Series 1960, No. 29

Issued March 1966

SOIL SURVEY

RENO COUNTY

Kansas

UNITED STATES DEPARTMENT OF AGRICULTURE
Soil Conservation Service
In cooperation with
KANSAS AGRICULTURAL EXPERIMENT STATION

HOW TO USE THIS SOIL SURVEY REPORT

THIS SOIL SURVEY of Reno County, Kans., will serve several groups of readers. It will help farmers and ranchers in planning the kind of management that will protect their soils and provide profitable yields; assist engineers in selecting sites for roads, buildings, ponds, and other structures; aid those who wish to establish windbreaks; add to soil scientists' knowledge of soils; and help prospective buyers and others in appraising a farm or other tract.

Locating the Soils

At the back of this report is an index map and a soil map consisting of many sheets. On the index map are rectangles numbered to correspond to the sheets of the soil map, so that the sheet showing any area can be located easily. On each map sheet, the soil boundaries are outlined and there is a symbol for each kind of soil. 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 the area and a pointer shows where it belongs. For example, an area on the map has the symbol Ta. The legend for the set of maps shows that this symbol identifies Tabler clay loam. That soil and all others mapped in the county are described in the section "Descriptions of the Soils."

Finding Information

In the "Guide to Mapping Units, Capability Units, and Range Sites" at the back of this report, each soil is listed in the alphabetic order of its map symbol. This guide gives the page where each soil is described, and the page of the capability unit and range site in which the soil has been placed. It also shows where to find the acreage of each soil, the yields that can be expected, and information about engineering uses of the soils.

Farmers and those who work with farmers can learn about the soils on a farm by reading the description of each soil and of its capability unit and other groupings. A convenient way of doing this is to turn to the soil map and list the soil symbols of a farm and then to use the "Guide to Mapping Units, Capability Units, and Range Sites," in finding the pages where each soil and its groupings are described.

Persons interested in establishing windbreaks can refer to the subsection "Management of Windbreaks." In that subsection the soils in the county are placed in groups according to their suitability for trees, and some factors affecting management are discussed.

Game managers, sportsmen, and others concerned with wildlife will find information about the main kinds of wildlife and their food and cover in the subsection "Use of the Soils for Wildlife."

Ranchers and others interested in range will find the subsection "Management of Rangeland" helpful. In that subsection the soils of the county are placed in groups according to their suitability as rangeland, and the management of each group is discussed.

Engineers and builders will find in the subsection "Engineering Properties of Soils" tables that give engineering descriptions of the soils in the county; name soil features that affect engineering practices and structures; and rate the soils according to their suitability for several kinds of work.

Scientists and others who are interested can read about how the soils were formed and how they were classified in the section "Genesis, Classification, and Morphology of Soils."

Students, teachers, and other users will find information about soils and their management in various parts of the report, depending on their particular interest.

Newcomers in Reno County will be especially interested in the section "General Soil Map," where broad patterns of soils are described. They may also be interested in the section "General Nature of the Area," which gives additional information about the county.

* * * * *

The Reno County Soil Conservation District arranges for farmers to receive technical help from the staff of the Soil Conservation Service with headquarters at Hutchinson, in planning good use and conservation of the soils on their farms. The survey furnishes some of the facts needed for this technical help.

The fieldwork for this survey was completed in 1960. Unless otherwise indicated, all statements in the report refer to conditions in the county at the time the survey was in progress.

Cover picture: An elevator used for storing wheat in Reno County.

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SOIL SURVEY OF RENO COUNTY, KANSAS

BY JAMES J. ROCKERS, IVAN RATCLIFF, LOUIE W. DOWD, AND EDWARD F. BOUSE, SOIL CONSERVATION SERVICE

UNITED STATES DEPARTMENT OF AGRICULTURE IN COOPERATION WITH THE KANSAS AGRICULTURAL EXPERIMENT STATION

RENO COUNTY is in the south-central part of Kansas (fig. 1). The county contains approximately 1,255 square miles. Hutchinson, the county seat, is the largest city.

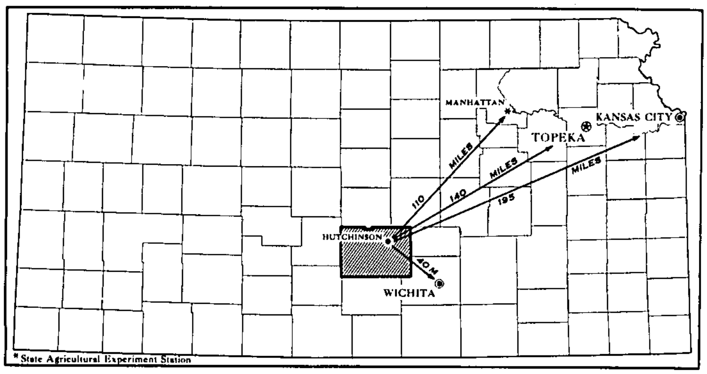

Figure 1.—**Location of Reno County in Kansas.**

This county is within the Great Bend Sand Plains area of the Central Great Plains. The topography is undulating to gently rolling throughout the northwestern and central parts of the county, and the areas adjacent to the major drainageways have slopes of as much as 15 percent. Hummocky sandhills are along the north side of the county. The general slope of the county is from northwest to southeast; the difference in altitude between the northeastern and southeastern corners is about 262 feet.

The Arkansas River is the major stream in the county. It enters the north-central part of the county, flows in a southeasterly direction, and leaves the county about 5 miles east of the town of Haven. The Little Arkansas River, in the northeastern corner of the county, and North Fork Ninnescah River, mainly in the southern part of the county, are other major streams.

This county is primarily agricultural. Wheat is by far the most extensively grown crop, but sorghum and alfalfa are grown on a large acreage. Beef cattle are the main kind of livestock. Hutchinson is a distribution center for food products and has storage and processing facilities for the agricultural products of the area.

Most of the soils of the county are well suited to wheat and grain sorghum. Water erosion is the main hazard on all the cultivated sloping soils that have a surface layer finer than loamy fine sand. Wind erosion is a hazard on all the cultivated soils and is a special problem on the sandy soils.

How This Soil Survey Was Made

Soil scientists made this survey to learn what kinds of soils are in Reno County, where they are located, and how they can be used.

They went into the county knowing they likely would find many soils they had already seen, and perhaps some they had not. As they traveled over the county, they observed steepness, length, and shape of slopes; size and speed of streams; kinds of native plants or crops; 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 by leaching or by roots of plants.

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. To use this report effciently, it is necessary to know the kinds of groupings most used in a local soil classification.

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, 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. Pratt and Vanoss, 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 go with their behavior in the natural, untouched landscape. Soils of one series can differ somewhat in texture of the surface soil and in slope, stoniness, or some other characteristic that affects use of the soils by man.

Many soil series contain soils that differ in texture of their surface layer. According to such differences in texture, separations called soil types are made. Within a series, all the soils having a surface layer of the same texture belong to one soil type. Shellabarger fine sandy loam and Shellabarger loamy fine sand are two soil types in the Shellabarger series. The difference in the texture of their surface layers is apparent from their names.

Some soil types vary so much in slope, degree of erosion, number and size of stones, or some other feature affecting their use, that practical suggestions about their management could not be made if they were shown on the soil map as one unit. Such soil types are divided into soil phases. The name of a soil phase indicates a feature that affects management. For example, Shellabarger fine sandy loam, 0 to 1 percent slopes, is one of several phases of Shellabarger fine sandy loam, a soil type that ranges from nearly level to sloping.

After a guide for classifying and naming the soils had been worked out, the soil scientists drew soil boundaries of the individual soils on aerial photographs. These photographs show buildings, field borders, trees, and other details that greatly help in drawing boundaries accurately. The soil map in the back of this report 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 type or a phase of a soil type. It is not exactly equivalent, because it is not practical to show on such a map all the small, scattered bits of soil of some other kind that have been seen within an area that is dominantly of a recognized soil type or soil phase.

In preparing some detailed maps, the soil scientists have a problem of delineating areas where different kinds of soils are so intricately mixed, and so small in size, that it is not practical to show them separately on the map. Therefore, they show this mixture of soils as one mapping unit and call it a soil complex. Ordinarily, a soil complex is named for the major kinds of soil in it, for example, Pratt-Carwile complex. If two or more soils that normally do not occur in regular geographic association are mapped together, the unit is called an undifferentiated mapping unit and is named for its major soils. An example is Shellabarger and Albion soils, 7 to 15 percent slopes.

Also, on most soil maps, areas are shown that are so rocky, so shallow, or so frequently worked by wind and water that they cannot be called soils. These areas are shown on a soil map like other mapping units, but they are given descriptive names, such as Wet alluvial land, and are called land types rather than soils.

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 a way that it is readily useful to different groups of readers, among them farmers, ranchers, engineers, and homeowners. Grouping soils that are similar in suitability for each specified use is the method of organization commonly used in the soil survey reports. On the basis of yield and practice tables and other data, the soil scientists set up trial groups, and test them by further study and by consultation with farmers, agronomists, engineers, and others. Then, the scientists 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 report shows, in color, the soil associations in Reno County. 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 county, who want to compare different parts of a county, or who want to know the location of large tracts that are suitable for a certain kind of farming or other land use. Such a map is not suitable for planning the management of a farm or field, because the soils in any one association ordinarily differ in slope, depth, stoniness, drainage, and other characteristics that affect management.

The 13 soil associations in Reno County are described briefly in this section. More detailed information about the individual soils in each association can be obtained by studying the detailed soil map and by reading the section "Descriptions of the Soils."

1. Renfrow-Vernon Association

Moderately deep and shallow, reddish soils over clayey shale

In this association are gently sloping to steep reddish soils in areas cut in a few places by drainageways. The soils are moderately deep or shallow over clayey shale. The association occupies a large area in the southeastern part of the county.

Renfrow and Vernon soils (fig. 2) make up about 85 percent of this association. The Renfrow are reddish, acid soils that are moderately deep over clayey shale. The Vernon soils have a profile similar to that of the Renfrow soils, but they are shallower over shale. The deep, reddish Port soils, along drainageways, and shallow nonarable Vernon soils make up the rest of this association.

The Renfrow and Vernon soils do not take in water readily. They have low natural fertility, but crops grown on all the soils of the association respond well to fertilizer. Runoff is high and erosion is a hazard.

Wheat and grain sorghum are the main crops grown in this association. Alfalfa is grown to some extent on the Port soils.

2. Nash-Lucien Association

Moderately deep and shallow, reddish soils over siltstone and soft sandstone

This association consists of reddish soils that are gently sloping to steep and of soils in rough, broken areas. The

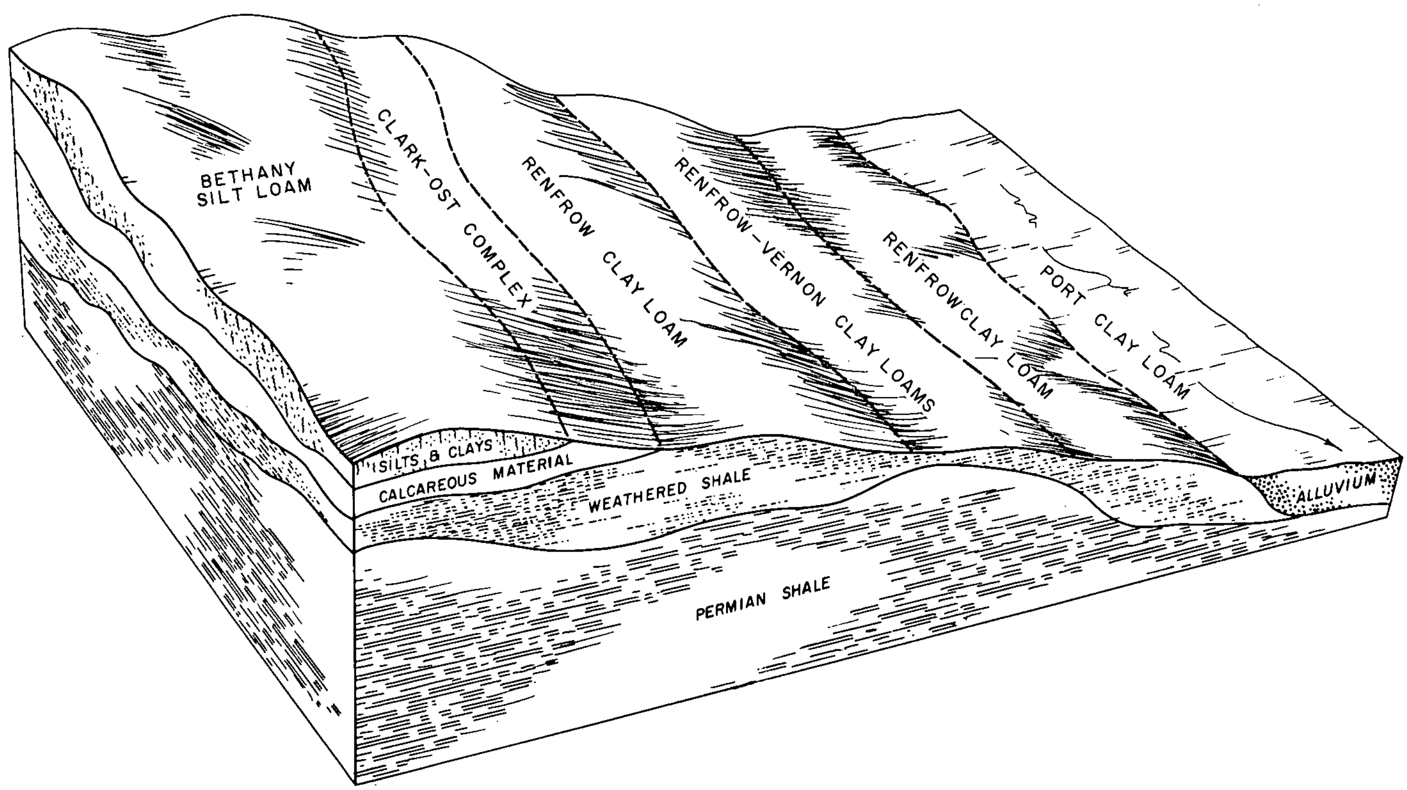

***Figure 2.*—Cross section of the Renfrow-Vernon association downslope from the Clark-Ost association.**

soils are moderately deep to shallow over siltstone and soft sandstone. The association is in the south-central part of the county.

Gently sloping to steep Nash and Lucien soils (fig. 3) make up about 90 percent of the association, and other Lucien soils in rough, broken areas make up nearly 10 percent. Deep, silty, friable Vanoss soils occupy a minor acreage in the more gently sloping areas. The Nash soils are reddish, moderately deep, and friable. The Lucien soils are also reddish, but they are calcareous and are shallow over siltstone.

The moisture-storing capacity of the Nash and Lucien soils is limited. Runoff is high on those soils, and erosion is a hazard. Crops grown on this association respond well to a fertilizer high in nitrogen.

Wheat is the main crop grown on the Nash and Lucien soils, and sorghum, wheat, and alfalfa are the main crops grown on the Vanoss soils. The steeper areas of the association are used mostly for native grass pasture.

3. Clark-Ost Association

Deep, dark soils over highly calcareous loamy material

In this association are dark, nearly level to moderately sloping soils that are deep over highly calcareous loamy material. In some of the areas, the slopes are complex. The association is within the watershed of the North Fork of the Ninnescah River and lies just above the Renfrow-Vernon and Nash-Lucien associations (fig. 4).

About 95 percent of this association is Clark and Ost soils, and the rest is Bethany soils. The Clark soils are dark grayish brown and are calcareous. The Ost soils are darker colored than the Clark, and they have a calcareous subsoil.

Lime is not needed on the soils of this association, but crops respond well to phosphate and to fertilizer high in nitrogen. Water erosion is a hazard in the steeper areas.

Wheat and alfalfa are the main crops, but grain sorghum is grown on the smoother areas that are only slightly eroded. On the more eroded, highly calcareous areas, grain sorghum is affected by chlorosis, and yields are lower.

4. Farnum-Shellabarger Association

Deep, brownish, loamy soils over somewhat sandy or gravelly material on sloping and dissected outwash plains

Nearly level to moderately sloping, brownish soils within areas of sloping, dissected outwash plains make up this association. The association occupies a large area along the southern boundary of the county.

Deep Farnum and Shellabarger soils make up about 75 percent of this association; Albion soils that are shallow over gravel make up about 10 percent; and Carwile and Pratt soils and Breaks and Alluvial land along drainageways make up the rest. The Farnum soils are grayish brown and slightly acid, and the Shellabarger soils are brownish and are also slightly acid. Both the Farnum and Shellabarger soils are underlain by somewhat sandy material, but the Farnum soils are less sandy than the Shellabarger.

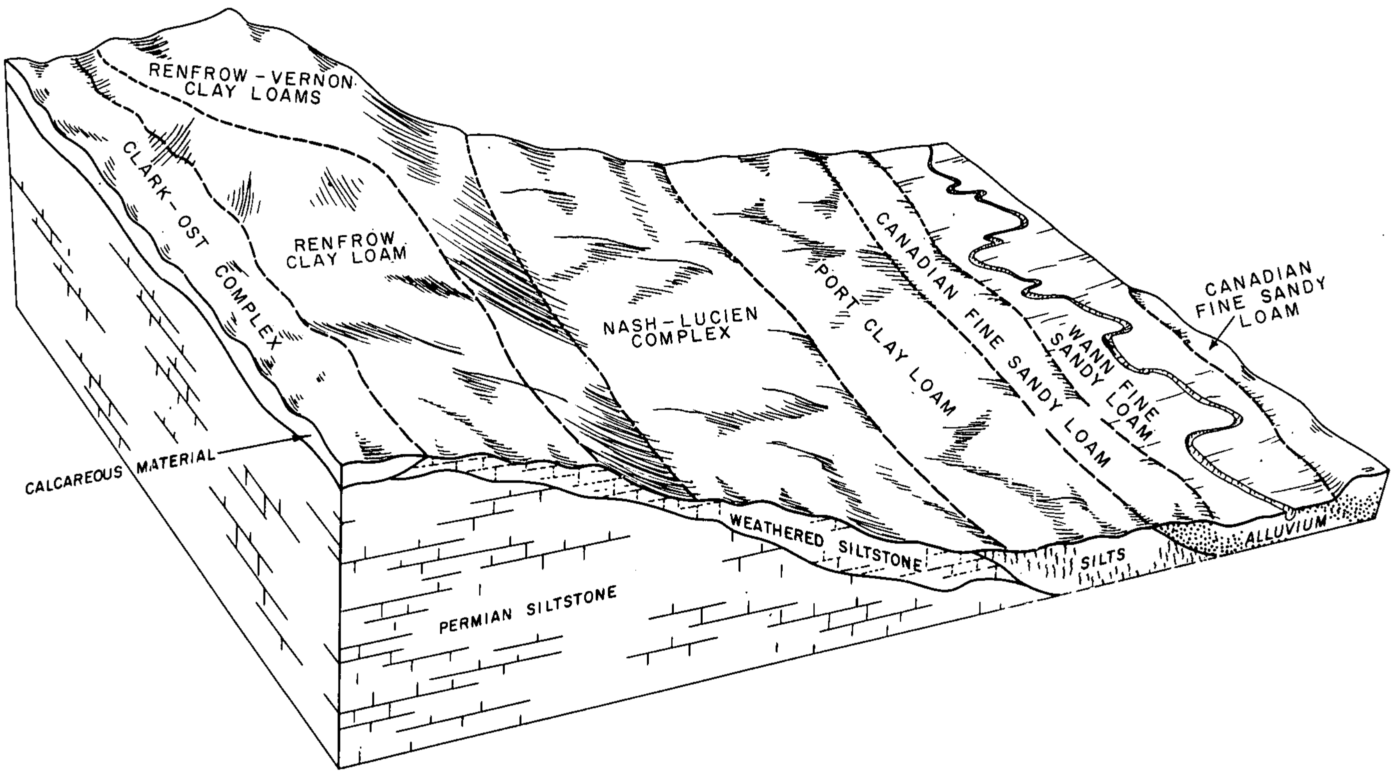

Figure 3.—Cross section of the Nash-Lucien association in the south-central part of the county.

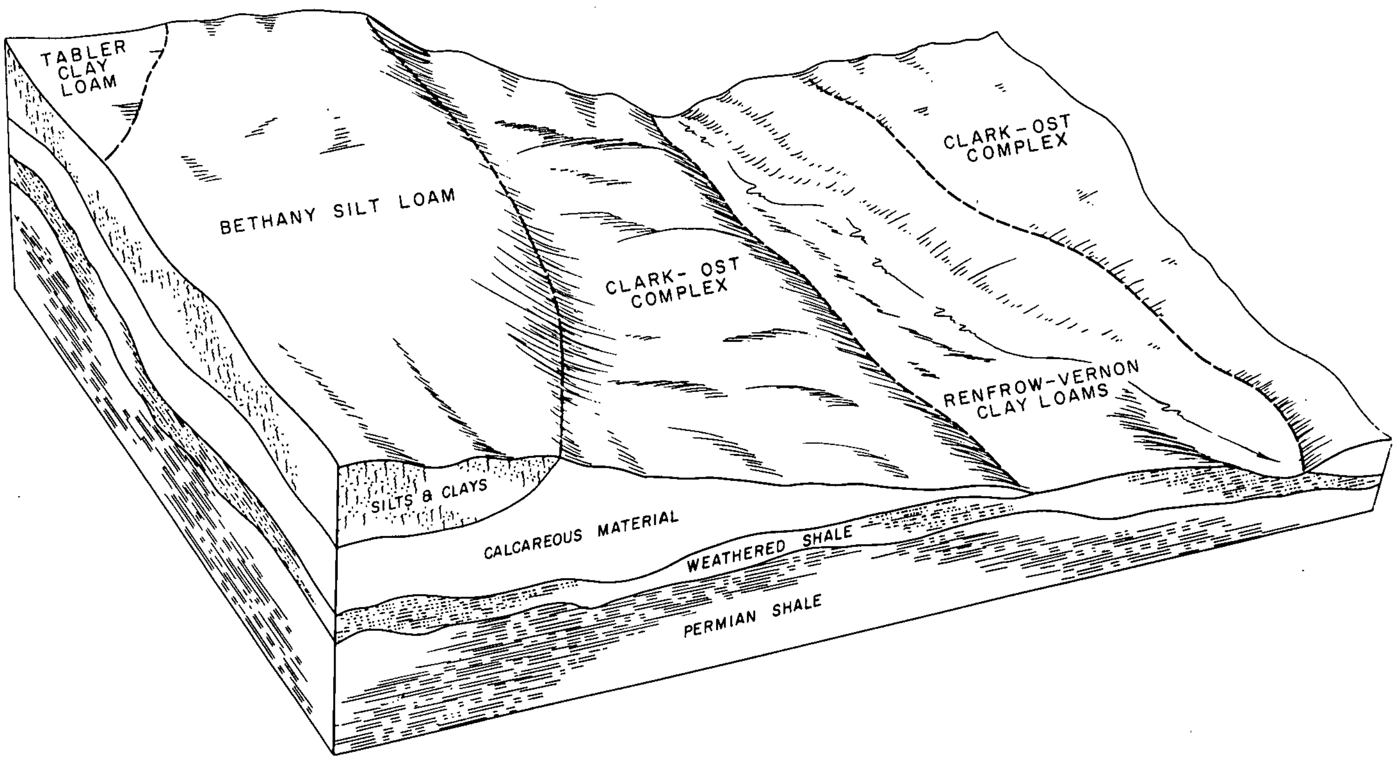

Figure 4.—Cross section of the Clark-Ost association showing the topographic relationship of the Clark and Ost soils to the soils of the Renfrow-Vernon association.

Wind and water erosion are a hazard on the soils of this association. Also, the Albion soils are droughty.

Small grains, sorghum, and alfalfa are all grown on this association, and much of the acreage of Albion soils has been reseeded to native grass. The areas of Breaks and Alluvial land along the small streams are mostly in native grass.

5. Farnum-Naron Association

Deep, brownish, nearly level to undulating, loamy soils on somewhat sandy, wind-modified plains

In this association are brownish soils that are deep and loamy. The soils are underlain by somewhat sandy material and are on plains where the relief has been modified by wind. The areas are mainly nearly level or undulating, but some areas in the southern part of the association are sloping. This association occupies a large area that extends from the north-central boundary of the county through the central part.

Dark grayish-brown, slightly acid Farnum soils and grayish-brown, neutral Naron soils make up about 75 percent of this association. The Naron soils contain less clay than the Farnum soils. Deep, nearly level or gently sloping, dark-colored Bethany soils, and nearly level, dark-colored Tabler soils that have a thin surface layer and a clayey subsoil, make up about 20 percent of this association. The rest of the association consists of small areas of other soils.

Crops grown on the main soils of this association respond well to fertilizer. Lime is needed if legumes are grown on any of the soils except the Naron. Erosion by wind and water is a hazard in the more sloping parts of the association, and wind erosion is a minor hazard on the Naron soils. Wheat, sorghum, and alfalfa are the main crops.

6. Bethany-Tabler Association

Deep, dark, nearly level to gently sloping, loamy soils that have a clayey subsoil

Nearly level or gently sloping, dark soils are in this association. The soils are loamy and have a clayey subsoil. The association occupies a small area in the northeastern part of the county.

Bethany and Tabler soils make up about 90 percent of this association. They are deep and dark colored, but the surface layer of the Bethany soils is thick and that of the Tabler soils in thin. Deep, reddish Smolan soils and deep, brownish Vanoss soils make up about 10 percent of this association. The Smolan and Vanoss soils are steeper than the Bethany and Tabler soils, and they occupy slopes along the valley of the Little Arkansas River. The Smolan soils have a thin surface layer and are less friable than the Vanoss.

The soils of this association have moderate natural fertility, but crops grown on them respond well to fertilizer in most years. Lime is needed if legumes are grown. The Smolan soils are especially susceptible to water erosion, but for that matter, water erosion is a serious hazard on all the sloping areas. Wheat, sorghum, and alfalfa are the crops commonly grown.

7. Vanoss-Bethany Association

Deep, dark, nearly level to moderately sloping, loamy soils on wind-deposited material

This association consists of nearly level to moderately sloping, dark soils developed in material deposited by wind. It occupies areas in the north-central and eastern parts of the county.

Deep, brownish Vanoss soils that are loamy and friable make up about 90 percent of the association. Most of the rest of the association consists of deep, dark Bethany soils, but there is a small acreage of Clark soils.

The Vanoss soils have high natural fertility, but the use of commercial fertilizer is profitable when these soils are used for wheat or sorghum. The Bethany soils have moderate to high natural fertility. Water erosion is a hazard on the moderately sloping areas of the association. Wheat, sorghum, and alfalfa are well-suited crops.

8. Canadian-Dale Association

Deep, nearly level, loamy soils of the flood plains and low stream terraces

In this association are loamy soils in alluvium on flood plains and low stream terraces in the valleys of the Arkansas and Ninnescah Rivers. The soils are nearly level. Those on flood plains are flooded occasionally if they are not protected by dikes.

Dark grayish-brown Canadian soils and dark-gray Dale soils make up about 70 percent of the association; Vanoss and Lesho soils make up about 15 percent; and Slickspot, Wann, and Platte soils make up approximately another 15 percent. The Canadian soils are well drained fine sandy loams, and the Dale are moderately well drained or well drained clay loams. The Vanoss are well drained silt loams underlain by clayey material, and the Lesho are somewhat poorly drained clay loams that are moderately shallow over gravel. The Wann, Platte, and Slickspot soils have a water table within a few feet of the surface.

The Canadian soils are especially low in nitrogen, but phosphate and a fertilizer high in nitrogen are needed on all the soils for the best production of crops. Wind erosion is a hazard, and wetness is a hazard on the finer textured soils.

Wheat and sorghum are grown on this association, and alfalfa is grown, mainly on the areas that are seldom flooded. The areas of Slickspots are used mainly for growing grain sorghum.

9. Slickspots-Farnum Association

Deep, imperfectly drained, saline-alkaline soils that have a loamy to clayey subsoil

Nearly level, imperfectly drained saline-alkaline soils make up this association. The areas are within the watershed of Salt Creek in the central part of the county, and along Peace Creek in the northwestern part.

Somewhat poorly drained saline-alkaline Slickspot soils make up about 60 percent of the association; Farnum and Tabler soils make up about 20 percent; Naron, Clark, and Ost soils make up about 15 percent; and small areas of soils severely affected by salts and alkali make up about 5 percent. The Slickspot soils have a surface layer of grayish-brown sandy loam to clay loam and a clayey subsoil. The Farnum and Tabler soils have a clayey subsoil that contains salts and alkali. The small areas of soils severely affected by salts and alkali are more numerous in some areas than in others. Most of this association is in grass.

10. Pratt-Carwile Association

Deep, nearly level, imperfectly drained soils that have a clayey subsoil, and well-drained, sandy, hummocky soils

In this association are nearly level and gently undulating to hummocky, deep soils of the uplands. The areas are in the western part of the county.

About 40 percent of the association is Pratt soils, about 35 percent is Carwile soils, about 20 percent is Naron soils, and about 5 percent is Tivoli soils. Both the Pratt and Carwile soils are grayish brown, but the Pratt soils have a surface layer of loamy fine sand and a subsoil of light fine sandy loam. The Carwile soils have a surface layer of fine sandy loam and a subsoil of clay to silty clay loam. The Naron soils are dark grayish-brown fine sandy loams that have a subsoil of sandy clay loam, and the Tivoli soils are hummocky fine sands.

Crops grown on these soils respond well to fertilizer, especially to a fertilizer high in nitrogen. In most of the association, the soils are cultivated, but the Tivoli soils are mainly in grass. Grain sorghum and wheat are commonly grown in the cultivated areas, but sorghum is better suited than wheat because of the hazard of wind erosion.

11. Elsmere-Tivoli Association

Deep, nearly level, imperfectly drained, sandy soils and excessively drained, hilly, sandy soils

This association consists of nearly level, imperfectly drained soils and hummocky areas of excessively drained soils. The areas are in the northern part of the county.

Deep, sandy Elsmere soils that have a high water table, and sandy Plevna soils, which have a loamy to clayey subsoil and a high water table, make up about 75 percent of the association. Deep, excessively drained Tivoli fine sands make up about 15 percent, and soils that have a profile intermediate between that of the excessively drained Tivoli soils and the somewhat poorly drained soils of the association make up the rest. The Tivoli soils are in rough, hummocky areas that resemble dunes.

The Elsmere and Plevna soils are excellent for grass. Wind erosion is a likely hazard if the areas of Tivoli soils are overgrazed. Nearly all of the association is in grass.

12. Plevna-Slickspots Association

Nearly level to gently sloping, poorly drained, loamy soils that have a high water table, and poorly drained saline-alkali soils that have a clayey subsoil

Nearly level to gently sloping soils that have a high water table, and wet saline-alkali soils that have a clayey subsoil, make up this association. The association is along the North Fork Ninnescah River and its tributaries, in the south-central part of the county.

Plevna fine sandy loam makes up about 75 percent of the association, Slickspot soils about 15 percent, and Wet alluvial land about 10 percent. The Plevna soils have a loamy subsoil and a high water table. The Slickspot soils are wet and clayey and have been affected by alkali. Wet alluvial land consists of areas that are near the streams and that are flooded occasionally.

The Plevna soils are well suited to grass, and a fairly large amount of forage is produced on the Slickspot soils under proper management. Nearly all of the association is in grass.

13. Carwile-Tabler Association

Deep, dark, nearly level, imperfectly drained soils that have a loamy surface layer and a clayey subsoil

In this association are nearly level, dark soils that are somewhat poorly drained. The association is in the valley of the Arkansas River and is also adjacent to the Little Arkansas River. It is north and east of Hutchinson.

Carwile soils make up about 60 percent of the association, and Tabler soils about 5 percent. The rest of the association is about 15 percent Vanoss soils and about 20 percent Naron soils, Slickspot soils, and Farnum soils. The Carwile soils have a sandy surface layer and a clayey, mottled subsoil, and the Tabler soils have a loamy, thin surface layer and a clayey subsoil. The Vanoss soils have a clayey substratum.

Most of this association is cultivated, and wheat, sorghum, and alfalfa are the crops commonly grown. In spring, wind erosion is a hazard on the sandy soils. In some years, wetness is a hazard on the Carwile and Tabler soils.

Descriptions of the Soils

In this section the soil series in Reno County are described in alphabetic order, and a typical profile is described briefly for each series. Each mapping unit is then discussed, and characteristics of its profile that are different from those of the typical profile are pointed out. Unless otherwise indicated, the color described is that of a dry soil. A more detailed description of a profile that is typical for each series is given in the section "Genesis, Classification, and Morphology of Soils." Terms used to describe the soils and that may not be familiar to the reader are defined in the Glossary at the back of the report.

The approximate acreage and proportionate extent of the soils are shown in table 1. Their location is shown on the detailed soil map at the back of the report. In the soil descriptions the symbol in parentheses after the name of the mapping unit identifies the mapping unit on the detailed soil map.

At the back of the report is given a list of the mapping units in the county and the capability unit and range site each is in. The page where each of the capability units or range sites is described is also given.

Albion Series

In the Albion series are dark-brown sandy soils underlain by sand or gravel at a depth of about 36 inches. These

TABLE 1.—*Approximate acreage and proportionate extent of the soils*

Soil	Acres	Percent
Albion-Shellabarger sandy loams, 0 to 1 percent slopes	1, 307	0. 2
Albion-Shellabarger sandy loams, 1 to 4 percent slopes	19, 940	2. 5
Bethany silt loam, 0 to 1 percent slopes	16, 407	2. 0
Bethany silt loam, 1 to 3 percent slopes	10, 730	1. 3
Breaks-Alluvial land complex	6, 010	. 7
Canadian fine sandy loam	18, 853	2. 3
Carwile fine sandy loam	22, 196	2. 8
Carwile-Farnum fine sandy loams	35, 885	4. 5
Clark fine sandy loam	1, 115	. 1
Clark-Ost complex, 0 to 1 percent slopes	7, 881	1. 0
Clark-Ost complex, 1 to 3 percent slopes	19, 642	2. 4
Clark-Ost complex, 3 to 6 percent slopes	1, 098	. 1
Dale clay loam	6, 487	. 8
Elsmere-Plevna complex	13, 108	1. 6
Elsmere-Tivoli complex	36, 402	4. 5
Farnum fine sandy loam, 0 to 1 percent slopes	7, 384	. 9
Farnum loam, 0 to 1 percent slopes	55, 256	6. 9
Farnum loam, 1 to 3 percent slopes	25, 599	3. 2
Farnum-Slickspot complex	18, 411	2. 3
Farnum-Tabler complex	6, 125	. 8
Lesho clay loam	3, 951	. 5
Naron fine sandy loam, 0 to 1 percent slopes	14, 180	1. 8
Naron fine sandy loam, 1 to 3 percent slopes	9, 496	1. 2
Naron-Farnum complex	16, 795	2. 1
Naron-Pratt complex	23, 615	2. 9
Nash-Lucien complex, 1 to 3 percent slopes	4, 461	. 6
Nash-Lucien complex, 3 to 6 percent slopes	606	. 1
Nash-Lucien complex, 6 to 15 percent slopes	2, 106	. 3
Platte soils	7, 510	. 9
Plevna fine sandy loam	19, 385	2. 4
Port clay loam	1, 424	. 2
Pratt loamy fine sand, undulating	30, 877	3. 8
Pratt loamy fine sand, hummocky	3, 361	. 4
Pratt-Carwile complex	28, 475	3. 5
Renfrow clay loam, 0 to 1 percent slopes	2, 801	0. 3
Renfrow clay loam, 1 to 3 percent slopes	15, 243	1. 9
Renfrow-Vernon clay loams	15, 238	1. 9
Shellabarger fine sandy loam, 0 to 1 percent slopes	13, 646	1. 7
Shellabarger fine sandy loam, 1 to 3 percent slopes	65, 736	8. 2
Shellabarger fine sandy loam, shale substratum, 0 to 3 percent slopes	7, 396	. 9
Shellabarger loamy fine sand, undulating	1, 959	. 2
Shellabarger and Albion soils, 7 to 15 percent slopes	5, 478	. 7
Shellabarger-Clark-Albion complex, 2 to 6 percent slopes	5, 315	. 7
Shellabarger-Farnum complex, 1 to 3 percent slopes	27, 094	3. 4
Shellabarger and Farnum soils, 3 to 7 percent slopes, eroded	1, 891	. 2
Slickspots	16, 590	2. 1
Smolan silty clay loam, 1 to 3 percent slopes	1, 657	. 2
Smolan silty clay loam, 3 to 6 percent slopes, eroded	676	. 1
Tabler clay loam	20, 150	2. 5
Tabler-Slickspot complex	4, 285	. 5
Tivoli fine sand, hilly	4, 543	. 6
Tivoli soils, hummocky	9, 989	1. 2
Vanoss silt loam, 0 to 1 percent slopes	30, 702	3. 8
Vanoss silt loam, 1 to 3 percent slopes	25, 409	3. 2
Vanoss silt loam, 3 to 7 percent slopes, eroded	758	. 1
Vernon soils	8, 134	1. 0
Wann fine sandy loam	13, 816	1. 7
Wet alluvial land	4, 838	. 6
Water (rivers and lakes)	3, 778	. 5
Total acreage	803, 200	99. 8

soils are in the southern and southwestern parts of the county.

In most places the surface layer is grayish-brown fine sandy loam about 8 inches thick. The subsoil is brown to reddish-brown light sandy clay loam about 19 inches thick. The substratum is loose sand or gravel. The combined thickness of the surface layer and subsoil ranges from 15 to 36 inches.

These soils are well drained to somewhat excessively drained. They have low natural fertility and very low water-holding capacity.

In Reno County the Albion soils are mapped only in complexes with the Shellabarger and Clark soils. They have a more sandy or gravelly substratum than the Shellabarger soils.

Most of the acreage of Albion soils is cultivated, and wheat is the principal crop. However, these soils are probably best suited to grass.

Albion-Shellabarger sandy loams, 0 to 1 percent slopes (Ab).—From 50 to 75 percent of this complex is Albion fine sandy loam, and from 25 to 50 percent is Shellabarger sandy loam. The Shellabarger soil occurs in bands, or stringers, within larger areas of Albion soils; therefore, mapping the soils separately was not practical. The profile of the Albion soil is like the one described for the series. The Shellabarger soil has a more sandy profile than that described as typical for the Shellabarger series, and it is underlain by sand at a depth of 36 to 50 inches.

These soils are susceptible to wind erosion. (Both soils are in capability unit IIIs–1 and Sandy range site; Albion soil is in windbreak suitability group 8, and Shellabarger soil is in windbreak suitability group 4)

Albion-Shellabarger sandy loams, 1 to 4 percent slopes (As).—From 40 to 60 percent of this complex is Albion soils, and the rest is Shellabarger soils. The profile of the Albion soil is like the one described for the series. The Shellabarger soil has a more sandy profile than that described as typical for the Shellabarger series, and it is underlain by sand at a depth of 36 to 50 inches.

Erosion by water and wind is a serious hazard where these soils are not protected. The soils are better suited to grass than to cultivated crops. A large acreage has been reseeded to native grass, but wheat is still grown on a large acreage. (Both soils are in capability unit IVe–3 and Sandy range site; Albion soil is in windbreak suitability group 8, and Shellabarger soil is in windbreak suitability group 4)

Bethany Series

The Bethany series consists of deep, dark grayish-brown silt loams of the uplands. These soils are mostly in the southeastern and northeastern parts of the county.

In most places the surface layer is dark grayish-brown, friable silt loam about 17 inches thick. Generally, the subsoil is silty clay that has angular blocky structure and is about 21 inches thick. The substratum is somewhat lighter textured than the subsoil, and in it concretions of calcium carbonate are common.

The thickness of the surface layer ranges from 12 to about 24 inches. The thickness of the subsoil ranges from 18 to about 36 inches.

Because of their thick silty surface layer, these soils take in and store enough moisture for good growth of plants, although their subsoil is slowly permeable. In places they may need lime if legumes are grown, even though the lower part of the subsoil and the substratum contain free lime. Natural fertility is medium to high.

The Bethany soils have a thicker surface layer and a somewhat less clayey subsoil than the Tabler soils. They are more clayey than the Vanoss soils.

Nearly all of the acreage of Bethany soils is cultivated, and wheat, alfalfa, and grain sorghum are the principal crops. Native grass is well suited.

Bethany silt loam, 0 to 1 percent slopes (Ba).—This soil occurs mainly in large areas. In most places it has a profile similar to the one described for the series, but the surface layer is loam in areas adjacent to the Vanoss or Shellabarger soils. Lack of moisture is the main limitation to the use of this soil. (Capability unit IIc–1, Loamy Upland range site, windbreak suitability group 2)

Bethany silt loam, 1 to 3 percent slopes (Be).—The surface layer of this soil is about 2 inches thinner than that in the profile described as typical for the series. In most places the slopes are about 2 percent.

Included in the areas mapped as this soil are small areas of Ost and Smolan soils. The included soils make up about 5 percent of the acreage in the mapping unit.

This Bethany soil is suited to all the crops commonly grown in the county. Good management includes returning all crop residue to the soil and using fertilizer according to the results of soil tests and field trials. (Capability unit IIe–3, Loamy Upland range site, windbreak suitabilty group 2)

Breaks-Alluvial Land Complex (Bk)

This land type consists of narrow areas of soils formed in alluvium and of soils on steep and broken side slopes of upland drains. These soils vary in texture but most are loams or clay loams. In most places the soils formed in alluvium are loam over sandy layers and are frequently flooded; the soils on the side slopes are well drained.

Nearly all of this land type is used for range, and big bluestem, switchgrass, indiangrass, and other tall grasses are native to the site. Good range management includes controlling weeds and stocking livestock at a proper rate. (Breaks is in capability unit VIe–5, Loamy Upland range site, and windbreak suitability group 4; Alluvial land is in capability unit VIw–1, Loamy Lowland range site, and windbreak suitability group 7)

Canadian Series

The Canadian series consists of deep, dark grayish-brown fine sandy loams. These soils are mainly in river valleys, but they also occupy small areas near the smaller permanent streams. They occur above areas ordinarily flooded.

In most places the surface layer is dark grayish-brown fine sandy loam about 24 inches thick. It is slightly acid or neutral in most places. Below the surface layer is a transitional layer similar to the surface layer in texture. The color of the transitional layer is mainly brown to yellowish brown, but there are a few brownish mottles in places. The substratum, normally at a depth of 40 to 54 inches, has a coarser texture than the material above. In some areas its texture is light loamy sand or sand.

These soils are subject to wind erosion, especially in spring when the cover of plants is sparse. They are moderately fertile. The water table is usually at a depth of 5 to 10 feet, but it may be higher or lower, depending on the level of the water in the river.

The Canadian soils are less clayey than the Dale soils. They are better drained and less mottled than the Wann soils, and their substratum is at a greater depth.

In this county most of the acreage of Canadian soils is cultivated. Forage sorghum, grain sorghum, alfalfa, and wheat are all well-suited crops, but tall native grasses are also adapted to these soils.

Canadian fine sandy loam (Ca.)—This is the only Canadian soil mapped in this county. It is nearly level. Included in the areas mapped as this soil is a small acreage of Wann fine sandy loam, Dale clay loam, and Lesho clay loam.

A growing crop or crop residue should be maintained on the surface to control wind erosion. Fertilizer ought to be applied according to the needs indicated by soil tests and field trials. For the best yields of alfalfa, lime may be necessary. (Capability unit IIe–1, Sandy Lowland range site, windbreak suitability group 7)

Carwile Series

In the Carwile series are deep, dark-colored soils that have a surface layer of fine sandy loam. These soils occur throughout the county but are mainly in the east-central and west-central parts.

The surface layer is grayish-brown fine sandy loam about 19 inches thick. It is slightly acid and is noticeably mottled below a depth of 12 to 15 inches. The subsoil is mottled and is generally grayish-brown clay in the upper part and light olive-gray silty clay loam in the lower part.

The clayey subsoil restricts the downward movement of water; this is desirable in dry periods, but during wet periods the excess water in the soil is likely to be harmful to crops. Wind erosion is a serious hazard in spring, and in many years it is a more serious problem than wetness. These soils are moderately fertile.

The Carwile soils are more clayey below the surface layer than the Pratt or Naron soils.

Nearly all of the acreage of Carwile soils is cultivated, and wheat and sorghum are the main crops. These soils are well suited to wheat and sorghum, and they are also well suited to native grass.

Carwile fine sandy loam (Cd).—This soil has a profile similar to the one described for the series, but the surface layer ranges from 8 to 22 inches in thickness. The soil is nearly level to gently sloping. Small areas of Shellabarger fine sandy loam, Naron fine sandy loam, Pratt loamy fine sand, and Farnum loam are included in the areas mapped as this soil.

Some areas of Carwile soil can be improved by drainage. Also, crop residue should be incorporated into the surface layer to improve the content of organic matter and the tilth. (Capability unit IIw-2, Sandy range site, windbreak suitability group 3)

Carwile-Farnum fine sandy loams (Cf).—Carwile fine sandy loam makes up about 55 percent of this mapping unit, and Farnum fine sandy loam about 35 percent. Areas of Farnum loamy fine sand and small areas of Pratt loamy fine sand and Shellabarger fine sandy loam make up the rest. Farnum loamy fine sand is not mapped separately in this county. The profile of the Carwile soil is similar to the profile described for the series. A profile that is typical of the Farnum soil is described under the Farnum series.

The Carwile soil is imperfectly drained, and artificial drainage is needed for the best yields. The Farnum soil is subject to wind erosion; therefore, stubble mulching should be used to control soil blowing and to maintain good tilth. For high yields, apply fertilizer according to the needs indicated by soil tests and field trials. (Carwile soil is in capability unit IIw-2, Sandy range site, and windbreak suitability group 3; Farnum soil is in capability unit IIe-4, Sandy range site, and windbreak suitability group 2)

Clark Series

The Clark series consists of deep, dark-colored, calcareous soils of the uplands. These soils are nearly level to sloping or undulating. They are mainly in the southern part of the county.

In most places the surface layer is dark grayish-brown calcareous loam that has granular structure and is about 10 inches thick. The subsoil is lighter colored than the surface layer but has similar texture and structure and is about 8 inches thick. It is transitional from the surface layer to the substratum and contains chunks of lime. The substratum is brownish and is calcareous. It also contains chunks of lime in most places. Its texture and structure are similar to those of the surface layer and subsoil.

The surface layer ranges from about 4 to 14 inches in thickness and from fine sandy loam to clay loam in texture. It is generally calcareous at the surface, but it is noncalcareous to a depth of 12 inches in places.

The Clark soils are well drained. Their capacity to hold water for plant use is good.

The profile of the Clark soils is similar to that of the Ost soils. The Clark soils have a less clayey subsoil than the Ost soils, however, and they are calcareous nearer the surface.

Most of the acreage of Clark soils in this county is cultivated, and wheat is the main crop. Sorghum, alfalfa, and native grass are also suited.

Clark fine sandy loam (Ck).—This soil is nearly level. Its surface layer is calcareous and is about 11 inches thick. Immediately below the surface layer is granular loam about 12 inches thick. The substratum is light-brown, highly calcareous, granular loam.

In places small areas of Clark loam and Shellabarger fine sandy loam are included in the areas mapped as this soil. Clark loam is not mapped separately in this county.

Wind erosion is a hazard, and a growing crop or crop residue should be kept on the surface to control soil blowing. Sorghum grown on this soil is likely to be affected by lime-induced chlorosis. (Capability unit IIc-2, Limy Upland range site, windbreak suitability group 4)

Clark-Ost complex, 0 to 1 percent slopes (Cm).—About 55 percent of this complex is Clark loam and clay loam, and the rest is Ost loam and clay loam. The profile of the Clark soil is similar to the one described for the Clark series. A profile of the Ost soil is described under the Ost series.

These soils are suited to all the crops commonly grown in the county, and good yields are obtained under proper management. Stubble mulching will help to control soil blowing. The proper kinds and amounts of fertilizer should be applied to insure good yields. (Both soils are in capability unit IIc-2 and windbreak suitability group 4; Clark soil is in the Limy Upland range site, and Ost soil is in the Loamy Upland range site)

Clark-Ost complex, 1 to 3 percent slopes (Co).—Clark loam and clay loam make up about 70 percent of this complex, and Ost loam and clay loam make up the rest. These soils are similar to the soils of Clark-Ost complex, 0 to 1 percent slopes, except that the surface layer of the Clark soil is only about 8 inches thick.

These soils are suited to all the crops commonly grown in the area. Construct terraces and practice contour farming on the smooth, regular slopes, and keep a good cover of sod on the terrace outlets. Apply nitrogen fertilizer to increase the yields of wheat. (Both soils are in capability unit IIIe-5 and windbreak suitability group 4; Clark soil is in Limy Upland range site, and Ost soil is in Loamy Upland range site)

Clark-Ost complex, 3 to 6 percent slopes (Cp).—The soils of this complex are similar to those of Clark-Ost complex, 1 to 3 percent slopes. The surface layer is only about 6 inches thick, however, in about 30 percent of the acreage. Where these soils have been plowed, the present surface layer is light-colored, calcareous material from the subsoil (fig. 5).

These soils are subject to water erosion and are better suited to native grass than to cultivated crops; the areas in native grass should not be overgrazed. If cultivated crops are grown, construct terraces and grassed water-

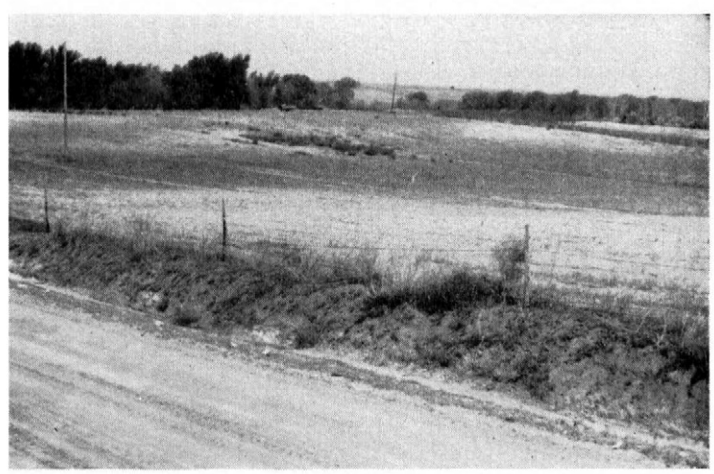

Figure 5.—**Soils of Clark-Ost complex, 3 to 6 percent slopes. The light-colored areas are highly calcareous.**

ways. Also, stubble mulch all crop residue and apply fertilizer according to the needs indicated by soil tests. (Both soils are in capability unit IVe-5 and windbreak suitability group 4; Clark soil is in Limy Upland range site, and Ost soil is in Loamy Upland range site)

Dale Series

In the Dale series are dark-brown to grayish-brown soils formed in alluvium. These soils have granular structure and are calcareous at a depth of about 15 inches. They are mainly in the valley of the Arkansas River.

In most places the surface layer is dark grayish-brown, friable clay loam about 11 inches thick. Immediately below the surface layer is a layer of dark grayish-brown clay loam that is transitional to the substratum. This layer is weakly calcareous and is faintly mottled. The substratum is at a depth of 40 to 50 inches and is loose, yellowish-brown sand or stratified sand and gravel. The surface layer ranges from 8 to 20 inches in thickness.

These soils are fertile and are moderately well drained. The water table is near the top of the substratum, and the extra moisture it provides is beneficial to plants growing on these soils. Occasional flooding is a hazard.

Dale soils are better drained and less frequently flooded than Lesho soils. They are more clayey than Canadian or Wann soils.

Nearly all of the acreage of Dale soils is cultivated. Sorghum, alfalfa, and wheat are all well-suited crops.

Dale clay loam (Da).—This is the only Dale soil mapped in the county. It is nearly level. Included in the areas mapped as this soil are small areas of Lesho clay loam and Vanoss silt loam.

This Dale soil is one of the best soils in the county for alfalfa. Where practical, the wet areas ought to be drained, however, and fertilizer ought to be applied according to the results of soil tests. Also, return all crop residue to the soil to maintain the content of organic matter and to improve soil tilth. (Capability unit IIw-1, Loamy Lowland range site, windbreak suitability group 7)

Elsmere Series

The Elsmere series consists of sandy soils that are imperfectly drained and are underlain by a clayey substratum. These soils are in the sandhill areas, mainly in the northwestern and northeastern parts of the county.

These soils consist of loamy sand to a depth of about 50 inches. In most places the surface layer has been darkened by organic matter to a depth of about 4 to 10 inches, and it is typically grayish brown. The rest of the profile is light yellowish brown or very pale brown. Mottles of strong brown and reddish brown are within 5 inches of the surface, and bands of more clayey material are below a depth of about 50 inches in many places.

Depth to the water table ranges from 18 inches to about 5 feet. The depth depends on the weather and the season of the year.

Elsmere soils are more sandy than Plevna soils.

Nearly all of the acreage of Elsmere soils is in native grass. These soils are used for range or meadow.

Elsmere-Plevna complex (Ep).—This complex is in nearly level areas or in slight depressions and occurs in the sandhill areas with the soils of the Elsmere-Tivoli complex. It is made up of about 60 percent Elsmere loamy fine sand and about 40 percent Plevna loamy fine sand, but humps of Pratt loamy fine sand, undulating, about 3 to 4 feet high, are also included in some areas. The profile of the Elsmere soil is like the one described for the Elsmere series. The profile of the Plevna soil is like the one described for the Plevna series, except that the surface layer is loamy fine sand in most places.

These soils support an excellent growth of tall native grass. Almost all of the acreage is in grass and is used for range. (Both soils are in capability unit Vw-1 and Subirrigated range site; the Elsmere soil was not placed in a windbreak suitability group; the Plevna soil is in group 9)

Elsmere-Tivoli complex (Et).—This complex consists of Elsmere loamy fine sand and Tivoli fine sand, hilly. The soils occur in such an intricate pattern that it was impractical to map them separately. Typical areas are about 30 percent Elsmere loamy fine sand, 20 percent Plevna loamy fine sand, 10 percent Tivoli fine sand, hilly, and 40 percent soils that have characteristics intermediate between those of the Tivoli soil and those of the Plevna or Elsmere soil. However, small areas of Pratt loamy fine sand, undulating, are also mapped with these soils in some places. The soils that have intermediate characteristics are not mottled so near the surface as the Elsmere or Plevna soils, and they have a more clayey substratum than the Tivoli soils.

The topography is dominated by sandy hummocks that are 5 to 30 feet high and 30 to 300 feet in diameter. Between the hummocks are nearly level to slightly depressed areas. The Elsmere soil is in the low areas, and the Tivoli soil is on the tops of the hummocks. Other soils of the complex occupy the middle and lower slopes of the hummocks.

The soils of this complex are used for range. (Elsmere soil is in capability unit VW-1 and Subirrigated range site but was not placed in a windbreak suitability group; Tivoli soil is in capability unit VIe-1, Sands range site, and windbreak suitability group 6)

Farnum Series

The Farnum series consists of deep, dark grayish-brown, loamy soils of the uplands. These soils are mainly in the central and southern parts of the county.

In most places the surface layer is about 16 inches thick, has a sandy or loamy texture, and has weak granular structure. The subsoil is grayish-brown clay loam of blocky structure. This layer is at a depth of 50 to 60 inches. The substratum is stratified sandy loam, clay loam, or sandy clay loam. The substratum, as well as the lower part of the subsoil, is mottled in places with strong brown.

The surface layer ranges from 14 to 28 inches in thickness.

These soils are moderately fertile, but they have moderately slow permeability. The surface layer is generally medium acid, and the subsoil is slightly acid to neutral.

The Farnum soils have a more clayey subsoil than the Shellabarger or Naron soils. They have a thicker surface layer and a less clayey subsoil than the Tabler soils.

Almost all of the acreage of Farnum soils in the county is cultivated, and wheat and grain sorghum are the principal crops. The Farnum soils are also well suited to native grass.

Farnum fine sandy loam, 0 to 1 percent slopes (Fa).—This soil has a surface layer of dark grayish-brown fine sandy loam. It is nearly level or slightly undulating. Included in the areas mapped as this soil are small areas of Farnum loam, 0 to 1 percent slopes; of Shellabarger fine sandy loam, 0 to 1 percent slopes; and Naron fine sandy loam, 0 to 1 percent slopes.

Where this soil is on the high parts of undulating areas, it is subject to wind erosion in spring if it is left bare. Stubble mulching of crop residue helps to control wind erosion in areas not protected by a growing crop. The low areas may need drainage, especially when rainfall is higher than average. Alfalfa grown on this soil may need lime for the best yields. (Capability unit IIe-4, Sandy range site, windbreak suitability group 2)

Farnum loam, 0 to 1 percent slopes (Fm).—The profile of this soil is like the one described for the series. The surface layer is dark grayish-brown loam. Included in the areas mapped as this soil are small areas of Tabler soils and smaller areas of Shellabarger fine sandy loam and Vanoss silt loam.

This Farnum soil is one of the best in the county for wheat. Stubble mulching is needed to control soil blowing, and fertilizer is needed for high yields. (Capability unit IIc-1, Loamy Upland range site, windbreak suitability group 2)

Farnum loam, 1 to 3 percent slopes (Fn).—The surface layer of this soil is 13 to 20 inches thick. The lower part of the subsoil and the substratum are less mottled than in the profile described for the series. Small areas of Shellabarger fine sandy loam, Bethany silt loam, and Vanoss silt loam are included in the areas mapped as this soil.

This Farnum soil is subject to wind erosion, and water erosion is a slight to moderate hazard. Use contour farming and stubble mulching to conserve moisture, to control soil blowing, and to maintain fertility and good tilth. (Capability unit IIe-3, Loamy Upland range site, windbreak suitability group 2)

Farnum-Slickspot complex (Fs).—About 50 percent of this complex is Farnum loam (fig. 6); about 40 percent is Slickspot soils; and about 10 percent is Tabler clay loam. All of these soils are nearly level. The Farnum soil is not typical of the Farnum series, because its subsoil and substratum generally contain salts and alkali. The Slickspot soils are described under Slickspots, and the Tabler soil is described under the Tabler series.

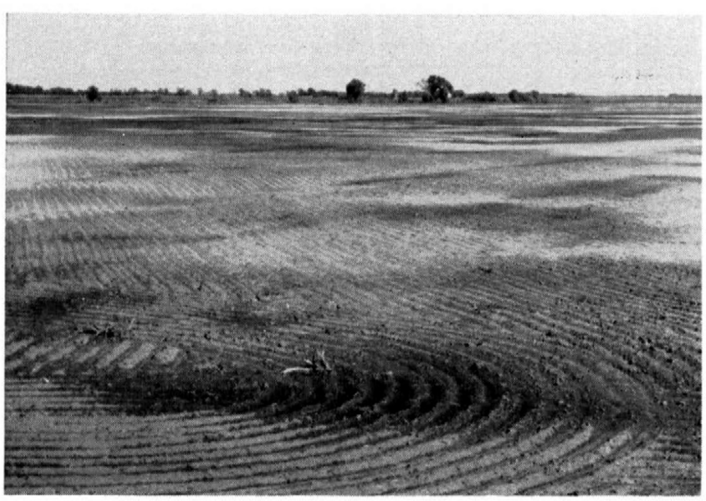

Figure 6.—**A typical area of Farnum-Slickspot complex. The lighter colored areas are Slickspots.**

Permeability of these soils is slow or very slow, and some areas need drainage. Yields of crops are low because the soils contain salts and alkali.

These soils are best suited to native grass. If cultivated crops are grown, sorghum is better suited than other crops. Drainage is needed in the low, wet areas, and stubble mulching should be used on all cropland. (Both soils are in capability unit IVs-1, Saline Lowland range site, and windbreak suitability group 9)

Farnum-Tabler complex (Ft).—This complex consists of about 40 to 45 percent Farnum loam, 40 to 45 percent Tabler clay loam, and 10 to 20 percent Shellabarger fine sandy loam. These soils are nearly level. The Farnum soil occupies the slightly higher spots, and the Tabler soil occupies the flats, or low areas, between the high spots. A profile of the Tabler soil is described under the Tabler series.

Some areas, mainly of the Tabler soil, are poorly drained, and in those areas artificial drainage is needed. Where cultivated crops are grown, improve the fertility and soil tilth by applying fertilizer according to the results of soil tests and by returning all crop residue to the soil. (Both soils are in capability unit IIc-1; Farnum soil is in Loamy Upland range site and windbreak suitability group 2; Tabler soil is in Clay Upland range site and windbreak suitability group 1)

Lesho Series

In the Lesho series are moderately deep, grayish-brown clay loams. These soils are on the flood plains of the major streams.

The surface layer is grayish-brown clay loam that is not acid and is generally calcareous. It is about 11 inches thick. The subsoil is similar to the surface layer, but it is lighter colored, is generally calcareous, and is mottled with splotches of brown. The substratum is coarse sand or gravel. It is generally at a depth of about 24 inches. In places, however, it is at a depth of only 18 inches, and in other places it is at a depth of as much as 30 inches.

These soils are somewhat poorly drained and are frequently flooded where they are not protected by dikes. When the river is at high stage, water often rises from underflow to flood these soils, even though the areas are protected by dikes. Natural fertility is good, and these soils do not need lime. They are droughty, however, during periods of less than average rainfall, when the water table drops into the gravelly substratum.

Lesho soils are shallower over sand or gravel and are more frequently flooded than Dale soils. They contain more clay than Canadian or Wann soils.

Most of the acreage of the Lesho soils in this county is cultivated, and grain sorghum and silage sorghum are the main crops. Alfalfa and wheat are seldom grown unless the soil is protected from flooding. Switchgrass is a well-adapted native grass.

Lesho clay loam (Lc).—This is the only Lesho soil mapped in the county. It is nearly level.

Dale clay loam and Platte soils are included in the areas mapped as this soil. The included soils make up as much as 10 percent of this mapping unit.

This Lesho soil is subject to flooding. (Capability unit IIIw-2, Subirrigated range site, windbreak suitability group 7)

Lucien Series

In the Lucien series are friable, neutral to calcareous, reddish-brown silt loams that are shallow over hard siltstone. These soils are gently sloping to steep and are on breaks along the North Fork Ninnescah River in the south-central part of the country.

The differences between the surface layer and subsoil are not readily apparent. Both are made up of reddish-brown loam that is slightly lighter colored with increasing depth and has weak granular structure. The two layers combined are about 20 inches thick.

Depth to hard siltstone ranges from about 10 to 25 inches. In some places the surface layer is weakly calcareous.

These soils are well drained to somewhat excessively drained. Their water-holding capacity is low because of the siltstone near the surface. Natural fertility is moderate, and these soils are highly susceptible to water erosion.

The Lucien soils are shallower over siltstone than the Nash soils. They are more silty and friable than the Vernon soils. The Lucien soils are mapped only in complexes with the Nash soils.

The soils are used mainly for wheat and native grass. About one-third of the acreage is used for wheat; the rest is in native grass.

Naron Series

Deep, dark grayish-brown, sandy soils make up the Naron series. These soils are mainly in the northern and western parts of the county.

In most places the surface layer is about 15 inches thick and is dark grayish-brown fine sandy loam that is easily worked. Generally, the subsoil is yellowish-brown to brown light sandy clay loam about 30 inches thick. It is neutral and has weak granular structure. The substratum is sandy loam and is more friable than the subsoil.

The thickness of the surface layer ranges from 10 to 25 inches, and that of the subsoil, from 20 to 40 inches. In places the substratum is stratified sandy loam and clay loam.

These soils are well drained, but they retain enough water for plants to make good growth. They have good natural fertility and need little or no lime. Wind erosion is a hazard unless the soils are properly managed. Water erosion is a slight hazard in the sloping areas.

The Naron soils contain more clay and are less acid than the Pratt soils. Also, the layers in their profile are more easily recognized. The Naron soils contain less clay than the Farnum soils.

Nearly all of the acreage is cultivated, and wheat and grain sorghum are the principal crops. Alfalfa and native grass are also well suited.

Naron fine sandy loam, 0 to 1 percent slopes (Na).—This soil has a subsoil that is slightly more clayey than the one in the profile described as typical for the series. Most of the areas are nearly level, but some are slightly undulating. Included in the areas mapped as this soil are small areas of Farnum fine sandy loam, 0 to 1 percent slopes, and of Carwile fine sandy loam.

This Naron soil is susceptible to wind erosion if it is not protected. Stubble mulching and fertilizing according to the results of soil tests will help to control erosion and to maintain production. (Capability unit IIe-4, Sandy range site, windbreak suitability group 4)

Naron fine sandy loam, 1 to 3 percent slopes (Ne.)—This soil has a profile like the one described for the series. Many areas are gently sloping, and some areas are undulating.

Erosion by wind and water is a serious hazard unless this soil is well managed. A cover crop or crop residue kept on the surface helps to control wind erosion, but terracing and contour farming are difficult. A moderate amount of fertilizer is required for good yields. (Capability unit IIIe-4, Sandy range site, windbreak suitability group 4)

Naron-Farnum complex (Nf.)—About 60 percent of this complex is Naron fine sandy loam, 39 percent is Farnum loam, and 1 percent is Carwile fine sandy loam. The soils are so intermingled that it was not feasible to map them separately. These soils are undulating; the Naron soil is on the swells, and the Farnum soil is in the troughs between the swells.

In many areas where these soils occur, there is no well-defined drainage pattern. Therefore, there is a slight hazard of wetness. Wind erosion is a hazard on the Naron soil, but a growing crop or crop residue kept on the surface helps to control erosion. Wheat and grain sorghum are the main crops grown on these soils. (Both soils are in capability unit IIe-4 and Sandy range site; Naron soil is in windbreak suitability group 4, and Farnum soil, in windbreak suitability group 2)

Naron-Pratt complex (Np).—Naron fine sandy loam occupies about 60 percent of the acreage in this complex, and Pratt loamy fine sand about 40 percent. These soils are undulating. The Pratt soil is on the swells, and the Naron is in low areas between the swells. Included in the areas mapped as this complex are small areas of Carwile soils.

The soils of this complex are well drained, except in the small areas where the Carwile soils occur. The main hazard is wind erosion, but stubble-mulch tillage and good management of crop residue can control soil blowing. The main crops are wheat and grain sorghum. (Both soils are in capability unit IIIe-1; Naron soil is in Sandy range site and in windbreak suitability group 4; Pratt soil is in Sands range site and in windbreak suitability group 5)

Nash Series

In the Nash series are friable, loamy, reddish-brown soils that are moderately deep over reddish siltstone. These soils are on the uplands in the southern part of the county.

The surface layer is reddish-brown loam or silt loam about 10 inches thick, and it has granular structure. The subsoil is also reddish-brown loam and has granular structure, but it is about 15 inches thick. Calcareous material is at a depth of about 25 inches. The underlying material, generally at a depth of 25 to 36 inches, is hard, unweathered siltstone. Roots cannot penetrate the siltstone.

These soils are well drained and have moderate permeability. The water-holding capacity is limited because of the moderate depth to siltstone. These soils have high natural fertility, but there is a serious hazard of water erosion.

Nash soils are deeper over siltstone and are noncalcareous to a greater depth than Lucien soils. They are mapped only in complexes with Lucien soils.

In this county most of the acreage of Nash soils is cultivated. Wheat and grain sorghum are the principal crops.

Nash-Lucien complex, 1 to 3 percent slopes (Ns).—From 60 to 80 percent of this complex is Nash loam and silt loam, and the rest is Lucien loam. The Nash soil has a profile like the one described for the series. The profile of the Lucien soil is like the one described under the Lucien series.

Nearly all the acreage is cultivated, and wheat and grain sorghum are the main crops. Water erosion is a hazard. (Both soils are in capability unit IIIe–3 and windbreak suitability group 8; Nash soil is in Loamy Upland range site, and Lucien soil is in Shallow Prairie range site)

Nash-Lucien complex, 3 to 6 percent slopes (Nt).—About 45 to 65 percent of this complex is Nash loam and silt loam. The rest is Lucien loam.

These soils are not well suited to cultivated crops, because of shallowness of the Lucien soil. Runoff and erosion are major problems. They are better suited to native grass, and a large acreage in recent years has been reseeded to native grass. Where these soils are cultivated, wheat is the main crop. The smooth, sloping fields in cultivated areas should be terraced and grassed waterways installed. Also, all crop residue should be returned to the soil. (Both soils are in capability unit IVe–4 and windbreak suitability group 8; Nash soil is in Loamy Upland range site, and Lucien soil is in Shallow Prairie range site)

Nash-Lucien complex, 6 to 15 percent slopes (Nu).—This complex consists of about 50 percent Nash loam, 45 percent Lucien loam, and about 5 percent Vanoss silt loam. Included in the areas mapped as this complex are small areas of Shellabarger, Clark, and Ost soils.

The soils of this complex are well suited to range. Most of the areas are in grass, but about 15 percent of the acreage is used for wheat. (Both soils are in capability unit VIe–3 and windbreak suitability group 8; Nash soil is in Loamy Upland range site, and Lucien soil is in Shallow Prairie range site)

Ost Series

The Ost series consists of deep, dark-colored, nearly level to sloping soils developed in highly calcareous material. These soils are mostly in the southern and southeastern parts of the county.

In most places the surface layer is very dark grayish-brown clay loam about 9 inches thick. It is slightly acid to neutral and has granular structure. Generally the subsoil is brown heavy clay loam that has subangular blocky structure and is about 12 inches thick. The upper part of the subsoil is neutral, but the lower part is calcareous at a depth of about 15 inches. The substratum is calcareous clay loam; about 40 percent of it, by volume, is segregated lime.

The surface layer ranges from about 7 to 15 inches in thickness. In small areas the texture of the surface layer is loam. The subsoil is somewhat reddish where it is adjacent to such reddish soils as the Renfrow.

The Ost soils are moderately well drained or well drained, and they have medium to slow internal drainage. Their water-holding capacity is good, but these soils are subject to water erosion where the slopes are greater than about 1 percent.

The Ost soils are leached of lime to a greater depth than the Clark soils. They are less deeply leached than the Bethany soils. The Ost soils are mapped only in complexes with the Clark soils.

The Ost soils are used mostly for wheat and sorghum. A minor acreage is used for alfalfa and native grass.

Platte Series

In the Platte series are soils developed in recently deposited alluvial sediments. These soils are adjacent to the major streams of the county and are flooded occasionally.

The surface layer is dark grayish-brown, calcareous clay loam about 13 inches thick. Below the surface layer is sand. In some areas the sand is mixed with gravel, and the sand and gravel extend to a depth of several feet.

The Platte soils have a high water table. The water table fluctuates with the level of the stream.

Platte soils (Pa).—These are the only Platte soils mapped in the county. They are generally in narrow bands between the major streams and cultivated areas of Wann or Lesho soils. The texture of the surface layer ranges from loamy fine sand to clay loam. Included in the areas mapped as Platte soils are small areas of Wann, Lesho, and Canadian soils.

Only a small acreage is cultivated, and a few large areas are fenced and used for pasture. The rest of the acreage is covered by trees, brush, weeds, annual grasses, and scattered clumps of tall native grass. The areas in pasture need protection from fire and overgrazing if the best yields are to be obtained. (Capability unit VIw–1, Unstable range site, not placed in a windbreak suitability group)

Plevna Series

The Plevna series consists of dark-colored, poorly drained soils that have a high water table. These soils are adjacent to the North Fork Ninnescah River and its tributaries, and also some are in the sandhill area.

The surface layer is dark-gray fine sandy loam about 24 inches thick. The subsoil is very dark gray heavy fine sandy loam, and contains many brownish mottles. The substratum is loamy sand that is saturated with water.

The water table is always within reach of roots. It is generally at a depth between about 10 inches and 4 feet.

The Plevna soils are less sandy than the Elsmere soils.

The Plevna soils are well suited to native grass, and nearly all of the acreage is in meadow or range. In dry years a small acreage is used for forage sorghum.

Plevna fine sandy loam (Pe).—This soil is nearly level to gently sloping. Small areas of marsh are included in the areas mapped as this soil. These included areas are as large as 2 acres in places.

Most areas of this Plevna soil are used for grazing. Protection from overgrazing is needed to maintain or increase the yield of grass. (Capability unit Vw–1, Subirrigated range site, windbreak suitability group 9)

Port Series

Deep, reddish-brown, friable clay loams are in the Port series. These soils are on bottom lands or low terraces along small drainageways that originate in areas of Vernon and Renfrow soils. They are mainly in the southeastern part of the county.

The surface layer is reddish-brown clay loam about 12 inches thick. In most places it is neutral, and it has granular structure. The subsoil is generally like the surface layer, but it is calcareous and is about 33 inches thick. The substratum consists of heavy silty clay loam and of partly weathered, reddish-brown shale. It is calcareous, has fine blocky structure, and is 15 or more inches thick. In most places hard unweathered shale is at a depth of more than 60 inches..

The Port soils are well drained, have good water-holding capacity, and have moderate to high natural fertility.

The Port soils are deeper and more friable than the Renfrow and Vernon soils. Also, they are on bottom lands instead of uplands.

Most of the acreage of Port soils is cultivated. These soils are suited to alfalfa, wheat, sorghum, and native grass.

Port clay loam (Pl).—This is the only Port soil mapped in the county. It is nearly level and is along small streams. The areas are flooded occasionally; flooding does not damage this soil, but it may damage crops.

This soil is used mainly for wheat, grain sorghum, and alfalfa. For the best yields, fertilizer should be applied according to the results of soil tests. (Capability unit IIc–1, Loamy Upland range site, windbreak suitability group 2)

Pratt Series

In the Pratt series are deep, light-colored, undulating and hummocky soils of the sandy uplands. These soils occur throughout the county, but they are the dominant soils in the western part.

In most places the surface layer is grayish-brown loamy fine sand that is slightly acid, structureless, and about 12 inches thick. The subsoil is brown, friable light fine sandy loam that has weak granular structure and is medium acid. Horizontal bands of slightly finer textured and darker colored material about an inch wide are at intervals of 8 to 12 inches. The substratum is light-brown, structureless loamy fine sand.

Where the Pratt soils are rough and hummocky, they are generally more sandy than in other areas. The texture of the subsoil ranges from fine sandy loam in the more gently sloping areas to loamy fine sand in the more hummocky areas.

These soils are well drained to somewhat excessively drained. They take in water well, but their water-holding capacity is somewhat low. Natural fertility is moderate to low, and the sands are highly susceptible to wind erosion.

The Pratt soils are more sandy than the Shellabarger and Naron soils, and the layers in their profile are less well defined. They are less sandy than the Tivoli soils.

Nearly all of the acreage of Pratt soils is cultivated. Grain sorghum and native grass are well suited, and both wheat and grain sorghum are grown on these soils. Some areas are in range.

Pratt loamy fine sand, undulating (Pm).—The profile of this soil is like the profile described for the series. The slopes range from 1 to 6 percent.

Small areas of Pratt loamy fine sand, hummocky, Naron fine sandy loam, and Shellabarger fine sandy loam are included in the areas mapped as this soil. Also included are small areas, locally called potholes, of Carwile fine sandy loam. In most places the size of these included areas is no larger than 1 acre.

This Pratt soil is subject to severe wind erosion. A growing crop or crop residue should be kept on the surface at all times to give protection from blowing. (Capability unit IIIe–1, Sands range site, windbreak suitability group 5)

Pratt loamy fine sand, hummocky (Pr).—In about 50 percent of the acreage of this soil, the plow layer is fine sand and the subsoil is more sandy than that in the typical profile. This soil is steeper and rougher than Pratt loamy fine sand, undulating, and it has slopes that range from 6 to 12 percent. In places the hummocks are 30 feet high. Included in the areas mapped as this soil are small areas of Pratt loamy fine sand, undulating, and areas of Tivoli soils.

Wind erosion is a serious hazard, and wheat is not well suited. Grain sorghum is grown extensively and is well suited. Soil blowing can be controlled by growing a winter cover crop, such as vetch or rye, and managing crop residue well. (Capability unit IVe–1, Sands range site, windbreak suitability group 5)

Pratt-Carwile complex (Pt).—The soils of this complex are so intermingled that it was impractical to separate them on the map. Typical areas consists of about 40 percent Pratt loamy fine sand, undulating; 25 percent Carwile fine sandy loam; 10 percent Naron fine sandy loam, 0 to 1 percent slopes; and 25 percent of soils that have characteristics intermediate between those of the Pratt and Carwile soils. The soils that have intermediate characteristics have a surface layer and subsoil like those of the Pratt soils and a substratum like that of the Carwile soils. A typical profile of the Carwile series is described under the Carwile series. Areas of this complex are generally hummocky. The Pratt and Naron soils occupy the higher areas and the Carwile soil occupies the nearly level or slightly depressed areas.

In areas of this complex, drainage is a problem during wet seasons because the Carwile soil is somewhat poorly drained. The Pratt soil is subject to wind erosion, and blowing is a serious hazard in spring unless that soil is protected by adequate cover. Wheat and grain sorghum are the principal crops. Tall native grass is also well adapted. (The Pratt soil is in capability unit IIIe–1, Sands range site, and windbreak suitability group 5; the Carwile soil is in capability unit IIw–2, Sandy range site, and windbreak suitability group 3)

Renfrow Series

In the Renfrow series are dark-colored, nearly level to sloping soils developed in material weathered from reddish shale. These soils are mainly in the southeastern part of the county in an area locally called red jaw country.

In most places the surface layer is very dark brown or dark grayish-brown clay loam. It has fine granular structure, is medium acid, and is about 14 inches thick. The subsoil is dark reddish-brown silty clay loam that has blocky structure, has neutral reaction, and is about 28 inches thick. It is extremely hard when dry. The substratum is reddish and grayish shale that is not penetrated by roots. It is generally at a depth of 40 inches.

The surface layer ranges from 6 to 18 inches in thickness. In places the lower part of the subsoil is weakly calcareous. Depth to the substratum ranges from 26 inches to more than 48 inches.

These soils take in water slowly, but their water-holding capacity is high. The more sloping areas are subject to water erosion. Natural fertility is moderate.

The Renfrow soils are deeper over shale than the Vernon soils. They are less friable and are more clayey than the Nash soils.

Nearly all of the acreage of these soils is cultivated, and wheat is the main crop. Grain sorghum and native grass are also well suited.

Renfrow clay loam, 0 to 1 percent slopes (Rc).—The surface layer of this soil is brown. It is 12 to 18 inches thick, or thicker than that in the typical profile, and shale is at a greater depth. Small areas of Vernon soils are included in the areas mapped as this soil.

This Renfrow soil is subject to wind erosion. Therefore, crop residue should be kept on the surface in winter and in spring for control of soil blowing. The gently sloping areas ought to be farmed on the contour to control erosion and to conserve moisture. (Capability unit IIs-1, Clay Upland range site, windbreak suitability group 8)

Renfrow clay loam, 1 to 3 percent slopes (Re).—The profile of this soil is like the one described for the series. Included in areas mapped as this soil are small areas of Vernon and Ost soils and of Shellabarger fine sandy loam, shale substratum, 0 to 3 percent slopes.

Runoff is rather high, and this Renfrow soil is subject to moderately severe erosion. Also, because the intake of water is slow, this soil is somewhat droughty. Terraces and grassed waterways are needed to control erosion and to conserve moisture. Stubble mulching should be used to add residue to the surface layer. (Capability unit IIIe-6, Clay Upland range site, windbreak suitability group 8)

Renfrow-Vernon clay loams (1 to 4 percent slopes) (Rv).—About 70 percent of this complex is Renfrow clay loam, and the rest is Vernon clay loam. The profile of the Renfrow soil is similar to the typical profile described for the survey, but it is generally shallower over shale. Also, the surface layer is only 6 to 10 inches thick, the subsoil is 10 to 16 inches thick, and the shale is at a depth of less than 26 inches. A profile that is typical for the Vernon soil is described under the Vernon series.

Runoff is high, and the hazard of water erosion is severe. Also, because their root zone is shallow, these soils are droughty. Wheat is grown, and the soils are also suited to native grass. About 20 percent of the acreage is still in grass. Contour farming, terraces, and grassed waterways should be used to control erosion and to conserve moisture. (Both soils are in capability unit IVe-4 and windbreak suitability group 8; Renfrow soil is in Clay Upland range site, and Vernon soil is in Red Clay Prairie range site)

Shellabarger Series

The Shellabarger series consists of deep, brownish, nearly level to sloping, sandy soils of the uplands. These soils occur throughout the county but are mainly in the south-central part.

In most places the surface layer is dark-brown or dark grayish-brown sandy loam or loamy sand that has weak granular structure, is medium acid, and is about 10 inches thick. Generally, the subsoil is reddish-brown sandy clay loam that is about 30 inches thick. It is slightly acid and has weak granular structure. The substratum is well-drained coarse loamy sand.

The thickness of the surface layer ranges from 8 to 22 inches. The thickness of the subsoil ranges from 20 inches to about 40 inches.

These soils are well drained and have moderate natural fertility. The sloping Shellabarger soils are subject to severe water erosion.

The Shellabarger soils are less sandy than the Pratt soils and are more sandy than the Farnum soils. Their texture is similar to that of the Naron soils, but the Shellabarger soils have more brownish and more acid lower layers than the Naron soils.

Most of the acreage of Shellabarger soils is cultivated, and wheat and grain sorghum are the main crops. Alfalfa and native grass are also well suited.

Shellabarger fine sandy loam, 0 to 1 percent slopes (Sa).—This soil has a thicker surface layer and subsoil than those in the typical profile. Included in the areas mapped as this soil are small areas of Farnum fine sandy loam, Pratt loamy fine sand, and Carwile fine sandy loam.

Water erosion is not a hazard, but there is a slight hazard of wind erosion. To control blowing, stubble mulch and plant a winter cover crop. Also apply fertilizer according to the needs indicated by soil tests. (Capability unit IIe-4, Sandy range site, windbreak suitability group 4)

Shellabarger fine sandy loam, 1 to 3 percent slopes (Sb).—This soil has a profile similar to the one described for the series. Small areas of Farnum fine sandy loam and Pratt loamy fine sand are included in the areas mapped as this soil.

Water erosion is a severe hazard, and wind erosion is a hazard unless good management is used. All cultivated areas should be terraced and farmed on the contour. Stubble mulching will help control erosion and increase the amount of water taken into this soil. (Capability unit IIIe-4, Sandy range site, windbreak suitability group 4)

Shellabarger fine sandy loam, shale substratum, 0 to 3 percent slopes (Sc).—In this soil the surface layer and the upper part of the subsoil are similar to those in the profile described for the series. The lower part of the subsoil at a depth of 30 to 36 inches grades to finer textured material, part of which was derived from shale. The depth from the surface to unweathered shale ranges from 25 to 55 inches. Small areas of Shellabarger fine sandy loam, 0 to 1 percent slopes, are included in the areas mapped as this soil.

The sloping areas ought to be farmed on the contour, and all crop residue should be returned to the soil to improve tilth. Apply fertilizer according to the needs indicated by soil tests. (Capability unit IIIe–4, Sandy range site, windbreak suitability group 8)

Shellabarger loamy fine sand, undulating (Se).—The surface layer of this soil is about 15 inches thick, but the subsoil and substratum are like those in the profile described for this series. Small areas of Albion fine sandy loam, of Shellabarger fine sandy loam, and of Pratt loamy fine sand are included in the areas mapped as this soil.

Runoff is slow, and there is little or no hazard of water erosion, because the surface layer is porous enough for water to penetrate easily. Wind erosion is a serious hazard. Therefore, a cover crop or crop residue should be kept on the surface at all times. Rye or vetch provides a good cover that will control blowing in winter and improve fertility. (Capability unit IIe–1, Sandy range site, windbreak suitability group 5)

Shellabarger and Albion soils, 7 to 15 percent slopes (Sg).—These soils are steep and are along or near upland drainageways. They lack the distinct layers that are typical for these soils. The texture of the surface layer ranges from loamy fine sand to heavy sandy loam, and the texture of the subsoil ranges from gravel to light sandy clay loam.

These soils are not suited to cultivated crops, but native grasses are well suited. Most of the acreage is used for range. The pastures should be protected from burning and overgrazing. (Both soils are in capability unit VIe–2 and Sandy range site; Shellabarger soils are in windbreak suitability group 4, and Albion soils are in windbreak suitability group 8)

Shellabarger-Clark-Albion complex, 2 to 6 percent slopes (Sh).—About 50 percent of this complex is Shellabarger fine sandy loam, about 35 percent is Clark loam and Clark fine sandy loam, and about 15 percent is Albion sandy loam.

Wheat is the crop best suited to these soils. Erosion by wind and water is a serious hazard. Terracing may not be feasible on some fields, because the slopes are irregular. Using stubble-mulch tillage and growing a winter cover crop will help to control erosion and to improve tilth and fertility. (Shellabarger and Albion soils are in capability unit IVe–3 and Sandy range site, and Clark soils are in capability unit IVe–5 and Limy Upland range site; Shellabarger and Clark soils are in windbreak suitability group 4, and Albion soil is in windbreak suitability group 8)

Shellabarger-Farnum complex, 1 to 3 percent slopes (Sm).—About 65 percent of this complex is Shellabarger fine sandy loam, about 25 percent is Farnum loam, and 10 percent is soils that have characteristics intermediate between those of the Shellabarger and Farnum soils.

Wheat and grain sorghum are the main crops. Water erosion is a serious hazard. In areas where water erosion has removed most of the surface layer, wind erosion is also a hazard. Contour farming, terraces, and grassed waterways should be used in the sloping areas to control erosion. Apply fertilizer for the best yields. (Shellabarger soil is in capability unit IIIe–4, Sandy range site, and windbreak suitability group 4; Farnum soil is in capability unit IIe–3, Loamy Upland range site, and windbreak suitability group 2)

Shellabarger and Farnum soils, 3 to 7 percent slopes, eroded (Sn).—These soils are similar to those in Shellabarger-Farnum complex, 1 to 3 percent slopes. In the steeper areas that are cultivated, the soils are eroded to the extent that part of the subsoil is turned up in about 30 to 40 percent or more of the acreage each time the soils are plowed. Where erosion is less severe, the surface layer of these soils is thinner than that in the typical profile.

These soils are best suited to native grass. If they are cultivated, fertilizer is needed to obtain the best yields. (Both soils are in capability unit IVe–2; Shellabarger soil is in Sandy range site and windbreak suitability group 4; Farnum soil is in Loamy Upland range site and windbreak suitability group 2)

Slickspots (So)

Slickspot soils vary in characteristics, but all of them have a high content of sodium. As a result, the surface layer puddles after heavy rains and is severely crusted after the soil dries. The Slickspot soils are mainly within the watersheds of Peace Creek and Salt Creek.

The surface layer is 8 to 18 inches thick and ranges from sandy loam to heavy loam in texture. In places the uppermost 1 inch of soil material is crusted and light colored, especially after a beating rain. The layers below the surface layer are grayish in most places, but they are mottled with olive or brownish colors in some places. The texture of these layers ranges from sandy clay loam to clay.

In some areas these soils are free of lime to a depth of about 30 inches, and in others they are calcareous to the surface. Seams of gypsum occur below a depth of 16 inches.

Included in the areas mapped as Slickspots are small areas of Plevna fine sandy loam, Farnum loam, and Tabler clay loam.

Permeability is very slow in the Slickspot soils, and drainage is restricted. The growth of plants that do not tolerate alkali is seriously retarded.

In this county nearly all of the acreage of Slickspot soils is in grass. Only plants that tolerate alkali grow in the areas where the soils contain the most alkali. Other areas are suited to switchgrass and wheatgrass. (Capability unit VIs–1, Saline Lowland range site, windbreak suitability group 9)

Smolan Series

In the Smolan series are deep soils that are dark colored and sloping. These soils are on uplands in the northeastern corner of the county.

In most places the surface layer is dark-brown silty clay loam that has weak granular structure. It is slightly acid and is about 7 inches thick. The subsoil is reddish-brown silty clay that has blocky structure and is about 50 to 60 inches thick. The upper part is slightly acid, but the lower part is neutral. The subsoil is very firm and compact and is slowly permeable. The substratum is yellowish-red silty clay loam that is more friable than the subsoil. It has weak blocky structure.

The surface layer ranges from 6 to 12 inches in thickness but is 7 to 8 inches thick in most places. It is separated from the subsoil by an abrupt boundary.

Runoff is rapid on these soils because the surface layer is thin over the clayey, slowly permeable subsoil. Natural fertility is moderate.

The Smolan soils have a thinner surface layer and a firmer, more slowly permeable subsoil than the Vanoss soils. They are more reddish than the Tabler soils.

Most of the acreage is cultivated, and wheat is the main crop. Grain sorghum and native grasses are also well suited.

Smolan silty clay loam, 1 to 3 percent slopes (Sp).—This soil occupies smooth, gentle slopes in the northeastern part of the county. Small areas of Bethany and Vanoss soils and small areas of Smolan silty clay loam, 3 to 6 percent slopes, moderately eroded, are included in the areas mapped as this soil.

Runoff is rapid, and water erosion is a serious hazard. Contour farming and terraces are needed in all cultivated areas. Fertilizer generally increases yields if there is enough rainfall. (Capability unit IIIe-2, Loamy Upland range site, windbreak suitability group 1)

Smolan silty clay loam, 3 to 6 percent slopes, eroded (St).—Runoff is rapid on this soil, and erosion has removed part of the surface layer. Enough soil material has been lost that part of the subsoil is mixed with the surface layer each time the soil is plowed. The present plow layer is reddish-brown silty clay loam. Gullies are not common; most of the soil material that has been lost was removed through sheet erosion.

Wheat is the main crop, but sorghum is also well suited. Commercial fertilizer or barnyard manure ought to be applied where crops are grown. The areas in pasture should be protected from burning and overgrazing. (Capability unit IVe-2, Clay Upland range site, windbreak suitability group 1)

Tabler Series

The Tabler series consists of deep, dark-colored, nearly level soils that are imperfectly drained (fig. 7). These soils are on uplands.

Figure 7.—**Water ponded on the Tabler soils 2 days after a rain.**

In most places the surface layer is very dark gray when dry and is about 8 inches thick. Generally, the subsoil is dark-gray, firm silty clay with weak blocky structure. The subsoil is 2 to 3 feet thick. The upper part is slightly acid, but the lower part is weakly calcareous at a depth of about 30 inches. The substratum has the same texture as the subsoil, but it is more friable and is generally mottled.

The surface layer ranges from 6 to about 12 inches in thickness and from loam to clay loam in texture. The texture of the subsoil ranges from silty clay to clay. Mottling occurs in the subsoil in about 20 percent of the acreage.

Tabler soils have a thinner surface layer than Bethany soils. They are less reddish than Smolan soils.

Almost all of the acreage of these soils is cultivated, and wheat is the main crop. Grain sorghum, alfalfa, and native grasses are also suited.

Tabler clay loam (Ta).—This soil has a profile like the one described for the series. It is nearly level. Drainage is a minor problem in many places. Small areas of Bethany silt loam, 0 to 1 percent slopes, and Farnum loam, 0 to 1 percent slopes, are included in the areas mapped as this soil. (Capability unit IIs-1, Clay Upland range site, windbreak suitability group 1)

Tabler-Slickspot complex (Tb).—From 5 to 35 percent of this complex is Slickspot soils, and the rest is Tabler clay loam. The surface layer and the upper part of the subsoil in the Tabler soil are like those in the profile described for the series, but the lower part of the subsoil and the substratum have been affected by salts. This soil is nearly level, and the imperfect drainage is a more severe problem than in the typical Tabler soils. The Slickspot soils are described under the mapping unit Slickspots.

The Tabler soil in this complex is less productive than Tabler clay loam mapped alone. The decrease in yields is in direct proportion to the proportion of Slickspot soils in the area. (Both soils are in capability unit IVs-1; Tabler soil is in Clay Upland range site and windbreak suitability group 1; Slickspot soils are in Saline Lowland range site and windbreak suitability group 9)

Tivoli Series

The Tivoli series consists of deep, light-colored, hummocky to hilly sands. These soils are in the sandhill areas in the northern and western parts of the county.

In most places the surface layer is light-brown fine sand 2 to 10 inches thick. The subsoil is mainly light-brown fine sand but contains thin bands of darker colored sand about 12 to 18 inches apart in some places. The substratum is fine sand that is lighter colored than the subsoil. The more hilly and rougher areas of these soils are lighter colored and more sandy than the hummocky areas.

These soils are excessively drained. Their water-holding capacity is low.

The Tivoli soils are more sandy and are in areas of rougher topography than the Pratt soils.

Nearly all the acreage of Tivoli soils is used for range. Native grasses are best suited to these soils.

Tivoli fine sand, hilly (Tf).—This soil is more hilly and choppy than Tivoli soils, hummocky. The surface layer is 2 to 5 inches thick, and the subsoil and substratum are fine sand that is very pale brown when dry.

Areas of Tivoli soils, hummocky, are included in the areas mapped as this soil. The included soils make up as much as 15 percent of the acreage. Blowouts occur within the more choppy parts of this soil.

This soil supports a sparse stand of vegetation. Giant sandreed, locally called blowout grass, is common in the stand. Wild plum and little bluestem are well suited to the sandier hills, and big bluestem and indiangrass are suited to the smoother areas.

This soil is used for range or is fenced and protected from livestock to minimize the hazard of wind erosion. Where it is used for range, it should be protected from overgrazing or burning. (Capability unit VIIe-1, Choppy Sands range site, windbreak suitability group 6)

Tivoli soils, hummocky (Th).—These soils have a profile similar to the one described for the series. In many places, however, the surface layer is loamy fine sand rather than fine sand. Where the surface layer is fine sand, it is 6 to 10 inches thick. These soils are more rolling than Tivoli fine sand, hilly, and the hummocks are smoother.

Areas of Pratt loamy fine sand and small areas of Elsmere and Plevna loamy fine sand are included in the areas mapped as Tivoli soils, hummocky. The Elsmere and Plevna soils occupy the low places between the hummocks.

Big bluestem, switchgrass, indiangrass, and other tall grasses are well suited to the Tivoli soils. The hazard of wind erosion is severe on these soils, and a good cover of grass must be maintained at all times. (Capability unit VIe-1, Sands range site, windbreak suitability group 5)

Vanoss Series

In the Vanoss series are deep, dark-colored, nearly level and sloping soils. These soils are on the high terraces and uplands adjacent to the Little Arkansas River.

In most places the surface layer is brown silt loam that has granular structure, is slightly acid, and is about 20 inches thick. It is easily worked. Generally, the subsoil is brown, friable clay loam that has subangular blocky structure. It is generally about 4 feet thick. The substratum is friable loam to clay loam and contains scattered concretions that are calcareous.

The thickness of the surface layer ranges from 12 to about 25 inches. In most places the texture of the subsoil is clay loam, but in some areas it is heavy loam.

These soils are naturally well drained. They have medium internal drainage, are moderately permeable, and have good water-holding capacity. Natural fertility is high.

Vanoss soils are less sandy than Shellabarger and Naron soils. They are less clayey than Bethany soils.

Most of the acreage of Vanoss soils is cultivated. These soils are well suited to the native grasses and to all of the field crops grown in the area.

Vanoss silt loam, 0 to 1 percent slopes (Va).—This soil has a profile like the one described for the series. Small areas of Bethany and Naron soils are included in the areas mapped as this soil.

Apply fertilizer according to the needs indicated by soil tests, and return all crop residue to the soil. These practices improve yields and increase the amount of water taken in. (Capability unit I-1, Loamy Upland range site, windbreak suitability group 4)

Vanoss silt loam, 1 to 3 percent slopes (Vb).—The surface layer of this soil is about 4 inches thinner than the one in the profile described for the series. The hazard of water erosion is moderate. Small areas of Naron fine sandy loam, 1 to 3 percent slopes, and Farnum loam, 1 to 3 percent slopes, are included in the areas mapped as this soil.

Terrace and farm on the contour to control water erosion. Also, keep a growing crop or crop residue on the surface to conserve moisture and to improve tilth. (Capability unit IIe-2, Loamy Upland range site, windbreak suitability group 4)

Vanoss silt loam, 3 to 7 percent slopes, eroded (Vc).—This soil is adjacent to drainageways in the uplands. It is moderately eroded; much of the surface layer has been lost through erosion. In about 20 percent of the acreage, part of the subsoil has been mixed with the surface layer. The surface layer in the rest of the acreage is less than 12 inches thick. Small areas of Clark loam are included in the areas mapped as this soil.

Stubble mulching, terracing, and contour farming will improve yields. Fertilizer should also be applied according to the needs indicated by soil tests. (Capability unit IVe-2, Loamy Upland range site, windbreak suitability group 4)

Vernon Series

In the Vernon series are brown to reddish-brown clayey soils of the uplands. These soils are shallow over reddish clayey shale.

In most places the surface layer is brown, friable clay loam that has fine granular structure. It is calcareous and is about 8 inches thick. Below the surface layer is 8 to 12 inches of reddish-brown friable heavy clay loam. This material is calcareous. Bits of shale are scattered throughout the layer. Hard, red and gray, unweathered shale is at a depth of about 20 inches.

The surface layer ranges from 6 to about 10 inches in thickness. The texture of the surface layer and subsoil ranges from clay loam to clay. Depth to shale ranges from 12 to about 26 inches.

The Vernon soils are shallower over shale than the Renfrow soils. They lack the distinct textural layers typical of the Renfrow soils.

These soils are well drained, but they are slowly permeable and have an impervious substratum. Because shale is near the surface, the water-holding capacity is low and runoff is high.

About half of the acreage of Vernon soils in this county is farmed. The areas that are farmed are mapped in a complex with Renfrow soils.

Vernon soils (Ve).—These soils are generally steep. In most places they have slopes of more than 7 percent, but in about one-fourth of the acreage they are nearly level or have slopes of less than 7 percent. In places the slopes are broken. In about 75 percent of the acreage, the profile is like the one described for the series, but in about 25 percent the soils are shallower over shale than in the typical profile.

These soils are not suited to cultivated crops, and nearly all of the acreage is in grass. The areas in grass should be protected from burning or overgrazing. The cultivated areas ought to be reseeded to native grass. (Capability unit VIe-4, Red Clay Prairie range site, windbreak suitability group 8)

Wann Series

The Wann series consists of soils developed in recently deposited alluvium. These soils are near the major streams and are underlain by stratified material, mainly sand and gravel.

The surface layer is dark-gray calcareous sandy loam about 16 inches thick. The subsoil is friable, calcareous sandy loam and is generally mottled. It is about 14 inches thick. The substratum is brownish sand but has thin layers of gravel, clay, or silt within the sand in many places.

These soils have a high water table that is generally within 4 feet of the surface. Unless they are protected by dikes, they are flooded occasionally. These soils respond well to nitrogen fertilizer.

Most of the acreage of Wann soils is cultivated. The principal crop is grain sorghum.

Wann fine sandy loam (Wa).—This is the only Wann soil mapped in the county. It is nearly level. Small areas of Canadian fine sandy loam and Platte soils are included in the areas mapped as this soil.

Some areas can be improved by providing artificial drainage. Fertilizer should be added according to the needs indicated by soil tests. (Capability unit IIIw-1, Subirrigated range site, windbreak suitability group 7)

Wet Alluvial Land (We)

Soils formed in alluvium make up this land type. They are along the North Fork Ninnescah River and its tributaries, and the areas have been dissected by stream channels. These soils developed in stratified material that ranges from sandy loam to clay loam in texture.

About 60 percent of the acreage is neutral to calcareous clay loam, and the water table is at a depth of 20 to 36 inches in those areas. About 20 to 35 percent of the acreage is made up of ridges or sandbars of sandy loam to fine sand, and the water table is at a depth of 36 to 50 inches in those areas. Oxbows are common along the North Fork Ninnescah River. Where they occur, water is ponded much of the time. Floods generally occur from one to six times a year, but they are usually of short duration. They last less than 48 hours.

The best use of this land type is for range, and switchgrass and prairie cordgrass are suitable range plants. Good management of the range includes controlling weeds and stocking livestock at a proper rate. (Capability unit Vw-1, Subirrigated range site, windbreak suitability group 7)

Use and Management of Soils

The soils of Reno County are used mainly for dryland crops and for pasture or range. This section explains how the soils may be managed for these main purposes, and also for irrigating crops or pasture, planting trees, providing habitats for wildlife, and building highways, farm ponds, and similar engineering structures. It also gives the predicted yields of the principal crops grown under two levels of management. The method of presenting information is that of describing general practices suitable for all the soils, then grouping soils that require similar management, describing the group, and suggesting suitable management practices.

Management of Cropland [1]

Shortage of rainfall and erosion by water and wind are the major problems in managing cropland in this county. Most of the soils are highly susceptible to erosion when they are cultivated and do not have an adequate cover. Also, the cultivated soils have generally been farmed for more than 50 years. As a result, they are eroded in varying degrees and are lower in content of organic matter and in fertility than they were originally.

The management practices needed for one soil may not be appropriate for another. Generally, however, the objectives of management are to control erosion, conserve moisture, maintain the supply of plant nutrients, and improve tilth. The general practices employed to accomplish this are explained in the following paragraphs.

Cropping systems.—The choice of a good cropping system can do much to control erosion and conserve moisture. In this county the cropping systems used vary widely because of differences in the soils and in the type of farm enterprise. One cropping system, commonly used on livestock farms, protects the soils and conserves moisture. It consists of 3 to 5 years of alfalfa, 1 or 2 years of small grains, and 1 year of grain sorghum or forage sorghum. Sweetclover is also included in this cropping system if it can be utilized by livestock.

On most farms where the products are marketed as cash crops, wheat and grain sorghum are the principal crops. If wheat and either grain sorghum or forage sorghum are the only crops grown in the cropping system, they are usually grown year after year in the same field. Wheat does not yield well, however, if it is grown after sorghum, because it cannot be planted until after the sorghum is harvested. By that time, the soil moisture and supply of plant nutrients are usually temporarily depleted. A cover crop can be used if other protective cover is lacking. In some fields stripcropping is practiced to help control erosion. It consists of growing a cover crop or other close-growing crops in a systematic arrangement of strips or bands, which serve as barriers that protect the soils.

Where a cropping system is used that conserves the soils and moisture, nitrogen fertilizer, phosphate, and potash are applied according to the needs indicated by soil tests. Lime is needed on some soils if alfalfa or sweetclover is to be grown. The amount required should be determined by soil tests.

Terracing and contour farming.—Terracing and contour farming help in controlling water erosion, and they conserve moisture. Terracing is feasible in many fields where the slopes are between 1 and about 7 percent, and some soils must be terraced if water erosion is to be kept within reasonable limits. Terracing is not feasible in some fields, however, even though erosion is damaging the soils. For example, in fields where the topography is irregular, terraces are not practical. If constructed, they are crooked, and contour farming, essential in terraced fields, cannot be practiced. Also, terraces are not feasible on some sandy

[1] By T. D. DICKEN, soil conservationist, Soil Conservation Service.

soils, because of the difficulty in maintaining the terrace ridge. Where terraces cannot be used, the area can be planted to trees, grass, small grains, or other crops that resist erosion. If the soils must be cultivated, stubble-mulch tillage is desirable.

The terraces serve as a guideline for tillage operations in contour farming. Each contour row is in itself a small terrace that increases the intake of water. Contour farming without terraces is desirable only if all the natural watercourses are grassed. This is because water tends to concentrate in the low areas and causes gully erosion.

A system for disposing of excess water is necessary in terraced fields, and three systems are commonly used for this purpose. One method is to run the water into a pasture or field of native hay; another is that of constructing a wide, flat-bottomed channel and then establishing a stand of either tame or native grasses in the channel; and a third is that of building one or more concrete chutes or overfalls. The method that moves water into a pasture or hayfield is generally considered to be the most desirable. Some landowners, however, prefer concrete structures, even though these are more expensive than grassed waterways. The second method—a wide, flat-bottomed channel—removes some land from cultivation, but the grass can be harvested, and should be harvested, annually.

Management of crop residue.—Proper management of crop residue helps to prevent erosion by water and wind, to maintain good tilth, and to maintain the supply of plant nutrients. It consists of incorporating crop residue into the surface soil. The crop residue ought to be protected from overgrazing and should never be burned. Where small grains or grain sorghum have made good growth and have been harvested, the residue from their leaves and stalks will add a ton or more of organic matter to the soils if it is incorporated in the surface soil.

Stubble mulching (fig. 8), a management practice used for keeping crop residue on the surface of the soil, gives greater protection from water and wind erosion than do similar practices. When stubble mulching is practiced, the residue from the previous crop is kept on the surface until the following crop has produced some cover that will protect the soils. The residue thus provides continuous protection from erosion. Stubble mulching is especially desirable on soils that are highly susceptible to erosion by water and wind. Where it is used, special tools, such as 24-inch to 7-foot sweeps or rod weeders that do not cover the residue, are necessary.

***Figure 8.*—A field where wheat has been harvested and stubble-mulch tillage has been used to protect against erosion.**

Drainage.—The construction of drainage ditches is a widely used practice where the natural drainage system is inadequate and crop yields are reduced by standing water. The cooperation of several farmers will likely be necessary in constructing the main drainage channel for the drainage system. After the main drainage channel is constructed, the drainage systems for individual farms empty into the main ditch. Several groups of farmers have already organized drainage districts so that they can establish satisfactory drainage systems.

Capability Groups of Soils

The capability classification is a grouping that shows, in a general way, how suitable soils are for most kinds of farming. It is a practical grouping based on limitations of the soils, the risk of damage when they are used, and the way they respond to treatment.

In this system all the kinds of soil are grouped at three levels, the capability class, subclass, and unit. The eight capability classes in the broadest grouping are designated by Roman numerals I through VII. In class I are the soils that have few limitations, the widest range of use, and the least risk of damage when they are used. The soils in the other classes have progressively greater natural limitations. In class VIII are soils and landforms so rough, shallow, or otherwise limited that they do not produce worthwhile yields of crops, forage, or wood products.

The subclasses indicate major kinds of limitations within the classes. Within most of the classes there can be up to four subclasses. The subclass is indicated 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* means that water in or on the soil will interfere 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 country, indicates 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 or no limitations. Class V can contain, at the most, only subclasses *w*, *s*, and *c*, because the soils in it are subject to little or no erosion but have other limitations that restrict their use largely to pasture, range, woodland, or wildlife.

Within the subclasses are the capability units, groups of soils 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 identified by numbers assigned locally, for example, IIe-1 or IIIe-2.

Soils are classified in capability classes, subclasses, and units in accordance with the degree and kind of their permanent limitations; but without consideration of major and generally expensive landforming that would change the slope, depth, or other characteristics of the soil; and without consideration of possible but unlikely major reclamation projects.

The eight classes in the capability system, and the subclasses and units in this county, are described in the list that follows.

Class I. Soils that have few limitations that restrict their use.
- (No subclasses)
  - Unit I–1. Deep, nearly level, dark-colored, friable soils.

Class II. Soils that have some limitations that reduce the choice of plants or require moderate conservation practices.
- Subclass IIe. Soils subject to moderate erosion if they are not protected.
  - Unit IIe–1. Nearly level, moderately deep or deep soils that have a sandy substratum
  - Unit IIe–2. Deep, gently sloping, brownish, friable soils.
  - Unit IIe–3. Deep, gently sloping, loamy soils.
  - Unit IIe–4. Deep, nearly level and gently undulating, sandy or loamy soils.
- Subclass IIw. Soils that have moderate limitations because of excess wetness.
  - Unit IIw–1. Dark-colored soils of valleys; moderately deep over sand and gravel.
  - Unit IIw–2. Nearly level or gently sloping, sandy soils underlain by clayey material.
- Subclass IIs. Soils that have moderate limitations of moisture capacity or tilth.
  - Unit IIs–1. Deep and moderately deep, nearly level soils.
- Subclass IIc. Soils that have moderate limitations because of low rainfall.
  - Unit IIc–1. Deep, nearly level, dark-colored soils.
  - Unit IIc–2. Deep, nearly level, loamy to sandy soils that have a calcareous, loamy to clayey subsoil.

Class III. Soils that have severe limitations that reduce the choice of plants, or require special conservation practices, or both.
- Subclass IIIe. Soils subject to severe erosion if they are cultivated and not protected.
  - Unit IIIe–1. Deep, gently undulating to hummocky, sandy soils.
  - Unit IIIe–2. Deep, gently sloping, reddish, clayey soils.
  - Unit IIIe–3. Moderately deep to shallow, reddish-brown, silty soils underlain by siltstone.
  - Unit IIIe–4. Deep and moderately deep, gently sloping, sandy soils that have a friable subsoil.
  - Unit IIIe–5. Dark-colored, gently sloping, loamy soils that are shallow over limy material.
  - Unit IIIe–6. Deep or moderately deep, clayey soils that have a clay loam surface layer.
- Subclass IIIw. Soils that have severe limitations because of excess water.
  - Unit IIIw–1. Brownish fine sandy loams that are moderately deep over sand and are in valleys.
  - Unit IIIw–2. Dark-colored, clayey soils that are moderately deep over sand or gravel and are in valleys.
- Subclass IIIs. Soils that have severe limitations of moisture capacity or tilth.
  - Unit IIIs–1. Sandy soils that are moderately deep over coarse sand and gravel.

Class IV. Soils that have very severe limitations that restrict the choice of plants, require very careful management, or both.
- Subclass IVe. Soils subject to very severe erosion if they are cultivated and not protected.
  - Unit IVe–1. Deep loamy fine sands in steep, hummocky areas.
  - Unit IVe–2. Deep, brownish to reddish-brown sandy loams to silty clay loams that are sloping and eroded.
  - Unit IVe–3. Deep and moderately deep, gently sloping, brownish, sandy soils that are underlain by coarse sand and gravel.
  - Unit IVe–4. Shallow and moderately deep, reddish-brown, silty and clayey soils that are gently sloping to strongly sloping.
  - Unit IVe–5. Strongly sloping, sandy to loamy, calcareous soils.
- Subclass IVs. Soils that have very severe limitations, mainly a high content of salts.
  - Unit IVs–1. Deep, nearly level, loamy to clayey soils and Slickspot soils.

Class V. Soils that are not likely to erode but that have other limitations, impractical to remove without major reclamation, that limit their use largely to pasture or range, woodland, or wildlife food and cover.
- Subclass Vw. Soils too wet for cultivation; drainage or protection not feasible.
  - Unit Vw–1. Sandy to loamy soils that have a permanent high water table.

Class VI. Soils that have severe limitations that make them generally unsuited to cultivation and that limit their use largely to pasture or range, woodland, or wildlife food and cover.
- Subclass VIe. Soils severely limited, chiefly by risk of erosion, if protective cover is not maintained.
  - Unit VIe–1. Deep, hummocky sands.
  - Unit VIe–2. Deep or moderately deep sandy loams that have steep slopes.
  - Unit VIe–3. Reddish, silty or loamy soils that are shallow and moderately deep over siltstone.
  - Unit VIe–4. Nearly level to steep, reddish, clayey soils that are shallow over shale; in some areas the slopes are broken.
  - Unit VIe–5. Deep, moderately steep, dark-colored loams and clay loams.
- Subclass VIw. Soils severely limited by excess water and generally unsuitable for cultivation.
  - Unit VIw–1. Mixed soils adjacent to streams that are frequently flooded.
- Subclass VIs. Soils generally unsuitable for cultivation and limited for other uses, mainly by a high content of salts.
  - Unit VIs–1. Deep, clayey soils that contain salts and alkali.

Class VII. Soils that have very severe limitations that make them unsuitable for cultivation without major reclamation and that restrict their use largely to grazing, woodland, or wildlife.

Subclass VIIe. Soils very severely limited, chiefly by risk of erosion if protective cover is not maintained.

Unit VIIe-1. Deep, light-colored soils that occupy rough hummocks and dunes.

Class VIII. Soils and landforms that, without major reclamation, have limitations that preclude their use for commercial production of plants and restrict their use to recreation, wildlife, water supply, or esthetic purposes. (None in Reno County)

Management of soils by capability units

In this section the soils of the county are placed in capability units and use and management is suggested for the soils of each unit. In planning management of the soils, the basic practices of management described in the subsection "Management of Cropland" are to be considered.

CAPABILITY UNIT I-1

Only Vanoss silt loam, 0 to 1 percent slopes, is in this capability unit. It is a deep, nearly level, dark-colored, friable soil.

This is one of the best soils in the county for agriculture. It is loamy to depths reached by most deep-rooted crops. The intake of water and the water-holding capacity are good. Natural fertility is moderately high, but lime may be needed for good yields of legumes.

Alfalfa, wheat, and sorghum are the main crops, but this soil is suited to all the crops commonly grown in the area. A good supply of plant nutrients should be maintained, and good management of crop residue is needed in areas that are cultivated.

CAPABILITY UNIT IIe-1

Canadian fine sandy loam is the only soil in this capability unit. It is a nearly level, moderately deep or deep soil that has a sandy substratum.

Natural fertility is moderate, but lime may be needed if legumes are to be grown successfully. Wind erosion is a hazard.

Wheat and sorghum are the main crops, but alfalfa is grown to some extent. Nitrogen and phosphate are needed to maintain fertility. Wind stripcropping and proper management of crop residue will help to control wind erosion.

CAPABILITY UNIT IIe-2

Only one soil, Vanoss silt loam, 1 to 3 percent slopes, is in this capability unit. It is a deep, gently sloping, brownish soil that is silty and friable.

This soil takes in water readily, but water erosion is a problem. Natural fertility is moderately high, but the use of nitrogen on wheat is profitable in most years.

Alfalfa, wheat, and sorghum are well-suited crops. Terraces and grassed waterways, are needed, and contour farming should be used for the control of water erosion. Also, fertilizer ought to be applied according to the results of soil tests, so that the proper level of fertility will be maintained.

CAPABILITY UNIT IIe-3

Deep, gently sloping, loamy soils make up this capability unit. These soils are—

Bethany silt loam, 1 to 3 percent slopes.
Farnum loam, 1 to 3 percent slopes.
Shellabarger-Farnum complex, 1 to 3 percent slopes (Farnum soil only).

The content of clay below the surface layer of these soils increases with increasing depth. Where these soils are bare, runoff is medium to high and water erosion is a hazard. Natural fertility is moderate, but the surface layer is acid. Lime may be needed to grow legumes. Wheat, sorghum, and alfalfa respond well to fertilizer.

All the crops commonly grown in the area are suited to these soils. Terraces, grassed waterways, and contour farming are needed to control water erosion. The fertility ought to be maintained by applying fertilizer according to the results of soil tests.

CAPABILITY UNIT IIe-4

In this capability unit are deep, nearly level and gently undulating, sandy or loamy soils that have a subsoil of sandy clay loam or clay loam. These soils are—

Carwile-Farnum fine sandy loams (Farnum soil only).
Farnum fine sandy loam, 0 to 1 percent slopes.
Naron fine sandy loam, 0 to 1 percent slopes.
Naron-Farnum complex.
Shellabarger fine sandy loam, 0 to 1 percent slopes.

The high areas of these undulating soils are the most sandy and are subject to wind erosion. At times after heavy rains, water stands on the surface in the low areas. Natural fertility is moderate, but lime may be needed to grow alfalfa.

Wheat and grain sorghum are the main crops, but alfalfa is also well suited. Wind stripcropping and keeping all crop residue on the surface are practices that protect the soils from erosion. Maintain fertility by adding fertilizer according to the results of soil tests.

CAPABILITY UNIT IIw-1

Only Dale clay loam is in this capability unit. This soil is dark colored and is moderately deep over sand and gravel. It is in the valley of the Arkansas River.

This soil is subject to occasional flooding, unless it is protected by dikes. The water table is within the depth reached by the roots of alfalfa, and at times it is high enough to damage crops. Natural fertility is moderately high, but nitrogen is needed. Lime is generally not needed to grow alfalfa.

Alfalfa, wheat, and sorghum are suited to this soil. Good management requires using all crop residue and maintaining the level of fertility.

CAPABILITY UNIT IIw-2

In this capability unit are nearly level or gently sloping, sandy soils underlain by clayey material. The soils are on the uplands and high terraces along the Arkansas River. These soils are—

Carwile fine sandy loam.
Carwile-Farnum fine sandy loams (Carwile soil only).
Pratt-Carwile complex (Carwile soil only).

The surface layer is underlain by clayey layers at a depth of about 10 to 36 inches. In wet years some areas may be too wet for good yields, especially where the clayey layers are near the surface. Wind erosion is a hazard in dry years. The intake of water and the water-holding capacity are good. Fertility is moderately low, but crops, especially sorghum, respond well if adequate fertilizer is applied.

Wheat, sorghum, and alfalfa are the main crops. Fertilizer is required, and drainage should be established where needed. Practices needed to control erosion include wind stripcropping and stubble-mulch farming.

CAPABILITY UNIT IIs-1

In this capability unit are deep and moderately deep, nearly level soils. These soils are—

Renfrow clay loam, 0 to 1 percent slopes.
Tabler clay loam.

The content of clay in these soils increases with increasing depth. The intake of water is slow, and drainage may be a problem in the nearly level or slightly depressed areas. Fertility is moderate, but lime may be needed for growing legumes.

Wheat and sorghum are well suited to these soils, and these crops respond well to fertilizer. Alfalfa is generally not suited to the Renfrow soil, because of the shale at a moderate depth. Surface drains need to be installed in places, and the fertility of the soils maintained.

CAPABILITY UNIT IIc-1

This capability unit consists of deep, nearly level, dark-colored soils. These soils are—

Bethany silt loam, 0 to 1 percent slopes.
Farnum loam, 0 to 1 percent slopes.
Farnum-Tabler complex.
Port clay loam.

These soils have a loamy surface layer and a clayey subsoil. Permeability is slow, and little water runs off these soils. Therefore, ponding is a minor problem in wet years. Fertility is moderately high, but crops respond well to nitrogen and phosphate. Except on the Port soil, lime may be needed for alfalfa.

Alfalfa, wheat, and sorghum are well suited to these soils. Practices that conserve moisture and that maintain fertility should be used. Also, surface drainage is needed in some areas.

CAPABILITY UNIT IIc-2

In this unit are deep, nearly level, loamy or sandy soils that have a calcareous, loamy or clayey subsoil. These soils are—

Clark fine sandy loam.
Clark-Ost complex, 0 to 1 percent slopes.

These soils have moderately high fertility. The high content of lime in the subsoil, however, may reduce the effectiveness of minor elements and phosphate.

Alfalfa and wheat are well suited. In areas where the surface layer is thin over the calcareous subsoil, yields of grain sorghum are lower than normal for other areas of these soils. Stubble-mulch farming and other practices that conserve moisture and maintain fertility are needed.

CAPABILITY UNIT IIIe-1

This capability unit consists of deep, gently undulating to hummocky, sandy soils that have a grayish-brown surface layer. These soils are—

Naron-Pratt complex.
Pratt loamy fine sand, undulating.
Pratt-Carwile complex (Pratt soil only).
Shellabarger loamy fine sand, undulating.

The soils of this unit that are in the high areas, or on the humps, are the most sandy. The ones in the low areas have a loamy or somewhat sandy texture. These soils are subject to wind erosion. Natural fertility of all these soils is moderately low or low, and crops grown on them respond well to fertilizer.

Sorghum and wheat are well suited to these soils. Alfalfa is less well suited, but it is grown successfully in some areas. Wind stripcropping, maintaining fertility, and managing crop residue properly are all good management practices for these soils.

CAPABILITY UNIT IIIe-2

Only Smolan silty clay loam, 1 to 3 percent slopes, is in this capability unit. It is a deep, gently sloping, reddish, clayey soil. This soil has a thin surface layer. A clear or abrupt boundary separates the surface layer from the subsoil of firm silty clay. Runoff is high, and water erosion is a serious problem. Fertility is moderate, but lime may be needed for legumes.

All crops commonly grown in the area are suited to this soil, but wheat and grain sorghum are the main crops. Constructing terraces and grassed waterways, using contour farming, and maintaining fertility are good management practices for this soil.

CAPABILITY UNIT IIIe-3

Only the soils of Nash-Lucien complex, 1 to 3 percent slopes, are in this capability unit. These are moderately deep to shallow, reddish-brown, silty soils that are underlain by siltstone at a depth of 10 to 30 inches.

Runoff is rapid, and water erosion is a hazard on these soils. These soils are somewhat droughty because the root zone is shallow. Natural fertility is moderate.

Wheat is the principal crop. Grain sorghum is fairly well suited, but alfalfa is not suited.

Farming on the contour and constructing terraces and grassed outlets are good management practices for these soils. Practices that conserve water and maintain fertility are also needed.

CAPABILITY UNIT IIIe-4

This capability unit consists of deep and moderately deep, gently sloping, sandy soils that have a friable subsoil. These soils are—

Naron fine sandy loam, 1 to 3 percent slopes.
Shellabarger fine sandy loam, 1 to 3 percent slopes.
Shellabarger fine sandy loam, shale substratum, 0 to 3 percent slopes.
Shellabarger-Farnum complex, 1 to 3 percent slopes (Shellabarger soil only).

The subsoil of these soils is sandy clay loam, and the content of clay increases with increasing depth. Erosion by wind and water is a hazard. Fertility is moderate, but lime may be needed to grow legumes sucessfully.

All crops commonly grown in the area are suited to these soils, but wheat and grain sorghum are the main crops. Constructing terraces and grassed waterways, farming on the contour, and maintaining fertility are management practices that are needed.

CAPABILITY UNIT IIIe-5

Only Clark-Ost complex, 1 to 3 percent slopes, is in this capability unit. The soils of this complex are dark colored, gently sloping, and shallow over limy material. They have a loamy surface layer and a calcareous subsoil.

In many places mounds and humps make up the uneven topography in areas of these soils. Calcareous material is exposed in places, which increases the hazard of wind erosion on the humps. The control of water erosion with terraces is not feasible in some fields, because of irregular slopes. In addition to the need for practices that control erosion, practices that maintain fertility are needed. Nitrogen and phosphate are needed, but lime is not required. The lime in these soils is likely to make iron and other minor elements unavailable to plants. This causes chlorosis, a nutritional deficiency of plants, to which sorghum is especially susceptible.

CAPABILITY UNIT IIIe-6

Only Renfrow clay loam, 1 to 3 percent slopes, is in this capability unit. It is a deep or moderately deep, dark-colored, clayey soil that has a subsoil of brownish to reddish silty clay loam or heavy clay loam. Shale is at a depth of about 26 to 48 inches.

Runoff is high, and the hazard of water erosion is moderately severe. The intake of water is limited, and this soil is somewhat droughty where runoff is not controlled. Fertility is moderate.

Wheat and grain sorghum are well suited and respond well to fertilizer. Alfalfa is fairly well suited, but lime may be needed in some places. Terracing, installing grassed waterways, contour farming, and maintaining fertility are practices that are needed on this soil.

CAPABILITY UNIT IIIw-1

Only Wann fine sandy loam is in this capability unit. It is a brownish soil of valleys and is moderately deep over sand; the fine sandy loam of the surface layer grades to sand at a depth of about 25 inches.

Where this soil is not protected by dikes, it is subject to occasional flooding. Wind erosion is a problem in spring if the soil is bare. Fertility is moderately low to low.

The principal crops are grain sorghum and forage sorghum. These crops respond well to additions of nitrogen and phosphate. Because flooding is a hazard and the water table is high, alfalfa and wheat are not well suited. Practices that maintain fertility and that control wind erosion are needed. Drainage is generally not practical.

CAPABILITY UNIT IIIw-2

Only Lesho clay loam is in this capability unit. This soil is dark colored, clayey, and moderately deep over sand or gravel. It is in valleys and is flooded occasionally.

This soil has a high water table and is mottled. It is weakly calcareous. Fertility is moderate, and wetness is a problem in spring.

Sorghum is the main crop grown because alfalfa and wheat are not well suited. Maintaining fertility is the main problem in managing this soil. Crops that tolerate wetness should be planted, and dikes can be installed in some places.

CAPABILITY UNIT IIIs-1

Only Albion-Shellabarger sandy loams, 0 to 1 percent slopes, is in this capability unit. It consists of sandy soils that are moderately deep over coarse sand and gravel. The soils have a sandy surface layer and a slightly more clayey subsoil.

These soils are droughty. In dry years not enough vegetation is produced to prevent wind erosion. Fertility is low; crops grown on these soils respond well to fertilizer, especially nitrogen, when moisture is ample.

Wheat is fairly well suited, but alfalfa and sorghum are not suited, because they grow during the driest season. Wind stripcropping, proper management of crop residue, and maintaining fertility are practices that are needed on these soils.

CAPABILITY UNIT IVe-1

Only Pratt loamy fine sand, hummocky, is in this capability unit. It is a deep soil that is steep and hummocky. Fertility is low. This soil is highly susceptible to wind erosion.

The best use of this soil is for pasture or range, and sand lovegrass, indiangrass, big bluestem, and sand bluestem are suitable grasses. This soil can be farmed if careful management is practiced. In cultivated areas ample fertilizer, especially nitrogen, should be added. Other good practices are wind stripcropping and planting close-growing crops so that a cover is maintained on the soil at all times. Crops such as rye and vetch are suitable for pasture.

CAPABILITY UNIT IVe-2

In this unit are deep, brownish to reddish-brown sandy loams to silty clay loams that are sloping and eroded. In many of the strongly sloping areas, erosion has removed much or all of the surface layer, and the clayey, infertile subsoil is exposed. Other areas are less eroded. These soils are—

Shellabarger and Farnum soils, 3 to 7 percent slopes, eroded.
Smolan silty clay loam, 3 to 6 percent slopes, eroded.
Vanoss silt loam, 3 to 7 percent slopes, eroded.

Permeability is slow, and runoff is high. Therefore, the hazard of further erosion is serious. The content of organic matter is low, and natural fertility is low or moderately low. Nitrogen especially is needed.

The best use of these soils is for grass. If the soils are cultivated, intensive management practices are needed that will maintain fertility and provide protection from further erosion. Such practices are contour farming, terracing, using grassed waterways, and growing close-growing, soil-improving crops. Ample fertilizer, especially nitrogen, needs to be applied, and a cover maintained on the soils at all times.

CAPABILITY UNIT IVe-3

In this unit are moderately deep and deep, gently sloping, brownish, sandy soils that are underlain by coarse sand and gravel. In the more sloping areas, most of the surface layer has been removed by erosion. These soils are—

Albion-Shellabarger sandy loams, 1 to 4 percent slopes.
Shellabarger-Clark-Albion complex, 2 to 6 percent slopes (Shellabarger and Albion soils only).

Fertility is low. These soils are also droughty because their water-holding capacity is low. If these soils are cultivated, plant small grains or other close-growing crops, construct terraces and grassed waterways, use contour stripcropping, and apply fertilizer. Also, control wind erosion by keeping all crop residue on the surface. The best use of these soils is for pasture or range.

CAPABILITY UNIT IVe-4

This capability unit consists of reddish-brown, silty and clayey soils that are moderately deep and shallow over shale or siltstone. These soils are gently sloping to strongly sloping, and the strongly sloping areas are severely eroded. These soils are—

Nash-Lucien complex, 3 to 6 percent slopes.
Renfrow-Vernon clay loams.

Runoff is high, and the hazard of further erosion is severe. The water-holding capacity is low in the Lucien and Vernon soils and is moderately low in the Renfrow and Nash soils.

The soils of this unit are best suited to pasture or range. If the soils are cultivated, only small grains or other close-growing crops should be grown, and a growing crop or crop residue should be kept on the surface at all times. These soils require intensive practices that will control erosion and conserve moisture, including terracing and contour farming. Also, fertilizer ought to be applied to maintain the level of fertility and to insure sufficient plant cover for the soils.

CAPABILITY UNIT IVe-5

Strongly sloping, sandy to loamy, calcareous soils make up this capability unit. In some areas the slopes are convex. These soils are—

Clark-Ost complex, 3 to 6 percent slopes.
Shellabarger-Clark-Albion complex, 2 to 6 percent slopes (Clark soil only).

In the more strongly sloping areas, these soils are severely eroded and the whitish subsoil is exposed. An abrupt boundary separates the lower part of the profile from highly calcareous underlying material.

These soils are best suited to pasture and range. If they are cultivated, practices that control erosion and maintain fertility are needed. The choice of crops is limited to wheat or other close-growing crops. The lime in these soils is likely to reduce the availability of iron and other minor elements needed by plants. This causes chlorosis, a nutritional deficiency of plants, to which sorghum is especially susceptible.

CAPABILITY UNIT IVs-1

In this capability unit are deep, nearly level, loamy to clayey soils and Slickspot soils. These soils are—

Farnum-Slickspot complex.
Tabler-Slickspot complex.

This unit consists of soils that have been affected by salts. In as much as 35 percent of the acreage, salts have affected the soils to the extent that the surface is slicked over and the soils are called Slickspots. In most of the remaining acreage, the soils have also been affected by salts, at least in the subsoil. In addition to the high content of salts, the soils are wet and need drainage. In cultivated areas wind erosion is a hazard in spring.

Cultivated crops are generally not suited, and range consisting of native grasses is the best use for these soils. Switchgrass, tall wheatgrass, and western wheatgrass are all well adapted.

CAPABILITY UNIT Vw-1

Nearly level to sloping, sandy and loamy soils that have a permanent high water table make up this capability unit. These soils are—

Elsmere-Plevna complex.
Elsmere-Tivoli complex (Elsmere soil only).
Plevna fine sandy loam.
Wet alluvial land.

The soils of this unit are permanently wet and are locally called subirrigated. They are excellent for range or pasture, and most of the acreage is in range. Stocking range at a proper rate and controlling weeds and brush are good management practices.

CAPABILITY UNIT VIe-1

In this capability unit are deep, hummocky sands. These soils are—

Elsmere-Tivoli complex (Tivoli soil only).
Tivoli soils, hummocky.

These soils are on steep, rolling topography. After a heavy rain water occasionally stands in low areas.

Range is the best use of these soils. If properly managed, the soils support abundant tall and mid grasses. If the range is overgrazed, weeds invade the stand and wind erosion may result. Therefore, it is important to stock livestock at a proper rate so that a good stand of grass is maintained. Because of the rough topography, other erosion control practices are not practical.

CAPABILITY UNIT VIe-2

Only Shellabarger and Albion soils, 7 to 15 percent slopes, is in this capability unit. The soils are steep, brownish, deep or moderately deep sandy loams underlain by coarse sand and gravel.

These soils are used for range, and they support tall grasses if they are properly managed. Grazing needs to be controlled so that a good stand of tall grasses will be maintained. If overgrazing is allowed, short and mid grasses take over. Western ragweed is common in areas that have been overgrazed. On these soils care must be taken to avoid gravelly and sandy material in selecting sites for ponds that will provide water for livestock. Such material is too porous to hold water.

CAPABILITY UNIT VIe-3

Only Nash-Lucien complex, 6 to 15 percent slopes, is in this capability unit. These are reddish, silty or loamy soils that are shallow and moderately deep over siltstone.

These soils are well suited to range, and tall and mid grasses are dominant in areas that are well managed. Grazing must be controlled, however, and livestock must be stocked at a proper rate, so that a good stand of tall and mid grasses will be maintained. Overgrazing allows weeds and short grasses to take over. Sites for ponds that supply water for livestock can be located on these soils.

CAPABILITY UNIT VIe-4

The only mapping unit in this capability unit is Vernon soils. These soils are in nearly level to steep and broken areas and have a reddish color. They are clayey and are shallow over shale.

Most of the acreage is in grass, and mid and short grasses are the native plants. Livestock must be stocked at a proper rate, so that a good stand of desirable grasses will be maintained and weeds controlled. In areas that have been overgrazed, annual broomweed, snow-on-the-mountain, other weeds, and blue grama and other short grasses take over.

In many areas of these soils, it is difficult to locate sites for ponds that can be used for watering livestock. Lack of water is therefore a problem in managing some areas of range on these soils.

CAPABILITY UNIT VIe-5

Only the Breaks part of Breaks-Alluvial land complex is in this capability unit. It consists of deep, moderately steep, dark-colored loams and clay loams that occupy short, broken areas along drainageways in the uplands. In places these soils are calcareous.

Runoff is rapid. The water-holding capacity is high.

Breaks is well suited to grass, and tall and mid grasses are the native plants. Livestock must be stocked at a proper rate and weeds eliminated, so that a good stand of grass will be maintained and erosion controlled.

CAPABILITY UNIT VIw-1

In this capability unit are soils adjacent to streams that frequently flood. Where these soils are adjacent to the larger streams of the county, they are 10 to 15 inches deep over coarse sand and gravel. These soils are—

Breaks-Alluvial land complex (Alluvial land only).
Platte soils.

These soils are productive and are well suited to grass. Frequent flooding, however, and the associated introduction of weeds are serious problems. In some areas flooding is controlled by dikes, and chemicals can be used for controlling weeds. Livestock should be stocked at a proper rate so that desirable grasses will be maintained.

CAPABILITY UNIT VIs-1

Only Slickspots is in this capability unit. It consists of deep, dark, clayey soils that contain salts and alkali.

The water table in these soils is near the surface for a short time nearly every year. Excessive alkali and wetness are the chief limitations.

Slickspot soils are used for range, and they support good stands of switchgrass and indiangrass if they are properly managed. If they are overgrazed, the dominant vegetation is saltgrass and weeds. Good management practices for these soils include proper stocking of the range and control of weeds. Cultivated areas or areas now supporting only saltgrass and weeds may be profitably reseeded to tall wheatgrass or other grasses that tolerate salt.

CAPABILITY UNIT VIIe-1

Tivoli fine sand, hilly, is the only soil in this capability unit. It is deep and light colored, and it occupies rough hummocky areas and dunes.

Fertility is low, and wind erosion is a serious problem. Blowouts and unstable dunes are common in the steeper areas.

Grass is the best use for this soil, and big sandreedgrass (*Calamovilfa gigantea*), little bluestem, and sand plum are the common plants. A good stand of grass must be maintained so that further damage to the soil from wind erosion will be prevented. Livestock need to be stocked at a proper rate, and unstable dunes should be fenced to prevent livestock from grazing in the area.

Predicted Yields

Table 2 gives the predicted average yields per acre of the principal crops—wheat, grain sorghum, and alfalfa—grown on the soils in capability classes I, II, III, and IV. The yields shown are for two levels of management. They are based mainly on information gathered from interviews with farmers, but partly from information obtained from the county agricultural agent and from members of the Farm Management Association. In addition, information was obtained from records of yields from test plots managed in cooperation with the Kansas State University.

Yields shown in columns A are to be expected under the average, or most common, management practiced in the county. This management consists of the following:

1. Planting recommended varieties of crops that are adapted to the area.
2. Seeding at the proper rate and on the proper dates, using suitable methods of planting, and harvesting efficiently.
3. Controlling weeds, insects, and diseases.
4. Applying starter fertilizer.
5. Using proper management of crop residue to a limited extent.

The yields given in columns B are to be expected under improved management. This management includes the practices listed for the average level of management plus the following:

1. Planning a good program of fertilization that provides for the use of fertilizer and lime, where required, for maximum yields.
2. Using practices, such as terraces, contour farming, and grassed waterways, that conserve soil and water.
3. Using crop residue to aid in the control of erosion by wind and water, to increase the infiltration of water, and to encourage the emergence of seedlings.
4. Planning a good cropping system that fits the needs of the operator and maintains good tilth.

Irrigation

Most of the county is underlain by a fair amount of water suitable for irrigation, but this practice is not widely used. The size of the irrigated acreage in the county varies from year to year, depending on the amount of rainfall. In drier years about 6,500 acres is irrigated, mainly by sprinkler systems. About 900 acres is irrigated in years of normal rainfall; nearly all of this is irrigated by gravity systems.

The amount of irrigated acreage has not increased as much as it has in many other areas in Kansas, even though farm records indicate that irrigation is economically

TABLE 2.—*Predicted average yields per acre of the principal crops grown under two levels of management on the soils suitable for cultivation*

[Yields in columns A are those obtained over a period of years under average management; yields in columns B are those to be expected under improved management. Absence of a yield figure indicates that the soil is not suited to the crop specified or that the crop is not commonly grown under the type of management indicated]

Soil	Wheat		Grain sorghum		Alfalfa	
	A	B	A	B	A	B
Albion-Shellabarger sandy loams, 0 to 1 percent slopes:	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Tons*	*Tons*
Albion soil	12	20	16	26	----	----
Shellabarger soil	14	24	22	36	1.5	2.5
Albion-Shellabarger sandy loams, 1 to 4 percent slopes:						
Albion soil	10	14	16	22	----	----
Shellabarger soil	13	23	19	35	1.5	2.0
Bethany silt loam, 0 to 1 percent slopes	20	30	30	45	2.0	3.0
Bethany silt loam, 1 to 3 percent slopes	18	30	28	45	1.2	2.0
Canadian fine sandy loam	17	28	30	45	3.0	4.0
Carwile fine sandy loam	15	22	25	35	1.5	2.5
Carwile-Farnum fine sandy loams:						
Carwile soil	15	22	25	35	1.5	2.5
Farnum soil	17	30	30	48	2.0	2.5
Clark fine sandy loam	16	28	22	30	2.0	3.0
Clark-Ost complex, 0 to 1 percent slopes:						
Clark soil	20	30	23	32	2.0	3.0
Ost soil	20	30	25	40	2.0	3.0
Clark-Ost complex, 1 to 3 percent slopes:						
Clark soil	17	28	23	31	2.0	3.0
Ost soil	17	28	24	35	2.0	3.0
Clark-Ost complex, 3 to 6 percent slopes:						
Clark soil	10	16	15	21	----	----
Ost soil	10	16	20	26	----	----
Dale clay loam	20	27	32	50	3.0	4.0
Farnum fine sandy loam, 0 to 1 percent slopes	17	30	30	48	2.0	2.5
Farnum loam, 0 to 1 percent slopes	18	32	30	48	2.0	2.5
Farnum loam, 1 to 3 percent slopes	17	30	28	45	2.0	2.5
Farnum-Slickspot complex:						
Farnum soil	10	15	15	20	1.5	2.0
Farnum-Tabler complex:						
Farnum soil	18	32	30	48	2.0	2.5
Tabler soil	17	27	20	32	2.0	2.5
Lesho clay loam	10	14	20	32	----	----
Naron fine sandy loam, 0 to 1 percent slopes	16	28	28	40	2.0	3.0
Naron fine sandy loam, 1 to 3 percent slopes	15	25	23	38	1.0	2.0
Naron-Farnum complex:						
Naron soil	16	28	28	40	2.0	3.0
Farnum soil	17	30	30	48	2.0	2.5
Naron-Pratt complex:						
Naron soil	16	28	28	40	2.0	3.0
Pratt soil	14	22	24	34	1.5	2.0
Nash-Lucien complex, 1 to 3 percent slopes:						
Nash soil	16	24	16	24	----	----
Lucien soil	10	16	----	----	----	----
Nash-Lucien complex, 3 to 6 percent slopes:	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Tons*	*Tons*
Nash soil	14	22	14	22	----	----
Lucien soil	8	15	----	----	----	----
Port clay loam	20	30	30	45	2.0	3.5
Pratt loamy fine sand, undulating	14	22	24	34	----	----
Pratt loamy fine sand, hummocky	9	12	15	25	----	----
Pratt-Carwile complex:						
Pratt soil	14	22	24	34	----	----
Carwile soil	15	22	25	35	1.5	2.5
Renfrow clay loam, 0 to 1 percent slopes	14	23	20	30	1.5	2.5
Renfrow clay loam, 1 to 3 percent slopes	12	22	18	28	1.0	2.0
Renfrow-Vernon clay loams:						
Renfrow soil	12	22	18	28	1.5	2.5
Vernon soil	8	13	----	----	----	----
Shellabarger fine sandy loam, 0 to 1 percent slopes	15	25	23	40	1.5	2.5
Shellabarger fine sandy loam, 1 to 3 percent slopes	14	25	20	38	1.5	2.0
Shellabarger fine sandy loam, shale substratum, 0 to 3 percent slopes	13	22	17	30	1.0	2.0
Shellabarger loamy fine sand, undulating	13	22	22	38	1.0	2.0
Shellabarger-Clark-Albion complex 2 to 6 percent slopes:						
Shellabarger soil	13	23	19	35	1.5	2.0
Clark soil	10	16	15	21	1.5	2.0
Albion soil	10	14	16	22	----	----
Shellabarger-Farnum complex, 1 to 3 percent slopes:						
Shellabarger soil	15	25	23	40	1.5	2.5
Farnum soil	18	30	28	45	1.5	2.5
Shellabarger and Farnum soils, 3 to 7 percent slopes, eroded:						
Shellabarger soil	11	17	17	23	----	----
Farnum soil	12	21	19	26	----	----
Smolan silty clay loam, 1 to 3 percent slopes	17	27	26	38	1.5	2.5
Smolan silty clay loam, 3 to 6 percent slopes, eroded	12	19	----	----	----	----
Tabler clay loam	17	27	20	32	2.0	2.5
Tabler-Slickspot complex:						
Tabler soil	9	14	15	20	----	----
Vanoss silt loam, 0 to 1 percent slopes	24	35	38	55	2.5	4.0
Vanoss silt loam, 1 to 3 percent slopes	22	32	30	52	2.0	3.5
Vanoss silt loam, 3 to 7 percent slopes, eroded	11	17	17	23	----	----
Wann fine sandy loam	12	18	22	32	----	----

sound in this county. These records, from several sources, show that irrigation is practical if intensive farming is practiced, if crops are grown that respond favorably to additional water, and if ample fertilizer is used. Generally, however, the annual rainfall has been great enough for profitable yields of wheat and grain sorghum if good management is practiced.

Some of those farmers engaged in dairy farming or the raising of beef cattle irrigate part of their land every year because cattle require a large acreage of pasture, hay, and silage crops. Farmers who raise truck crops also irrigate some land every year.

Farming under irrigation is more complex than dryland farming. In each field there is a different problem of design. Even similar soils may take in water at a different rate as a result of differences in past management. Before deciding to irrigate his land, the farmer needs to know the quality and quantity of water available. He also needs to know the suitability of the soils for irrigation in relation to the quality of the water available. Areas that are likely to have a good supply of ground water can be located by consulting "Geology and Ground-Water Resources in Reno County, Kansas" (*5*) [2] and the accompanying maps. The quality of the water and the yield to be expected can also be determined from this publication. A technician of the Soil Conservation Service can help in designing and planning an efficient irrigation system.

Management of Rangeland [3]

Rangeland makes up about 22 percent of the total acreage in Reno County. It is scattered throughout the county, but some areas are concentrated along the Arkansas River and along the North Fork Ninnescah River. Generally, this land is not suitable for cultivation.

The raising of livestock is the second largest agricultural enterprise in the county. Its success depends upon the way ranchers and farmers manage their range and other sources of feed. The livestock are mainly feeder-stocker cattle, but there are a few breeding herds in the county.

Range sites and condition classes

Different kinds of range produce different kinds and amounts of forage. If the operator of a range is to manage his rangeland properly, he needs to know the different kinds of land, or range sites, in his holdings and the plants each site is capable of producing. He is then able to determine what his range can be expected to produce in different seasons and under different degrees of grazing use.

Range sites are distinctive kinds of rangeland that differ from each other in their ability to produce a distinct kind or amount of climax, or original, vegetation. A significant difference is one great enough to require different grazing practices or other management practices that will maintain or improve the present vegetation.

Climax vegetation is the combination of plants that originally grew on a given site. The most productive combination of forage plants on a range site is generally the climax type of vegetation.

Range condition is the present state of the vegetation in relation to the highest stage of plant growth the site can support. It is determined by computing the percentage of the present vegetation in relation to the climax vegetation for the site. Changes in range condition are caused primarily by the degree of use or the kind of use of the rangeland. The effects of grazing become more apparent during periods of drought. Four range condition classes are defined. A range in excellent condition has from 76 to 100 percent of the vegetation that is characteristic of the climax vegetation on the same site; one in good condition, 51 to 75 percent; one in fair condition, 26 to 50 percent; and one in poor condition, less than 26 percent.

In the descriptions of range sites, native vegetation is referred to in terms of *decreasers*, *increasers*, and *invaders*. Decreasers and increasers are climax plants. Decreasers are generally the most heavily grazed and are consequently the first to be injured by overgrazing. Increasers withstand grazing better or are less palatable to livestock; they increase under grazing and replace the decreasers. Invaders are weeds that become established after the climax vegetation has been reduced by grazing.

The range sites in this county are described in the following pages. The description of each site gives the names of the soils in the site and the dominant vegetation when the site is in excellent condition. The estimated yield of air-dry top growth for each site is also given. These yields vary from year to year, depending on the amount of rainfall and on the amount the range site has been grazed in past years. Some forage is also destroyed by rodents and insects or by trampling of livestock.

SUBIRRIGATED RANGE SITE

In this range site are subirrigated soils adjacent to sandhills and in the valleys of the Arkansas and North Fork Ninnescah Rivers. These soils are in nearly level areas or in slight depressions (fig. 9). The texture of their surface layer is loamy fine sand to clay loam, but the underlying material is sand and gravel through which water passes readily. The water table is normally within 4 feet of the surface. These soils are—

Elsmere-Plevna complex.
Elsmere-Tivoli complex (Elsmere soil only).
Lesho clay loam.
Plevna fine sandy loam.
Wann fine sandy loam.
Wet alluvial land.

The climax plant cover on this range site is a mixture of big bluestem, indiangrass, switchgrass, prairie cordgrass, and other decreaser grasses. These plants make

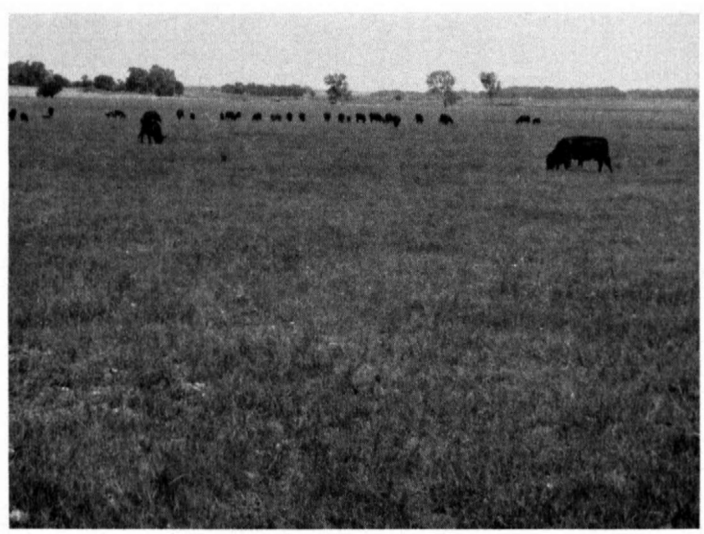

Figure 9.—Typical area of the Subirrigated range site. The soil is Plevna fine sandy loam.

[2] Italic numbers in parentheses refer to Literature Cited, p. 71.

[3] By PETER N. JENSEN, range conservationist, Soil Conservation Service.

up at least 90 percent of the total plant cover, and other perennial grasses, plants that resemble grasses, and forbs make up the rest. Sedges and rushes are the principal increasers, and western ragweed, buffalograss, and foxtail barley are the common invaders.

If rainfall is normal, the estimated annual yield of air-dry top growth is 6,000 to 8,000 pounds per acre when this site is in excellent condition.

LOAMY LOWLAND RANGE SITE

In this range site are nearly level, moderately deep, permeable, loamy soils. The soils receive extra moisture from occasional flooding or runoff and have high water-holding capacity. These soils are—

Breaks-Alluvial land complex (Alluvial land only).
Dale clay loam.

The climax plant cover on this site is a mixture of big bluestem, indiangrass, switchgrass, Canada wildrye, and other decreaser grasses. These plants make up at least 80 percent of the total cover, and other perennial grasses and forbs make up the rest. Western wheatgrass, tall dropseed, and sideoats grama are the principal increasers; ironweed and verbena are the common invaders.

If rainfall is normal, the estimated annual yield of air-dry top growth is 4,000 to 6,000 pounds per acre when this site is in excellent condition.

SANDY LOWLAND RANGE SITE

Only Canadian fine sandy loam is in this range site. It is nearly level or slightly undulating and is on low terraces along streams. The surface layer of this soil is fine sandy loam, and the subsoil is sandy loam. Permeability is moderately rapid. The water table is normally at a depth of 5 to 10 feet.

The climax plant cover is a mixture of big bluestem or sand bluestem, little bluestem, switchgrass, Canada wildrye, and other decreaser grasses. These plants make up at least 50 percent of the total plant cover, and other perennial grasses and forbs make up the rest. Sideoats grama and purpletop are the principal increasers. Annuals are common invaders.

If rainfall is normal, the estimated annual yield of air-dry top growth is 2,500 to 4,000 pounds per acre when this site is in excellent condition.

SALINE LOWLAND RANGE SITE

In this range site are nearly level or gently sloping soils on the uplands and stream terraces. These soils have a surface layer of sandy loam to silty clay loam and a subsoil of clay loam or clay. They are moderately well drained to imperfectly drained, and as a result, they contain a high concentration of salts. The water table is normally at a depth of 3 to 10 feet. These soils are—

Farnum-Slickspot complex.
Slickspots.
Tabler-Slickspot complex (Slickspot soil only).

The climax plant cover is a mixture of such decreaser grasses as alkali sacaton, switchgrass, indiangrass, sideoats grama, and western wheatgrass. These plants make up at least 75 percent of the total cover, and other perennial grasses and forbs make up the rest. Inland saltgrass, blue grama, and buffalograss are the principal increasers; common invaders are alkali muhly and tamarisk.

If rainfall is normal, the estimated annual yield of air-dry top growth is 3,500 to 4,500 pounds per acre when this site is in excellent condition.

LOAMY UPLAND RANGE SITE

Nearly level to steep soils of the uplands make up this range site. These soils have a loamy surface layer and loamy to clayey subsoil. They are moderately to slowly permeable, are well drained, and have high water-holding capacity. These soils are—

Bethany silt loam, 0 to 1 percent slopes.
Bethany silt loam, 1 to 3 percent slopes.
Breaks-Alluvial land complex (Breaks only).
Clark-Ost complex, 0 to 1 percent slopes (Ost soil only).
Clark-Ost complex, 1 to 3 percent slopes (Ost soil only).
Clark-Ost complex, 3 to 6 percent slopes (Ost soil only).
Farnum loam, 0 to 1 percent slopes.
Farnum loam, 1 to 3 percent slopes.
Farnum-Tabler complex (Farnum soil only).
Nash-Lucien complex, 1 to 3 percent slopes (Nash soil only).
Nash-Lucien complex, 3 to 6 percent slopes (Nash soil only).
Nash-Lucien complex, 6 to 15 percent slopes (Nash soil only).
Port clay loam.
Shellabarger-Farnum complex, 1 to 3 percent slopes (Farnum soil only).
Shellabarger and Farnum soils, 3 to 7 percent slopes, eroded (Farnum soil only).
Smolan silty clay loam, 1 to 3 percent slopes.
Vanoss silt loam, 0 to 1 percent slopes.
Vanoss silt loam, 1 to 3 percent slopes.
Vanoss silt loam, 3 to 7 percent slopes, eroded.

The climax plant cover is a mixture of such decreaser grasses as little bluestem, big bluestem, indiangrass, and switchgrass. These grasses make up at least 50 percent of the total cover, and other perennial grasses and forbs make up the rest. Sideoats grama, blue grama, buffalograss, and western wheatgrass are the principal increasers, and common invaders are ironweed, verbena, and annuals.

If rainfall is normal, the estimated annual yield of air-dry top growth is 3,000 to 4,500 pounds per acre when this site is in excellent condition.

CLAY UPLAND RANGE SITE

Nearly level to rolling soils of the uplands make up this range site. These soils have a surface layer of loam to silty clay loam and a subsoil of silty clay loam to clay. They are very slowly permeable. These soils are—

Farnum-Tabler complex (Tabler soil only).
Renfrow clay loam, 0 to 1 percent slopes.
Renfrow clay loam, 1 to 3 percent slopes.
Renfrow-Vernon clay loams (Renfrow soil only).
Smolan silty clay loam, 3 to 6 percent slopes, eroded.
Tabler clay loam.
Tabler-Slickspot complex (Tabler soil only).

The climax plant cover on this site is a mixture of such decreaser grasses as little bluestem, big bluestem, and switchgrass. These grasses make up at least 25 percent of the total plant cover, and other perennial grasses and forbs make up the rest. Western wheatgrass, sideoats grama, blue grama, and buffalograss are the principal increasers. The common invaders are winter annuals and snow-on-the-mountain.

If rainfall is normal, the estimated annual yield of air-dry top growth is 2,000 to 4,000 pounds per acre when this site is in excellent condition.

LIMY UPLAND RANGE SITE

In this range site are nearly level to sloping soils of the uplands. These soils have a surface layer and subsoil of calcareous sandy loam to clay loam; they are permeable and well drained. These soils are—

- Clark fine sandy loam.
- Clark-Ost complex, 0 to 1 percent slopes (Clark soil only).
- Clark-Ost complex, 1 to 3 percent slopes (Clark soil only).
- Clark-Ost complex, 3 to 6 percent slopes (Clark soil only).
- Shellabarger-Clark-Albion complex, 2 to 6 percent slopes (Clark soil only).

The climax plant cover on this site is a mixture of such decreaser grasses as little bluestem, sideoats grama, and big bluestem. These grasses make up at least 75 percent of the total cover, and other perennial grasses and forbs make up the rest. Blue grama, hairy grama, and buffalograss are the principal increasers. Annuals and broom snakeweed are the common invaders.

If rainfall is normal, the estimated annual yield of air-dry top growth is 2,000 to 4,000 pounds per acre when this site is in excellent condition.

SHALLOW PRAIRIE RANGE SITE

The soils of this range site are gently sloping to steep. They have a surface layer of loam or silt loam and a subsoil of silt loam. These soils are shallow over siltstone, and ledges of siltstone are exposed in the more sloping areas (fig. 10). The water-holding capacity is low, and the soils tend to be droughty. These soils are—

- Nash-Lucien complex, 1 to 3 percent slopes (Lucien soil only).
- Nash-Lucien complex, 3 to 6 percent slopes (Lucien soil only).
- Nash-Lucien complex, 6 to 15 percent slopes (Lucien soil only).

The climax plant cover is a mixture of little bluestem, big bluestem, indiangrass and other decreaser grasses. These grasses make up at least 50 percent of the total plant cover, and other perennial grasses and forbs make up the rest. Sideoats grama, blue grama, and hairy grama are the principal increasers; annuals are common invaders.

***Figure 10.*—An area of the Shallow Prairie range site where siltstone crops out in the Lucien soils. In the background is an area of the Subirrigated range site along the North Fork Ninnescah River.**

If rainfall is normal, the estimated annual yield of air-dry top growth is 1,500 to 2,500 pounds per acre when this site is in excellent condition.

SANDY RANGE SITE

Deep, nearly level to strongly sloping soils of the uplands make up this range site. These soils have a surface layer of sandy loam, fine sandy loam, or loamy fine sand, and a subsoil of sandy loam to clay. The rate of infiltration is moderate to rapid, and the water-holding capacity is moderate. These soils are—

- Albion-Shellabarger sandy loams, 0 to 1 percent slopes.
- Albion-Shellabarger sandy loams, 1 to 4 percent slopes.
- Carwile fine sandy loam.
- Carwile-Farnum fine sandy loams.
- Farnum fine sandy loam, 0 to 1 percent slopes.
- Naron fine sandy loam, 0 to 1 percent slopes.
- Naron fine sandy loam, 1 to 3 percent slopes.
- Naron-Farnum complex.
- Naron-Pratt complex (Naron soil only).
- Pratt-Carwile complex (Carwile soil only).
- Shellabarger fine sandy loam, 0 to 1 percent slopes.
- Shellabarger fine sandy loam, 1 to 3 percent slopes.
- Shellabarger fine sandy loam, shale substratum, 0 to 3 percent slopes.
- Shellabarger loamy fine sand, undulating.
- Shellabarger and Albion soils, 7 to 15 percent slopes.
- Shellabarger-Clark-Albion complex, 2 to 6 percent slopes (Shellabarger and Albion soils only).
- Shellabarger-Farnum complex, 1 to 3 percent slopes (Shellabarger soil only).
- Shellabarger and Farnum soils, 3 to 7 percent slopes, eroded (Shellabarger soil only).

The climax plant cover is a mixture of such decreaser grasses as little bluestem, sand bluestem, big bluestem, and switchgrass. These grasses make up at least 60 percent of the total plant cover, and other perennial grasses and forbs make up the rest. Sideoats grama, hairy grama, sand dropseed, and fall witchgrass are the principal increasers, and windmillgrass, gumweed, and broomweed are the common invaders.

If rainfall is normal, the estimated annual yield of air-dry top growth is 4,000 to 6,000 pounds per acre when this site is in excellent condition.

SANDS RANGE SITE

In this range site are deep, rolling or hummocky soils that have a surface layer and subsoil of loamy fine sand or fine sand. The rate of infiltration is rapid, and the water-holding capacity is low. These soils are—

- Elsmere-Tivoli complex (Tivoli soil only).
- Naron-Pratt complex (Pratt soil).
- Pratt loamy fine sand, undulating.
- Pratt loamy fine sand, hummocky.
- Pratt-Carwile complex (Pratt soil only).
- Tivoli soils, hummocky.

The climax plant cover is a mixture of such decreaser grasses as sand bluestem, big bluestem, little bluestem, indiangrass, switchgrass, and sand lovegrass. These plants make up at least 70 percent of the total plant cover, and other perennial grasses and forbs make up the rest. Sand dropseed, sand paspalum, and fall witchgrass are the principal increasers, and chickasaw plum is the principal increasing shrub. Common invaders are windmillgrass, sandbur, and western ragweed.

If rainfall is normal, the estimated annual yield of air-dry top growth is 3,000 to 5,000 pounds per acre when this site is in excellent condition.

CHOPPY SANDS RANGE SITE

Only Tivoli fine sand, hilly, is in this range site. It is a deep soil in areas of rough hummocky or dune topography. The subsoil is fine sand. The rate of infiltration is very rapid, and the water-holding capacity is low.

The climax plant cover is big sandreedgrass, little bluestem, and chickasaw plum. Common invaders are western ragweed and sandbur.

If rainfall is normal the estimated annual yield of air-dry top growth is 2,000 to 3,000 pounds per acre when this site is in excellent condition.

RED CLAY PRAIRIE RANGE SITE

This range site consists of nearly level to strongly sloping soils of the uplands. These soils are shallow to moderately deep. They have a surface layer of clay loam that is underlain by shale. The water-holding capacity is low. These soils are—

Renfrow-Vernon clay loams (Vernon soil only).
Vernon soils.

The climax plant cover is a mixture of little bluestem, sideoats grama, and other decreaser grasses. These grasses make up at least 50 percent of the total plant cover, and other perennial grasses and forbs make up the rest. Blue grama, hairy grama, and buffalograss are the principal increasers. Annuals are the common invaders.

If rainfall is normal, the estimated annual yield of air-dry top growth is 1,000 to 2,000 pounds per acre when this site is in excellent condition.

UNSTABLE RANGE SITE

This is not a true range site because the soils and vegetation are unstable. It consists only of Platte soils.

These soils are made up of recently deposited alluvial material that is stratified and is frequently flooded. They are adjacent to the major streams, and scouring and cutting make the plant cover unstable. The vegetation is primarily cottonwood trees, willows, johnsongrass, and annuals.

Management principles and practices

High production of forage, and conservation of soil, water, and plants on rangeland, are obtained by maintaining range that is already in good or excellent condition, and by improving range that is depleted. The vegetation is improved by managing the grazing so as to encourage the growth of the best native forage plants.

The development of leaves, the growth of roots, the formation of flowers and stalks, the production of seed, the regrowth of forage, and the storage of food in the roots are all essential in the development and growth of grass. Grazing must be regulated to permit these natural processes of growth to take place, if maximum yields of forage and peak production of livestock are to be maintained.

Livestock are selective in grazing, and they constantly seek the more palatable plants. If grazing is not carefully controlled, the better plants are eventually eliminated. If heavy grazing is continued, even the second-choice plants will be thinned out or eliminated, and undesirable weeds or invaders take their place.

Research and the experience of ranchers have shown that when only about half the yearly volume of grass is grazed, damage to the desirable plants is minimized and the range is improved. The grass that is left to grow has the following effects on the range:

1. It permits the better range plants to maintain or improve their vigor and thus to crowd out or prevent weeds from gaining a foothold.
2. It enables plants to store plant nutrients for quick and vigorous growth after droughts and in spring.
3. It causes the roots to increase in number and length so that they can reach additional moisture and plant nutrients. (Roots of overgrazed grass cannot reach deep moisture, because not enough green shoots are left to provide food needed for good root growth.)
4. It protects the soils from erosion by wind and water.
5. It serves as a mulch that allows rapid intake of water. The more moisture stored in the ground, the better the growth of grass for grazing.
6. It stops snow where it falls, so that it can melt and soak into the soil for later use.
7. It provides a greater reserve of feed for the dry years and thus removes possible need for emergency sale of livestock.

Sound range management requires adjustment in the stocking rate from season to season, according to the amount of forage produced. It should provide for reserve pastures or for other feed during droughts or other periods when the production of forage has been low. Thus, the range forage can be grazed moderately at all times. It is often desirable to keep part of the livestock, such as stocker steers, readily salable. Such flexibility allows the rancher to adjust the number of livestock to the amount of forage available without selling breeding animals.

Proper range use and deferred grazing or rotation-deferred grazing are practices that are applicable on all rangeland, regardless of other practices used. They cost little and improve the range. Other practices that improve the range are range seeding, development of suitable watering places, constructing fences, placing salt in areas where it encourages uniform grazing and controlling undesirable plants.

1. *Proper range use* consists of grazing rangeland at a rate that will maintain the vigor of the plants, a reserve of forage, and enough plant residue to conserve soil and water. At the same time, proper range use keeps the most desirable vegetation on the site or improves the quality of the vegetation that has deteriorated.
2. *Deferred grazing* is resting a pasture during any growth period of the year. All livestock are kept off the range while it is rested. This practice increases the vigor of the forage plants and permits the desirable plants to reproduce naturally by seed. It also allows a reserve of forage to be built up for fall and winter grazing or for emergency use.
3. *Rotation-deferred* grazing is a practice in which one or more pastures are rested at planned intervals throughout the growing season. Each pasture is rested during a different period each successive year so that desirable forage plants can develop and produce seed.

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4. *Range seeding* consists of establishing native or improved grasses and forbs, by seeding or reseeding, on land suitable for range. The area to be seeded should have a climate and soils that will support range. Also, the plants need to be adapted to the climate and soils. This insures that the supply of forage can be maintained with no care other than the proper management of grazing.

   A mixture of species that are dominant in the climax vegetation on the particular site should be seeded. The seed of the native grasses or forbs to be planted ought to have originated from an area as near as feasible to the area to be seeded. Generally, the origin of the seed should be no farther away than 250 to 400 miles south or 100 to 150 miles north of the area to be seeded.

   The grasses should be seeded in forage stubble or in the stubble of grain sorghum because this type of cover protects the soils from erosion, provides a firm seedbed, and helps to control weeds. The mulch also helps to retain moisture in the surface layer. The newly seeded area should not be grazed until the plants have had time to become firmly established.
5. *Water developments* need to be distributed over the entire range, if feasible, so that livestock do not have to travel far for water. Good distribution of watering places helps achieve uniform use of the range. Generally, wells and ponds supply water for livestock. The characteristics of each range site determine which type of water development is the most practical.
6. *Fences* need to be constructed to provide for good management of the livestock and range. This can mean separating different areas of range on the basis of seasonal use. In some places different range sites that are large enough are fenced separately.
7. *Salting* is necessary on rangeland to supplement the supply of native forage. Proper distribution of salt is used to improve the distribution of grazing.
8. *Control of undesirable plants* through chemical or mechanical means may be needed in some areas. It permits improvement in the forage on the range and also makes handling of livestock easier.

To summarize, livestock management that achieves high production and conserves the resources of the range includes—

1. A feed and forage program that provides available range forage and also provides concentrates, tame and native hay, tame pasture, or harvested roughage to keep livestock in good condition throughout the year. During emergencies, the use of roughage reserves for feed, and the deferred grazing of native pastures, will indirectly conserve the plant cover, soils, and water. Shortages of feed can be avoided by storing for future use the surplus produced in years of high yields. Reserves of feed may be stored in stacks, pits, or silos.
2. A breeding program that provides for the type of livestock most suitable for the range and for the ranching system, for a supply of calves in seasons when forage is most nutritious, and for continued improvement of the herd, consistent with the type of range and climate.
3. Culling nonproductive animals from the herd.

Management of Windbreaks [4]

This section gives information about the management of windbreaks. Most of the trees in Reno County are grown in windbreaks. The trees in natural stands grow only on the bottom lands along the Arkansas River and smaller streams and in natural depressions. None of the trees, except cottonwood, willow, and wild plum, are native to this county. They were introduced from other areas.

The first settlers planted trees for protection and shade. They established hedgerows of Osage-orange in many places to provide fence posts and to serve as fences for livestock. Some of the settlers also planted catalpa for use as fence posts. Through the ensuing years, landowners have continued to plant trees, and today the landscape is dotted with hundreds of field and farmstead windbreaks, remnants of hedgerows, and some plantations of catalpa.

Planting for windbreaks is done more extensively than planting for other uses, although trees are occasionally planted for fence posts. However, a much larger acreage of windbreaks is needed in this county. During the period from 1938–42, about 7,000 acres was planted in about 900 windbreaks as a result of the U.S. Forest Service Shelterbelt Project. The prolonged droughts of the midfifties severely damaged many of the windbreaks, especially those on clayey, shallow, or very sandy soils. On most of the other soils, the trees survived.

Kinds of windbreaks.—Windbreaks are generally of two kinds. The first kind, farmstead windbreaks, are established around the farmstead to protect against the blasts of cold, wintry winds, and they provide shelter for the home, farmyard, and livestock corrals. If they are properly designed and are in a suitable location, field windbreaks control the drifting of snow and keep snow out of the farmyard. They also protect landscape plantings, fruit trees, and gardens, and they provide a nesting site for songbirds and shelter for other kinds of wildlife. A good farmstead windbreak adds hundreds of dollars to the value of a farm.

The second kind, field windbreaks, are effective in helping to control soil blowing in areas of cropland, primarily in areas of sandy soils. In some years they also increase crop yields by protecting the crops from hot winds and from mechanical damage caused by wind. For a field windbreak to be most effective, other practices are needed to control erosion and conserve moisture. Field windbreaks normally consist of strips only one to three rows wide, with 20 to 40 rods between the strips. Strips of that width require only a comparatively small acreage and are adequate for protecting soils and crops.

Planting of windbreaks.—On most soils the area in which windbreaks are to be planted should be prepared in the same way as for ordinary field crops. It ought to be deep plowed to break up the plowsole if one is present. If the soils are not sandy, the area to be planted ought to

[4] By ARTHUR E. FERBER, woodland conservationist, Denver, Colo.

be prepared far enough in advance that the soil will have time to settle. Because sandy soils, especially those in groups 5 and 6, are likely to blow unless they are protected, it may be best to plant the sandy soils without advance preparation or to seed a cover crop. The cover crop will protect the soils both before and after the trees are planted, and it will protect the young seedlings.

To be most effective, windbreaks should be carefully planned and the site staked out before the trees are planted. Farmstead windbreaks should not be too close or too far from the areas to be protected. In planning windbreaks for the protection of cropland, the number of field windbreaks needed ought to be determined by the susceptibility of the soils to blowing, by the other practices used to control erosion and conserve moisture, and by the mature height of the trees that will be used in the windbreak.

When stock is chosen for planting, it is preferable to select species that grow best on the kinds of soils at the site where the windbreak is to be established. For example, only evergreens are suited to the soils of group 6. Also, only the most drought-tolerant species should be planted on the soils of group 8. Purchase healthy seedlings grown from seeds produced locally, and from reputable nurseries or other agencies. Plant early in spring, protect the seedlings from drying out while they are being planted, and tamp the ground so that it will be firm around the roots.

Young trees need considerable care if they are to survive and grow well on prairie soils where the climate is like that in Reno County. Rainfall is likely to be limited and irregular. Therefore, all weeds should be controlled by cultivation or by using chemical weedkillers in the windbreak planting so that the weeds cannot compete for moisture. The soils of group 1 require clean and continued cultivation and a wider space between the rows than the soils in other groups. The soils in all the groups ought to be kept open so that they will soak up the moisture from rainfall. Careful and regular cultivation is needed until the crowns of the trees close over, and an area around the outer margin of the windbreak ought to be cultivated throughout the lifespan of the windbreak.

The windbreak must be protected from livestock and fire, and the seedlings need protection from rabbits and mice. When the trees are 7 to 10 years old, they may need thinning to provide more growing space. A local forestry expert or person who is acquainted with the soils of the county can be consulted for additional information about the arrangement and spacing of the trees and for other information about windbreaks.

Soils in relation to windbreaks.—Successful growth of trees in areas of the High Plains is influenced to a great extent by the kinds of soils and by the soil-air-moisture relationships. Trees normally grow best on sandy loams. They make only fair to poor growth on clayey soils because clayey soils absorb and release moisture slowly. Very sandy soils are not well suited to trees, because those soils do not store enough water and plant nutrients. The soils that are well suited to trees have a good supply of plant nutrients and, in addition, texture and structure that permit good infiltration and retention of moisture. Such soils are also deep enough that moisture is stored for use during droughty periods. Elms, mulberry trees, hackberry trees, and other hardwoods require better soils than conifers, although conifers make their best growth on the better soils.

Table 3 also gives the expected height at 20 years of age of trees suitable for windbreaks in this county. In preparing table 3 forestry technicians made detailed measurements of the trees that were in approximately 3 dozen windbreaks and that were about 20 years of age. They then grouped the soils in nine different windbreak suitability groups. The soils in each group are similar in the characteristics that affect the growth of trees.

The suitability ratings given in table 3 are based on observations of the general vigor and condition of the trees in the windbreak. A rating of *excellent* indicates that the trees are growing well, the leaves have a good color, there are no dead branches in the upper part of the crown, and there are no indications of damage by fungi or insects. A rating of *good* indicates that the trees are growing moderately well, there are a few dead branches and some dieback in the upper part of the crown, and there is slight indication of damage by fungi or insects. A rating of *fair* indicates that at least half of the trees have a significant number of dead branches in the upper part of the crown, that about one-fourth of the trees are dead, that growth has slowed significantly, and that there are indications of moderate damage by fungi or insects. A rating of *poor* indicates that the remaining living trees have had severe dieback, more than one-fourth of the trees in the stand are dead, and there are indications of severe damage by fungi or insects.

Growth of the various species named in table 3 varies because of differences in the soils and differences in the amount of care provided through cultivation. Also, some species, such as Siberian elm and cottonwood, grow much faster than others. Some species tend to be short lived, especially when planted on soils that have poor soil-moisture relationships.

Conifers, such as pine and eastern redcedar, at first grow more slowly than hardwoods, but their growth is likely to catch up with that of the hardwoods. Also, conifers generally surpass hardwoods in length of life and in overall effectiveness as a windbreak. Many successful landowners plant conifers in only half of the windbreaks, and hardwoods in the other half, because hardwoods grow faster than conifers and therefore provide protection earlier. When the hardwoods die, the conifers remain.

Eastern redcedar is the best all-round species for planting (fig. 11). When mature, it has a height of 30 to 40 feet if it is planted on the better soils. Pines and hardwoods are normally somewhat taller when they are mature.

Use of the Soils for Wildlife

Soils influence wildlife, mainly through the kind of vegetation they produce. Fertility, or the lack of it, in a soil directly affects the kind and amount of vegetation a soil can produce and therefore determines the carrying capacity of an area for wildlife. Fertile soils are capable of producing greater numbers of wildlife than less fertile soils.

The development of suitable habitats for fish, waterfowl, and aquatic animals also depends on the type of soil present. Wet, poorly drained soils can be turned into marsh areas suitable for waterfowl and aquatic animals.

TABLE 3.—*Suitability of adapted trees for windbreaks and their estimated*

[Measurements of height are not generally

Windbreak suitability group	Eastern redcedar		Ponderosa pine		Green ash	
		Ft.		*Ft.*		*Ft.*
Group 1: Clayey soils that are poorly aerated and have poor soil-moisture relationships. Farnum-Tabler complex (Tabler soil only). Smolan silty clay loam, 1 to 3 percent slopes. Smolan silty clay loam, 3 to 6 percent slopes, eroded. Tabler clay loam. Tabler-Slickspot complex (Tabler soil only).	Excellent	22	Fair to good	17	Poor	----
Group 2: Loamy soils that are fairly well aerated and have fair soil-moisture relationships.[1] Bethany silt loam, 0 to 1 percent slopes. Bethany silt loam, 1 to 3 percent slopes. Carwile-Farnum fine sandy loams (Farnum soil only). Farnum fine sandy loam, 0 to 1 percent slopes. Farnum loam, 0 to 1 percent slopes. Farnum loam, 1 to 3 percent slopes. Farnum-Tabler complex (Farnum soil only). Naron-Farnum complex (Farnum soil only). Port clay loam. Shellabarger-Farnum complex, 1 to 3 percent slopes (Farnum soil only). Shellabarger and Farnum soils, 3 to 7 percent slopes (Farnum soil only).	Excellent	25	Fair to good	19	Poor	----
Group 3: Fine sandy loams that have a clayey subsoil.[1] Carwile fine sandy loam. Carwile-Farnum fine sandy loams (Carwile soil only). Pratt-Carwile complex (Carwile soil only).	Excellent	25	Fair to good	25	Good	28
Group 4: Soils that have a surface layer and subsoil of loamy fine sand to clay loam and that generally are well drained or moderately well drained. Albion-Shellabarger sandy loams, 0 to 1 percent slopes (Shellabarger soil only). Albion-Shellabarger sandy loams, 1 to 4 percent slopes (Shellabarger soil only). Breaks-Alluvial land complex (Breaks part only). Clark fine sandy loam. Clark-Ost complex, 0 to 1 percent slopes. Clark-Ost complex, 1 to 3 percent slopes. Clark-Ost complex, 3 to 6 percent slopes. Naron fine sandy loam, 0 to 1 percent slopes. Naron fine sandy loam, 1 to 3 percent slopes. Naron-Farnum complex (Naron soil only). Naron-Pratt complex (Naron soil only). Shellabarger fine sandy loam, 0 to 1 percent slopes. Shellabarger fine sandy loam, 1 to 3 percent slopes. Shellabarger and Albion soils, 7 to 15 percent slopes (Shellabarger soil only). Shellabarger-Clark-Albion complex, 2 to 6 percent slopes (Shellabarger and Clark soils only). Shellabarger-Farnum complex, 1 to 3 percent slopes (Shellabarger soil only). Shellabarger and Farnum soils, 3 to 7 percent slopes, eroded (Shellabarger soil only). Vanoss silt loam, 0 to 1 percent slopes. Vanoss silt loam, 1 to 3 percent slopes. Vanoss silt loam, 3 to 7 percent slopes, eroded.	Excellent	24	Good	25	Fair	26
Group 5: Deep sandy loams and loamy fine sands that are mainly well drained or somewhat excessively drained. Naron-Pratt complex (Pratt soil only). Pratt loamy fine sand, undulating. Pratt loamy fine sand, hummocky. Pratt-Carwile complex (Pratt soil only). Shellabarger loamy fine sand, undulating. Tivoli soils, hummocky.	Excellent	19	Good	26	Fair	22
Group 6: Deep, excessively drained sands. Elsmere-Tivoli complex (Tivoli soil only). Tivoli fine sand, hilly.	Excellent	18	Good	20	Poor	----

See footnote at end of table.

height at 20 years of age on the soils of nine different soil groups

shown for soils given a rating of poor]

Catalpa		Cottonwood		Siberian elm (Chinese)		Hackberry		Honeylocust		Mulberry		Osage-orange		Russian-olive	
	Ft.		*Ft.*		*Ft.*		*Ft.*		*Ft.*		*Ft.*		*Ft.*		*Ft.*
Poor	----	Poor	----	Fair	25	Poor	----	Poor	----	Poor	----	Good	17	Poor	----
Poor	----	Poor	----	Good	44	Good	22	Fair	22	Fair	15	Excellent	19	Poor	----
Fair	21	Good	53	Excellent	46	Good	25	Fair	22	Good	22	Excellent	22	Poor	----
Fair	----	Fair	40	Good	44	Good	27	Good	35	Good	28	Excellent	22	Fair	18
Good	30	Poor to good.	45	Fair	36	Fair	18	Fair	28	Fair to good.	24	Good	12	Fair	15
Poor	----	Poor	----	Poor	----	Poor	----	Poor	----	Poor	22	Poor	----	Poor	----

TABLE 3.—*Suitability of adapted trees for windbreaks and their estimated height*

[Measurements of height are not generally

Windbreak suitability group	Eastern redcedar		Ponderosa pine		Green ash	
		Ft.		*Ft.*		*Ft.*
Group 7: Soils formed in alluvium. Breaks-Alluvial land complex (Alluvial land part only). Canadian fine sandy loam. Dale clay loam. Lesho clay loam. Wann fine sandy loam. Wet alluvial land.	Excellent	30	Excellent	30	Good	40
Group 8: Soils that are shallow to moderately deep over shale or gravel. Albion-Shellabarger sandy loams, 0 to 1 percent slopes (Albion soil only). Albion-Shellabarger sandy loams, 1 to 4 percent slopes (Albion soil only). Nash-Lucien complex, 1 to 3 percent slopes. Nash-Lucien complex, 3 to 6 percent slopes. Nash-Lucien complex, 6 to 15 percent slopes. Renfrow clay loam, 0 to 1 percent slopes. Renfrow clay loam, 1 to 3 percent slopes. Renfrow-Vernon clay loams. Shellabarger fine sandy loam, shale substratum, 0 to 3 percent slopes. Shellabarger and Albion soils, 7 to 15 percent slopes (Albion soil only). Shellabarger-Clark-Albion complex, 2 to 6 percent slopes (Albion soil only). Vernon soils.	Excellent	19	Fair to good	15	Poor	----
Group 9: Poorly drained alkaline soils and saline-alkali soils. Elsmere-Plevna complex (Plevna soil only). Farnum-Slickspot complex. Plevna fine sandy loam. Slickspots. Tabler-Slickspot complex (Slickspot soil only).	Poor	----	Poor	----	Poor[1]	----

[1] The rating for lilac is *good* for the soils of this group.

Habitats for fish depend on the water-holding capacity of the soils, as well as on the source of water.

Table 4 shows the potential of the soil associations in this county for producing habitats for the more important species of wildlife. The ratings of "*good*," "*fair*," and "*poor*" indicate the ability of the soil associations to provide cover, food, and water for the specified species. The soil associations are described in the section "General Soil Map." The location of each is shown on the general soil map at the back of the report.

***Figure 11.*—A windbreak, mainly of eastern redcedar, used to protect a field of very sandy soils. Eastern redcedar is better adapted to these sandy soils than hardwoods.**

Wildlife in the county is dominated mainly by species common to the prairie region, but the plum thickets in the sandhill area, shelterbelts, and areas of timber along streams are inhabited by wildlife more common to timber or bush areas. The kinds of wildlife have changed since the county was settled. Buffalo were once abundant, and a sparse population of antelope and deer inhabited the area. Of these animals, only deer are present today, and they are more numerous perhaps than they were 100 years ago. This is a result of the change in vegetation from all grass to both grass and woody plants. In addition, deer have been protected by game laws since 1939.

Ring-necked pheasant, mourning dove, and fox squirrel did not inhabit the area 100 years ago but are numerous at the present time. This also is largely the result of the change in vegetation brought about by changes in land use.

Fish, cottontail rabbit, ring-necked pheasant, and bobwhite quail are important game species in this county. Other species include raccoon, badger, opossum, skunk, *at 20 years of age on the soils of nine different soil groups*—Continued

shown for soils given a rating of poor]

Catalpa		Cottonwood		Siberian elm (Chinese)		Hackberry		Honeylocust		Mulberry		Osage-orange		Russian-olive	
	Ft.		*Ft.*		*Ft.*		*Ft.*		*Ft.*		*Ft.*		*Ft.*		*Ft.*
Good	35	Excellent	50	Excellent	50	Excellent	35	Good	40	Excellent	35	Excellent	25	Good	25
Poor	----	Poor	----	Fair	25	Poor	----	Poor	----	Poor	----	Fair	10	Poor	----
Poor	----	Poor	----	Poor	----	Poor	----	(2)	----	Poor	----	Poor	----	Fair	15

2 Not suited to the soils of this group.

gray squirrel, fox squirrel, coyote, jackrabbit, beaver, muskrat, mink, and waterfowl.

Fish are perhaps the most important kind of wildlife for recreational use in the county. The larger streams provide an opportunity to fish, mainly for several species of catfish. Also, about 170 farm ponds were built between 1945 and 1960. These ponds, mostly stocked with largemouth bass, bluegill, and channel catfish, provide fishing for many people each year. Some of these ponds yield as much as 150 pounds of fish per surface acre with little management, and under excellent management ponds may yield as much as 300 pounds per surface acre. Additional information and assistance in planning habitats for wildlife can be obtained from the Extension Service, the Soil Conservation Service, and the Kansas Forestry, Fish and Game Commission.

Engineering Properties of Soils [5]

This section describes the outstanding engineering properties of the soils, particularly in relation to highway construction and conservation engineering. A brief description of the engineering soil classification systems and definitions of engineering terms used in the tables are also given.

[5] By GERALD D. NORRIS, agricultural engineer, Soil Conservation Service.

Some properties of soils are of special interest to engineers because they affect the construction and maintenance of roads, airports, building foundations, embankments, water storage basins, structures for erosion control, drainage systems, irrigation systems, and systems for disposing of sewage. The properties most important to the engineer are shear strength, compaction characteristics, grain size, plasticity, permeability to water, texture, depth, water-holding capacity, reaction, and topography.

The engineering interpretations reported here can be used for many purposes. It should be emphasized, however, that these interpretations may not eliminate the need for sampling and testing at the site of specific engineering works involving heavy loads and where the excavations are deeper than the depths of layers here reported. Even in these situations, the soil map is useful for planning more detailed field investigations and for suggesting the kinds of problems that may be expected.

The information in this report can be used to—

1. Make preliminary studies that will aid in selecting and locating sites for industries, residences, businesses, and recreational purposes.
2. Make preliminary evaluations that will aid in selecting locations for highways, airports, and other transportation facilities.

TABLE 4.—*Potential of the soil associations for providing habitats required by some of the more important kinds of wildlife*

[Dashes indicate a rating is not applicable]

Soil association	Species	Potential for producing, for species of wildlife named—		
		Cover	Food	Water
Renfrow-Vernon, Nash-Lucien, and Clark-Ost.	Cottontail rabbit.	Fair	Fair	
	Deer	Poor	Fair	
	Dove	Poor	Fair	
	Pheasant	Fair	Fair	
	Quail	Fair	Fair	
	Fish	----------	----------	Poor.
Farnum-Shellabarger and Farnum-Naron.	Cottontail rabbit.	Good	Good	
	Deer	Good	Good	
	Dove	Good	Good	
	Pheasant	Good	Good	
	Quail	Good	Good	
	Fish	----------	----------	Fair.
	Waterfowl	----------	Good	Fair.
Bethany-Tabler.	Cottontail rabbit.	Good	Good	
	Deer	Fair	Fair	
	Dove	Fair	Good	
	Pheasant	Good	Good	
	Quail	Fair	Good	
	Fish	----------	----------	Poor.
	Waterfowl	----------	Good	Fair.
Vanoss-Bethany.	Cottontail rabbit.	Good	Good	
	Deer	Good	Good	
	Dove	Good	Good	
	Pheasant	Good	Good	
	Quail	Good	Good	
	Fish	----------	----------	Good.
	Waterfowl	----------	Good	Fair.
	Squirrel	Fair	Good	
Canadian-Dale and Pratt-Carwile.	Cottontail rabbit.	Good	Good	
	Deer	Good	Good	
	Dove	Good	Good	
	Pheasant	Good	Good	
	Quail	Good	Good	
	Fish	----------	----------	Good.
	Waterfowl	----------	Good	Good.
	Squirrel	Good	Good	
Slickspots-Farnum.	Cottontail rabbit.	Good	Good	
	Pheasant	Good	Good	
	Quail	Good	Good	
	Deer	Poor	Poor	
	Waterfowl	Good	Good	Good.
	Squirrel	Poor	Poor	
Elsmere-Tivoli.	Cottontail rabbit.	Good	Fair	
	Deer	Fair	Fair	
	Dove	Fair	Poor	
	Pheasant	Fair	Poor	
	Quail	Fair	Poor	
	Fish	----------	----------	Fair.
	Waterfowl	----------	Poor	Fair.

TABLE 4.—*Potential of the soil associations for providing habitats required by some of the more important kinds of wildlife*—Continued

Soil association	Species	Potential for producing, for species of wildlife named—		
		Cover	Food	Water
Plevna-Slickspots.	Cottontail rabbit.	Fair	Poor	
	Deer	Poor	Poor	
	Dove	Poor	Poor	
	Pheasant	Good	Fair	
	Quail	Fair	Fair	
	Fish	----------	----------	Good.
	Waterfowl	----------	Good	Good.
	Aquatic animals.	----------	Good	Good.
Carwile-Tabler.	Cottontail rabbit.	Good	Good	
	Deer	Poor	Poor	
	Dove	Fair	Good	
	Pheasant	Good	Good	
	Quail	Fair	Good	
	Waterfowl	----------	Good	Fair.

3. Make preliminary estimates that will aid in planning irrigation systems, agricultural drainage systems, farm ponds, terraces, waterways, and diversions or dams for the control of erosion.
4. Make preliminary studies and evaluations for selecting locations for pipelines and other buried utilities.
5. Locate probable sources of sand, gravel, and topsoil.
6. Develop information that will be useful in designing and maintaining engineering structures.
7. Supplement information obtained from other sources to give a broader general understanding of the conditions pertinent to the particular area.
8. Develop other preliminary estimates that might be useful for construction purposes.

Some of the terms used by the soil scientist may be unfamiliar to the engineer, and some words—for example, *clay*, *silt*, *sand*, and *aggregate*—may have a special meaning in soil science. These terms, as well as other special terms used in the soil survey report, are defined in the Glossary at the back of this report. The term "soil," as used in this section, refers to all the earthen material above bedrock.

Engineering classification systems

Agricultural scientists of the U.S. Department of Agriculture (USDA) classify soils according to texture, color, and structure. This system is useful only as the initial step in making engineering classifications of soils. The engineering properties of a soil must be determined or estimated after the initial classifications have been made. Two systems are used by engineers for classifying soils.

One is the system used by the American Association of State Highway Officials (AASHO), and the other is the Unified system. These systems are explained briefly in the following paragraphs. The explanations are taken largely from the PCA Soil Primer (*10*).

AASHO Classification System.—The AASHO system is based on actual performance of material used as a base for roads and highways (*1*). In this system all the soils are classified in seven groups. The soils most suitable for road subgrade are classed as A–1, and the soils least suitable are classed as A–7. Within rather broad limits, soils are classified numerically between these two extremes, according to their load-carrying ability. Three of the seven basic groups may also be divided into subgroups to designate within-group variations. Within each group, the relative engineering value of the soil material is indicated by a group index number, which is shown in parentheses following the group classification. Group index numbers range from 0 for the best material to 20 for the poorest. Increasing values of group index numbers denote decreasing load-carrying capacity.

In the AASHO system the soil material may be further divided into the following two major groups: (1) Granular material in which 35 percent or less of the material passes a 200-mesh sieve, and (2) silt-clay material in which more than 35 percent of the material passes a 200-mesh sieve. The silty part of the silt-clay material has a plasticity index of 10 or less, and the clayey material has a plasticity index greater than 10.

Unified Classification System.—In the Unified system the soils are grouped on the basis of their texture and plasticity, as well as on their performance when used as material for engineering structures (*16*). The soil materials are identified as coarse grained, which are gravels (G) and sands (S); fine grained, which are silts (M) and clays (C); and highly organic (Pt). No highly organic soils are mapped in this county.

Under the Unified system, clean sands are identified by the symbols SW or SP; sands with fines of silt and clay are identified by the symbols SM and SC; silts and clays that have a low liquid limit are identified by the symbols ML and CL; and silts and clays that have a high liquid limit are identified by the symbols MH and CH.

Engineering interpretations of soils

Three tables are given in this section. In the first (table 5) the soils are briefly described, and their physical properties important to engineering are estimated. In the second table (table 6) the suitability of the soils for various engineering uses is indicated. The third table (table 7) contains engineering test data for samples from seven soil series.

In table 5 some of the descriptions of the soil layers and of depth from the surface differ slightly from the description of the typical profile given in the sections "Descriptions of the Soils" and "Genesis, Classification, and Morphology of Soils." The purpose of the descriptions given in table 5 is to show the horizons that have features significant to engineering.

Depth to the water table is generally not given in table 5. Many of the soils that have a more permeable surface layer, however, contain a slowly permeable layer, which causes a perched or seasonal water table. In these soils the level of the water table usually varies according to the season. At sites where there is a high or fluctuating water table, the area should be studied before any engineering structures are designed.

The kind of bedrock is generally not named in table 5, but most of the soils of the county are underlain by Ninnescah and Wellington shales. In places, particularly in the southern part of the county, Ninnescah shale crops out at the surface, but the shale lies a hundred feet or more below the surface in places nearby. This suggests that depth to shale may vary widely within short distances and can be a problem where foundation construction to bedrock is of engineering importance.

The column that shows permeability gives the estimated rate, expressed in inches per hour, at which water moves through a soil that is not compacted. The estimates are based on soil structure and porosity.

The estimates given for available water capacity show, in inches per inch of soil depth, the amount of capillary water in the soil when it is wet to field capacity. When the moisture in the soil is at the wilting point of common crops, this amount of water will wet the soil material to a depth of 1 inch without deeper percolation.

The column that shows reaction gives the pH value (the degree of acidity or alkalinity) of the soils. In this system of notations, pH 7.0 is neutral; lower values indicate acidity, and higher values indicate alkalinity. The values listed in this column are estimates and are therefore expressed as a range.

Salinity is not indicated in this table, because it is not generally a problem in this county. The Slickspot soils and those of the Farnum-Slickspot complex and the Tabler-Slickspot complex, however, are affected by salts.

Dispersion is the deflocculation of the soil and its suspension in water. The soils are given a rating of "low," "moderate," and "high." A rating of high means that the soil particles slake readily.

By shrink-swell potential is meant the amount a soil will expand when wet and contract when dry. The soils are rated "low," "moderate," and "high," and the rating indicates the amount of plastic fines in the soil. This rating was obtained by comparing the liquid limit of the soils of this county to the liquid limit of similar soils throughout the county.

The suitability of the soils of this county for various engineering uses is shown in table 6. The table lists specific features or characteristics of the soils that affect the selection, design, or application of engineering works. Generally, only detrimental or undesirable features are listed, but some important desirable features are listed. The information in this table is based on the estimates listed in table 5, on actual test data, and on field experience.

The suitability of the soils as a source of topsoil is rated "good," "fair," or "poor." These ratings are for the whole soil profile, unless a specific soil horizon is named.

The suitability of the soils as a source of sand and gravel was based on the availability of the material. No consideration was given to the total quantity or to the quality of the material for specific engineering uses.

The soils were rated as a source of subgrade or road fill by a representative of the Kansas State Highway Commission. The ratings are based upon a thorough knowledge of the material and its properties, as they affect use for highway construction.

775-726—66——4

TABLE 5.—*Brief description of soils of Reno County,*

Symbol on map	Soil name	Description of soil and site	Depth from surface
			Inches
Ab As	Albion-Shellabarger sandy loams, 0 to 1 percent slopes. Albion-Shellabarger sandy loams, 1 to 4 percent slopes.	This complex is about 50 percent Albion sandy loam and 50 percent Shellabarger sandy loam. The Albion soil consists of 15 to 36 inches of sandy loam over sand and gravel, and it is in convex areas in the upland. See the Shellabarger fine sandy loams for estimated properties of the Shellabarger soil.	0–26 26–48+
Ba Be	Bethany silt loam, 0 to 1 percent slopes. Bethany silt loam, 1 to 3 percent slopes.	14 to 18 inches of silt loam over a subsoil of silty clay loam that formed in loess or fine-textured old alluvium; the subsoil extends to a depth of about 45 inches; the texture of the substratum is similar to that of the subsoil. In nearly level and gently sloping convex areas of the upland.	0–16 16–45 45–76
Bk	Breaks-Alluvial land complex.	Steep, broken topography along upland drains. The areas are generally narrow and of mixed material.	(2)
Ca	Canadian fine sandy loam.	20 to 45 inches of fine sandy loam over stratified sand and loamy sand. This soil is nearly level and is in valleys; it has a seasonal water table that rises to within 4 or 5 feet of the surface.	0–32 32–72+
Cd	Carwile fine sandy loam.	8 to 22 inches of fine sandy loam over stratified clayey alluvium that shows weak profile development. A seasonally high water table rises to within about 6 feet of the surface. This soil has slow internal drainage and a temporary perched water table. It is in nearly level or slightly depressed areas in the upland.	0–16 16–55
Cf	Carwile-Farnum fine sandy loams.	This complex is about 55 percent Carwile fine sandy loam, about 35 percent Farnum fine sandy loam, and 10 percent other soils. See Carwile fine sandy loam for estimated properties of the Carwile soil, and Farnum fine sandy loam, 0 to 1 percent slopes, for estimated properties of the Farnum soil.	
Ck	Clark fine sandy loam.	8 to 28 inches of calcareous fine sandy loam over calcareous loam. In places below a depth of about 48 inches, the loam is stratified with sandy loam.	0–18 18–48
Cm Co Cp	Clark-Ost complex, 0 to 1 percent slopes. Clark-Ost complex, 1 to 3 percent slopes. Clark-Ost complex, 3 to 6 percent slopes.	Clark loam: This is the dominant soil in these complexes and its texture is loam throughout; in places the content of lime, by volume, below a depth of 10 to 15 inches is as much as 25 percent. Ost clay loam: This soil consists of about 10 to 12 inches of friable clay loam that overlies about 4 feet of heavy clay loam. In places from 25 to 75 percent of the lower layer is segregated lime. Nearly level or gently sloping.	0–60 0–12 12–60
Da	Dale clay loam.	30 to 50 inches of clay loam over a sand substratum. In most places depth to sand is 36 to 40 inches. The water table is at a depth of 36 to 70 inches. In valleys and is flooded occasionally.	0–40 40–70
Ep	Elsmere-Plevna complex.	This complex is about 60 percent Elsmere loamy fine sand and 40 percent Plevna loamy fine sand. See the Elsmere-Tivoli complex for estimated properties of the Elsmere soils and Plevna fine sandy loam for estimated properties of the Plevna soil.	
Et	Elsmere-Tivoli complex.	This complex is about 30 percent Elsmere loamy fine sand, 10 percent Tivoli fine sand, 20 percent Plevna loamy fine sand, and 40 percent soils that are like Tivoli soils but are loamy below a depth of 36 inches. The Elsmere soil consists of mottled loamy fine sand and has a water table within 3 feet of the surface during the cool months. Clayey strata are common below a depth of 5 feet. See the Tivoli soils for estimated properties of the Tivoli soil and Plevna fine sandy loam for estimated properties of the Plevna soil.	0–50
Fa	Farnum fine sandy loam, 0 to 1 percent slopes.	14 to 28 inches of fine sandy loam over 3 to 4 feet of sandy clay loam. Gently undulating.	0–24 24–72
Fm Fn	Farnum loam, 0 to 1 percent slopes. Farnum loam, 1 to 3 percent slopes.	12 to 28 inches of loam over 3 to 4 feet of sandy clay loam. Gently undulating or sloping and on uplands.	0–20 20–72

See footnote at end of table.

Kans., and their estimated physical properties

Classification			Percentage passing sieve—			Permeability	Available water capacity	Reaction	Dispersion	Shrink-swell potential
USDA texture	Unified	AASHO	No. 4	No. 10	No. 200					
						Inches per hour	*Inches per inch of soil*	*pH value*		
Sandy loam	SM	A-2-4	100	95–100	15–35	0. 5–1. 0	0. 15	6. 6–7. 3	Low	Low.
Sand	SP-SM	A-1-b	90–100	(1)	5–10	>5. 0	. 09	6. 6–7. 3	Low	Low.
Silt loam	CL	A-6	100	100	85–90	0. 2–0. 5	. 18	6. 1–6. 5	High	Moderate.
Silty clay loam	CH	A-7-6	100	100	90–95	0. 2–0. 5	. 17	6. 6–7. 3	High	High.
Silty clay loam	CL	A-7-6	100	100	90–95	0. 2–0. 5	. 18	7. 9–8. 4	High	High.
(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2).
Fine sandy loam	SM	A-2-4	98–100	90–98	20–35	1. 0–2. 0	. 15	6. 6–7. 3	Low	Low.
Sand and loamy sand.	SP-SM	A-2 or A-3	90–100	70–80	5–10	2. 0–5. 0	. 12	7. 4–7. 8	Low	Low.
Fine sandy loam	SM	A-2-4	95–100	95–100	15–25	0. 5–1. 0	. 15	6. 1–6. 5	Low	Low.
Sandy clay loam	CL	A-7-6	95–100	95–100	80–85	0. 05–0. 2	. 18	6. 6–7. 3	Low	Moderate to high.
Fine sandy loam	SM	A-2 or A-4		95–100	30–40	0. 5–1. 0	. 15	7. 4–7. 8	Moderate	Low.
Loam	CL	A-6		100	60–70	0. 2–0. 5	. 18	7. 4–7. 8	Moderate	Moderate.
Loam	CL	A-6	100	100	70–85	0. 2–0. 5	. 18	7. 4–7. 8	None	Low.
Clay Loam	CL	A-6	100	100	70–85	0. 2–0. 5	. 18	7. 4–7. 8	None	Moderate.
Heavy clay loam	CL	A-6	100	100	70–85	0. 2–0. 5	. 17	7. 9–8. 4	None	High.
Clay loam	CL	A-7-6	100	100	50–80	0. 2–0. 5	. 18	6. 6–7. 3	Moderate	Moderate.
Fine sand	SP-SM	A-2 or A-3	90–100	70–80	5–10	2. 0–5. 0	. 09	7. 4–7. 8	Low	Low.
Loamy sand	SM	A-2	100	100	12–20	2. 0–5. 0	. 09	6. 1–6. 5	None	Low.
Fine sandy loam	SM	A-2-4	98–100	95–100	25–35	0. 2–0. 5	. 15	6. 6–7. 3	Low	Low.
Sandy clay loam	CL	A-7-6	100	100	70–80	0. 2–0. 5	. 17	6. 6–7. 3	Moderate	Moderate.
Loam	CL	A-6	100	100	60–70	0. 2–0. 5	. 18	5. 6–6. 0	Moderate	Low.
Sandy clay loam	CL	A-7-6	100	100	70–80	0. 2–0. 5	. 17	6. 6–7. 3	Moderate	Moderate.

TABLE 5.—*Brief description of soils of Reno County,*

Symbol on map	Soil name	Description of soil and site	Depth from surface
			Inches
Fs	Farnum-Slickspot complex.	This complex is about 50 percent Farnum loam, 40 percent Slickspot soils, and 10 percent Tabler clay loam. See the Farnum loams for estimated properties of the Farnum soil, Slickspots for the estimated properties of the Slickspot soils, and Tabler clay loam for the estimated properties of the Tabler soil.	
Ft	Farnum-Tabler complex.	This complex is about 50 percent Farnum loam and 50 percent Tabler clay loam. See the Farnum loams for estimated properties of the Farnum soil and Tabler clay loam for estimated properties of the Tabler soil.	
Lc	Lesho clay loam.	18 to 30 inches of clay loam over water-deposited sand and gravel; the water table is 2 to about 4 feet from the surface. This soil is on flood plains and is frequently flooded.	0–24 24–48+
Na Ne	Naron fine sandy loam, 0 to 1 percent slopes. Naron fine sandy loam, 1 to 3 percent slopes.	10 to 25 inches of fine sandy loam over 4 or 5 feet of sandy clay loam or heavy sandy loam. These soils are well drained, are nearly level or gently sloping, and are on uplands.	0–18 18–80
Nf	Naron-Farnum complex.	This complex is about 60 percent Naron fine sandy loam and 40 percent Farnum loam. See the Naron fine sandy loams for estimated properties of the Naron soil, and the Farnum loams for estimated properties of the Farnum soil.	
Np	Naron-Pratt complex.	This complex is about 60 percent Naron fine sandy loam and about 40 percent Pratt loamy fine sand. See the Naron fine sandy loams, for estimated properties of the Naron soil, and Pratt loamy fine sand for estimated properties of the Pratt soil.	
Ns Nt Nu	Nash-Lucien complex, 1 to 3 percent slopes. Nash-Lucien complex, 3 to 6 percent slopes. Nash-Lucien complex, 6 to 15 percent slopes.	Nash loam: This soil makes up 50 to 80 percent of the acreage of these complexes. It consists of about 30 inches of loam or silt loam over hard siltstone and is on the upland. Lucien loam: This soil makes up 20 to 45 percent of the acreage of these complexes. It consists of 2 to 20 inches of loam or silt loam over consolidated siltstone.	0–30 30–48+ 0–15 15–48+
Pa	Platte soils.	6 to 20 inches of material of variable texture over sand and gravel. The water table is at a depth of 20 to 48 inches. These soils are frequently flooded.	(2)
Pe	Plevna fine sandy loam.	15 to 28 inches of fine sandy loam over stratified sandy loam and clay loam. The water table is within 1 to 2 feet of the surface.	0–21 21–48
Pl	Port clay loam.	4 feet or more of friable clay loam in valleys along small streams.	0–60
Pm Pr	Pratt loamy fine sand, undulating. Pratt loamy fine sand, hummocky.	Deep loamy fine sand that is undulating or hummocky	0–60
Pt	Pratt-Carwile complex.	This complex is about 40 percent Pratt loamy fine sand, 25 percent Carwile fine sandy loam, 10 percent Naron fine sandy loam, and 25 percent soils that have characteristics intermediate between those of the Pratt and Carwile soils. See the Pratt loamy fine sands for estimated properties of the Pratt soil, Carwile fine sandy loam for estimated properties of the Carwile soil, and the Naron fine sandy loams for estimated properties of the Naron soil.	
Rc Re	Renfrow clay loam, 0 to 1 percent slopes. Renfrow clay loam, 1 to 3 percent slopes.	6 to 18 inches of clay loam over firm blocky clay. Shale is at a depth of 26 to 48 inches.	0–12 12–40
Rv	Renfrow-Vernon clay loam.	This complex is about 70 percent Renfrow clay loam and 30 percent Vernon clay loam. See the Renfrow clay loams for estimated properties of the Renfrow soils and Vernon soils for estimated properties of the Vernon soil.	

See footnote at end of table.

Kans., and their estimated physical properties—Continued

Classification			Percentage passing sieve—			Permeability	Available water capacity	Reaction	Dispersion	Shrink-swell potential
USDA texture	Unified	AASHO	No. 4	No. 10	No. 200					
						Inches per hour	*Inches per inch of soil*	*pH value*		
Clay loam	CL	A-6	100	95–100	60–75	0. 2–0. 5	0. 18	6. 6–7. 3	Low	Moderate.
Sand and gravel	SW-SM	A-1-b	90–95	60–80	4–10	>5. 0	. 09	6. 6–7. 3	Low	Low.
Fine sandy loam	SM	A-2-4	98–100	95–100	25–35	0. 2–0. 5	. 15	6. 6–7. 3	Low	Low.
Sandy clay loam	SC	A-2-6	98–100	95–100	25–35	0. 2–0. 5	. 18	6. 6–7. 3	Low	Low.
Silt loam	ML	A-4	100	100	70–85	0. 2–0. 5	. 18	6. 6–7. 3	Low	Low.
Hard siltstone	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3).
Loam	ML	A-4	100	100	70–85	0. 2–0. 5	. 18	6. 6–7. 3	Low	Low.
Siltstone	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3).
(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2).
Fine sandy loam	SM	A-4	100	100	35–45	0. 5–1. 0	. 15	6. 6–7. 3	Low	Low.
Sandy loam and clay loam.	CL	A-6	100	100	55–65	0. 5–2. 0	. 17	6. 6–7. 3	Moderate	Moderate.
Clay loam	CL	A-6	100	100	70–80	0. 2–0. 5	. 18	6. 6–7. 3	Moderate	Low.
Loamy fine sand	SM	A-2-4	100	100	15–20	2. 0–5. 0	. 12	6. 6–7. 3	Low	Low.
Clay loam	CL	A-7-6	100	100	70–80	0. 2–0. 5	. 18	6. 1–6. 5	Moderate	Moderate.
Clay	CH	A-7-6	100	100	80–90	0. 05–0. 2	. 16	6. 6–7. 3	Moderate	Moderate.

TABLE 5.—*Brief description of soils of Reno County,*

Symbol on map	Soil name	Description of soil and site	Depth from surface
			Inches
Sa Sb	Shellabarger fine sandy loam, 0 to 1 percent slopes. Shellabarger fine sandy loam, 1 to 3 percent slopes.	8 to 20 inches of fine sandy loam over heavy sandy loam or light sandy clay loam; underlain by coarse-textured and stratified material.	0–14 14–50
Sc	Shellabarger fine sandy loam, shale substratum, 0 to 3 percent slopes.	8 to 20 inches of fine sandy loam over light sandy clay loam that grades to finer textured material at a depth of about 36 inches. Unweathered shale is at a depth of about 48 inches.	0–14 14–36 36–48
Se	Shellabarger loamy fine sand, undulating.	Same as the Shellabarger fine sandy loams that lack a shale substratum, except that this soil has a surface layer of loamy fine sand.	0–15 15–50
Sg	Shellabarger and Albion soils, 7 to 15 percent slopes.	This complex consists of steep Shellabarger and Albion soils. See the Shellabarger fine sandy loams that lack a shale substratum for estimated properties of the Shellabarger soil and the Albion-Shellabarger sandy loams for estimated properties of the Albion soil.	
Sh	Shellabarger-Clark-Albion complex, 2 to 6 percent slopes.	This complex is about 50 percent Shellabarger fine sandy loam, about 35 percent Clark fine sandy loam, and about 15 percent Albion sandy loam. See the Shellabarger fine sandy loams that lack a shale substratum for estimated properties of the Shellabarger soil; Clark fine sandy loam for estimated properties of the Clark soil; and the Albion-Shellabarger sandy loams for estimated properties of the Albion soil.	
Sm Sn	Shellabarger-Farnum complex, 1 to 3 percent slopes. Shellabarger and Farnum soils, 3 to 7 percent slopes, eroded.	These mapping units are about 35 percent Shellabarger fine sandy loam, about 25 percent Farnum loam, and about 40 percent soils that have characteristics intermediate between those of the Shellabarger fine sandy loams and Farnum loams. Where these soils are eroded, the A horizon is thinner than typical for the series.	
So	Slickspots.	Imperfectly drained saline-alkali soils that vary in texture------	(2)
Sp St	Smolan silty clay loam, 1 to 3 percent slopes. Smolan silty clay loam, 3 to 6 percent slopes, eroded.	6 to 12 inches of light silty clay loam that grades to silty clay with increasing depth. The substratum is poorly graded material that resembles loess and is less clayey than the upper layers.	0–9 9–60
Ta	Tabler clay loam.	6 to 12 inches of clay loam or loam that grades to firm, fine, blocky silty clay or clay. This soil is nearly level and is imperfectly drained.	0–8 8–50
Tb	Tabler-Slickspot complex.	This complex is 5 to 35 percent Slickspot soils, and the rest is Tabler clay loam. See Tabler clay loam for estimated properties of the Tabler soil and Slickspots for estimated properties of the Slickspot soils.	
Th Tf	Tivoli soils, hummocky. Tivoli fine sand, hilly.	Rough, hummocky, and duned sand--------------------------	0–72+
Va Vb Vc	Vanoss silt loam, 0 to 1 percent slopes. Vanoss silt loam, 1 to 3 percent slopes. Vanoss silt loam, 3 to 7 percent slopes, eroded.	About 2 feet of silt loam or loam over about 4 feet or more of clay loam. These soils were derived from loess and are generally poorly graded. They are friable. These soils are on the upland and are in nearly level areas or on long convex slopes as steep as 7 percent.	0–24 24–72+
Ve	Vernon soils.	Shallow clayey soils that overlie shale and have slopes of 2 to 7 percent. Depth to shale ranges from 6 to 25 inches.	0–18
Wa	Wann fine sandy loam.	18 to 36 inches of fine sandy loam over sand and gravel. The water table is at a depth of about 4 feet. Flooded frequently if not protected.	0–36 36–48+
We	Wet alluvial land.	Material of mixed textures on flood plains; frequently flooded.	(2)

[1] More than 70.

Kans., and their estimated physical properties—Continued

Classification			Percentage passing sieve—			Permeability	Available water capacity	Reaction	Dispersion	Shrink-swell potential
USDA texture	Unified	AASHO	No. 4	No. 10	No. 200					
						Inches per hour	*Inches per inch of soil*	*pH value*		
Fine sandy loam	SM	A-2-4	98-100	90-100	25-35	0. 5-1. 0	0. 15	6. 6-7. 3	Low	Low.
Light sandy clay loam.	SP-SC	A-2-6	98-100	90-100	25-35	0. 2-0. 5	. 17	6. 6-7. 3	Low	Low.
Fine sandy loam	SM	A-4	100	100	35-45	0. 2-0. 5	. 15	6. 6-7. 3	Low	Low.
Sandy clay loam	CL	A-6	100	100	50-60	0. 2-0. 5	. 17	6. 6-7. 3	Low	Low.
Clay	CL	A-6	100	100	60-70	0. 05-0. 2	. 16	6. 6-7. 3	Moderate	Moderate.
Loamy fine sand	SM	A-2-4	100	100	15-20	2. 0-5. 0	. 12	6. 6-7. 3	Low	Low.
Light sandy clay loam.	SC	A-2-6	98-100	90-100	25-35	0. 2-0. 5	. 17	6. 6-7. 3	Low	Low.
(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2).
Silty clay loam	CL	A-6	100	100	85-95	0. 2-0. 5	. 18	6. 6-7. 3	Moderate	Moderate.
Silty clay	CH	A-7-6	100	100	85-95	0. 05-0. 2	. 17	6. 6-7. 3	Moderate	Moderate.
Clay loam	CL	A-6	100	100	70-80	0. 05-0. 2	. 18	6. 1-6. 5	Low	Moderate.
Clay	CH	A-7-6	100	100	90-95	0. 05-0. 2	. 16	7. 9-8. 4	Low to slight.	Moderate.
Fine sand	SP-SM	A-2 or A-3	100	100	6-20	2. 0-5. 0	. 09	6. 1-6. 5	Low	Low.
Silt loam or loam	CL	A-6	100	100	65-75	0. 2-0. 5	. 18	6. 1-6. 5	Low	Low.
Clay loam	CL	A-6	100	100	70-80	0. 2-0. 5	. 18	6. 6-7. 3	Low	Low.
Clay loam	CL	A-7-6	100	100	70-80	0. 2-0. 5	. 18	6. 6-7. 3	Moderate	Moderate.
Fine sandy loam	SM	A-2-4	98-100	90-98	20-35	1. 0-2. 0	. 15	6. 6-7. 3	Low	Low.
Sand	SW-SM	A-1-b	90-95	60-80	4-10	>5. 0	. 09	6. 6-7. 3	Low	Low.
(2)	(2)	(2)	(3)	(2)	(2)	(2)	(2)	(2)	(2)	(2)

[2] Variable.

[3] Bedrock.

TABLE 6.—*Interpretation of engineering*

Soil series and map symbol	Suitability as a source of—					Soil features affecting engineering practices
	Topsoil	Sand	Gravel	Road subgrade [2]	Road fill [2]	Highway location [2]
Albion (Ab, As)	Surface layer and subsoil fair; substratum poor.	Good	Good	Good if mixed	Good if mixed	(4)
Bethany (Ba, Be)	Surface layer good; subsoil fair.	Not suitable	Not suitable	Poor	Fair	Highly plastic
Canadian (Ca)	Fair	Good	Good	Good	Good	(4)
Carwile (Cd, Cf)	Surface layer fair; subsoil poor.	Not suitable	Not suitable	Surface layer good; subsoil poor.	Fair	Imperfectly drained
Clark (Ck, Cm, Co, Cp)	Fair	Not suitable	Not suitable	Fair	Good	Calcareous; seepage problems where these soils are adjacent to Nash, Vernon, Renfrow, or Lucien soils.
Dale (Da)	Good	Good	Good	Poor	Good	Water table within 3 to 6 feet of the surface; flooding hazard.
Elsmere (Ep, Et)	Poor	Poor	Not suitable	Good on elevated grade.	Good	High water table
Farnum (Fa, Fm, Fn, Fs, Ft).	Good	Not suitable	Not suitable	Poor	Fair	(4)
Lesho (Lc)	Surface layer good; substratum not suitable.	Good	Good	Poor	Good	Water table within 2 to 4 feet of surface; flooding hazard.
Lucien (mapped only in complexes with Nash soils).	Good	Not suitable	Not suitable	Fair	Good	Limited depth to siltstone.
Naron (Na, Ne, Nf, Np)	Good	Not suitable	Not suitable	Fair	Good	(4)
Nash (Ns, Nt, Nu)	Good	Not suitable	Not suitable	Fair	Good	Limited depth to siltstone.
Ost (mapped only in complexes with Clark soils).	Surface layer good; subsoil poor.	Not suitable	Not suitable	Poor	Fair	Highly calcareous; well drained.

See footnotes at end of table.

properties of soils [1]

Soil features affecting engineering practices—Continued						
Dikes	Farm ponds		Agricultural drainage	Irrigation	Terraces and diversions	Waterways
	Reservoir area	Embankment[3]				
([5])	Rapid permeability.	Well graded; substratum lacks fines.	([5])	Low water-holding capacity.	Unstable; intensive maintenance required.	Low water-holding capacity; highly erodible.
([5])	Slow permeability.	Highly plastic; low strength.	([5])	Slowly permeable	([6])	([6]).
Well graded; stable substratum; highly permeable.	Rapid permeability.	Well graded; stable.	([5])	([6])	([5])	([5]).
([5])	Slow permeability; in places there is a high rate of seepage in the substratum.	Well graded	Temporary perched water table; slowly permeable subsoil; undulating.	Moderate intake rate; slowly permeable subsoil.	([5])	([5]).
([5])	([6])	Calcareous	([5])	Unsuitable for leveling.	([6])	Highly calcareous; difficult to establish vegetation where subsoil is exposed.
([6])	Rapidly permeable substratum.	Moderately low strength.	Temporary high water table; not applicable in most places.	Flooding hazard	([5])	([5]).
([5])	Contains coarse-textured strata.	Stable in fill; high strength; unstable on steep slopes.	High water table; drainage not desirable under present land use.	([5])	([5])	([5]).
([5])	([6])	([6])	Slow permeability; undulating microrelief.	Slow permeability	([6])	([6]).
([6])	Rapidly permeable substratum.	Limited depth for borrow.	Drainage difficult because of position occupied by these soils.	Soil depth limited; flooding hazard.	([5])	([5]).
([5])	Limited depth	Limited depth for borrow.	([5])	Shallow; not suitable.	Siltstone is at a depth of 2 to 20 feet.	Shallow root zone; moderately erodible.
([5])	([6])	([6])	([5])	([6])	Complex topography is common.	([6]).
([5])	Limited depth; seepage problem.	Limited depth for borrow.	([5])	Moderately shallow; not suitable.	Siltstone at a depth of 2 to 3½ feet.	Moderately shallow root zone; moderately erodible.
([5])	([6])	Cracks when dry.	([5])	Slow permeability	([6])	Subsoil only fair to poor for vegetation.

TABLE 6.—*Interpretation of engineering*

Soil series and map symbol	Suitability as a source of—					Soil features affecting engineering practices
	Topsoil	Sand	Gravel	Road subgrade [2]	Road fill [2]	Highway location [2]
Platte (Pa)	Surface layer poor; substrata not suitable.	Good	Good	Good if confined.	Good	High water table; flooding hazard.
Plevna (Pe)	Surface layer poor; fair below surface layer.	Poor	Not suitable	Surface layer good if elevated; subsoil poor.	Fair	High water table
Port (Pl)	Good	Not suitable	Not suitable	Fair	Fair	Flooding hazard
Pratt (Pm, Pr, Pt)	Fair	Poor	Not suitable	Good	Good	Unstable slopes
Renfrow (Rc, Re, Rv)	Surface layer fair; subsoil poor.	Not suitable	Not suitable	Poor	Fair	Limited depth to hard shale; high shrink-swell potential, high compressibility.
Shellabarger (Sa, Sb, Sc, Se, Sg, Sh, Sm, Sn).	Fair	Fair	Poor	Poor to fair	Good	([4])
Smolan (Sp, St)	Surface layer good; subsoil fair.	Not suitable	Not suitable	Fair to poor	Good to fair	([4])
Tabler (Ta, Tb)	Surface layer fair; subsoil poor.	Not suitable	Not suitable	Poor	Fair	Poor surface drainage; high shrink-swell potential.
Tivoli (Tf, Th)	Not suitable	Good; very fine and poorly graded.	Not suitable	Good if confined.	Good if confined.	Unstable slopes
Vanoss (Va, Vb, Vc)	Good	Not suitable	Not suitable	Fair	Good	([4])
Vernon (Ve)	Poor	Not suitable	Not suitable	Poor	Fair	Limited depth to hard shale.
Wann (Wa)	Poor	Good	Good	Good	Good	Flooding hazard; high water table.

[1] Interpretations for the taxonomic units in soil complexes and undifferentiated units are given under the respective series. Interpretations are not given for Breaks-Alluvial land complex, Slick-spots, and Wet alluvial land, because these land types are too variable to warrant estimates.

[2] C. W. HECKATHORN, field soils engineer, and HERBERT E. WORLEY, soils research engineer, Kansas State Highway Commission, helped prepare these columns. This assistance was performed

properties of soils [1]—Continued

Soil features affecting engineering practices						
Dikes	Farm ponds		Agricultural drainage	Irrigation	Terraces and diversions	Waterways
	Reservoir area	Embankment [3]				
Unstable	Rapid permeability.	Rapid permeability; lacks fines.	(5)	(5)	(5)	(5).
(6)	Contains strata of coarse-textured material.	The stronger slopes are unstable.	High water table; drainage difficult because of position occupied by these soils.	(5)	(5)	(5).
(6)	(6)	(6)	(5)	Moderate intake rate: good water-holding capacity.	(5)	(5).
(5)	Rapid permeability.	Unstable	(5)	Moderate to high intake rate; low water-holding capacity; suited to sprinkler irrigation only.	(5)	(5).
(5)	(6)	Cracks when dry; low shear strength.	(5)	Moderate intake rate; slowly permeable subsoil.	(6)	Moderately shallow to shallow root zone; subsoil poor for vegetation.
(5)	Moderate permeability.	(6)	(5)	Moderate intake rate; moderate permeability.	(6)	Surface layer highly erodible.
(5)	(6)	Highly plastic; low shear strength.	(5)	Very slow intake rate; slow permeability.	(6)	(6).
(5)	(6)	Cracks when dry.	Nearly level; outlets difficult to locate.	Very slow permeability; imperfectly drained.	(5)	(5).
(5)	(5)	(5)	(5)	(5)	(5)	(5).
(6)	(6)	(6)	(5)	(6)	(6)	(6).
(5)	(6)	Cracks when dry; limited depth for borrow.	(5)	Not suitable	Hard shale at a depth of 10 to 25 inches.	Shallow root zone; moderately erodible.
Rapid permeability; fair stability.	Rapid permeability.	(5)	(5)	Fluctuating water table.	(5)	(5).

under a cooperative agreement with the U.S. Department of Commerce, Bureau of Public Roads.
[3] Embankments more than 25 feet high not considered.
[4] No detrimental features.
[5] Practice generally not applicable.
[6] No features that significantly affect design.

TABLE 7.—*Engineering*

Soil name and location	Parent material	Bureau of Public Roads report No.	Depth	Horizon	Moisture-density [2]	
					Maximum dry density	Optimum moisture
			Inches		*Lb. per cu. ft.*	*Percent*
Bethany silt loam:						
330 feet W. and 1,320 feet N. of S¼ corner of sec. 14, T. 25 S., R. 5 W.[5]	Old alluvial sediments of Pleistocene age.	S33627	0–7	Ap	111	16
		S33628	27–36	B22	104	19
		S33629	45–60	Bca1	109	17
1,020 feet S. and 206 feet E. of NW. corner of sec. 4, T. 25 S., R. 5 W.	Old alluvial sediments of Pleistocene age.	S33630	0–6	Ap	108	16
		S33631	23–38	B22	101	23
		S33632	49–73	Bca1	107	18
820 feet E. and 75 feet N. of SW. corner of sec. 8, T. 22 S., R. 4 W.	Old alluvial sediments of Pleistocene age.	S34276	0–12	A1p	112	15
		S34277	24–34	B22	94	26
		S34278	56–88	Bca	104	20
Carwile fine sandy loam:						
406 feet N. and 267 feet W. of E¼ corner of sec. 18, T. 22 S., R. 9 W.	Eolian mantle.	S33633	0–7	Ap	114	11
		S33634	13–17	A12	122	11
		S33635	33–48	B2b2	109	17
270 feet N. and 305 feet W. of SE. corner of sec. 21, T. 23 S., R. 9 W.	Eolian mantle.	S33636	0–7	Ap	117	10
		S33637	11–19	A3	121	11
		S33638	29–46	B2b2	106	18
Farnum loam:						
825 feet W. and 660 feet S. of E¼ corner of sec. 5, T. 24 S., R. 6 W.	Alluvial sediments of Pleistocene age.	S33639	0–9	Ap	121	11
		S33640	44–53	B23	111	16
		S33641	60–76	B3ca	113	15
1.668 feet E. and 20 feet N. of W¼ corner of sec. 17, T. 24 S., R. 6 W.	Alluvial sediments of Pleistocene age.	S33642	0–5	Ap	119	12
		S33643	21–29	B21	109	18
		S33644	56–78	B3	109	18
65 feet S. and 160 feet E. of NW. corner of sec. 22, T. 24 S., R. 7 W.	Alluvial sediments of Pleistocene age.	S34282	0–8	Ap	117	12
		S34283	19–32	B21	105	19
		S34284	62–92	C	122	12
Pratt loamy fine sand:						
650 feet W. and 700 feet N. of SE. corner of sec. 10, T. 24 S., R. 10W.	Eolian deposits.	S33645	0–7	Ap	114	11
		S33646	19–29	B21	120	11
		S33647	53–69	C1	114	13
600 feet S. and 280 feet E. of W¼ corner of sec. 35, T. 23 S., R. 10 W.	Eolian deposits.	S33648	0–7	Ap	110	13
		S33649	18–28	B22	118	12
		S33650	50–66	C	113	12
200 feet W. and 36 feet N. of S¼ corner of sec. 3, T. 25 S., R. 10 W.	Eolian deposits.	S34285	0–7	Ap	110	13
		S34286	13–20	B21	118	12
		S34287	46–74	C	116	12
Shellabarger fine sandy loam:						
900 feet S. and 175 feet W. of NE. corner of sec. 11, T. 26 S., R. 6 W.[5]	Beds of reworked outwash.	S33651	0–7	Ap	117	13
		S33652	19–33	B22	127	9
		S33653	57–76	C	121	11
15 feet S. and 25 feet E. of W¼ corner of sec. 2, T. 23 S., R. 9 W.	Beds of reworked outwash.	S34288	0–8	Ap	122	11
		S34289	17–28	B2	117	13
		S34290	56–82	C1	118	13
Tabler clay loam:						
1,000 feet E. and 400 feet N. of W¼ corner of sec. 16, T. 24 S., R. 6 W.	Old alluvial sediments.	S33657	0–8	Ap	108	18
		S33658	8–16	B21	98	24
		S33659	59–81	B3ca3	110	17
1,420 feet E. and 167 feet N. of SW. corner of sec. 14, T. 24 S., R. 6 W.	Old alluvial sediments.	S33660	0–5	Ap	120	12
		S33661	8–20	B21	99	22
		S33662	61–83	B3ca2	108	18
60 feet N. and 290 feet E. of SW. corner of sec. 24, T. 22 S., R. 4 W.	Old alluvial sediments.	S34291	0–6	Ap	112	15
		S34292	22–31	B22	100	23
		S34293	53–78	C1	106	19

See footnotes at end of table.

test data [1]

Mechanical analysis [3]								Liquid limit	Plasticity index	Classification	
Percentage passing sieve—				Percentage smaller than—						AASHO	Unified [4]
No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 200 (0.074 mm.)	0.05 mm.	0.02 mm.	0.005 mm.	0.002 mm.				
--------	100	97	87	80	48	29	26	29	8	A-4(8)	ML-CL.
--------	100	98	91	86	57	41	38	48	25	A-7-6(16)	CL.
96	93	91	87	82	56	38	31	43	21	A-7-6(13)	CL.
--------	100	98	93	85	50	31	27	30	11	A-6(8)	CL.
--------	100	96	92	87	64	48	43	58	32	A-7-6(20)	CH.
--------	100	97	92	87	57	40	35	48	26	A-7-6(16)	CL.
--------	--------	100	85	76	41	24	21	27	9	A-4(8)	CL.
--------	--------	--------	98	95	70	50	46	58	31	A-7-6(20)	CH.
--------	--------	--------	97	92	59	41	38	47	24	A-7-6(15)	CL.
--------	100	89	23	18	11	8	6	[6] NP	NP	A-2-4(0)	SM.
--------	100	87	24	20	14	12	12	NP	NP	A-2-4(0)	SM.
--------	100	99	84	80	54	32	29	45	25	A-7-6(15)	CL.
--------	100	95	25	19	11	7	6	NP	NP	A-2-4(0)	SM.
--------	100	96	31	25	16	12	11	NP	NP	A-2-4(0)	SM.
--------	100	99	87	84	60	38	34	47	26	A-7-6(16)	CL.
--------	100	90	59	53	30	17	14	20	4	A-4(5)	ML-CL.
--------	100	93	59	56	42	35	32	40	21	A-6(9)	CL.
--------	100	93	72	63	41	28	26	34	16	A-6(10)	CL.
--------	100	89	67	60	32	18	15	21	3	A-4(6)	ML.
--------	100	90	74	69	47	33	29	44	22	A-7-6(13)	CL.
--------	100	95	80	74	49	34	31	44	23	A-7-6(14)	CL.
--------	100	93	65	58	30	19	16	23	6	A-4(6)	ML-CL.
--------	100	95	80	76	56	41	38	52	30	A-7-6(18)	CH.
--------	100	93	52	48	34	24	18	25	11	A-6(4)	CL.
--------	100	87	19	13	8	7	5	NP	NP	A-2-4(0)	SM.
--------	100	88	31	22	13	12	11	NP	NP	A-2-4(0)	SM.
--------	100	93	14	11	8	7	6	NP	NP	A-2-4(0)	SM.
--------	100	92	11	9	7	6	4	NP	NP	A-2-4(0)	SW-SM.
--------	100	96	21	17	14	12	10	NP	NP	A-2-4(0)	SM.
--------	100	96	15	12	9	8	7	NP	NP	A-2-4(0)	SM.
--------	100	91	12	8	5	3	2	NP	NP	A-2-4(0)	SP-SM.
--------	100	90	16	15	13	11	9	NP	NP	A-2-4(0)	SM.
--------	100	91	15	13	12	9	8	NP	NP	A-2-4(0)	SM.
98	90	49	22	22	19	17	15	38	16	A-2-6(0)	SC.
--------	100	80	42	38	21	12	10	16	1	A-4(1)	SM.
98	72	16	7	7	7	6	6	35	17	A-2-6(0)	SP-SC.
--------	100	95	38	31	18	13	11	17	3	A-4(1)	SM.
--------	100	98	56	47	30	21	19	26	11	A-6(5)	CL.
--------	100	95	46	40	28	21	19	26	11	A-6(2)	SC.
--------	100	95	86	81	54	34	28	37	15	A-6(10)	CL.
--------	100	94	84	82	68	51	46	61	31	A-7-5(20)	MH-CH.
99	96	92	82	76	57	43	37	48	27	A-7-6(16)	CL.
--------	100	83	50	46	28	18	16	24	8	A-4(3)	SC.
--------	100	95	85	83	68	51	46	62	37	A-7-6(20)	MH.
--------	100	95	82	77	55	40	37	47	26	A-7-6(16)	CL.
--------	--------	--------	96	86	45	25	20	28	8	A-4(8)	CL.
--------	--------	--------	99	96	75	54	48	64	37	A-7-6(20)	CH.
--------	--------	--------	94	88	60	40	35	47	26	A-7-6(16)	CL.

TABLE 7.—*Engineering*

Soil name and location	Parent material	Bureau of Public Roads report No.	Depth	Horizon	Moisture-density [2]	
					Maximum dry density	Optimum moisture
			Inches		*Lb. per cu. ft.*	*Percent*
Tivoli fine sand:						
200 feet N. and 100 feet W. of SE. corner of sec. 28, T. 22 S., R. 10 W.	Eolian deposits.	S35094	0–6	A1	103	11
		S35095	32–52	C1	102	13
		S35096	52–90	C2	103	13
800 feet S. and 225 feet E. of NW. corner of sec. 9, T. 22 S., R. 10 W.	Eolian deposits.	S35097	0–9	A1	100	13
		S35098	15–28	AC	99	15
		S35099	48–68	C1	97	17

[1] Tests performed by the Bureau of Public Roads in accordance with standard procedures of the American Association of State Highway Officials (AASHO) (*1*).
[2] Based on AASHO Designation T 99–57, Method A (*1*).
[3] Mechanical analyses according to AASHO Designation T 88–57 (*1*). Results by this procedure frequently 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 mm. in diameter. In the SCS soil survey procedure, the fine material is analyzed by

Table 7 gives engineering test data from several extensive soil series of the county. The tests were performed by the Bureau of Public Roads in accordance with standard procedures of the American Association of State Highway Officials. The information presented in this table is based on data obtained by moisture-density tests, grain-size analysis, and tests to determine the liquid limit and the plastic limit. The grain-size analysis was made by combining the sieve and hydrometer methods.

Table 7 gives compaction (moisture-density) data for the soils tested. If a soil material is compacted a successively higher moisture content, assuming the compactive effort remains constant, the density of the compacted material will increase until the optimum moisture content is reached. After that, the density decreases with increase in moisture content. The highest dry density obtained in the compaction test is termed maximum dry density. Moisture-density data are important to earthwork because, generally, optimum stability is obtained if the soil is compacted to about the maximum dry density when it is approximately at the optimum moisture content.

The tests to show liquid limit and plastic limit measure the effect of water on the consistence of the soil material. As the moisture content of a soil material increases from a dry state, the material changes from a semisolid to a plastic state. As the moisture content is further increased, the material changes from a plastic to a liquid state. The plastic limit is the moisture content at which the soil material passes from a semisolid to a plastic state. The liquid limit is the moisture content at which the soil material passes from a plastic to a liquid state. The plasticity index is the numerical difference between the liquid limit and the plastic limit. It indicates the range of moisture content within which a soil material is in a plastic condition. Some soils are termed nonplastic; that is, the plastic limit or the liquid limit cannot be determined, or the plastic limit is equal to the liquid limit.

Genesis, Classification, and Morphology of Soils

The purpose of this section is to present the outstanding morphologic characteristics of the soils of Reno County and to relate them to the factors of soil formation. Physical and chemical data are limited for these soils, and the discussion of soil genesis and morphology is correspondingly incomplete. The first part of the section deals with the environment of the soils; the second, with the classification and morphology of the soils; and the third with the mechanical and chemical analyses of selected soils.

Factors of Soil Formation

Soil is produced by the action of soil-forming processes on material deposited or accumulated by geologic agencies. The characteristics of the soil at any given point are determined by (1) the physical and mineralogical composition of the parent material; (2) the climate under which the soil material has accumulated and existed since accumulation; (3) the plant and animal life on and in the soil; (4) the relief, or lay of the land; and (5) the length of time the forces of soil development have acted on the soil material.

Climate and vegetation are active factors of soil genesis. They act on the parent material that has accumulated through the weathering of rocks and slowly change it to a natural body with genetically related horizons. The effects of climate and vegetation are conditioned by relief. The parent material also affects the kind of profile that can be formed and in extreme cases, determines it almost entirely. Finally, time is needed for the changing of the parent material to a soil profile. The amount of time may be much or little, but some time is always required for horizon differentiation. Usually, a long time is required for the development of distinct horizons.

test data [1]—Continued

Mechanical analysis [3]								Liquid limit	Plasticity index	Classification	
Percentage passing sieve—				Percentage smaller than—						AASHO	Unified [4]
No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 200 (0.074 mm.)	0.05 mm.	0.02 mm.	0.005 mm.	0.002 mm.				
----------	100	84	10	8	5	2	1	NP	NP	A-3(0)	SP-SM.
----------	100	85	8	7	4	2	1	NP	NP	A-3(0)	SP-SM.
----------	100	82	9	7	4	4	2	NP	NP	A-3(0)	SP-SM.
----------	100	94	8	5	4	3	2	NP	NP	A-3(0)	SP-SM.
----------	100	95	8	6	4	3	1	NP	NP	A-3(0)	SP-SM.
----------	100	99	8	6	4	4	3	NP	NP	A-3(0)	SP-SM.

the pipette method and the material coarser than 2 mm. 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 for soils.

[4] The Soil Conservation Service and Bureau of Public Roads have agreed that all soils having plasticity indexes within two points of the A-line are to be given borderline classification.

[5] 100 percent of the material in sample No. S33629 passed a 1½-inch sieve, and 100 percent of the material in sample No. S33653 passed a ¾-inch sieve.

[6] NP=Nonplastic.

The factors of soil genesis are so closely interrelated in their effects on the soil that few generalizations can be made regarding the effect of any one factor unless conditions are specified for the other four. Many of the processes of soil development are unknown.

Parent Material

Parent material is the unconsolidated material from which soils develop. It is formed as the result of the weathering of rocks through the processes of freezing and thawing, as the result of wind erosion, and as the result of the grinding away of rocks by rivers and glaciers. It is also formed as the result of chemical processes.

The soils of Reno County developed partly in material weathered from rocks and partly in outwash that is indirectly associated with the glacial age. Geologically, the oldest material that has actively furnished soil material within the county is a part of the Ninnescah shale of the Permian system. The youngest material of Permian age exposed in the county is Harper sandstone.

The area that is now Reno County was probably subjected to geologic erosion during the Tertiary period. No deposits of Tertiary age have been found, however, in geologic studies of the county. Late in the Tertiary period this was an area of low relief, but renewed erosion in early Pleistocene time dissected the land surface and cut deep valleys into the Permian beds. These valleys were later filled with outwash deposits. Four major periods of erosion and deposition within the Pleistocene series are evident in the county (*5*). These cycles of erosion and deposition left a mantle of outwash of Pleistocene age over most of the county. The mantle is lacking, however, in two areas in the southeastern corner of the county where beds of reddish shale of the Permian system are exposed.

Soils developed in the material where the beds of the Permian system are exposed are reddish brown to brown and have a texture of clay loam to clay. In places these soils are calcareous at the point of contact with the parent shale.

In the south-central part of the county, a younger, silty and calcareous part of the Permian beds is exposed. Soils in that area are reddish brown, silty, and neutral to calcareous.

The younger strata consist of calcareous loam and clay loam that are in contact with the Permian beds. Observations suggest that this represents the remains of a thin mantle of calcareous material deposited in early Pleistocene time. Subsequently, the county was covered by outwash during the Nebraskan, Kansan, and Illinoian stages of Pleistocene time. In Reno County this outwash consists mostly of coarse sand and gravel that contain lenses of clayey material. Later deposition covered most of this material, except a few areas in the southern part of the county. Over most of the county, this material is covered to a depth of 10 to 50 feet by later and less coarse deposits of Pleistocene age.

Late in the Pleistocene epoch, eolian silts were deposited adjacent to the major streams. This material is more than 15 feet thick and it feathered out with distance from the streams. Wind has mixed these silts with the sandy Pleistocene material that was previously deposited. As a result, most of the soils in the central part of the county generally have a B horizon of sandy clay loam. In an area near Haven in the southeastern part of the county and in one near Buhler in the northeastern part are wind-deposited silts that were not mixed with the sandy outwash.

In recent geologic time, sands have been transported into the northern and western parts of the county. These sands are believed to have been carried and deposited by the Arkansas River. After they were deposited, they were reworked by wind, and as a result, the topography is now hummocky and dunelike. Recent alluvium occurs along the major streams. Some of this material is deposited each time an area is flooded.

Climate and soil

Climate has had a definite effect on the development of soils in this county. The county has a continental type of climate typical of that in the subhumid Great Plains. The seasonal variations in temperature are wide; annual rainfall is moderate, about 29 inches, and the average frost-free period is about 185 days. The air is dry. The rate of evaporation from a free-water surface is about 55 inches during the period from April to October.

In the past the climate of this county was favorable for the growth of a large amount of vegetation, and this vegetation has influenced the characteristics of the soils. The annual amount of rainfall is not great enough that plant nutrients are leached beyond the depth penetrated by roots. In addition, rainfall is highest during the growing season, which has helped produce vegetation.

Plant and animal life

Living organisms, including grasses, rodents, worms, and micro-organisms, live on and in the soils and contribute much to the development of soil profiles. The climate in this county favors grasses, and the original vegetation was wholly mid and tall grasses. Such vegetation encouraged vast numbers of worms, insects, rodents, and grazing animals to occupy the area. Decaying grass roots and stems, as well as the remains of animals, furnished large amounts of organic matter. This organic matter made the surface layer of the soils dark colored.

Relief

The effects of climate and vegetation on parent material may be modified by relief. For example, sloping areas lose water through runoff, and this loss modifies the effects of rainfall. In depressions the effect is the opposite. Water stands on the surface, and plants and animals react to the greater amount of moisture.

The relief in this county is mostly rolling to undulating. In some places there are depressions, and in others there are high spots. The soils exhibit many effects of relief, considering the somewhat narrow range of the other soil-forming factors.

Time

The development of a soil profile requires time, usually a long period. The degree of development depends on the interaction of all the soil-forming factors. Easily weathered parent material, a favorable climate, and smooth topography allow a soil profile to develop in less time than a combination of weather-resistant parent material, steep slopes, and unfavorable climate. The combined action of all the soil-forming factors is reflected in the degree of profile development.

Classification and Morphology of Soils

Soils are placed in narrow classes for the organizaton and application of knowledge about their behavior within farms, ranches, or counties. They are placed in broad classes for study and comparisons of large areas, such as continents. In the comprehensive system of soil classification followed in the United States (*2*), the soils are placed in six categories, one above the other. Beginning at the top, the six categories are order, suborder, great soil group, family, series, and type.

In the highest category, the soils of the whole country are grouped into three orders, whereas thousands of soil types are recognized in the lowest category The suborder and family categories have never been fully developed and thus have been little used. Attention has been given largely to the classification of soils into soil types and series within counties or comparable areas and to the subsequent grouping of series into great soil groups and orders. The soil series, type, and phase are defined in the section "How This Soil Survey Was Made."

Classes in the highest category of the classification scheme are the zonal, intrazonal, and azonal orders (*13*). The zonal order comprises soils with evident, genetically related horizons that reflect the predominent influences of climate and living organisms in their formation. The intrazonal order is made up of soils with evident, genetically related horizons that reflect the dominant influence of a local factor of topography or parent material over the effects of climate and living organisms. The azonal order consists of soils that lack distinct, genetically related horizons, commonly because of youth, resistant parent material, or steep topography. In table 8 the soil series are classified by higher categories and their important characteristics are given. Following the table is a discussion of the morphology of each soil series, and a description of a typical soil profile for each series.

Descriptions of the soil series

In the following pages the soil series in the county are described in alphabetic order. For each series a detailed description of a typical profile is given.

ALBION SERIES

In the Albion series are moderately sandy, medium acid to slightly acid Reddish Prairie soils that are moderately deep over sand and gravel. These soils are in nearly level areas or in areas of convex slopes. They developed in outwash of Pleistocene age and have a moderately well developed profile.

Albion soils are shallower to coarse-textured material than Shellabarger soils. They are more clayey than Pratt soils.

The following describes a typical profile of Albion sandy loam, 1 to 3 percent slopes, 200 feet east and 150 south of the northwest corner of the northeast quarter of section 20, T. 25 S., R. 8 W.:

A1—0 to 8 inches, brown (10YR 5/3) fine sandy loam; dark brown (10YR 3/3) when moist; weak to moderate, fine, granular structure; slightly hard when dry; few pebbles as much as 2 centimeters in diameter; medium acid; gradual boundary.

B2t—8 to 16 inches, brown (7.5YR 4/2) light sandy clay loam; dark brown (7.5YR 3/2) when moist; moderate, medium, granular structure; slightly hard when dry; friable when moist; few fine roots; slightly acid; gradual boundary.

B3—16 to 27 inches, reddish-brown (5YR 4/4) coarse sandy loam; dark reddish brown (5YR 3/4) when moist; weak granular structure; slightly hard when dry, friable when moist; slightly acid; diffuse boundry.

IIC—27 to 48 inches, light yellowish-brown (10YR 6/4, dry) sand; single grain (structureless); neutral.

The thickness of the A1 horizon ranges from 6 to about 12 inches, and the color of that horizon ranges from dark

TABLE 8.—*Soil series classified by higher categories and factors that contribute to their morphology*

ZONAL

Great soil group and soil series	Parent material	Relief	Drainage class	Native vegetation
Brunizems (Prairie soils):				
Farnum	Moderately fine textured outwash.	Nearly level to gently sloping.	Well drained to moderately well drained.	Grasses.
Chernozems:				
Clark [1]	Medium-textured, calcareous outwash.	Nearly level to sloping	Well drained	Grasses.
Ost	Moderately fine textured, calcareous outwash.	Nearly level to sloping	Moderately well drained or well drained.	Grasses.
Smolan	Fine-textured loess	Gently sloping to sloping	Well drained	Grasses.
Chestnut soils:				
Elsmere [2]	Coarse-textured alluvium	Nearly level	Imperfectly drained	Grasses.
Reddish Chestnut soils:				
Pratt	Moderately coarse textured, wind-modified outwash.	Undulating to hummocky	Well drained	Grasses.
Reddish Prairie soils:				
Albion	Moderately coarse textured outwash.	Nearly level to sloping	Well drained to somewhat excessively drained.	Grasses.
Bethany	Moderately fine textured old alluvium.	Nearly level to gently sloping.	Well drained	Grasses.
Naron	Medium-textured to moderately fine textured, wind-modified material.	Nearly level to gently sloping.	Well drained	Grasses.
Nash	Medium-textured siltstone of Permian age.	Gently sloping to steep	Well drained	Grasses.
Renfrow	Moderately fine textured shale of Permian age.	Nearly level to gently sloping.	Well drained	Grasses.
Shellabarger	Medium-textured outwash	Nearly level to sloping	Well drained	Grasses.
Tabler	Moderately fine textured or fine textured old alluvium.	Nearly level	Moderately well drained	Grasses.
Vanoss	Medium-textured to moderately fine textured loess.	Nearly level to sloping	Well drained	Grasses.

INTRAZONAL

Great soil group and soil series	Parent material	Relief	Drainage class	Native vegetation
Humic Gley soils:				
Plevna	Medium-textured and moderately fine textured outwash.	Nearly level	Poorly drained	Grasses.
Planosols:				
Carwile	Moderately coarse textured and moderately fine textured outwash.	Nearly level	Imperfectly drained	Grasses.

AZONAL

Great soil group and soil series	Parent material	Relief	Drainage class	Native vegetation
Alluvial soils:				
Canadian	Moderately coarse textured alluvium.	Nearly level	Well drained	Grasses.
Dale	Moderately fine textured alluvium.	Nearly level	Moderately well drained or well drained.	Grasses.
Lesho	Stratified alluvium	Nearly level	Imperfectly drained	Grasses.
Platte	Stratified alluvium	Nearly level	Imperfectly drained or poorly drained.	Grasses.
Port	Moderately fine textured alluvium	Nearly level	Well drained	Grasses.
Wann	Moderately coarse textured alluvium.	Nearly level	Imperfectly drained	Grasses.
Lithosols:				
Lucien	Medium-textured siltstone of Permian age.	Nearly level to strongly sloping.	Well drained to somewhat excessively drained.	Grasses.
Vernon	Moderately fine textured shale of Permian age.	Nearly level to steep	Well drained	Grasses.
Regosols:				
Tivoli	Eolian sands	Hummocky to hilly	Excessively drained	Grasses.

[1] Intergrading toward Calcisols. [2] Intergrading toward Humic Gley soils.

grayish brown to brown. The texture of the B horizon ranges from heavy sandy loam to sandy clay loam, and the structure of that horizon from granular to subangular blocky. Depth to sand and gravel ranges from 15 to 36 inches.

BETHANY SERIES

The Bethany series consists of nearly level or gently sloping Reddish Prairie soils of the uplands. These soils developed in silts and clays of Pleistocene age. In areas that have not been cultivated, they have a thick, dark-colored A1 horizon; the texture of their B2 horizons is light silty clay.

The Bethany soils have thicker A horizons and more gradual boundaries than the Tabler soils. Their solum is less sandy and more silty throughout than that of the Farnum soils, and their B3 horizon lacks the mottling that is generally present in the B3 horizon of the Farnum soils.

The following describes a typical profile of Bethany silt loam, 1,020 feet south and 206 feet east of the northwest corner of section 4, T. 25 S., R. 5 W.:

Ap—0 to 6 inches, dark grayish-brown (10YR 4/2) silt loam; very dark grayish brown (10YR 3/2) when moist; weak granular structure; friable; noncalcareous; clear boundary.

A3—6 to 12 inches, dark grayish-brown (10YR 4/2) light silty clay loam; very dark brown (10YR 2/2) when moist; moderate, fine, granular structure; moderately friable when moist; few worm casts; noncalcareous; gradual boundary.

B1—12 to 17 inches, dark grayish-brown (10YR 4/2) heavy silty clay loam; dark brown (10YR 3/3) when moist; moderately strong, fine and very fine, subangular blocky structure; weak, patchy clay skins on the surfaces of peds; firm when moist; few worm casts; few fine and very fine sand grains; noncalcareous; gradual boundary.

B21t—17 to 23 inches, dark grayish-brown (10YR 4/2) silty clay; very dark grayish brown (10YR 3/2) when moist; moderate, medium and coarse, blocky structure breaking to fine, weak, blocky structure; distinct continuous clay skins on the surfaces of peds; very firm when moist; few open rootlet channels; few, fine, dark-colored concretions, probably cemented with iron; noncalcareous; gradual boundary.

B22t—23 to 38 inches, brown (10YR 5/3) silty clay that has fine, old, vertical cracks filled with darker material from the horizons above; dark brown (10YR 3/3) when moist; moderate, coarse and fine, blocky structure; distinct, continuous clay skins on the surfaces of peds; few distinct slickensides that cover areas as much as 2 square inches in size; very firm when moist; few rootlets in the peds; noncalcareous; diffuse boundary.

B3—38 to 49 inches, yellowish-brown (10YR 5/4) silty clay loam; brown (10YR 4/3) when moist; weak, moderate, fine, blocky structure; thin, continuous clay skins on the surfaces of peds; few distinct slickensides that cover areas as much as 1 square inch in size; very firm when moist; noncalcareous; 1 to 3 percent, by volume, few, fine, hard concretions of lime; diffuse boundary.

Cca—49 to 73 inches, light-brown (7.5YR 6/4) heavy silty clay loam; brown (7.5YR 5/4) when moist; weak, fine, subangular blocky and blocky structure; firm when moist; noncalcareous; contains about 10 percent, by volume, fine to very coarse, soft and hard concretions of lime; diffuse boundary.

C—73 to 96 inches, reddish-yellow (7.5YR 6/5) silty clay loam; (7.5YR 6/6) when moist; about 5 percent, by volume, soft, fine to coarse concretions of lime; augered.

Depth to the B2t horizons ranges from 12 to about 24 inches, but it is generally about 16 to 18 inches. The texture of the B2t horizons ranges from heavy silty clay loam to light clay, and the hue from 10YR to 7.5YR. The chroma is 2 when dry, but it increases with increasing depth.

CANADIAN SERIES

Deep, well-drained, dark-colored slightly acid, moderately sandy Alluvial soils make up the Canadian series. These soils developed in alluvium on terraces that are above the level ordinarily reached by floodwaters.

The Canadian soils are more sandy than the Dale soils. They are deeper and better drained than the Wann soils.

The following describes a typical profile of Canadian fine sandy loam, 220 feet north and 75 feet west of the southeast corner of the southwest quarter of section 9, T. 22 S., R. 7 W.:

A1—0 to 20 inches, dark grayish-brown (10YR 4/2) fine sandy loam; very dark grayish brown (10YR 3/2) when moist; weak granular structure; very friable when moist; pH 6.3; gradual boundary.

AC—20 to 30 inches, brown (10YR 5/3) sandy loam; dark brown (10YR 3/3) when moist; moderate, fine, granular structure; very friable when moist; open rootlet channels are common; pH 6.5; gradual boundary.

C1—30 to 41 inches, yellowish-brown (10YR 5/4) sandy loam; brown (10YR 4/3) when moist; moderate, fine, granular structure; very friable when moist; faint fine mottles; pH 7.0; gradual boundary.

C2—41 to 53 inches, light sandy loam that is pale brown (10YR 6/3) and brownish yellow (10YR 6/6) when moist; weak, fine, granular structure; friable when moist; calcareous.

The thickness of the A1 horizon ranges from 12 to 24 inches, and the texture of that horizon ranges from fine sandy loam to heavy loamy sand. In some places faint mottling occurs below a depth of 30 inches. The depth from the surface to calcareous material ranges from 24 to 40 inches, and the depth to sand ranges from 40 to 60 inches.

CARWILE SERIES

The Carwile series consists of dark-colored, imperfectly drained Planosols. These soils have a fine sandy loam surface layer and a clayey subsoil. They are mottled in the lower part of the A horizon, or at a depth of about 10 to 20 inches.

The Carwile soils are mottled and have a much finer textured subsoil than the Shellabarger soils. They have a less gradual boundary between the A and B horizons than the Farnum soils. Unlike the Farnum soils, which are not mottled above the B21t horizon, the Carwile soils have mottling in the lower part of the A horizon.

The following describes a typical profile of Carwile fine sandy loam, 270 feet north and 300 feet west of the southeast corner of section 21, T. 23 S., R. 9 W.

Ap—0 to 7 inches, grayish-brown (10YR 5/2) light fine sandy loam; very dark grayish brown (10YR 3/2) when moist; structure destroyed by cultivation; very friable when moist; pH 6.5; clear boundary.

A1—7 to 11 inches, dark grayish-brown (10YR 4/2) fine sandy loam; very dark brown (10YR 2/2) when moist; porous; massive; very friable when moist; pH 6.3; clear boundary.

A3—11 to 19 inches, dark grayish-brown (10YR 4/2) heavy fine sandy loam; brown (10YR 4/3) when moist; faintly mottled; porous; massive; friable when moist; pH 6.2; clear boundary.

B21t—19 to 23 inches, brown (10YR 5/3) heavy fine sandy loam; brown (10YR 4/3) when moist; weak subangular blocky structure; common, faint, brownish mottles, one fourth of an inch in diameter; friable when moist; pH 6.4; abrupt boundary.

IIB22t—23 to 29 inches; grayish-brown (2.5Y 5/2) clay; dark grayish brown (2.5Y 4/3) when moist; moderate, medium, irregular blocky structure; thick, continuous clay skins on the surfaces of peds; few, fine, faint, brown mottles; very firm when moist; many open channels made by rootlets; pH 6.4; gradual boundary.

IIB23t—29 to 46 inches, light olive-gray (5Y 6/2) silty clay loam; olive gray (5Y 5/2) when moist; moderate, medium, irregular blocky structure; thick continuous clay skins on the surfaces of peds; very firm when moist; few old cracks about 1/8 to 1/4 inch in width filled with material similar to that in the A3 horizon; pH 6.5; diffuse boundary.

IIB3—46 to 55 inches, pale-olive (5Y 6/3) loam; olive (5Y 5/3) when moist; weak, coarse, granular structure; patches of clay skins on the surfaces of peds; firm when moist; many fine rootlet channels; common, fine, distinct, brown mottles; pH 7.0; gradual boundary.

IIC—55 to 68 inches, light yellowish-brown (2.5Y 6/3) fine sandy loam; light olive brown (2.5Y 5/3) when moist; weak, granular structure to almost structureless; friable when moist; few, medium and fine, distinct mottles of strong brown; few fine rootlet channels; pH 7.0.

The thickness of the combined A horizons ranges from about 8 inches to about 22 inches. Mottling generally occurs above the B21t horizon, at a depth of about 8 inches, but it is within 10 inches of the surface in some places. The structure of the B2t horizons ranges from weak to moderate angular blocky. When the soil is wet, the structure is not readily discernible.

CLARK SERIES

The soils of the Clark series are dark-colored, calcareous Chernozems that intergrade toward Calcisols. These soils lack a textural B horizon. Below the surface layer is heavy loam to clay loam. About 25 to 75 percent of the underlying material, by volume, is calcium carbonate. These soils are on the uplands and developed in calcareous outwash sediments of Pleistocene age. They are adjacent to the Renfrow and Vernon soils, which developed in shale of Permian age.

Clark soils are less deeply leached of lime than the Ost soils. They also lack a textural B horizon that is typical of the Ost soils.

The following describes a typical profile of Clark loam, 150 feet north and 150 feet west of the southeast corner of section 1, T. 26 S., R. 8 W.:

A1—0 to 10 inches, very dark grayish-brown (10YR 3/2) loam; very dark brown (10YR 2/2) when moist; moderate, medium, granular structure; friable when moist; calcareous; clear, wavy boundary.

AC—10 to 18 inches, dark grayish-brown (10YR 4/2) loam; very dark grayish brown (10YR 3/2) when moist; moderate to strong, medium, granular structure; friable when moist; numerous worm casts; hard and soft nodules and concretions of lime make up about 20 percent of the soil material, by volume; gradual, wavy boundary.

Cca—18 to 60 inches +, strong-brown (7.5YR 5/6) loam; brown (7.5YR 4/4) when moist; moderate, medium, granular structure; friable when moist; about 35 percent, by volume, consists of masses of calcium carbonate.

The thickness of the A1 horizon ranges from 4 to 12 inches, and the texture of that horizon ranges from loam to sandy loam. The thickness of the AC horizon ranges from 3 to 15 inches.

DALE SERIES

In the Dale series are deep, dark-colored, moderately well drained or well drained Alluvial soils that are underlain by stratified sand and gravel. These soils are mainly on terraces along the Arkansas River, and they are rarely flooded.

The Dale soils are deeper than the Lesho soils and are leached of lime to a greater depth. They are less sandy than the Canadian and Wann soils.

The following describes a typical profile of Dale clay loam, 1,290 feet west and 660 feet north of the southeast corner of section 19, T. 24 S., R. 4 W.:

A1—0 to 11 inches, dark-gray (10YR 4/1) clay loam; very dark brown (10YR 2/2) when moist; weak, fine, granular structure; very friable when moist; clear boundary.

AC—11 to 26 inches, dark grayish-brown (10YR 4/2) clay loam; very dark grayish brown (10YR 3/2) when moist; fine, faint mottles are at a depth of 23 inches; moderate, medium, granular structure; very friable when moist; few worm casts; weakly calcareous; gradual boundary.

C1—26 to 40 inches, grayish-brown (10YR 5/2) sandy clay loam; dark grayish brown (10YR 4/2) when moist; weak to moderate, medium, granular structure; very friable when moist; calcareous; few, fine, faint mottles; diffuse boundary.

IIC2—40 to 48 inches +, yellowish-brown (10YR 5/4) sand; single grain.

The thickness of the A1 horizon ranges from 8 to about 20 inches, and the color ranges from dark gray or dark brown to grayish brown. The texture of the AC horizon is generally clay loam, but it ranges to sandy clay loam in some areas. In some places stratified sand or gravel is at a depth of 30 to 50 inches, but it is at a depth of 36 to 40 inches in a modal profile. The water table is normally at a depth of about 48 inches, but sometimes it is well below the root zone of common crops during part of the growing season.

ELSMERE SERIES

In the Elsmere series are nearly level, imperfectly drained Chestnut soils that are intergrading toward soils of the Humic Gley great soil group. These soils have developed in coarse-textured alluvium. They occupy areas adjacent to and within the sandhill areas of the county. The water table is at a depth of about 26 inches, or well within the root zone of the adapted native grass.

Below the A1 horizon, the Elsmere soils have more sandy material than the Plevna soils. They are less well drained than the Pratt soils.

The following describes a typical profile of Elsmere loamy fine sand, 200 feet north and 100 feet west of the southeast corner of the northwest quarter of section 18, T. 22 S., R. 5 W.:

A1—0 to 16 inches, grayish-brown (10YR 5/2) loamy fine sand; very dark brown (10YR 2/2) when moist; weak granular structure to single grain; loose when moist or dry; gradual boundary.

AC—16 to 24 inches, very pale brown (10YR 7/4) loamy sand; light yellowish brown (10YR 6/4) when moist; massive; common, fine, distinct mottles of strong brown; diffuse boundary.

C1—24 to 49 inches, very pale brown (10YR 7/4) loamy sand; light yellowish brown (10YR 6/4) when moist; common and prominent mottles.

C2—49 to 53 inches, light-gray (10YR 7/2) sandy loam that grades to sandy clay at a depth of about 53 inches; gray (10YR 6/1) when moist; mottling decreases with increasing depth.

The A1 horizon ranges from 4 to 20 inches in thickness. Its texture is generally loamy fine sand, but it is light fine sandy loam in some areas. The Elsmere soils in this county are underlain by a clayey layer at a depth of about 5 feet.

FARNUM SERIES

The Farnum series consists of well drained or moderately well drained Brunizems that have thick, dark-colored, loamy A horizons and B2 horizons of heavy sandy clay loam or clay loam. These soils are nearly level to gently sloping and developed in wind- and water-worked material of Pleistocene age.

Farnum soils are more clayey than Shellabarger soils. Their solum is more sandy and less silty throughout than that of the Bethany soils.

The following describes a typical profile of Farnum loam, 825 feet west and 660 feet south of the northeast corner of the southeast quarter of section 5, T. 24 S., R. 6 W.:

Ap—0 to 9 inches, dark grayish-brown (10YR 4/2) loam; very dark brown (10YR 2/2) when moist; weak granular structure; friable when moist; noncalcareous; clear boundary.

A3—9 to 16 inches, dark grayish-brown (10YR 4/2) loam; very dark grayish brown (10YR 3/2) when moist; moderate, fine, granular structure; friable when moist; many worm casts; noncalcareous; gradual boundary.

B1—16 to 22 inches, dark grayish-brown (10YR 4/2) heavy loam; very dark grayish brown (10YR 3/2) when moist; moderate, fine, granular structure; weak patchy clay skins on the surfaces of peds; firm when moist; many worm casts; clear boundary.

B21t—22 to 32 inches, dark grayish-brown (10YR 4/2) clay loam; very dark grayish brown (10YR 3/2) when moist; common, fine, distinct mottles of strong brown; moderate, medium, prismatic structure that breaks to moderate or strong, medium, blocky structure; prominent, continuous clay skins on the surfaces of peds; very firm when moist; few rootlets in peds; most rootlet channels have been plugged, but a few are open; noncalcareous; gradual boundary.

B22t—32 to 44 inches, grayish-brown (10YR 5/2) clay loam; very dark grayish brown (10YR 3/2) when moist; moderate, medium, prismatic structure that breaks to moderate or strong, medium and coarse blocky structure; distinct, continuous, clay skins on the surfaces of peds; firm when moist; common, fine, distinct mottles of strong brown; few rootlet channels in peds; noncalcareous; clear boundary.

B23t—44 to 53 inches, grayish-brown (2.5Y 5/2) clay loam; dark grayish brown (2.5YR 4/2) when moist; moderate, fine and very fine, blocky structure; distinct, continuous, clay skins on the surfaces of peds; extremely firm when moist; many rootlet channels in peds; noncalcareous; gradual boundary.

B3—53 to 60 inches, grayish-brown (10YR 5/2) heavy clay loam; dark grayish brown (10YR 4/2) when moist; moderate, medium and coarse, blocky and subangular blocky structure; distinct, continuous clay skins on the surfaces of peds; firm when moist; common, medium, strong-brown mottles; few rootlet channels; noncalcareous; gradual boundary.

Cca—60 to 76 inches, brown (7.5YR 5/4) heavy sandy clay loam; (7.5YR 4/4) when moist; moderate, medium, blocky structure; firm when moist; many, fine, faint mottles of strong brown; few, fine, hard concretions of lime and many fine to very coarse seams of soft lime; diffuse boundary.

C—76 to 101 inches, light-brown (7.5YR 6/5) sandy clay loam; brown (7.5YR 5/3) when moist; many fine mottles of reddish yellow; very firm when moist; calcareous; augered.

Because the topography is slightly undulating, depth to the B21t horizon ranges from 14 to about 28 inches. The texture of the B2 horizons ranges from heavy sandy clay loam to light clay. The color of the B horizons is generally midway between 7.5YR and 10YR, but the hue ranges from 7.5YR to 2.5Y, in many places within a single profile. Stratified material of various textures is below a depth of 4 feet in some areas.

LESHO SERIES

The Lesho series is made up of dark-colored, calcareous, imperfectly drained Alluvial soils that are moderately fine textured. These soils are on flood plains of the major streams and are occasionally to frequently flooded; the water table is generally within 4 feet of the surface.

Lesho soils are shallow over sand and gravel, and they contain more free lime in the upper horizons than the Dale soils. They are less sandy than the Platte soils.

The following describes a typical profile of a Lesho clay loam, 385 feet west and 120 feet north of the west end of the bridge across the Arkansas River in section 8, T. 22 S., R. 7 W.:

A1—0 to 11 inches, grayish-brown (10YR 5/2) clay loam; very dark grayish brown (10YR 3/2) when moist; moderate, coarse, granular structure; firm when moist, hard when dry; calcareous; gradual boundary.

AC—11 to 23 inches, light brownish-gray (10YR 6/2) heavy clay loam; very dark grayish brown (10YR 3/2) when moist; coarse granular structure and strong, fine, angular blocky structure; firm when moist, hard when dry; calcareous; few, fine, faint mottles; clear boundary.

IIC—23 to 48 inches, light-brown fine sand.

Depth to sand and gravel ranges from 18 to about 30 inches. In most places the soils are calcareous to the surface, but they are noncalcareous to a depth of about 12 inches in some places.

LUCIEN SERIES

In the Lucien series are Lithosols that developed in material weathered from reddish siltstone of Permian age. These soils are nearly level to strongly sloping.

The Lucien soils are shallower and less deeply leached of lime than the Nash soils. They are less clayey than the Vernon soils.

The following describes a typical profile of Lucien loam, 940 feet east and 120 feet south of the northwest corner of section 1, T. 26 S., R. 8 W.:

AP—0 to 8 inches, reddish-brown (5YR 4/3) loam; dark reddish brown (5YR 3/4) when moist; weak granular structure when disturbed by cultivation; loose when dry, very friable when moist; weakly calcareous; clear boundary.

A1—8 to 12 inches, reddish-brown (5YR 5/3) silt loam; dark reddish brown (5YR 3/3) when moist; moderate, fine, granular structure; common worm casts; very friable when moist; weakly calcareous; clear boundary.

C—12 to 14 inches, reddish-brown (5YR 5/3) silt loam and partly weathered siltstone; reddish brown (5YR 4/3) when moist; weakly calcareous; abrupt boundary.

R—14 inches, reddish siltstone or very fine sandstone.

The color of the A and C horizons ranges from dark reddish brown to reddish brown. Depth to consolidated siltstone ranges from 2 to 20 inches. The reaction ranges from weakly calcareous to calcareous.

NARON SERIES

The Naron series consists of deep, brownish Reddish Prairie soils that developed in wind-modified sandy outwash and eolian deposits. These soils have a moderately well developed profile; they have an A horizon of fine sandy loam and a textural B horizon of heavy fine sandy loam or sandy clay loam that is neutral to alkaline in reaction. Thin lenses of silty material are below a depth of 36 inches. These soils are nearly level to gently sloping. They are in areas of complex slopes that are smooth and convex and in the uplands.

The Naron soils contain more clay than the Pratt soils and less clay than the Farnum soils. They have a more brownish and more alkaline B2t horizon than the Shellabarger soils.

The following describes a typical profile of Naron fine sandy loam, 1 to 3 percent slopes, 200 feet west and 85 feet south of the northeast corner of the southeast quarter of section 12, T. 23 S., R. 9 W.:

A1—0 to 8 inches, dark grayish-brown (10YR 4/2) fine sandy loam; very dark grayish brown (10YR 3/2) when moist; weak to moderate, fine, granular structure; friable when moist, slightly hard when dry; pH 6.0; gradual boundary.

B1—8 to 19 inches, brown (10YR 4/3) light sandy clay loam; very dark grayish brown (10YR 3/2) when moist; coarse prismatic structure that breaks to weak to moderate, fine, granular structure; friable when moist, hard when dry; pH 7.0; gradual boundary.

B2t—19 to 36 inches, brown (10YR 4/3) sandy clay loam; dark brown (10YR 3/3) when moist; moderate, medium, subangular blocky structure; friable to firm when moist; thin patchy clay skins on the surfaces of peds; pH 7.2; gradual boundary.

B3—36 to 54 inches, brown (10YR 4/3) light sandy clay loam; very dark grayish brown (10YR 3/2) when moist; coarse prismatic structure that breaks to weak granular structure; friable when moist; common worm casts; pH 7.2; gradual boundary.

C—54 to 65 inches, brown (10YR 5/3) stratified heavy sandy loam and loam; brown (10YR 4/3) when moist; fine faint mottles; moderate, medium, granular structure; friable when moist; pH 7.2.

The thickness of the A horizon ranges from 10 to 24 inches, and the lower part is an A3 horizon in some places. The hue in the B2t horizon ranges from 10YR to 7.5YR, but it is generally less reddish than a true 7.5YR hue. In most places the chroma does not exceed 4 and has a value of 3 to 5 when dry. The pH value at the surface ranges from 6.0 to 6.5. In many places these soils are stratified below a depth of 4 feet, and the texture of the strata ranges from silt to coarse sand.

NASH SERIES

The Nash soils are in the Reddish Prairie great soil group. These soils developed in friable, reddish-brown, silty material and are less than 3 feet deep over reddish siltstone or very fine sandstone of Permian age. The profile in most places is noncalcareous to depths greater than 20 inches.

The Nash soils are deeper over siltstone than the Lucien soils. They are also noncalcareous to a greater depth.

The following describes a typical profile of Nash loam, 1,500 feet west and 190 feet south of the northeast corner of section 6, T. 25 S., R. 8 W.:

A1—0 to 10 inches, reddish-brown (5YR 4/3) loam; dark reddish brown (5YR 3/3) when moist; weak to moderate, fine, granular structure; friable when moist, hard when dry; clear boundary.

B2—10 to 20 inches, reddish-brown (5YR 4/3) loam; dark reddish brown (5YR 3/4) when moist; moderate, fine, granular structure; slightly hard when dry; numerous worm casts; abrupt boundary.

C—20 to 30 inches, reddish-yellow (5YR 6/6) very fine sandy loam; yellowish red (5YR 4/6) when moist; weak granular and platy structure; some material is only partly weathered; friable when moist, slightly hard when dry; weakly calcareous; abrupt boundary.

R—30 inches, unweathered reddish siltstone or fine-grained sandstone (Harper sandstone of Permian age).

The thickness of the A1 horizon ranges from 7 to about 15 inches, the color ranges from dark brown to reddish brown, and the texture ranges from loam to silt loam. The color of the C horizon ranges from reddish brown to yellowish red. Depth to siltstone ranges from 20 to 35 inches.

OST SERIES

The thickness of the A1 horizon ranges from 7 to about veloped in moderately fine textured sediments that are 25 to 75 percent calcium carbonate, by volume. These soils are generally nearly level to sloping and are on uplands. In most places the solum is more than 5 feet thick over shale of Permian age.

The Ost soils are leached of lime to a greater depth than the associated Clark soils. Also, they have a textural B horizon, which is lacking in the Clark soils.

The following describes a typical profile of Ost clay loam, 298 feet west and 197 feet south of the northeast corner of the northwest quarter of section 6, T. 25 S., R. 5 W.:

A1—0 to 9 inches, very dark grayish-brown (10YR 3/2) clay loam; black (10YR 2/1) when moist; moderate, fine, granular structure; friable when moist; pH 6.4; clear boundary.

B21t—9 to 14 inches, brown (10YR 5/3) heavy clay loam; dark brown (10YR 3/3) when moist; moderate to strong, medium, subangular blocky structure; firm when moist; pH 6.8; continuous clay skins on the surfaces of peds; wavy boundary.

B22ca—14 to 21 inches, brown (7.5YR 5/3) heavy clay loam; dark brown (7.5YR 4/2) when moist; moderate and strong, medium, subangular blocky structure; firm when moist; generally noncalcareous, but lime concretions are scattered throughout; thin, continuous clay skins on the surfaces of peds; wavy boundary.

Cca—21 to 50 inches, brown (10YR 4/3) and white (N 8/0) when moist clay loam; moderate, medium, granular structure; friable to firm when moist; calcareous; about 40 percent, by volume, consists of impure masses of lime that is mostly soft.

The A1 horizon ranges from 7 to 14 inches in thickness, from very dark brown to very dark grayish brown in color when moist, and from loam to clay loam in texture. The texture of the B horizon ranges from medium to heavy clay loam. Depth of free lime in the lower part of the B22ca horizon ranges from 12 to about 20 inches. In places the lower part of the B horizon is faintly mottled.

PLATTE SERIES

The Platte series consists of shallow, imperfectly drained or poorly drained Alluvial soils that are underlain by coarse-textured material at a depth of 10 to 18 inches. These soils are flooded occasionally if they are not protected by dikes. The water table generally is within 4 feet of the surface.

The Platte soils are shallower over sand than the Wann or Lesho soils.

The following describes a typical profile of Platte clay loam, 100 feet east and 600 feet south of the bridge across the Arkansas River in section 22, T. 22 S., R. 7 W.:

A1—0 to 7 inches, grayish-brown (10YR 5/2) clay loam; very dark grayish brown (10YR 3/2) when moist; moderate, medium, granular structure; friable; calcareous; gradual boundary.
AC—7 to 13 inches, light brownish-gray (10YR 6/2) silt loam; dark grayish brown (10YR 4/2) when moist; contains faint brown mottles; moderate, medium, granular structure; very friable; calcareous; gradual boundary.
C—13 to 25 inches, light yellowish-brown (10YR 6/4) sand; structureless; noncalareous.

The texture of the A1 horizon ranges from clay loam to loamy fine sand or fine sandy loam, but clay loam is the dominant texture. The depth from the surface to the underlying sand ranges from 7 to 18 inches.

PLEVNA SERIES

In the Plevna series are dark-gray, poorly drained Humic Gley soils. These soils are generally on stream terraces. In these soils distinct mottling generally occurs below a depth of 15 inches. The water table is normally within the subsoil but fluctuates between a depth of 10 inches and 4 feet.

The Plevna soils are more poorly drained and are less clayey than the Carwile soils. They are less sandy and more poorly drained than the Elsmere soils.

The following describes a typical profile of Plevna fine sandy loam, 200 feet south and 75 feet east of the northwest corner of the southwest quarter of section 30, T. 24 S., R. 8 W.:

A11—0 to 14 inches, dark-gray (10YR 4/1) light fine sandy loam; black (10YR 2/1) when moist; weak granular structure; very friable; noncalcareous; pH 7.3; clear boundary.
A12—14 to 24 inches, same as A11 horizon except for a few very fine, brownish mottles.
A13—24 to 40 inches, very dark gray (10YR 3/1) heavy fine sandy loam; black (10YR 2/1) when moist; about one-fifth of the soil material is fine streaks and spots of strong brown to yellowish brown; structureless; friable; pH 7.5; noncalcareous.
IIC—40 to 48 inches +, water-saturated sand.

The combined A horizons range from 10 to 40 inches in thickness. They range from light loam to light fine sandy loam in texture.

PORT SERIES

The Port series consists of Alluvial soils developed in sediments derived from reddish shale of Permian age. These soils are well drained and are on bottom lands and low terraces along small drainageways that originate in areas of Vernon and Renfrow soils. These soils are nearly level and are only occasionally flooded. They are mainly in the southeastern part of the county.

The Port soils lack a B2t horizon, which is present in the Renfrow soils. Also, they are more friable than the Renfrow soils.

The following describes a typical profile of Port clay loam, 1,600 feet east and 100 feet south of the northwest corner of section 30, T. 26 S., R. 4 W.:

Ap—0 to 6 inches, reddish-brown (5YR 5/3) clay loam; reddish brown (5YR 4/3) when moist; weak, fine, granular structure; loose when dry; neutral reaction; abrupt boundary.
A1—6 to 12 inches, reddish-brown (5YR 5/3) clay loam; reddish brown (5YR 4/3) when moist; strong, medium granular structure; many worm casts; very friable when moist; neutral reaction; gradual boundary.
B2—12 to 45 inches, reddish-brown (2.5YR 5/4) clay loam; reddish brown (2.5YR 4/4) when moist; moderate, fine, granular structure; many worm casts; friable when moist; calcareous; abrupt boundary.
C—45 to 60 inches, reddish-brown (5YR 5/4) heavy silty clay loam; reddish brown (5YR 4/4) when moist; moderate, fine, angular blocky structure; firm when moist; few fine roots; calcareous; abrupt boundary.
IIR—60 inches +, reddish-brown shale.

The thickness of the combined A horizons ranges from 8 to 20 inches; the hue ranges from 5YR to 7.5YR and the value and chroma range from about 5/3 to 4/3. The texture of the A horizons ranges from clay loam to loam. In places the C horizon contains fragments of shale.

PRATT SERIES

In the Pratt series are Reddish Chestnut soils of the uplands. These soils developed in wind-modified loamy sands. They are extensive in the western part of the county and are undulating and hummocky.

The Pratt soils are more sandy throughout the profile and are less reddish than the Shellabarger soils. They are finer textured than the Tivoli soils.

The following describes a typical profile of Pratt loamy fine sand, 600 feet south and 280 feet east of the northwest corner of the southwest quarter of section 35, T. 23 S., R. 10 W.:

Ap—0 to 7 inches, pale-brown (10YR 6/3) loamy fine sand; brown (10YR 4/3) when moist; single grain; loose when dry; clear boundary.
A1—7 to 12 inches, grayish-brown (10YR 5/2) loamy fine sand; very dark grayish brown (10YR 3/2) when moist; very weak granular structure to massive; very friable when moist; clear boundary.
B21t—12 to 18 inches, brown (10YR 5/3) light fine sandy loam; dark yellowish brown (10YR 4/4) when moist; very weak granular structure to massive; very friable when moist; discontinuous clay skins on the surfaces of peds and bridges across sand grains; contains horizontal bands of slightly darker and more clayey material ¼ to ½ inch thick; many fine rootlet channels; gradual boundary.
B22t—18 to 28 inches, brown (7.5YR 5/5) light fine sandy loam; strong brown (7.5YR 4/6) when moist; very weak granular structure; very friable when moist; thin discontinuous clay skins on the surfaces of peds and bridges across sand grains; horizontal bands similar to those in the B21t horizon but ⅓ to ¾ inch thick; many fine rootlet channels; gradual boundary.
C1—28 to 41 inches, light-brown (7.5YR 6/5) loamy fine sand; strong brown (7.5YR 4/6) when moist; massive; loose when dry; horizontal bands similar to those in the B22t horizon and as much as ⅓ inch thick; also horizontal bands of medium sand as much as 1 inch thick; gradual boundary.
C2—41 to 50 inches, reddish-yellow (7.5YR 6/6) fine sand; strong brown (7.5YR 5/6) when moist; massive; loose when dry; faint, thin layers with colors of strong brown and brown (7.5YR 5/8 and 4/4) when moist; diffuse boundary.

C3—50 to 66 inches, reddish-yellow (7.5YR 7/6) fine sand; strong brown (7.5YR 5/6) when moist; massive; loose when dry; bands similar to those in the B and C1 horizons; diffuse boundary.

C4—66 to 98 inches, pink (7.5YR 7/4) fine sand; strong brown (7.5YR 5/6) when moist; massive; loose when dry; augered.

The thickness of the combined A horizons ranges from 12 to 24 inches. In localized areas the texture of the Ap horizon approaches a sandy loam. The texture of the B2 horizons ranges from fine sandy loam to loamy fine sand.

RENFROW SERIES

The Renfrow series is made up of well-drained Reddish Prairie soils of the uplands. These soils developed in reddish clayey shale of Permian age. They are nearly level or gently sloping and are in the southeastern part of the county.

The Renfrow soils have a textural B horizon, which is lacking in the Vernon soils. They developed in material similar to that in which the Vernon soils developed.

The following describes a typical profile of Renfrow clay loam, 75 feet west and 1,150 feet north of the southeast corner of section 32, T. 26 S., R. 4 W.:

A1—0 to 11 inches, brown (7.5YR 4/2) clay loam; dark brown (7.5YR 3/2) when moist; weak granular structure; friable when moist, very hard when dry; gradual boundary.

B1—11 to 16 inches, reddish-brown (5YR 4/3) heavy clay loam; dark reddish brown (5YR 3/4) when moist; moderate, fine, subangular blocky structure; firm when moist, very hard when dry; gradual boundary.

B21t—16 to 25 inches, reddish-brown (2.5YR 4/4) silty clay; dark reddish brown (2.5YR 3/4) when moist; strong, medium and fine, blocky structure; firm when moist, very hard when dry; continuous clay skins on the surfaces of peds; clear boundary.

B22t—25 to 32 inches, reddish-brown (2.5YR 4/4) clay when crushed; dusky red (2.5YR 3/2) on the surfaces of peds; dark reddish brown (2.5YR 3/4) when moist; moderate, fine and medium, blocky structure; very hard when dry; continuous clay skins on the surfaces of peds; clear boundary.

C—32 to 40 inches, reddish-brown (5YR 5/4) silty clay loam and bits of partly weathered shale; dark reddish brown (5YR 3/4) when moist; weak, medium, granular structure; firm when moist, very hard when dry; weakly calcareous; clear boundary.

R—40 inches, unweathered yellowish-red shale.

The thickness of the A1 horizon ranges from 6 to 18 inches, the texture ranges from heavy silt loam to clay loam, and the color ranges from brown or dark brown to dark grayish brown. The color of the B2t horizons ranges from dark brown to reddish brown. In general, depth to shale ranges from 26 to about 48 inches. In some areas, however, shale is at a depth of 12 to 26 inches.

SHELLABARGER SERIES

In the Shellabarger series are well-drained Reddish Prairie soils that have A horizons of fine sandy loam and B2 horizons of sandy clay loam. These soils developed in medium-textured outwash that in most places has been reworked by water or wind. Their B2t horizon is brown to reddish-brown, slightly acid, granular sandy clay loam. This horizon is underlain by stratified sediments that generally have a texture of sandy loam.

The Shellabarger soils are more acid and more reddish than the Naron soils, and they are less sandy and more clayey than Pratt soils. Their B2t horizon is less clayey than that of the Farnum soils.

The following describes a typical profile of Shellabarger fine sandy loam, 900 feet south and 175 feet west of the northeast corner of section 11, T. 26 S., R. 6 W.:

Ap—0 to 7 inches, dark grayish-brown (10YR 4/2) fine sandy loam; very dark grayish brown (10YR 3/2) when moist; weak granular structure; very friable when moist; pH 5.7; clear boundary.

A1—7 to 11 inches, dark-brown (7.5YR 4/2) heavy sandy loam; very dark grayish brown (10YR 3/2) when moist; weak granular structure; friable when moist; few worm casts; pH 6.4; clear boundary.

B1—11 to 19 inches, brown (7.5YR 4/3) coarse sandy loam; weak, very coarse, prismatic structure that breaks to weak granular structure; thin patchy clay skins on the surfaces of peds; moderately firm when moist; few worm casts; pH 6.9; gradual boundary.

B2t—19 to 33 inches, reddish-brown (5YR 5/4) light sandy clay loam; reddish brown (5YR 4/4) when moist; weak, very coarse, prismatic structure and weak granular structure; thin, patchy clay skins on the surfaces of peds and many clay bridges; moderately firm when moist; few pores; pH 7.4; noncalcareous; diffuse boundary.

B3—33 to 47 inches, yellowish-red (5YR 4/5) light sandy clay loam; yellowish red (5YR 4/6) when moist; weak granular structure; sand grains coated and bridged with clay; moderately friable when moist; few rootlet channels; pH 7.1; diffuse boundary.

C—47 to 57 inches, strong-brown (7.5YR 5/6) light coarse sandy loam when dry and moist; porous; massive; sand grains clay coated; very friable when moist; few rootlet channels; noncalcareous; pH 7.1; diffuse boundary.

The combined A horizons range from 8 to 20 inches in thickness, and their texture ranges from fine sandy loam to loamy sand. The texture of the B horizons ranges from heavy sandy loam to sandy clay loam, and the content of clay ranges from about 17 to 25 percent, by volume. The hue of the B horizons ranges from 7.5YR to 5YR. Depth to sand and gravel ranges from about 36 to 60 inches, but it is more than 50 inches in most places.

SMOLAN SERIES

The soils of the Smolan series are well-drained, gently sloping or sloping Chernozems of the uplands. These soils developed mainly in fine-textured loess. They occupy a minor acreage in the northeastern part of the county.

The Smolan soils contain more clay and have a better developed profile than the Vanoss soils. They have a thinner A1 horizon than the Vanoss or Bethany soils and are more reddish than the Tabler soils.

The following describes a typical profile of Smolan silty clay loam, 778 feet west and 135 feet south of the northeast corner of the northwest quarter of section 7, T. 22 S., R. 4 W.:

A1—0 to 8 inches, dark-brown (7.5YR 4/2) light silty clay loam; dark brown (7.5YR 3/2) when moist; moderate, medium, granular structure; friable when moist; clear boundary.

B1—8 to 16 inches, brown (7.5YR 4/4) heavy silty clay loam or light silty clay; dark brown (7.5YR 3/4) when moist; moderate or strong, fine, subangular blocky structure; friable to firm when moist; patchy clay skins on the surfaces of peds; gradual boundary.

B2t—16 to 40 inches, brown (7.5YR 5/4) silty clay; brown (7.5YR 4/4) when moist; moderate, medium, blocky structure; firm when moist; continuous clay skins on the surfaces of peds; gradual boundary.

B3ca—40 to 69 inches, strong-brown (7.5YR 5/6) silty clay; brown (7.5YR 5/4) when moist; moderate to strong, medium, blocky structure; firm when moist; continuous clay skins on the surfaces of peds; few concretions of lime; gradual boundary.

C—69 to 89 inches, light-brown (7.5YR 6/4) silty clay loam; brown (7.5YR 5/4) when moist; moderate, fine, subangular blocky structure; friable to firm when moist.

The thickness of the A1 horizon ranges from 6 to 12 inches. In many places tongues of material from the A1 horizon extend downward into the B1 horizon.

TABLER SERIES

The Tabler series consists of nearly level Reddish Prairie soils on the uplands and on high stream terraces. These soils are moderately well drained and developed in moderately fine textured or fine textured alluvium of Pleistocene age.

The Tabler soils have thinner A horizons than the Bethany soils, and they have an abrupt or clear boundary between the A and B horizons. Their A horizons are thinner than those of the Farnum soils, and their B2t horizons are more clayey. Their B horizons are more grayish than those of the Bethany or Farnum soils.

The following describes a typical profile of Tabler clay loam, 1,420 feet east and 167 feet north of the southwest corner of section 14, T. 24 S., R. 6 W.:

Ap—0 to 5 inches, very dark gray (10YR 3/1) clay loam; black (10YR 2/1) when moist; weak granular structure; friable when moist; noncalcareous; clear boundary.

A1—5 to 8 inches, very dark gray (10YR 3/1) clay loam; very dark brown (10YR 2/2) when moist; weak granular structure; firm when moist; noncalcareous; clear boundary.

B21t—8 to 20 inches, very dark gray (10YR 3/1) clay; very dark brown (10YR 2/2) when moist; weak, very fine, blocky structure; thin, nearly continuous clay skins on the surfaces of peds; very firm when moist; few open rootlet channels; noncalcareous.

B22t—20 to 32 inches, light brownish-gray (2.5Y 6/2) silty clay; grayish brown (2.5Y 5/2) when moist; moderate, fine, angular blocky structure; distinct continuous clay skins on the surfaces of peds; extremely firm when moist; rootlet channels partly plugged; fine, vertical, old cracks filled with very dark brown clay loam; noncalcareous; few fine concretions of lime; diffuse boundary.

B3ca—32 to 40 inches, light olive-gray (5Y 6/2) clay; olive gray (5Y 5/2) when moist; nearly massive; extremely firm when moist; rootlet channels partly plugged; fine, vertical, old cracks filled with very dark brown clay loam; 10 percent fine mottles of strong brown and light olive brown; calcareous and contains few fine and medium concretions of lime; diffuse boundary.

C1—40 to 61 inches, light brownish-gray (2.5Y 6/2) clay; grayish brown (2.5Y 5/2) when moist; weak, medium, subangular and angular blocky structure; thin, patchy clay skins on the surfaces of peds; very firm when moist; 20 to 30 percent of the soil material has fine mottles of strong brown and light olive brown; many open rootlet channels; calcareous and contains common seams and medium concretions of lime; diffuse boundary.

C2—61 to 83 inches, same as the C1 horizon, except that the mottles are predominantly strong brown; diffuse boundary.

C3—83 to 97 inches, pale-olive (5Y 6/3) heavy clay loam; olive (5Y 5/4) when moist; firm when moist; calcareous, contains many fine concretions of lime; many fine mottles of strong brown; augered; diffuse boundary.

C4—97 to 110 inches, pale-yellow (5Y 7/3) heavy clay loam; pale olive (5Y 6/4) when moist; firm when moist; calcareous; few fine mottles of strong brown; augered.

The thickness of the combined A horizons ranges from 6 to 12 inches. The color of the B2t horizons ranges from olive gray to very dark grayish brown, and the grade of structure of those horizons ranges from moderate to weak.

TIVOLI SERIES

In the Tivoli series are deep, light-colored, excessively drained Regosols that developed in deep eolian sands. These soils are hummocky or hilly and are in the sandhill areas of the county.

The Tivoli soils are more sandy than the Pratt soils. Also, they are in areas of rougher topography than those soils.

The following describes a typical profile of Tivoli fine sand, 800 feet north and 250 feet west of the southeast corner of the northeast quarter of section 7, T. 22 S., R. 5 W.:

A1—0 to 5 inches, pale-brown (10YR 6/3) fine sand; dark grayish brown (10YR 4/2) when moist; single grain; loose when dry or moist; gradual boundary.

C—5 to 60 inches, very pale brown (10YR 7/4) fine sand; yellowish brown (10YR 5/4) when moist; single grain; loose when dry or moist.

The A1 horizon ranges from 4 to 14 inches in thickness. The color of the C horizon ranges from very pale brown to yellowish brown.

VANOSS SERIES

The Vanoss series consists of deep, well-drained, dark-colored Reddish Prairie soils on the uplands and on high stream terraces along the major streams. These soils are nearly level to sloping; the slopes are as steep as about 7 percent. The soils developed in loess, probably of local origin.

The Vanoss soils have thicker A horizons and a less clayey B2t horizon than the Smolan soils. Their B2t horizon is less clayey and more brownish than that of the Bethany soils, and they are less sandy throughout the solum than the Naron soils.

The following describes a typical profile of Vanoss silt loam, 495 feet east and 350 feet south of the northwest corner of section 17, T. 25 S., R. 4 W.:

A1—0 to 11 inches, brown (10YR 4/3) silt loam; very dark grayish brown (10YR 3/2) when moist; moderate, fine, granular structure; very friable when moist; many fine roots; gradual boundary.

A3—11 to 17 inches, brown (7.5YR 4/2) silt loam; dark brown (7.5YR 3/2) when moist; moderate, medium, granular structure; friable when moist; numerous worm casts; gradual boundary.

B2t—17 to 33 inches, brown (7.5YR 5/4) clay loam; brown (7.5YR 4/4) when moist; moderate to strong, medium, subangular blocky structure; friable to slightly firm when moist; thin clay skins on the surfaces of peds; a few, black shot concretions; gradual boundary.

B3—33 to 49 inches, light-brown (7.5YR 6/5) clay loam; strong brown (7.5YR 5/5) when moist; coarse prismatic structure that breaks to moderate, medium, subangular blocky structure; friable to slightly firm when moist; few, black shot concretions; diffuse boundary.

C—49 to 58 inches +, reddish-yellow (7.5YR 6/6) clay loam; brown (7.5YR 5/5) when moist; moderate, medium, subangular blocky structure; friable when moist; mildly calcareous.

The combined thickness of the A horizons ranges from 12 to about 25 inches. In general the texture of the B horizons is clay loam or silty clay loam, but in some areas it is heavy loam. In a few places depth to the C horizon is less than 48 inches.

VERNON SERIES

The soils of the Vernon series are Lithosols that have a clay loam to clay texture throughout the profile. They developed in shale of Permian age, and shale crops out in the areas. These soils are mainly in the southeastern part of the county. Some areas of Vernon soils are nearly level, and others have slopes of as much as 7 percent.

Vernon soils lack a textural B horizon and are shallower over consolidated shale than the Renfrow soils. They are more clayey than the Lucien soils.

The following describes a typical profile of Vernon clay loam, 300 feet east and 200 feet south of the northwest corner of the northeast quarter of section 21, T. 25 S., R. 5 W.:

A1—0 to 8 inches, brown (7.5YR 4/2) clay loam; dark brown (7.5YR 3/2) when moist; moderate, fine, granular structure; friable when moist; calcareous; gradual boundary.

AC—8 to 15 inches, reddish-brown (5YR 5/4) heavy clay loam; dark reddish brown (5YR 3/4) when moist; moderate, medium, granular structure; firm when moist; calcareous; clear boundary.

R—15 to 20 inches, light reddish-brown (5YR 6/4 dry), slightly weathered shale that grades to impervious shale at a depth of 20 inches.

The A1 horizon ranges from 6 to 10 inches in thickness, from brown to reddish brown in color, and from calcareous to weakly calcareous. Depth to shale ranges from 12 to about 25 inches.

WANN SERIES

In the Wann series are dark-colored, imperfectly drained, calcareous Alluvial soils that are mainly on the flood plains of the Arkansas River. These soils are flooded occasionally where they are not protected by dikes. The water table is generally within 4 feet of the surface.

The Wann soils are shallower over sand, are more mottled, are more frequently flooded, and have a higher water table than the Canadian soils. They contain more sand and less clay than the Lesho soils.

The following describes a typical profile of Wann fine sandy loam, 665 feet east and 115 feet north of the southwest corner of section 8, T. 22 S., R. 7 W.:

A1—0 to 13 inches, dark-gray (10YR 4/1) fine sandy loam; very dark grayish brown (10YR 3/2) when moist; fine granular structure; slightly hard when dry; calcareous; gradual boundary.

AC—13 to 23 inches, grayish-brown (10YR 5/2) sandy loam; dark grayish brown (10YR 4/2) when moist; moderate, fine, granular structure; hard when dry; common, faint to distinct, fine mottles; calcareous; many fine rootlet channels; clear boundary.

IIC—23 to 36 inches +, very pale brown (10YR 7/3) single grain sand.

The A1 horizon ranges from 10 to about 20 inches in thickness and from dark grayish brown or dark gray to grayish brown in color. The texture of the A1 horizon is generally fine sandy loam, but in some small areas it is loamy fine sand or clay loam. The transitional layer to the C horizon ranges from neutral to calcareous. Depth to sand and gravel ranges from 18 to 36 inches.

Laboratory Determinations

Data obtained by mechanical and chemical analyses of selected soils of this county are given in table 9. Profiles of these selected soils are described in the section "Genesis, Classification, and Morphology of Soils." The data in this table are useful to soil scientists in classifying soils and in developing concepts of soil genesis. They are also helpful for estimating water-holding capacity, wind erosion, fertility, tilth, and other properties that affect soil management.

Field and laboratory methods

The samples used to obtain the data in table 9 were collected from carefully selected pits. These samples are considered representative of the soil material made up of particles less than three-fourths inch in diameter. Estimates of the fraction of the sample consisting of particles larger than three-fourths inch were made during the sampling. If necessary, the sample was sieved after it was dried, and rock fragments larger than three-fourths inch in diameter were discarded. Then the material made up of particles less than three-fourths inch was rolled, crushed, and sieved by hand to remove rock fragments larger than 2 millimeters in diameter.

The percentage of the fraction that consists of particles between 2 millimeters and three-fourths inch in diameter is somewhat arbitrary. The accuracy of the data depends on the severity of the preparative treatment, which may vary with the objectives of the study. But the fraction of this size does contain relatively unaltered fragments of rock larger than 2 millimeters in diameter and does not contain slakable clods of earthy materials. Unless otherwise noted, all laboratory analyses were made on ovendry material that passes the 2-millimeter sieve.

Standard methods of the Soil Survey Laboratory were used to obtain most of the data in table 9. Determinations of clay were made by the pipette method (*6*, *7*, *8*). The reaction of the saturated paste was measured with a glass electrode. Organic carbon was determined by wet combustion, using a modification of the Walkley-Black method (*9*). The calcium carbonate equivalent was determined by measuring the volume of carbon dioxide evolved from soil samples treated with concentrated hydrochloric acid.

The cation-exchange capacity was determined by direct distillation of absorbed ammonia (*9*). To determine the extractable calcium and magnesium, calcium was separated as calcium oxalate and magnesium as magnesium ammonium phosphate (*9*). Extractable sodium and potassium were determined on original extracts with a flame spectrophotometer (*11*). The base saturation is the percentage of bases computed by using the cation-exchange capacity as measured by distillation.

Climate [6]

Reno County has a subhumid climate that is especially suited to the production of wheat (*12*). The tall and mid grasses and the groups of trees indicate that this area receives a greater amount of rainfall than areas to the west. It receives less rainfall, however, than the tree-covered

[6] By A. D. Robb, State climatologist, U.S. Weather Bureau, Topeka, Kans.

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TABLE 9.—*Mechanical and chemical*

[Analyses made at Soil Survey Laboratory, Soil Conservation Service,

Soil	Depth	Mechanical analysis						
		Size class and diameter of particles (in millimeters)						
		Very coarse sand (2.0–1.0)	Coarse sand (1.0–0.5)	Medium sand (0.5–0.25)	Fine (0.25–0.10)	Very fine sand (0.10–0.05)	Silt (0.05–0.002)	Clay (<0.002)
	Inches	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Bethany silt loam:								
A1p	0–6	0.6	1.8	1.6	3.5	10.3	58.2	24.0
A3	6–12	.6	2.0	1.4	1.6	9.8	54.6	30.0
B1	12–17	1.8	2.3	1.1	1.2	7.2	49.4	37.0
B21	17–23	2.8	2.9	1.4	1.7	6.6	43.0	41.6
B22	23–38	1.8	2.8	1.2	1.2	7.0	45.2	40.8
B23	38–49	1.4	3.1	1.2	1.6	7.9	46.4	38.4
Bca1	49–73	.8	2.4	1.4	1.4	7.6	52.7	33.7
Bca2	73–96	.2	1.2	1.0	1.0	9.8	53.4	33.4
Carwile fine sandy loam:								
A1p	0–7	.2	6.5	20.9	42.1	13.3	12.2	4.8
A1	7–11	.1	4.1	16.1	38.2	14.7	16.9	10.0
A3	11–19	.1	4.4	16.2	40.5	14.2	13.6	11.1
B2	19–23	.3	5.2	13.8	36.5	10.5	16.4	17.3
B2b1	23–29	.1	1.8	4.5	5.5	8.8	39.3	40.1
B2b2	29–46	.1	.8	2.2	5.5	3.3	51.9	36.3
B3b1	46–55	.2	4.3	9.4	11.6	17.2	36.4	20.9
B3b2	55–68	.5	8.4	15.5	30.5	10.2	19.4	15.5
C	68–104	.7	9.1	17.5	35.7	12.5	12.5	12.0
Farnum loam:								
A1p	0–9	.3	11.6	17.3	10.0	8.4	37.9	14.5
A3	9–16	.3	11.0	15.3	8.9	6.1	40.2	18.2
B1	16–22	.7	13.9	17.7	9.2	5.2	29.9	23.4
B21	22–32	.1	10.7	17.8	8.9	8.7	23.8	30.0
B22	32–44	.4	6.7	10.5	10.2	7.2	37.9	27.1
B23	44–53	.3	2.6	3.0	2.2	8.6	49.4	33.9
B3	53–60	.6	5.3	5.9	4.0	13.0	44.6	26.6
B3ca	60–76	.5	7.0	7.3	6.1	16.3	37.8	25.0
Cu	76–101	1.4	4.8	5.3	9.5	14.7	37.5	26.8
Pratt loamy fine sand:								
A1p	0–7	.3	7.5	23.8	44.8	15.8	4.2	3.6
A1	7–12	.3	8.3	22.2	43.8	11.6	6.8	7.0
B21	12–18	.1	6.0	22.0	31.4	24.9	5.6	10.1
B22	18–28	.1	4.2	16.1	42.1	20.7	5.4	11.4
C1	28–41	.2	7.5	22.5	31.7	25.1	5.1	7.9
C	41–50	.1	6.9	28.0	45.4	9.6	3.5	6.5
C	50–66	.1	4.8	25.2	36.6	23.9	3.0	6.4
C	66–98	.1	8.4	24.4	30.3	27.4	3.2	6.3
Shellabarger fine sandy loam:								
A1p	0–7	1.4	19.1	19.0	14.4	7.3	29.2	9.6
A1	7–11	2.7	14.7	15.9	10.5	8.2	29.1	18.9
B21	11–19	19.4	19.5	12.5	9.4	3.0	17.2	19.0
B22	19–33	13.3	30.9	18.1	9.0	1.6	7.3	19.8
B3	33–47	11.3	30.9	22.3	10.8	1.4	7.1	16.2
C1	47–57	25.6	37.2	16.5	10.7	.7	1.3	8.0
C	57–76	44.8	33.9	8.7	3.7	.4	1.2	7.3
C	76–100	12.9	42.9	25.7	11.2	1.2	1.2	4.9
Tabler clay loam:								
A1p	0–5	.8	16.2	17.6	11.0	7.9	31.1	15.4
A1	5–8	1.0	9.8	9.3	4.5	4.5	34.1	36.8
B21	8–20	.2	5.0	4.8	3.3	2.2	38.6	45.9
B22	20–32	.4	2.4	2.1	1.0	2.1	51.2	40.8
B2ca	32–40	.6	.7	.3	.4	2.7	62.6	32.7
B3ca1	40–61	.6	2.6	2.6	2.2	7.6	49.3	35.1
B3ca2	61–83	1.3	4.7	4.2	6.6	8.4	40.1	34.7
C1	83–97	1.0	5.2	5.1	8.8	10.4	34.0	35.5
C	97–110	1.6	4.2	3.9	3.0	11.9	38.6	36.8

analyses of selected soils

Lincoln, Nebr. Dashes indicate values were not determined]

Textural class	Chemical analysis									
	Reaction (saturated paste)	Organic carbon	Electrical conductivity EC × 10^3 millimhos per cm. at 25° C.	$CaCO_3$ equivalent	Cation-exchange capacity (NH_4Ac)	Extractable cations				Base saturation (NH_4Ac)
						Ca	Mg	Na	K	
	pH	*Percent*		*Percent*	*Meq./100 gr.*	*Meq./100 gr.*	*Meq./100 gr.*	*Meq./100 gr.*	*Meq./100 gr.*	*Percent*
Silt loam	6.0	1.83	0.4	----------	18.9	12.1	3.3	0.1	0.9	87
Silty clay loam	6.1	1.73	.4	----------	22.4	15.1	4.2	.1	.6	89
Silty clay loam	6.4	1.23	.4	----------	25.7	18.6	5.5	.1	.5	96
Silty clay	6.5	.75	.4	1	29.7	22.2	7.4	.2	.5	102
Silty clay	7.0	.46	.5	1	28.7	22.5	7.7	.4	.5	108
Silty clay loam	7.9	.21	.6	1	27.1	------	------	.6	.5	----------
Silty clay loam	8.0	.04	.5	4	23.4	------	------	.8	.5	----------
Silty clay loam	8.0	.01	.5	2	21.8	------	------	.9	.6	----------
Loamy sand	6.5	.43	.5	1	4.1	2.5	.5	.1	.4	83
Fine sandy loam	6.3	.57	.4	----------	7.4	4.4	1.1	.1	.6	84
Fine sandy loam	6.2	.48	.4	----------	7.5	4.7	1.2	.1	.4	84
Fine sandy loam	6.4	.48	.4	----------	11.9	8.1	2.2	.1	.4	90
Clay	6.4	.50	.4	----------	28 9	20.8	6.0	.1	.7	96
Silty clay loam	6.5	.23	.3	1	25.9	18.8	5.6	.1	.6	97
Loam	7.0	.10	.4	1	16.1	11.9	3.3	.1	.3	97
Fine sandy loam	7.0	.06	.4	1	12.1	9.0	2.6	.1	.3	99
Sandy loam	6.7	.05	.4	1	9.2	6.7	1.9	.1	.2	96
Loam	5.7	.99	.4	----------	9.9	5.5	1.4	.1	.7	77
Loam	6.2	.97	.4	----------	12.8	9.2	2.6	.1	.7	98
Loam	6.8	.65	.5	1	15.5	11.1	3.6	.1	.5	98
Sandy clay loam	6.9	.39	.4	1	20.0	14.4	5.6	.1	.5	103
Clay loam	7.1	.25	.4	1	18.1	12.8	4.9	.1	.5	101
Silty clay loam	7.2	.24	.3	1	23.2	16.5	6.2	.3	.7	102
Loam	7.6	.17	.5	1	18.7	15.0	4.7	.3	.5	110
Loam	8.0	.13	.5	6	16.8	------	------	.4	.4	----------
Loam	8.1	.05	.5	1	19.1	------	------	.8	.5	----------
Sand	6.4	.17	.5	----------	2.3	1.3	.8	.1	.2	100
Loamy sand	6.2	.33	.4	----------	5.0	3.0	1.0	.1	.2	84
Loamy sand	6.3	.25	.4	----------	7.0	4.5	1.9	.1	.2	94
Loamy fine sand	6.5	.19	.4	1	7.5	4.9	1.8	.1	.2	92
Loamy sand	6.8	.13	.4	1	5.3	3.5	1.4	.1	.2	96
Sand	6.9	.06	.4	1	4.1	2.6	1.2	.1	.1	95
Sand	7.0	.06	.4	1	4.1	2.5	1.0	.1	.1	88
Sand	7.0	.03	.4	1	4.1	2.6	1.2	.1	.1	95
Sandy loam	5.7	.59	.3	----------	6.3	2.9	.7	.1	.5	65
Sandy loam	6.4	.82	.4	----------	10.4	6.5	2.0	.1	.5	86
Sandy loam	6.9	.63	.4	1	12.5	7.9	2.7	.1	.4	88
Sandy loam	7.4	.36	.4	1	12.9	8.4	3.9	.1	.3	98
Sandy loam	7.3	.09	.3	1	10.7	6.7	3.4	.1	.3	97
Sand	7.1	.05	.4	1	6.1	3.7	1.9	.1	.2	95
Sand	7.1	.03	.4	1	5.1	3.0	1.5	.1	.1	90
Sand	7.1	.01	.4	1	3.3	2.0	.9	.1	.1	91
Sandy loam	6.3	1.02	.5	----------	12.7	9.1	1.9	.1	.5	----------
Clay loam	6.7	.97	.5	1	27.1	19.8	5.2	.4	.5	----------
Clay	7.2	.59	.5	1	34.3	25.9	6.9	1.0	.6	----------
Silty clay	8.0	.33	.7	1	29.4	------	------	1.7	.5	----------
Silty clay loam	8.0	.17	1.4	2	25.9	------	------	2.4	.4	----------
Silty clay loam	8.2	.18	1.2	1	29.5	------	------	2.4	.3	----------
Clay loam	8.2	.10	.8	1	28.2	------	------	2.1	.4	----------
Clay loam	8.1	.03	.6	4	27.4	------	------	1.4	.5	----------
Clay loam	7.7	.02	.6	8	26.8	------	------	1.5	.6	----------

TABLE 10.—*Temperature and precipitation data*

[All data from Hutchinson, Kans.]

Month	Temperature: Average daily maximum[1]	Temperature: Average daily minimum[1]	Temperature: 2 years in 10 will have at least 4 days with— Maximum temperature equal to or higher than[2]—	Temperature: 2 years in 10 will have at least 4 days with— Minimum temperature equal to or lower than[2]—	Precipitation: Average total[3]	Precipitation: 1 year in 10 will have— Monthly totals less than[3]—	Precipitation: 1 year in 10 will have— Monthly totals more than[3]—	Precipitation: Days with a snow cover of 1 inch or more[4]	Precipitation: Average depth of snow on days with snow cover[4]
			°F.	°F.	*Inches*	*Inches*	*Inches*	*Number*	*Inches*
January	41.9	20.0	60	2	0.73	0.08	1.63	8	3.5
February	46.5	23.0	65	7	1.15	.15	2.12	7	3.6
March	57.1	31.4	76	16	1.65	.18	3.39	5	3.8
April	68.1	42.7	84	29	2.69	.87	5.40	2	3.3
May	76.5	51.2	90	39	4.46	1.21	7.51	0	0
June	87.2	62.8	100	52	4.37	.97	9.36	0	0
July	92.9	67.1	103	59	3.34	.78	6.33	0	0
August	92.6	66.3	103	57	3.16	.81	6.11	0	0
September	84.2	57.8	98	44	3.04	.72	6.32	0	0
October	72.2	46.0	89	34	2.15	.42	3.94	1	2.0
November	57.7	32.7	72	15	1.38	.01	3.74	2	1.9
December	44.6	22.9	63	9	.93	.12	2.59	8	3.5
Year	68.5	43.7	[5] 106	[6] −8	29.05	[7] 18.01	[7] 38.96	33	3.1

[1] For the period 1898–1961.
[2] For the period 1937–61.
[3] For the period 1898–1961.
[4] For the period 1901–49.
[5] Average annual highest maximum.
[6] Average annual lowest minimum.
[7] Annual values less or more than.

areas to the east. Moisture from the Gulf of Mexico is the principal source of precipitation.

The temperatures undergo the usual wide daily and seasonal fluctuation typical of a continental climate. Records of temperature show a gradual seasonal progression from warm to cool and an occasional sudden change from hot to cold or from cold to hot. A sudden drop in temperature is more common, however, than an abrupt rise.

Tables 10 and 11 give facts about the temperature and precipitation in the county. The information was taken from records of the U.S. Weather Bureau at Hutchinson.

In addition to the daily, seasonal, and annual variations in temperature and precipitation, there are longer climatic periods of cool, wet weather alternating irregularly with periods of drier and warmer years. Excessively wet periods generally last less than 3 years, but heat and dryness may persist and intensify for 5 years or more. As a result, droughts may be severe.

TEMPERATURES: The average daily maximum and minimum temperature for each month and for the year are shown in table 10. This table also shows extreme temperatures that are likely to occur with a definite probability on 4 days, 2 years in 10. For example, on at least 4 days, 2 years in 10, July and August will have a maximum temperature of 103° or higher and January will have a minimum temperature of 2° or lower.

Figure 12 gives an overall picture of the ranges in temperature, including the mean maximum, the mean minimum, and the mean monthly temperature. It also shows the approximate season of the year that extremely high or extremely low temperatures may be expected. Extreme variations in temperature are more likely to occur in winter than in summer. In February, for example, the range

TABLE 11.—*Frequency of specified amounts of rainfall during stated time intervals at Hutchinson*

Length of return period in years[1]	30 min.	1 hr.	2 hr.	3 hr.	6 hr.	12 hr.	24 hr.
	Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
1	1.0	1.4	1.5	1.6	2.0	2.2	2.5
2	1.4	1.6	2.0	2.1	2.5	2.8	3.1
5	1.8	2.2	2.5	2.8	3.2	3.7	4.2
10	2.1	2.6	3.0	3.3	3.7	4.4	5.0
25	2.4	3.0	3.5	3.8	4.4	5.1	5.8
50	2.7	3.4	4.0	4.3	5.0	5.9	6.5
100	3.0	3.9	4.5	4.9	5.6	6.5	7.4

[1] Expresses the frequency of the specified number of inches of rainfall at given time intervals. For example, 1.0 inch of rain can be expected to fall in 30 minutes once in every year (100 percent probability), but 3.0 inches can be expected to fall in 30 minutes only once in 100 years (1 percent probability).

in temperatures is 111°, from the warmest of 84° to the coldest of −27°, but in July the range is only 70°, from the warmest of 116° to the coolest of 46°. The range of temperatures in winter reflects the influence of waves of cold air that sweep in immediately behind a wave of pronounced warm air.

Only in the winter of 1904–05 were there 2 consecutive months in which the mean minimum temperature was as low as 10° or slightly lower. These were January of 1904, when the mean minimum temperature was 9.8° and February of the same year when the mean minimum temperature was 9.6°. January of 1940 was exceptionally cold; in only four other Januaries has the mean minimum tem-

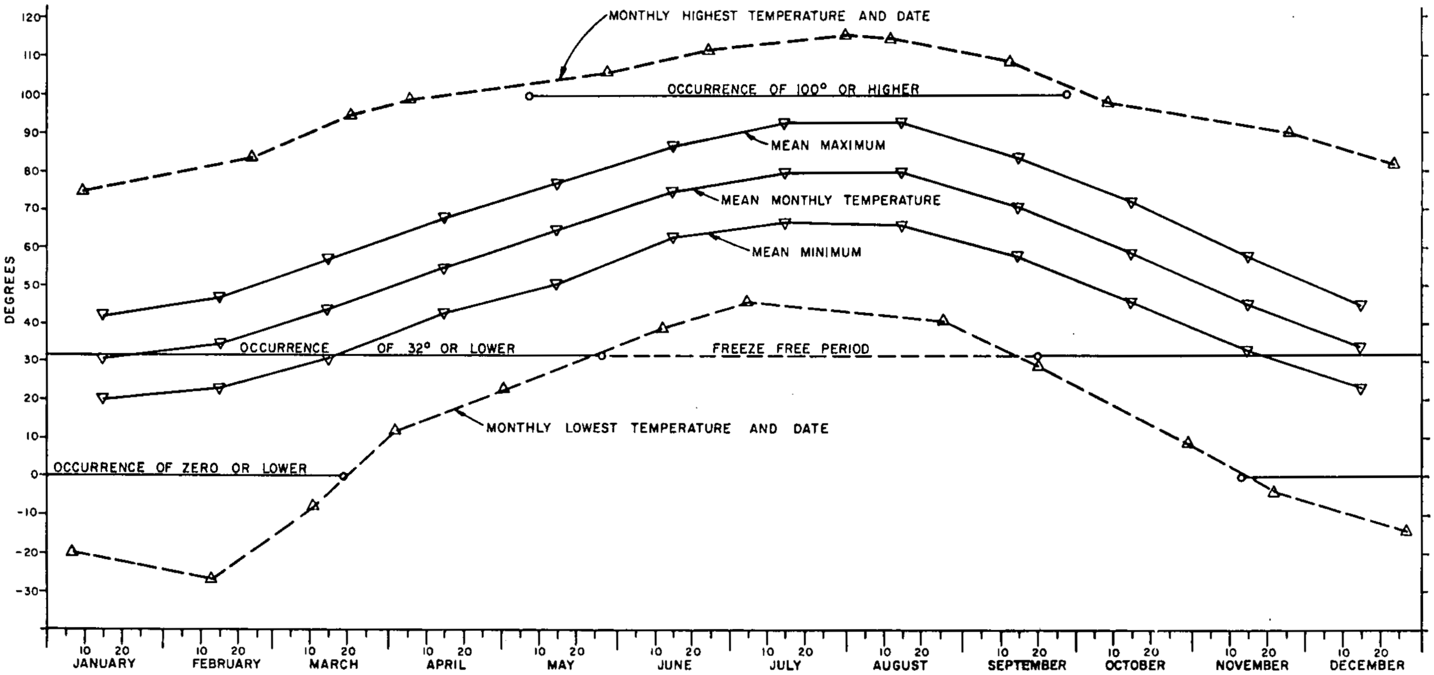

Figure 12.—**Means and extremes of temperature at Hutchinson, Kans.**

perature been lower than 10°. Only eight winters have passed without a temperature of zero or lower, and the 4 months of December 1894 through March 1895 and the same period in 1947–48 were the only winters in which there were readings of zero or below in all 4 months.

Freezing temperatures do little damage in this county because the growing season is long and farming practices are adapted to the climate. Occasionally, in spring, however, some garden plants or fruit trees may be nipped by frost. Also, crops that are planted late and that mature slowly may be damaged by frost early in fall. The probabilities that a damaging freeze will occur by the dates indicated in spring or in fall are given in figure 13 (*3*).

Precipitation: The average annual precipitation in this county is 29.05 inches (see table 10). The amount, however, varies greatly from year to year. For example, a total of 46.97 inches was received in 1944, but only 15.40 inches was received in 1952. Also, a total of 37 inches or more has been received in 10 years, and 21 inches or less has been received in another 10 years.

The amount of monthly precipitation increases and decreases with the rise and fall of the temperature throughout the year. The lowest average precipitation for any 1 month is 0.73 inch, received in January, and the greatest is 4.46 inches, received in May. The amount declines gradually throughout the summer and fall (see table 10).

A more precise picture of the amount of precipitation received in this county and the time of its occurrence is given in figure 14. This figure shows the probability, in percent, of receiving a specified amount of precipitation each week throughout the year. In the weeks from the beginning of May to the middle of June (weeks numbered 11 through 16) the probability of receiving any of the specified totals is the greatest. The probability of receiving at least 0.02 inch is greatest, almost 90 percent, for the

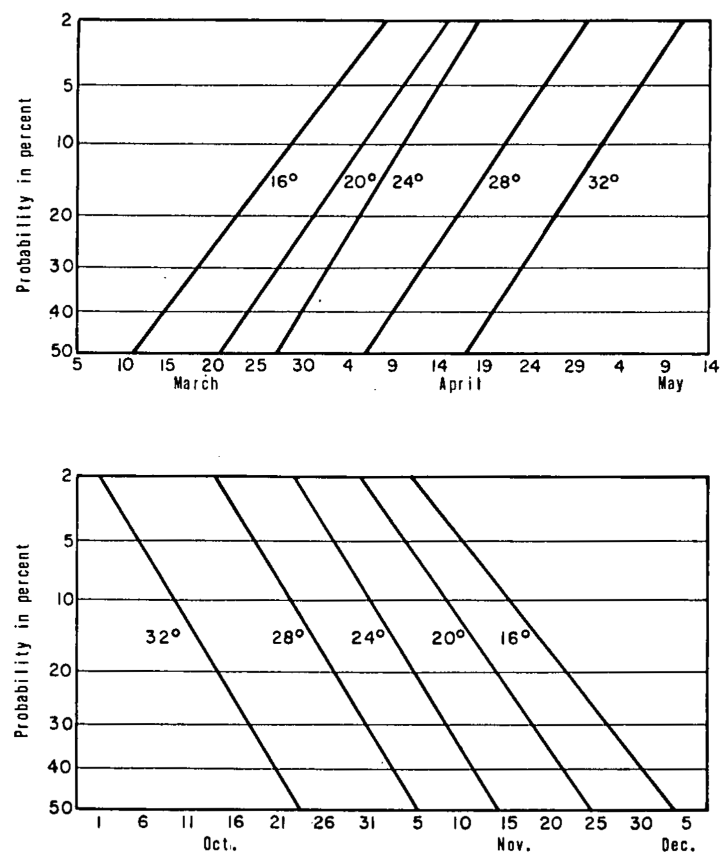

Figure 13.—**Probabilities that temperatures of 16°, 20°, 24°, 28°, or 32° will occur in spring after the indicated dates or in fall before the indicated dates.**

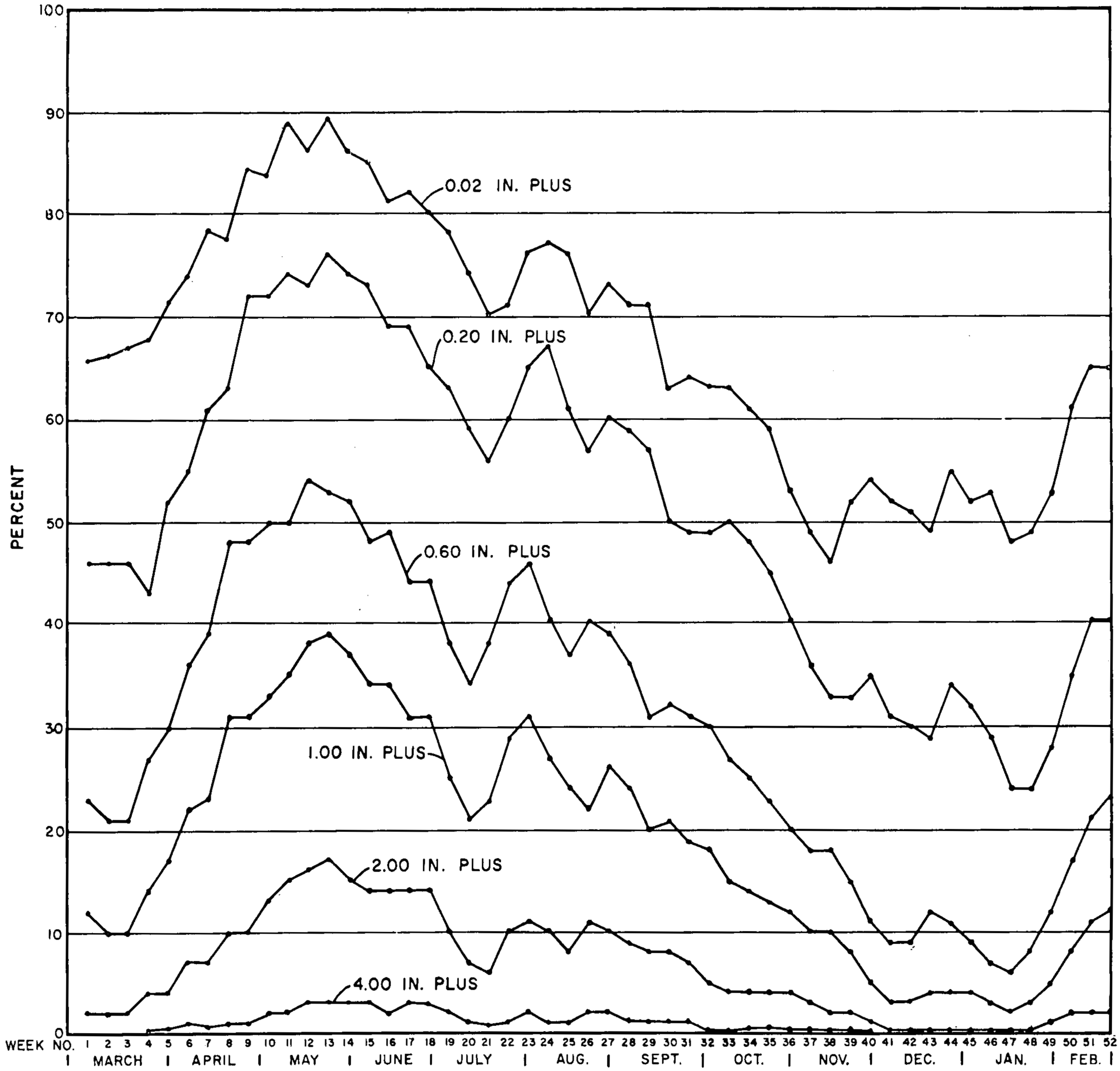

Figure 14.—**Probabilities of receiving at least the indicated amount of precipitation weekly. Data were taken from McPherson, Kans., for the period of 1901 to 1956.**

last week in May. The chance of receiving 2 inches is also greatest for the same week, but the probability is only 17 percent. The probability of receiving any of the specified totals is least in January (*4*).

Fortunately, in most years precipitation comes when it is most needed by crops. In this county 21.06 inches, approximately 72 percent of the annual amount, falls in the period from April to September. Figure 15 gives the annual total as well as the total received during the growing season from April to September.

Figure 15 also shows when precipitation has been average, above average, or below average.

The probabilities of receiving a specified amount of precipitation during the period from April to September are shown in figure 16. In about half the summers represented in this figure, from 13.5 to 23.5 inches of rain is

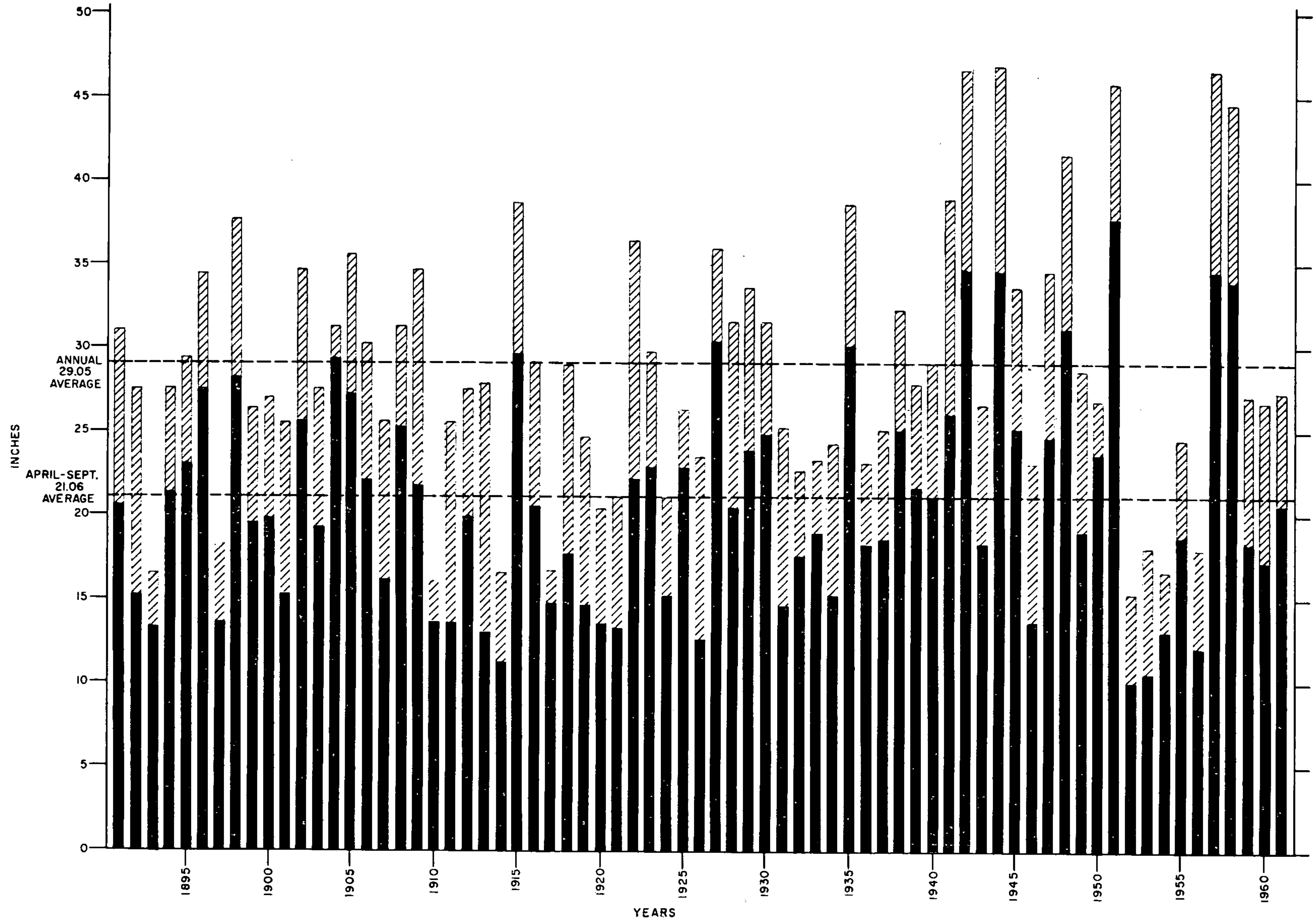

Figure 15.—**Annual and April to September precipitation at Hutchinson for the period from 1891 to 1961.**

received. In about 25 percent of the summers, from 10 to 13.5 inches is received, and in another 25 percent, from 23 to 39 inches is received.

Plans for many drainage and construction projects are based on figures that show the frequency with which various amounts of rainfall are received in a relatively short space of time. Table 11 shows the expected frequency of rainfall of a specified duration for return periods of 1 year, 2 years, 5 years, 10 years, 25 years, 50 years, and 100 years (*14*). In a 24-hour period, for example, 2.5 inches or more of rainfall may be expected once a year; 5 inches or more, once in 10 years; and 7.4 inches or more, once in 100 years.

The amount of snowfall varies from year to year, but the average yearly amount is about 20 inches. Snow is not much of a problem in this county, and because of the uncertainty in the time it will occur and in the amount that will fall, it is not much of an asset. During the period of record, 10 inches or less of snow has been received in 14 winters and 30 inches or more has been received in 8 winters.

WINDS AND STORMS: The wind blows almost constantly in this county, but it is not particularly noticeable most of the time. The average speed of the wind is about 13 miles per hour, but the speed ranges from about 15 miles per hour in March and April to 12 miles per hour in July and August. Southerly winds predominate. Only in February are the prevailing winds from the north. Winds of extremely high velocity are generally from the north and occur as shifting currents of air, either in summer thunderstorms or in prominent cold waves in winter. Extreme velocities range from about 50 to 70 miles per hour (*15*).

The storms that are the most destructive in this county are hailstorms, severe windstorms, tornadoes, or a combination of these. The frequency of such storms varies, but hail in some quantity may be expected at any one point in the county about four times each year. Approximately 50 thunderstorms are reported annually (*15*). Lightning often accompanies summer thunderstorms and causes livestock casualties, damage to property, and interruptions in electric and telephone service.

General Nature of the Area

This section gives facts about the population of Reno County and about the industries, transportation and markets, and agriculture. The figures for population were taken from reports of the U.S. Bureau of the Census, and agricultural statistics were taken from annual reports of the Kansas State Board of Agriculture.

The county had a population of 59,055 in 1960. Hutchinson, the county seat, had a population of 37,574 in that year.

Agriculture is the main source of income in this county, but a number of industries related to agriculture are located in Hutchinson. These include meatpacking plants, canning and vinegar works, plants where flour and feed are processed, fertilizer plants, factories where farm machinery, grain-loading equipment, and paperboard are manufactured, plants where dairy products are processed,

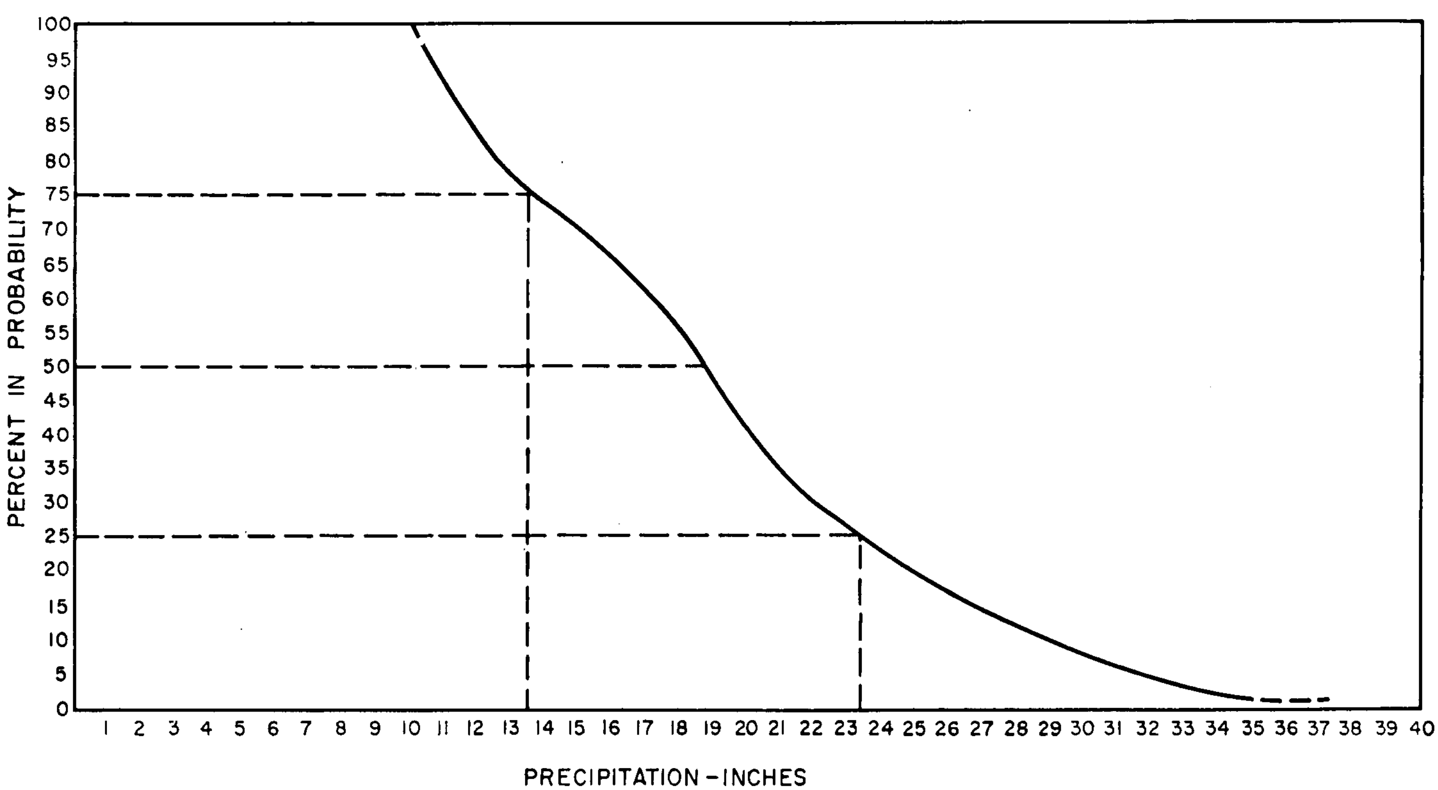

Figure 16.—Probabilities of receiving at least the specified amounts of precipitation from April to September. These figures are based on records kept at Hutchinson, from 1891 to 1961.

and factories where engines are rebuilt. Other industries located at Hutchinson are wholesale grocers, book publishers, a factory where mobile homes are manufactured, salt mines, and three salt-evaporating plants. The average annual production of salt in this county is 15,000 carloads.

Hutchinson is the largest primary wheat market in the world and has storage facilities for grain in excess of 48 million bushels. The flourmills in Hutchinson have a combined capacity of 5,700 barrels of flour per day. Markets for farm products are also available in Hutchinson, but some products are marketed in Wichita, in Sedgwick County. Some of the farm products and manufactured products are transported to market over Federal Highway 50 and State Highways 96 and 61, which pass through Hutchinson. Others are transported by using the main or branch lines of the several railroads that pass through the city. Hutchinson is also served by an airline.

About 90 percent of the farmland in the county has been farmed for more than 50 years, but only a small acreage has been farmed as long as 70 years. Wheat, sorghum, and alfalfa are the main crops, and beef cattle is the main kind of livestock. Corn was formerly grown extensively, but the acreage in corn has dropped greatly since 1939. During the same period, the acreage in grain sorghum has increased greatly, for this crop is much better suited to the climate than is corn. About 15,000 acres used for grain crops early in the century is now used for other purposes. Table 12 gives the harvested acreage of the principal crops in stated years.

Table 13 shows the number of livestock in the county. The number of beef cattle, sheep, and hogs has increased somewhat during the past few years. The number of milk cows has decreased, although the total amount of milk produced is higher.

TABLE 12.—*Harvested acreage of the principal crops in stated years* [1]

Crop	1939	1949	1959
	Acres	*Acres*	*Acres*
Wheat	343, 000	387, 000	269, 000
Corn	23, 600	5, 500	2, 900
Oats	18, 540	10, 890	8, 400
Grain sorghum	12, 700	27, 190	127, 000
Alfalfa	18, 840	28, 560	24, 800

[1] Statistics from annual reports of the Kansas State Board of Agriculture.

TABLE 13.—*Number of livestock in the county in stated years*

Livestock	1939	1949	1959
Horses and mules	7, 870	2, 740	1, 460
Milk cows	18, 470	13, 000	9, 700
Beef cattle	30, 670	43, 800	58, 300
Sheep	19, 460	8, 700	24, 230
Hogs	14, 070	12, 500	16, 900

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Glossary

Aggregate, soil. Many fine particles held in a single mass or cluster, such as a clod, crumb, block, or prism.

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 reduced.

Alluvium. Soil material, such as sand, silt, or clay, that has been deposited on land by streams.

Blowout. An area from which soil material has been removed by wind.

Calcareous soil. A soil containing enough calcium carbonate (often with magnesium carbonate) to effervesce (fizz) visibly when treated with cold, dilute hydrochloric acid. (Called also limy soil)

Chlorosis. The yellowing or blanching of green parts of a plant, particularly the leaves, that is a condition resulting from the failure of chlorophyll (the green coloring matter) to develop, usually because of some deficiency of an essential nutrient. The color of leaves of chlorotic plants ranges from light green through yellow to almost white.

Clay. As a soil separate, the mineral soil particless 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 sils. (See also, Texture, soil)

Concretions. Grains, pellets, or nodules of various sizes, shapes, and colors consisting of a concentration of compounds or of soil grains cemented together. The composition of some concretions is unlike that of the surrounding soil. Calcium carbonate and iron oxide are examples of material commonly found in concretions.

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; will 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 thumb and forefinger.

Sticky.—When wet, adheres to other material, and tends to stretch somewhat and pull apart, rather than 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.

Erosion. The wearing away of the land surface by wind, running water, and other geological agents.

Horizon, soil. A layer of soil, approximately parallel to the surface that has distinct characteristics produced by soil-forming processes.

Internal soil drainage. The downward movement of water through the soil profile. The rate of movement is determined by the texture, structure, and other characteristics of the soil profile and underlying layers, and by the height of the water table, either permanent or perched. Relative terms for expressing internal drainage are *none, very slow, slow, medium,* and *very rapid.*

Natural drainage. Refers to moisture conditions 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. The following terms are used to express natural drainage: *Excessively drained, somewhat excessively drained, well drained, moderately well drained, imperfectly* or *somewhat poorly drained, poorly drained,* and *very poorly drained.*

Outwash. Thick deposits of old sediments carried by streams of melt water in glacial times and deposited beyond the glacial ice front. The sediments consist of sand, silt, or clay that has been sorted to some extent, and they are now generally in upland positions.

Parent material. The unconsolidated mass from which the soil profile develops.

Permeability, soil. The quality of a soil horizon that enables water or air to move through it. Terms used to describe permeability are *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. (See also, Reaction, soil)

Profile. 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 nor 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		*pH*
Extremely acid	Below 4.5	Neutral	6.6 to 7.3
Very strongly acid	4.5 to 5.0	Mildly alkaline	7.4 to 7.8
Strongly acid	5.1 to 5.5	Moderately alkaline	7.9 to 8.4
Medium acid	5.6 to 6.0	Strongly alkaline	8.5 to 9.0
Slightly acid	6.1 to 6.5	Very strongly alkaline	9.1 and higher

Saline-alkali soil. A soil having a combination of a harmful quantity of salts and either a high degree of alkalinity or a large amount of exchangeable sodium, or both, so distributed in the profile that the growth of most crop plants is less than normal.

Saline soil. A soil that contains soluble salts in an amount large enough to impair the growth of plants but that does not contain excess exchangeable sodium.

Sand. Individual rock or mineral fragments in soil having a diameter ranging from 0.05 millimeter to 2.0 millimeters. Most sand grains consist of quartz, but they may be of any mineral composition. The textural class name of any soil that contains 85 percent or more sand and not more than 10 percent clay. (See also, Texture, soil)

Silt. Individual mineral particles in a soil that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). Soil material of the silt textural class is 80 percent or more silt and less than 12 percent clay. (See also, Texture, soil)

Slickspots. Small areas in a field that are slick when wet because they contain excess exchangeable sodium, or alkali.

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 soils 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.

Subsoil. Technically, the B horizon; roughly, the part of the profile below plow depth.

Substratum. Any layer lying beneath the solum, or true soil; the C or D horizon.

Surface layer. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, about 5 to 8 inches in thickness.

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."

Water table. The highest part of the soil or underlying rock material that is wholly saturated with water. In some places an upper, or perched, water table may be separated from a lower one by a dry zone.

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