuitable	Unsuitable	Poor	Fair stability, moderate frost-action potential.
Nihill: Nh (For properties of the Elso soil in this mapping unit, refer to the Elso series.)	Fair for upper 8 inches.	Unsuitable	Fair to good: needs washing for concrete aggregate.	Good	Good stability
Ocean Lake: Oc (Rock land soils are too variable to evaluate.)	Fair to poor.	Unsuitable: high content of silt.	Unsuitable	Fair	Moderate to good stability, fair to good compactability.
Rapelje: Ra, Rc	Fair for upper 10 inches.	Unsuitable	Unsuitable	Poor	Fair stability, high frost-action potential.
Relan: Re, Rf, Rh, Rk (For properties of the Cabba soil in mapping unit Rh, refer to the Cabba series.)	Good	Unsuitable	Unsuitable to fair.	Fair to poor.	Moderate stability, high to moderate frost-action potential.
Relan, gravelly variant: Rk	Good for upper 10 inches.	Unsuitable	Fair	Fair to good.	No unfavorable features.

PROPERTIES OF SOILS--Continued

Soil features affecting--Continued						Limitation to use for sewage disposal fields
Farm ponds		Agricultural drainage	Land leveling	Irrigation	Building sites	
Reservoir area	Embankment					
No unfavorable features.	Fair stability, high shrink-swell potential, high compactability, low shear strength.	Shallow; steep slopes.	Shallow; steep slopes.	Shallow; steep slopes.	Low bearing capacity, high shrink-swell potential.	Severe: slow permeability, some steep slopes, shale at a depth of 10 to 20 inches.
Moderately rapid permeability.	Highly porous, good stability.	Shallow; steep slopes.	Shallow; steep slopes.	Shallow; steep slopes.	High bearing capacity, good stability.	Severe: 8-15 percent slopes.
Rapid permeability.	Moderate to good stability, fair to good compactability.	Shallow; steep slopes.	Shallow; steep slopes.	Shallow; steep slopes.	High bearing capacity.	Severe: moderately steep to steep slopes, sandstone bedrock within 20 inches.
No unfavorable features.	Fair stability, moderate shrink-swell potential.	Moderately slow permeability.	No unfavorable features.	Moderately slow permeability.	Moderate bearing capacity, moderate shrink-swell potential.	Severe: moderately slow permeability.
Moderate permeability.	Moderate stability, poor compactability.	No unfavorable features.	No unfavorable features.	No unfavorable features.	Moderate bearing capacity.	Slight to moderate: some moderately steep slopes.
Moderately rapid permeability.	Fair stability-	Shallow to shale.	Shallow to shale.	Shallow to shale.	High bearing capacity.	Moderate: steep slopes.

TABLE 4.--INTERPRETATION OF ENGINEERING

Soil series and map symbol	Suitability as source of--				Soil features affecting--
	Topsoil	Sand	Gravel	Road fill	Highway location
Remmit: Rm, Rn, Ro (For properties of the Ocean Lake soil in mapping unit Ro, refer to the Ocean Lake series.)	Good	Unsuitable: high content of silt.	Unsuitable	Poor	Fair stability, high frost-action potential.
Ringling: Rs, Rt, Ru (For properties of Cabba soil in mapping unit Rt and Relan soil in mapping unit Ru, refer to their respective series.)	Poor	Unsuitable	Unsuitable to fair.	Good: shallow depth to fractured rock.	Fair stability, steep slopes.
Riverwash: Rw	Poor	Fair: needs washing.	Fair to good	Fair to good.	Good stability
Terrace escarpments: Te	Poor	Unsuitable	Unsuitable	Fair to poor.	Fair to poor stability, steep slopes.
Thurlow: Th, Tm, To, Tr	Good for upper 15 inches.	Unsuitable	Unsuitable	Poor	Fair to good, stability, high frost-action potential.
Vananda: Va	Unsuitable	Unsuitable	Unsuitable	Poor	Moderate stability, moderate frost-action potential.

Soil features affecting--Continued						Limitation to use for sewage disposal fields
Farm ponds		Agricultural drainage	Land leveling	Irrigation	Building sites	
Reservoir area	Embankment					
Moderate permeability.	Fair stability, good compactability.	No unfavorable features.	No unfavorable features.	No unfavorable features.	Moderate to high bearing capacity.	Slight, 0-4 percent slopes; moderate, 4-8 percent slopes; severe, 8-25 percent slopes.
Shallow depth to fractured rock.	Fair stability, shallow depth to fractured rock.	Shallow to shale.	Shallow to shale.	Shallow to shale.	High bearing capacity.	Severe: shallow to rock, steep slopes.
Very porous---	Good stability, rapid permeability.	Loose gravel---	Loose gravel-	Loose gravel---	High bearing capacity.	Severe: subject to flooding, high water table.
No unfavorable features.	Fair to poor stability, poor compactability, low shear strength.	Very steep and narrow.	Very steep and narrow.	Very steep and narrow.	Moderate to low bearing capacity, moderate to high shrink-swell potential.	Severe: steep slopes.
No unfavorable features.	Fair to good stability, poor compactability.	Moderately slow permeability.	Silty clay loam texture.	Moderately slow permeability.	Moderate bearing capacity.	Severe: moderately slow permeability.
No unfavorable features.	Moderate stability, high shrink-swell potential, low shear strength.	Very slow permeability.	Clay texture.	Very slow permeability.	High shrink-swell potential, low bearing capacity.	Severe: very slow permeability.

TABLE 4.--INTERPRETATION OF ENGINEERING

Soil series and map symbol	Suitability as source of--				Soil features affecting--
	Topsoil	Sand	Gravel	Road fill	Highway location
Vona: Vo, Vr (For properties of the Remmit soil in mapping unit Vr, refer to the Remmit series.)	Good	Unsuitable	Unsuitable	Poor	Moderate stability, high frost-action potential.

PROPERTIES OF SOILS--Continued

Soil features affecting--Continued						Limitation to use for sewage disposal fields
Farm ponds		Agricultural drainage	Land leveling	Irrigation	Building sites	
Reservoir area	Embankment					
Moderately rapid permeability.	Moderate stability, moderately rapid permeability, high frost-action potential.	No unfavorable features.	No unfavorable features.	No unfavorable features.	High bearing capacity.	Slight, 0-4 percent slopes; moderate, 4-8 percent slopes.

DESCRIPTION OF SOILS

This section describes the soil series and mapping units in the Powder River Area. The approximate acreage and extent of each mapping unit are given in table 5.

The procedure in this section is first to describe the soil series and then the mapping units in the series. To get full information on any one mapping unit, therefore, it is necessary to read the description of the unit and the description of the soil series to which it belongs. The description of a soil series mentions features that apply to all soils in the series. Differences among soils of a series are pointed out in the descriptions of the individual soils or are indicated in the soil name. Soils that are mapped only in a complex or association are described under the name of the complex or association. Unless otherwise stated, the descriptions of all mapping units in this section are for dry soils. Not all mapping units are members of a soil series. For example, Rock land is a miscellaneous land type and does not belong to a soil series. It is, nevertheless, listed in alphabetic order along with the series.

An essential part of each soil series is the description of the soil profile, the sequence of layers beginning at the surface and continuing down to the depth beyond which roots of most plants do not penetrate. Each soil series contains a short description of a typical soil profile and a much more detailed description of the same profile that scientists, engineers, and others can use in making highly technical interpretations.

A symbol in parentheses follows the name of the mapping unit. This symbol identifies the mapping unit on the detailed soil map. Listed at the end of each description of a mapping unit is the capability unit in which the mapping unit has been placed. For those mapping units that have been placed in a windbreak suitability group, that group is also listed. The pages on which each of these groups are described can be found by referring to the "Guide to Mapping Units" at the back of this soil survey. Many terms used in the soil descriptions and other sections of the survey are defined in the Glossary at the back of this soil survey and in the "Soil Survey Manual" (6).

TABLE 5.--APPROXIMATE ACREAGE AND PROPORTIONATE EXTENT OF SOILS IN POWDER RIVER AREA

Soil	Acres	Extent
Arvada-Bone complex, 0 to 4 percent slopes	14,985	0.7
Bankard fine sandy loam	8,113	.4
Bew silty clay, 0 to 2 percent slopes	3,206	.1
Bew silty clay, 2 to 4 percent slopes	400	(1/)
Bew silty clay, 4 to 8 percent slopes	958	(1/)
Cabba association, 15 to 50 percent slopes	238,970	10.4
Campspass-Barvon association, 15 to 50 percent slopes	5,622	.2
Cushman-Elso silt loams, 4 to 8 percent slopes	35,864	1.6
Cushman-Elso silt loams, 8 to 15 percent slopes	6,992	.3
Elso silt loam, 8 to 15 percent slopes	123,030	5.3
Elso silt loam, 15 to 45 percent slopes	82,000	3.6
Elso-Ocean Lake association, 15 to 45 percent slopes	21,947	1.0
Epsie clay, 4 to 15 percent slopes	2,122	.1
Farland silt loam, 0 to 2 percent slopes	916	(1/)
Farland silt loam, 2 to 4 percent slopes	5,720	.2
Farland silt loam, 4 to 8 percent slopes	8,838	.4
Farland-Cabba association, 4 to 8 percent slopes	5,118	.2
Farland-Cabba association, 8 to 20 percent slopes	16,818	0.7
Farland-Rock land association, 0 to 6 percent slopes	5,855	.3
Farland and Havrelon soils, 4 to 8 percent slopes	34,498	1.5
Fergus-Relan association, 2 to 8 percent slopes	9,593	.4
Fort Collins silt loam, 0 to 2 percent slopes	8,491	.4
Fort Collins silt loam, 2 to 4 percent slopes	10,863	.5
Fort Collins silt loam, 4 to 8 percent slopes	18,219	.8
Galata silty clay, 4 to 8 percent slopes	3,106	.1
Gilt Edge silt loam, 0 to 2 percent slopes	1,749	.1
Gilt Edge silt loam, 2 to 6 percent slopes	5,204	.2
Glenberg fine sandy loam, 0 to 2 percent slopes	17,094	.7
Haverson loam	5,042	.2
Haverson silt loam	27,678	1.2
Haverson silty clay loam	10,760	.5
Haverson silty clay	20,864	.9
Haverson soils, channeled	23,788	1.0
Haverson soils, saline	6,148	.3
Heldt silty clay loam, 0 to 2 percent slopes	16,543	.7
Heldt silty clay loam, 2 to 4 percent slopes	10,932	.5

TABLE 5.--APPROXIMATE ACREAGE AND PROPORTIONATE EXTENT OF SOILS IN POWDER RIVER AREA--Continued

Soil	Acres	Extent
Heldt silty clay loam, 4 to 8 percent slopes	12,702	0.6
Hesper silty clay loam, 0 to 2 percent slopes	7,065	.3
Hesper silty clay loam, 2 to 4 percent slopes	30,352	1.3
Hesper silty clay loam, 4 to 8 percent slopes	40,682	1.8
Hesper silty clay loam, 8 to 15 percent slopes	4,694	.2
Hopley and Relan loams, 4 to 8 percent slopes	11,398	.5
Hydro silty clay loam, 0 to 2 percent slopes	12,066	.5
Hydro silty clay loam, 2 to 4 percent slopes	16,380	.7
Hydro silty clay loam, 4 to 8 percent slopes	11,513	.5
Hydro-Arvada complex, 2 to 8 percent slopes	33,418	1.4
Hydro-Elso association, 8 to 15 percent slopes	4,237	.2
Hydro-Fort Collins silt loams, 0 to 2 percent slopes	442	(1/)
Keiser silty clay loam, 0 to 2 percent slopes	2,656	.1
Keiser silty clay loam, 2 to 4 percent slopes	4,072	.2
Keiser silty clay loam, 4 to 8 percent slopes	2,581	.1
Kyle clay, 2 to 4 percent slopes	5,320	.2
Kyle clay, 4 to 8 percent slopes	6,629	.3
Kyle clay, 8 to 15 percent slopes	6,532	.3
McRae silt loam, 0 to 2 percent slopes	5,735	.2
McRae silt loam, 2 to 4 percent slopes	16,481	.7
McRae silt loam, 4 to 8 percent slopes	8,057	.3
Midway silty clay loam, 2 to 8 percent slopes	9,313	.4
Midway-Elso association, 8 to 35 percent slopes	379,438	16.5
Midway-Rock land association, 15 to 35 percent slopes	3,749	.2
Midway-Thurlow association, 8 to 15 percent slopes	94,182	4.1
Midway and Elso rocky soils, 35 to 75 percent slopes	238,018	10.3
Nihill-Elso association, 8 to 15 percent slopes	12,625	.5
Ocean Lake-Rock land association, 15 to 45 percent slopes	3,581	.2
Rapelje silt loam, 0 to 2 percent slopes	1,103	.1
Rapelje silt loam, 2 to 8 percent slopes	14,974	.7
Relan loam, 4 to 8 percent slopes	790	(1/)
Relan association, 5 to 30 percent slopes	745	(1/)
Relan-Cabba association, 4 to 8 percent slopes	8,441	.4
Relan gravelly loam, gravelly variant, 4 to 8 percent slopes	5,555	.2
Remmit fine sandy loam, 2 to 4 percent slopes	750	(1/)
Remmit fine sandy loam, 4 to 8 percent slopes	4,606	.2
Remmit-Ocean Lake fine sandy loam, 8 to 25 percent slopes	80,858	3.5
Ringling slaty loam, 20 to 50 percent slopes	44,188	1.9
Ringling-Cabba association, 15 to 50 percent slopes	240,688	10.4
Ringling-Relan association, 6 to 25 percent slopes	20,074	.9
Riverwash	3,918	.2
Shale outcrop	11,000	.5
Terrace escarpments	23,148	1.0
Thurlow silty clay loam, 0 to 2 percent slopes	4,524	.2
Thurlow silty clay loam, 2 to 4 percent slopes	3,816	.2
Thurlow silty clay loam, 4 to 8 percent slopes	11,701	.5
Thurlow silty clay loam, 8 to 15 percent slopes	2,051	.1
Vananda clay	477	(1/)
Vona fine sandy loam, 2 to 4 percent slopes	3,556	.2
Vona-Remmit fine sandy loams, 4 to 8 percent slopes	16,833	.7
Total	2,305,760	100.0

1/ Less than 0.05 percent.

Arvada Series

The Arvada series consists of moderately well drained clayey soils that are more than 60 inches deep. These soils formed in clayey alluvium under short grasses. Slopes are 0 to 4 percent, and elevation ranges from 3,000 to 3,500 feet. The annual precipitation is about 12 inches, the average annual soil temperature is 47 to 49° F., and the frost-free season is about 115 to 120 days. These soils are associated with Bone, Gilt Edge, and Hydro soils.

Typically the surface layer is light brownish-gray silt loam about 3 inches thick. The subsoil is very dark grayish-brown to grayish-brown clay and silty clay that extends to a depth of about 17 inches. The substratum, to a depth of about 23 inches, is light olive-brown and light brownish-gray sandy clay loam. It is underlain by highly calcareous layers of silty clay loam, sandy clay loam, and fine sandy loam 4 to 6 inches thick. Salt and gypsum segregations occur in the lower part of the subsoil and the upper part of the substratum.

The Arvada soils are used primarily for range.

Typical profile of Arvada silt loam that has 0 to 4 percent slopes, 1,400 feet north, 700 feet east of the SW. corner of section 11, T. 9 S., R. 53 E.:

A2--0 to 3 inches, light brownish-gray (10YR 6/2) silt loam, dark grayish brown (2.5Y 4/2) when moist; weak platy structure that separates to weak, fine, granular; soft when dry, very friable when moist, nonsticky and nonplastic when wet; noncalcareous; pH 7.0; abundant roots; abrupt boundary.

B21t--3 to 10 inches, very dark grayish-brown (10YR 3/2) clay stained on the peds with a darker color that does not change in hue, value, or chroma when moist or crushed; strong columnar structure in which peds have rounded gray caps; caps of columns have a thick coating of clear sand grains; extremely hard when dry, firm when moist, very sticky and very plastic when wet; thick continuous clay films; noncalcareous; pH 8.4; few roots crushed between columns; gradual boundary.

B22t--10 to 12 inches, dark grayish-brown (10YR 4/2) clay, dark brown (10YR 3/3) when moist; strong columnar structure that separates to strong blocky; extremely hard when dry, firm when moist, very sticky and very plastic when wet; noncalcareous; pH 8.2; few roots; thick continuous clay films; clear, wavy boundary.

B3cs--12 to 17 inches, grayish-brown (10YR 5/2) silty clay, dark grayish brown (2.5Y 4/2) when moist; light-gray (10YR 7/1) mottles when dry; moderate, medium, blocky structure; hard when dry, friable when moist, very sticky and plastic when wet; noncalcareous; pH 8.0; seams and pockets of salt crystals; gradual boundary.

C1cs--17 to 19 inches, light olive-brown (2.5Y 5/3) sandy clay loam, olive brown (2.5Y 4/3) when moist; common light olive-brown (2.5Y 5/6) mottles when dry; massive; slightly hard when dry, friable when moist, sticky and plastic when wet; weakly calcareous; pH 8.0; gypsum and salt crystals; gradual boundary.

C2--19 to 23 inches, light brownish-gray (2.5Y 6/2) sandy clay loam, grayish brown (2.5Y 5/2) when moist; massive; slightly hard when dry, friable when moist, sticky and plastic when wet; strongly calcareous; pH 8.6; gradual boundary.

IIC3ca--23 to 30 inches, light brownish-gray (2.5Y 6/2) silty clay loam, grayish brown (2.5Y 5/2) when moist; many, prominent, white (2.5Y 8/1) mottles when dry; massive; slightly hard when dry, friable when moist, sticky and plastic when wet; very strongly calcareous; pH 9.2; many, prominent seams, pockets, and threads of lime; clear, wavy boundary.

IIIC4--30 to 62 inches, light brownish-gray (2.5Y 6/2) fine sandy loam, grayish brown (2.5Y 5/2) when moist; massive; slightly hard when dry, friable when moist, nonsticky and nonplastic when wet; very strongly calcareous; pH 9.0; specks of lime.

The A horizon, where present, ranges from 2 to 5 inches in thickness. The A2 horizon ranges from 10YR to 2.5Y in hue, is 5 or 6 in value when dry and 3 or 4 when moist, and is 2 or 3 in chroma. The B2t horizon ranges from weak to strong columnar or prismatic structure and has clear sand grains that thinly coat the structure faces. Depth to lime ranges from 6 to 17 inches. Gypsum crystals are at a depth ranging from 10 to 26 inches. Where the Arvada soils occur in a complex with other soils, the A2 horizon is thinner than typical and depth to gypsum crystals ranges from 8 to 10 inches. The B2t horizon ranges from silty clay to clay. The dark staining on peds in the B2t horizon extends 2 to 3 inches down from the top of the horizon.

Arvada-Bone complex, 0 to 4 percent slopes (Ab).--This complex occurs on stream and fan terraces. A typical area is about 70 percent Arvada silt loam and 30 percent Bone silty clay loam. Included with these soils in mapping are areas of Hydro and Gilt Edge soils less than 2 acres in size.

The Arvada soil is moderately well drained, and the Bone soil is well drained. Both soils are very slowly permeable. The available water capacity is 7 to 9 inches for a 5-foot depth. These soils are subject to erosion.

Because they are saline or alkali, the soils of this complex are not suited to cultivated crops. The largest acreage is used for range. (Capability unit VIs-1; range-soil group 10; and windbreak suitability group 5)

Bankard Series

The Bankard series consists of somewhat excessively drained fine sandy loams that formed in sandy alluvium on river and stream flood plains. Slopes are 0 to 4 percent, and elevation ranges

from 2,700 to 3,500 feet. The native vegetation is mid and short grasses. The average annual precipitation is 12 inches, the average annual soil temperature is 47 to 49° F., and the frost-free season is about 120 days. These soils are associated with Glenberg and Haverson soils.

Typically the surface layer is grayish-brown and light brownish-gray fine sandy loam about 11 inches thick. The subsoil and substratum consist of light grayish-brown, brown, and light brownish-gray stratified sand, fine sandy loam, and gravelly sand and some strata of silt and loam. The substratum extends to a depth of 60 inches or more.

The Bankard soils are used for range.

Typical profile of Bankard fine sandy loam that has 0 to 4 percent slopes, 1,200 feet south, 1,000 feet west of the NE. corner of section 17, T. 5 S., R. 51 E.:

A1--0 to 5 inches, grayish-brown (2.5Y 5/2) fine sandy loam, dark grayish brown (2.5Y 4/2) when moist; massive; soft when dry, very friable when moist, nonsticky and nonplastic when wet; very weakly calcareous; pH 7.4; clear boundary.

AC--5 to 11 inches, light brownish-gray (2.5Y 6/2) fine sandy loam, grayish brown (2.5Y 5/2) when wet; massive; soft when dry, very friable when moist, nonsticky and nonplastic when wet; 5 percent fine pebbles, 85 percent coarse sand, and 10 percent fines, by weight; noncalcareous; pH 6.8; clear boundary.

IIC1--11 to 20 inches, light grayish-brown (2.5Y 6/2) gravelly loamy coarse sand, grayish brown (2.5Y 5/2) when wet; single grain; loose when dry or moist, nonsticky and nonplastic when wet; 20 percent coarse quartz and porcelanite fragments, the sand fractions are principally quartz; noncalcareous; pH 6.8; clear boundary.

IIIC2--20 to 36 inches, brown (10YR 5/3) fine sandy loam, dark grayish brown (10YR 4/2) when moist; many, coarse, prominent mottles of yellowish and reddish colors; massive; soft when dry, very friable when moist, nonsticky and nonplastic when wet; mildly calcareous; pH 6.8; clear boundary.

IVC3--36 to 62 inches, light brownish-gray (10YR 6/2) coarse sand, grayish brown (10YR 5/2) when moist; single grain; sand grains are primarily quartz; loose when dry or moist, nonsticky and nonplastic; mildly calcareous; pH 6.8.

The A1 horizon, where it is present, ranges from 4 to 6 inches in thickness. It ranges from 10YR to 2.5Y in hue, is 5 or 6 in value, and ranges from 2 to 4 in chroma. The A horizon ranges from fine sandy loam to sand. In wooded areas the A1 horizon is 2.5Y 4/2 when dry and 2.5Y 3/2 when moist. The C horizons range from 2.5Y to 10YR in hue, are 6 or 7 in value, and range from 2 to 4 in chroma. The depth to loose gravelly sand ranges from 8 to 15 inches. Gravel does not occur in all places, but gray coarse sand occurs where the gravel is absent. The IIIC horizon is absent in many places.

Bankard fine sandy loam (0 to 4 percent slopes) (Ba).--This soil occurs on flood plains and stream terraces along the large drainageways. Included with this soil in mapping are areas of Glenberg fine sandy loam and Riverwash less than 2 acres in size.

This soil has slow runoff and rapid permeability. The available water capacity is 4 to 5 inches. Periodic flooding is likely in spring and after heavy rains. This soil blows readily when dry if not protected by a cover of vegetation. Organic-matter content and fertility are low. Roots penetrate to a depth of 60 inches or more in places.

This soil is used mainly for range or pasture. Cottonwood trees grow well. (Capability unit VIw-1; range-soil group 9)

Barvon Series

The Barvon series consists of moderately permeable, well-drained, medium-textured soils that are 40 to 60 inches deep. The Barvon soils formed in softly consolidated shale beds on uplands. The native vegetation is Idaho fescue, bluebunch wheatgrass, and ponderosa pine. Slopes range from 15 to 50 percent, and elevation ranges from 3,500 to 4,500 feet. The annual precipitation is 15 to 19 inches, the average annual soil temperature is 45 to 47° F., and the frost-free season is about 100 days. These soils are associated with Campspass, Relan, Cabba, and Midway soils. In the Powder River Area, Barvon soils are mapped only in association with Campspass soils.

Typically the surface layer is covered with 1/4 to 1 inch of partly decomposed humus. The mineral surface layer is dark grayish-brown loam about 14 inches thick. The subsoil is brown to light yellowish-brown clay loam that is underlain by stratified beds of shale at a depth of about 42 inches.

Barvon soils are used for forest and range.

Typical profile of Barvon loam, NW1/4 of section 17, T. 3 S., R. 47 E.:

O1--3/4 to 1/4 inch, pine needles, grasses, twigs, and leaves.

O2--1/4 inch to 0, decomposed pine needles, grasses, and leaves mixed with mineral soil.

A11--0 to 4 inches, dark grayish-brown (10YR 4/2) loam, very dark grayish brown (10YR 3/2) when moist; weak, fine, granular structure; soft when dry, friable when moist; slightly sticky and nonplastic when wet; noncalcareous except for lime-coated pebbles; pH 6.6 to 7.3; many krotovinas; abundant fine roots; clear, smooth boundary.

A12--4 to 6 inches, dark grayish-brown (10YR 4/2) loam, very dark grayish brown (10YR 3/2) when moist; weak, medium, subangular blocky structure; soft when dry, very friable when moist, sticky and plastic when wet; common fine roots; calcareous; lime-coated pebbles and small pockets of lime; pH 7.4 to 7.8; many large krotovinas; clear, wavy boundary.

A13--6 to 14 inches, dark grayish-brown (10YR 4/2) loam, very dark grayish brown (10YR 3/2) when moist; weak, medium, subangular blocky structure; slightly hard when dry, very friable when moist, sticky and plastic when wet; common, fine and few, medium roots; calcareous; pockets of lime and many large krotovinas; pH 7.4 to 7.8; clear, wavy boundary.

C1ca--14 to 20 inches, brown (10YR 4/3) light clay loam, dark brown (10YR 3/3) when moist; weak, medium, subangular blocky structure; slightly hard when dry, friable when moist; sticky and plastic when wet; few fine and medium roots; strongly calcareous; common seams and threads of lime; pH 7.9 to 8.4; many large krotovinas; gradual boundary.

C2ca--20 to 24 inches, brown (10YR 4/3) clay loam, dark brown (10YR 3/3) when moist; massive, slightly hard when dry, friable when moist, sticky and plastic when wet; few, fine, medium and large roots; common fine seams and threads of lime; lime coats root channels; strongly calcareous; few soft lime masses; pH 7.9 to 8.4; clear, smooth boundary.

C3--24 to 34 inches, light yellowish-brown (2.5Y 6/4) clay loam; massive; slightly hard when dry, friable when moist, sticky and plastic when wet; few fine roots; strongly calcareous; common seams and threads of lime; pH 7.9 to 8.4; gradual, wavy boundary.

C4--34 to 42 inches, olive-brown (2.5Y 5/4) fine sandy loam; massive; soft when dry, friable when moist, sticky and slightly plastic when wet; very few fine roots; strongly calcareous; pH 7.9 to 8.4; clear, smooth boundary.

C5--42 to 60 inches, stratified shale; fine roots between top shale layers; streaks of yellowish brown, dark yellowish brown, and gray in shale layers.

The A1 horizon ranges from 8 to 15 inches in thickness and from 10YR to 2.5Y in hue. In places many distinct mottles occur below a depth of 36 inches. Roots penetrate the soil to a depth of 48 inches and in most places are matted between the shale layers below 48 inches. Numerous large krotovinas are present, mainly in the A horizon.

Bew Series

The Bew series consists of well-drained, fine-textured soils that are more than 60 inches deep. These soils formed in clay alluvium on fans, foot slopes, and terraces. The native vegetation is mostly perennial mid and short grasses and a few woody plants. Slopes are 0 to 8 percent, and elevation ranges from 2,700 to 3,500 feet. The annual precipitation is about 12 inches, the average annual soil temperature is 47 to 49° F., and the frost-free season is about 115 days. These soils are associated with Thurlow, Hesper, and Hydro soils.

Typically the surface layer is grayish-brown silty clay about 3 inches thick. The subsoil is grayish-brown silty clay about 23 inches thick. It contains some lime in the lower part. The substratum, which extends to a depth of more than 60 inches, is light brownish-gray and light olive-brown silty clay loam and clay. It contains thin threads and seams of lime.

Bew soils are used for dryfarmed small grains and hay and range.

Typical profile of Bew silty clay, 0 to 2 percent slopes, 800 feet south and 400 feet east of the NW. corner of section 9, T. 4S., R. 49 E.:

A1--0 to 3 inches, grayish-brown (2.5Y 5/2) silty clay, very dark grayish brown (2.5Y 3/2) when moist; weak, thin, platy structure, granular when dry; hard when dry, friable when moist; nonsticky and nonplastic when wet; noncalcareous; pH 7.2; clear boundary.

B21t--3 to 9 inches, grayish-brown (2.5Y 5/2) silty clay, very dark grayish brown (2.5Y 3/2) when moist; weak prismatic structure that separates to moderate, medium and fine, blocky; hard when dry, friable when moist, sticky and plastic when wet; thick continuous clay films on peds; noncalcareous; pH 7.6; clear boundary.

B22t--9 to 17 inches, grayish-brown (2.5Y 5/2) silty clay, dark grayish brown (2.5Y 4/2) when moist; moderate, medium, prismatic structure that separates to moderate, medium and fine, blocky; hard when dry, very friable when moist, sticky and plastic when wet; thick continuous clay films; weakly calcareous; pH 8.0; clear boundary.

B3ca--17 to 26 inches, grayish-brown (2.5Y 5/2) silty clay, dark grayish brown (2.5Y 4/2 crushed) when moist; moderate prismatic structure that separates to strong, medium and fine, blocky; hard when dry, friable when moist, sticky and plastic when wet; moderately thick patchy clay films; strongly calcareous; many threads and seams of lime and few patches of lime; less than 1 percent of sandstone fragments are lime coated; mottled with yellow and rust-colored iron concretions; pH 8.4; gradual boundary.

C1ca--26 to 36 inches, light brownish-gray (2.5Y 6/2) silty clay loam, brown (10YR 5/3) when moist; massive; hard when dry, friable when moist; strongly calcareous; network of prominent threads and seams of lime; root channels are smooth because clay flow has smoothed their surfaces; few patches of clay films; pH 8.6; gradual boundary.

C2ca--36 to 65 inches, light olive-brown (2.5Y 5/4) clay, brown (10YR 4/3) when moist; massive; hard when dry, friable when moist, sticky and plastic when wet; netted with threads and seams of lime; strongly calcareous; pH 8.6.

The A1 horizon ranges from 3 to 5 inches in thickness. It ranges from 10YR to 2.5Y in hue, from 3 to 6 in value, and is 2 or 3 in chroma.

Texture ranges from silt loam to silty clay. The B2t horizon ranges from 12 to 19 inches in thickness and from silty clay to clay in texture. It ranges from 10YR to 2.5Y in hue, ranges from 4 to 6 in value, and is 2 or 3 in chroma. The B3ca horizon ranges from 10YR to 2.5Y in hue, is 5 or 6 in value, and is 2 or 3 in chroma. At an average depth of 26 inches the Cca horizon is strongly calcareous. Threads and seams of lime occur in netlike pattern, and there are lime coats on all pebbles. Shale occurs at a depth of more than 60 inches.

Bew silty clay, 0 to 2 percent slopes (Bc). This soil occurs on smooth terraces, fans, foot slopes, and uplands. It is underlain by silty, clayey, and sandy beds at a depth of more than 60 inches. This soil has the profile described as typical for the series. Included with this soil in mapping are areas of Thurlow, Hesper, and Hydro soils less than 5 acres in size.

This soil is slowly permeable and has slow runoff. The available water capacity is 9 to 11 inches for a 5-foot depth. Fertility and organic-matter content are medium. The surface layer is granular, and soil blowing is likely in cultivated fields.

This soil is used for alfalfa, small grains, and range. (Capability unit IIIs-1, dryland; range-soil group 5; windbreak suitability group 3)

Bew silty clay, 2 to 4 percent slopes (Be).--This soil occurs on upland foot slopes. It is underlain by shale beds at a depth of more than 60 inches. This soil is similar to Bew silty clay loam, 0 to 2 percent slopes, but it is more sloping. Surface runoff is medium, and the hazard of water erosion is slight to moderate. Because of its granular surface layer, this soil blows readily when dry. Included with this soil in mapping are areas of Hesper, Thurlow, and Hydro soils less than 5 acres in size.

This soil is used for alfalfa and small grains, but the largest acreage is in range. (Capability unit IIIe-2, dryland; range-soil group 5; windbreak suitability group 3)

Bew silty clay, 4 to 8 percent slopes (Bw).--This soil occurs on fans and foot slopes. It is similar to Bew silty clay, 0 to 2 percent slopes, except that it is more sloping and occurs only on fans and foot slopes. Runoff is medium, and the hazard of water erosion is moderate. The granular surface soil blows easily when dry. Included with this soil in mapping are areas of Thurlow, Hesper, and Hydro soils less than 5 acres in size.

This soil is used mainly for range, but alfalfa and small grains are grown in some places. (Capability unit IVe-3, dryland; range-soil group 5; windbreak suitability group 3)

Bone Series

The Bone series consists of slowly permeable, moderately fine to fine textured soils that are more than 60 inches deep. These soils formed in clay alluvium on stream terraces, fans, and foot slopes. The native vegetation is western wheatgrass, sixweeks fescue, and greasewood. Slopes are 0 to 4 percent, and elevation ranges from 2,700 to 3,500 feet. The annual precipitation is about 12 inches, the average annual soil temperature is 47 to 49° F., and the frost-free season is about 120 days. Bone soils are mapped only in a complex with Arvada soils.

Typically the surface layer is light-gray silt loam about a quarter inch thick. The subsoil is dark-gray to dark grayish-brown silty clay loam about 8 inches thick. The substratum is grayish-brown and light brownish-gray silty clay and clay that has pockets of salt and gypsum crystals.

Bone soils are used for range.

Typical profile of Bone silty clay loam, 1,000 feet east and 340 feet north of the W1/4 corner of section 3, T. 5 S., R. 53 E.:

A2--0 to 1/4 inch, light-gray (2.5Y 7/2) silt loam vesicular crust, grayish brown (2.5Y 5/2) when moist; weak crumb structure; soft when dry, very friable when moist, nonsticky and nonplastic when wet; noncalcareous; pH 7.2; abrupt boundary.

B2t--1/4 to 1 inch, dark-gray (10YR 4/1) silty clay loam, very dark gray (10YR 3/1) when moist; moderate, fine, columnar structure that separates to fine blocky; hard when dry, friable when moist, sticky and plastic when wet; patchy clay films; noncalcareous; pH 7.6; abrupt boundary.

B3cs--1 to 8 inches, dark grayish-brown (2.5Y 4/6/2) silty clay loam, very dark grayish brown (2.5Y 3/2) when moist; few, coarse, distinct mottles of white and light gray (2.5Y 8/2 and 7/2); fine prismatic structure that separates to moderate, medium and coarse, blocky; hard when dry, friable when moist, sticky and plastic when wet; noncalcareous; pH 8.0; clear boundary.

C1cs--8 to 26 inches, grayish-brown (2.5Y 5/2) light silty clay, dark grayish brown (2.5Y 4/2) when moist; mottled with common, medium and distinct salt crystals that are light gray (2.5Y 7/2) when dry and white (2.5Y 8/2) when moist; massive; hard when dry, friable when moist, sticky and plastic when wet; noncalcareous; many salt crystals; pH 8.0; clear boundary.

C2cs--26 to 36 inches, light brownish-gray (2.5Y 6/2) light silty clay, dark grayish brown (2.5Y 4/2) when moist; medium and distinct mottles of white (2.5Y 8/2); massive; hard when dry, friable when moist, sticky and plastic when wet; very strongly calcareous; many large seams and pockets of gypsum crystals; pH 8.0; clear boundary.

C3cs--36 to 62 inches, light brownish-gray (2.5Y 6/2) clay, dark grayish brown (2.5Y 4/2) when moist; few, fine, distinct mottles of white (2.5Y 8/0) gypsum crystals; massive; hard when dry, friable when moist, sticky and plastic when wet; very strongly calcareous;

pH 8.8; many clusters of gypsum and salt crystals.

The A horizon ranges from 1/4 inch to 3 inches in thickness, from 10YR to 5Y in hue, and from 5 to 7 in value. The B2t horizon ranges from 2.5Y to 10YR in hue and is 3 or 4 in value. The B2t horizon is silty clay and clay, and silty clay is dominant. Depth to the Ccs horizon ranges from 3 to 12 inches. Gypsum crystals may accumulate below a depth of 3 inches.

Cabba Series

The Cabba series consists of well-drained, medium-textured soils that are less than 20 inches deep over softly consolidated shale. These soils formed on uplands under mid and short grasses. Slopes are 15 to 50 percent, and elevation ranges from 4,000 to 4,500 feet. The annual precipitation is 15 to 19 inches, the average annual soil temperature is 45 to 47° F., and the frost-free season is about 100 days. The Cabba soils are associated with Midway, Barvon, Campspass, Farland, and Relan soils.

Typically the surface layer is grayish-brown silt loam about 7 inches thick. The subsoil, which extends to a depth of 16 inches, is light-gray silt loam and loam that is strongly calcareous. It is underlain by stratified shale beds.

Cabba soils are used mostly for range, but some areas are dryfarmed.

Typical profile of Cabba silt loam, NW1/4 of section 11, T. 7 S., R. 46 E., in native grass:

A1--0 to 7 inches, grayish-brown (10YR 5/2) silt loam, dark grayish brown (10YR 4/2) when moist; weak, fine, granular structure; soft when dry, friable when moist, nonsticky and nonplastic when wet; 2 percent, by volume, is pebbles less than one half inch in diameter; abundant fine roots; calcareous; pH 8.4; clear boundary.

C1--7 to 12 inches, light-gray (10YR 7/2) heavy silt loam, grayish brown (10YR 5/2) when moist; massive; soft when dry, friable when moist, slightly sticky and nonplastic when wet; common lime accumulations in seams and splotches; strongly calcareous; pH 8.0; common fine roots; gradual boundary.

C2--12 to 16 inches, light-gray (10YR 7/1) loam, gray (10YR 5/1) when moist; massive; soft when dry, friable when moist, nonsticky and nonplastic when wet; strongly calcareous; pH 8.0; abrupt boundary.

IIC3--16 inches +, softly consolidated siltstone, sandstone, and shale beds. Roots penetrate the bedrock in fractures and between layers.

The A horizon ranges from silt loam to loam and is 4 to 8 inches thick. It ranges from 10YR to 2.5Y in hue and is 5 or 6 in value. Depth to bedrock ranges from 12 to 18 inches.

Cabba association, 15 to 50 percent slopes (Ca).--This association occurs on uplands and consists of Cabba silt loam, Cabba clay loam, and Midway clay loam. The Cabba soils occupy the upper part of slopes, and the Midway soils occupy the middle and lower parts. A typical area is about 40 percent Cabba silt loam, 15 percent Midway clay loam, and the rest minor soils. The Cabba and Midway soils have profiles similar to those described as typical for their series.

Included with these soils in mapping are areas of Farland silt loam and Barvon soils less than 5 acres in size. These included soils generally are on smooth foot slopes, terraces, and fans. Also included are small areas of Shale outcrop and prominent sandstone ledges on the steep southern slopes. The north-facing slopes normally are smooth and steep.

The soils of this association are well drained, are moderately permeable, and have a medium rate of water intake. Runoff is medium to rapid, and the available water capacity is 2 to 3 inches. The effective rooting depth for crops is about 2 feet and includes rooting into the shattered platy siltstone, sandstone, and clay shale beds. Grass and tree roots extend to a depth of more than 5 feet. These soils have low fertility and organic-matter content. The erosion hazard is moderate where soils are protected by grass and trees, but it is severe in unprotected areas.

These soils are used mainly for grazing. A small amount of marketable timber is produced on the minor Barvon and Farland soils. Less timber is harvested on Cabba silt loam and none on Midway clay loam. Trees grow mainly on north-facing slopes, and in most places stands are poorly stocked and have many grassy openings.

The average site index for ponderosa pine is 51 on Cabba silt loam. The annual yield from unmanaged stands is less than 1,000 board feet per acre. Because ponderosa pine trees root deeply in these soils, there is no windthrow hazard. Erosion is a hazard where overgrazing has removed the grass cover in parklike areas and under thin stands of trees. Seedling mortality is severe; more than 75 percent of the plants die. Competition from plants that interfere with the growth of trees is moderate to severe. (Capability unit VIIe-1; range-soil group 7)

Campspass Series

The Campspass series consists of well-drained soils that are more than 40 inches deep over shale beds. These soils developed under a forest canopy at an elevation ranging from 3,500 to 4,500 feet. Slopes are 15 to 50 percent. The annual precipitation is 16 to 20 inches, the average annual soil temperature is 45 to 47° F., and the frost-free season about 100 days. The Campspass soils are associated with Barvon, Relan, and Cabba soils.

Typically Campspass soils are covered with a 1/2- to 2-inch layer of pine needles and litter.

The surface layer is grayish-brown and light brownish-gray loam. The subsoil extends to a depth of about 34 inches. It is light yellowish-brown and pale-brown clay loam and silty clay loam to a depth of about 25 inches, and pale-brown channery loam below. The substratum contains segregations of lime and is yellowish-red silty clay loam to clay loam to a depth of 43 inches. Below this are fractured and weathered slate, sandstone, and porcelanite shale beds.

The Campspass soils are mostly wooded.

Typical profile of Campspass loam that has 15 to 50 percent slopes, SW1/4 of section 23, T. 2 S., R. 46 E.:

01--1 3/4 inches to 1/2 inch, pine needles, grass, and leaves partly decomposed.

02--1/2 inch to 0, decomposed pine needles, grass, and leaves mixed with mineral soil; clear boundary.

A1--0 to 1 inch, very dark-gray (10YR 3/1) loam; black (10YR 2/1) when moist; weak, very fine, granular structure; soft when dry, friable when moist; nonsticky and nonplastic when wet; abundant fine and very fine roots; common pores; noncalcareous; pH 6.5; abrupt boundary.

A2--1 inch to 5 inches, grayish-brown (10YR 5/2) loam, very dark gray (10YR 3/1) when moist; weak, medium, platy structure that separates to weak, fine and medium, blocky structure; slightly hard when dry, friable when moist, nonsticky and nonplastic when wet; coating and patches of light-gray silt and fine sand grains; less than 1 percent of horizon is red and yellow sandstone and slate fragments that weathered in place; common medium and abundant fine roots; common pores; noncalcareous; pH 6.5; clear, wavy boundary.

A&B--5 to 10 inches, loam that is light brownish gray (10YR 6/2) on bottom of peds and light gray (10YR 7/2) on top of peds; dark brown (10YR 4/3) when moist; moderate, fine and medium, subangular blocky structure; slightly hard when dry, friable when moist, sticky and slightly plastic when wet; thin continuous coating of clear silt and fine sand grains on peds; tongues of clear silt and fine sand through the peds; broken silt film on tops of peds; less than 1 percent of horizon is red and yellow sandstone and slate fragments that weathered in place; common medium roots; common fine pores; horizon firmer in places; noncalcareous; pH 6.5; clear, wavy boundary.

B&A--10 to 14 inches, clay loam that is pale brown (10YR 6/3) on top of peds and yellowish brown (10YR 5/4) on bottom of peds, brown (10YR 5/3) when wet; moderate, fine and medium, subangular blocky structure; hard when dry, friable when moist, sticky and plastic when wet; broken silt film on top of peds and tonguing of silt film between peds; less than 1 percent of horizon is red and yellow sandstone and slate fragments that weathered in place; common medium roots; common fine pores; noncalcareous; pH 7.0; gradual boundary.

B2t--14 to 19 inches, light yellowish-brown (10YR 6/4) clay loam, yellowish brown (10YR 5/4) when moist; moderate, fine and medium, subangular blocky structure; slightly hard when dry, friable when moist, sticky and plastic when wet; broken distinct clay film on peds; less than 1 percent of horizon is red and yellow sandstone and shale fragments that weathered in place; common medium and fine roots; few fine pores; noncalcareous; pH 7.0; many large krotovinas.

B22t--19 to 25 inches, very pale-brown (10YR 7/4) silty clay loam, dark yellowish brown (10YR 4/4) when moist; moderate, medium, subangular blocky structure; hard when dry, firm when moist, sticky and plastic when wet; prominent, broken, brown clay films on peds; common medium roots; few fine pores; noncalcareous; pH 7.5; abrupt, wavy boundary.

B3ca--25 to 34 inches, pale-brown (10YR 6/3) channery loam, yellowish brown (10YR 5/4) when moist; weak, fine, blocky structure; hard when dry, friable when moist, nonsticky and nonplastic when wet; 25 percent porcelanite fragments 1/4 inch or less in diameter; few fine matted roots; common fine pores; common fine threads of lime; strongly calcareous; pH 8.0; horizon hard in places; clear, wavy boundary.

IIC1--34 to 43 inches, yellowish-red (5YR 4/6) silty clay loam, yellowish red (10YR 5/6) when moist; weak, fine, blocky structure; hard when dry, very firm when moist, sticky and plastic when wet; calcareous; pH 8.0; abrupt boundary.

IIIC2--43 inches, fractured and weathered slate, sandstone, and porcelanite shale.

The A2 horizon ranges from 3 to 6 inches in thickness. It ranges from 10YR to 2.5Y in hue, is 5 or 6 in value when dry, and is 1 or 2 in chroma. The A&B horizon ranges from 4 to 12 inches in thickness. The B2t horizon is silty clay loam or clay loam 12 to 35 inches thick. The B3ca horizon has many to common lime segregations. Depth to shale ranges from 43 to 50 inches.

Campspass-Barvon association, 15 to 50 percent slopes (Cb).--This association consists mainly of Campspass loam and Barvon loam on high terraces and steep north-facing upland slopes. Campspass loam occurs mainly in drainageways, on high upland terraces, and at the foot of steep slopes; Barvon loam is in intermediate positions between Campspass and Cabba soils. Cabba and Ringling soils occupy the tops of knolls, ridges, and divides. Most areas are wooded. Ponderosa pine grows on the woodland and provides a 60 to 90 percent crown cover. The understory consists of abundant shrubs and grasses.

This association is about 50 percent Campspass loam, 20 percent Barvon loam, 20 percent Cabba and

Ringling soils, and the rest minor soils. Included with these soils in mapping are small areas of dark-colored soils and, in areas of less than one-quarter acre, small but prominent outcrops of clinkerlike rock and sandstone.

The soils of this association are well drained. Permeability is moderately slow in the Campspass soils and moderate in the Barvon soils. Runoff is medium to rapid on bare soil. The available water capacity is 6 to 8 inches for a 5-foot depth. Roots penetrate readily to a depth of 40 inches or more. These soils are high in organic-matter content and fertility.

Trees grow well on the Campspass and Barvon soils, and stands are generally well stocked. Trees grow poorly on the Cabba and Ringling soils, and stands are generally poorly stocked and have many grassy openings. Very little timber is harvested on Cabba and Ringling soils.

The site index for ponderosa pine is 65 on Campspass and Barvon soils, 50 on Ringling soils, and 54 on Cabba soils. The annual yield from unmanaged stands on Campspass and Barvon soils is about 5,000 board feet per acre. Because ponderosa pine trees root deeply in these soils, there is no windthrow hazard. Seedling mortality is slight on Campspass and Barvon soils and moderate to severe on Cabba and Ringling soils. Competition from other plants is only a moderate hazard on all these soils.

Cross trenches are outsloped across haul roads to control soil blowing. Roads that are used the year round must be surfaced. Unsurfaced roads can be used only when the soils are dry or frozen. (Capability unit VIe-1; range-soil group 3; windbreak suitability group 1)

Cushman Series

The Cushman series consists of well-drained soils on uplands. These soils are 20 to 40 inches deep over soft shale. The native vegetation is mid and short grasses. Slopes are 4 to 15 percent, and elevation ranges from 3,200 to 3,500 feet. The annual precipitation is 10 to 15 inches, the average annual soil temperature is 47 to 49° F., and the frost-free season is 115 to 120 days. These soils are associated with Fort Collins, Thurlow, and Elso soils.

Typically the surface layer is light grayish-brown silt loam about 4 inches thick, and the subsoil is grayish-brown clay loam about 11 inches thick. The substratum is light brownish-gray heavy loam and very fine sandy loam. It is underlain by soft shale at a depth of about 26 inches.

The Cushman soils are used primarily for dryfarming and for range.

Typical profile of grass-covered Cushman silt loam that has 4 to 8 percent slopes, 600 feet west, 200 feet north of SW. corner of section 19, T. 1 S., R. 51 E.:

A1--0 to 4 inches, light grayish-brown (10YR 6/2) loam, very dark grayish brown (10YR 3/2) when moist; weak, fine, granular structure; soft when dry, friable when moist, nonsticky and nonplastic when wet; noncalcareous; pH 7.0; gradual boundary.

B2--4 to 12 inches, grayish-brown (10YR 5/2) clay loam, dark grayish brown (10YR 4/2) when moist; moderate, medium, prismatic structure that separates to moderate, medium and fine, blocky; slightly hard when dry, friable when moist, sticky and plastic when wet; thin patchy clay films on ped faces; noncalcareous; pH 7.2; gradual boundary.

B3ca--12 to 15 inches, light olive-brown (2.5Y 5/4) clay loam, olive brown (2.5Y 4/4) when moist; moderate, medium, prismatic structure that separates to moderate, coarse, blocky; slightly hard when dry, friable when moist, sticky and plastic when wet; noncalcareous; pH 7.2; thin patchy clay films on ped faces; gradual boundary.

C1ca--15 to 23 inches, light brownish-gray (2.5Y 6/2) heavy loam, grayish brown (2.5Y 5/2) when moist; mottled with white (2.5Y 8/0) when dry, light gray (2.5Y 7/2) when moist; massive, slightly hard when dry, friable when moist, sticky and plastic when wet; very strongly calcareous; common threads and few small nodules of lime; pH 8.6; abrupt boundary.

C2--23 to 26 inches, light brownish-gray (2.5Y 6/2) very fine sandy loam, grayish brown (2.5Y 5/2) when moist; many, fine, prominent, yellow mottles; massive; soft when dry, friable when moist, nonsticky and nonplastic when wet; very strongly calcareous; lime pockets and flour lime; pH 8.6; gradual boundary.

C3--26 inches, light brownish-gray (2.5Y 6/2) soft sandstone, grayish brown (2.5Y 5/2) when moist; many, fine, prominent, yellow mottles; strongly calcareous; pH 7.6.

The A horizon ranges from 10YR to 2.5Y in hue, is 5 or 6 in value when dry and 3 or 4 when moist, and is 2 or 3 in chroma. It ranges from loam to silt loam or very fine sandy loam. The B horizon, where present, has values of 4 or 5 when dry. The B horizon ranges from clay loam to heavy silt loam. The C1ca horizon has values of 5 or 6 when dry. The depth to soft sandstone or sandy, silty, or clayey shale ranges from 20 to 40 inches.

Cushman-Elso silt loams, 4 to 8 percent slopes (Ce).--This complex of soils on uplands consists of moderately deep Cushman silt loam and shallow Elso silt loam. The profiles of these soils are similar to those described as typical for their series. Cushman silt loam occupies long, smooth foot slopes and swales, and Elso silt loam occupies knobs and ridges. A typical area is about 70 percent Cushman soils and 30 percent Elso soils. Included with these soils in mapping are areas of Fort Collins, Thurlow, and McRae soils less than 5 acres in size.

These soils are well drained and have slow runoff and moderate permeability. The available water

capacity is 4 to 6 inches in Cushman soils and 2 to 3 inches in Elso soils. These soils blow easily when dry. Organic-matter content and fertility are medium in the Cushman soils and low in the Elso soils. Plant roots penetrate readily to the shale or sandstone.

These soils are used for dryfarmed crops and for range. (Both soils in capability unit IIIe-1, dryland, and range-soil group 4; Cushman soil in windbreak suitability group 2; Elso soil not assigned windbreak suitability group)

Cushman-Elso silt loams, 8 to 15 percent slopes (Ch).--This soil complex occurs on uplands and is about 70 percent Cushman silt loam, 20 percent Elso silt loam, and the rest minor soils. Cushman soils are on smooth foot slopes and in swales, and Elso soils are on knobs and narrow ridges. Included with these soils in mapping are areas of Thurlow, Fort Collins, and McRae soils less than 5 acres in size.

These soils are used mostly for range. A small acreage is used for dryfarmed hay and grain. (Both soils in capability unit IVe-1, dryland, and range-soil group 4; and Cushman soil is in windbreak suitability group 2; Elso soil not assigned windbreak suitability group)

Elso Series

The Elso series consists of well-drained, medium-textured, shallow soils on uplands. These soils formed from softly consolidated shale on foot slopes, narrow ridges, knobs, and tabular divides. The native vegetation is short grasses. Slopes are 8 to 45 percent, and elevation ranges from 3,000 to 3,500 feet. The annual precipitation is about 12 inches, the average annual soil temperature is 47 to 49° F., and the frost-free season is about 115 to 120 days.

Typically the surface layer is light brownish-gray silt loam about 7 inches thick. The subsoil is light brownish-gray silt loam. It is underlain by softly consolidated, interbedded silty, clayey, and sandy shale that lies at a depth of less than 20 inches.

The Elso soils are used mostly for range.

Typical profile of grass-covered Elso silt loam, 8 to 15 percent slopes, 600 feet west and 2,640 feet south of the NE. corner of sec. 3, T. 4 S., R. 51 E.:

A11--0 to 2 inches, light-gray (2.5Y 7/2) silt loam, light olive brown (2.5Y 5/4) when moist; weak, fine, granular structure; soft when dry, friable when moist, nonsticky and nonplastic when wet; strongly calcareous; pH 8.4; gradual boundary.

A12--2 to 7 inches, light brownish-gray (2.5Y 6/2) silt loam, olive brown (2.5Y 4/4) when moist; weak, fine, granular structure; soft when dry, friable when moist, nonsticky and nonplastic when wet; strongly calcareous; pH 8.4; gradual boundary.

C1--7 to 15 inches, light brownish-gray (2.5Y 6/2) silt loam, light olive brown (2.5Y 5/4) when moist; mottled with few lime splotches that are light brownish gray (2.5Y 6/2) and white (2.5Y 8/2) when dry and light brownish gray (2.5Y 6/2) when moist; massive; soft when dry, friable when moist, nonsticky and nonplastic when wet; strongly calcareous; pH 8.4; abrupt boundary.

C2--15 to 20 inches, light-gray (2.5Y 7/2) silt loam, light olive brown and light brownish gray (2.5Y 5/4 and 2.5Y 6/2) when moist; common mottles of yellow and gray; massive; friable when moist, nonsticky and nonplastic when wet; mildly calcareous; pH 8.2.

C3--20 inches, light-gray softly consolidated shale.

The A1 horizon ranges from 3 to 8 inches. It is predominantly silt loam, but includes loam, light silty clay loam, light clay loam, and heavy fine sandy loam. The A1 horizon ranges from 2.5Y to 10YR in hue, and from 5 to 7 in value when dry and more than 3 when moist. The upper 2 to 4 inches of the A1 horizon is noncalcareous in places. Gravelly, cobbly, and stony types may occur where associated with sandstone outcrops. The depth to soft, interbedded shale is shallower than 20 inches or less. The C horizon is silt loam or loam 2 to 14 inches thick. It is strongly calcareous in the upper part and has few segregations of lime in threads or soft nodules.

Elso silt loam, 8 to 15 percent slopes (Ec).--This soil occurs on smooth foot slopes, ridges, and narrow tabular divides in the uplands. It is underlain by softly consolidated shale at a depth of less than 20 inches. This soil has the profile described as typical for the series. Included with this soil in mapping are areas of Thurlow, Fort Collins, and Remmit soils less than 5 acres in size.

This soil has medium runoff and moderate permeability. The available water capacity is 2 to 3 inches. The organic-matter content and fertility are low. Bare soil blows easily. Plant roots penetrate the soil readily, and can penetrate the shale layer through fractures.

This soil is used mostly for range. Small areas are used for dryfarmed small grains. (Capability unit VIe-2; range-soil group 4)

Elso silt loam, 15 to 45 percent slopes (El).--This soil is steeper, shallower over shale, and has a thinner surface layer than Elso silt loam, 8 to 15 percent slopes. Runoff is rapid, and the hazard of erosion is severe. Included with this soil in mapping are areas of Thurlow, Fort Collins, and Remmit soils less than 5 acres in size.

This soil is used for range. (Capability unit VIe-1; range-soil group 7)

Elso-Ocean Lake association, 15 to 45 percent slopes (Eo).--This association occurs on uplands and consists mostly of Elso silt loam and Ocean Lake fine sandy loam. These soils have profiles

similar to those described as typical for their respective series. A typical area is about 45 percent Elso silt loam, 35 percent Ocean Lake fine sandy loam, and 20 percent minor soils. The minor soils are Vona, Remmit, and Cushman soils. The Elso and Ocean Lake soils are moderately steep and steep in most places. The minor soils occupy areas less than 15 acres in size on foot slopes, on fans, and in swales.

The soils of this association are used only for range. (Capability unit VIIe-1 for Elso soils and VIIe-3 for Ocean Lake soils; range-soil group 7 for Elso soils and 6 for Ocean Lake soils)

Epsie Series

The Epsie series consists of well-drained, fine-textured soils that are less than 20 inches deep over shale beds. These soils formed under salt- and alkali-tolerant short grasses. Slopes are 4 to 15 percent, and elevation ranges from 3,000 to 3,200 feet. The annual precipitation is 11 to 12 inches, the average annual soil temperature is 47 to 49° F., and the frost-free season is 115 to 120 days. These soils are associated with Midway, Elso, and Vananda soils.

Typically the surface layer is light-gray clay about 2 inches thick. The subsoil is gray to grayish-brown clay that is underlain by light olive-gray shale at a depth of about 21 inches. Gypsum and salt crystals occur between the layers of shale.

The Epsie soils are used mostly for range.

Typical profile of Epsie clay, 4 to 15 percent slopes, 1,200 feet west, 100 feet south of the NE. corner of sec. 12, T. 3 S., R. 50 E.; in native grass:

A11--0 to 1/4 inch, light-gray (5Y 6/1) clay, gray (5Y 5/1) when moist; massive crust in hexagonal blocks 2x4 inches in diameter and 1/8 to 1/2 inch thick; clusters of granules firmly adhere to the undersides and thick continuous clear sand grains are on the surface of crust; hard when dry, friable when moist, sticky and plastic when wet; noncalcareous; pH 5.2; abrupt boundary.

A12--1/4 inch to 2 inches, light-gray (5Y 7/1 and 6/1) clay, gray (5Y 6/1) when moist; weak, very fine, platy structure that separates to strong, very fine, granular; very hard when dry, firm when moist, sticky and plastic when wet; noncalcareous; pH 5.4; clear sand grains throughout peds or mass of soil; clear boundary.

C1--2 to 6 inches, gray (5Y 5/1) clay, dark gray (5Y 4/1) when moist; massive; extremely hard when dry, very firm when moist, sticky and very plastic when wet; mildly calcareous; pH 8.4; gradual boundary; horizon 4 to 6 inches thick.

C2cs--6 to 18 inches, grayish-brown (2.5Y 5/2) clay, light brownish gray (2.5Y 6/2) when moist; few light-gray (2.5Y 7/4) mottles; massive; extremely hard when dry, very firm when moist, sticky and very plastic when wet; strongly calcareous; pH 8.0; seams and pockets of lime and salt crystals; abrupt boundary; horizon 6 to 12 inches thick.

C3cs--18 to 21 inches, light olive-gray (5Y 6/2 and 5/3) shaly clay, light olive brown (2.5Y 5/4 and 5/6) when moist; common, medium, distinct mottles of light olive brown (2.5Y 5/4 and 5/6) and white (2.5Y 8/0); massive; extremely hard when dry, very firm when moist, sticky and plastic when wet; noncalcareous; pH 6.8; salt crystals between layers of shale and carbonaceous shale particles; clear boundary.

C4Cs3--21 inches, light brownish-gray (2.5Y 6/2, 4/4 and 5/4) shale of clay texture, light brownish gray (2.5Y 6/2 and 4/2) when moist; common, medium, distinct mottles of light olive brown (2.5Y 5/6) and white (2.5Y 8/0); platy structure; pH 7.2.

The A11 horizon ranges from 1/8 to 1/2 inch in thickness. Clusters of granules on the underside of the crust range from 2.5Y to 5Y in hue, are 5 in value, and are 1 or 2 in chroma. The A horizon forms a hexagonal crust that has thick coatings of bleached sand grains. The A12 horizon has bleached sand grains throughout the mass. The C horizon is massive and in some places it has many common mottles that are 10YR or 2.5Y in hue, 5 or 6 in value, and range from 6 to 8 in chroma. The C2cs horizon ranges from 6 to 10 inches in depth and from 10 to 16 inches in thickness. This horizon has few to many distinct mottles that range from 10YR to 2.5Y in hue, 5 to 7 in value, and are 4 in chroma. The mottles appear as thin strata. Salt crystals occur between the thin shale plates in clusters and seams. The C3cs horizon has many light olive-brown to yellow mottles and salt crystals.

Epsie clay, 4 to 15 percent slopes (Ep).--This soil occurs on smooth, rounded foot slopes of uplands. Slopes are dominantly 12 percent. This soil has rapid runoff and very slow permeability. The available water capacity is 2 to 4 inches. Organic-matter content and fertility are low. Plant roots do not penetrate the shale. Included with this soil in mapping are deeper soils in swales and drainageways and areas of Vananda, Arvada, and Hydro soils less than 5 acres in size.

This Epsie soil is used for range. Plants grow poorly because the surface layer is crusted and the soil is shallow. (Capability unit VIIs-1; range-soil group 11)

Farland Series

The Farland series consists of deep, well-drained, medium-textured soils on stream and alluvial-fan terraces and foot slopes of the uplands. These soils formed in silt loam alluvium. Slopes are 0 to 20 percent, and elevation ranges from 3,000 to 4,000 feet. The annual precipitation is 16 to 19 inches, the average annual soil temperature is 45

to 47° F., and the frost-free season is about 100 days. Farland soils are associated with Fergus, Relan, and Rapelje soils.

Typically the surface layer is grayish-brown silt loam about 5 inches thick. The subsoil is about 29 inches thick and ranges from grayish-brown to dark grayish-brown silty clay loam and silt loam. The substratum is light brownish-gray and pale-brown fine sandy loam to silt loam. It is mottled with lime in the upper part.

The Farland soils are used mainly for dryfarmed crops and for range. A small acreage is irrigated.

Typical profile of Farland silt loam, 0 to 2 percent slopes, 1,800 feet south and 1,700 feet east of the NW. corner of sec. 7, T. 4 S., R. 48 E.:

Ap--0 to 5 inches, grayish-brown (10YR 5/2) silt loam, very dark brown (10YR 2/2) when moist; weak, fine, granular structure; soft when dry, friable when moist, nonsticky and nonplastic when wet; noncalcareous; pH 7.2; abrupt boundary.

B21t--5 to 10 inches, grayish-brown (10YR 5/2) light silty clay loam, very dark grayish brown (10YR 3/2) when moist; moderate, medium, prismatic structure that separates to weak, medium and fine, blocky; slightly hard when dry, friable when moist, sticky and plastic when wet; thin continuous clay films on ped faces; noncalcareous; pH 7.6; gradual boundary.

B22t--10 to 18 inches, dark grayish-brown (10YR 4/2) light silty clay loam, very dark grayish brown (10YR 3/2) when moist; strong, coarse and medium, blocky structure that separates to moderate, medium and fine, blocky; slightly hard when dry, firm when moist, sticky and plastic when wet; moderately thick clay films on ped faces; noncalcareous; pH 7.8; gradual boundary.

B23t--18 to 25 inches, grayish-brown (10YR 5/2) silt loam, dark grayish brown (10YR 4/2) when moist; moderate, medium and fine, blocky structure; hard when dry, firm when moist, slightly sticky and plastic when wet; moderately thick continuous clay films on ped faces; noncalcareous; pH 8.2; gradual boundary.

B3ca--25 to 34 inches, grayish-brown (2.5Y 5/2) silt loam, dark grayish brown (10YR 4/2) when moist; mottled with white (2.5Y 8/2) when dry and light gray (10YR 7/2) when moist; weak, medium and fine, blocky structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; strongly calcareous; common, medium, distinct threads and seams of lime; vesicular; pH 8.6; gradual boundary.

C1ca--34 to 46 inches, light brownish-gray (10YR 6/2) fine sandy loam, grayish brown (10YR 5/2) when moist; mottled with white (10YR 8/2) when dry and light gray (10YR 7/2) when moist; massive; slightly hard when dry, friable when moist, nonsticky and nonplastic; strongly calcareous; few, medium, distinct mottles of lime; pH 8.8; gradual boundary.

C2--46 to 58 inches, pale-brown (10YR 6/3) stratified fine sandy loam and silt loam, brown (10YR 5/3) when moist; massive; soft when dry, friable when moist, nonsticky and nonplastic when wet; mildly calcareous; pH 8.6; gradual boundary.

C3--58 to 72 inches, pale-brown (10YR 6/3) stratified heavy silt loam, brown (10YR 5/3) when moist; massive; soft when dry, friable when moist, slightly sticky and plastic when wet; mildly calcareous; pH 8.8.

Where present, the upper 2 inches of the A1 horizon is light brownish gray when dry. The A horizon ranges from 10YR to 2.5Y in hue, is 4 or 5 in value when dry and 3 when moist, and is 2 or 3 in chroma. The texture ranges from loam to silt loam. The Bt horizon ranges from silty clay loam to silt loam in texture and from 10 to 25 inches in thickness. It is 10YR in hue, 4 or 5 in value when dry and 3 or 4 when moist, and is 2 or 3 in chroma. The clay films range from faint to distinct. The Cca horizon ranges from fine sandy loam to light silty clay loam, and has few to many pockets and films of segregated lime. It ranges from 5 to 8 in value when dry and 4 to 7 when moist. In places it has a coarse blocky structure. Stratified silt loam and fine sandy loam occur at a depth of more than 30 inches and extend to more than 6 feet.

Farland silt loam, 0 to 2 percent slopes (Fa).--This soil occurs on smooth stream terraces in the valleys of Pumpkin and Otter Creeks. It has the profile described as typical for the series. Included with this soil in mapping are areas of Relan, Fergus, and Rapelje soils less than 5 acres in size.

This soil has very slow runoff and moderate permeability. The available water capacity is 8 to 10 inches for a 5-foot depth. Organic-matter content and fertility are high. Plant roots penetrate the soil easily. The hazard of erosion is slight.

This soil is used mainly for dryfarmed small grains and for range. A small acreage is irrigated with water from intermittent streams and is used to grow alfalfa for hay or seed, small grains, and pasture. Alfalfa hay, wheat, barley, and oats grow well on irrigated soils. (Capability unit IIe-1, dryland; range-soil group 3; windbreak suitability group 1)

Farland silt loam, 2 to 4 percent slopes (Fd).--This soil occurs mainly on the high terraces in Custer National Forest. This soil is more sloping than Farland silt loam, 0 to 2 percent slopes. Runoff is slow, and the hazard of erosion is slight. Dry, bare soil blows easily. Included with this soil in mapping are areas of Relan and Fergus soils less than 5 acres in size.

This soil is used mostly for range. It is also used for small grains and for alfalfa grown for hay and seed. Small areas are irrigated. (Capability unit IIe-1, dryland; range-soil group 3; windbreak suitability group 1)

Farland silt loam, 4 to 8 percent slopes (Fe).--This soil occupies foot slopes on uplands north of Sayle in Custer National Forest. This soil is similar to Farland silt loam, 0 to 2 percent slopes, but it is more sloping. Runoff is medium, and the hazard of water erosion is moderate. Included with this soil in mapping are areas of Relan, Fergus, and Cabba soils less than 5 acres in size.

This soil is used mainly for range. A very small acreage is used for dryfarmed small grains. (Capability unit IIIe-3, dryland; range-soil group 3; windbreak suitability group 1)

Farland-Cabba association, 4 to 8 percent slopes (Fh).--This association is about 65 percent Farland silt loam and 35 percent Cabba silt loam. Each soil has a profile similar to that described as typical for its series. Farland soils occur in swales and on foot slopes in areas 10 to 15 acres in size; Cabba soils occupy knobs and ridges. Included with these soils in mapping are areas of Rapelje and Kyle soils less than 5 acres in size.

The soils of this association are used mostly for range. (Capability unit IIIe-3, dryland, for Farland soils and IVe-2, dryland, for Cabba soils; range-soil group 3 for Farland soils and 7 for Cabba soils; windbreak suitability group 1 for Farland soils and Cabba soils not assigned)

Farland-Cabba association, 8 to 20 percent slopes (Fk).--This association consists of about 70 percent Farland silt loam and 30 percent Cabba silt loam. The profile of each soil is similar to that described as typical for its series. Farland soils are in swales and on short side slopes, and Cabba soils are on ridges and tabular divides. Included with these soils in mapping are areas of Rapelje, Galata, and Kyle soils less than 10 acres in size.

These soils are used mainly for range. (Both soils in capability unit VIe-1; range-soil group 3 for Farland soils and 7 for Cabba soils; windbreak suitability group 1 for Farland soils and not assigned for Cabba soils)

Farland-Rock land association, 0 to 6 percent slopes (Fl).--This association occurs on high terraces in Custer National Forest. It consists of about 65 percent Farland silt loam and 35 percent Rock land. Sandstone crops out in bands 10 to 20 feet wide and 200 to 800 feet long throughout the survey area. Wet, basinlike areas occur on the wide terraces. Included with this association in mapping are small areas of Rapelje and Cabba soils less than 5 acres in size.

This association is used only for range. (Capability unit IIIe-3, dryland, for Farland soils and VIIIs-2 for Rock land; range-soil group 3 for Farland soils and not assigned for Rock land; windbreak suitability group 1 for Farland soils and not assigned for Rock land)

Farland and Havrelon soils, 4 to 8 percent slopes (Fm).--This undifferentiated soil group consists of Farland silt loam and Havrelon silt loam on coalescing alluvial fans and narrow flood plains in drainageways. The bottoms of the drainageways are 30 to 300 feet wide. Meandering stream channels break the fans into irregular areas less than 200 feet wide and 1,000 feet long.

These soils are well drained, deep, and moderately permeable. The available water capacity is 10 to 12 inches for a 5-foot depth. Runoff is slow to medium, and channel cutting is common during periods of seasonal runoff. Fertility is high.

These soils are used mostly for range. Small areas are used for alfalfa hay or seed and for small grains. (Capability unit IIIe-3, dryland; range-soil group 3; windbreak suitability group 1)

Fergus Series

The Fergus series consists of deep, well-drained soils that formed in silty clay loam and clay loam alluvium. These soils occur on fans and foot slopes on uplands. The native vegetation is western wheatgrass, green needlegrass, winterfat, needle-and-thread, and Sandberg bluegrass. Elevation ranges from 3,500 to 4,500 feet. The annual precipitation is about 16 inches, the average annual soil temperature is 45 to 47° F., and the frost-free season is about 100 days. These soils are associated with Relan and Farland soils.

Typically the surface layer is brown silt loam about 5 inches thick. The subsoil is brown and reddish-brown heavy silty clay loam about 17 inches thick. The substratum extends to a depth of more than 60 inches. The upper part is light reddish-brown clay loam that contains segregations of lime, and the lower part is pinkish-gray channery silt loam.

These soils are used mostly for range. On well-managed range, the stands of grass are excellent.

Typical profile of Fergus silt loam that has 2 to 8 percent slopes, NW1/4 NW 1/4 of sec. 3, T. 6 S., R. 44 E. in Custer National Forest:

A1--0 to 5 inches, brown (7.5YR 5/2) silt loam, dark brown (7.5YR 3/2) when moist; weak, medium, granular structure; soft when dry, friable when moist, slightly sticky and nonplastic when wet; about 1 percent porcelanite fragments less than 1 inch in size; abundant roots; noncalcareous; pH 6.5; gradual boundary.

B1--5 to 11 inches, brown (7.5YR 5/2) light silty clay loam, dark brown (7.5YR 3/2) when moist; moderate, medium, prismatic structure that separates to moderate, fine, blocky; hard when dry, friable when moist, sticky and plastic when wet; about 1 percent is porcelanite fragments less than 1 inch in

size; thin patchy clay films on peds; noncalcareous; pH 6.5; abundant fine roots; clear, smooth boundary.

B21t--11 to 16 inches, reddish-brown (5YR 5/4) heavy silty clay loam, dark reddish brown (5YR 3/4) when moist; moderate, medium, prismatic structure that separates to strong, very fine, blocky; very hard when dry, friable when moist, sticky and plastic when wet; about 2 percent is small porcelanite fragments; medium thick continuous clay films and patches of thick clay films; noncalcareous; pH 6.0; common fine roots; clear, smooth boundary.

B22t--16 to 22 inches, reddish-brown (5YR 5/4) heavy silty clay loam; weak, medium, prismatic structure that separates to strong, medium and fine, blocky; very hard when dry, firm when moist, sticky and plastic when wet; about 2 percent is small porcelanite fragments; moderately thick and thick clay films on peds; few fine roots; noncalcareous; pH 8.0; clear, wavy boundary.

C1ca--22 to 35 inches, light reddish-brown (5YR 6/4) clay loam, reddish brown (5YR 4/4) when moist; massive; very hard when dry, firm when moist, sticky and plastic when wet; strongly calcareous; many lime masses or seams and threads; 5 percent is small porcelanite fragments; very few fine roots; strongly calcareous; pH 8.0; gradual, smooth boundary.

C2--35 to 60 inches, pinkish-gray (5YR 7/2) channery heavy silt loam, reddish brown (5YR 4/4) when moist; massive; hard when dry, firm when moist, nonsticky and nonplastic when wet; contains about 30 percent porcelanite fragments; strongly calcareous; pH 8.0.

The A1 horizon ranges from 7.5YR to 5YR in hue, is 4 or 5 in value when dry and 3 or 2 when moist, and is 2 or 3 in chroma. The B2 horizon ranges from 10YR to 5YR in hue, is 4 or 5 in value when dry and 2 or 3 when moist. The B2 horizon ranges from 11 to 20 inches in thickness. The B2 horizon ranges from silty clay loam to light silty clay. Depth to the C2 horizon ranges from 30 to 60 inches.

Fergus-Relan association, 2 to 8 percent slopes (Fn).--This association consists of about 70 percent Fergus silt loam and 30 percent Relan loam. These soils have profiles similar to those described as typical for their series. The Fergus soils occur mostly in swales and on gentle slopes; Relan soils are on smooth foot slopes above the Fergus soils. Included with these soils in mapping are areas of Ringling soils less than 5 acres in size on fans, knobs, and ridges. Also included are small, nearly level basins that are seasonally wet.

These soils are well drained. Permeability is moderately slow in Fergus soils and moderate in Relan soils. Runoff is slow to medium. The available water capacity is 9 to 11 inches for a 5-foot depth. Organic-matter content and fertility are high. Plant roots penetrate these soils readily.

These soils are used mainly for range. A small acreage is used for small grains. (Capability unit IIIe-3, dryland; range-soil group 3; windbreak suitability group 1)

Fort Collins Series

The Fort Collins series consists of well-drained, moderately fine textured soils on uplands. These soils formed in deep alluvium on stream terraces, fans, and foot slopes. The soils on fans and foot slopes are underlain by shale beds at a depth of more than 60 inches. The native vegetation is western wheatgrass, needle-and-thread, green needlegrass, Sandberg bluegrass, and shrubs. Slopes are 0 to 8 percent, and elevation ranges from 3,200 to 3,500 feet. The annual precipitation is about 12 inches, the average annual soil temperature is 47 to 49° F., and the frost-free season is 115 to 120 days. These soils are associated with Cushman, Hesper, Thurlow, and Hydro soils.

Typically the surface layer is light brownish-gray silt loam about 4 inches thick. The subsoil is grayish-brown and light brownish-gray silty clay loam about 10 inches thick. The substratum is light brownish-gray and grayish-brown heavy silt loam and silty clay loam. The lower 6 inches of the subsoil and the entire substratum are calcareous. Threads and seams of lime are common throughout the substratum.

The Fort Collins soils are used mostly for dry-farmed crops and for range.

Typical profile of Fort Collins silt loam, 2 to 4 percent slopes, 1,600 feet south, 1,080 feet east of the NW. corner of sec. 11, T. 4 S., R. 51 E.:

A1--0 to 4 inches, light brownish-gray (10YR 6/2) silt loam, dark grayish brown (10YR 4/2) when moist; weak, platy structure that separates to weak, medium, crumb; soft when dry, friable when moist, nonsticky and nonplastic when wet; noncalcareous; pH 7.0; gradual boundary.

B21t--4 to 8 inches, grayish-brown (10YR 5/2) light silty clay loam, dark grayish brown (10YR 4/2) when moist; moderate, medium, prismatic structure that separates to moderate, medium and coarse, blocky; soft when dry, friable when moist, slightly sticky and plastic when wet; moderate thick continuous clay films on all peds; noncalcareous; pH 7.2; clear boundary.

B22t--8 to 14 inches, light brownish-gray (10YR 6/2) silty clay loam, brown (10YR 5/3) when moist; moderate, medium and coarse, blocky structure that separates to moderate, medium and fine, blocky; soft when dry, friable when moist, sticky and plastic when wet; thin continuous clay films on ped faces; noncalcareous; pH 7.4; clear boundary.

C1ca--14 to 30 inches, grayish-brown (10YR 5/2) heavy silt loam, dark grayish brown (10YR 4/2) when moist; weak, coarse, blocky structure; soft when dry, friable when moist,

sticky and plastic when wet; strongly calcareous; few lime splotches; pH 8.0; clear boundary.

C2ca--30 to 38 inches, light brownish-gray (2.5Y 6/2) heavy silt loam, grayish brown (2.5Y 5/2) when moist; massive; hard when dry, friable when moist, sticky and plastic when wet; very strongly calcareous; many distinct lime specks and small nodules; pH 8.4; gradual boundary.

C3--38 to 62 inches, light brownish-gray (2.5Y 6/2) silty clay loam, grayish brown (2.5Y 5/2) when moist; mottled with light gray (2.5Y 7/2); massive; some reworked shale; hard when dry, friable when moist, sticky and plastic when wet; very strongly calcareous; threads and nodules of lime through the soil mass; small shell and rock fragments.

The A1 horizon ranges from 10YR to 2.5Y in hue, is 5 or 6 in value when dry, and 3 or 4 when moist, and is 2 in chroma. The surface 2 to 6 inches ranges from heavy loam to silt loam. The Bt horizon ranges from 10YR to 2.5Y in hue, is 5 or 6 in value, and ranges from 2 to 4 in chroma. The Bt horizon ranges from light silty clay loam to clay loam and from medium prismatic to coarse blocky structure. Clay films are continuous on all ped faces of the Bt horizon and range from thin to moderately thick.

The Cca horizon ranges from 10YR to 2.5Y in hue, is 5 or 6 in value, and is dominantly 2 in chroma. The soil mass is strongly calcareous. Below a depth of 38 to 40 inches are many small shell and rock fragments.

Fort Collins silt loam, 0 to 2 percent slopes (Fo).--This soil occurs on stream terraces and alluvial fans in the uplands. It has a profile similar to that described as typical for the series. Included with this soil in mapping are small areas of Hesper and Hydro soils.

Runoff is slow, and permeability is moderately slow. The available moisture capacity is 10 to 12 inches for a 5-foot depth. Organic-matter content is medium, and fertility is high. Plant roots penetrate this soil readily. The hazard of erosion is slight.

This soil is used mostly for dryfarmed crops. Small areas are used for range or for irrigated small grains and alfalfa grown for hay or seed. Irrigation water is supplied by wells and reservoirs. Alfalfa hay, wheat, barley, and oats grow well on irrigated soils. (Capability unit IIIc-1, dryland; range-soil group 4; windbreak suitability group 2)

Fort Collins silt loam, 2 to 4 percent slopes (Fr).--This soil occurs on stream terraces and alluvial fans. It has the profile described as typical for the series. Included with this soil in mapping are small areas of Cushman, Hesper, and Hydro soils.

This soil is used mostly for dryfarmed small grains and alfalfa grown for hay or seed. Small areas are irrigated by water supplied by wells and small reservoirs. Crops grow well where this soil is irrigated. Where cultivated, this soil is moderately susceptible to soil blowing and water erosion. (Capability unit IIIe-1, dryland; range-soil group 4; windbreak suitability group 2)

Fort Collins silt loam, 4 to 8 percent slopes (Fs).--This soil is more strongly sloping than other Fort Collins soils. Runoff is medium, and the hazard of erosion is moderate. Included with this soil in mapping are small areas of Cushman, Hesper, McRae, and Hydro soils.

This soil is used mainly for range, but small areas are used for dryfarmed small grains and alfalfa grown for hay. (Capability unit IIIe-1, dryland; range-soil group 4; windbreak suitability group 2)

Galata Series

The Galata series consists of well-drained, fine-textured soils on uplands. These soils are more than 40 inches deep over shale. The native vegetation is mid or short grasses. Elevation ranges from 3,500 to 4,500 feet. The annual precipitation is about 15 inches, the average annual soil temperature is 45 to 47° F., and the frost-free season is about 100 days. These soils are associated with Rapelje and Kyle soils.

Typically the surface layer is gray silty clay about 3 inches thick. The subsoil is grayish-brown clay about 21 inches thick. The substratum is light yellowish-brown fine sandy loam that is strongly calcareous and contains segregated gypsum and salt crystals. Shale beds are at a depth of about 42 inches.

The Galata soils are used mostly for range.

Typical profile of Galata silty clay, 4 to 8 percent slopes, 1,200 feet north and 100 feet east of the SW. corner of sec. 7, T. 3 S., R. 52 E.:

A2--0 to 3 inches, gray (10YR 5/1) silty clay, dark gray (10YR 4/1) when crushed and moist; weak platy structure that separates to fine granular; thin 1/4-inch vesicular crust on surface; soft when dry, friable when moist, sticky and plastic when wet; noncalcareous; pH 7.0; abrupt boundary.

B2&A2--3 to 7 inches, dark-gray (10YR 4/1) clay, very dark grayish brown (10YR 3/2) when moist; moderate prismatic structure that separates to medium platy; top of plates are lighter colored than bottom of plates; few coated and clear sand grains on peds; hard when dry, friable when moist, sticky and plastic when wet; patchy clay films on ped faces; noncalcareous; pH 7.4; clear boundary.

B21t--7 to 16 inches, grayish-brown (10YR 5/2) clay, dark grayish brown (10YR 4/2) when moist; strong prismatic structure that separates to coarse and medium blocky; extremely hard when dry, firm when moist, sticky and plastic when wet; thick continuous clay films; noncalcareous; pH 8.2; clear boundary.

B22t--16 to 24 inches, grayish-brown (2.5Y 5/2) silty clay, olive brown (2.5Y 4/4) when moist; strong, coarse and medium, blocky structure; extremely hard when dry, firm when moist, sticky and plastic when wet; thin patchy clay films; noncalcareous; pH 8.0; clear boundary.

IIC1--24 to 42 inches, light yellowish-brown (2.5Y 6/4) fine sandy loam, light olive brown (2.5Y 5/4) when moist; massive; hard when dry, friable when moist, nonsticky and nonplastic when wet; strongly calcareous; pH 8.6; many fine pores; gypsum crystals in streaks and pockets; splotches of lime; clear boundary.

IIIC2--42 inches, light brownish-gray (2.5Y 6/2) stratified clay shale and sandstone; mottled with light olive brown (2.5Y 5/6) and olive yellow (2.5Y 6/6); strongly calcareous; pH 8.4; seams of lime and nests of gypsum crystals.

The thin vesicular surface crust is 1/4 to 1 inch thick. The A2 horizon ranges from 10YR to 2.5Y in hue, is 5 or 6 in value when dry and 3 or 4 when moist, and ranges from 1 to 3 in chroma. A distinct B2&A2 horizon ranges from 3 to 10 inches in thickness and has many clean sand grains. It is underlain by a B2t horizon that has moderate to strong, medium, prismatic structure. This horizon ranges from 10YR to 2.5Y in hue, is 4 or 5 in value when dry and 3 or 4 when moist, and is 2 in chroma. The IIC horizon ranges from a coarse blocky structure to massive.

Galata silty clay, 4 to 8 percent slopes (Ga).--This soil occurs on foot slopes, swales, and fan terraces. It has the profile described as typical for the series. Included with this soil in mapping are small areas of Rapelje, Kyle, and Bone soils less than 5 acres in size.

This soil has medium runoff and slow permeability. The available water capacity is 8 to 10 inches for a 5-foot depth. Organic-matter content and fertility are medium. The shrink-swell potential is high.

This soil is used mostly for range. Small areas are used for dryfarmed alfalfa for hay and for small grains. (Capability unit IVe-3, dryland; range-soil group 5; windbreak suitability group 4)

Gilt Edge Series

The Gilt Edge series consists of well-drained soils that have a fine-textured subsoil. These soils formed in clay alluvium on stream terraces, fans, and foot slopes under a cover of mid and short grasses. Slopes are 0 to 6 percent, and elevation ranges from 3,000 to 3,500 feet. The annual precipitation is about 12 inches, the average annual soil temperature is 47 to 49° F., and the frost-free season is 115 to 120 days. These soils are associated with Arvada, Hydro, and Bone soils.

Typically the surface layer is light brownish-gray silt loam about 8 inches thick, and the subsoil is grayish-brown and light brownish-gray dense clay. The lower part of the subsoil contains segregations of lime. The substratum is light olive-gray calcareous silty clay loam that contains salt and gypsum crystals.

The Gilt Edge soils are used mostly for range.

Typical profile of grass-covered Gilt Edge silt loam, 0 to 2 percent slopes, 2,000 feet west and 2,640 feet south of the NE. corner of sec. 18, T. 6 S., R. 54 E.:

A2--0 to 8 inches, light brownish-gray (10YR 6/2) silt loam, dark grayish brown (10YR 4/2) when moist; weak platy structure that separates to weak crumb; soft when dry, very friable when moist, slightly sticky and slightly plastic when wet; noncalcareous; pH 6.8; abrupt boundary.

B2t--8 to 16 inches, grayish-brown (10YR 5/2) clay, very dark grayish brown (10YR 4/2) when moist; strong columnar structure that separates to strong, coarse, blocky; extremely hard when dry, very firm when moist, very sticky and very plastic when wet; thick prominent clay films; noncalcareous; pH 7.2; clear boundary.

B3ca--16 to 24 inches, light brownish-gray (10YR 6/2) clay, brown (10YR 5/3) when moist; coarse, prominent white (10YR 7/2) mottles of lime; moderate, medium and coarse, blocky structure; hard when dry, firm when moist, very sticky and very plastic when wet; weakly calcareous; pockets, seams, and nodules of lime and salt crystals; distinct patches of clay films; pH 8.4; clear boundary.

C1cs--24 to 33 inches, light olive-gray (5Y 6/2) silty clay loam, olive (5Y 5/3) when moist; massive; hard when dry, friable when moist, sticky and plastic when wet; very strongly calcareous; few threads of lime and pockets of gypsum crystals; pH 8.6; clear boundary.

C2--33 to 48 inches, light olive-gray (5Y 6/2) light silty clay loam, olive gray (5Y 5/2) when moist; massive; hard when dry, friable when moist, sticky and plastic when wet; very strongly calcareous; common threads of lime; pH 8.8; clear boundary.

IIC3--48 to 62 inches, light olive-gray (5Y 6/2) heavy silt loam, olive (5Y 5/3) when moist; mottled with light olive gray (5Y 6/2) when moist; massive; soft when dry, friable when moist, slightly sticky and plastic when wet; strongly calcareous; few threads of lime; pH 8.8.

The A2 horizon ranges from 5 to 12 inches in thickness, and from silt loam to clay loam in texture. The A2 horizon ranges from 10YR to 2.5Y in hue, is 5 or 6 in value when dry and 4 when moist, and is 2 or 3 in chroma. A vesicular crust 1/4 to

3/4 inch thick is present during dry hot weather. Segregated lime and gypsum crystals are common in the C horizon.

Gilt Edge silt loam, 0 to 2 percent slopes (Gd).--This soil occurs on stream terraces and fans. Permeability is slow and the available water capacity is 8 to 10 inches for a 5-foot depth. This soil has the profile described as typical for the series. Included with this soil in mapping are areas of Arvada and Hydro soils less than 5 acres in size.

This soil is used mostly for range. Small areas are used for dryfarmed small grains and alfalfa hay. (Capability unit IIIs-1, dryland; range-soil group 4; windbreak suitability group 3)

Gilt Edge silt loam, 2 to 6 percent slopes (Ge).--This soil is moderately susceptible to water erosion. This soil is similar to Gilt Edge silt loam, 0 to 2 percent slopes, but has stronger slopes.

This soil is mostly used for range. (Capability unit IIIe-2, dryland; range-soil group 4; windbreak suitability group 3)

Glenberg Series

The Glenberg series consists of calcareous fine sandy loam soils that are well drained and rapidly permeable. These soils formed in alluvium on flood plains and low terraces of rivers and streams. The vegetation is mid and short grasses. Slopes are 0 to 2 percent, and elevation ranges from 2,500 to 3,000 feet. The average annual precipitation is about 12 inches, the average annual soil temperature is 47 to 49° F., and the frost-free season is 115 to 120 days. These soils are associated with Haverson and Bankard soils.

Typically the surface layer and subsoil are light brownish-gray fine sandy loam that extends to a depth of 36 inches. The substratum is light brownish-gray sand and thin layers of silt and clay.

The Glenberg soils are used primarily for dryfarmed alfalfa and small grains. A small acreage is irrigated.

Typical profile of Glenberg fine sandy loam, 0 to 2 percent slopes, 1,840 feet west and 400 feet north of the SE. corner of sec. 4, T. 5 S., R. 51 E.:

A1--0 to 6 inches, light brownish-gray (10YR 6/2) fine sandy loam, grayish brown (10YR 5/2) when moist; moderate, thin, platy structure; slightly hard when dry, friable when moist, nonsticky and nonplastic when wet; weakly calcareous; pH 6.8; clear boundary.

C1--6 to 12 inches, light brownish-gray (10YR 6/2) fine sandy loam and thin strata of silt loam and very fine sandy loam 1/4 to 1/2 inch thick; grayish brown (10YR 5/2) when moist; massive; slightly hard when dry, friable when moist, nonsticky and nonplastic when wet; weakly calcareous; pH 8.4; clear boundary.

C2--12 to 36 inches, light brownish-gray (10YR 6/2) fine sandy loam and thin layers of fine sand, grayish brown (10YR 5/2) when moist; massive; soft when dry, very friable when moist, nonsticky and nonplastic when wet; weakly calareous; pH 8.4; clear boundary.

C3--36 to 60 inches, light brownish-gray (10YR 6/2) sand, grayish brown (10YR 5/2) when moist; loose; weakly calcareous; pH 8.6.

The A horizon ranges from 3 to 8 inches in thickness. It ranges from 10YR to 2.5Y in hue, is 5 or 6 in value, and is 2 or 3 in chroma. The C horizon ranges from 2.5Y to 10YR in hue, is 6 or 7 in value, and ranges from 2 to 4 in chroma. The C horizon is stratified and ranges from sand to clay, but the average C horizon is sandy loam that has silt and clay strata less than 1/2 inch thick.

Glenberg fine sandy loam, 0 to 2 percent slopes (Gf).--This soil occurs on flood plains and stream terraces. It has slow runoff and rapid permeability. The available water capacity is 6 to 8 inches for a 5-foot depth. The hazard of soil blowing is moderate. Content of organic matter and fertility are low. The profile of this soil is that described as typical for the series. Included with this soil in mapping are areas of Haverson silt loam or loam and Bankard fine sandy loam less than 5 acres in size.

This soil is used mainly for range or irrigated for pasture. A small acreage is used for dryfarmed or irrigated alfalfa and small grains. Alfalfa hay, wheat, and barley grow well on irrigated soil. (Capability unit IVe-4, dryland; range-soil group 2; windbreak suitability group 2)

Haverson Series

The Haverson series consists of well-drained, medium-textured soils that are more than 60 inches deep. These soils formed in loamy alluvium under short and mid grasses. Slopes are 0 to 4 percent, and elevation ranges from 2,700 to 3,500 feet. The annual precipitation is about 12 inches, the average annual soil temperature is 47 to 49° F., and the frost-free season is about 115 days. These soils are associated with Glenberg, Heldt, and McRae soils.

Typically the surface layer is light brownish-gray silt loam about 6 inches thick. The subsoil and substratum are calcareous grayish-brown and light brownish-gray stratified silt loam, fine sandy loam, and silty clay loam.

The Haverson soils are used mainly for irrigated and dryfarmed hay and small grains.

Typical profile of cultivated Haverson silt loam that has 0 to 2 percent slopes, 1,000 feet south and 600 feet east of the NW. corner of sec. 36, T. 4 S., R. 51 E.:

Ap--0 to 6 inches, light brownish-gray (2.5Y 6/2)

silt loam, dark grayish brown (2.5Y 4/2) when moist; weak platy to granular structure; soft when dry, friable when moist, nonsticky and nonplastic when wet; weakly calcareous; pH 8.2; clear boundary.

C1--6 to 20 inches, grayish-brown (2.5Y 5/2) fine sandy loam with 1/2 to 2-inch layer of silt loam, dark grayish brown (2.5Y 4/2) when moist; silt loam material has weak, thin, platy structure, fine sandy loam is massive; soft when dry, friable when moist, nonsticky and nonplastic when wet; weakly calcareous; pH 8.6; clear boundary.

C2--20 to 26 inches, light brownish-gray (2.5Y 6/2) very fine sandy loam and 1/2-inch layers of light brownish gray (10YR 6/2) silt loam, 2 to 3 inches apart, including a 1/2- to 3/4-inch layer of light-gray (2.5Y 7/2) fine sand; massive; soft when dry, friable when moist, nonsticky and nonplastic when wet; weakly calcareous; pH 8.6; clear boundary.

C3--26 to 38 inches, light brownish-gray (10YR 6/2) silt and silt loam in 1/2-inch layers, grayish brown (10YR 5/2) when moist; massive; common, medium and fine pores, few distinct lime specks; slightly hard when dry, very friable when moist, nonsticky and nonplastic when wet; mildly calcareous; pH 8.4; clear boundary.

C4--38 to 60 inches, light brownish-gray silt loam, silty clay loam, and very fine sandy loam layers 1/2 inch to 2 inches thick and thin strata of light-gray fine and coarse sand 1 inch thick; massive and thin platy structure; soft when dry, very friable when moist, nonsticky and nonplastic when wet; weakly calcareous; pH 8.2.

The A horizon, 3 to 6 inches thick, ranges from fine sandy loam to silty clay. It ranges from 10YR to 2.5Y in hue, and is 1 or 2 in chroma. The stratified silty and sandy materials of the substratum occur mainly at a depth of 18 to 48 inches.

Haverson loam (2 to 4 percent slopes) (Ha).--This soil occupies fans and stream terraces. Except for the texture of the surface layer, it has a profile similar to that described as typical for the series. Included with this soil in mapping are areas of Glenberg, Heldt, and other Haverson soils less than 5 acres in size.

This soil has slow runoff and moderate permeability. The available water capacity is 9 to 11 inches for a 5-foot depth. The organic-matter content is low, and the fertility is medium. Root penetration is deep. Fallowed soil blows easily.

This soil is used for dryfarmed or irrigated alfalfa for hay or seed, wheat, barley, and corn. Alfalfa hay, wheat, barley, and oats grow well on irrigated soil. (Capability unit IIIe-1, dryland; range-soil group 4; windbreak suitability group 2)

Haverson silt loam (0 to 2 percent slopes) (Hc).--This soil occurs on flood plains and stream terraces. It is underlain by stratified alluvium at a depth of 20 inches or more. It has the profile described as typical for the series. Included with this soil in mapping are areas of Glenberg fine sandy loam and Haverson silty clay loam less than 5 acres in size.

This soil has slow runoff and moderate permeability. The available water capacity is 9 to 11 inches for a 5-foot depth. The organic-matter content is low, and the fertility is medium. Plant roots penetrate deeply. Fallowed soil blows easily.

This soil is used for dryfarmed or irrigated small grains and alfalfa for hay or seed. Alfalfa hay, wheat, barley, and oats grow well on irrigated soil. (Capability unit IIIc-1, dryland; range-soil group 4; windbreak suitability group 2)

Haverson silty clay loam (0 to 2 percent slopes) (Hd).--This soil occurs on flood plains, stream terraces, fans, and foot slopes. On the foot slopes it is underlain by clay alluvium at a depth of more than 60 inches. Except for the texture of the surface layer and a stratified loamy subsoil and substratum, this soil has a profile similar to that described as typical for the series.

This soil has slow runoff and moderately slow permeability. The available water capacity is 10 to 12 inches for a 5-foot depth. The organic-matter content is low, and the fertility is medium. Plant roots penetrate deeply.

This soil is well suited to alfalfa for seed or hay, small grains, and grass. Alfalfa hay, wheat, barley, and oats grow well on irrigated soil. (Capability unit IIIc-1, dryland; range-soil group 5; windbreak suitability group 2)

Haverson silty clay (0 to 2 percent slopes) (He).--This soil occurs on stream terraces, fans, and foot slopes. On the foot slopes it is underlain by clay alluvium at a depth of more than 60 inches. Except that it has a calcareous silty clay surface layer over a stratified silty, clayey, and sandy subsoil and substratum, the profile of this soil is similar to that described as typical for the series.

This soil has slow runoff and moderately slow permeability. The available water capacity is 9 to 11 inches for a 5-foot depth. The organic-matter content is low, and the fertility is medium. Plant roots penetrate this soil readily.

Most of this soil is in native grasses. Some areas are used for dryfarmed and irrigated wheat, barley, oats, and alfalfa grown for hay or seed. Alfalfa hay, wheat, barley, and oats grow well on irrigated soil. (Capability unit IIIc-1, dryland; range-soil group 5; windbreak suitability group 2)

Haverson soils, channeled (0 to 4 percent slopes) (Hf).--These soils occupy narrow flood plains and coalescing alluvial fans in valleys 100 to 800 feet wide. A typical area is about 85 percent Haverson soils and 15 percent Glenberg, Heldt, and Bankard soils in areas less than 2 acres in size. A meandering stream channel 5 to 15 feet

wide and 4 to 6 feet deep cuts the valley bottom or flood plain into irregular areas less than 200 feet wide and 1,000 feet long. The streams flow only during spring thaws or after occasional cloudbursts. The drainageways are not tillable, but they make up 10 to 20 percent of the mapping unit. The Haverson soils are moderately permeable and have an available water capacity of about 10 inches.

These soils are used mainly for range. Small fields are used for alfalfa, wheat, barley, and grass. (Capability unit VIw-1; range-soil group 4; windbreak suitability group 2)

Haverson soils, saline (0 to 4 percent slopes) (Hg).--These subirrigated and saline Haverson soils occupy the flood plains of large drainageways and small stream valleys that are 1,000 to 6,000 feet wide. A meandering stream channel 5 to 15 feet wide and 4 to 8 feet deep cuts these soils into irregular areas of 15 acres or less. A typical area is about 85 percent Haverson soils and 15 percent Bankard, Heldt, and McRae soils in areas less than 5 acres in size.

The Haverson soils are moderately slow in permeability and have an available water capacity of about 8 inches. The stream that crosses these soils flows only during seasonal runoff or after summer cloudbursts. The soils are subirrigated and salinized by water that is dammed up in the channels of natural drainageways. Some salts are brought in by runoff water from higher lying shale.

Because these soils have a high water table and are saline, they are not suited to cultivated crops. (Capability unit VIw-1; range-soil group 1; windbreak suitability group 5)

Havrelon Series

The Havrelon series consists of well-drained, moderately permeable, medium-textured soils on flood plains and stream terraces. These soils formed in deep alluvium under mid and short grasses. Elevation ranges from 3,000 to 3,500 feet. The annual precipitation is about 16 inches, the average annual soil temperature is 45 to 47° F., and the frost-free season is about 100 days. These soils are associated with Relan and Farland soils. They are mapped only with Farland soils in an undifferentiated soil group.

Typically the surface layer is light brownish-gray silt loam about 8 inches thick. The subsoil and substratum extend to a depth of 60 inches or more. They consist of thinly stratified pale-brown, calcareous silt loam, sandy loam, and fine sandy loam.

The Havrelon soils are used for hay and small grains, but the largest acreage is in native grass.

Typical profile of Havrelon silt loam that has 4 to 8 percent slopes, NE 1/4 of sec. 23, T. 5 S., R. 46 E. on 20-mile Ranger Station site:

A1--0 to 5 inches, light brownish-gray (10YR 6/2) silt loam, dark grayish brown (10YR 4/2) when moist; weak granular to weak platy structure; soft when dry, friable when moist, nonsticky and nonplastic when wet; noncalcareous; pH 7.5; clear boundary.

C1--5 to 8 inches, light-gray (10YR 7/2) very fine sandy loam, yellowish brown (10YR 5/4) when moist; weak, fine, platy structure; soft when dry, friable when moist, nonsticky and nonplastic when wet; pH 8.0; gradual boundary.

C2--8 to 60 inches, pale-brown (10YR 7/3) silt loam, sandy loam, and fine sandy loam in strata 1/4 to 1/2 inch thick; massive; soft when dry, very friable when moist, nonsticky and nonplastic when wet; strongly calcareous; pH 8.0; few nests of salt and gypsum crystals in lower part.

The A1 horizon ranges from 4 to 8 inches in thickness. It ranges from 10YR to 2.5Y in hue and is 5 or 6 in value when dry and 4 or 5 when moist. The C horizon is thinly stratified. Below a depth of 30 inches are a few nests of salt and gypsum crystals.

Heldt Series

The Heldt series consists of well-drained, deep, calcareous soils on stream terraces, fans, and foot slopes of the uplands. These soils are moderately fine textured. Slopes are 0 to 8 percent, and elevation ranges from 2,500 to 3,500 feet. The annual precipitation is about 12 inches, the average annual soil temperature is 47 to 49° F., and the frost-free season is 115 to 120 days. These soils are associated with the Haverson, McRae, and Glenberg soils.

Typically the surface layer is light brownish-gray silty clay loam about 9 inches thick. The subsoil is grayish-brown silty clay loam. The substratum is light-gray, light brownish-gray, and light yellowish-brown silty clay loam. The lower part of the substratum contains crystals of salt or gypsum.

The Heldt soils are used mostly for dryfarmed alfalfa, grass, and small grains.

Typical profile of Heldt silty clay loam, 0 to 2 percent slopes, 1,050 feet west and 40 feet north of the SE. corner of sec. 33, T. 3 S., R. 50 E.:

Ap1--0 to 5 inches, light brownish-gray (2.5Y 6/2) silty clay loam, dark grayish brown (2.5Y 4/2) when moist; weak, fine and medium, blocky structure; hard when dry, firm when moist, sticky and plastic when wet; mildly calcareous; pH 8.0; diffuse boundary.

Ap2--5 to 9 inches, light brownish-gray (2.5Y 6/2) silty clay loam, grayish brown (2.5Y 5/2) when moist; weak, fine and medium, blocky structure that separates to fine granular; hard when dry, firm when moist, sticky and plastic when wet; mildly calcareous; pH 8.0; diffuse boundary.

B2--9 to 10 inches, grayish-brown (2.5Y 5/2) silty clay loam, dark grayish brown (2.5Y 4/2) when

moist; weak prismatic structure that separates to moderate, medium and fine, blocky; hard when dry, firm when moist, sticky and plastic when wet; mildly calcareous; pH 8.2; clear boundary.

C1--10 to 34 inches, light-gray (2.5Y 7/2) silty clay loam, light olive brown (2.5Y 5/4) when moist; weak prismatic structure that separates to moderate, medium and fine, blocky; hard when dry, firm when moist, sticky and plastic when wet; strongly calcareous; pH 8.4; clear boundary.

C2ca--34 to 44 inches, light brownish-gray (2.5Y 6/2) silty clay loam, light olive brown (2.5Y 5/4) when moist; weak, coarse, blocky structure; slightly hard when dry, friable when moist, sticky and plastic when wet; strongly calcareous; common lime specks, threads, and seams along root channels and lime throughout the soil mass; pH 8.4; clear boundary.

C3cs--44 to 62 inches, light yellowish-brown (2.5Y 6/4) silty clay loam, light olive brown (2.5Y 5/4) when moist; massive; slightly hard when dry, friable when moist, sticky and plastic when wet; strongly calcareous; gypsum crystals in seams and small pockets; pH 8.6.

The A horizon ranges from 10YR to 2.5Y in hue, is 5 or 6 in value when dry and 4 or 5 when moist. The A horizon may or may not be calcareous. The Cca horizon has segregated lime in seams and splotches below a depth of 30 inches. In some places thin strata occur below a depth of 30 inches. Gypsum crystals are in seams and pockets below a depth of 42 inches.

Heldt silty clay loam, 0 to 2 percent slopes (Hh).--This soil is on stream terraces and fans. It developed in alluvium more than 60 inches deep. The profile of this soil is that described as typical for the series. Included with this soil in mapping are areas of Haverson, McRae, and Glenberg soils less than 5 acres in size.

This soil has slow runoff and permeability. The available water capacity is 10 inches for a 5-foot depth. Organic-matter content and fertility are medium. Fallowed soil blows easily. Roots penetrate deeply.

This soil is used for dryfarmed and irrigated small grains, alfalfa grown for hay or seed, and range. Alfalfa hay, wheat, barley, and oats grow well on irrigated soil. (Capability unit IIIc-1, dryland; range-soil group 5; windbreak suitability group 2)

Heldt silty clay loam, 2 to 4 percent slopes (Hk).--This soil occurs on fans and foot slopes. It is similar to Heldt silty clay loam, 0 to 2 percent slopes, but is more strongly sloping. Bare, cultivated soils are susceptible to soil blowing and water erosion.

This soil is used for range and for dryfarmed and irrigated small grains and alfalfa grown for hay or seed. Alfalfa hay, wheat, barley, and oats grow well on irrigated soils. (Capability unit IIIe-1, dryland; range-soil group 5; windbreak suitability group 2)

Heldt silty clay loam, 4 to 8 percent slopes (Hm).--This soil is on fans and foot slopes. It is underlain by shale beds at a depth of more than 5 feet. This soil is more sloping than Heldt silty clay loam, 0 to 2 percent slopes, and contains more lime because it receives runoff from calcareous soils at higher elevations.

This soil is mostly in range. Small areas are used for dryfarmed grains and hay. (Capability unit IIIe-1, dryland; range-soil group 5; windbreak suitability group 2)

Hesper Series

The Hesper series consists of well-drained, moderately fine textured and fine textured soils that are more than 5 feet deep. These soils formed in deep alluvium on stream terraces, fans, and foot slopes. The native vegetation is mid and short grasses. Slopes are 0 to 15 percent, and elevation ranges from 2,500 to 3,500 feet. The annual precipitation is about 12 inches, the average annual soil temperature is 47 to 49° F., and the frost-free season is 115 to 120 days. These soils are associated with Hydro, Arvada, and Fort Collins soils.

Typically the surface layer is light brownish-gray silty clay loam about 4 inches thick. The subsoil is brown heavy silty clay loam about 14 inches thick. The substratum is light yellowish-brown silty clay loam that extends to a depth of more than 60 inches. Segregations of lime are few in the lower part of the subsoil and are common in the upper part of the substratum, and in places in the lower part of the substratum are a few nests of gypsum crystals.

Hesper soils are used primarily for range. Some areas are used for dryfarmed or irrigated hay and small grains.

Typical profile of Hesper silty clay loam, 0 to 2 percent slopes, 20 feet west of NW. corner of sec. 17, T. 9 S., R. 51 E.:

A2--0 to 2 inches, light brownish-gray (10YR 6/2) silty clay loam, brown (10YR 4/3) when moist; strong, very thin, platy structure; slightly hard when dry, very friable when moist, slightly sticky and slightly plastic when wet; continuous coating of bleached silt and very fine sand grains on plates and throughout mass; the upper quarter inch is a vesicular crust; noncalcareous; pH 6.6 to 7.4; clear boundary.

AB--2 to 4 inches, grayish-brown (10YR 5/2) clay loam that is light brownish gray (10YR 6/2) on top of plates, brown (10YR 4/3) on bottom of plates, very dark grayish brown (10YR 3/2) when moist; strong very thin, platy structure;

slightly hard when dry, very friable when moist, slightly sticky and slightly plastic when wet; moderately thick clay films, and a thin frosting of clear silt grains on surface of plates; noncalcareous; pH 6.6 to 7.4; abrupt boundary.

B21t--4 to 7 inches, brown (10YR 5/3) heavy silty clay loam or light silty clay, dark yellowish brown (10YR 3/4) when moist; strong, fine, subangular blocky structure; very hard when dry, friable when moist, sticky and plastic when wet; thick continuous clay films on all ped faces; few clear sand grains; many fine and very fine pores; noncalcareous; pH 6.6 to 7.4; clear boundary.

B22t--7 to 10 inches, brown (10YR 4/3) heavy silty clay loam or light silty clay, dark yellowish brown (10YR 3/4) when moist; strong, medium, prismatic structure that separates easily to strong, fine, blocky; very hard when dry, friable when moist, sticky and plastic when wet; thick continuous clay film on all ped faces; noncalcareous; pH 6.6 to 7.4; clear boundary.

B23--10 to 14 inches, brown (10YR 5/3), heavy silty clay loam or light silty clay, brown (10YR 4/3) when moist; strong, medium, prismatic structure that separates to strong, fine and medium, blocky; very hard when dry, friable when moist, sticky and plastic when wet; thick continuous clay films; noncalcareous; pH 7.4 to 7.8; diffuse boundary.

B3ca--14 to 18 inches, pale-brown (10YR 6/3) silty clay loam, brown (10YR 4/3) when moist; moderate, medium, prismatic structure that separates to moderate, medium, blocky; very hard when dry, friable when moist, sticky and plastic when wet; distinct clay films; weakly calcareous; few lime segregations in seams, few lime films; pH 7.9 to 8.4; gradual boundary.

C1ca--18 to 30 inches, light yellowish-brown (2.5Y 6/3) light silty clay loam or heavy silt loam, light yellowish brown (2.5Y 6/4) when moist; weak, coarse, blocky structure; very hard when dry, friable when moist; mildly calcareous; common soft masses of lime segregations; pH 7.9 to 9.4; diffuse boundary.

C2--30 to 60 inches, light yellowish-brown (2.5Y 6/3) silt loam and light silty clay loam, light yellowish brown (2.5Y 6/4) when moist; hard when dry, friable when moist; weakly calcareous; pH 8.5 to 9.0.

The A2 horizon ranges from 10YR to 2.5Y in hue, is 6 or 7 in value, and 2 or 3 in chroma. The A2 horizon is clay loam or silty clay loam. The B2t horizon ranges from 2.5Y to 7.5YR in hue, is 4 or 5 in value, and ranges from 2 to 4 in chroma. The B2t horizon is 35 to 45 percent clay by field estimate. The C horizon ranges from silt loam to silty clay loam. A few nests of gypsum crystals are present below a depth of 48 inches. Depth to lime ranges from 14 to 18 inches.

Hesper silty clay loam, 0 to 2 percent slopes (Hn).--This deep soil is on stream terraces and fans. Runoff is slow and permeability is moderately slow. The profile of this soil is that described as typical for the series. Included with this soil in mapping are areas of Hydro, Arvada, and Fort Collins soils less than 5 acres in size.

This soil is easily tilled and worked into a seedbed. It is high in fertility, and medium in organic-matter content. The available water capacity is about 10 to 12 inches for a 5-foot depth. The hazard of erosion is slight.

This soil is used for range and for dryfarmed and irrigated small grains and alfalfa grown for hay and seed. Alfalfa hay, wheat, barley, and oats grow well on irrigated soil. (Capability unit IIIc-1, dryland; range-soil group 5; windbreak suitability group 2)

Hesper silty clay loam, 2 to 4 percent slopes (Ho).--This soil is similar to Hesper silty clay loam, 0 to 2 percent slopes, but is more sloping. It is on fans and foot slopes. Runoff is slow to medium, and the erosion hazard is slight to moderate.

This soil is used for range and for dryfarmed and irrigated small grains and alfalfa grown for hay or seed. Alfalfa hay, wheat, barley, and oats grow well on irrigated soil. (Capability unit IIIe-1, dryland; range-soil group 5; windbreak suitability group 2)

Hesper silty clay loam, 4 to 8 percent slopes (Hp).--This soil is similar to Hesper silty clay loam, 0 to 2 percent slopes, but is moderately sloping. It is on alluvial fans and foot slopes. Shale is at a depth of more than 5 feet. Runoff is medium, and the erosion hazard is moderate.

This soil is used mainly for range. Some areas are used for dryfarmed small grains and alfalfa grown for hay or seed. (Capability unit IIIe-1, dryland; range-soil group 5; windbreak suitability group 2)

Hesper silty clay loam, 8 to 15 percent slopes (Hr).--This soil is similar to Hesper silty clay loam, 0 to 2 percent slopes, but is strongly sloping to hilly. It is on foot slopes and fans on uplands. Shale occurs at a depth of more than 5 feet. Because of the steep slopes, runoff is rapid. Permeability is slow, and the hazard of erosion is high in cultivated fields.

This soil is used mainly for range. Some areas are used for dryfarmed small grains and alfalfa grown for hay and seed. (Capability unit IVe-1, dryland; range-soil group 5; windbreak suitability group 2)

Hopley Series

The Hopley series consists of well-drained, medium-textured soils that are more than 40 inches deep. These soils occur on fans, foot slopes, and stream terraces. They formed in loamy alluvium

under mid and short grasses. Slopes are 4 to 8 percent, and elevation ranges from 3,000 to 4,000 feet. The annual precipitation is 15 to 19 inches, the average annual soil temperature is 45 to 47° F., and the frost-free season is 100 to 115 days. These soils are associated with Relan, Farland, and Fergus soils.

Typically the surface layer is dark grayish-brown loam about 5 inches thick. The subsoil is brown and grayish-brown loam about 21 inches thick. The substratum is light brownish-gray loam that is strongly calcareous and is underlain by shale at a depth of about 42 inches.

The Hopley soils are used mostly for grazing.

Typical profile of Hopley loam that has 4 to 8 percent slopes, 900 feet west and 2,640 feet south of the NE. corner of sec. 4, T. 3 S., R. 50 E.:

Ap--0 to 5 inches, dark grayish-brown (10YR 4/2) loam, very dark grayish brown (10YR 3/2) when moist; moderate, thin, platy structure that breaks to weak, fine, granular; soft when dry, friable when moist, nonsticky and nonplastic when wet; noncalcareous; pH 7.0; clear boundary.

B2--5 to 11 inches, brown (10YR 5/3) loam, dark brown (10YR 4/3) when moist; moderate, medium, prismatic structure that separates to moderate, medium and fine, blocky; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; noncalcareous; pH 7.4; clear boundary.

B3--11 to 26 inches, grayish-brown (10YR 5/2) loam, dark grayish brown (10YR 4/2) when moist; moderate, medium and fine, blocky structure; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; mildly calcareous; common distinct threads and seams of segregated lime; pH 7.8; gradual boundary.

Clca--26 to 42 inches, light brownish-gray (2.5Y 6/2) loam, grayish brown (2.5Y 5/2) when moist; massive; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; strongly calcareous; common distinct lime segregations; pH 8.2; clear boundary.

C2--42 inches, light-gray (2.5Y 7/2) shale; strongly calcareous; pH 8.4.

The A horizon ranges from 4 to 8 inches in thickness. It is 10YR in hue and 4 or 5 in value when dry and 3 moist. The B horizon is 4 or 5 value dry and 2 or 3 moist. The B and C horizons are less than 18 percent noncarbonate clays. The depth to the Cca horizon ranges from 10 to 26 inches. All horizons are about 1 percent porcelanite shale chips, by volume. Hard porcelanite shale occurs at a depth of 40 to 70 inches.

Hopley and Relan loams, 4 to 8 percent slopes (Hs).--This unit consists of undifferentiated areas of Hopley loam and Relan loam on smooth terraces, fans, and short foot slopes. These soils are moderately permeable and have medium runoff. They are moderately high in fertility. The available water capacity is 6 to 8 inches. Included with these soils in mapping are areas of Farland and Fergus soils less than 2 acres in size.

These soils are mostly in range. Small areas are used for dryfarmed small grains and alfalfa grown for hay or seed. (Capability unit IIIe-3, dryland; range-soil group 3; windbreak suitability group 1)

Hydro Series

The Hydro series consists of well-drained, moderately fine textured soils that are more than 5 feet deep. These soils are on stream terraces, fans, and foot slopes on uplands. They formed in deep alluvium under mid and short grasses. Slopes are 0 to 15 percent, and elevation ranges from 3,000 to 3,500 feet. The annual precipitation is about 12 inches, the average annual soil temperature is 47 to 49° F., and the frost-free season is 115 to 120 days. These soils are associated with Gilt Edge, Arvada, Hesper, and Fort Collins soils.

Typically the surface layer is light brownish-gray and gray silty clay loam. The subsoil extends to a depth of about 22 inches. It is grayish-brown silty clay loam that has lime in the lower part. The substratum is grayish-brown and light brownish-gray silty clay loam and has nests of gypsum or salt crystals in the lower part.

The Hydro soils are used for range and dryfarmed crops.

Typical profile of Hydro silty clay loam, 0 to 2 percent slopes, 1,600 feet north and 800 feet west of the SE. corner of sec. 2, T. 5 S., R. 53 E.:

A2--0 to 2 inches, light brownish-gray (10YR 6/2) silty clay loam, dark grayish brown (10YR 4/2) when moist; weak, thin, platy structure that separates to weak, fine, crumb; soft when dry, friable when moist, nonsticky and nonplastic when wet; noncalcareous; pH 7.0; abrupt boundary.

B&A--2 to 5 inches, gray and dark grayish-brown (10YR 4/1 and 4/2) silty clay loam, dark grayish brown (10YR 4/2) when moist; weak, thin, platy structure; soft when dry, friable when moist, slightly sticky and slightly plastic when wet; noncalcareous; pH 7.2; abrupt boundary.

B2t--5 to 14 inches, grayish-brown (10YR 5/2) silty clay loam, dark grayish brown (10YR 4/2) when moist; strong prismatic structure that separates to moderate coarse and medium blocky; hard when dry, firm when moist, sticky and plastic when wet; thick clay films on all ped faces; noncalcareous; pH 7.4; abrupt boundary.

B3--14 to 22 inches, grayish-brown (2.5Y 5/2) silty clay loam, dark grayish brown (2.5Y 4/2) when moist; strong prismatic structure that separates to moderate, coarse and medium, blocky; hard when dry, firm when moist, sticky and plastic when wet; thick clay films on ped

faces; weakly calcareous; pH 9.0; abrupt boundary.

C1ca--22 to 29 inches, grayish-brown (10YR 5/2) light silty clay loam, dark grayish brown (2.5Y 4/2) when moist; massive; hard when dry, friable when moist, sticky and plastic when wet; very strongly calcareous; white lime in seams, nodules, pockets, and through the soil mass; pH 8.4; gradual boundary.

C2--29 to 43 inches, light brownish-gray (2.5Y 6/2) silty clay loam, dark grayish brown (2.5Y 4/2) when moist; massive; hard when dry, friable when moist, sticky and plastic when wet; strongly calcareous; white lime and gypsum crystals, pH 8.4; gradual boundary.

C3--43 to 62 inches, light brownish-gray (2.5Y 6/2) heavy silty clay loam, very dark grayish brown (2.5Y 3/2) when moist; massive; hard when dry, friable when moist, sticky and plastic when wet; strongly calcareous; white lime seams; pH 8.4.

The A2 horizon ranges from 1 to 5 inches in thick-thickness and in places has a fragile vesicular crust 1 inch thick. The A2 horizon interfingers between prisms and blocks to a depth of 12 to 14 inches. It ranges from 10YR to 2.5Y in hue, is 6 or 7 in value when dry and 3 or 4 when moist, and is 1 or 2 in chroma. The B&A horizon ranges from 2 to 9 inches in thickness. The B2 horizon ranges from 10YR to 2.5Y in hue and is 4 or 5 in value when dry. It ranges from silty clay loam to clay loam. The B3 horizon is weakly calcareous and has visible segregations of lime. Lime segregations occur in seams and splotches at an average depth of 20 inches and extend to 60 inches; gypsum crystals occur below a depth of 20 inches and extend to 60 inches. The profile is noncalcareous for about 20 inches and weakly to strongly calcareous below. The ground surface has numerous micropits, and spots of gray are visible in cultivated fields. Areas adjacent to Ringling soils have a more reddish hue than the typical soil. Dry soil under grass cover has a weak, thick, prismatic structure within 2 inches of the surface.

Hydro silty clay loam, 0 to 2 percent slopes (Ht).--This deep, well-drained soil is on stream terraces and alluvial fans. Permeability is moderately slow, and the available water capacity is about 10 inches for a 5-foot depth. The profile of this soil is that described as typical for the series. Included with this soil in mapping are areas of Hesper, Arvada, Gilt Edge, and Fort Collins soils less than 5 acres in size. Also included are small areas of alkaline soils on which crops grow poorly in dry years; these soils have a spotty appearance.

This soil is used mostly for range. Small areas are used for dryfarmed or irrigated small grains, tame grasses, and alfalfa grown for hay or seed. Alfalfa hay, wheat, barley, and oats grow well on irrigated soil. (Capability unit IIIc-1, dryland; range-soil group 5; windbreak suitability group 4)

Hydro silty clay loam, 2 to 4 percent slopes (Hu).--This soil is similar to Hydro silty clay loam, 0 to 2 percent slopes, but is more sloping. It is gently sloping and undulating and occurs on fan terraces and foot slopes. The erosion hazard is moderate. Shale is at a depth of more than 5 feet.

This soil is used mainly for range. Small areas are used for dryfarmed and irrigated small grains and alfalfa grown for hay or seed. Alfalfa hay, wheat, barley, and oats grow well on irrigated soil. (Capability unit IIIe-1, dryland; range-soil group 5; windbreak suitability group 4)

Hydro silty clay loam, 4 to 8 percent slopes (Hv).--This soil is similar to Hydro silty clay loam, 0 to 2 percent slopes, except that it occurs on foot slopes and is strongly sloping. It is underlain by clay shale at a depth of more than 5 feet. The erosion hazard is moderate.

Most of this soil is in range. Small areas are used for dryfarmed alfalfa and small grains. (Capability unit IIIe-1, dryland; range-soil group 5; windbreak suitability group 4)

Hydro-Arvada complex, 2 to 8 percent slopes (Hw).--This complex consists of about 80 percent Hydro silty clay loam and 20 percent Arvada silt loam that are so intermingled that they cannot be shown separately on the soil map. These soils occur on stream terraces and fans. Each kind of soil has a profile similar to that described as typical for its series. Included in mapping are some areas of Gilt Edge and Fort Collins soils less than 5 acres in size.

The Hydro soils are deep, well drained, and moderately slow in permeability. They have an available water capacity of about 10 inches for a 5-foot depth. Arvada soils are deep, are moderately well drained, are very slowly permeable, and have an available water capacity of 7 to 9 inches for a 5-foot depth.

The soils of this complex are used mostly for range. Small areas are used for dryfarmed small grains and alfalfa. (Capability unit IVe-3, dryland; range-soil group 5 for Hydro soils and 10 for Arvada soils; windbreak suitability group 4 for Hydro soils and 5 for Arvada soils)

Hydro-Elso association, 8 to 15 percent slopes (Hx).--This association occurs on uplands and is about 65 percent Hydro silt loam and 35 percent Elso silt loam. Hydro silt loam occupies swales and foot slopes, and Elso silt loam occupies the knobs, smooth rounded ridges, and divides. These soils are underlain by shale. Each soil has a profile similar to that described as typical for its series, but the surface layer of the Hydro soil is silt loam instead of silty clay loam. Included with these soils in mapping are areas of McRae and Fort Collins soils less than 5 acres in size.

The Hydro soil is deep, well drained, and moderately slowly permeable. Available water capacity is about 10 inches for a 5-foot depth. The Elso

soil is shallow, well drained, and moderately permeable. Its available water capacity is 2 to 3 inches. The soils of this association are low in fertility. Soil blowing and water erosion are moderate to severe hazards in cultivated areas.

These soils are used mainly for range. (Capability unit VIe-2; range-soil group 5 for Hydro soils and 4 for Elso soils; windbreak suitability group 4 for Hydro soils and not assigned for Elso soils)

Hydro-Fort Collins silt loams, 0 to 2 percent slopes (Hy).--This complex occurs on stream terraces and fans and is about 70 percent Hydro silt loam and 30 percent Fort Collins silt loam. These soils are so intermingled that they cannot be shown separately on the soil map. Each soil has a profile similar to that described as typical for its series, but the Hydro soil has a silt loam instead of a silty clay loam surface layer. Included with these soils in mapping are areas of Hydro silty clay loam and Hesper and McRae soils less than 5 acres in size.

The soils of this complex are deep, well drained, and moderately slow in permeability. They have an available water capacity of about 10 inches for a 5-foot depth. Organic-matter content and fertility are medium. The erosion hazard is slight.

These soils are used mainly for range. Small areas are used for dryfarmed small grains. (Capability unit IIIc-1, dryland; range-soil group 5 for Hydro soils and 4 for Fort Collins soils; windbreak suitability group 4 for Hydro soils and 2 for Fort Collins soils)

Keiser Series

The Keiser series consists of deep, well-drained soils on stream terraces, fans, and foot slopes of the uplands. These soils formed in transported calcareous silt loam under a cover of mid and short grasses. Slopes are 0 to 8 percent, and elevation ranges from 2,500 to 3,500 feet. The annual precipitation is about 12 inches, the average annual soil temperature is 47 to 49° F., and the frost-free season is 115 to 120 days. These soils are associated with Hesper, Fort Collins, and Hydro soils.

Typically the surface layer is grayish-brown and light brownish-gray silty clay loam about 6 inches thick. The subsoil is dark-brown and light brownish gray silty clay loam and silt loam about 9 inches thick. The substratum is light brownish-gray and grayish-brown silt loam. It extends to a depth of 60 inches or more and contains segregations of lime.

The Keiser soils are used mostly for range and for dryfarmed small grains.

Typical profile of Keiser silty clay loam, 0 to 2 percent slopes, S1/2 NE1/4 NE1/4 sec. 16, T. 3 S., R. 50 E.:

Ap--0 to 3 inches, grayish-brown (10YR 5/2) silty clay loam, very dark grayish brown (10YR 3/2) when moist; weak platy structure that separates to fine crumb; soft when dry, friable when moist, nonsticky and nonplastic when wet; noncalcareous; pH 7.0; abrupt boundary.

A2--3 to 6 inches, light brownish-gray (10YR 6/2) light silty clay loam that is light gray (10YR 7/2) on top of plates and grayish brown (10YR 5/2) on bottom of plates; very dark grayish brown (10YR 3/2) on top of plates and dark brown (10YR 3/3) on bottom of plates when moist; moderate, medium, platy structure that separates to coarse crumb; slightly hard when dry, firm when moist, sticky and plastic when wet; thin patchy clay films; thick coating of sand grains on peds; noncalcareous; pH 7.2; clear, wavy boundary.

B2t--6 to 9 inches, dark-brown (10YR 4/3) silty clay loam, dark brown (10YR 4/3) when moist; medium prismatic structure that separates to moderate, medium and fine, blocky; extremely hard when dry, firm when moist, sticky and plastic when wet; moderate thick clay films; noncalcareous; pH 7.2; abrupt boundary.

B3ca--9 to 15 inches, light brownish-gray (10YR 6/2) silt loam, grayish brown (10YR 5/2) when moist; mottled with white (10YR 8/2) concretions of lime; strong prismatic structure that separates to moderate, medium, blocky; hard when dry, friable when moist, nonsticky and plastic when wet; thin patchy clay films; strongly calcareous; pH 8.6; lime splotches and common small krotovinas; gradual boundary.

C1ca--15 to 23 inches, light brownish-gray (10YR 6/2) silt loam, grayish brown (10YR 5/2) when moist; mottled with lime that is white (10YR 8/2) when dry and light brownish gray (10YR 6/2) when moist; massive; extremely hard when dry, firm when moist, nonsticky and nonplastic when wet; strongly calcareous; pH 8.8; gradual boundary.

C2--23 to 60 inches, grayish-brown (10YR 5/2) silt loam, dark grayish brown (10YR 4/2) when moist; massive; slightly hard when dry, friable when moist, nonsticky and nonplastic when wet; strongly calcareous; pH 8.8; gradual boundary.

The surface is covered by a fragile, gray, vesicular crust that is massive and 1/4 to 1 inch thick. The A2 horizon ranges from 10YR to 2.5Y in hue, is 5 or 6 in value when dry, and is 2 or 3 in chroma. The B2 horizon ranges from silty clay loam to silty clay. It is yellower than 10YR in hue and it is 3 or 4 in chroma. The Cca horizon is strongly calcareous and has seams, splotches, and pockets of segregated lime. The C horizon ranges from silt loam to stratified fine sandy loam, loam, and silt loam alluvium to softly consolidated beds of silty clay loam. Where these Keiser soils lie adjacent to Ringling soils, they are redder than 10YR in hue. In most places lime is at a depth of 9 inches, but depth to lime ranges from 6 to 12 inches.

Keiser silty clay loam, 0 to 2 percent slopes (Kc).--This soil formed on smooth terraces, fans, and foot slopes in silt loam deposits that are thicker than 60 inches. It has the profile described as typical for the series. Included with this soil in mapping are areas of Hesper, Fort Collins, and McRae soils less than 5 acres in size.

This soil has slow runoff and moderately slow permeability. The available water capacity is 10 to 12 inches for a 5-foot depth. Organic-matter content is low, and fertility is medium. The erosion hazard is slight.

This soil is used for range and for dryfarmed alfalfa and small grains. (Capability unit IIIc-1, dryland; range-soil group 5; windbreak suitability group 3)

Keiser silty clay loam, 2 to 4 percent slopes (Ke).--Except for stronger slopes, this soil is similar to Keser silty clay loam, 0 to 2 percent slopes. Runoff is slow to medium, and the erosion hazard is slight to moderate. Included with this soil in mapping are areas of Hesper, Fort Collins, and McRae soils less than 5 acres in size.

This soil is used for range and for dryfarmed alfalfa and small grains. (Capability unit IIIe-1, dryland; range-soil group 5; windbreak suitability group 3)

Keiser silty clay loam, 4 to 8 percent slopes (Kf).--Except for stronger slopes, this soil is similar to Keiser silty clay loam, 0 to 2 percent slopes. Runoff is medium, and the erosion hazard is moderate. Included with this soil in mapping are areas of Hesper, Fort Collins, and McRae soils less than 5 acres in size.

This soil is used for range, and for dryfarmed alfalfa and small grains. (Capability unit IIIe-1, dryland; range-soil group 5; windbreak suitability group 3)

Kyle Series

The Kyle series consists of well-drained, fine-textured soils that are more than 40 inches deep. These soils are on fans, stream terraces, and foot slopes in the uplands. They formed in clay alluvium under mid and short grasses. Slopes are 2 to 15 percent, and elevation ranges from 3,700 to 4,300 feet. The annual precipitation is about 10 to 14 inches, the average annual soil temperature is 47° F., and the frost-free season is about 100 days. These soils are associated with Vananda and Galata soils.

Typically the surface layer is grayish-brown clay about 3 inches thick. The subsoil is dark grayish-brown clay about 12 inches thick and contains lime concretions in the lower part. The substratum is grayish-brown calcareous clay. It is underlain by shale at a depth of more than 40 inches.

Kyle soils are used mostly for range. Some areas are used for dryfarmed small grains and alfalfa for hay.

Typical profile of Kyle clay, 2 to 4 percent slopes, 1,600 feet east and 100 feet north of the SW. corner of sec. 20, T. 9 S., R. 46 E.:

A1--0 to 3 inches, grayish-brown (2.5Y 5/2) clay, very dark grayish brown (2.5Y 3/2) when moist; 1/4-inch crust on barren spots; strong, very fine, granular structure; soft when dry, friable when moist, sticky and plastic when wet; noncalcareous; pH 7.6; clear boundary.

B21--3 to 5 inches, gray (2.5Y 6/1) clay, dark grayish brown (2.5Y 4/2) when moist; strong, very fine and fine, subangular blocky structure; soft when dry, friable when moist, sticky and plastic when wet; very weakly calcareous; pH 8.0; clear boundary.

B22--5 to 8 inches, dark grayish-brown (2.5Y 4/2) clay, dark grayish brown (2.5Y 4/2) when moist; strong, fine, subangular blocky structure; extremely hard when dry, friable when moist, sticky and plastic when wet; weakly calcareous; pH 8.4; clear, irregular boundary.

B3ca--8 to 15 inches, dark grayish-brown (2.5Y 4/2) clay, dark grayish brown (2.5Y 4/2) when moist; strong, coarse and medium, subangular blocky structure; extremely hard when dry, friable when moist, sticky and very plastic when wet; weakly calcareous; pH 8.2; faint mottles and flour lime; diffuse boundary.

C1ca--15 to 24 inches, grayish-brown (2.5Y 5/2) clay, dark grayish brown (2.5Y 4/2) when moist; weak, coarse, blocky structure; extremely hard when dry, friable when moist, sticky and plastic when wet; weakly calcareous; pH 8.4; weak nodules of lime; diffuse boundary.

C2--24 to 32 inches, grayish-brown (2.5Y 5/2) clay, dark grayish brown (2.5Y 4/2) when moist; mottled with light olive brown (2.5Y 5/6) when dry and olive brown (2.5Y 4/6) when moist; mottles are common, medium, distinct; weak, coarse, blocky structure; extremely hard when dry, friable when moist; weakly calcareous; pH 8.2; very few lime masses; diffuse boundary.

C3--32 to 38 inches, grayish-brown (2.5Y 5/2) clay, dark grayish brown (2.5Y 4/2) when moist; mottled with light olive brown (2.5Y 5/6) when dry and olive brown (2.5Y 4/6) when moist; mottles are common and distinct; massive; extremely hard when dry, friable when moist; weakly calcareous; pH 8.2; diffuse boundary.

C4--38 to 52 inches, grayish-brown (2.5Y 5/2) light clay or clay loam, dark grayish brown (2.5Y 4/2) when moist; common, medium, distinct mottles of olive brown (2.5Y 4/6) when moist; massive; extremely hard when dry, friable when moist, sticky and plastic when wet; strongly calcareous; seams and pockets of gypsum; pH 8.2; diffuse boundary.

C5--52 inches, light yellowish-brown (2.5Y 6/4) shale, light olive brown (2.5Y 5/3) when

moist; few, medium, distinct mottles of light olive brown (2.5Y 5/6) when moist; weakly calcareous; pH 6.8; seams and pockets of gypsum crystals.

The A horizon ranges from 10YR to 5YR in hue, is 4 or 5 in value when dry and 3 or 4 when moist. The B2 horizon is 2.5Y or 5Y in hue and 4 or 5 in value when dry. The B3ca horizon has splotches, seams, threads, and nodules of lime at an average depth of 8 inches. In places, the surface layer is calcareous. Considerable fine rounded sandstone occurs throughout the profile. The C horizon ranges from 2.5Y to 5Y in hue and is 4 or 5 in value when dry and ranges from 2 to 4 in value when moist. It ranges from fine clay to silty clay. Where the soil is underlain by shale, threads, seams, and pockets of gypsum crystals are common.

Kyle clay, 2 to 4 percent slopes (Kl).--This soil is on fans and foot slopes in the uplands and is underlain by shale at a depth of more than 48 inches. It has the profile described as typical for the series. Included with this soil in mapping are small areas of Galata, Midway, Vananda, and Rapelje soils less than 5 acres in size.

Runoff is slow to medium, and permeability is slow. The available water capacity is 8 to 10 inches for a 5-foot depth. Organic-matter content and fertility are medium. The erosion hazard is slight.

This soil is used mainly for range. Small areas are used for small grains and alfalfa. (Capability unit IIIe-2, dryland; range-soil group 5; windbreak suitability group 3)

Kyle clay, 4 to 8 percent slopes (Km).--Except for stronger slopes, this soil is similar to Kyle clay, 2 to 4 percent slopes. Runoff is medium, and the erosion hazard is moderate. Included with this soil in mapping are areas of Galata, Midway, Vananda, and Rapelje soils less than 5 acres in size.

This soil is used mainly for range; small areas are used for small grains and alfalfa. (Capability unit IVe-3, dryland; range-soil group 5; windbreak suitability group 3)

Kyle clay, 8 to 15 percent slopes (Kn).--This soil is on fans, foot slopes, and smooth tabular divides. It is underlain by clay shale at a depth of more than 40 inches. Except for stronger slopes, this soil is similar to Kyle clay, 2 to 4 percent slopes. Runoff is medium, and the erosion hazard is moderate. Included with this soil in mapping are areas of Vananda, Galata, and Rapelje soils less than 5 acres in size.

This soil is used mostly for range. Small areas are used for small grains and alfalfa. (Capability unit VIe-2; range-soil group 5; windbreak suitability group 3)

McRae Series

The McRae series consists of well-drained silt loam soils that are more than 5 feet deep. These soils formed in deep alluvial materials on fan terraces, stream terraces, and foot slopes. The native vegetation is mid and short grasses. Slopes are 0 to 8 percent, and elevation ranges from 3,000 to 3,500 feet. The annual precipitation is about 12 inches, the average annual soil temperature is 47 to 49° F., and the frost-free season is 100 to 120 days. These soils are associated with Heldt, Fort Collins, and Cushman soils.

Typically the surface layer is grayish-brown silt loam about 9 inches thick. The subsoil and substratum are pale-brown calcareous silt loam that extends to a depth of more than 60 inches.

The McRae soils are used for small grains and alfalfa grown for hay or seed. A large acreage is range.

Typical profile of McRae silt loam, 0 to 2 percent slopes, 200 feet north of SE. corner of sec. 10, T. 2 S., R. 50 E.:

A11--0 to 3 inches, grayish-brown (10YR 5/2) silt loam, dark grayish brown (10YR 4/2) when moist; weak, fine, crumb structure; soft when dry, friable when moist, nonsticky and nonplastic when wet; noncalcareous; pH 7.0; gradual boundary.

A12--3 to 6 inches, grayish-brown (10YR 5/2) silt loam, very dark grayish brown (10YR 3/2) when moist; weak platy structure that separates to weak, medium and fine, blocky; slightly hard when dry, friable when moist, nonsticky and nonplastic when wet; noncalcareous; pH 7.0; gradual boundary.

B2--6 to 9 inches, grayish-brown (10YR 5/2) silt loam, brown (10YR 4/3) when moist; weak prismatic structure that separates to moderate, coarse, medium and fine, blocky; slightly hard when dry, friable when moist, nonsticky and nonplastic when wet; noncalcareous; pH 7.6; clear, wavy boundary.

C1ca--9 to 34 inches, pale-brown (10YR 6/3) silt loam, brown (10YR 5/3) when moist; massive; slightly hard when dry, friable when moist, nonsticky and nonplastic when wet; very strongly calcareous; white lime in pockets, splotches, and seams; pH 8.6; clear, wavy boundary.

C2--34 to 48 inches, pale-brown (10YR 6/3) heavy silt loam, brown (10YR 5/3) when moist; massive; soft when dry, friable when moist, slightly sticky and plastic when wet; very strongly calcareous; pH 8.6; gradual boundary.

C3--48 to 65 inches, pale-brown (10YR 6/3) light silty clay loam, brown (10YR 5/3) when moist; massive; soft when dry, friable when moist, sticky and plastic when wet; very strongly calcareous; pH 8.6.

The A1 horizon ranges from 3 to 8 inches in thickness. It ranges from 10YR to 2.5Y in hue and is 5 or 6 in value when dry and 3 or 4 when moist. The B2 horizon ranges from silt loam to heavy silt loam. It ranges from 10YR to 2.5Y in hue, is 4 or 5 in value when dry, and is 2 or 3 in chroma. The Cca horizon has segregated lime in splotches and threads. The solum ranges from 9 to 12 inches in thickness and the Cca horizon ranges from 20 to 26 inches. The Cca horizon rests on loamy stratified material in places.

McRae silt loam, 0 to 2 percent slopes (Mc).--This soil is on fan terraces and stream terraces. It formed in silt loam alluvium that is more than 5 feet deep and has the profile described as typical for the series. Included with this soil in mapping are areas of Heldt and Fort Collins soils less than 5 acres in size.

Runoff is slow and permeability is moderate. The available water capacity is 10 to 12 inches for a 5-foot depth. Organic-matter content is medium and fertility is high. The hazard of erosion is slight.

This soil is used mainly for range and irrigated small grains. Some alfalfa is grown for hay and seed. Alfalfa hay, wheat, barley, and oats grow well on irrigated soil. (Capability unit IIIc-1, dryland; range-soil group 4; windbreak suitability group 2)

McRae silt loam, 2 to 4 percent slopes (Md).--Except for stronger slopes, this soil is similar to McRae silt loam, 0 to 2 percent slopes. Runoff is slow to medium, and the hazard of soil blowing is moderate. Included with this soil in mapping are areas of Hesper, Fort Collins, and Heldt soils less than 5 acres in size.

This soil is used mainly for range and for small grains. Some alfalfa is grown for hay and seed. (Capability unit IIIe-1, dryland; range-soil group 4; windbreak suitability group 2)

McRae silt loam, 4 to 8 percent slopes (Me).--Except for stronger slopes and thicker deposits of alluvium, this soil is similar to McRae silt loam, 0 to 2 percent slopes. Runoff is medium and the erosion hazard is moderate. This soil occurs on fans and foot slopes. Included with this soil in mapping are areas of Hesper, Fort Collins, and Heldt soils less than 5 acres in size.

This soil is used mostly for range. Some areas are used for dryfarmed small grains and hay. (Capability unit IIIe-1, dryland; range-soil group 4; windbreak suitability group 2)

Midway Series

The Midway series consists of well-drained, moderately fine textured soils that are underlain by shale, generally at a depth of less than 20 inches. These soils are on uplands under a cover of short grasses. Slopes are 2 to 75 percent, and elevation ranges from 3,000 to 4,000 feet. The average annual precipitation is about 12 inches, and the average annual soil temperature is 47 to 49° F., and the frost-free season is 100 to 120 days. These soils are associated with Elso, Kyle, Thurlow, and Ocean Lake soils.

Typically the surface layer is light yellowish-brown clay loam and clay 7 inches thick. The substratum is light brownish-gray interbedded silty, clayey, and sandy material underlain by softly consolidated pale-olive clayey shale at a depth of 7 to 20 inches. Salt and gypsum crystals are interbedded between the shale layers below a depth of 10 inches.

Midway soils are used primarily for range.

Typical profile of silty clay loam, 2 to 8 percent slopes, 300 feet east of N1/4 corner of sec. 23, T. 3 S., R. 49 E.:

A1--0 to 3 inches, light yellowish-brown (2.5Y 6/4) clay loam, light olive brown (2.5Y 5/4) when moist; weak, thin, platy structure that separates to fine granular structure; soft when dry, friable when moist, sticky and plastic when wet; strongly calcareous; pH 8.4; gradual boundary.

AC--3 to 7 inches, light yellowish-brown (2.5Y 6/4) light clay, light olive brown (2.5Y 5/4) when moist; massive; thin platy silty clay loam and clay loam shale fragments; sticky and plastic when wet; strongly calcareous; pH 8.0; abrupt boundary.

C1--7 to 14 inches, light brownish-gray (2.5Y 6/2) interbedded silty, clayey, and sandy shale, light olive brown (2.5Y 5/6 and 5Y 5/3)when moist; mottled with light gray (2.5Y 7/2); masses of gypsum crystals between thin shale plates; strongly calcareous; pH 8.0; abrupt boundary.

C2--14 inches, pale-olive (5Y 6/3) interbedded silty and clayey shale that has gypsum crystals between shale plates at varying depths; shale is mottled with black, yellowish, and brownish colors; strongly calcareous.

The A horizon ranges from clay loam or silty clay loam to light clay or light silty clay. It ranges from 10YR to 2.5Y in hue, is 5 or 6 in value when dry, and 4 or 5 when moist, and ranges from 2 to 4 in chroma. The depth to shale ranges from 7 to 20 inches. The shale is silty, sandy, and clayey. In places segregated lime occurs in the AC horizon, and abundant gypsum crystals are between the shale plates at a depth of 10 to 14 inches.

Midway silty clay loam, 2 to 8 percent slopes (Mf).--This soil occurs on divides and ridges of the uplands. It has the profile described as typical for the series. Included with this soil in mapping are areas of Elso, Ocean Lake, and Thurlow soils less than 5 acres in size.

This soil is slowly permeable, and at depths of more than 2 feet, roots penetrate only through

fractures in the shale. This soil is low in organic-matter content and fertility. The available water capacity is 1 to 3 inches, and runoff is slow to medium. The erosion hazard is slight to moderate.

This soil is used for range. (Capability unit VIe-2; range-soil group 5)

Midway-Elso association, 8 to 35 percent slopes (Mg).--This association is made up of Midway clay loam and Elso silt loam. In most places, the Midway soil occupies the lower foot slopes and valley sides and the Elso soil occupies the narrow divides, ridgetops, knolls, and upper part of the valley sides. The valley sides are cut by numerous gullies that join to form larger drainageways. These gullies are 50 to 100 feet apart at their widest spacing, and between them is 1 to 15 acres of soils that are smooth and gently sloping. These soils normally are in the Thurlow, Cushman, and Fort Collins series. Typically this association is about 60 percent Midway soils, 30 percent Elso soils, and 10 percent other soils. Midway and Elso soils have profiles similar to those described as typical for their series. Permeability is slow in Midway soils and moderate in Elso soils. Runoff is medium to rapid, and the erosion hazard is moderate to severe. Where gully erosion is active, broken slopes and shale exposures are common.

The soils in this association are too steep and too shallow for cultivation. They are used for range. (Capability unit VIIe-1; range-soil group is 8 for Midway soil and 7 for Elso soil)

Midway and Elso rocky soils, 35 to 75 percent slopes (Mw).--This association consists of Midway rocky clay loam, Elso rocky silt loam, and exposures of silty, clayey, and sandy shale and sandstone. The dominant feature is the large amount of shale and sandstone that crops out along the deeply entrenched gullies and from very steep south-facing slopes.

Some valley bottoms are only 10 to 25 feet wide. They have barren, almost vertical sides and isolated stream terraces less than 5 acres in size. Midway soils are almost half way up the slope and at the lower part of the slope. Elso soils occupy part of the slopes and narrow ridges, tabular divides, and knobs. These rocky soils and shale exposures are on the very steep south-facing slopes, and ledges of sandstone rock outcrop are on the north-facing slopes. Numerous lignite seams can be seen in the shale exposures. The small smooth valley slopes normally are remnants of deeper soils. Typically this mapping unit is about 75 percent rocky Midway and Elso soils and 25 percent rock outcrop.

These soils are low in organic-matter content and fertility. They are well drained and have moderate to slow permeability. Because of the barren shale areas and very steep slopes, runoff is very rapid. The erosion hazard is severe, and gullies are numerous and deep.

This mapping unit is used for range. (Capability unit VIIe-1 for Midway and Elso soils, VIIIs-2 for rock outcrop; range-soil group 12 for Midway and Elso soils; rock outcrop unsuited)

Midway-Rock land association, 15 to 35 percent slopes (Mr).--This mapping unit consists of Midway silty clay loam and Rock land that occur on narrow ridges, tabular divides, and steep buttes covered with slabs of sandstone. The Midway soils are on the middle of slopes and shale ridges, generally below the Ocean Lake soils. Included with this unit in mapping are small areas of Vona, Remmit, and Cushman soils on isolated foot slopes, fans, and ridgetops. These included soils are in areas less than 15 acres in size. They are deeper than the Midway soils. Typically this association is about 60 percent Midway soils and 40 percent Rock land. The Rock land consists of the remains of receding sandstone cliffs, and in some places slabs of sandstone cover more than 95 percent of the area.

This association is used for range. (Capability unit VIIe-1 for Midway soil and VIIIs-2 for Rock land; range-soil group 8 for Midway soil but Rock land not suited as range)

Midway-Thurlow association, 8 to 15 percent slopes (Mt).--This mapping unit consists of Midway clay loam and Thurlow silty clay loam on smooth foot slopes and divides in the uplands. Midway clay loam occupies the rounded convex ridges, divides, and gully side slopes; Thurlow silty clay loam occupies the foot slopes and remnants of alluvial fans between the gullies. Typically this association is about 55 percent Midway and 45 percent Thurlow soils.

Permeability is moderately slow to slow, and runoff is medium. The hazard of erosion is moderate.

Included with these soils in mapping are areas of Fort Collins, Cushman, and Elso soils less than 5 acres in size. Also included, at the heads of drainageways and on ridgetops, are areas of Arvada and Bone soils less than 2 acres in size.

The soils of this association are used primarily for range. (Capability unit VIe-2 for Midway soil, IVe-1, dryland for Thurlow soil; range-soil group 5 for both kinds of soil; windbreak suitability group 2 for Thurlow soil but not assigned for Midway soil)

Nihill Series

The Nihill series consists of well-drained soils on uplands. These soils formed in very gravelly loam alluvium on old stream terraces. The native vegetation is mid and short grasses. Slopes are 8 to 15 percent, and elevation ranges from 3,500 to 3,900 feet. The annual precipitation is 10 to 14 inches, the average annual soil temperature is 47 to 49° F., and the frost-free season is 100 to 120 days. These soils are associated with Elso soils.

Typically the surface layer is grayish-brown gravelly loam about 8 inches thick. The subsoil and substratum are pale-brown very gravelly loam that extends to a depth of 60 inches and is over

softly consolidated sandstone or shale.

Nihill soils are used mostly for range.

Typical profile of Nihill gravelly loam that has 8 to 15 percent slopes, 700 feet south of N1/4 corner of sec. 6, T. 4 S., R. 48 E.:

A1--0 to 8 inches, grayish-brown (7.5YR 5/2) gravelly loam, dark grayish brown (7.5YR 4/2) when moist; moderate, coarse, granular structure; soft when dry, friable when moist, nonsticky and nonplastic when wet; mildly calcareous; pH 8.2; small pebbles and coarse sand are coated with lime and are 2 percent of horizon, by volume; abrupt boundary.

C1ca--8 to 35 inches, pale-brown (10YR 6/3) very gravelly loam, brown (10YR 5/3) when moist; many white and very pale-brown (10YR 8/2 and 8/3) mottles, light brownish gray (10YR 6/2) when moist; moderate, coarse, granular structure; soft when dry, friable when moist, nonsticky and nonplastic when wet; very strongly calcareous; pH 8.4; roots are mottled in the upper part of the horizon; abrupt boundary.

C2--35 to 60 inches, pale-brown (10YR 6/3) very gravelly loam, brown (10YR 5/3) when moist; mottled with white and pale brown (10YR 8/2 and 8/3) when dry and with brownish gray (10YR 6/2) when moist; massive; increased fine and coarse sand, small pebbles, and cobbles; very strongly calcareous; lime coats on gravel; pH 8.4; gradual boundary.

C3--60 inches, softly consolidated sandstone or shale beds.

The A1 horizon ranges from 4 to 10 inches in thickness. It is as yellow as 2.5Y in hue, is 5 or 6 in value when dry and 4 or 5 when moist.

Nihill-Elso association, 8 to 15 percent slopes (Nh).--This association is made up of about 60 percent Nihill gravelly loam and 40 percent Elso gravelly silt loam. These strongly sloping and rolling soils occur on smooth rounded uplands. The soils are remnants of deep gravelly loam alluvium mantles on old high terraces. The Nihill soils are on smooth, rounded ridge crests; the Elso soils are on smooth convex side slopes and smooth foot slopes and in swales. Included with these soils in mapping are areas of McRae, Fort Collins, and Hesper soils less than 5 acres in size.

The soils of this unit are well drained to somewhat excessively drained. The Nihill soils are moderately rapid in permeability. Elso soils are moderately permeable in the upper 24 inches. The available water capacity of Nihill soils is about 5 inches for a 5-foot depth. Runoff is medium, fertility is low, and the hazard of erosion is moderate for these soils.

These soils are used mainly for range. (Capability unit VIe-3 for Nihill soils and VIe-2 for Elso soils; range-soil group 4 for both kinds of soil)

Ocean Lake Series

The Ocean Lake series consists of well-drained fine sandy loam soils less than 20 inches deep over softly consolidated sandstone on uplands. These soils formed under mid and short grasses. Slopes are 15 to 45 percent, and elevation ranges from 3,000 to 3,500 feet. The annual precipitation is about 12 inches, the average annual soil temperature is 47 to 49° F., and the frost-free season is 115 to 120 days. These soils are associated with Remmit, Vona, Elso, and Midway soils.

Typically the surface layer is grayish-brown and light brownish-gray fine sandy loam about 8 inches thick. The subsoil is light-gray fine sand that extends to a depth of about 15 inches. The substratum is softly consolidated sandstone that contains seams and splotches of segregated lime. The sandstone is easy to dig, but it is impenetrable to roots when dry. Roots penetrate the surface layers readily, but they penetrate the sandstone only through fractures.

The Ocean Lake soils are used mainly for range.

Typical profile of grass-covered Ocean Lake fine sandy loam that has 15 to 45 percent slopes, 800 feet north and 400 feet east of the SW. corner of sec. 14, T. 3 S., R. 51 E.:

A1--0 to 5 inches, grayish-brown (10YR 5/2) fine sandy loam, dark grayish brown (10YR 4/2) when moist; weak, fine, granular structure; soft when dry, friable when moist, nonsticky and nonplastic when wet; noncalcareous; pH 7.5; abundant roots; gradual boundary.

AC--5 to 8 inches, light brownish-gray (2.5Y 6/2) fine sandy loam, grayish brown (2.5Y 5/2) when moist; weak, fine, granular structure; soft when dry, very friable when moist, nonsticky and nonplastic when wet; strongly calcareous; pH 7.4; clear boundary.

IIC1--8 to 15 inches, light-gray (2.5Y 7/2) fine sand, light brownish gray (2.5Y 6/2) when moist; massive; slightly hard when dry, very friable when moist, nonsticky and nonplastic when wet; noncalcareous; few seams and splotches of lime; roots penetrate horizon; pH 7.4; gradual boundary.

IIC2--15 inches, light-gray (2.5Y 7/2) softly consolidated sandstone beds, light brownish gray (2.5Y 6/2) when moist; noncalcareous; few seams and splotches of lime; matted roots in fractures of bedded sandstone; roots do not penetrate the sandstone mass except through fractures; sandstone is easily dug out and disintegrates when exposed to air.

The A horizon varies from 4 to 12 inches in thickness. Color values are 5 or 6 when dry and 4 or 5 when moist. The IIC2 horizon has prominent fine mottles in some places. Depth to shale or soft sandstone ranges from 8 to 20 inches.

Ocean Lake-Rock land association, 15 to 45 percent slopes (Oc).--This association is made up of about 65 percent Ocean Lake fine sandy loam and 35 percent Rock land. The Ocean Lake soils are on ridgetops and foot slopes and on small isolated benches between the sandstone ledges on talus slopes. The Rock land occurs as ledges, outcrops, and huge sandstone boulders (see plate). Included with this association in mapping are areas of Vona, Remmit, and Midway soils less than 10 acres in size.

Ocean Lake soil has medium to rapid runoff and rapid permeability. The available water capacity is 1 to 2 inches. This soil is low in fertility and organic-matter content. The erosion hazard is severe to very severe.

This association is used mainly for range. (Capability unit VIIe-3 for Ocean Lake soils and VIIIs-2 for Rock land; range-soil group 6 for Ocean Lake soils and not assigned for Rock land)

Rapelje Series

The Rapelje series consists of well-drained silt loam soils that are more than 5 feet deep. These soils formed in deep silty materials on high terraces, foot slopes, and basins. The native vegetation is mid and short grasses. Slopes are 0 to 8 percent, and elevation ranges from 3,000 to 4,000 feet. The annual precipitation is about 16 inches, the average annual soil temperature is 45 to 47° F., and the frost-free season is about 100 days. These soils are associated with Farland and Fergus soils.

Typically the surface layer is light brownish-gray silt loam about 8 inches thick. The subsoil is dark grayish-brown and pale-brown silty clay loam. Gypsum and salt crystals are common in the lower part of the subsoil. The substratum is light-gray silt loam and fine sandy loam that extends to a depth of 60 inches or more.

The Rapelje soils are used mainly for range. A small acreage is used for small grains and hay.

Typical profile of Rapelje silt loam, 0 to 2 percent slopes, 1,320 feet E. and 600 feet N. of west quarter corner sec. 21, T. 7 S., R. 47 E.:

A2--0 to 5 inches, silt loam that is light brownish gray (10YR 6/2) on top of plates and grayish brown (10YR 5/2) on bottom of plates; very dark grayish brown (10YR 3/2) when moist; weak, thin, platy structure; soft when dry, friable when moist, nonsticky and nonplastic when wet; many clean unstained silt grains; noncalcareous; pH 6.5; clear boundary.

A&B--5 to 8 inches, silty clay loam that is light brownish gray (10YR 6/2) on top of peds and dark grayish brown (10YR 4/2) on interior of peds, dark brown (10YR 3/3) when moist; moderate, fine, blocky structure; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; patchy distinct clay films on peds; noncalcareous; pH 6.5; many clear sand grains on upper faces; clear boundary.

B2t--8 to 18 inches, dark grayish-brown (10YR 4/2) silty clay loam, same color when moist; strong, medium, blocky structure; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; patchy distinct clay films on peds; noncalcareous; pH 7.0; few nests of gypsum crystals; clear boundary.

B3cs--18 to 26 inches, pale-brown (10YR 6/3 and 5/3) silty clay loam, brown (10YR 4/3) when moist; moderate, fine, blocky structure; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; strongly calcareous; pH 8.2; common seams of gypsum crystals; gradual boundary.

C1ca--26 to 43 inches, light-gray (10YR 7/2) silt loam, grayish brown (10YR 5/2) when moist; massive; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; strongly calcareous; few seams of lime; pH 8.0; gradual boundary.

IIC2--43 to 60 inches, light-gray (10YR 7/2) fine sandy loam, brown (10YR 5/3) when moist; massive; soft when dry, friable when moist; strongly calcareous; pH 8.0.

The A2 horizon ranges from 2 to 12 inches in thickness, and the transitional A&B horizon ranges from 2 to 4 inches. The A horizon ranges from 10YR to 2.5Y in hue and is 5 or 6 in value when dry and 5 when moist. The B2t horizon is silt loam or silty clay loam 10 to 15 inches thick. The B3 horizon has a few nests of gypsum crystals in places. Where present, the Cca and Ccs horizons range from 8 to 17 inches in thickness and have many nests of gypsum crystals.

Rapelje silt loam, 0 to 2 percent slopes (Ra).--This soil is on terraces, fans, and foot slopes. It has the profile described as typical for the series. Included with this soil in mapping are areas of Farland and Fergus soils less than 5 acres in size.

This soil has slow runoff and moderately slow permeability. The available water capacity is 9 to 11 inches for a 5-foot depth. Organic-matter content and fertility are medium. The erosion hazard is slight.

This soil is used mostly for range. Some areas are used for dryfarmed small grains and alfalfa grown for hay and seed. (Capability unit IIIc-1, dryland; range-soil group 3; windbreak suitability group 4)

Rapelje silt loam, 2 to 8 percent slopes (Rc).--This soil is on foot slopes and fans. Except for stronger slopes, it is similar to Rapelje silt loam, 0 to 2 percent slopes. Runoff is slow to medium and the erosion hazard is slight to moderate.

This soil is used for range. (Capability unit IIIe-1, dryland; range-soil group 3; windbreak suitability group 4)

Relan Series

The Relan series consists of well-drained, medium-textured soils that are more than 60 inches deep. These soils formed in loamy alluvium on fans, foot slopes, and swales. The native vegetation is mainly western wheatgrass, green needlegrass, bluegrass, blue grama, and needle-and-thread. Slopes are 4 to 30 percent, and elevation ranges from 3,000 to 4,000 feet. The annual precipitation is 15 to 19 inches, the average annual soil temperature is 45 to 47° F., and the frost-free season is 90 to 100 days. These soils are associated with Fergus and Ringling soils.

Typically the surface layer is brown loam about 8 inches thick. The subsoil is dark-brown loam about 5 inches thick. The substratum, which extends to a depth of 60 inches or more, is pinkish-gray, calcareous light loam and fine sandy loam. Porcelanite chips occur throughout the profile.

Relan soils are used mainly for range. Small areas are used for dryfarmed small grains and alfalfa.

Typical profile of Relan loam, 4 to 8 percent slopes, 1,200 feet north and 800 feet west of the SE. corner of sec. 12, T. 4 S., R. 50 E.:

A1--0 to 8 inches, brown (7.5YR 5/2) loam, dark brown (7.5YR 3/2) when moist; weak, fine, granular structure; soft when dry, friable when moist, nonsticky and nonplastic when wet; noncalcareous; pH 7.4; numerous porcelanite fragments; gradual boundary.

B2--8 to 13 inches, dark-brown (7.5YR 5/2) loam, dark brown (7.5YR 3/3) when moist; weak, fine and medium, blocky structure that separates to weak, fine, crumb; soft when dry, friable when moist, nonsticky and nonplastic when wet; noncalcareous; pH 7.6; numerous fine porcelanite pebbles; clear, wavy boundary.

C1ca--13 to 26 inches, pinkish-gray (7.5YR 6/2) light loam, light brown (7.5YR 6/4) when moist; massive; slightly hard when dry, friable when moist, nonsticky and nonplastic when wet; strongly calcareous; few threads of lime; pH 8.4; numerous fine porcelanite pebbles; gradual boundary.

C2--26 to 30 inches, pinkish-gray (7.5Y 6/2) fine sandy loam, light brown (7.5YR 4/4) when moist; soft when dry, very friable when moist, nonsticky and nonplastic when wet; strongly calcareous; pH 8.4; numerous fine porcelanite chips and pebbles that are lime-coated on under sides; approximately 15 percent gravel, by volume; gradual boundary.

C3--30 to 60 inches, pinkish-gray (7.5YR 6/2) gravelly light loam, light brown (7.5YR 4/4) when moist; massive; 30 percent gravel, by volume; soft when dry, very friable when moist, nonsticky and nonplastic when wet; strongly calcareous; pH 8.6.

The A horizon ranges from 4 to 8 inches in thickness. It ranges from 7.5YR to 2.5YR in hue, is 4 or 5 in value when dry, and is 2 or 3 in chroma. The A horizon ranges from fine sandy loam to silt loam. Porcelanite fragments 1/4 to 1/2 inch in size, are less than 20 percent of the A horizon, by volume. The B2 horizon ranges from weak crumb or granular structure to very weak, fine and medium, blocky structure. It ranges from 5 to 15 inches in thickness and from loam to light clay loam in texture. It is 4 or 5 in value when dry and is 2 or 3 in chroma. Patches of thin clay films occur. Porcelanite fragments in the B2 horizon range from 5 to 25 percent, by volume.

The Cca horizon has common pockets of lime threads and seams. Porcelanite shale fragments less than 1 inch in diameter range from few to 35 percent in the Cca horizon. This Cca horizon is silt loam, fine sandy loam, loam, and slaty loam. The C2 and C3 horizons have approximately 15 to 35 percent small pebbles of porcelanite shale. The underlying material is stratified layers or loose porcelanite shale beds that are at a depth of 30 inches to more than 5 feet. The percentage of porcelanite fragments increases with increasing depth.

Relan loam, 4 to 8 percent slopes (Re).--This soil is on smooth foot slopes, fans, and swales. It has the profile described as typical for the series. Included with this soil in mapping are areas of Fergus and Ringling soils less than 5 acres in size.

Runoff is slow to medium, and permeability is moderate. The available water capacity is 7 to 9 inches for a 5-foot depth. Organic-matter content and fertility are medium. The erosion hazard is slight to moderate.

This soil is used mainly for range. Small areas are used for dryfarmed small grains and alfalfa. (Capability unit IIIe-3, dryland; range-soil group 3; windbreak suitability group 1)

Relan association, 5 to 30 percent slopes (Rf).--This association of soils on uplands is made up of about 70 percent Relan loam and 30 percent Ringling slaty loam. The Relan soils occupy the broad swales, flats, and side slopes; Ringling soils are on the knobs and narrow ridges. The Ringling soils are commonly capped by clinkers of molten shale 2 to 5 feet in diameter. In some places smaller clinkers are strewn over the surface of the Relan soils and make cultivation difficult. Runoff is medium to rapid, and the erosion hazard is moderate to severe.

Included with these soils in mapping are small, nearly level, undrained basins. Also included are areas of Rapelje, Farland, and Fergus soils less than 5 acres in size.

The soils of this association are used mainly for range. (Capability unit VIe-1; range-soil group 3;

Relan-Cabba association, 4 to 8 percent slopes (Rh).--This association is made up of about 60

percent Relan loam and 40 percent Cabba silt loam. The Relan soils occupy foot slopes, swales, and fans; Cabba soils are on smooth, rounded knobs and ridges. Runoff is slow to medium, and the erosion hazard is slight to moderate. Included with these soils in mapping are areas of Fergus, Farland, and Ringling soils less than 5 acres in size.

The soils of this association are used mainly for range. Small areas are used for small grains and alfalfa. (Capability unit IIIe-3, dryland, for Relan soils and IVe-2, dryland, for Cabba soils; range-soil group 3 for Relan soils and 7 for Cabba soils; windbreak suitability group 1 for Relan soils and not assigned for Cabba soils)

Relan Series, Gravelly Variant

The gravelly variant from the Relan series consists of well-drained, medium-textured soils on alluvial fans and terraces. These soils formed in gravelly loam alluvium under mid and short grasses. Slopes are 4 to 8 percent, and elevation ranges from 3,000 to 3,200 feet. The annual precipitation ranges from 15 to 19 inches, the average annual soil temperature is 45 to 47° F., and the frost-free season is about 100 days. These soils are associated with Fergus soils.

Typically the surface layer and upper part of the subsoil are brown gravelly loam that extends to a depth of about 20 inches. The lower part of the subsoil and the substratum are light-brown, stratified gravelly loam and very gravelly sandy loam to a depth of more than 60 inches.

The Relan gravelly variant is used mostly for range.

Typical profile of Relan gravelly loam, gravelly variant, 4 to 8 percent slopes, 300 feet north and 2,640 feet east of the SW. corner of sec. 20, T. 3 S., R. 45 E.:

A1--0 to 3 inches, brown (7.5YR 5/2) gravelly loam, dark brown (7.5YR 3/2) when moist; weak, thin, platy structure that separates to weak, fine, granular; soft when dry, friable when moist, nonsticky and nonplastic when wet; mildly calcareous; pH 7.4; abrupt boundary.

B2--3 to 14 inches, brown (7.5YR 5/2) gravelly heavy loam, dark brown (7.5YR 3/2) when moist; moderate, medium and fine, blocky structure; soft when dry, friable when moist, nonsticky and nonplastic when wet; strongly calcareous; pH 7.8; clear boundary.

C1--14 to 20 inches, brown (7.5YR 5/4) gravelly loam, dark brown (7.5YR 3/4) when moist; massive; soft when dry, very friable when moist, nonsticky and nonplastic when wet; 5 percent, by volume, is flat porcelanite chips and 1 percent, by volume, is pebbles 2 1/2 to 3 inches in size; strongly calcareous; lime coatings on pebbles; pH 8.2; clear boundary.

C2--20 to 60 inches, light-brown (7.5YR 6/4) very gravelly sandy loam, dark brown (7.5YR 4/4) when moist; massive; soft when dry, very friable when moist, nonsticky and nonplastic when wet; very strongly calcareous; pH 8.8.

Some areas have many large clinker stones on the surface. The A horizon ranges from 7.5YR to 2.5YR in hue, is 5 or 6 in value when dry, and is 2 to 4 in chroma. The C horizon ranges from 7.5YR to 2.5YR in hue, is 5 or 6 in value, and ranges from 2 to 4 in chroma. The C2 horizon is sandy loam or loam. It is more than 35 percent coarse fragments.

Relan gravelly loam, gravelly variant, 4 to 8 percent slopes (Rk).--This soil occurs on alluvial fans and terraces in the valley of Otter Creek. Slopes are short and dominantly 6 percent. On narrow terraces this soil is underlain by very gravelly loam or coarse sand at a depth of more than 48 inches. Included with this soil in mapping are areas of Relan and Fergus soils less than 5 acres in size.

Runoff is medium and permeability is rapid. The available water capacity is about 4 to 6 inches for a 5-foot depth. Organic-matter content and fertility are low. The erosion hazard is slight.

This soil is used mainly for range. It is fairly well suited to small grains and alfalfa grown for seed or hay. (Capability unit IIIe-3, dryland; range-soil group 3; windbreak suitability group 1)

Remmit Series

The Remmit series consists of well-drained soils that formed in deep fine sandy loam material underlain by softly consolidated shale beds. The native vegetation is mid and short grasses. Slopes are 2 to 25 percent, and elevation ranges from 3,000 to 4,000 feet. The annual precipitation is 10 to 15 inches, the average annual soil temperature is 47 to 49° F., and the frost-free season is 100 to 120 days. These soils are associated with Vona and Ocean Lake soils.

Typically the surface layer is grayish-brown fine sandy loam about 12 inches thick. The subsoil is grayish-brown and light olive-brown fine sandy loam about 44 inches thick. The substratum is grayish-brown silt loam that contains threads and seams of lime.

This soil is used mostly for range. Some areas are used for dryfarmed small grains and alfalfa.

Typical profile of Remmit fine sandy loam, 2 to 4 percent slopes, 1,100 feet south and 1,300 feet east of the NE. corner of section 25, T. 2 S., R. 50 E.:

A11--0 to 4 inches, grayish-brown (10YR 5/2) fine sandy loam, dark grayish brown (10YR 4/2) when moist; weak crumb structure; soft when dry, very friable when moist, nonsticky and nonplastic when wet; noncalcareous; pH 7.3; abundant roots; gradual boundary.

A12--4 to 12 inches, grayish-brown (10YR 5/2) fine sandy loam, dark grayish brown (10YR 4/2) when moist; weak, very fine, crumb structure; soft when dry, very friable when moist, nonsticky and nonplastic when wet; noncalcareous; pH 7.4; abundant roots; gradual boundary.

B2--12 to 24 inches, grayish-brown (2.5Y 5/2) fine sandy loam, dark grayish brown (2.5Y 4/2) when moist; soft when dry, very friable when moist, nonsticky and nonplastic when wet; noncalcareous; pH 7.5; few roots; gradual boundary.

C1--24 to 44 inches, light olive-brown (2.5Y 4/2) fine sandy loam, olive brown (2.5Y 4/4) when moist; massive; slightly hard when dry, friable when moist, nonsticky and nonplastic when wet; numerous small sandstone and siltstone fragments; mildly calcareous; pH 8.4; abrupt boundary.

IIC2--44 to 62 inches, grayish-brown (2.5Y 5/2) heavy silt loam, dark grayish brown (2.5Y 4/2) when moist; mottled with white (2.5Y 8/2) lime, light brownish gray (2.5Y 5/2) when moist; massive; slightly hard when dry, friable when moist; slightly sticky and slightly plastic when wet; moderately calcareous; pH 9.0; threads of lime and lime through mass.

The A horizon ranges from 10 to 15 inches in thickness and from fine sandy loam to loamy fine sand in texture. It is 10YR in hue and 5 or 6 in value when dry. The B horizon ranges from 10YR to 2.5Y in hue and is 5 or 6 in value when dry and 4 or 5 when moist. It has weak to moderate prismatic structure. The C horizon is calcareous and has segregations of lime in some places. The soil color lightens considerably as depth increases.

Remmit fine sandy loam, 2 to 4 percent slopes (Rm).--This soil is on foot slopes and fan terraces in the uplands. It is underlain by sandy shale at a depth of more than 60 inches and has the profile described as typical for the series. Included with this soil in mapping are areas of Vona, Ocean Lake, and McRae soils less than 5 acres in size.

Runoff is slow and permeability is moderate. The available water capacity is about 8 to 10 inches for a 5-foot depth. Organic-matter content and fertility are medium. The hazard of water erosion is slight.

This soil is used mainly for range. Some areas are used for dryfarmed small grains and alfalfa. (Capability unit IIIe-4, dryland; range-soil group 2; windbreak suitability group 2)

Remmit fine sandy loam, 4 to 8 percent slopes (Rn).--Except for stronger slopes, this soil is similar to Remmit fine sandy loam, 0 to 2 percent slopes. Runoff is slow to medium, and the erosion hazard is slight to moderate. Included with this soil in mapping are areas of Vona, Ocean Lake, and McRae soils less than 5 acres in size.

This soil is used for range and for dryfarmed small grains and alfalfa. (Capability unit IVe-4, dryland; range-soil group 2; windbreak suitability group 2)

Remmit-Ocean Lake fine sandy loams, 8 to 25 percent slopes (Ro).--This complex of soils on smooth uplands is made up of about 65 percent Remmit fine sandy loam and 35 percent Ocean Lake fine sandy loam. The Remmit soils occupy short foot slopes and swales, and the Ocean Lake soils are on convex ridgetops. Runoff is medium to rapid, and the erosion hazard is moderate to severe. Included with these soils in mapping are areas of Fort Collins, Cushman, and Elso soils of less than 15 acres in size.

The soils of this complex are used for range. (Both soils in capability unit VIe-3 and range-soil group 2; windbreak suitability group 2 for Remmit soils and not assigned for Ocean Lake soils)

Ringling Series

The Ringling series consists of well-drained loamy soils less than 20 inches deep over porcelainite shale beds. The native vegetation is mid grasses and sparse trees. Slopes are 6 to 50 percent, and elevation ranges from 3,500 to 4,500 feet. The annual precipitation is 15 to 19 inches, the average annual soil temperature is 45 to 47° F., and the frost-free season is 90 to 100 days. These soils are associated with Relan, Fergus, and Cabba soils.

Typically the surface layer is weak-red slaty loam about 16 inches thick. The substratum is shattered porcelanite shale.

The Ringling soils are used mostly for range.

Typical profile of Ringling slaty loam, 20 to 50 percent slopes, 1,600 feet east and 600 feet north of SW. corner of section 11, T. 3 S., R. 50 E.:

A1--0 to 9 inches, weak-red (2.5YR 5/2) slaty loam, dusky red (2.5YR 3/2) when moist; moderate, fine, granular structure; soft when dry, friable when moist, nonsticky and nonplastic when wet; noncalcareous; pH 7.6; 30 percent porcelanite shale fragments 1/4 to 1 inch in size; abrupt boundary.

AC--9 to 16 inches, pale-red (2.5YR 6/2) very slaty loam, weak red (2.5Y 5/2) when moist; 85 percent porcelanite shale fragments 1 inch to 3 inches in size; strongly calcareous; pH 8.4; lime coatings on all sides of shale fragments; gradual boundary.

C1--16 to 50 inches, partly weathered reddish-brown porcelanite shale; 95 percent porcelanite fragments more than 6 inches wide; very strongly calcareous; pH 8.0; abrupt boundary.

C2--50 inches, shattered porcelanite shale; no soil.

The A1 horizon ranges from 5 to 9 inches in thickness and is slaty silt loam and slaty loam. It ranges from 2.5YR to 7.5YR in hue, is 4 or 5 in

value when dry and 2 or 3 when moist, and is 2 or 3 in chroma. Depth to bedded porcelanite containing 5 percent or less soil material ranges from 6 to 16 inches. The porcelanite in the A1 horizon ranges from 15 to 75 percent. Lime coats are common on the underside of shale fragments in the upper few inches of the porcelanite beds. Below a depth of 10 inches lime coatings completely cover the shale fragments.

Ringling slaty loam, 20 to 50 percent slopes (Rs).--This soil occurs on uplands. Included with this soil on short foot slopes, swales, and U-shaped drainageways are areas of Relan, Fergus, Farland, and Cabba soils less than 15 acres in size. Included in small forested areas are Campspass and Barvon soils that generally occupy north-facing slopes. These slopes have an 80 percent crown cover of ponderosa pine. Included on convex ridges and buttes are areas of 1 to 2 acres in size where clinkers 2 to 5 feet in diameter cover as much as 30 percent of the surface. These included soils make up about 10 percent of any mapped area.

This Ringling soil is rapidly permeable and has a high rate of water intake. Runoff is slow to medium, and the erosion hazard is slight. The available water capacity is 1 to 2 inches. Roots penetrate easily to a depth of 16 inches and can penetrate the shale beds to a depth of more than 6 feet through fractures. Organic-matter content and fertility are low.

This soil is used mainly for range. Trees grow poorly on Ringling soil, and the site index for ponderosa pine is 50. Trees for commercial use grow only on the small areas of Campspass and Barvon soils on north-facing slopes. Because ponderosa pine trees root deeply, there is no windthrow hazard. Seedling mortality is severe on Ringling soil, but there is little or no plant competition. (Capability unit VIIe-2; range-soil group 13)

Ringling-Cabba association, 15 to 50 percent slopes (Rt).--This association of soils on uplands consists of about 50 percent Ringling slaty loam and 50 percent Cabba silt loam. Runoff is slow to medium on the Ringling soils and rapid on the steep Cabba soils. Included with these soils in mapping are areas of Relan, Rapelje, Farland, and Kyle soils less than 15 acres in size. These included soils occupy short foot slopes, swales, and U-shaped drainageways. Also included are small areas of Campspass and Barvon soils on north-facing slopes.

The soils of this association are used for range. The only trees harvested commercially grow on the small isolated areas of Campspass or Barvon soils on north-facing slopes.

Trees grow poorly on Ringling and Cabba soils. The site index for ponderosa pine is 50 on Ringling soils and 45 on Cabba soils. Because ponderosa pine trees root deeply, there is no windthrow hazard. The hazard of erosion is moderate on stock trails and on road grades that have no cross-trenches and are not outshaped. Seedling mortality is severe although plant competition is slight or none. (Capability unit VIIe-2 for both types of soils; range-soil group 13 for Ringling soils and 7 for Cabba soils)

Ringling-Relan association, 6 to 25 percent slopes (Ru).--This association of soils on uplands is made up of about 50 percent Ringling slaty loam and 50 percent Relan loam. The Ringling soils occupy steep knobs, ridges, and narrow divides; the Relan soils are on lower foot slopes, swales, and drainageways. Runoff is slow to medium on these soils, and the erosion hazard is moderate. Included with these soils in mapping are small areas of Fergus and Farland soils less than 5 acres in size. Also included are areas 5 to 10 acres in size that have clinker outcrops over 30 percent of the ground surface. Clinkers 2 to 5 feet in diameter are common on the landscape and generally occur on convex slopes.

The soils of this association are used for range. Small, isolated areas of Relan soils are used for dryfarmed small grains, grasses, and alfalfa for hay and seed. (Capability unit VIIe-2 for Ringling soils and VIe-1 for Relan soils; range-soil group 13 for Ringling soils and 3 for Relan soils; windbreak suitability group 1 for Relan soils and not assigned for Ringling soils)

Riverwash

Riverwash (Rw) consists of recently deposited materials on barren sand and gravel bars on islands in channels of rivers and large streams. These bars are above water most of the year, but they are sometimes shifted by floodwaters.

Riverwash has no value for farming and is used mainly for wildlife habitat and recreational areas. It has some use as road fill material, but it contains too much silt to be suitable for use in concrete. (Capability unit VIIIw-1)

Shale Outcrop

Shale outcrop (Sl) is a miscellaneous land type consisting mostly of nearly barren shale that is exposed in buttes, cone-shaped knobs, and very steep escarpments (see plate). The shale is stratified with layers of clay, siltstone, and soft sandstone.

The buttes, cones, and escarpments may have a red-capped layer of porcelanite shale or clinker material. The red-capped buttes generally are associated with the Ringling soils.

The erosion hazard is severe on this land type, which has value only for watershed purposes and wildlife habitats. (Capability unit VIIIs-2)

Terrace Escarpments

Terrace escarpments (8 to 35 percent slopes) (Te) consists of escarpments, breaks, and ledges in very

deep loamy and clayey materials. This land type occupies smooth rounded breaks and walled drainageways 100 to 200 feet wide. In most places the drainageways are eroded by channels 4 to 6 feet deep and 10 to 20 feet wide. Runoff is rapid, and the erosion hazard is severe. Vegetation is very sparse, and many areas are barren.

This land type is used mainly for limited grazing. (Capability unit VIIe-1; range-soil group 7)

Thurlow Series

The Thurlow series consists of well-drained, moderately fine textured soils that are more than 60 inches deep. These soils formed in deep silty clay loam alluvium in stream terraces, fans, and foot slopes on the uplands. The native vegetation is mid and short grasses. Slopes are 0 to 15 percent, and elevation ranges from 3,000 to 4,000 feet. The annual precipitation is 10 to 15 inches, the average annual soil temperature is 47 to 49° F., and the frost-free season is 100 to 120 days. These soils are associated with Hesper, Fort Collins, and Heldt soils.

Typically the surface layer is grayish-brown silty clay loam about 6 inches thick. The subsoil is dark grayish-brown, light olive-brown, and pale-brown silty clay loam about 18 inches thick. The substratum is pale-brown calcareous silty clay loam and pale-yellow calcareous silty clay.

Thurlow soils are used mainly for dryfarmed and irrigated small grains and alfalfa. A small acreage is used for pasture.

Typical profile of Thurlow silty clay loam, 0 to 2 percent slopes, 880 feet south and 2,300 feet west of the NW. corner of section 22, T. 2 S., R. 50 E.:

Ap--0 to 6 inches, grayish-brown (10YR 5/2) silty clay loam, dark grayish brown (10YR 4/2) when moist; coarse platy structure that separates to fine granular; soft when dry, friable when moist, sticky and plastic when wet; noncalcareous; pH 7.0; abrupt boundary.

B21t--6 to 9 inches, dark grayish-brown (10YR 4/2) heavy silty clay loam, very dark grayish brown (10YR 3/2) when moist; weak prismatic structure that separates to moderate, medium, coarse, and fine, blocky; soft when dry, friable when moist, sticky and plastic when wet; noncalcareous; pH 7.2; moderate thick clay films; diffuse boundary.

B22t--9 to 16 inches, light olive-brown (2.5Y 5/3) heavy silty clay loam, olive brown (2.5Y 4/3) when moist; weak prismatic structure that separates to moderate, medium, coarse, and fine, blocky; soft when dry, friable when moist, sticky and plastic when wet; moderate thick clay films; noncalcareous; pH 7.8; clear, wavy boundary.

B3--16 to 24 inches, pale-brown (10YR 6/3) light silty clay loam, brown (10YR 4/3) when moist; strong, medium and coarse, blocky structure that separates to moderate, medium and fine, blocky; slightly hard when dry, friable when moist, sticky and plastic when wet; thin patchy clay films; mildly calcareous; pH 8.6; gradual boundary.

C1ca--24 to 48 inches, pale-brown (10YR 6/3) light silty clay loam, brown (10YR 4/3) when moist; massive; slightly hard when dry, friable when moist, sticky and plastic when wet; strongly calcareous; white lime in pockets, seams, and threads; pH 8.8; many small krotovinas; clear boundary.

C2--48 to 62 inches, pale-yellow (2.5Y 7/4) silty clay, light olive brown (2.5Y 5/4) when moist; massive; soft when dry, friable when moist; very sticky and very plastic when wet; strongly calcareous; white lime in specks and threads; pH 9.0.

The A horizon ranges from 4 to 8 inches in thickness. In places it has a gray vesicular crust 1/2 to 3/4 inch thick. In places the A horizon may be as yellow as 2.5Y in hue. It is 5 or 6 in value when dry and 4 or 5 when moist. The solum ranges from 20 to 24 inches in thickness, and depth to lime ranges from 20 to 28 inches. The Cca horizon has considerable segregation of lime and in places gypsum crystals occur in the lower part.

Thurlow silty clay loam, 0 to 2 percent slopes (Th).--This soil is on terraces, fans, and foot slopes. It has the profile described as typical for the series. Included with this soil in mapping are areas of Hesper, Fort Collins, and Heldt soils less than 5 acres in size.

Runoff is slow and permeability is moderately slow. The available water capacity is 9 to 11 inches for a 5-foot depth. Organic-matter content is medium, and fertility is high. The hazard of erosion is slight.

This soil is used mostly for small grains and alfalfa grown for hay and seed. A small acreage is used for range. (Capability unit IIIc-1, dryland; range-soil group 5; windbreak suitability group 2)

Thurlow silty clay loam, 2 to 4 percent slopes (Tm).--Except for stronger slopes, this soil is similar to Thurlow silty clay loam, 0 to 2 percent slopes. Runoff is slow to medium, and the erosion hazard is slight to moderate. Included with this soil in mapping are areas of Hesper, Fort Collins, and Heldt soils less than 5 acres in size.

This soil is used for small grains and alfalfa and for range. (Capability unit IIIe-1, dryland; range-soil group 5; windbreak suitability group 2)

Thurlow silty clay loam, 4 to 8 percent slopes (To).--This soil occurs on foot slopes and fans in the uplands. It is underlain by clay shale beds at a depth of more than 5 feet. Except for stronger slopes, this soil is similar to Thurlow silty clay loam, 0 to 2 percent slopes. Runoff is medium, and the erosion hazard is moderate. Included with this soil in mapping are areas of Hesper, Bew, and Heldt soils less than 5 acres in size.

This soil is used for dryfarmed small grains and alfalfa grown for hay and seed. It is also used for range. (Capability unit IIIe-1, dryland; range-soil group 5; windbreak suitability group 2)

Thurlow silty clay loam, 8 to 15 percent slopes (Tr).--This soil occupies foot slopes and fans in the uplands. It is underlain by clay shale beds at a depth of more than 5 feet. Except for stronger slopes, this soil is similar to Thurlow silty clay loam, 0 to 2 percent slopes. Runoff is medium to rapid, and the erosion hazard is moderate to severe. Included with this soil in mapping are areas of Hesper, Fort Collins, and Bew soils less than 5 acres in size.

This soil is used mainly for range. (Capability unit IVe-1, dryland; range-soil group 5; windbreak suitability group 2)

Vananda Series

The Vananda series consists of well-drained, fine-textured soils that are more than 60 inches deep. These soils formed in deep clay alluvium on stream terraces, fans, and foot slopes. The native vegetation is mainly short grasses. Slopes are 2 to 4 percent, and elevation ranges from 3,000 to 3,500 feet. The annual precipitation is 10 to 15 inches, the average annual soil temperature is 47 to 49° F., and the frost-free season is 90 to 100 days. These soils are associated with Bew and Midway soils.

Typically the surface layer is a crusted grayish-brown clay about 2 inches thick. The subsoil and substratum are brown and pale-brown clay. They extend to a depth of 60 inches or more and contain gypsum and salt crystals.

The Vananda soils are used mostly for range. A small acreage is used for dryfarmed small grains.

Typical profile of Vananda clay, that has 2 to 4 percent slopes, 200 feet south and 400 feet west of the NE. corner of section 15, T. 5 S., R. 45 E.:

A11--0 to 1/2 inch, light-gray (2.5Y 7/2) clay, light olive brown (2.5Y 5/4) when moist; thin surface crust, soft when dry, friable when moist, sticky and plastic when wet; mildly calcareous; pH 8.4; abrupt boundary.

A12--1/2 inch to 2 inches, grayish-brown (10YR 5/2) clay, dark grayish brown (10YR 4/2) when moist; strong, thin, platy structure that separates to moderate, fine, subangular blocky; soft when dry, friable when moist, sticky and plastic when wet; mildly calcareous; pH 7.9; abrupt boundary.

B2--2 to 14 inches, brown (10YR 5/3) clay, brown (10YR 4/3) when wet; moderate, medium and fine, angular blocky structure; extremely hard when dry, very firm when moist, very sticky and very plastic when wet; strongly calcareous; pH 9.0; abrupt boundary.

C1cs--14 to 26 inches, light brownish-gray (10YR 6/2) clay, dark grayish brown (10YR 4/2) when moist; white (10YR 8/2) mottles; weak, medium, angular blocky structure; very hard when dry, very firm when moist, very sticky and plastic when wet; mildly calcareous; large white pockets or nests of gypsum crystals; pH 8.4; abrupt boundary.

C2--26 to 39 inches, pale-brown (10YR 6/3) clay, brown (10YR 5/3) when moist; massive; very hard when dry, very firm when moist, very sticky and very plastic when wet; mildly calcareous; pH 9.6; gradual boundary.

C3--39 to 60 inches, pale-brown (10YR 6/3) clay, brown (10YR 5/3) when moist; massive; very hard when dry, very firm when moist, very sticky and very plastic when wet; mildly calcareous; pH more than 9.6.

The thin surface crust ranges from 1/4 to 1 inch in thickness, and granules adhere to the under surface. The A horizon is 2 to 6 inches thick and calcareous. It ranges from 10YR to 5Y in hue. Depth to gypsum crystals ranges from 14 to 16 inches. The lower C horizon ranges from 10YR to 5Y in hue.

Vananda clay (2 to 4 percent slopes) (Va).--This soil occurs on stream terraces, fans, and foot slopes. It formed in clay alluvium more than 5 feet deep. Included with this soil in mapping are areas of Bew and Midway soils less than 5 acres in size.

Runoff is slow to medium, and permeability is very slow. The available water capacity is 8 to 10 inches for a 5-foot depth. This soil has low fertility and a high alkali content. The hazard of erosion is slight to moderate.

This soil is used mostly for range. (Capability unit VIs-1; range-soil group 11; windbreak suitability group 5)

Vona Series

The Vona series consists of well-drained, moderately coarse textured soils that are more than 60 inches deep. These soils formed in deep alluvium on fans and foot slopes in the uplands. The native vegetation is short and mid grasses. Slopes are 2 to 8 percent, and elevation ranges from 3,000 to 3,500 feet. The annual precipitation is 10 to 15 inches, the average annual soil temperature is 47 to 49° F., and the frost-free season is about 100 to 120 days. These soils are associated with Remmit and Ocean Lake soils.

Typically the surface layer is grayish-brown fine sandy loam about 10 inches thick. The subsoil is grayish-brown fine sandy loam about 8 inches thick. The substratum is pale-brown and light brownish-gray calcareous fine sandy loam.

The Vona soils are used mainly for range. A small acreage is used for dryfarmed small grains and alfalfa.

Typical profile of Vona fine sandy loam, 2 to 4 percent slopes, 800 feet north and 700 feet west of the SW. corner of section 18, T. 4 S., R. 51 E.:

Ap1--0 to 6 inches, grayish-brown (10YR 5/2) fine sandy loam, dark brown (10YR 3/3) when moist; wet, fine, granular structure; soft when dry, friable when moist, nonsticky and nonplastic when wet; noncalcareous; pH 7.4; gradual boundary.

A2--6 to 10 inches, grayish-brown (10YR 5/2) fine sandy loam, brown (10YR 4/3) when moist; moderate, fine, granular structure; soft when dry, very friable when moist, nonsticky and nonplastic when wet; noncalcareous; pH 7.4; gradual boundary.

B2--10 to 18 inches, grayish-brown (10YR 5/2) fine sandy loam, brown (10YR 4/3) when moist; weak coarse, prismatic structure; soft when dry, friable when moist, nonsticky and nonplastic when wet; noncalcareous; pH 8.2; gradual boundary.

C1ca--18 to 40 inches, pale-brown (10YR 6/3) fine sandy loam, brown (10YR 5/3) when moist; massive; soft when dry, friable when moist, nonsticky and nonplastic when wet; strongly calcareous; seams, threads, and splotches of lime; pH 8.6; diffuse boundary.

C2--40 to 60 inches, light brownish-gray (10YR 6/2) fine sandy loam, dark grayish brown (10YR 4/2) when moist; massive; soft when dry, friable when moist; nonsticky and nonplastic when wet; strongly calcareous; pH 8.8.

The A horizon ranges from 5 to 14 inches in thickness. It ranges from 10YR to 2.5Y in hue, is 4 to 5 in value when dry, and is 2 or 3 in chroma. The B2 horizon ranges from 7 to 14 inches in thickness and from sandy loam to fine sandy loam in texture. In places it is yellower than 10YR in hue, is 5 or 6 in value when dry, and ranges from 4 to 6 in chroma. More clay is in the B2 horizon than in the A1 horizon. The Cca horizon ranges from sandy loam to fine sandy loam. The segregated lime in the Cca horizon ranges from few to many seams and threads.

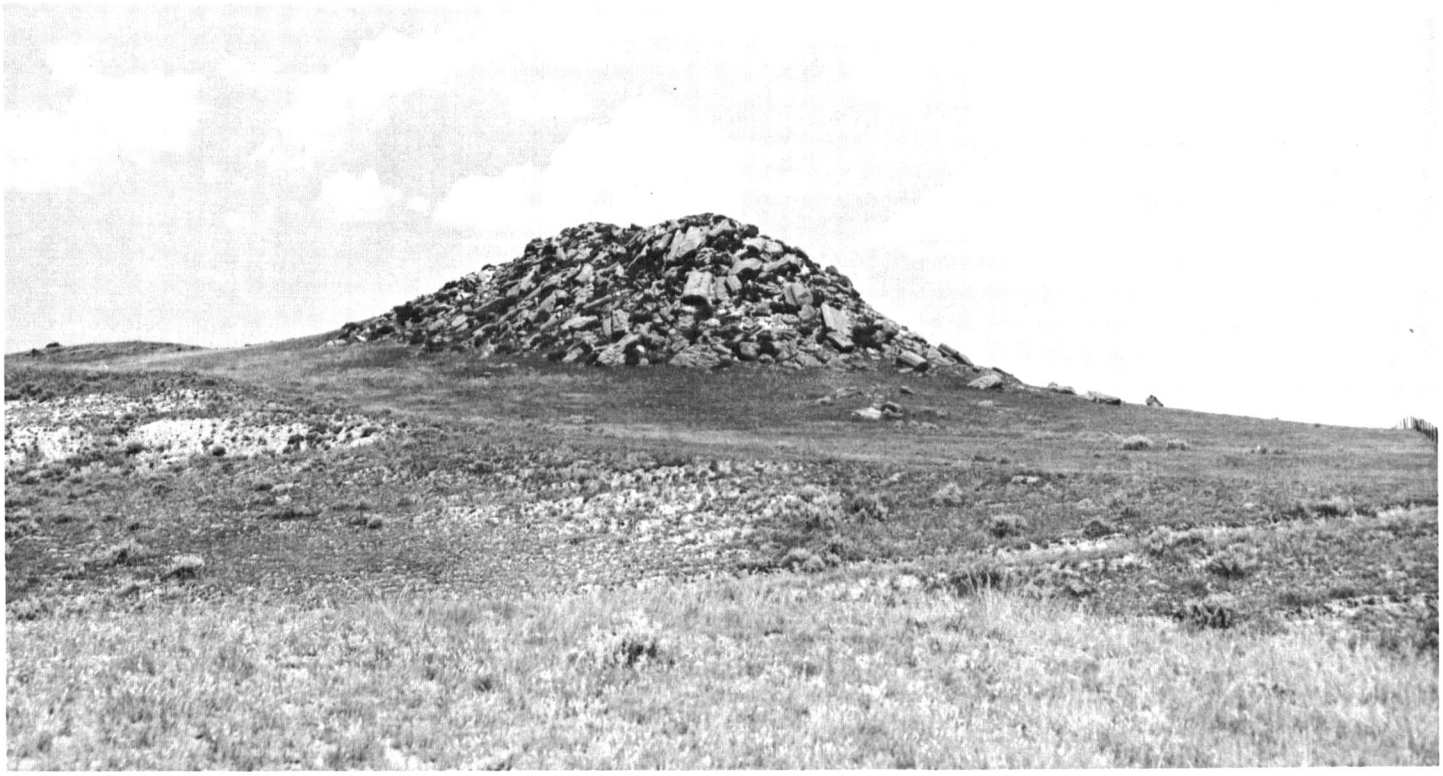
Vona fine sandy loam, 2 to 4 percent slopes (Vo).--This soil is on fans and foot slopes in the uplands. It has the profile described as typical for the series. This soil is underlain by sandy shale at a depth of more than 5 feet. Included with this soil in mapping are areas of Remmit and Ocean Lake soils less than 5 acres in size.

This soil is well drained and has moderately rapid permeability. The available water capacity is 7 to 9 inches for a 5-foot depth. Runoff is slow, and the soil is susceptible to rill and gully erosion where water concentrates on stronger slopes. The erosion hazard is slight to moderate. Organic-matter content is low, and fertility is medium.

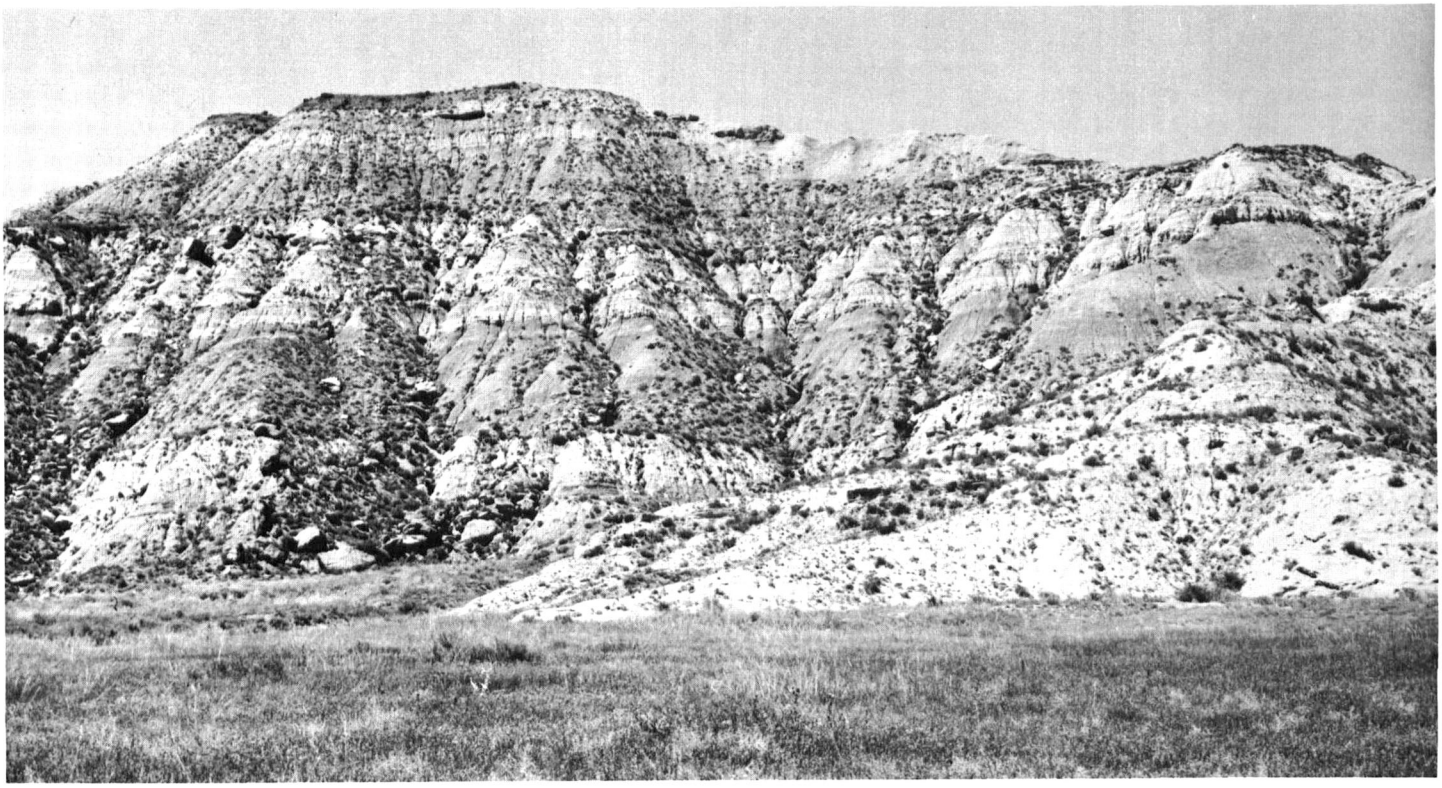
This soil is used mainly for range. Small areas are used for dryfarmed small grains and alfalfa. (Capability unit IIIe-4, dryland; range-soil group 2; windbreak suitability group 2)

Vona-Remmit fine sandy loam, 4 to 8 percent slopes (Vr).--This complex of soils on uplands is made up of about 60 percent Vona fine sandy loam and 40 percent Remmit fine sandy loam. These soils have profiles like those described as typical for their series. They are underlain by sandy shale at a depth of more than 5 feet. Runoff is medium, and the erosion hazard is moderate. Vona soils are on the lower part of foot slopes and in swales and drainageways. Remmit soils occupy the upper part of foot slopes and ridges. Included with these soils in mapping are areas of Ocean Lake and Cushman soils less than 5 acres in size.

These soils are used mainly for range. Small areas are used for dryfarmed small grains. (Capability unit IVe-4, dryland; range-soil group 2; windbreak suitability group 2)



Ocean Lake-Rock land association landscape.



View of Shale outcrop.

FORMATION AND CLASSIFICATION OF SOILS

This section first discusses the five factors of soil classification as they relate to the development of soils in the Powder River Area. Then the current system of soil classification is explained, and the soil series represented in the county are placed in some categories of the current system.

Formation of Soils

Soils are formed by forces of the environment acting on materials deposited or accumulated by geologic processes. The characteristics of a soil at any particular place are determined by (1) the physical and mineralogical composition of the parent material; (2) the relief, or lay of the land, which influences drainage, moisture content, aeration, and exposure to the sun and elements; (3) plants and animals living in and on the soil; (4) the climate in which the soil material has accumulated and existed since accumulation; and (5) the length of time that climate and the biological forces have acted upon the soil material.

Parent Material

All material from which soils developed was derived from weathered bedrock that was either local or was transported from other areas. The material may have been weathered from the rock directly beneath the soil, or it may have been moved by gravity, wind, or water to its present location.

Midway soils are examples of soils that formed in place. The Haverson soils formed in material transported from other locations.

Parent material directly influences the texture of a soil. The soils of the survey area range from sandy to loamy because they formed from sandstone and shale and in alluvium. Many kinds of material have been mixed in alluvium, and the soils that form generally are loamy. For example, Glenberg soils formed in alluvium and are loamy. The loamy soils in the Powder River Area formed from a mixture of weathered sandstone and shale. Soils derived from sandstone, such as those in the Ocean Lake series, generally are sandy. The Midway and other soils formed from shale and are clayey because clay is a basic ingredient of shale. The Gilt edge and Galata soils developed from alkaline shale and from alluvium that was derived from alkaline shale.

Relief

Powder River County lies in the unglaciated part of the Missouri Plateau, which is in the northern part of the Great Plains province. The area is a dissected pediment surface that has remnants of the former upland surface remaining along the divides. Some places, such as the Mizpah Valley west of the Powder River Valley, have low to moderate relief, broad alluvial valleys, and gently sloping divides. On the west side of the Powder River Valley, there are dissected surfaces cut by short steep tributaries that have formed breaks. The sedimentary rock and shale that underlies the survey area resists erosion to a varying degree.

The survey area has an average elevation of more than 1,500 feet. Elevation ranges from 2,768 feet on the Tongue River on the northeastern edge of the survey area to about 4,305 feet in the southwestern corner of Powder River County. Elevation rises gradually from northeast to southwest toward the Big Horn Mountains.

Plants and Animals

Plants and animals are active agents in soil formation. Fungi and algae, among the earliest inhabitants of rock material, contribute to the decomposition of rocks. As the decomposition progresses, larger plants are established and contribute acids and litter. The litter from a coniferous forest generally is acid, and that from grass is less acid. Soils formed under grass, such as those in the Farland and Fort Collins series, do not leach readily.

Plants contribute most of the organic matter to the soil. When leaves, twigs, stems, and roots decompose they are incorporated into the soil. Organic matter is the main cause of the dark color in surface soils.

Animals contribute manure and dead bodies to the organic-matter content of the soil, and they are also involved in mixing and moving soil material. Cicada casts contribute substantially to the structure of some soils; earthworms and burrowing animals mix and move soil material and thereby help incorporate the decomposing organic material.

The plants and animals present on or in the soil of the Powder River Area are highly diverse. Plants range from short bunch grasses in the driest parts of the survey area to ponderosa pine in the Custer National Forest.

Climate

Climate is an active force in soil formation. It includes temperature, precipitation, intensity and time of storms, proportion of precipitation that occurs as snow, number of frost-free days, and length of growing season. In a sense, climate provides the total energy budget for the formation of soils.

In the Powder River Area, precipitation ranges from about 11 to 19 inches. Soils of the Cushman series are dominant in the driest and warmest parts of the survey area. The Campspass and Farland soils are representative in the coolest and most humid

parts. For more information on temperature and precipitation, refer to the section on climate under "General Nature of the Area."

Time

Because it is difficult to tell precisely how many years a soil material has weathered since it was deposited, soils are defined in relative terms such as "young" and "mature." Properties used to establish the relative age of a soil are thickness of the A1 horizon, content of organic matter, depth of leaching of soluble salts, and the form and distribution of calcium carbonate and gypsum. For any given soil, increases in clay percentages, clay movement, orientation of illuvial clay, kind and grade of structure, and degree of weathering are determined by the alteration of primary and secondary minerals.

Haverson silt loam on the first bottom of a flood plain adjacent to an active stream, contains little organic matter in the surface layer, has no clay accumulation and little translocation of carbonates, and is considered a young soil. A similar soil in the Heldt series that is on the second bottom and has slightly more organic matter and segregation of lime, is considered to be an older soil than the Haverson silt loam. A soil in the Farland series is farther away from the apparent source of material, has enough organic matter to give a dark color to the surface layer, has a distinct clay accumulation, and has had most of the carbonates removed from the solum, and is considered to be older than the Haverson and Heldt soils.

Classification of Soils

Soils are classified so that we can more easily remember their significant characteristics. Classification enables us to assemble knowledge about the soils, to see their relationship to one another and to the whole environment, and to develop principles that help us understand their behavior. First through classification and then through use of soil maps, we can apply our knowledge to specific fields and other tracts.

In classification, soils are placed in narrow categories that are used in detailed soil surveys so that knowledge about the soils can be used in managing farms, range, and woods; in developing rural areas; in engineering work; and in many other ways. They are placed in broad classes to facilitate study and comparison in large areas, such as countries and continents.

The current system for classifying soils was adopted for general use by the National Cooperative Soil Survey in 1965. This system is under continual study. Therefore, readers interested in developments of this system should search the latest literature available (2, 3). Table 6 gives some of the classes in the current system for each soil series. These classes are briefly defined in the following paragraphs.

Ten soil orders are recognized in the current system, of which four are represented in the Powder River Area--Aridisols, Alfisols, Entisols, and Mollisols. The Alfisols have clay enriched horizons that have more than 35 percent base saturation. The Aridisols are primarily light-colored soils of dry places. Entisols are recent mineral soils that do not have genetic horizons or have only the beginings of such horizons. Mollisols have surface layers that are darkened by organic matter.

Each order is subdivided into suborders on the basis of characteristics that seem to produce classes with the greatest genetic similarities. The soil properties used to separate suborders mainly reflect differences resulting from climate or vegetation.

Suborders are separated into great groups on the basis of uniformity in the kinds and sequence of major soil horizons and features. The features are the self-mulching properties of clays, soil temperature, major differences in chemical composition, and the like. The great group is not shown separately in table 8, because it is the last word in the name of the subgroup.

Great groups are divided into subgroups, one representing the central (typic) segment of the group and the others, called intergrades, that have properties of the group and also one or more properties of another great group, suborder, or order.

Families are separated within a subgroup primarily on the basis of properties important to the growth of plants or behavior of soils when used for engineering. Among the properties considered are texture, mineralogy, reaction, soil temperature, permeability, thickness of horizons, and consistence. An example is the coarse-loamy, mixed family of Typic Haploborolls.

TABLE 6.--SOIL SERIES CLASSIFIED ACCORDING TO THE CURRENT SYSTEM OF CLASSIFICATION

Series	Family	Subgroup	Order
Arvada	Fine, montmorillonitic, mesic	Ustollic Natrargids	Aridisols.
Bankard	Sandy, mixed, calcareous, mesic	Ustic Torrifluvents	Entisols.
Barvon	Fine-loamy, mixed	Entic Haploborolls	Mollisols.
Bew	Fine, montmorillonitic, mesic	Ustollic Haplargids	Aridisols.
Bone	Fine, montmorillonitic, mesic	Ustollic Natrargids	Aridisols.
Cabba	Loamy, mixed, calcareous, frigid, shallow-	Typic Ustorthents	Entisols.
Campspass	Fine, montmorillonitic	Typic Eutroboralfs	Alfisols.
Cushman	Fine-loamy, mixed, mesic	Ustollic Haplargids	Aridisols.
Elso	Loamy, mixed, calcareous, mesic, shallow--	Ustic Torriorthents	Entisols.
Epsie	Shallow, clayey, montmorillonitic, non-acid, mesic.	Ustic Torriorthents	Entisols.
Farland	Fine-silty, mixed	Typic Argiborolls	Mollisols.
Fergus	Fine, mixed	Typic Argiborolls	Mollisols.
Fort Collins	Fine-loamy, mixed, mesic	Ustollic Haplargids	Aridisols.
Galata	Very fine, montmorillonitic	Borollic Glossic Natrargids-	Aridisols.
Gilt Edge	Fine, montmorillonitic, mesic	Ustollic Natrargids	Aridisols.
Glenberg	Coarse-loamy, mixed, calcareous, mesic	Ustic Torrifluvents	Entisols.
Haverson	Fine-loamy, mixed, calcareous, mesic	Ustic Torrifluvents	Entisols.
Havrelon	Fine-loamy, mixed, calcareous, mesic	Typic Ustifluvents	Entisols.
Heldt	Fine, montmorillonitic, mesic	Ustollic Camborthids	Aridisols.
Hesper	Fine, montmorillonitic, mesic	Ustollic Haplargids	Aridisols.
Hopley	Coarse-loamy, mixed	Typic Haploborolls	Mollisols.
Hydro	Fine, montmorillonitic, mesic	Glossic Ustollic Natrargids-	Aridisols.
Keiser	Fine-silty, mixed, mesic	Ustollic Haplargids	Aridisols.
Kyle	Fine, montmorillonitic, mesic	Ustertic Camborthids	Aridisols.
McRae	Fine-loamy, mixed, mesic	Ustollic Camborthids	Aridisols.
Midway	Clayey, montmorillonitic, calcareous, mesic, shallow.	Ustic Torriorthents	Entisols.
Nihill	Loamy-skeletal, mixed, calcareous, mesic--	Ustic Torriorthents	Entisols.
Ocean Lake	Loamy, mixed, calcareous, mesic, shallow--	Typic Torriorthents	Entisols.
Rapelje	Fine-silty, mixed	Borollic Glossic Natrargids-	Aridisols.
Relan	Coarse-loamy, mixed	Typic Haploborolls	Mollisols.
Relan, gravelly variant-	Loamy-skeletal, mixed	Cumulic Haploborolls	Mollisols.
Remmit	Coarse-loamy, mixed, mesic	Ustollic Camborthids	Aridisols.
Ringling	Loamy-skeletal, mixed	Lithic Haploborolls	Mollisols.
Thurlow	Fine, montmorillonitic, mesic	Ustollic Haplargids	Aridisols.
Vananda	Fine, montmorillonitic, mesic	Torertic Camborthids	Aridisols.
Vona	Coarse-loamy, mixed, mesic	Ustollic Haplargids	Aridisols.

This section was written mainly for readers not familiar with the Powder River Area. It tells about the history and development, climate, physiography and drainage, and natural resources of the survey area.

History and Development

The Powder River Area was part of Custer County until 1919, when a bill that created Powder River County was passed. In 1920 the town of Broadus was made the county seat. The county gets its name from the bluish-gray clay and sand along the banks of the Powder River. This clay and sand look like gunpowder.

The survey area does not have a railroad, but U.S. Highway No. 212 crosses the area from east to west and U.S. Highway No. 312 crosses it from north to south. Broadus is at the junction of these two highways. Numerous gravel roads are maintained as secondary roads.

The population of Powder River County is 2,485, and 628 people live in Broadus. The longtime trend in population is downward in the rural part of the survey area, but Broadus shows a little growth each year. Churches of several denominations are in Broadus and in many rural communities. Telephones service most of the ranches and small communities. The county provides elementary and high schools in the Powder River Area. Because roads have been improved, most of the small rural schools have been closed and the largest schools centralized in Broadus.

During the warm season, rodeo is the favorite pastime. The county has several roping and saddle clubs. It is active in 4-H club work; 4-H activities culminate in a county fair at Broadus in August. Other activities in the county are bowling and swimming; a modern outdoor swimming pool was built in 1962.

Cattle ranching was the first and major industry in the survey area. Beef production reached its peak between 1880 and 1920, when the open range prevailed. Homesteading in the area reached a peak between 1909 and 1920. The homesteaders started farming, and in 1920 all of the land was closed to open range grazing.

Farming in the area has always been a supplement to the livestock industry. One of the most important crops is winter wheat, and another is alfalfa grown for hay or seed. In 1959 there were 376 individual farms in the survey area. The average-sized farm was 4,660 acres. Table 7 gives the acreage of principal crops grown in 1959, 1960, and 1961. Although fertilizer is not used extensively in the survey area, crops respond well when it is used.

In recent years the trend has been from ranches of about 640 acres to those of about 4,500 acres. A few ranches exceed 10,000 acres. Movement of cattle out of the Powder River Area was 45,289 steers, cows, heifers, bulls, and calves in 1960 and 42,712 in 1961. Moving into the area were 3,431 of these animals in 1960 and 4,403 in 1961. Except for protein or protein supplements, all feed for livestock is produced on the farms in the survey area. The protein supplements generally are purchased elsewhere. Table 8 shows the number of livestock raised in the survey area in 1960, 1961, and 1962.

Coal mining, lumbering, and post-treating plants are of limited importance in the area. There are no local processing plants. Farm products are either used in the Powder River Area or shipped to market outside the Area.

Climate[3]

Powder River Area has a continental climate that is cold in winter, is warm in summer, and has large variations in seasonal precipitation. In a normal year, about three-fourths of the annual precipitation falls during the growing season from April to September. May and June normally are the wettest months. Except for some leeward slopes that have an average annual precipitation of slightly more than 10 inches, the driest areas are at lower elevations and receive an average of about 12 inches a year. The wettest places are in the mountainous parts of the survey area, where the average annual precipitation is as much as 20 inches. At elevations of 3,900 feet or more, precipitation averaged 17 inches a year for a 22-year period. Moisture usually does not penetrate the soil to a depth of more than 36 inches in dry areas or 28 inches in wet areas. Although the survey area has several severe storms and high winds every year, it is not noted for any particular kind of storm.

Average monthly and annual precipitation at four weather stations are shown in table 9. Table 10 gives precipitation probabilities for a 25-year period. Table 11 gives maximum amount of rainfall that is likely during storms of varied duration and how frequently such storms can be expected.

Table 12 shows the means and extremes of temperature recorded at four weather stations and the mean snowfall at three stations. On summer afternoons it is usually cooler in the Powder River Area than along the Yellowstone River farther north. In the survey area, less than 30 days a year have maximum temperatures of more than 80° F. and 20 days or less have a minimum temperature below zero.

The survey area generally has winters during which snow does not prevent access of livestock to grazing areas, and rangeland at lower elevations generally is free of snow. About once in 3 or 4 years, however, snow and cold combine to make the

[3] By R. A. Dightman, State climatologist, Helena, Mont.

TABLE 7.--ACREAGE OF PRINCIPAL CROPS IN STATED YEARS

Crop	1959	1960	1961
	Acres	Acres	Acres
Wheat harvested	25,600	23,400	20,400
Barley and oats harvested	7,600	8,500	3,900
Alfalfa seed	7,100	7,000	3,900
Alfalfa hay	39,900	40,100	35,500
Wild hay	6,800	4,000	1,400
Corn silage	500	7,000	3,900

TABLE 8.--KINDS AND NUMBER OF LIVESTOCK ON FARMS IN STATED YEARS

Livestock	1960	1961	1962
	Number	Number	Number
Cattle and calves	61,500	52,900	46,000
Milk cows	700	700	600
Hogs and small pigs	300	300	300
Sheep and lambs	63,300	62,300	55,400
Horses and mules	1,800	1,800	1,800
Chickens	10,800	10,400	9,300

TABLE 9.--MONTHLY AND ANNUAL AVERAGE PRECIPITATION IN INCHES AT FOUR WEATHER STATIONS

Station	Period	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Boyes--------	1950-1961	0.36	0.43	0.57	0.95	2.15	2.74	1.61	1.84	1.08	0.74	0.52	0.36	13.35
Broadus------	1937-1961	.50	.46	.80	1.24	2.24	3.11	1.39	1.04	1.05	.88	.67	.43	13.81
Moorhead-----	1948-1958	.24	.31	.64	.13	2.08	2.75	1.38	1.00	.61	.76	.59	.41	10.90
Sonnette 4N--	1951-1961	.23	.37	.41	.97	2.21	2.36	1.32	1.06	.90	.86	.59	.27	11.55

TABLE 10.--PROBABILITY OF LISTED AMOUNT OF MONTHLY PRECIPITATION AT BROADUS

[Based on 25-year period from 1937 to 1961]

Month	One year in 10 will have:		Two years in 10 will have:		Three years in 10 will have:		Four years in 10 will have:	
	Less than--	More than--	Less than--	More than--	Less than--	More than--	Less than--	More than--
	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches
January-----	0.1	1.2	0.2	0.9	0.3	0.5	0.4	0.4
February----	.1	.9	.2	.7	.3	.6	.4	.5
March-------	.3	1.7	.4	1.4	.4	1.0	.5	.8
April-------	.3	2.6	.5	2.2	.6	1.7	.7	1.4
May---------	1.0	4.1	1.3	3.1	1.5	2.8	1.6	2.3
June--------	1.4	4.7	1.7	4.4	1.9	3.6	2.5	3.2
July--------	.3	2.5	.8	2.1	1.0	1.9	1.1	1.4
August------	.1	2.5	.4	1.7	.6	1.4	.6	1.1
September---	.3	2.4	.4	1.9	.5	1.5	.6	1.1
October-----	.1	1.9	.2	1.8	.3	1.2	.5	1.0
November----	.2	1.3	.2	1.0	.3	.9	.5	.8
December----	.1	.8	.2	.7	.2	.7	.3	.5
Annual----	9.4	17.5	11.1	16.8	11.9	16.4	13.0	13.9

TABLE 11.--ESTIMATED MAXIMUM AMOUNTS OF RAINFALL IN POWDER RIVER COUNTY FOR STATED PERIODS OF DURATION AND THE FREQUENCY THAT THESE AMOUNTS OCCUR

[Based on data from U.S. Weather Bureau Technical Paper No. 40 (6)]

Duration	Frequency of once in--				
	2 years	5 years	10 years	25 years	50 years
	Inches	Inches	Inches	Inches	Inches
30 minutes-----	0.6	0.9	1.1	1.3	1.5
1 hour---------	.8	1.1	1.3	1.6	1.9
3 hours--------	1.0	1.5	1.7	2.0	2.5
6 hours--------	1.3	1.7	2.0	2.5	2.9
12 hours-------	1.5	2.0	2.4	2.8	3.3
24 hours-------	1.7	2.4	2.8	3.2	3.7

TABLE 12.--AVERAGE TEMPERATURES AT FOUR STATIONS AND AVERAGE SNOWFALL AT THREE STATIONS FOR STATED PERIODS

MEAN MAXIMUM TEMPERATURE IN °F.

Station	Period	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Boyes--------	1950-1961	33.3	37.5	42.5	56.2	67.8	77.8	87.2	86.7	74.1	63.3	44.7	38.0	59.1
Broadus------	1937-1961	31.9	36.3	43.9	57.8	68.0	75.8	87.1	86.4	74.5	63.4	45.0	37.7	59.0
Moorhead-----	1948-1958	29.8	40.3	43.1	59.3	69.6	79.2	90.4	89.2	79.6	66.9	47.2	36.9	61.0
Sonnette 4N--	1951-1961	33.3	37.7	42.8	54.8	67.5	76.9	89.1	87.8	73.6	61.7	44.5	39.0	59.1

MEAN MINIMUM TEMPERATURE IN °F.

Boyes--------	1950-1961	4.8	9.6	16.7	26.7	38.3	47.6	53.7	52.3	40.4	29.6	16.5	10.7	28.9
Broadus------	1937-1961	5.8	10.6	19.3	30.9	41.5	49.8	56.0	53.7	42.6	32.1	19.4	12.2	31.2
Moorhead-----	1948-1958	-.6	9.1	15.9	28.6	40.3	48.7	54.4	52.6	41.6	30.9	19.2	8.2	29.1
Sonnette 4N--	1951-1961	6.1	11.8	17.5	27.9	39.6	46.6	54.8	52.9	39.4	29.6	17.6	13.9	29.8

MEAN MONTHLY TEMPERATURE IN °F.

Boyes--------	1950-1961	19.1	23.6	29.6	41.5	53.1	62.7	70.5	69.5	57.3	46.5	30.6	24.4	44.0
Broadus------	1937-1961	18.9	23.5	31.6	44.4	54.8	62.8	71.6	70.1	58.6	47.8	32.2	25.0	45.1
Moorhead-----	1948-1958	14.6	24.7	29.5	43.9	55.0	64.0	72.4	70.9	60.6	48.9	33.2	22.6	45.1
Sonnette 4N--	1951-1961	19.7	24.8	30.2	41.4	53.6	61.8	72.0	70.4	56.5	45.7	31.1	26.5	44.5

HIGHEST TEMPERATURE IN °F.

Boyes--------	1950-1961	69.0	68.0	78.0	87.0	92.0	104.0	105.0	105.0	104.0	92.0	72.0	67.0	105.0
Broadus------	1937-1961	61.0	67.0	83.0	90.0	96.0	105.0	108.0	105.0	104.0	92.0	73.0	69.0	108.0
Moorhead-----	1948-1958	58.0	67.0	76.0	86.0	92.0	102.0	106.0	109.0	101.0	91.0	73.0	65.0	109.0
Sonnette 4N--	1951-1961	61.0	68.0	75.0	87.0	92.0	99.0	105.0	103.0	104.0	90.0	70.0	68.0	105.0

LOWEST TEMPERATURE IN °F.

Boyes--------	1950-1961	-40.0	-29.0	-38.0	1.0	18.0	26.0	37.0	34.0	13.0	4.0	-30.0	-32.0	-40.0
Broadus------	1937-1961	-38.0	-42.0	-27.0	4.0	12.0	31.0	38.0	36.0	17.0	8.0	-28.0	-31.0	-44.0
Moorhead-----	1948-1958	-42.0	-35.0	-22.0	7.0	12.0	30.0	39.0	36.0	21.0	10.0	-24.0	-31.0	-42.0
Sonnette 4N--	1951-1961	-42.0	-35.0	-12.0	-7.0	12.0	30.0	39.0	21.0	10.0	-27.0	-38.0	-38.0	

MEAN SNOWFALL IN INCHES

Broadus------	1937-1961	5.9	5.4	6.3	2.9	.5	.1	0	0	(1/)	1.8	5.0	4.6	32.5
Moorhead-----	1948-1958	6.6	5.2	10.1	2.5	(1/)	(1/)	0	0	(1/)	2.7	3.5	4.6	35.2
Volborg------	1951-1961	4.6	7.0	2.3	2.4	(1/)	(1/)	0	0	0	3.3	5.3	3.6	28.5

1/ Traces (less than 0.5 inch).

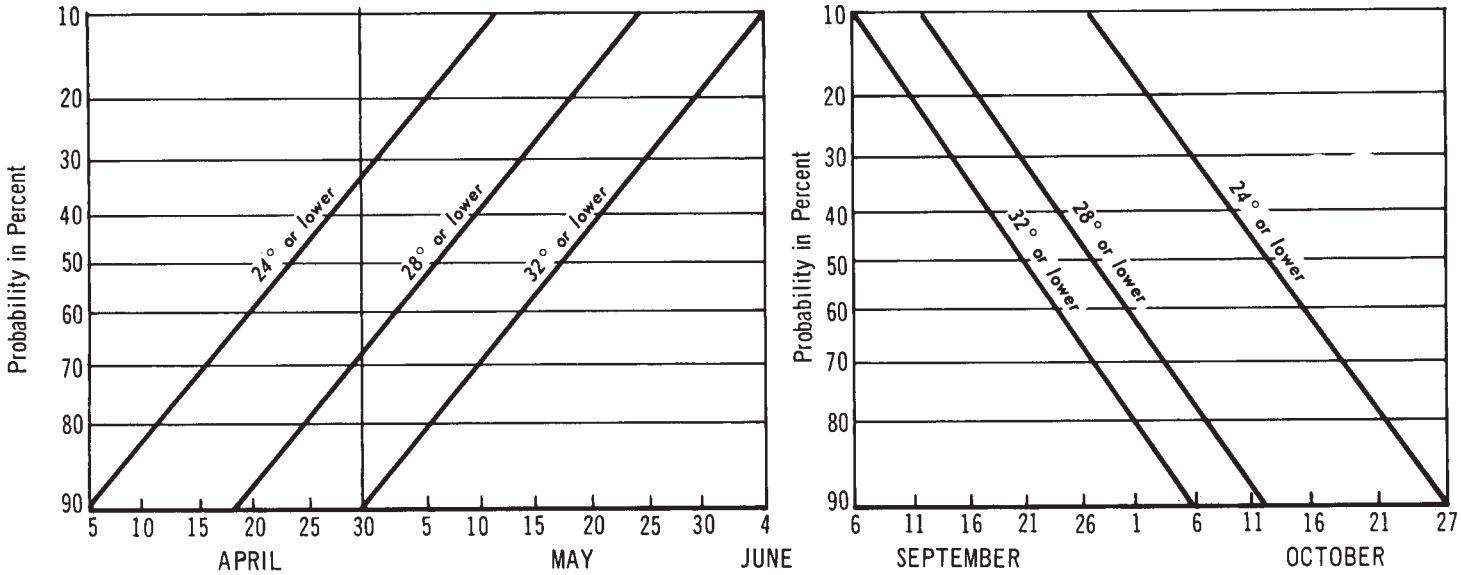


Figure 7.--Left: Probability that temperatures at Broadus will be 24°, 28°, 28°, or lower than each of these temperatures, after any date in spring. Right: Probability that temperatures at Broadus will be 32°, 28°, 24°, or lower than each of these temperatures before any date in fall.

supplementary feeding of livestock necessary. In some of the higher places of the southwest quarter of the survey area, annual snowfall and summer rains insure a good supply of grass for the winter feeding of livestock and for grazing in the high areas in summer.

All seasons have considerable sunshine, except for the annual rainy period in May and June and the occasional cloudy periods in November and December. Only a few days each summer have humid heat, and the cooling at night always brings relief.

Because of the cold winters and warm summers, the average length of the growing season is important. The weather station at Broadus records an average of 100 to 128 days when the temperature is above 32°, 144 days above 28°, and 172 days above 24°.

From figure 7, a farmer can determine the probability that freezing temperatures of 24°, 28°, and 32° will occur at any date at Broadus. To determine the probability that there will be a temperature of 28° or lower after April 30, look up to the point where a vertical line from April 30 intersects the 28° line. The probability is about 68 percent. In the same way, the farmer can determine from the right side of figure 20 the probability that the temperatures listed will occur before any date in fall.

Physiography and Drainage

The survey area is an upland plain that is 2,304,760 acres in size and deeply trenched by numerous streams. It is part of the Missouri Plateau, an unglaciated region of the northern Great Plains. In the survey area are the Fort Union formation, Hell Creek formation, Fox Hills sandstone, and Wasatch formation. Also present is alluvium laid down in the Quaternary period. Remnants of the original upland surfaces remain on the high divides. The steep-sided, narrow-topped remnants of the upland plain are underlain by soft bedrock. At the heads of gullies, erosion is cutting back toward remnants of ridges, divides, and high terraces. The sides of the drainageways are steep and on them nearly barren shale exposures are dominant. In the western part of the survey area are widely separated sandstone ledges of varying thickness and bands of hard red porcelanite shale. The burned-out Roland coalbeds give the hills a red color.

Along the drainageways are smooth coalescing alluvial fans, foot slopes, and stream terraces 1/4 mile to 3 miles wide. The area has a typical branching drainage pattern in which the main trunk streams flow northward. These streams are the Little Powder, Powder, and Tongue Rivers and Mizpah, Pumpkin, and Otter Creeks. The elevation in the survey area ranges from 2,500 feet at the lowest point near the Tongue River to 4,310 feet on Cook Mountain. The various formations range from 200 feet to several thousands of feet in thickness. They consist mainly of softly consolidated and cross-bedded silt, clay, sandy and hard porcelanite shale of the Cenozoic era and Tertiary period.

Natural Resources

The most important natural resource in the survey area is soil, which is used for growing grain, hay, and forage. Attracted by the nourishing grasses in the area, the settlers established livestock ranches along the major streams, and raising livestock is still the principal enterprise. In

cultivated areas the principal crops are small grains and hay, which are used mainly for feeding livestock. Excess grain or hay is sold for supplementary income. About 10 percent of the survey area is cultivated, and about 90 percent is rangeland.

Water, particularly ground water, is important in raising livestock. Throughout the survey area, ground water is readily obtained from shallow to moderately deep wells. A few deep artesian wells have been drilled to obtain water for household use. Stock ponds and springs are developed in the upland drainageways to trap runoff in spring and seasonal flood water for use during the dry part of the year. Dikes are constructed on the nearly level bottom lands to catch seasonal runoff and spread it over the soil surface. These water-spreading dikes help to store more water in the soil and increase the growth of hay and grain. Some parts of the valleys along the Powder River and Otter and Pumpkin Creeks are irrigated with water from those streams. Wells are drilled along the Powder River to furnish additional water when that river goes dry in summer. The total irrigated acreage in the survey area is 33,186 acres, but that is small compared with the acreage that could be irrigated if water were available. Most of the smooth bottom lands consist of soils that are suited to irrigated crops.

Stands of ponderosa pine cover approximately 250,000 acres in the southwestern and western parts of the Powder River Area. A little of this pine is in well-stocked stands of mature trees that have commercial value. A few small sawmills in the area cut lumber of a certain size for making laminated beams and studdings.

The abundant coal in the survey area was important as heating fuel, but propane gas has replaced much of the coal. Although natural gas is plentiful in the northern part of the area, it has not been developed. Oil resources are limited, but a few wells are being drilled.

Deer and antelope provide big game hunting. Sharp-tailed grouse, sage grouse, Hungarian partridge, and ring-necked pheasant can be found, but they are not in large numbers. In the timbered areas, wild turkeys have increased enough to provide limited hunting. In fall a number of ranchers and businessmen supplement their incomes by acting as guides for hunters from other States.

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GLOSSARY

AC soil. A soil that has an A and a C horizon but no B horizon. Commonly such soils are immature, as those developing from alluvium or those on steep, rocky slopes.

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

Alkali soil. Generally, a highly alkaline soil. Specifically, an alkali soil has so high a degree of alkalinity (pH 8.5 or higher) or so high a percentage of exchangeable sodium (15 percent or more of the total exchangeable bases), or both, that the growth of most crop plants is low from this cause.

Alkaline soil. Generally, a soil that is alkaline throughout most or all of the parts occupied by plant roots, although the term is commonly applied to only a specific layer or horizon of a soil. Precisely, any soil horizon having a pH value greater than 7.0; practically, a soil having a pH above 7.3.

Alluvial soil. A group of soils that are made up of alluvium that has been modified only slightly if at all by soil-forming processes.

Alluvium. Soil material, such as sand, silt, or clay, that has been deposited on land by streams.

Available water capacity. The capacity of a soil to hold water in a form available to plants. Amount of moisture held in soil between field capacity, or about one-third atmosphere of tension, and the wilting coefficient, or about 15 atmospheres of tension.

Blowout. A small area from which all or most of the soil material has been removed by wind.

Calcareous soil. A soil containing enough calcium carbonate (often with magnesium carbonate) to fizz visibly when treated with cold, dilute hydrochloric acid.

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

Claypan. A compact, slowly permeable soil horizon that contains more clay than the horizon above and below it. A claypan is commonly hard when dry and plastic or stiff when wet.

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

Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are--

Loose.--Noncoherent; does not hold together in a mass.

Friable.--When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

Firm.--When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Plastic.--When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a "wire" when rolled between thump and forefinger.

Sticky.--When wet, adheres to other material, and tends to stretch somewhat and pull apart, rather than to pull free from other material.

Hard.--When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Soft.--When dry, breaks into powder or individual grains under very slight pressure.

Cemented.--Hard and brittle; little affected by moistening.

Deep soil. A soil that has an upper limit of 30 to 50 inches below the surface and a lower limit of 50 to 60 inches or deeper.

Degradation. The lowering of surfaces by erosion.

Eluviation. The transportation of dissolved or suspended soil material by the downward or lateral movement of water.

Erosion. The wearing away of the land surface by wind (sandblast), running water, and other geological agents.

Fertility, soil. The quality of a soil that enables it to provide compounds, in adequate amounts and in proper balance, for the growth of specified plants, when other growth factors such as light, moisture, temperature, and the physical condition of the soil, are favorable.

Fertilizer. Any material put on or in the soil to improve the quality or quantity of plant growth, as manure, chemicals, or crop residue.

Field moisture capacity. The moisture content of a soil, expressed as a percentage of the oven-dry weight, after the gravitational, or free, water has been allowed to drain away; the field moisture content 2 or 3 days after a soaking rain; also called normal field capacity, normal moisture capacity, or capillary capacity.

Genesis, soil. The manner in which a soil originates. Refers especially to the processes initiated by climate and organisms that are responsible for the development of the solum, or true soil, from the unconsolidated parent material, as conditioned by relief and age of landform.

Horizon, soil. A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes. These are the major horizons:

O horizon.--The layer or organic matter on the surface of a mineral soil. This layer consists of decaying plant residues.

A horizon.--The mineral horizon at the surface or just below an O horizon. This horizon is the one in which living organisms are most active and therefore is marked by the accumulation of humus. The horizon may have lost one or more of soluble salts, clay, and sesquioxides (iron and aluminum oxides)

B horizon.--The mineral horizon below an A horizon. The B horizon is in part a layer of change from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics caused (1) by accumulation of clay, sesquioxides, humus, or some combination of these; (2) by prismatic or blocky structure; (3) by redder or stronger colors than the A horizon; or (4) by some combination of these. Combined A and B horizons are usually called the solum, or true soil. If a soil lacks a B horizon, the A horizon along is the solum.

C horizon.--The weathered rock material immediately beneath the solum. In most soils this material is presumed to be like that from which the overlying horizons were formed. If the material is known to be different from that in the solum, a Roman numeral precedes the letter C.

R layer.--Consolidated rock beneath the soil. The rock usually underlies a C horizon but may be immediately beneath an A or B horizon.

Humus. The well-decomposed, more or less stable

part of the organic matter in mineral soils.

Illuviation. Accumulation of dissolved or suspended soil materials in a horizon as a result of eluviation from another horizon.

Krotovinas. Irregular tubular streaks of material transported from another soil horizon. Caused when the tunnels made by burrowing animals are filled with material from outside the horizon.

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

Loess. Geological deposit of fine material, mostly silt, transported by wind.

Mottled. Irregularly marked with spots of different colors that vary in number and size. Mottling in soils usually indicates poor aeration and lack of drainage. Descriptive terms are as follows: Abundance--few, common, and many; size--fine, medium, and coarse, and contrast--faint, distinct, and prominent. The size measurements are these: Fine, less than 5 millimeters (about 0.2 inch) in diameter along the greatest dimension; medium, ranging from 5 millimeters to 15 millimeters (about 0.2 to 0.6 inch) in diameter along the greatest dimension; and coarse, more than 15 millimeters (about 0.6 inch) in diameter along the greatest dimension.

Natural soil drainage. Refers to the conditions of frequency and duration of periods of saturation or partial saturation that existed during the development of the soil, as opposed to altered drainage, which is commonly the result of artificial drainage or irrigation but may be caused by the sudden deepening of channels or the blocking of drainage outlets. Seven different classes of natural soil drainage are recognized.

Excessively drained soils are commonly very porous and rapidly permeable and have a low water-holding capacity.

Somewhat excessively drained soils are also very permeable and are free from mottling throughout their profile.

Well-drained soils are nearly free from mottling and are commonly of intermediate texture.

Moderately well drained soils commonly have a slowly permeable layer in or immediately beneath the solum. They have uniform color in the A and upper B horizons and have mottling in the lower B and the C horizons.

Imperfectly or somewhat poorly drained soils are wet for significant periods but not all the time, and in Podzolic soils commonly have mottlings below 6 to 16 inches, in the lower A horizon and in the B and C horizons.

Poorly drained soils are wet for long periods and are light gray and generally mottled from the surface downward, although mottling may be absent or nearly so in some soils.

Very poorly drained soils are wet nearly all the time. They have a dark-gray or black surface layer and are gray or light gray, with or without mottling, in the deeper parts of the profile.

Normal soil. A soil having a profile in near equilibrium with its environment. A normal soil developed under good but not excessive drainage from parent material of mixed mineral, physical, and chemical composition. Its characteristics show the full effects of climate and living matter.

Organic soil. A soil composed of a high percentage of plant and animal matter.

Parent material. The weathered rock or partly weathered soil material from which a soil has formed; the C horizon.

Permeability. The quality of a soil horizon that enables water or air to move through it. Terms used to describe permeability are as follows: very slow, slow, moderately slow, moderate, moderately rapid, rapid, and very rapid.

pH value. A numerical means for designating relatively weak acidity and alkalinity in soils. A pH value of 7.0 indicates precise neutrality; a higher value, alkalinity; and a lower value, acidity.

Planosol. An intrazonal group of soils with strongly leached upper layer over compacted clay or silt, that is developed on smooth flat uplands.

Porcelanite. A hard, dense siliceous rock, having the appearance of unglazed porcelain on fresh fractures.

Profile, soil. A vertical section of the soil through all its horizons and extending into the parent material.

Reaction, soil. The degree of acidity or alkalinity of a soil expressed in pH values. A soil that tests to pH 7.0 is precisely neutral in reaction because it is neither acid or alkaline. An acid, or "sour," soil is one that gives an acid reaction; an alkaline soil is one that is alkaline in reaction. In words, the degrees of acidity or alkalinity are expressed thus:

	pH
Extremely acid	Below 4.5
Very strongly acid	4.5 to 5.0
Strongly acid	5.1 to 5.5
Medium acid	5.6 to 6.0
Slightly acid	6.1 to 6.5
Neutral	6.6 to 7.3
Mildly alkaline	7.4 to 7.8
Moderately alkaline	7.9 to 8.4
Strongly alkaline	8.5 to 9.0
Very strongly alkaline	9.1 and higher

Regosols. A group of soils lacking definite genetic horizons and developing from deep unconsolidated or soft rocky deposits.

Relief. The elevations or inequalities of a land surface, considered collectively.

Runoff. Surface drainage of rainwater or water from melted snow.

Saline soil. A soil that contains soluble salts in

amounts that impair growth of plants but that does not contain excess exchangeable sodium.

Saline-alkali soil. A soil that has a combination of harmful quantities of salts and either a high alkalinity or high exchangeable sodium or both, so distributed in the profile that the growth of most plants is reduced.

Series, soil. A group of soils developed from a particular type of parent material and having genetic horizons that, except for texture of the surface layer, are similar in differentiating characteristics and in arrangement in the profile.

Site index. A numerical means of expressing the quality of a forest site that is based on the height of the dominant stand at an arbitrarily chosen age; for example, the average height attained by dominant and codominant trees in a fully stocked stand at the age of 50 years.

Slick spots. Small areas in a field that are slick when wet because they contain excess exchangeable sodium, or alkali.

Slope. The incline of the soil surface, generally expressed as the number of feet of fall per 100 feet of horizontal distance.

Soil. A natural, three-dimensional body on the earth's surface that supports plants and that has properties resulting from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by relief over periods of time.

Soil association. A group of soils geographically associated in a characteristic repeating pattern.

Solum. The upper part of a soil profile, above the parent material, in which the processes of soil formation are active. The solum in mature soil includes the A and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the underlying material. The living roots and other plant and animal life characteristic of the soil are largely confined to the solum.

Structure, soil. The arrangement of primary soil particles into compound particles or clusters that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil particles. The principal forms of soil structure are--platy (laminated), prismatic (vertical axis of aggregates longer than horizontal), columnar (prisms with rounded tops), blocky (angular or subangular), and granular. Structureless soils are (1) single grain (each grain by itself, as in dune sand) or (2) massive (the particles adhering together without any regular cleavage, as in many claypans and hardpans).

Subsoil. Technically, the B horizon; roughly, the part of the solum below plow depth.

Substratum. Technically, the part of the soil below the solum.

Surface soil. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, about 5 to 8 inches in thickness. The plowed layer.

Tabular. Having a plane surface, as a plateau or cliff-bound mesa.

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

GUIDE TO MAPPING UNITS

For a full description of a mapping unit, read both the description of the mapping unit and the description of the soils series to which it belongs. To learn about the management of a capability unit or a woodland suitability group, read the description of the unit or group and also the introduction to the section in which the unit of group is described. Other information is given in tables and text as follows:

Predicted yields, table 1, page 17.
Engineering uses of soils, tables 2 through 4, pages 24 through 49.

Acreage and extent, table 5, pages 50 and 51.

Map symbol	Mapping unit	Described on page	Capability unit		Range-soil group		Windbreak suitability group	
			Symbol	Page	Number	Page	Number	Page
Ab	Arvada-Bone complex, 0 to 4 percent slopes	52	VIs-1	15	10	20	5	22
Ba	Bankard fine sandy loam	53	VIw-1	15	9	19	---	---
Bc	Bew silty clay, 0 to 2 percent slopes	55	IIIs-1	13	5	19	3	21
Be	Bew silty clay, 2 to 4 percent slopes	55	IIIe-2	12	5	19	3	21
Bw	Bew silty clay, 4 to 8 percent slopes	55	IVe-3	14	5	19	3	21
Ca	Cabba association, 15 to 50 percent slopes	56	VIIe-1	15	7	19	---	---
Cb	Campspass-Barvon association, 15 to 50 percent slopes	57	VIe-1	14	3	18	1	21
Ce	Cushman-Elso silt loams, 4 to 8 percent slopes	58						
	Cushman soil	--	IIIe-1	12	4	18	2	21
	Elso soil	--	IIIe-1	12	4	18	---	---
Ch	Cushman-Elso silt loams, 8 to 15 percent slopes	59						
	Cushman soil	--	IVe-1	13	4	18	2	21
	Elso soil	--	IVe-1	13	4	18	---	---
Ec	Elso silt loam, 8 to 15 percent slopes	59	VIe-2	14	4	18	---	---
El	Elso silt loam, 15 to 45 percent slopes	59	VIe-1	14	7	19	---	---
Eo	Elso-Ocean Lake association, 15 to 45 percent slopes	59						
	Elso silt loam	--	VIIe-1	15	7	19	---	---
	Ocean Lake fine sandy loam	--	VIIe-3	15	6	19	---	---
Ep	Epsie clay, 4 to 15 percent slopes	60	VIIs-1	15	11	20	---	---
Fa	Farland silt loam, 0 to 2 percent slopes	61	IIe-1	12	3	18	1	21
Fd	Farland silt loam, 2 to 4 percent slopes	61	IIe-1	12	3	18	1	21
Fe	Farland silt loam, 4 to 8 percent slopes	62	IIIe-3	12	3	18	1	21
Fh	Farland-Cabba association, 4 to 8 percent slopes	62						
	Farland silt loam	--	IIIe-3	12	3	18	1	21
	Cabba silt loam	--	IVe-2	14	7	19	---	---
Fk	Farland-Cabba association, 8 to 20 percent slopes	62						
	Farland silt loam	--	VIe-1	14	3	18	1	21
	Cabba silt loam	--	VIe-1	14	7	19	---	---
Fl	Farland-Rock land association, 0 to 6 percent slopes	62						
	Farland silt loam	--	IIIe-3	12	3	18	1	21
	Rock land	--	VIIIs-2	16	---	---	---	---
Fm	Farland and Havrelon soils, 4 to 8 percent slopes	62	IIIe-3	12	3	18	1	21
Fn	Fergus-Relan association, 2 to 8 percent slopes	63	IIIe-3	12	3	18	1	21
Fo	Fort Collins silt loam, 0 to 2 percent slopes	64	IIIc-1	13	4	18	2	21
Fr	Fort Collins silt loam, 2 to 4 percent slopes	64	IIIe-1	12	4	18	2	21
Fs	Fort Collins silt loam, 4 to 8 percent slopes	64	IIIe-1	12	4	18	2	21
Ga	Galata silty clay, 4 to 8 percent slopes	65	IVe-3	14	5	19	4	21
Gd	Gilt Edge silt loam, 0 to 2 percent slopes	66	IIIs-1	13	4	18	3	21
Ge	Gilt Edge silt loam, 2 to 6 percent slopes	66	IIIe-2	12	4	18	3	21
Gf	Glenberg fine sandy loam, 0 to 2 percent slopes	66	IVe-4	14	2	18	2	21
Ha	Haverson loam	67	IIIe-1	12	4	18	2	21
Hc	Haverson silt loam	67	IIIc-1	13	4	18	2	21
Hd	Haverson silty clay loam	67	IIIc-1	13	5	19	2	21
He	Haverson silty clay	67	IIIc-1	13	5	19	2	21
Hf	Haverson soils, channeled	67	VIw-1	15	4	18	2	21
Hg	Haverson soils, saline	68	VIw-1	15	1	18	5	22
Hh	Heldt silty clay loam, 0 to 2 percent slopes	69	IIIc-1	13	5	19	2	21
Hk	Heldt silty clay loam, 2 to 4 percent slopes	69	IIIe-1	12	5	19	2	21

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Map symbol	Mapping unit	Described on page	Capability unit		Range-soil group		Windbreak suitability group	
			Symbol	Page	Number	Page	Number	Page
Hm	Heldt silty clay loam, 4 to 8 percent slopes	69	IIIe-1	12	5	19	2	21
Hn	Hesper silty clay loam, 0 to 2 percent slopes	70	IIIc-1	13	5	19	2	21
Ho	Hesper silty clay loam, 2 to 4 percent slopes	70	IIIe-1	12	5	19	2	21
Hp	Hesper silty clay loam, 4 to 8 percent slopes	70	IIIe-1	12	5	19	2	21
Hr	Hesper silty clay loam, 8 to 15 percent slopes	70	IVe-1	13	5	19	2	21
Hs	Hopley and Relan loams, 4 to 8 percent slopes	71	IIIe-3	12	3	18	1	21
Ht	Hydro silty clay loam, 0 to 2 percent slopes	72	IIIc-1	13	5	19	4	21
Hu	Hydro silty clay loam, 2 to 4 percent slopes	72	IIIe-1	12	5	19	4	21
Hv	Hydro silty clay loam, 4 to 8 percent slopes	72	IIIe-1	12	5	19	4	21
Hw	Hydro-Arvada complex, 2 to 8 percent slopes	72						
	Hydro silty clay loam	--	IVe-3	14	5	19	4	21
	Arvada silt loam	--	IVe-3	14	10	20	5	22
Hx	Hydro-Elso association, 8 to 15 percent slopes	72						
	Hydro silty clay loam	--	VIe-2	14	5	19	4	21
	Elso silt loam	--	VIe-2	14	4	18	---	---
Hy	Hydro-Fort Collins silt loam, 0 to 2 percent slopes	73						
	Hydro silty clay loam	--	IIIc-1	13	5	19	4	21
	Fort Collins silt loam	--	IIIc-1	13	4	18	2	21
Kc	Keiser silty clay loam, 0 to 2 percent slopes	74	IIIc-1	13	5	19	3	21
Ke	Keiser silty clay loam, 2 to 4 percent slopes	74	IIIe-1	12	5	19	3	21
Kf	Keiser silty clay loam, 4 to 8 percent slopes	74	IIIe-1	12	5	19	3	21
Kl	Kyle clay, 2 to 4 percent slopes	75	IIIe-2	12	5	19	3	21
Km	Kyle clay, 4 to 8 percent slopes	75	IVe-3	14	5	19	3	21
Kn	Kyle clay, 8 to 15 percent slopes	75	VIe-2	14	5	19	3	21
Mc	McRae silt loam, 0 to 2 percent slopes	76	IIIc-1	13	4	18	2	21
Md	McRae silt loam, 2 to 4 percent slopes	76	IIIe-1	12	4	18	2	21
Me	McRae silt loam, 4 to 8 percent slopes	76	IIIe-1	12	4	18	2	21
Mf	Midway silty clay loam, 2 to 8 percent slopes	76	VIe-2	14	5	19	---	---
Mg	Midway-Elso association, 8 to 35 percent slopes	77						
	Midway silty clay loam	--	VIIe-1	15	8	19	---	---
	Elso silty clay loam	--	VIIe-1	15	7	19	---	---
Mw	Midway and Elso rocky soils, 35 to 75 percent slopes	77						
	Midway rocky clay loam	--	VIIe-1	15	12	20	---	---
	Elso rocky silt loam	--	VIIe-1	15	12	20	---	---
	Rock outcrop	--	VIIIs-2	16	---	---	---	---
Mr	Midway-Rock land association, 15 to 35 percent slopes	77						
	Midway silty clay loam	--	VIIe-1	15	8	19	---	---
	Rock land	--	VIIIs-2	16	---	---	---	---
Mt	Midway-Thurlow association, 8 to 15 percent slopes	77						
	Midway silty clay loam	--	VIe-2	14	5	19	---	---
	Thurlow silty clay loam	--	IVe-1	13	5	19	2	21
Nh	Nihill-Elso association, 8 to 15 percent slopes	78						
	Nihill gravelly loam	--	VIe-3	15	4	18	---	---
	Elso silt loam	--	VIe-2	14	4	18	---	---
Oc	Ocean Lake-Rock land association, 15 to 45 percent slopes	79						
	Ocean Lake fine sandy loam	--	VIIe-3	15	6	19	---	---
	Rock land	--	VIIIs-2	16	---	---	---	---
Ra	Rapelje silt loam, 0 to 2 percent slopes	79	IIIc-1	13	3	18	4	21
Rc	Rapelje silt loam, 2 to 8 percent slopes	79	IIIe-1	12	3	18	4	21
Re	Relan loam, 4 to 8 percent slopes	80	IIIe-3	12	3	18	1	21
Rf	Relan association, 5 to 30 percent slopes	80	VIe-1	14	3	18	1	21
Rh	Relan-Cabba association, 4 to 8 percent slopes	80						
	Relan loam	--	IIIe-3	12	3	18	1	21
	Cabba loam	--	IVe-2	14	7	18	---	---
Rk	Relan gravelly loam, gravelly variant, 4 to 8 percent slopes	81	IIIe-3	12	3	18	1	21

GUIDE TO MAPPING UNITS--Continued

Map symbol	Mapping unit	Described on page	Capability unit		Range-soil group		Windbreak suitability group	
			Symbol	Page	Number	Page	Number	Page
Rm	Remmit fine sandy loam, 2 to 4 percent slopes----------	82	IIIe-4	13	2	18	2	21
Rn	Remmit fine sandy loam, 4 to 8 percent slopes----------	82	IVe-4	14	2	18	2	21
Ro	Remmit-Ocean Lake fine sandy loams, 8 to 25 percent slopes----------	82						
	Remmit fine sandy loam----------	--	VIe-3	15	2	18	2	21
	Ocean Lake fine sandy loam----------	--	VIe-3	15	2	18	---	---
Rs	Ringling slaty loam, 20 to 50 percent slopes----------	83	VIIe-2	15	13	20	---	---
Rt	Ringling-Cabba association, 15 to 50 percent slopes----	83						
	Ringling slaty loam----------	--	VIIe-2	15	13	20	---	---
	Cabba silt loam----------	--	VIIe-2	15	7	19	---	---
Ru	Ringling-Relan association, 6 to 25 percent slopes-----	83						
	Ringling slaty loam----------	--	VIIe-2	15	13	20	---	---
	Relan loam----------	--	VIe-1	14	3	18	1	21
Rw	Riverwash----------	83	VIIIw-1	15	---	---	---	---
Sl	Shale outcrop----------	83	VIIIs-2	16	---	---	---	---
Te	Terrace escarpments----------	83	VIIe-1	15	7	19	---	---
Th	Thurlow silty clay loam, 0 to 2 percent slopes---------	84	IIIc-1	13	5	19	2	21
Tm	Thurlow silty clay loam, 2 to 4 percent slopes---------	84	IIIe-1	12	5	19	2	21
To	Thurlow silty clay loam, 4 to 8 percent slopes---------	84	IIIe-1	12	5	19	2	21
Tr	Thurlow silty clay loam, 8 to 15 percent slopes--------	85	IVe-1	13	5	19	2	21
Va	Vananda clay----------	85	VIs-1	15	11	20	5	22
Vo	Vona fine sandy loam, 2 to 4 percent slopes----------	86	IIIe-4	13	2	18	2	21
Vr	Vona-Remmit fine sandy loams, 4 to 8 percent slopes----	86	IVe-4	14	2	18	2	21

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