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SOIL SURVEY

FINNEY COUNTY

Kansas



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

HOW TO USE THE SOIL SURVEY REPORT

THIS SOIL SURVEY of Finney County, Kans., will serve several groups of readers. It will help farmers in planning the kind of management that will protect their soils and provide good yields; assist engineers in selecting sites for roads, buildings, ponds, and other structures; and add to our knowledge of soil science.

Locating the soils

Use the index to map sheets at the back of this report to locate areas on the large map. The index is a small map of the county on which numbered rectangles have been drawn to show where each sheet of the large map is located. When the correct sheet of the large map has been found, it will be seen that boundaries of the soils are outlined, and that there is a symbol for each kind of soil. All areas marked with the same symbol are the same kind of soil, wherever they occur on the map. The symbol is inside the area if there is enough room; otherwise, it is outside the area and a pointer shows where the symbol belongs.

Finding Information

This report contains sections that will interest different groups of readers, as well as some sections that may be of interest to all.

Farmers and those who work with farmers can learn about the soils in the section "Descriptions of the Soils" and then turn to the section "Use and Management of Soils." In this way they first identify the soils on their farm and then learn how these soils can be managed and what yields of grain or forage can be expected. The "Guide to Mapping Units, Capability Units, and Range Sites" at the back of the report will simplify use of the map and report. This guide lists each soil and land type mapped in the county, and the page where each is described. It also lists, for each soil and land type, the capa-

bility units and range site and the pages where each of these is described.

Persons who raise livestock will be interested in the section "Management of Rangeland." In that section the soils are grouped according to their suitability, use, and management for grazing.

Persons interested in establishing windbreaks can refer to the section "Management of Windbreaks." In that section the soils in the county are grouped according to their suitability as sites for shelterbelts and windbreaks, and some factors affecting management are briefly discussed.

Engineers and builders will want to refer to the section "Engineering Properties of Soils." Tables in that section show characteristics of the soils that affect engineering.

Persons interested in soil science will find information 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. The soil survey map and report also are useful to land appraisers, credit agencies, and others who are concerned with the use and management of soils.

Newcomers in Finney 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 "Additional Facts About the County."

* * * * *

The Finney County Soil Conservation District arranges for farmers to receive technical help from the Soil Conservation Service in planning how to use and conserve the soils on their farm. This soil survey furnishes some of the facts needed for this technical help.

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

Cover picture:
Harvesting wheat on a farm in
Finney County.

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SOIL SURVEY OF FINNEY COUNTY, KANSAS

BY RODNEY F. HARNER, RAYMOND C. ANGELL, MARION A. LOBMEYER, AND DONALD R. JANTZ, SOIL CONSERVATION SERVICE, UNITED STATES DEPARTMENT OF AGRICULTURE

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

FINNEY COUNTY, the second largest county in Kansas, is in the southwestern part of the State (fig. 1). It occupies about 1,302 square miles, or 833,280 acres. Garden City, the county seat, has a population of about 12,000.

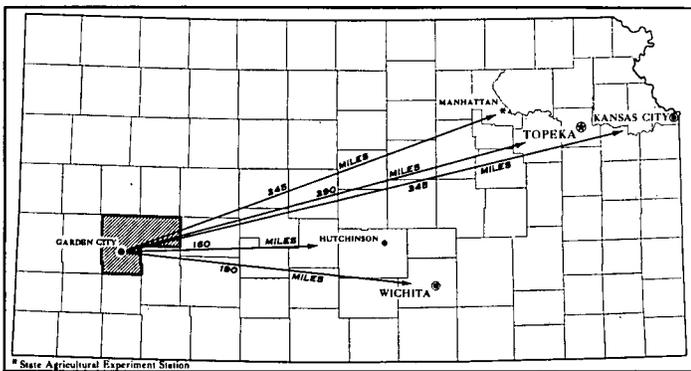


Figure 1.—Location of Finney County in Kansas.

The county consists of five distinct physiographic areas. These are the High Plains tableland, the Scott-Finney depression, the drainage basin of the Pawnee River, the valley of the Arkansas River, and the sandhills. The High Plains tableland is in the northwestern and north-central parts of the county. It lies on both sides of the Scott-Finney depression, a broad, shallow basin that extends from the valley of the Arkansas River northward into Scott County. The drainage basin of the Pawnee River occupies most of the northeastern, or panhandle, part of the county. The Pawnee River runs from west to east through that area. The valley of the Arkansas River extends roughly from about 16 miles north of the southwestern corner of the county to about 9 miles north of the southeastern corner. South of that valley is the broad band of the sandhills.

Agriculture is the main enterprise in this county, and wheat, grain sorghum, and cattle are the main sources of income. Irrigation is extensive. The natural gas and oil industries are the most extensive nonagricultural enterprises.

How This Soil Survey Was Made

Soil scientists made this survey to learn what kinds of soils are in Finney 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 or bored 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 to the rock material that has not been changed much 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 uniform procedures. To use this report efficiently, 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. Richfield and Ulysses, 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 natural characteristics.

Many soil series contain soils that are alike except for the texture of their surface layer. According to this difference 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. Ulysses silt loam and Ulysses loam are two soil types in the Ulysses series. The difference in the texture of their surface layer 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, Ulysses silt loam, 1 to 3 percent slopes, is one of several phases of Ulysses silt loam, a soil type that ranges from nearly level to sloping.

After a fairly detailed guide for classifying and naming the soils had been worked out, the soil scientists drew soil boundaries on aerial photographs. They used photos for their base map because they show buildings, field borders, trees, and similar detail 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 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 soil maps, the soil scientist has 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, he shows this mixture of soils as one mapping unit and calls it a soil complex. Ordinarily, a soil complex is named for the major soil series in it, for example, Mansker-Potter complex. Also, in most mapping, there are areas to be 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 Alluvial land or Rock land, and are called land types rather than soils.

Only part of the soil survey was done when the soil scientist had named and described the soil series and mapping units, and had shown the location of the mapping units on the soil map. The mass of detailed information he had recorded then needed to be presented in different ways for different groups of users, among them farmers, managers of rangeland, and engineers.

To do this efficiently, he had to consult with persons in other fields of work and jointly prepare with them groupings that would be of practical value to different users. Such groupings are the capability classes, subclasses, and units, designed primarily for those interested in producing short-lived crops and tame pasture; range sites, for those using large tracts of native grass; wind-break suitability groups, for those who need to plant or manage windbreaks; and the classifications used by engineers who build highways or structures to conserve soil and water.

General Soil Map

As one travels over a county or other large tract, it is fairly easy to see differences in the landscape from place to place. There are many obvious differences. Some of them are in the shape, steepness, and length of slopes, in the course, depth, and speed of the streams, in the width of the bordering valleys, in the kinds of wild plants, and in the kind of agriculture. With these more obvious differences, there are others less easily noticed in the patterns of soils. The soils differ along with the other parts of the environment.

By drawing lines around the different patterns of soils on a small map, one may obtain a general map of the soils. Each kind of pattern is called a soil association. Such a map is useful to those who want a general idea of the soils, who want to compare different parts of a county, or who want to locate large areas suitable for some particular kind of farming or other broad land use. It does not show accurately the kinds of soils on a single farm or a small tract.

The associations are named for the major soil series in them, but soils of other series may be present in any of the areas. Also, the major soil series of one area may occur in the others. Each association has a distinct pattern of soils, and the soil differences are important to the farms or ranches within each of them.

The seven soil associations in Finney County are shown on the colored map at the back of this report. Two of the associations are on the High Plains tableland, one is in the Pawnee River drainage basin, another is in the valley of the Arkansas River, and still another is in the Scott-Finney depression. The other associations are in the sandhills and in transitional areas.

1. Richfield-Ulysses Association

Loamy soils of the High Plains tableland

This association occupies the broad High Plains tableland north of the valley of the Arkansas River and west of the drainage area of the Pawnee River. Northwest of Garden City, the tableland slopes gently eastward toward the Scott-Finney depression, which divides the association. The area of the association east of the Scott-Finney depression is much more rolling than that to the west.

The association lacks a well-defined drainage pattern, but depressions dot the landscape and collect runoff from the surrounding slopes. Also, a few entrenched drainageways extend into the association from Kearny County to the west. These drainageways gradually become more shallow as they extend farther into the county; they eventually disappear on the western slope of the Scott-Finney depression.

Nearly level and gently sloping, deep, permeable, loamy Richfield and Ulysses soils are dominant in the association. The Richfield and Ulysses soils are well drained and fertile, and they formed in thick deposits of silty loess.

Sandy Manter and Otero soils occupy a small acreage in the association, and small areas of Keith soils occur with them. Randall soils occupy the bottoms of depressions. The Randall soils are ponded after rains.

Practically all of this association is cultivated. The Richfield and Ulysses soils are well suited to the dryland and irrigated crops commonly grown in the county, and they are used mainly for wheat and sorghum. The chief problems where cultivated crops are grown are conserving moisture and controlling erosion. Wind erosion is the major hazard in nearly level areas, but both wind erosion and water erosion are hazards on the sloping soils.

2. Spearville-Harney Association

Clayey soils of the High Plains tableland

The broad High Plains tableland along the southern edge of the panhandle of Finney County makes up this association. The areas lack a well-defined drainage pattern, but scattered throughout the association are many depressions where water is ponded after rains.

Nearly level and gently sloping, deep, clayey Spearville and Harney soils are dominant in the association. These soils are well drained and fertile, and they formed in thick deposits of silty loess. The Spearville soils have a more compact, more slowly permeable subsoil than the Harney

soils. Richfield soils occupy small areas in this association, and Randall soils occupy the bottoms of the depressions.

This association is used mainly for growing wheat and sorghum. The Harney soils are well suited to both of these crops. Because of their droughty subsoil, the Spearville soils are better suited to wheat than sorghum. Where these crops are grown, the main problems are conserving moisture and controlling erosion. Wind erosion is the major hazard in nearly level areas, but both wind erosion and water erosion are hazards on the sloping soils.

3. Richfield-Ulysses-Mansic Association

Loamy soils of the Pawnee River drainage basin

This association occupies a large area that is the drainage basin of the Pawnee River (fig. 2). It is in the northeastern part of the county, where the landscape differs greatly from that of the plains to the west and south. The Pawnee River has deeply dissected the area. The drainageways that empty into it have steep sides and are separated by broad, rolling divides. Steep bluffs of limestone and shale form the sides of the lower valleys.

Loamy, deep, and permeable Richfield, Ulysses, and Mansic soils are dominant in this association. The Richfield and Ulysses soils are nearly level or gently sloping, and they formed in silty loess that caps the broad, rolling divides. The Mansic soils formed in plains outwash, which is exposed in places along the steep sides of the drainageways.

A minor acreage in this association is occupied by Rock land and by Lismas, Promise, Mansker, Potter, Roxbury, Humbarger, Manter, Otero, Spearville, and Harney soils.

Rock land consists of shallow soils and of limestone outcrops. The Lismas soils are shallow over shale and formed in material weathered from shale. The Promise soils formed in clayey sediment washed from shale. The Mansker and Potter soils formed over thick beds of caliche that are exposed around the margin of the Pawnee River drainage area, on the rim of the High Plains tableland.

The Roxbury and Humbarger soils are nearly level and formed in alluvium on the floors of the valleys. The Roxbury soils are darker colored and more clayey than the Humbarger soils. They are on low terraces, and the Humbarger soils are on flood plains.

Manter and Otero soils occupy only a few small areas. The largest area lies just west of State Highway No. 23, on the south side of the valley of the Pawnee River.

The Pawnee River drainage area is especially well suited to a combination of dryland farming and the raising of livestock. The Richfield and Ulysses soils are well suited to dryland wheat and sorghum; the rolling areas are still in native grass and provide grazing for livestock in summer. Some farmers grow alfalfa on the floors of the valleys to supplement the forage used by livestock that graze the winter wheat and sorghum residue.

Water erosion is a serious problem on the sloping soils of this association. Wind erosion is a hazard on all areas under cultivation.

4. Las-Las Animas Association

Soils in the valley of the Arkansas River

Soils of the bottom lands and low terraces in the valley of the Arkansas River make up this association (fig.

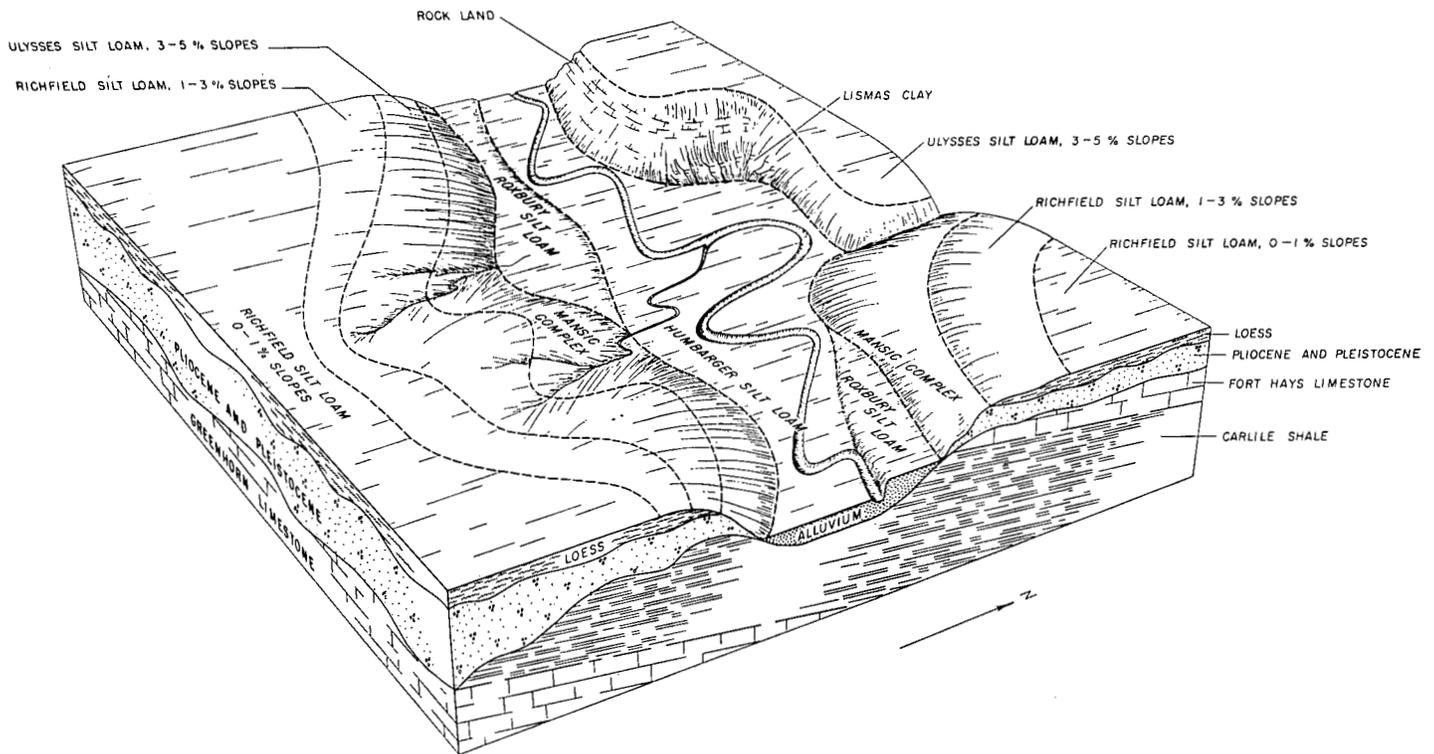


Figure 2.—Typical cross section of the Pawnee River drainage basin.

soil and substratum. Their leached, gray subsurface layer and the columnar structure in the upper part of their subsoil show that the Drummond soils have been severely affected by salts.

Saline Church and Colby soils occupy a minor acreage in the association. The Church soils are clayey and formed in old lakebed material. They are on low benches around undrained lakes. The Colby soils are loamy and are in a low area along the eastern edge of the association.

The Ulysses and Richfield soils are suited to wheat and sorghum, but yields vary from place to place because of differences in the salinity of the soils. The Drummond soils are better suited to wheat than to sorghum. The Church and Colby soils are also suited to wheat and sorghum, but the salts reduce yields.

Conserving moisture and controlling wind erosion are problems throughout this association. Salinity causes yields to be reduced, especially when the supply of moisture is limited.

6. Tivoli-Vona Association

Soils of the sandhills

This association consists of a broad band of sandhills, mostly south of the valley of the Arkansas River. Three

small, isolated areas of sandhills, however, lie north of the valley. One of these small areas is along the northern border of the county, adjacent to the corners of Scott and Lane Counties; another lies a few miles north of Garden City, on the east side of the Scott-Finney depression; and the third is east of Garden City, along the north side of the valley of the Arkansas River.

Nearly all of the acreage in the broad band of sandhills south of the Arkansas River consists of Tivoli and Vona soils. Deep, loose Tivoli fine sands are in the areas of choppy dunes just south of the valley. Less sloping Tivoli and Vona loamy fine sands are farther back from the valley, near the southern edge of the areas of sandhills. In those areas the topography is more subdued than that farther north.

In the small area of this association east of Garden City and north of the valley of the Arkansas River, drainageways finger back into the upland. On the steep sides of these drainageways are Otero fine sandy loams and gravelly soils.

Practically all of this association is in native grass. Except for a few small areas that are less sandy than the rest of the association, the soils are too erodible and lacking in fertility to be suitable for crops. Maintaining and im-

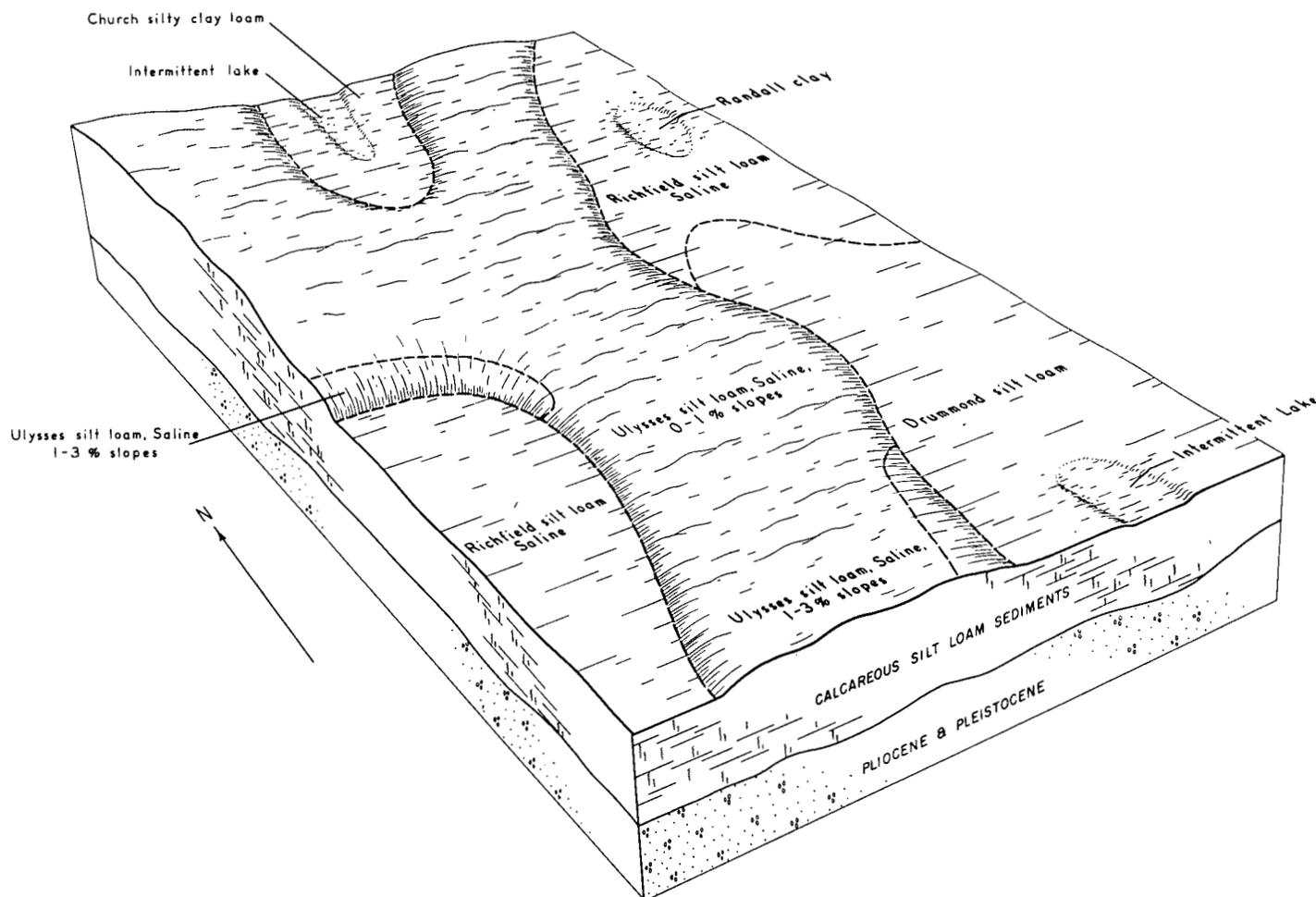


Figure 4.—Typical cross section of the Scott-Finney depression.

proving the native forage plants is the chief concern throughout the area.

7. Manter-Keith Association

Sandy and loamy soils between the sandhills and tableland

This association consists of transitional areas between the very sandy soils of the sandhills and the loamy soils of the High Plains tableland (fig. 5). The largest area is in the southern part of the county. In that area the soils range from Vona loamy fine sand, at one extreme, to Keith loam, at the other. Manter fine sandy loam is intermediate in texture between the Vona and Keith soils.

Besides the areas of this association south of the valley of the Arkansas River, three small areas lie north of the valley. These areas surround small patches of sandhills. Within each of these small tracts, the soils are similar to those in the large area in the southern part of the county, except that one or more of the soils may be absent.

The Vona soils, the most sandy of the soils in the association, are in undulating areas next to the sandhills. The Keith soils are in nearly level areas farthest from the sandhills. The Manter soils occupy nearly level and undulating areas between the Vona and Keith soils.

Otero and Ulysses soils, mapped as a complex, are also in this association. The Otero soils are calcareous fine sandy loams. They are on undulating ridges and knolls that are separated by small flats. The Ulysses soils of the complex are on low flats between the ridges and knolls. Undulating Ulysses loams occur with the soils of the Otero-Ulysses complex.

The Manter soils are well suited to small grains and sorghum. The Keith soils are deep, permeable, and fertile, and they are well suited to all the dryland and irrigated crops commonly grown. The Vona soils are best suited to native grass, but if they are cultivated, they are better suited to sorghum than to wheat. Where the Vona soils are cultivated, wind erosion is a serious hazard. The Ulysses loams and the soils of the Otero-Ulysses complex are suited to small grains and sorghum. Conserving moisture and controlling wind erosion are problems on all the soils throughout this association.

Effects of Erosion

Erosion is the wearing away of the land surface, mainly by wind, running water, and gravity. Erosion and its ef-

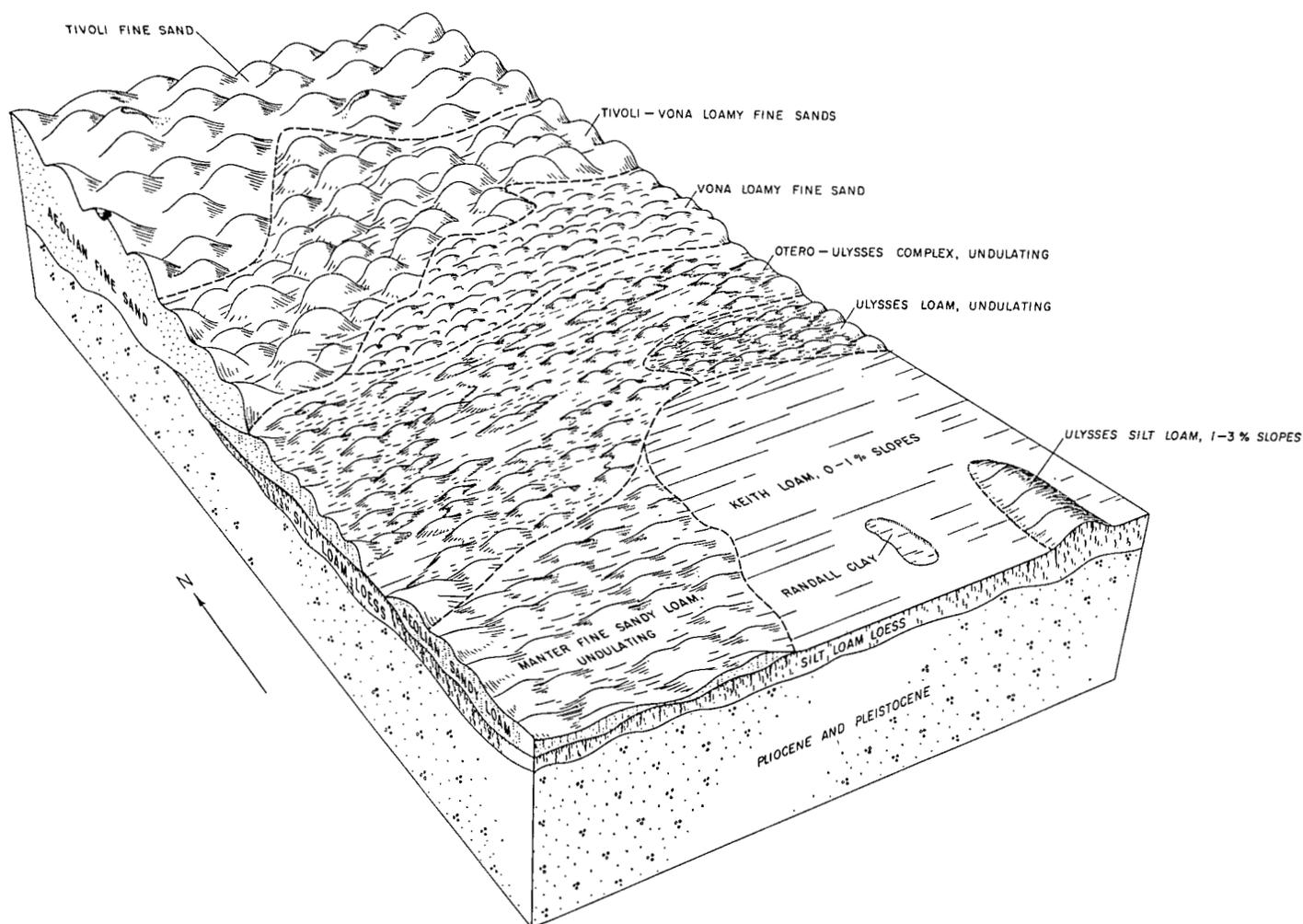


Figure 5.—Typical cross section of the Manter-Keith association.

fects on the soils of Finney County are discussed in the following paragraphs. The discussion deals with accelerated soil erosion and not with the gradual, normal process of soil removal, known as geologic erosion, that takes place in an undisturbed environment. In contrast, accelerated erosion is the increased rate of soil removal brought about by man through changes in the natural cover or in the condition of the soils.

Some effects of erosion are permanent; the soil is damaged to the extent that it requires a change in its use and management. Other effects are transitory but may impair the use of the land until restorative measures are taken.

Wind and water are the main causes of soil erosion in Finney County. Wind erosion is always a hazard when the soils are dry and unprotected, and it is serious during the recurrent periods of drought. Strong winds and the limited growth of vegetation that are characteristic during periods of drought on the High Plains are conducive to widespread soil blowing (fig. 6). The soils that have a silty or clayey surface layer are more resistant to blowing than those that have a sandy surface layer. Also, it is easier to maintain a cloddy surface on these silty and clayey soils than on sandy soils. Keeping the surface sufficiently cloddy or protecting the soils with a cover of growing plants or plant residue helps to restrict blowing.

Water erosion is a hazard on all the sloping soils that are cultivated. Runoff occurs during the hard, dashing thunderstorms, when rain falls more rapidly than the water can enter the soil. In places it removes thin layers of soil material, more or less evenly, from the entire surface and causes sheet erosion. The evidence of sheet erosion is obliterated if the soils are cultivated; little evidence of destructive erosion is apparent until the material in the subsoil is exposed. Water tends to concentrate, however, and small channels develop in a short time. Unless the area is soon protected by vegetation or by practices that slow down or decrease runoff, the channels continue to grow with each successive rain. They may increase in size and form gullies too large to be smoothed over by normal tillage. The eroded material is sometimes deposited at the base of the slope, where it damages crops and other soils.

Gully erosion is more evident in the Pawnee River drainage area than in the rest of the county. In that area there is a well-defined drainage pattern. Channels have been cut into the soils where water has concentrated. Plowing, which has removed the native vegetation, has caused accelerated erosion in the natural drainageways. In many places trails made by cattle through areas of native grass have eroded to a depth of several inches or, as much as 1 foot.

During fieldwork on this soil survey, observations of the effects of erosion were made. Some of the following results of wind erosion were observed:

1. Small, low hummocks and drifts of soil material form in cultivated fields, in fence rows, and in areas of native grass adjacent to cultivated fields where active soil blowing is in progress. In places, especially in sandy soils, the drifts in fence rows may be several feet high. These hummocks and drifts will blow again unless they are smoothed out and the soils are tilled to provide a roughened surface that is resistant to erosion.



Figure 6.—A field of Richfield silt loam, 0 to 1 percent slopes, where surface roughening was used to check soil blowing.

2. Soil material may drift from actively eroding cultivated fields onto adjacent rangeland and damage or destroy the native vegetation. No permanent damage occurs, but the use of the land is impaired until the grass has become reestablished, either by deferred grazing or by reseeding.
3. During drought, overuse of some of the very sandy, nonarable rangeland may result in the loss of protective vegetation and in severe wind erosion. These areas are thus permanently damaged, and their value for grazing is greatly reduced. Damage to cultivated crops and grass on adjacent areas is caused by the drifting sand. The sandy sediments also increase the hazard of wind erosion on the soils on which they are deposited.

Erosion is serious, not only because of the permanent modification of the soils, but also because of the short-time damage to crops and forage. Replanting of crops, reseeding of rangeland, and emergency tillage and smoothing operations may correct most of the temporary effects of erosion and restore full use of the land. However, these practices are time consuming and costly.

In Finney County eroded soils are mapped as separate soil units only if erosion has modified some important quality or characteristic of the soil that is significant to use and management. Some soils have been eroded to some degree and are subject to further erosion. The hazard of erosion on all the soils is indicated in the section "Use and Management of Soils."

An eroded soil is designated as an eroded phase of a soil type if it still retains many characteristics of the soil type. Some soils have been so altered by erosion that they now have characteristics similar to those of some associated soil type, and they are mapped as such. For example, if the dark-colored surface layer has been removed from a soil that was once Ulysses silt loam, and the lighter colored, more calcareous subsoil is exposed, the soil is now designated as Colby silt loam.

In this county the Ulysses and Colby soils were mapped together as a complex. The Colby soils are on the convex ridgetops or on the steeper part of the slopes where erosion has been the most active. The eroded areas are susceptible to further damage. They are a hazard to the soils and crops in adjoining fields because calcareous soils blow readily.

Other soils have been modified extremely by erosion and have lost their original identity; these soils are now classified as miscellaneous land types. Active dunes, now a miscellaneous land type, was presumably Tivoli fine sand before it became eroded.

Measures needed to control erosion vary according to the kind of soil, the degree of slope, and the land use. A combination of practices that will control erosion at a particular time can generally be chosen. These practices are indicated for each capability unit in the section "Use and Management of Soils." For more specific and detailed information, consult a representative of the Soil Conservation Service.

Descriptions of the Soils

In this section the soil series in Finney County are described in alphabetic order, and a typical profile is described briefly for each series. Each mapping unit is then discussed, and characteristics 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 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 a list of the mapping units in the county and the dryland or irrigated capability unit and range site each is in. The page where each of the capability units or other groups is described is also given.

Active Dunes (Ad)

This land type consists of nearly bare sand dunes; vegetation covers less than 20 percent of each area. The loose sand is continually shifted by wind, and it does not remain in the same place long enough for grass to become established. In some of the lowest areas, the sand has been swept away and calcareous, silty material is exposed. The sand spreads slowly outward, a constant menace to adjoining land.

This land type has little value for grazing. The areas must be fenced to keep livestock out if the dunes are to be stabilized. A protective cover of sorghum or weeds ought to be established, and then such adapted native grasses as sand bluestem, switchgrass, little bluestem, and big sandreed should be seeded. (Capability unit VIIe-1, dryland; not placed in an irrigated capability unit or windbreak suitability group; Choppy Sands range site)

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

Mapping unit	Area		Mapping unit	Area	
	Acres	Percent		Acres	Percent
Active dunes.....	1, 185	0. 1	Richfield-Spearville complex, 0 to 1 percent slopes.....	31, 126	3. 7
Alluvial land.....	3, 560	. 4	Richfield and Ulysses complexes, bench leveled.....	9, 036	1. 1
Bayard fine sandy loam.....	850	. 1	Rock land.....	1, 465	. 2
Bridgeport clay loam.....	6, 387	. 8	Roxbury silt loam.....	5, 062	. 6
Broken land.....	1, 670	. 2	Spearville silty clay loam, 0 to 1 percent slopes.....	24, 535	2. 9
Church silty clay loam.....	2, 993	. 4	Spearville complex, 1 to 3 percent slopes, eroded.....	2, 453	. 3
Colby loam, saline.....	482	. 1	Sweetwater clay loam.....	1, 410	. 2
Drummond silt loam.....	11, 352	1. 4	Tivoli fine sand.....	65, 012	7. 8
Harney silt loam, 0 to 1 percent slopes.....	8, 630	1. 0	Tivoli-Dune land complex.....	15, 362	1. 8
Humbarger silt loam.....	6, 556	. 8	Tivoli-Vona loamy fine sands.....	63, 876	7. 7
Keith loam, 0 to 1 percent slopes.....	26, 414	3. 2	Ulysses silt loam, 0 to 1 percent slopes.....	49, 249	5. 9
Las clay loam, deep.....	5, 452	. 7	Ulysses silt loam, 1 to 3 percent slopes.....	42, 126	5. 0
Las clay loam, moderately deep.....	5, 895	. 7	Ulysses silt loam, 3 to 5 percent slopes.....	25, 006	3. 0
Las-Bayard sandy loams.....	2, 200	. 3	Ulysses-Colby silt loams, 1 to 3 percent slopes, eroded.....	9, 360	1. 1
Las-Las Animas complex.....	3, 221	. 4	Ulysses-Colby silt loams, 3 to 5 percent slopes, eroded.....	7, 704	. 9
Las Animas sandy loam.....	1, 776	. 2	Ulysses loam, undulating.....	4, 742	. 6
Las Animas-Lincoln loamy sands.....	4, 394	. 5	Ulysses silt loam, saline, 0 to 1 percent slopes.....	13, 116	1. 6
Lincoln soils.....	1, 509	. 2	Ulysses silt loam, saline, 1 to 3 percent slopes.....	2, 659	. 3
Lismas clay.....	1, 773	. 2	Ulysses and Richfield complexes, saline, bench leveled.....	1, 723	. 2
Lofton clay loam.....	1, 085	. 1	Ulysses and Richfield soils, silted, 0 to 1 percent slopes.....	11, 471	1. 4
Mansic complex.....	41, 193	4. 9	Vona loamy fine sand.....	11, 266	1. 4
Mansker-Potter complex.....	1, 054	. 1	Arkansas River.....	455	. 1
Manter fine sandy loam, level.....	2, 700	. 3	Intermittent lakes.....	623	. 1
Manter fine sandy loam, undulating.....	20, 093	2. 4	Sand pits.....	117	(¹)
Manter-Otero fine sandy loams, undulating.....	2, 015	. 2	State lake.....	265	(¹)
Otero fine sandy loam, 5 to 15 percent slopes.....	2, 109	. 2			
Otero gravelly complex.....	1, 002	. 1			
Otero-Ulysses complex, undulating.....	17, 393	2. 1			
Promise clay, 1 to 3 percent slopes.....	423	. 1			
Randall clay.....	9, 752	1. 2			
Richfield silt loam, 0 to 1 percent slopes.....	184, 320	22. 1			
Richfield silt loam, 1 to 3 percent slopes.....	45, 549	5. 5			
Richfield silt loam, saline.....	9, 074	1. 1			
			Total acreage.....	833, 280	100. 0

¹ Less than 0.05 percent.

Alluvial Land (An)

Loamy alluvium on flood plains in the valleys of local intermittent streams make up this land type. The soil material is mainly stratified, calcareous loam and clay loam, but there are some thin layers of sandy loam. The slopes are 0 to 3 percent.

The floors of the valleys are more than 150 feet wide, and they are generally bordered by steep nonarable soils. The areas are large enough and continuous enough that they can be managed separately for grazing. The land is dissected by meandering stream channels that divide it into many small, isolated areas. These isolated areas are not suitable for cultivated crops, because of their small size and the difficulty in reaching them. The floors of the valleys are flooded occasionally. In places springs supply moisture for grass.

This land type is productive as grassland, and it is suitable for grazing (fig. 7). More than half the vegetation consists of mid and tall grasses, such as switchgrass, big bluestem, Indiangrass, Canada wildrye, and little bluestem. Deferred grazing or rotation deferred grazing can be used along with a proper stocking rate to maintain or improve the vigor and composition of the grasses. Weeds can be controlled by mechanical methods or by chemicals. (Capability unit VIw-1, dryland; not placed in an irrigated capability unit; Loamy Lowland range site; Lowland windbreak suitability group)

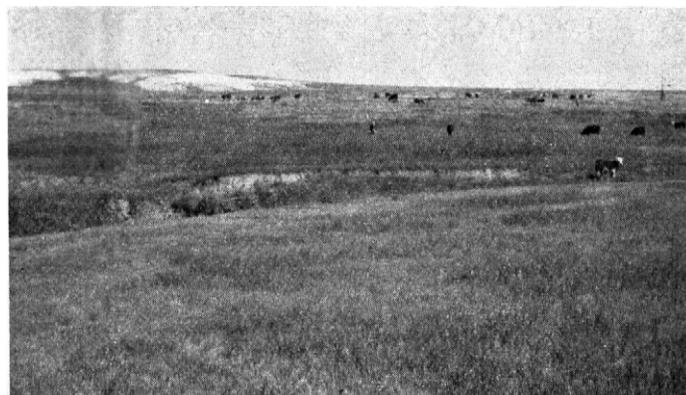


Figure 7.—Cattle grazing western wheatgrass on Alluvial land. Rock land is in the left background.

On the lower, smooth parts of the fans, some small areas of Bridgeport clay loam are mapped with this soil. Also included are small areas of shallow, gravelly soils.

This Bayard soil is suited to wheat and grain sorghum, but conserving moisture and controlling erosion by wind and water are problems. Stubble mulching and strip-cropping help protect the soil from erosion. Because of the complex slopes, contour farming and terracing are generally impractical, but they may be beneficial in some places. (Capability unit IIIe-6, dryland; capability unit IIs-1, irrigated; Sandy range site; Sandy Upland windbreak suitability group)

Bayard Series

Soils of the Bayard series are gently sloping, calcareous sandy loams that have a weakly developed profile. These soils are on alluvial fans. They are well drained and have moderate moisture-holding capacity. The native vegetation is grass.

In most places the surface layer is grayish-brown fine sandy loam about 6 inches thick. It has granular structure. The surface layer is porous and admits water readily, but it is susceptible to wind erosion when it is dry and unprotected.

The subsoil is mainly pale-brown, porous sandy loam, but it contains thin layers of clay loam and loamy sand. It is calcareous and contains a few lime concretions. The subsoil is easily penetrated by moisture and roots. Below the subsoil is calcareous, sandy local alluvium.

The texture of the surface layer and subsoil ranges from fine sandy loam to light loam. In places these soils contain scattered pebbles. In some places they are non-calcareous to a depth of 8 inches, but they are generally calcareous to the surface.

The Bayard soils are better drained than the Las Animas soils, and they lack mottling in the subsoil. They are less clayey than the Bridgeport soils.

Bayard fine sandy loam (0 to 3 percent slopes) (Ba).— This is the only Bayard soil mapped in the county. It is on alluvial fans, mainly on the north side of the valley of the Arkansas River, southeast of Garden City. The texture is the coarsest where this soil occurs on low, convex ridges that finger out from the mouth of the drainageways.

In areas of this soil below the mouths of the present water courses, where the drainageways flatten out, local flooding occurs. The flooding is infrequent and is of short duration.

Bridgeport Series

The Bridgeport soils are deep and loamy, and they have a weakly developed profile. They formed in alluvium on high terraces and fans in the valley of the Arkansas River. These soils are fertile and well drained, and their moisture-holding capacity is high. The native vegetation was grass.

In most places the surface layer is dark grayish-brown, granular, friable clay loam about 10 inches thick. It is generally calcareous, but it is noncalcareous in some areas. This layer is easily worked. It pulverizes, however, if tillage is excessive, and a crust forms after rains. A plowpan is likely to form if tillage is always at the same depth.

The subsoil is generally granular, porous clay loam. The upper part is brown, but the color grades to pale brown in the lower part. The subsoil is unmottled to a depth of at least 40 inches. It is calcareous and generally contains concretions or threads of lime below a depth of 18 inches. The subsoil is readily permeable to water and roots. Below the subsoil is calcareous, silty local alluvium.

The color of the surface layer is grayish brown in some places, instead of dark grayish brown. The thickness of that layer ranges from 6 to 12 inches. The texture of the surface layer and of the subsoil ranges from heavy loam to clay loam. In places there are thin layers of sandy loam in the subsoil.

The Bridgeport soils have a deeper root zone and better drainage in the subsoil than the Las soils. They are more clayey than the Bayard soils.

Bridgeport clay loam (0 to 1 percent slopes) (Bp).— This is the only Bridgeport soil mapped in the county. It is on nearly level alluvial fans and terraces on the north

side of the valley of the Arkansas River. The slopes are generally less than 1 percent, but in places they are as much as 2 percent. This soil is below the Richfield and Ulysses soils of the upland, but it is several feet higher than the Las and Las Animas soils of the bottom lands.

Where water from the Arkansas River has been used for a long period for irrigating this soil, as much as 10 inches of heavy silty clay loam has been deposited on the surface. About 10 percent of the acreage is Las clay loam.

Bridgeport clay loam is well suited to wheat and grain sorghum, but conserving moisture and controlling wind erosion are problems. Keeping plant residue on the surface will protect this soil from wind erosion when no crop is growing. Other practices that will help to conserve moisture and give protection from erosion are contour farming, stripcropping, and terracing. (Capability unit IIc-1, dryland; capability unit I-1, irrigated; Loamy Upland range site; Silty Upland windbreak suitability group)

Broken Land (Bx)

This land type occupies the steep, broken banks of the Pawnee River, a deeply entrenched, intermittent stream. Most of the areas are 150 feet or more wide and are continuous enough to be shown on the soil map. The slopes range from a minimum of 6 percent to almost vertical on streambanks. Whenever the drainageway carries water, this land is subject to flooding. This land type is unstable; the banks along the channel are actively eroding in many places. In other places material is deposited when flooding occurs.

It is difficult for grass to become established on this land. The land is not used for range, because the vegetation varies and the soil material is unstable. (Capability unit VIIw-1, dryland; not placed in an irrigated capability unit, range site, or windbreak suitability group)

Church Series

The Church series consists of deep, clayey, calcareous soils on benches around undrained basins. The soils are moderately well drained and are saline. The native vegetation was grass.

In most places the surface layer is dark grayish-brown, calcareous silty clay loam about 6 inches thick. It is hard when dry and friable when moist. If tillage is excessive, this layer pulverizes and a crust forms after rains. There is a gradual transition from the surface layer to the subsoil.

The subsoil is generally gray or light-gray, calcareous silty clay loam that has granular structure. It is very hard when dry and firm when moist, but it is permeable to moisture and roots. Below the subsoil is light-colored, strongly calcareous, lakebed material that is high in soluble salts.

The thickness of the surface layer ranges from 4 to 10 inches, and the color ranges from dark grayish brown to gray. The surface layer is generally calcareous, but it is noncalcareous in places. The texture of the surface layer and the subsoil ranges from silty clay loam to light clay. The degree of salinity ranges from slight to moderate. The location of the salts varies. In places there is a concentration of soluble salts within a few inches of the sur-

face, but a short distance away, the layer that contains soluble salts may be several feet below the surface. All variations between these two extremes occur. The soil layers that are saline generally contain a concentration of gypsum.

Church soils lack the columnar structure in the subsoil that is typical of the Drummond soils, and their subsoil is calcareous, rather than noncalcareous. They are more clayey and less well drained than the Ulysses soils.

Church silty clay loam (0 to 1 percent slopes) (Ch).—This is the only Church soil mapped in the county. It is on benches around undrained basins in the Scott-Finney depression. This soil occupies positions about halfway between the soils of the undrained basins and the associated Drummond, Richfield, and Ulysses soils. The water table is generally at a depth of 5 to 10 feet, but during periods of excessive rainfall, it may rise to within 2 feet of the surface.

Areas mapped as this soil include some small areas of Drummond and saline Richfield soils, and they also include a small acreage of saline Ulysses soils. The Drummond soils make up about 10 percent of the acreage, and the Richfield soils make up about 5 percent.

This Church soil is suited to wheat and grain sorghum, but yields are reduced to some extent, as a result of the salts in the soil and of the somewhat restricted soil drainage. Also, grain sorghum is affected by iron chlorosis. Conserving moisture and controlling wind erosion are additional problems. Good management of plant residue will help to control erosion and to conserve moisture. Contour farming and stripcropping are other desirable practices. (Capability unit IVs-3, dryland; capability unit IIIs-2, irrigated; Saline Upland range site; Saline Upland windbreak suitability group)

Colby Series

In the Colby series are calcareous soils that have a weakly developed profile. The soils are in the uplands. They are deep and have high moisture-holding capacity. The native vegetation was grass.

In most places the surface layer is grayish-brown loam or silt loam that has granular structure and is generally about 4 inches thick; its maximum thickness is 5 inches. This layer is easily worked but pulverizes if tillage is excessive. When dry, it blows easily.

The subsoil is mainly pale-brown loam or silt loam that has granular structure. It is calcareous and contains concretions or threads of lime. The subsoil is easily penetrated by moisture and roots. Below the subsoil is light-colored, calcareous, loamy material.

The color of the surface layer ranges from pale brown to dark grayish brown. These soils are generally calcareous to the surface, but the uppermost few inches is noncalcareous in some places.

The Colby soils are lighter colored and more calcareous than the Ulysses soils. Their profile is also less well developed.

Colby loam, saline (0 to 1 percent slopes) (Cs).—This soil is on low mounds in gently undulating areas of the Scott-Finney depression. It is nearly level.

In this soil the degree of salinity ranges from slight to moderate, but the location of the salts varies. In places there is an excessive concentration of soluble salts at a depth of only 18 inches, and in other places the saline

layer is at a depth of 5 feet. All variations between these two extremes occur. The soil layers that are saline generally contain a concentration of gypsum.

As a rule, the water table is 4 to 10 feet below the surface. It rises to within 2 feet of the surface, however, during periods of excessive rainfall.

Mapped with this soil are small areas of Otero fine sandy loam, saline Ulysses silt loam, and Drummond silt loam. Generally, about 5 percent of the acreage consists of the Otero soil, and about 10 percent consists of the Ulysses and Drummond soils.

This Colby soil is suited to wheat and grain sorghum, but the salinity reduces yields. Also, sorghum grown on it is affected by iron chlorosis. Conserving moisture and controlling wind erosion are additional problems. Good management of plant residue will help to control erosion and to conserve moisture. Contour farming and strip-cropping can also be used. (Capability unit IVs-3, dryland; capability unit IIIs-2, irrigated; Saline Upland range site; Saline Upland windbreak suitability group)

Drummond Series

Soils of the Drummond series have a loamy surface layer and a clayey subsoil; the subsoil contains an excessive amount of sodium and soluble salts. These soils are deep, moderately well drained, and nearly level. The native vegetation was grass.

In most places the surface layer is grayish-brown silt loam about 5 inches thick. Its structure is granular. In places the lower 1 to 2 inches of the surface layer is lighter colored than the upper part. The boundary between the surface layer and the subsoil is abrupt.

The upper part of the subsoil is generally dark-gray heavy silty clay loam. It normally has columnar structure, but it breaks to fine, blocky and subangular blocky structure. The lower part of the subsoil is grayish brown and lacks columnar structure. In most places the subsoil is about 8 inches thick. It is noncalcareous but high in sodium and soluble salts.

The layer just below the subsoil is calcareous and contains numerous crystals of gypsum. That layer is also high in sodium and soluble salts.

The substratum is light-colored, calcareous, loamy material.

The thickness of the surface layer ranges from 3 to 6 inches. In places plowing has mixed the material in the upper and lower parts of the surface layer so that the lighter colored material cannot be distinguished. The color of the subsoil ranges from dark gray to brown. In places the upper part of the subsoil lacks columnar structure. Depth to calcareous material ranges from 9 to 17 inches.

The noncalcareous subsoil and the columnar structure of the subsoil distinguish the Drummond from the Church soils. The columnar structure of the subsoil and the high content of sodium and soluble salts in the subsoil distinguish the Drummond from the Richfield soils.

Drummond silt loam (0 to 1 percent slopes) (Dr).—This is the only Drummond soil mapped in this county. It is generally in the lower part of the Scott-Finney depression. The water table is usually 6 to 12 feet below the surface, but during periods of excessive rainfall, it may rise to within 2 feet of the surface.

Areas of saline Richfield silt loam and a small acreage of saline Ulysses silt loam and Church silty clay loam are mapped with this soil. The Richfield soil makes up about 10 percent of the total acreage.

On this Drummond soil, wheat makes better yields than grain sorghum because it is less affected by salinity. The excessive sodium and soluble salts severely reduce yields (fig. 8). Conserving moisture and controlling wind erosion are problems. Good management of crop residue will help to control erosion and conserve moisture. Contour farming and strip-cropping can also be used on this soil. (Capability unit IVs-3, dryland; capability unit IVs-2, irrigated; Saline Upland range site; Saline Upland windbreak suitability group)

Harney Series

The Harney series consists of deep, nearly level, loamy soils of the upland. The soils are fertile and well drained, and they have high moisture-holding capacity. The native vegetation was grass.

In most places the surface layer is dark grayish-brown silt loam about 8 inches thick. Its structure is granular. The surface layer is easily worked, but if tillage is excessive, it pulverizes and a crust forms after rains. A plowpan is likely to form if tillage is always at the same depth. The transitional layer between the surface layer and the subsoil is about 5 inches thick.

The upper part of the subsoil is generally dark grayish-brown silty clay loam that has subangular blocky structure. The texture in the lower part of the subsoil ranges from heavy silty clay loam to light silty clay, and the structure in the lower part is more blocky than that in the upper part. The subsoil is generally about 14 inches thick. It is noncalcareous, but there is a layer of accumulated lime just below it.

The substratum is light-colored, calcareous, silty loess.

The thickness of the surface layer ranges from 5 to 10 inches, and that of the transitional layer between the surface layer and the subsoil ranges from 5 to 10 inches. The color of the subsoil ranges from dark grayish brown to brown, and the thickness of that layer, from 12 to 18



Figure 8.—Spotty growth of grain sorghum on Drummond silt loam.

inches. Depth to calcareous material ranges from 18 to 30 inches.

The lower part of the subsoil in the Harney soils is more clayey than that in the Richfield soils. The Harney soils have less clay in the upper part of the subsoil than the Spearville soils, and there is a thicker transitional layer between the surface layer and the subsoil.

Harney silt loam, 0 to 1 percent slopes (Hc).—This is the only Harney soil mapped in the county. It is in the uplands. Generally, about 10 percent of the acreage consists of Richfield silt loam, and 5 percent, of Spearville silty clay loam.

This Harney soil is well suited to wheat and grain sorghum. Conserving moisture and controlling wind erosion are the major problems. Keeping plant residue on the surface will conserve moisture and provide protection from erosion. Contour farming, stripcropping, and terracing are also desirable practices. (Capability unit IIc-1, dryland; capability unit I-1, irrigated; Loamy Upland range site; Silty Upland windbreak suitability group)

Humbarger Series

The Humbarger series consists of calcareous, loamy soils formed in alluvium. The soils are on the flood plains of the Pawnee River and its tributaries. They are deep, fertile, and well drained, and they have high moisture-holding capacity. The native vegetation was grass.

In most places the surface layer is grayish-brown, calcareous silt loam about 8 inches thick. The structure is granular. This layer is easily worked, but the structure breaks down if tillage is excessive.

The subsoil is generally light brownish-gray, calcareous, weakly stratified silt loam and loam. It has weak, granular structure. The subsoil is porous and takes water readily. Below the subsoil is calcareous, silty alluvium.

The color of the surface layer ranges from dark grayish brown to brown. The texture of the surface layer and the subsoil is mainly loam to light silty clay loam, but the subsoil contains some layers of sandy loam. These soils are generally calcareous to the surface, but they are non-calcareous to a depth of 6 inches in some places.

The Humbarger soils are less clayey and are not darkened to so great a depth as the Roxbury soils. Also, their subsoil is less well defined.

Humbarger silt loam (0 to 3 percent slopes) (Hu).—This is the only Humbarger soil mapped in the county. It is on the flood plains of the Pawnee River and its tributaries, but flooding is infrequent and of short duration. Most of the areas are nearly level, although the slopes are as steep as 3 percent in some areas.

In places this soil lies just below areas of Roxbury silt loam, which is on terraces. In other places it is several feet lower than the Roxbury soil. Mapped with it are small areas of Roxbury silt loam.

Wheat and grain sorghum are grown on this Humbarger soil (fig. 9), and alfalfa is grown in many areas. Conserving moisture and controlling wind erosion are problems. Keeping plant residue on the surface will provide protection against erosion and conserve moisture, and stripcropping can also be used. (Capability unit IIc-2, dryland; capability unit I-1, irrigated; Loamy Lowland range site; Lowland windbreak suitability group)



Figure 9.—Wheat on a field of Humbarger silt loam. The trees in the background are along the channel of the Pawnee River.

Keith Series

Soils of the Keith series are deep, nearly level, and loamy. They are fertile and well drained, and they have high moisture-holding capacity. These soils are in the uplands. The native vegetation was grass.

In most places the surface layer is dark grayish-brown loam about 9 inches thick. The structure is granular. This layer is easily worked, but it pulverizes if tillage is excessive, and a crust forms after rains. A plowpan is likely to form if tillage is always at the same depth. The transitional layer between the surface layer and the subsoil is about 6 inches thick.

The subsoil is generally grayish-brown, light clay loam, and it has subangular blocky structure. It is easily penetrated by moisture and roots. The subsoil is noncalcareous, but there is a layer of accumulated lime just below the subsoil.

The substratum is light-colored, calcareous, loamy loess.

The thickness of the surface layer ranges from 6 to 12 inches, and that of the transitional layer between the surface layer and the subsoil, from 4 to 8 inches. The subsoil ranges from dark grayish brown to brown in color and from 8 to 14 inches in thickness. Depth to calcareous material ranges from 15 to 30 inches.

The Keith soils are less clayey than the Richfield soils. They are darkened by organic matter and are leached of lime to a greater depth than the Ulysses soils. They also have a better defined subsoil.

Keith loam, 0 to 1 percent slopes (Kc).—This is the only Keith soil mapped in the county. It is in the uplands in the transitional zone between the sandy soils and the more clayey soils of the High Plains. In some areas the texture of the plow layer is fine sandy loam.

Small areas of Ulysses and Richfield silt loam are mapped with this soil. As much as 8 percent of the acreage is Ulysses silt loam, and about 4 percent is Richfield silt loam.

This Keith soil is well suited to wheat and grain sorghum. Conserving moisture and controlling wind erosion are the major problems in managing it. Keeping plant residue on the surface provides protection from erosion and helps to conserve moisture. Contour farming, stripcrop-

ping, and terracing are also desirable practices. (Capability unit IIc-1, dryland; capability unit I-1, irrigated; Loamy Upland range site; Silty Upland windbreak suitability group)

Las Series

The Las series consists of calcareous, loamy soils formed in alluvium in the valley of the Arkansas River. The soils have a weakly developed profile. They are moderately deep and deep and are imperfectly drained. The native vegetation was grass.

In most places the surface layer is grayish-brown clay loam about 8 inches thick. It has granular structure. This layer is easily worked, but it pulverizes if tillage is excessive, and a crust forms after rains.

The subsoil is generally light brownish-gray clay loam mottled with strong brown.

These soils are underlain at a variable depth by coarse sand and gravel. This coarse material limits the depth of the root zone and moisture-holding capacity of the soils. The water table is at a depth of 3 to 12 feet. The depth to the water table varies as the result of variations in the amount of precipitation and streamflow. In most places these soils are slightly saline, but they are moderately to strongly saline in some small areas. Below the subsoil is calcareous, loamy alluvium.

The texture of the surface layer and the subsoil ranges from heavy loam to clay loam and sandy clay loam. Small pebbles and layers of more sandy and more clayey material occur throughout the profile.

The Las soils have a more clayey, more coherent subsoil than the Las Animas soils, and they are less well drained and have a shallower root zone than the Bridgeport soils. The Las soils are lighter colored and have better drainage than the Sweetwater soils.

Las clay loam, deep (0 to 1 percent slopes) (lb).—This soil is on low stream terraces, about halfway between the low flood plains and the high terraces where the Bridgeport soils occur. Coarse sand and gravel are at a depth between 40 and 60 inches. The water table fluctuates, but it is normally 6 to 12 feet below the surface. A few small areas of Las Animas sandy loam are mapped with this soil.

This Las soil is suited to wheat and grain sorghum, but yields are reduced to some extent as the result of the fluctuating water table and the associated salinity. Conserving moisture and controlling wind erosion are additional problems. Managing crop residue well is the most effective way of conserving moisture and controlling erosion, but stripcropping can also be used. (Capability unit IIIw-3, dryland; capability unit IIw-1, irrigated; Saline Lowland range site; Saline Lowland windbreak suitability group)

Las clay loam, moderately deep (0 to 1 percent slopes) (lc).—This soil occurs with Las clay loam, deep, on low stream terraces. The terraces are about halfway between the low flood plains and the high terraces where the Bridgeport soils occur. Coarse sand and gravel are at a depth between 20 and 40 inches. The water table fluctuates, but it is normally 6 to 12 feet below the surface. A few small areas of Las Animas sandy loam are mapped with this soil.

Wheat and grain sorghum are the major crops grown on this Las soil. Yields are reduced to some extent as the result of the fluctuating water table and the associated salinity. Conserving moisture and controlling wind erosion are additional problems. Good management of crop residue is the most effective way of conserving moisture and controlling erosion, but stripcropping can also be used. (Capability unit IVw-2, dryland; capability unit IIIw-1, irrigated; Saline Lowland range site; Saline Lowland windbreak suitability group)

Las-Bayard sandy loams (0 to 2 percent slopes) (lc).—This complex is in the valley of the Arkansas River in areas that apparently have been reworked by wind to some extent. The topography is gently undulating. Las sandy loam makes up about 55 percent of the acreage, and Bayard sandy loam makes up about 35 percent. The Bayard soil occupies higher areas and is better drained than the Las soil. The Las soil is between the mounds occupied by the Bayard soil.

In the Las soil the thickness of the surface layer ranges from a few inches to as much as 15 inches. The surface layer is generally calcareous, but it is noncalcareous in some places. The subsoil is typical of that in the profile described for the Las series. Depth to coarse sand and gravel ranges from 3 to 6 feet.

The profile of the Bayard soils is like the one described for the Bayard series. In most places the Bayard soil is calcareous to the surface, but the surface layer is noncalcareous in some places. Depth to coarse sand and gravel ranges from 4 to 7 feet.

The water table is 7 to 12 feet below the surface. The Las soils are affected by the fluctuating water table, but the Bayard soils are well drained.

Mapped with the soils of this complex are areas of Las clay loam, deep. Generally, about 10 percent of the acreage consists of this included soil.

The soils of this complex are suited to wheat and grain sorghum. Conserving moisture and controlling wind erosion are problems. Stubble mulching will help protect these soils from erosion, and stripcropping is a desirable practice. Contour farming can be used, but it is generally impractical, because of the complex slopes. (Capability unit IIIe-6, dryland; capability unit IIs-1, irrigated; the Las soil is in the Saline Lowland range site, and the Bayard is in the Sandy range site; Sandy Upland windbreak suitability group)

Las-Las Animas complex (0 to 1 percent slopes) (ld).—This complex consists of moderately deep, nearly level Las and Las Animas soils on the flood plains of the Arkansas River (fig. 10). The soils occur where old, meandering streams deposited clay loam and sandy loam in an erratic pattern. Las soils make up about 55 percent of the acreage of the complex, and Las Animas soils make up about 30 percent.

In the soils of both series, the texture of the surface layer ranges from clay loam to sandy loam. The subsoil of the Las soil is like the one in the profile described for the Las series. That of the Las Animas soil is like the one in the profile described for the Las Animas series. Depth to coarse sand and gravel ranges from 20 to 40 inches. The water table fluctuates and is 3 to 6 feet below the surface.

Mapped with the soils of this complex are areas of Las Animas loamy sand and a few small areas of Sweetwater

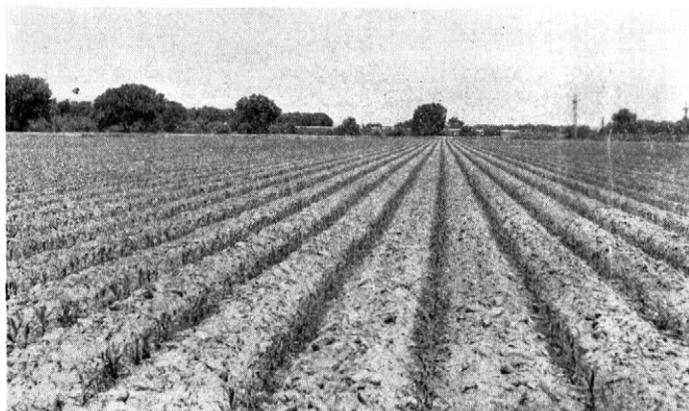


Figure 10.—A field of Las-Las Animas complex planted to grain sorghum. The trees in the background are along the channel of the Arkansas River and are on Las Animas and Lincoln soils.

clay loam. About 15 percent of the acreage consists of Las Animas loamy sand.

Wheat and grain sorghum are grown on this complex. Yields are reduced to some extent, however, as the result of the fluctuating water table and the associated salinity. Conserving moisture and controlling wind erosion are additional problems. Managing crop residue well is the most effective way of conserving moisture and controlling erosion, but stripcropping can also be used. (Capability unit IVw-2, dryland; capability unit IIIw-1, irrigated; Saline Subirrigated range site; Saline Lowland windbreak suitability group)

Las Animas Series

The Las Animas series consists of calcareous, sandy soils that have a weakly developed profile. These soils formed under native grasses in calcareous, sandy alluvium on the flood plains of the Arkansas River. They are moderately deep and are imperfectly drained. Their moisture-holding capacity is moderate.

In most places the surface layer is grayish-brown sandy loam or loamy sand that varies in thickness. It is porous and admits water readily, but it is susceptible to wind erosion when it is dry and unprotected.

The subsoil is generally brown sandy loam mottled with strong brown. Coarse sand and gravel underlie the subsoil at variable depths. This coarse material limits the moisture-holding capacity of the soils and the depth to which roots can penetrate. The water table is generally at a depth of 3 to 7 feet. When variations in the amount of precipitation and in streamflow have been extreme, however, the water table may be higher than 3 feet or lower than 7 feet from the surface. In most places the soils are slightly saline, but they are moderately to strongly saline in small areas.

The surface layer ranges from dark grayish brown to pale brown in color and from light loam to loamy sand in texture. The subsoil is dominantly sandy loam, but it contains layers of clay loam, loam, and loamy sand. Depth to strong-brown mottling ranges from 16 to 40 inches.

The Las Animas soils are more sandy than the Las soils, but they are less sandy and have a more coherent subsoil

than the Lincoln soils. The Las Animas soils are less well drained than the Bayard soils.

Las Animas sandy loam (0 to 1 percent slopes) (lk).—This soil occurs throughout the valley of the Arkansas River. The texture of its surface layer and subsoil ranges from sandy loam to light loam. Coarse sand and gravel underlie the subsoil at a depth of 24 to 40 inches.

Mapped with this soil are small areas of Las clay loam and of shallow Las Animas soils. About 10 percent of the acreage is Las clay loam, and about 5 percent is shallow Las Animas soils.

Las Animas sandy loam is well suited to wheat and grain sorghum. The fluctuating water table and the associated salinity limit the yields of crops. Conserving moisture and controlling wind erosion are additional problems. Managing plant residue well is the most effective way of conserving moisture and protecting this soil from erosion. However, stripcropping can also be used. (Capability unit IVw-2, dryland; capability unit IIIw-2, irrigated; Saline Subirrigated range site; Saline Lowland windbreak suitability group)

Las Animas-Lincoln loamy sands (0 to 2 percent slopes) (ll).—This complex occupies slightly irregular slopes in the valley of the Arkansas River. Las Animas soils make up about 55 percent of the acreage, and Lincoln soils make up about 35 percent. About 10 percent of the acreage is Las and Sweetwater soils.

The surface layer of the soils in this complex is loamy sand. The subsoil of the Las Animas soil is like that in the profile described for the Las Animas series, and the subsoil of the Lincoln soil is like that in the profile described for the Lincoln series. Depth to the coarse sand and gravel that underlies these soils is variable, ranging from 18 to 60 inches. The soils of this complex are deepest in the areas along the southern edge of the river valley, next to the sandhills. In that area a mantle of windblown sand apparently overlies the alluvium.

These soils are not suitable for cultivation, because of their low moisture-holding capacity and susceptibility to erosion. They are suited to grazing. Where they are grazed, a proper stocking rate is essential, and deferred grazing or rotation deferred grazing can be used. Locating fences, salt, and water properly will help distribute livestock over the range. Brush and trees can be controlled by chemical or mechanical means. The vegetation is largely switchgrass, alkali sacaton, Indiangrass, and western wheatgrass. (Capability unit VI-2, dryland; not placed in an irrigated capability unit; Saline Subirrigated range site; Saline Lowland windbreak suitability group)

Lincoln Series

The Lincoln series consists of sandy and gravelly soils that are subject to recurrent flooding. These soils formed in alluvium. Their fertility and moisture-holding capacity are very low. The vegetation is grass, trees, and brush.

In general these soils consist of fine sand and loamy fine sand, but the surface layer and the subsoil contain more loamy material in some places. Coarse sand is at a depth of less than 18 inches. The amount of gravel in these soils varies from place to place. The soils are noncalcareous.

ous in some places and calcareous in others. They are unmottled, except for some faint mottles in the loamy material. The underlying material is very sandy and gravelly alluvium.

The Lincoln soils are more sandy than the Las Animas soils. Also they lack mottling in the subsoil.

Lincoln soils (0 to 2 percent slopes) (lm).—These soils are adjacent to the Arkansas River and are about halfway between the channel and the nearly level flood plain. They are subject to recurrent flooding and to the resulting erosion and deposition of new material. The topography is irregular. Within the areas are numerous ridges of sand and low spots that roughly parallel the river. Depth to the water table varies as the result of differences in the level of the water in the river.

These soils support a sparse stand of mid and tall grasses, tamarisk, and cottonwoods. They have only limited value for grazing because they are unstable and the vegetation is extremely variable. (Capability unit VIIw-1, dryland; not placed in an irrigated capability unit, range site, or windbreak suitability group)

Lismas Series

In the Lismas series are soils that are steep and clayey. The depth of the root zone and the moisture-holding capacity of these soils is limited by the clay shale near the surface. Runoff is rapid; only a small amount of moisture penetrates the subsoil.

In most places the surface layer is grayish-brown, non-calcareous clay that is about 5 inches thick over shale. It is very hard when dry. The surface layer contains pebbles and small, angular fragments of limestone.

These soils formed in material weathered from non-calcareous, dense clay shale. The color of the shale, when moist, ranges from very dark gray to dark grayish brown with streaks of yellowish brown. In the shale are thin seams and crystals of gypsum.

The main variation in these soils is in the thickness of the soil material over shale. The maximum thickness is 12 inches. Where the soil material is thinnest, it consists of only 1 to 2 inches of slightly darkened, weathered material over shale.

Lismas clay (10 to 20 percent slopes) (ln).—This is the only Lismas soil mapped in the county. It is on steep, broken side slopes in the valley of the Pawnee River. The slopes are generally less than 20 percent, but some bare outcrops of shale form almost vertical escarpments. Thin plates of gypsum, and boulders that have weathered from the shale, are scattered over the surface. Mapped with this soil are small areas of Promise clay.

Lismas clay is not suitable for field crops. Also, grass does not grow well, because water does not penetrate this soil readily and is released slowly to plants. Grazing must be regulated to prevent the native grasses from being depleted. A proper stocking rate is essential, and deferred grazing or rotation deferred grazing can be used. Locating fences, salt, and water properly will help distribute livestock over the range. Adapted native grasses are little bluestem, side-oats grama, switchgrass, western wheatgrass, and blue grama. (Capability unit VIIs-3, dryland; not placed in an irrigated capability unit or windbreak suitability group; Shale Breaks range site)

Lofton Series

The Lofton series consists of soils that are deep and clayey. These soils are in slightly concave areas where runoff from surrounding areas is ponded. They have a compact subsoil that restricts the penetration of water and air. The native vegetation was grass.

In most places the surface layer is dark grayish-brown clay loam that has granular structure and is about 6 inches thick. The surface layer is difficult to till if it is either too wet or too dry. A plowpan is likely to form if tillage is always at the same depth.

The subsoil is generally gray clay that has blocky structure and is about 12 inches thick. It is very hard when dry and very firm when moist. The subsoil is slowly permeable to moisture and roots. It is noncalcareous, but a layer of lime has accumulated just below the subsoil.

The substratum is light-colored, calcareous, silty material.

The surface layer ranges from 5 to 10 inches in thickness. The color of the subsoil ranges from gray to dark gray. The degree of mottling in the subsoil and substratum ranges from none to distinct. Depth to calcareous material ranges from 15 to 30 inches.

The Lofton soils are less clayey and less compact than the Randall soils. They also have better surface drainage.

Lofton clay loam (0 to 2 percent slopes) (lo).—This soil is mainly on benches, about halfway between the well-drained soils of the uplands and the Randall soils in undrained depressions. Most of the areas are nearly level or slightly concave, but those on side slopes are as steep as 2 percent in some places.

This soil receives runoff from the surrounding slopes. Water ponds on the surface, and it sometimes damages crops. The soil is better suited to wheat than to grain sorghum.

Good management of crop residue will make the surface layer more porous so that more moisture will be taken in. The residue also protects this soil from erosion. Using practices that protect this soil from runoff from surrounding areas will help reduce ponding by holding the raindrops where they fall. (Capability unit IVw-1, dryland; not placed in an irrigated capability unit or windbreak suitability group; Clay Upland range site)

Mansic Series

The soils of the Mansic series are moderately steep. They are calcareous and are loamy. These soils are on the uplands. They are well drained and have high moisture-holding capacity. The native vegetation was grass.

In most places the surface layer is dark grayish-brown clay loam that is about 8 inches thick and has granular structure. This layer is friable and takes water readily, but it erodes easily. The soil material in the surface layer grades to that in the subsoil.

The subsoil is generally clay loam, and it has granular structure. It is brown in the upper part, but the color grades to very pale brown in the lower part. The subsoil is calcareous and contains numerous lime concretions. It is permeable to moisture and plant roots. Below the subsoil is loamy Plains outwash.

The texture of the surface layer ranges from heavy loam to clay loam. The reaction of the surface layer ranges from calcareous to noncalcareous. The texture of the subsoil ranges from medium to heavy clay loam.

The Mansic soils are more clayey and less silty than the Ulysses soils. Their subsoil lacks the strong accumulation of lime that is typical in the subsoil of the Mansker soils.

Mansic complex (0 to 15 percent slopes) (Mh).—This is a complex of Mansic clay loams, on the sides of narrow valleys, and of grayish-brown, loamy soils formed in alluvium on the floors of valleys. The Mansic soils occupy both sides of the valley walls. They make up about 57 percent of the acreage of the complex. The soils formed in alluvium are on valley floors that are less than 150 feet wide. They occupy about 20 percent of the acreage in the complex.

This complex occurs with Lismas clay, the soils of the Mansker-Potter complex, and Rock land, and areas of these associated soils were included in mapping. Inclusions of Lismas, Mansker, and Potter soils make up about 8 percent of the acreage in the complex, inclusions of Ulysses soils make up about 10 percent, and inclusions of Colby soils make up about 5 percent.

The soils of this complex are not suitable for cultivation, because the areas that are moderately steep are highly susceptible to erosion. They are productive if kept in grass. Grazing must be managed, however, so that growth of the best native forage plants will be encouraged. This can be done by using a proper stocking rate and practicing deferred grazing or rotation deferred grazing. Locating fences, salt, and water properly will help distribute livestock over the range. (Capability unit VIe-1, dryland; not placed in an irrigated capability unit; Loamy Upland range site; Silty Upland windbreak suitability group)

Mansker Series

In the Mansker series are calcareous, loamy soils of the upland. These soils are moderately deep over caliche, and they have a strong accumulation of lime in their subsoil. The native vegetation was grass.

In most places the surface layer is dark grayish-brown loam that is about 5 inches thick and has granular structure. It is calcareous and contains pebbles and fragments of caliche. The surface layer is friable and takes water readily, but it erodes easily.

The lower part of the subsoil is porous loam, so high in lime that it is white. This zone of lime accumulation is within 18 inches of the surface. It is penetrated by water and roots, but the soil material is massive and contains a variable amount of caliche fragments. Below this zone of lime accumulation, at a depth of 12 to 36 inches, is consolidated caliche.

The surface layer ranges from dark grayish brown to grayish brown in color and from loam to light clay loam in texture. The surface layer and subsoil both contain a varying amount of gravel and fragments of caliche.

The Mansker soils have a more calcareous subsoil than the Mansic soils, and they are shallower over caliche. They are less sloping and are deeper over caliche than the Potter soils.

Mansker-Potter complex (5 to 15 percent slopes) (Mm).—About 55 percent of the acreage of this complex is Mansker soils, and about 28 percent is Potter soils. A

profile of the Potter soils is described under the Potter series. The soils of this complex are on the sides of drainageways along the upper reaches of the Pawnee River. The Mansker soils are less sloping than the Potter soils, and they are mostly along the upper rim of the areas. The Potter soils occupy the steeper, more broken slopes. Outcrops of slightly weathered caliche are common within the areas.

Mapped with this complex are areas of Mansic clay loam. The Mansic soil makes up about 17 percent of the complex.

Because they have strong slopes and are shallow over caliche, the soils of this complex are not suitable for cultivation. They are productive, however, if they are properly managed and used as grassland. Deferred grazing or rotation deferred grazing can be used along with a proper stocking rate. These practices will maintain or improve the vigor of the native grasses and the composition of the stand. Locating fences, salt, and water properly will help distribute the livestock over the range. (Capability unit VIe-4, dryland; not placed in an irrigated capability unit or windbreak suitability group; the Mansker soils are in the Limy Upland range site, and the Potter are in the Rough Breaks range site)

Manter Series

Deep, noncalcareous, sandy soils that are nearly level and gently sloping are in the Manter series. These soils are fertile. They are well drained and have moderate moisture-holding capacity. The native vegetation was grass.

In most places the surface layer is dark grayish-brown fine sandy loam about 8 inches thick. It has granular structure and is porous. The surface layer takes water readily, but it is susceptible to wind erosion when it is dry and unprotected.

The subsoil has granular structure and is generally brown fine sandy loam about 18 inches thick. It is noncalcareous and is readily penetrated by moisture and roots. Just below the subsoil is calcareous, sandy, wind-deposited material that contains concretions and threads of lime. This sandy material is underlain, at variable depths, by calcareous silt loam or loam, which is generally within 5 feet of the surface.

In areas that have been cultivated, the surface layer consists of a thin, winnowed layer of loamy fine sand. The thickness of the surface layer and the depth to calcareous material vary according to the shape and degree of the slope. Depth to calcareous material ranges from 12 inches, on convex ridgetops, to 48 inches, on the concave slopes between the ridges. The texture of the subsoil ranges from fine sandy loam to light loam.

The Manter soils are darker and less calcareous than the Otero soils. They have a darker, less sandy surface layer than the Vona soils.

Manter fine sandy loam, level (0 to 1 percent slopes) (Mn).—In this soil the depth to calcareous material is generally more than 20 inches.

Areas of Keith and Ulysses soils were included with this soil in mapping. About 10 percent of the acreage is Keith soils, and about 5 percent is Ulysses soils.

This Manter soil is suited to wheat and grain sorghum, but conserving moisture and controlling wind erosion are

problems. Managing crop residue well is the most effective way of conserving moisture and providing protection from erosion. However, contour farming, stripcropping, and terracing can also be used. (Capability unit IIe-3, dryland; capability unit IIs-1, irrigated; Sandy range site; Sandy Upland windbreak suitability site)

Manter fine sandy loam, undulating (0 to 3 percent slopes) (Mr).—This soil is in areas of convex slopes separated by small, nearly level areas. The landscape where it occurs is dotted by small depressions where water is ponded briefly after rains.

Areas of Ulysses, Keith, Otero, and Vona soils were included with this soil in mapping. Ulysses soils occupy about 10 percent of the acreage; Keith soils, about 6 percent; and Otero soils, about 4 percent. Vona soils occupy only a small acreage.

This Manter soil is suited to wheat and grain sorghum, but conserving moisture and controlling wind erosion are problems. Stubble mulching helps to protect this soil from erosion, and stripcropping is another desirable practice. Contour farming and terracing may be beneficial in some places, but they are generally impractical, because of the complex slopes. (Capability unit IIIe-6, dryland; capability unit IIe-2, irrigated; Sandy range site; Sandy Upland windbreak suitability group)

Manter-Otero fine sandy loams, undulating (1 to 4 percent slopes) (Mt).—This is a complex of undulating Manter and Otero fine sandy loams. The Manter soils are in the less sloping, weakly convex to weakly concave areas, and the Otero are in the steepest, most convex areas. Manter soils make up about 50 percent of the acreage in the complex, and Otero soils make up about 30 percent. A profile of the Otero soils is described under the Otero series.

Areas of Keith and Ulysses soils were included with the soils of this complex in mapping. These included soils make up about 20 percent of the acreage.

Wheat and grain sorghum are the principal crops grown on this complex. Conserving moisture and controlling wind erosion are the major problems. Stubble mulching helps to protect these soils from erosion, and stripcropping can also be used. Contour farming and terracing may be used in some places, but they are generally impractical, because of the complex slopes. (Capability unit IVe-3, dryland; not placed in an irrigated capability unit; Sandy range site; Sandy Upland windbreak suitability group)

Otero Series

The Otero series consists of deep, calcareous, sandy soils that are undulating and moderately steep. These soils have a weakly developed, calcareous profile. They are well drained and have moderate moisture-holding capacity. The native vegetation was grass.

In most places the surface layer is brown fine sandy loam about 5 inches thick. Its structure is weak granular. The surface layer is porous and admits water readily, but it is susceptible to wind erosion when dry and unprotected.

The subsoil is generally brown, massive fine sandy loam that contains concretions and threads of lime. It is readily penetrated by moisture and roots. Below the subsoil is calcareous, wind-deposited, sandy material.

The color of the surface layer ranges from grayish brown to pale brown, and the thickness, from 4 to 10 inches.

Although these soils are generally calcareous to the surface, the surface layer is noncalcareous in some places. The subsoil contains thin layers of loam and loamy sand.

The Otero soils are lighter colored and more calcareous than the Manter soils. They are more calcareous than the Vona soils, and they have a less sandy surface layer.

Otero fine sandy loam, 5 to 15 percent slopes (Ot).—This moderately steep soil is on the sides of upland drainageways and on convex ridges. Mapped with it are small areas of Mansic clay loam and Manter fine sandy loam. Each of these included soils makes up about 10 percent of the acreage.

This Otero soil is too steep for cultivation, but it is productive of grass if it is properly managed. Using a proper stocking rate is essential, and deferred grazing or rotation deferred grazing is a good practice. Brush can be controlled by mechanical or chemical means. Sand bluestem, little bluestem, switchgrass, side-oats grama, and blue grama are among the native grasses that are suited to this soil. (Capability unit VIe-3, dryland; not placed in an irrigated capability unit; Sandy range site; Sandy Upland windbreak suitability group)

Otero gravelly complex (5 to 15 percent slopes) (Ox).—About 20 percent of this complex is Otero sandy loam, and about 65 percent is gravelly and very sandy soils. The profile of the Otero soils is like that described under the Otero series, but it contains more coarse sand and has small pebbles throughout. The gravelly soils consist of thin layers of soil material of different textures. The texture of the surface layer ranges from coarse sandy loam to coarse sand. A variable amount of gravel is on the surface and in the profile.

This complex is along the north side of the valley of the Arkansas River, east of Garden City. In general, the slopes are between 5 and 15 percent, but there are some short, broken slopes of more than 15 percent. The Otero soils are on the longer, smoother slopes, in many places below the mounds occupied by gravelly soils. The gravelly soils are on short, steep slopes.

Mapped with the soils of this complex are small areas of wind-deposited, calcareous loamy fine sands. Also included are sandy soils on the narrow bottoms of drainageways.

The soils of this complex are too steep and gravelly to be suitable for cultivation. They are well suited to grazing if they are properly managed to encourage the growth of the native grasses. Use of a proper stocking rate is essential, and deferred grazing or rotation deferred grazing are desirable practices. Locating fences, salt, and water properly will help distribute livestock over the range. The brush can be controlled by mechanical or chemical means. Sand bluestem, little bluestem, switchgrass, side-oats grama, and blue grama are among the native grasses suited to these soils. (Capability unit VIe-6, dryland; not placed in an irrigated capability unit or windbreak suitability group; the Otero soils are in the Sandy range site, and the gravelly soils are in the Gravelly Hills range site)

Otero-Ulysses complex, undulating (0 to 5 percent slopes) (Oy).—About 60 percent of this complex is Otero fine sandy loam, and 25 percent is Ulysses loam. The areas are undulating. The Otero soils occupy the sloping areas, and the Ulysses soils occupy the nearly level areas.

Small areas of Manter fine sandy loam and of Keith loam are mapped with the soils of this complex. The Manter soil makes up about 10 percent of the acreage, and the Keith soil makes up about 5 percent.

The soils of this complex are suited to wheat and grain sorghum. Conserving moisture and controlling wind erosion are problems in managing them. Stubble mulching will help protect the soils from erosion, and stripcropping is a desirable practice. Contour farming and terracing can be used in some places, but they are generally impractical, because of the complex slopes. (Capability unit IVE-3, dryland; capability unit IIE-2, irrigated; the Otero soil is in the Sandy range site and Sandy Upland windbreak suitability group; the Ulysses soil is in the Loamy Upland range site and Silty Upland windbreak suitability group)

Potter Series

The Potter series consists of calcareous, loamy soils that are shallow over caliche. These soils are in the uplands. The depth of their root zone is limited by consolidated caliche.

In most places the surface layer is grayish-brown loam that has granular structure and is about 10 inches thick. The surface layer contains pebbles and fragments of caliche. An abrupt boundary separates the surface layer from the underlying consolidated caliche. The caliche is many feet thick.

The surface layer ranges from 4 to 12 inches in thickness over the caliche beds. Its texture ranges from loam to silt loam, and there are varying amounts of pebbles and fragments of caliche.

In this county the Potter soils occur with the Mansker soils and are mapped with those soils in the Mansker-Potter complex. They are more sloping and are less deep over caliche than the Mansker soils.

The Potter soils are too steep and too shallow over caliche to be suitable for cultivation. However, they produce grass for livestock.

Promise Series

The Promise series consists of deep, calcareous, clayey soils that are gently sloping. The soils are in the uplands. They have high moisture-holding capacity, but they take in water slowly and release it slowly to plants.

In most places the surface layer is dark grayish-brown clay about 4 inches thick. Its structure is granular. This layer is difficult to work if it is either too wet or too dry. It pulverizes if tillage is excessive, and a crust forms after rains.

The subsoil is generally grayish-brown clay that has blocky structure. It is very hard when dry and very firm when moist. The dense subsoil restricts the movement of water and air. Small pebbles are scattered throughout the subsoil, and the lower part of the subsoil contains threads and crystals of gypsum. The subsoil is about 30 inches thick. It is underlain by less clayey, more friable material that is local alluvium washed from shale.

The color of the surface layer ranges from dark grayish brown to grayish brown. In places the structure of the subsoil is blocky, and in other places it is subangular

blocky. The clayey material ranges from 12 to 48 inches in thickness over stratified material. The texture of the stratified material ranges from clay loam to coarse sandy loam.

Promise clay, 1 to 3 percent slopes (Pc).—This is the only Promise soil mapped in the county. It occurs along the sides of the valley of the Pawnee River. In places the shale from which this soil was derived is at the top of the slopes. In other places it has been eroded away. At the base of the slopes, the clayey sediments, washed from the shale, feather out over the loamy soil material on the valley floor.

Areas of Lismas clay and Mansic clay loam are mapped with this soil. These included soils make up less than 10 percent of the acreage.

Because of the droughty subsoil, wheat does better than grain sorghum on this Promise soil. Careful management is needed to maintain the favorable structure and tilth of the surface layer. Additional problems are conserving moisture and controlling erosion by water and wind. Terraces, contour farming, and good management of plant residue will control runoff and help to protect this soil from erosion. Stripcropping is another desirable practice. (Capability unit IVE-10, dryland; not placed in an irrigated capability unit or windbreak suitability group; Clay Upland range site)

Randall Series

The Randall series consists of compact silty clays in undrained depressions that receive runoff from surrounding areas. These soils have very slow permeability. The native vegetation was grass.

The surface layer is gray clay or silty clay, and the subsoil is clayey and has blocky structure. These soils are very hard when dry and very firm when moist. Reaction ranges from calcareous at the surface to noncalcareous at a depth of 48 inches. The silty clay is 24 to 48 inches thick over the substratum of more permeable, loamy material. These soils formed in areas that receive an excessive amount of moisture.

The Randall soils are more clayey, more compact, and less well drained than the Lofton soils. Also they lack the strongly defined subsoil that is characteristic of the Lofton soils.

Randall clay (0 to 1 percent slopes) (Rc).—This is the only Randall soil mapped in this county. It is in depressions that range from a few inches to almost 10 feet in depth. The depressions occur throughout the plains area. They range from less than 10 acres to more than 80 acres in size.

This soil is generally farmed along with the adjoining soils. The crops are frequently drowned out, however, or the areas are too wet for a crop to be planted. The frequency and amount of ponding are variable in the different depressions, depending on the extent of the drainage area. Wind erosion is a hazard when the areas are bare and dry.

Ponding is a hazard to the native grasses. Most areas of this soil that are not cultivated are either bare or have a sparse stand of western wheatgrass. In many places burragweed and smartweed grow in the depressions. (Capability unit VIW-2, dryland; not placed in an irrigated capability unit, range site, or windbreak suitability group)

Richfield Series

In the Richfield series are deep, nearly level and gently sloping, loamy soils of the upland. These soils are fertile. They are well drained and have high moisture-holding capacity. The native vegetation was grass.

In most places the surface layer is dark grayish-brown silt loam about 6 inches thick. Its structure is granular. This layer is easily worked, but it pulverizes if tillage is excessive, and a crust forms after rains. A plowpan is likely to form if tillage is always at the same depth. The transitional layer between the surface layer and the subsoil is about 4 inches thick.

The subsoil has subangular blocky structure and is generally dark grayish-brown silty clay loam about 12 inches thick. It is hard when dry and firm when moist, but it is permeable to moisture and roots. It is noncalcareous, but there is a layer of accumulated lime just below the subsoil.

The substratum is light-colored, calcareous, silty loess.

The thickness of the surface layer ranges from 5 to 10 inches, that of the transitional layer between the surface layer and the subsoil ranges from 2 to 6 inches, and that of the subsoil ranges from 8 to 14 inches. Depth to calcareous material ranges from 12 to 20 inches.

The Richfield soils have a less clayey, less compact subsoil than the Spearville soils, and they are more clayey and have a more strongly defined subsoil horizon than the Ulysses soils. The Richfield soils have a more clayey subsoil than the Keith soils. The lower part of their subsoil is less clayey than that of the Harney soils.

Richfield silt loam, 0 to 1 percent slopes (Rm).—This nearly level soil is in the uplands. It has a thicker profile than the more sloping Richfield soils. Depth to calcareous material ranges from 15 to 20 inches.

In the northwestern part of the county, areas of Ulysses silt loam and Keith loam are mapped with this soil. In the central and eastern parts, small areas of Harney silt loam and of Spearville silty clay loam are mapped with it. The Ulysses soil makes up about 10 percent of the acreage, and the Keith soil, about 5 percent.

This Richfield soil is well suited to wheat and grain sorghum. Conserving moisture and controlling wind erosion are the major problems in managing it. Keeping plant residue on the surface will conserve moisture and provide protection from erosion. Contour farming, stripcropping, and terracing are other good practices. (Capability unit IIc-1, dryland; capability unit I-1, irrigated; Loamy Upland range site; Silty Upland windbreak suitability group)

Richfield silt loam, 1 to 3 percent slopes (Rn).—This gently sloping soil is in the uplands, mainly in the area drained by the Pawnee River. The profile is thinner than that of Richfield silt loam, 0 to 1 percent slopes. Depth to calcareous material ranges from 12 to 16 inches.

Mapped with this soil are small areas of Ulysses silt loam. The Ulysses soil occupies as much as 10 percent of the acreage.

This Richfield soil is well suited to wheat and grain sorghum. Conserving moisture and controlling erosion by water and wind are problems in managing it. Terraces, contour farming, and good management of plant residue will help to control runoff and erosion. Contour stripcropping is also a good practice. (Capability unit IIe-1, dryland; capability unit IIe-4, irrigated; Loamy

Upland range site; Silty Upland windbreak suitability group)

Richfield silt loam, saline (0 to 1 percent slopes) (Ro).—This nearly level soil is in the Scott-Finney depression. It is slightly to moderately saline at depths ranging from 16 inches to more than 5 feet. This soil contains an accumulation of white crystalline salts (calcium sulfate) in the substratum, generally in the same zone as the soluble salts. Profiles of buried soils underlie this soil in many places. In some areas this soil is calcareous to the surface, and in other areas it is noncalcareous to a depth of as much as 18 inches.

Mapped with this soil are small spots of Drummond silt loam that are generally less than 50 feet in diameter. The Drummond soil makes up about 12 percent of the acreage. Another 8 percent is saline Ulysses silt loam.

Wheat and grain sorghum are the principal crops grown on this saline Richfield soil. The growth of crops is uneven, because of variability in the degree of salinity and in the location of the concentration of soluble salts in the profile. The closer the salts are to the surface, the more the growth of crops is retarded. The growth of crops is especially variable where the supply of moisture is low.

Conserving moisture and controlling wind erosion are additional problems in managing this soil. Good management of plant residue is important. Contour farming, stripcropping, and terracing are also desirable practices. (Capability unit III-4, dryland; capability unit II-4, irrigated; Saline Upland range site; Saline Upland windbreak suitability group)

Richfield-Spearville complex, 0 to 1 percent slopes (Rs).—This complex of nearly level soils is on the plain between the Scott-Finney depression and the area drained by the Pawnee River. Richfield silt loam makes up about 55 percent of the acreage, and Spearville silty clay loam makes up about 30 percent. The profile of the Richfield soil is like the one described for the Richfield series, and the profile of the Spearville soil is like the one described for the Spearville series.

Mapped with the soils of this complex are small areas of Harney silt loam and a few small areas of Ulysses silt loam. The Harney soil makes up about 10 percent of the acreage.

The soils of this complex are suited to wheat and grain sorghum. Wheat does better than sorghum on the Spearville soil, however, because of the droughty subsoil. Conserving moisture and controlling wind erosion are the major management problems. Keeping plant residue on the surface will help to conserve moisture and provide protection from erosion. Additional practices that are desirable are contour farming, stripcropping, and terracing. (Capability unit IIc-1, dryland; capability unit I-1, irrigated; the Richfield soil is in the Loamy Upland range site, and the Spearville soil is in the Clay Upland range site; Silty Upland windbreak suitability group)

Richfield and Ulysses complexes, bench leveled (0 to 1 percent slopes) (Ru).—These complexes consist of areas of Richfield, Ulysses, Colby, and Keith soils that have been leveled for irrigation. As a result of cutting and filling, the soils are so intermingled that they cannot be mapped separately. Not every area contains soils of all these series. Every area, however, contains some Richfield or Ulysses soils, or both, in combination with Colby or Keith soils. In some areas soils of both the Colby

and Keith series occur. The areas indicated on the soil map as Richfield and Ulysses complexes, bench leveled, are those in the county at the end of 1960. Since 1960, many other areas have been bench leveled, but they are not shown on the soil map as a part of this mapping unit.

Leveling has affected the soils in several ways. In areas where some soil material has been removed, the subsoil is exposed at the surface. The kind of soil material that is now cultivated depends on the depth to which soil material has been removed and on the characteristics of the original soil. The Colby soils are mainly in areas where soil material from the Richfield, Ulysses, and Keith soils has been removed to a considerable depth. Where there are fill areas, the soil material is stratified. Texture, color, and reaction are affected by the various sources of the fill material and the mixing of that material. In some areas where the layer of fill material is as thick as 20 inches, the soil series to which the soils belong cannot be identified.

Much of the leveling has been done in areas where the soils originally had a slope of less than 1 percent. Cuts of as much as 5 feet have been made in small areas that had an original slope of more than 1 percent, however, so that fields could be squared. The difference in elevation between the benches is generally about 1 to 2 feet.

A few areas of undulating Ulysses loam have been leveled. Originally, these areas had slopes of between 0 and 3 percent. A few small areas of Manter fine sandy loam have also been leveled along with some of the Keith and Ulysses soils, and a few depressions where Randall clay occurs have been filled. In these areas that were formerly depressions, the slowly permeable layer of clay below the fill material restricts the movement of water and air. Crops grown on such areas are damaged if the soil is saturated for too long after a rain, because of the lack of adequate subsurface drainage.

In some places leveling has exposed light-colored, calcareous material that is low in fertility. The growth of crops is generally reduced on these highly calcareous areas for at least several years after the areas are leveled. Iron chlorosis commonly affects young sorghum plants grown on them. Where residue from crops or animals is worked into the soils in cut areas, it helps to improve the fertility and structure of the soils.

All of the acreage of these complexes is irrigated. The soils are suited to sorghum, wheat, sugar beets, alfalfa, and other irrigated crops. (Capability unit I-1, irrigated; not placed in a dryland capability unit or windbreak suitability group; Loamy Upland range site)

Rock Land (Rw)

This land type is on the steep sides of drainageways that empty into the Pawnee River (fig. 11) and along the north side of the valley of the Pawnee River. Soils that occur with it are Lismas clay and Mansic clay loam. About 45 percent of the acreage of this land type consists of calcareous, loamy soils that are shallow over limestone; about 30 percent consists of outcrops of limestone; about 15 percent consists of deep, calcareous, loamy soils on foot slopes below the outcrops of limestone; and about 10 percent consists of areas of Mansic clay loam and of Lismas clay.

The topography where this land type occurs is rough and broken, and the slopes are generally between 10 and 20

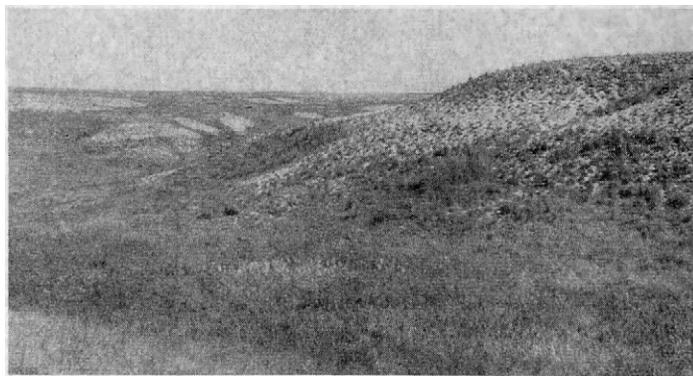


Figure 11.—Rock land on the sides of a drainageway.

percent. Some limestone outcrops form almost vertical escarpments.

Because the soils are shallow over limestone and the areas contain limestone outcrops, this land is not suitable for cultivation. The areas may be grazed if care is taken to prevent overgrazing. If excessive grazing is allowed, however, the areas become eroded. The dominant grasses on this land type are little bluestem and side-oats grama. Deferred grazing or rotation deferred grazing can be used along with a proper stocking rate to maintain or improve the range. Locating water, fences, and salt properly will help to distribute livestock over the range. (Capability unit VIIIs-2, dryland; not placed in an irrigated capability unit or windbreak suitability group; Rough Breaks range site)

Roxbury Series

The Roxbury series consists of deep, loamy soils on low stream terraces in the valley of the Pawnee River and its major tributaries. The soils formed in alluvium. They are fertile and well drained, and they have high moisture-holding capacity. The native vegetation was grass.

In most places the surface layer is dark grayish-brown, calcareous silt loam about 12 inches thick. The structure is granular. This layer is easily worked, but the structure breaks down if tillage is excessive.

The subsoil is generally dark grayish-brown, calcareous silty clay loam that has subangular blocky structure. It takes water readily. The lower part of the subsoil contains concretions and threads of lime. Below the subsoil is calcareous, silty alluvium.

The texture of the surface layer ranges from silt loam to loam. The color of the surface layer and subsoil ranges from dark grayish brown to grayish brown. In places the structure of the subsoil is granular, rather than subangular blocky. Depth to calcareous material ranges from 0 to 12 inches.

The Roxbury soils are more clayey than the Humbarger soils. Also, they have been darkened to a greater depth by organic matter, and they have a more strongly defined subsoil.

Roxbury silt loam (0 to 1 percent slopes) (Rx).—This is the only Roxbury soil mapped in this county. It is mainly nearly level, but the slopes are as steep as 2 percent in places.

Small areas of Humbarger silt loam are mapped with this soil. The Humbarger soil makes up about 10 percent of the acreage.

Wheat and grain sorghum are the principal crops grown on this Roxbury soil, but alfalfa is also grown in many places. Conserving moisture and controlling wind erosion are management problems. Stubble mulching helps to conserve moisture and to protect this soil from erosion. Stripcropping is also a desirable practice, and contour farming and terracing can be used where the area is suitable. (Capability unit IIc-2, dryland; capability unit I-1, irrigated; Loamy Upland range site; Silty Upland windbreak suitability group)

Spearville Series

In the Spearville series are deep, nearly level and gently sloping, clayey soils of the upland. These soils are fertile and well drained. They have high moisture-holding capacity, but their compact subsoil restricts the penetration of water and air. The native vegetation was grass.

In most places the surface layer is dark grayish-brown silty clay loam about 6 inches thick. Its structure is granular. This layer is difficult to work if it is either too wet or too dry. If tillage is excessive, it pulverizes and a crust forms after rains. A plowpan is likely to form if tillage is always at the same depth. The transitional layer between the surface layer and the subsoil is less than 2 inches thick.

The subsoil is generally dark grayish-brown silty clay that has blocky structure and is about 10 inches thick. The subsoil is very hard when dry and very firm when moist, and it is slowly permeable to moisture and roots. It is noncalcareous, but a layer where lime has accumulated lies just below the subsoil.

The substratum is light-colored, calcareous, silty loess.

The surface layer ranges from 5 to 10 inches in thickness, and the subsoil, from 8 to 14 inches. The color of the subsoil ranges from dark grayish brown to brown. Depth to calcareous material ranges from 12 to 20 inches, but it is about 16 inches in most places.

The Spearville soils have a more clayey, more compact subsoil than the Richfield soils. The upper part of their subsoil is more clayey than that of the Harney soils, and there is a thinner transitional layer between the surface layer and the subsoil.

Spearville silty clay loam, 0 to 1 percent slopes (Sp).—This nearly level soil is in the uplands. Mapped with it are small areas of Richfield and Harney silt loams. The Richfield soil makes up about 10 percent of the acreage, and the Harney soil, about 5 percent.

Because of the droughty subsoil, this Spearville soil is better suited to wheat than grain sorghum. Careful management is required to maintain favorable structure and good tilth in the surface layer. Also, conserving moisture and controlling wind erosion are problems, and good management of plant residue is important. Contour farming, stripcropping, and terracing are desirable practices. (Capability unit IIs-3, dryland; capability unit IIs-2, irrigated; Clay Upland range site; Silty Upland windbreak suitability group)

Spearville complex, 1 to 3 percent slopes, eroded (Sr).—About 75 percent of the acreage of this complex is eroded Spearville soils, and about 20 percent is eroded

clay loams, other than Spearville soils, that are calcareous within 6 inches of the surface. The Spearville soils have a surface layer of heavy silty clay loam or light silty clay. Erosion has caused their surface layer to be more clayey than that of the normal Spearville soils. Silty clay from the subsoil has been mixed into the plow layer. Depth to calcareous material ranges from about 6 to 12 inches.

The eroded clay loams have a surface layer that is dark grayish brown to brown and has subangular blocky structure. The texture of their surface layer ranges from medium to heavy clay loam or silty clay loam. The lighter colored spots are calcareous to the surface. These clay loams become less clayey with increasing depth. They are underlain by material similar to that beneath the Spearville soils. Included areas of Richfield soils make up about 5 percent of the acreage of this complex.

Because the soils of this complex are somewhat droughty, they are better suited to wheat than to grain sorghum. Careful management is required to maintain favorable structure and good tilth in the surface layer. Conserving moisture and controlling water and wind erosion are major problems. Terraces, contour farming, and good management of plant residue are essential, and stripcropping is a desirable practice. (Capability unit IIIe-4, dryland; not placed in an irrigated capability unit; Clay Upland range site; Silty Upland windbreak suitability group)

Sweetwater Series

Poorly drained, calcareous, loamy soils in the valley of the Arkansas River are in the Sweetwater series. These soils are shallow over coarse sand and gravel. This coarse material is generally at a depth of less than 24 inches. The native vegetation was grass.

In most places the surface layer is gray clay loam that has granular structure. It is about 8 inches thick.

The subsoil is also clay loam that has granular structure, but its color ranges from gray to very dark gray with many mottles of strong brown. It is about 7 inches thick.

Beneath the subsoil is coarse sand and gravel. The water table is at a depth between 10 and 36 inches. Salinity ranges from slight to moderate.

The Sweetwater soils are darker colored and more poorly drained than the Las soils. They are darker colored, more clayey, and more poorly drained than the Las Animas soils.

Sweetwater clay loam (0 to 1 percent slopes) (Sw).—This is the only Sweetwater soil mapped in the county. It occurs in the lowest areas on the flood plains of the Arkansas River.

Mapped with this soil are small areas of Las clay loams and of Las Animas sandy loam. The Las soils make up about 10 percent of the acreage, and the Las Animas soil makes up about 5 percent.

This Sweetwater soil is not suited to cultivation, because it is too wet and has a shallow root zone. It is among the most productive soils for grass in the county, and it is used for grazing and meadow. Deferred grazing or rotation deferred grazing can be used along with a proper stocking rate to maintain or improve the quality of the grass. Switchgrass, alkali sacaton, Indiangrass, and western wheatgrass are among the adapted native grasses. (Capability unit Vw-1, dryland; not placed in an irrigated

capability unit; Saline Subirrigated range site; Saline Lowland windbreak suitability group)

Tivoli Series

The Tivoli series consists of deep, noncalcareous, very sandy soils in areas of steep, dunny topography. The soils are low in fertility and have excessive internal drainage. The native vegetation was grass.

In most places the surface layer is brown fine sand or loamy fine sand about 4 inches thick. It absorbs water rapidly, and there is little or no runoff. It blows easily when it is not protected by vegetation.

The subsoil is generally light yellowish-brown fine sand. Its moisture-holding capacity is low, but a large part of the moisture taken in is held available to plants. Below the subsoil is noncalcareous, wind-deposited fine sand.

The surface layer ranges from brown to pale brown in color and from 2 to 8 inches in thickness. The color of the subsoil is yellowish brown to very pale brown.

The Tivoli soils are more sandy than the Vona, and they lack a calcareous layer just below the subsoil. Also, they are in areas where the topography is more strongly sloping than that where the Vona soils occur.

Tivoli fine sand (8 to 20 percent slopes) (Tf).—This soil occurs in a broad band along the south side of the valley of the Arkansas River. The topography is choppy and dunny. Small blowout areas are scattered over the landscape.

Areas of Vona loamy fine sand are mapped with this soil. The Vona soil makes up about 10 percent of the acreage.

This Tivoli soil is not suited to cultivation, because of its low fertility and susceptibility to erosion. Sand bluestem, switchgrass, little bluestem, and big sandreed are among the grasses that will grow on it. Sand sagebrush is a problem in a large part of the acreage. It must be controlled if the range is to be improved. A proper stocking rate is essential where this soil is used for range. Deferred grazing or rotation deferred grazing can also be used. Locating fences, salt, and water properly will help to distribute livestock over the range. (Capability unit VIIe-1, dryland; not placed in an irrigated capability unit or windbreak suitability group; Choppy Sands range site)

Tivoli-Dune land complex (5 to 20 percent slopes) (Tx).—This complex is a mixture of areas of Tivoli fine sand and of active dunes that are less than 20 acres in size. The composition of the complex ranges from 60 to 80 percent Tivoli fine sand and from 20 to 40 percent active dunes.

The dunes are almost bare of vegetation. The loose sands, a constant menace to adjacent areas, shift back and forth as they are blown about by wind. Fencing the areas to keep livestock out, and reseeding to native grasses, will help to stabilize the areas. Sand bluestem, switchgrass, little bluestem, and big sandreed are among the grasses that will grow on these soils.

Control of sand sagebrush is necessary if the range is to be improved. A proper stocking rate is essential where these soils are used for range. Deferred grazing or rotation deferred grazing can also be used. Locating fences, salt, and water properly will help to distribute livestock over the range. (Capability unit VIIe-1, dryland; not

placed in an irrigated capability unit or windbreak suitability group; Choppy Sands range site)

Tivoli-Vona loamy fine sands (3 to 8 percent slopes) (Tv).—About 50 percent of this complex is Tivoli loamy fine sand, and 50 percent is Vona loamy fine sand. These soils occur in undulating areas of low dunes (fig. 12). The Tivoli soils occupy most of the high areas, or knolls, and Vona soils occupy the lower, smoother areas. The profile of the Vona soils is like the one described for the Vona series.

Mapped with this complex are small areas of Otero-Ulysses complex, undulating.

The Tivoli and Vona loamy fine sands of this complex are not suited to cultivation, because of their susceptibility to erosion. Sand bluestem, little bluestem, switchgrass, side-oats grama, and big sandreed are among the grasses that will grow on these soils. Sand sagebrush is a problem on much of the acreage.

Controlling brush and managing the range properly will encourage the growth of the native grasses. A proper stocking rate is essential where these soils are used for range, and deferred grazing or rotation deferred grazing is a good practice. Locating fence, salt, and water properly will help to distribute livestock over the range. (Capability unit VIe-2, dryland; not placed in an irrigated capability unit; Sands range site; Sandy Upland windbreak suitability group)

Ulysses Series

The Ulysses series consists of deep, loamy, well-drained, nearly level to sloping soils of the upland. These soils are fertile, and they have high moisture-holding capacity. The native vegetation was grass.

In most places the surface layer is dark grayish-brown silt loam about 6 inches thick. It has granular structure. It is easily worked, but if tillage is excessive, the soil material pulverizes and a crust forms after rains. When dry, the soil material blows easily.

The subsoil is generally dark grayish-brown, friable silt loam or light silty clay loam. It is easily penetrated by moisture and roots. Below the subsoil is light-colored, calcareous, silty loess.

The thickness of the surface layer ranges from 4 to 8 inches. Where the Ulysses soils occur with more sandy



Figure 12.—An area of range where Tivoli-Vona loamy fine sands are in the foreground and Tivoli fine sand is in the background.

soils, the texture of the surface layer is loam and the texture of the subsoil is loam or light clay loam. The subsoil of the Ulysses soils is poorly defined, and its structure ranges from granular to subangular blocky. Its reaction ranges from calcareous at the surface to noncalcareous to a depth of 15 inches.

The Ulysses soils are less clayey than the Richfield soils, and they have a more poorly defined subsoil than the Richfield and Keith soils. They are not dark colored to so great a depth as are the Keith soils. The Ulysses soils are darker colored and less calcareous than the Colby soils, and their subsoil is more strongly defined.

Ulysses silt loam, 0 to 1 percent slopes (Uc).—This is a nearly level soil of the uplands. It is generally more clayey and less calcareous than the sloping Ulysses soils. Small areas of Richfield and Keith soils were included in mapping. About 10 percent of the acreage is Richfield silt loam, and about 5 percent is Keith loam.

This Ulysses soil is well suited to wheat and grain sorghum, but conserving moisture and controlling wind erosion are problems. Keeping plant residue on the surface will provide protection from erosion and conserve moisture. Contour farming, stripcropping, and terracing are also desirable practices. (Capability unit IIc-1, dryland; capability unit I-1, irrigated; Loamy Upland range site; Silty Upland windbreak suitability group)

Ulysses silt loam, 1 to 3 percent slopes (Ub).—This soil is on weakly convex slopes. In much of the acreage, it is calcareous to the surface.

Where this soil occurs with more sandy soils, areas of Manter fine sandy loam make up as much as 5 percent of the acreage. Small areas of Richfield silt loam and a small acreage of Keith loam were also included in mapping. The Richfield soil makes up about 12 percent of the acreage.

This Ulysses soil is well suited to wheat and grain sorghum, but conserving moisture and controlling erosion by wind and water are problems. Terraces, contour farming, and good management of plant residue are essential. Stripcropping is also a good practice. (Capability unit IIIe-1, dryland; capability unit IIe-4, irrigated; Loamy Upland range site; Silty Upland windbreak suitability group)

Ulysses silt loam, 3 to 5 percent slopes (Uc).—This soil is on weakly convex slopes, mainly within the drainage area of the Pawnee River. Much of it is calcareous to the surface. Mapped with it are small areas of Richfield and Mansic soils and a small acreage of Mansker soils. About 7 percent of the acreage is Richfield silt loam, and about 5 percent is Mansic clay loam.

Wheat and grain sorghum are the main crops grown on this Ulysses soil. Conserving moisture and controlling erosion by wind and water are the principal management problems. Terraces, contour farming, and good management of plant residue are essential, and stripcropping is a good practice. (Capability unit IVe-2, dryland; not placed in an irrigated capability unit; Loamy Upland range site; Silty Upland windbreak suitability group)

Ulysses-Colby silt loams, 1 to 3 percent slopes, eroded (Ue).—This complex of Ulysses and Colby soils is on weakly convex slopes. Ulysses silt loam makes up 50 to 65 percent of the acreage, and Colby silt loam makes up 25 to 40 percent. About 10 percent of the acreage is Richfield silt loam.

The areas of Colby silt loam were formerly Ulysses silt loam, but erosion stripped away the dark-colored, original surface layer and exposed the lighter colored, more calcareous subsoil. The Colby soil of this complex is generally on the tops or crests of slopes, where the effects of erosion have been more pronounced than on the lower parts of the slopes.

The soils of this complex are well suited to wheat and grain sorghum. Careful management will conserve moisture and control erosion by wind and water. Terracing, contour farming, and good management of crop residue are essential, and stripcropping is a desirable practice. (Capability unit IIIe-1, dryland; capability unit IIe-4, irrigated; Limy Upland range site; Silty Upland windbreak suitability group)

Ulysses-Colby silt loams, 3 to 5 percent slopes, eroded (Um).—This complex of Ulysses and Colby soils is on weakly convex slopes. Ulysses silt loam makes up about 50 percent of the acreage, and Colby silt loam makes up about 30 percent. About 7 percent of the acreage is Richfield silt loam, 5 percent is Mansic clay loam, and a small acreage is Mansker loam.

The Colby soil is generally on the more convex parts of the slopes, where erosion has been most pronounced. Like the Colby soil in the less sloping complex of Ulysses and Colby soils, this Colby soil was formerly Ulysses silt loam. It was classified as a Colby soil, after the surface layer of the Ulysses soil was lost through erosion.

Wheat and grain sorghum are the principal crops grown on the soils of this complex. Careful management will conserve moisture and prevent further erosion by water and wind. Terraces, contour farming, and good management of crop residue are essential, and stripcropping is a desirable practice. (Capability unit IVe-2, dryland; not placed in an irrigated capability unit; Limy Upland range site; Silty Upland windbreak suitability group)

Ulysses loam, undulating (0 to 3 percent slopes) (Ud).—The slopes of this soil are generally less than 3 percent, but they are as steep as 5 percent in a few places. The profiles in the sloping areas contain more sand than those in the nearly level areas. About 10 percent of the acreage consists of included Colby soils, and about 5 percent, of Otero soils.

This Ulysses soil is well suited to wheat and grain sorghum. Conserving moisture and controlling erosion by wind and water are problems in managing it. Good management of crop residue is essential, and stripcropping is helpful. In most places the slopes are too irregular for terraces and contour farming. (Capability unit IIIe-1, dryland; capability unit IIe-4, irrigated; Loamy Upland range site; Silty Upland windbreak suitability group)

Ulysses silt loam, saline, 0 to 1 percent slopes (Us).—This soil is in the Scott-Finney depression. It is slightly to moderately saline at a depth of 2 to more than 5 feet. The substratum contains an accumulation of white crystalline salts (calcium sulfate). These salts are generally in the same zone as the soluble salts. About 12 percent of the acreage consists of Richfield silt loam, saline, and about 4 percent, of Drummond silt loam. The Drummond soil occurs as small spots, generally less than 50 feet in diameter, that are scattered over the landscape.

Wheat and grain sorghum are the principal crops grown on this Ulysses soil, but the growth of crops is uneven.

This is caused by differences in the degree of salinity, in the location of the concentration of soluble salts in the soil profile, and in the supply of moisture. Where the salts are near the surface, they retard the growth of crops more than where they are deeper in the profile. The differences in crop growth are most pronounced when the supply of moisture is low.

Conserving moisture and controlling wind erosion are additional problems on this soil. Good management of plant residue is important. Contour farming, stripcropping, and terracing can also be used to help conserve moisture and to protect the soil. (Capability unit IIIs-4, dryland; capability unit IIs-4, irrigated; Saline Upland range site; Saline Upland windbreak suitability group)

Ulysses silt loam, saline, 1 to 3 percent slopes (U₁).—This soil is slightly to moderately saline at a depth of 2 to more than 5 feet. It has an accumulation of white crystalline salts of calcium sulfate in the substratum, generally in the same zone as the soluble salts. In most places this soil has gentle slopes that are weakly convex, but some areas are somewhat undulating. A small acreage of saline Richfield and Drummond silt loams is mapped with it. The Richfield and Drummond soils are in the low parts of the undulating areas.

Wheat and grain sorghum are grown on this soil, but the growth of crops is uneven. This is caused mainly by differences in the degree of salinity, in the location of the concentration of soluble salts in the soil profile, and in the supply of moisture. Where the salts are near the surface, they retard the growth of crops more than where they are deeper in the profile. The differences in crop growth are most pronounced when the supply of moisture is low.

Moisture can be conserved and erosion by water and wind can be controlled by managing this soil carefully. Stripcropping is helpful, but terraces, contour farming, and good management of crop residue are essential. (Capability unit IVe-2, dryland; not placed in an irrigated capability unit; Saline Upland range site; Saline Upland windbreak suitability group)

Ulysses and Richfield complexes, saline, bench leveled (0 to 1 percent slopes) (U_v).—This mapping unit consists of areas of saline Ulysses, Richfield, and Colby silt loams that have been leveled for irrigation. As a result of cutting and filling, these soils are so intermingled that they cannot be mapped separately. Some areas contain all three soils, others contain only Ulysses and Colby soils, and still others contain only Richfield and Colby soils.

Leveling has affected the soils in several ways. In some places the surface layer consists of material that was formerly subsoil. The kind of soil material in the plow layer depends on the characteristics of the original soil and on how much soil material was removed when the soils were leveled. The Colby soils are mainly in areas where a large amount of soil material has been removed from the upper part of the Ulysses and Richfield soils.

Before these Ulysses, Richfield, and Colby soils were leveled, the horizon that contains a large amount of soluble salts was generally below a depth of 24 inches in the Ulysses soils and below a depth of 16 inches in the Richfield soils. Leveling has caused this saline horizon to be closer to the surface than it formerly was. The soil material in the fill areas is stratified. Texture, color, and

reaction are variable as a result of the different sources and the mixing of the material. In some areas where the layer of fill is 20 inches or more thick, the soil series to which the soil material belongs cannot be identified.

Much of the leveling has been done where originally the soils had a slope of less than 1 percent. However, deep cuts were made to square up fields in some small areas where the slope was more than 1 percent. The difference in elevation between the benches is generally about 1 to 2 feet.

In some areas leveling has exposed light-colored, calcareous material that is low in fertility and is saline in places. The growth of crops on such areas is usually reduced for at least several years after the area is leveled. Iron chlorosis commonly affects young sorghum plants in these calcareous cut areas. Crop residue and animal residue worked into the soils will help to improve the fertility and structure. Commercial fertilizer improves the soils by increasing the amount of crop residue available.

These soils are suited to sorghum, wheat, sugar beets, alfalfa, and other irrigated crops, and all of the acreage is irrigated. Since 1960, when mapping of these soils was completed, other areas have been leveled. As a result, some acreage of bench-leveled areas are not shown on the soil map. (Not placed in a dryland capability unit; capability unit IIs-4, irrigated; Saline Upland range site; Saline Upland windbreak suitability group)

Ulysses and Richfield soils, silted, 0 to 1 percent slopes (U_x).—The soils of this mapping unit are on the tableland north and northwest of Garden City, in an area where the soils are generally irrigated. The mapping unit consists of Ulysses and Richfield soils that have received deposits of silt and clay from irrigation water taken from the Arkansas River.

These soils have a more clayey, compact, calcareous surface layer than the normal Ulysses and Richfield soils. Their surface layer is silty clay loam or light silty clay and is 5 to 12 inches thick. The thickest deposits of silt and clay are generally at the lower end of the irrigation run. At that place the water is ponded, and the silt and clay are allowed to settle.

The Ulysses subsoil is like the one in the profile described for the Ulysses series, and the Richfield subsoil is like the one in the profile described for the Richfield series. The deposits of silt and clay mask the original Ulysses and Richfield profiles to such an extent that it was not practical to separate these soils on the soil map. A few small areas of silted Keith soils are included in the mapping unit.

These Ulysses and Richfield soils are suited to all the crops commonly grown in this area. Their clayey surface layer is difficult to work, however, if it is either too wet or too dry. Careful management is required to maintain the favorable structure and tilth of the surface layer. (Not placed in a dryland capability unit; capability unit IIs-2, irrigated; Clay Upland range site; Silty Upland windbreak suitability group)

Vona Series

The Vona series consists of deep, noncalcareous, sandy soils that are undulating. The soils are well drained and have moderate moisture-holding capacity.

In most places the surface layer is grayish-brown loamy fine sand about 10 inches thick. The material in the sur-

face layer is loose and takes water readily. It blows easily when it is dry and is not protected by vegetation.

The subsoil is generally grayish-brown fine sandy loam about 14 inches thick, and it has weak, granular structure. The subsoil is noncalcareous, but the layer just below the subsoil is calcareous and contains concretions and threads of lime. Moisture and roots readily penetrate the subsoil.

These soils formed in calcareous, wind-deposited, sandy material. The native vegetation was grass.

The surface layer ranges from 6 to 18 inches in thickness. The color of the surface layer and the subsoil ranges from grayish grown to brown. Depth to calcareous material ranges from 14 to 30 inches.

The Vona soils have a lighter colored, more sandy surface layer than the Manter soils. They are more sandy and are less calcareous than the Otero soils but are less sandy than the Tivoli soils.

Vona loamy fine sand (1 to 5 percent slopes) (Vo).— This is the only Vona soil mapped in Finney County. About 11 percent of the acreage is included areas of Otero fine sandy loam, 4 percent is Tivoli loamy fine sand, and a minor acreage is Manter fine sandy loam.

Grain sorghum is the principal crop grown on this soil. Conserving moisture and controlling wind erosion are problems, and good management of plant residue is essential. (Capability unit IVe-1, dryland; capability unit IVe-7, irrigated; Sands range site; Sandy Upland wind-break suitability group)

Use and Management of Soils

This section discusses the use and management of the soils under dryland farming in Finney County, explains the system of capability classification used by the Soil Conservation Service, and gives predicted average acre yields for the principal crops grown under dryland farming. Then, it gives the same kind of information for the soils under irrigated farming. Finally, it discusses management of the soils for range, windbreaks, and wildlife, and gives engineering interpretations for the soils.

Management of Dryland¹

The soils of Finney County were covered with grass before they were cultivated. Roots penetrated the soils, and living and dead vegetation protected the surface. Rain and wind did little damage to these protected soils. Water was absorbed rapidly, and there was little flash runoff. Only geologic erosion occurred, and this was at a slow, harmless rate.

Cultivation of crops, especially without irrigation, has reduced the content of organic matter in the soils and has caused the structure and tilth to deteriorate. As a result of the poorer tilth and use of management systems that left the surface unprotected, the soils were eroded by both wind and water.

A cover needs to be kept on the surface to protect the soils from erosion and to conserve moisture. It is not necessary to restore the native grass. However, as in nature, a plant cover of some kind must be provided at all times.

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Practices, such as use of a suitable cropping system, stubble mulching, and minimum tillage, are necessary on all the cropland. Contouring, terracing, and strip-cropping are other practices that may be used effectively to control erosion by wind and water. Soil and water can be conserved best by a combination of these practices. A single practice may reduce erosion or conserve some moisture, or it may do both, but it seldom provides complete control of erosion, nor does it conserve enough moisture.

Following is a discussion of the practices needed to control erosion and to conserve moisture under dryland farming in Finney County.

A *cropping system* is a sequence of crops grown on a given area over a period of time. Some cropping systems consist of a rotation of different crops, and the crops follow a definite order of appearance in the field. Other cropping systems consist of only one crop grown year after year in the same field. A flexible cropping system generally consists of different crops, but the crops do not succeed one another in a definite, previously planned order. After the cropping system has been chosen, such practices as summer fallowing, contour farming, stubble mulching, and minimum tillage should be used to conserve moisture, to keep damage by wind and water to a minimum, and to maintain or improve the productivity of the soils.

In this county winter wheat and grain sorghum are the principal dryland crops, and the cropping system most frequently used is summer fallow, winter wheat, and grain sorghum. Most farmers, however, like to keep their cropping system flexible. Where a flexible cropping system is used, the selection of the next crop or fallow period depends on the amount of moisture stored in the soil at the time winter wheat or sorghum is to be planted. It also depends on the need for a protective cover and on the economic needs of the particular farm.

Summer fallowing, as applied to dry-farmed areas, consists of keeping the soils free of vegetation during one crop season so that moisture will be stored for the crop that follows. Much of the time, the total amount of moisture available under a continuous cropping system is too low for the economical production of crops. Therefore, the practice of summer fallowing is considered a necessary part of most cropping systems. Summer fallowing is not very efficient in adding to the total amount of moisture stored. However, each additional inch of moisture that is stored, above a minimum of about 10 inches, will add 2 to 3½ bushels to the yield per acre of wheat.

Stubble mulching is a system of residue management in which harvesting, preparation of the seedbed, planting, and subsequent cultivation are performed in a manner that will keep adequate residue on the surface until the next growing crop is large enough to provide protection. Because even with summer fallowing, the production of crops in Finney County is rather uncertain, a practice such as stubble mulching is necessary to help prevent erosion by wind and water. Also, where this practice is used, more moisture soaks into the soil because the tendency of the surface layer to seal over after rains is reduced. Stubble mulching should be used on all the cropland in this county. The methods used depend on the soil type, the cropping system, the amount of residue, the season of the year, and the kind of equipment available. The amount of residue required to give protection varies with the kind of residue,

the height of the stubble, the roughness of the surface, and the texture of the soils.

Tillage has many objectives in a dryland area. Among other things, it is used to manage crop residue, to control weeds, and to prepare a suitable seedbed for the crop that follows. It is also used to protect the soil from erosion. Through tillage, the farmer carries out much of his management program. In using tillage equipment to manage crop residue and to kill weeds, he makes the seedbed suitable for seeding and managing the next crop. The residue left on the surface protects the soils from erosion. It also keeps the soil structure from deteriorating as the result of the splashing effect of raindrops. With undercutting equipment, the farmer can kill weeds but still leave the residue on the surface.

The surface must be roughened by tillage whenever the soil becomes bare of vegetation and is subject to wind erosion. Surface roughening minimizes the damage from soil blowing as long as the clods are big enough to resist blowing. Soils that have stable aggregates have desirable soil structure. On such soils, tillage is needed only to kill weeds and to manage residue. It should be used only to meet those needs. Too much tillage breaks down the clods or aggregates and leaves the soils subject to blowing and crusting. Tilling at the proper time is important in maintaining good soil structure. If the soils are tilled when too wet, a compact layer, or tillage pan, may form. This is especially likely in loams or silt loams.

In *contouring*, tillage and planting operations are performed parallel to terraces or contour guidelines. As a result, furrows, ridges, and wheel tracks are nearly on the level. The furrows and ridges hold much of the water from precipitation where it falls, thus decreasing runoff and erosion. Yields of crops increase when contouring is practiced because more water is absorbed by the soil and is made available to crops. Also, somewhat less power is required than when up-and-down-hill farming is practiced.

Contouring is most effective when it is used with other practices that conserve moisture and protect the soils. Such practices are stubble mulching, terracing, and contour stripcropping.

Terracing consists of constructing ridges across the slope to intercept runoff water. In sloping areas terraces help to control erosion and to conserve moisture that otherwise would be lost through runoff. In nearly level areas, terraces are used mainly to conserve moisture.

Contouring and other practices to conserve moisture and protect the soils should be used along with terracing. Each row planted on the contour between terraces acts as a miniature terrace, holding back some water to soak into the soil. When terracing and contouring are used together, yields are increased and soil losses are decreased.

The horizontal distance needed between terraces depends on the slope and the kind of soil. Because much of the precipitation falls during severe storms, a terrace system acts as a safety valve that protects other conservation practices, such as contouring, stubble mulching, and contour stripcropping.

Stripcropping is a system of growing suitable crops in narrow strips in the same field. Strips of crops that resist erosion, or their residue, are alternated with strips of oth-

er crops or fallowed land. Stripcropping helps to control wind erosion by shortening the distance that loose soil can move. It reduces water erosion by providing a barrier of growing crops.

Two types of stripcropping are (1) contour stripcropping and (2) wind stripcropping. Contour stripcropping is used on sloping fields to help control erosion by both wind and water. The strips are arranged on the contour; terraces or contour guidelines are used to establish the pattern. Wind stripcropping is used on fields of nearly level or coarse-textured soils where water erosion is not a problem but where wind erosion is a hazard. It is also used on some sloping fields where the slopes are so complex that farming on the contour is not practical. The strips are uniform in width, are usually straight, and are arranged at right angles to the direction of prevailing winds.

The width of the strips necessary to control soil blowing varies according to the kind of soil. The strips may need to be wider on silt loams and clay loams than on sandy soils.

Stripcropping will reduce soil blowing, but it does not completely control blowing, when used alone. It is much more effective when used along with good management of crop residue, minimum tillage, and other practices needed to conserve moisture and protect the soils from erosion.

Capability Groups of Soils

The capability classification is a grouping of soils that shows, in a general way, how suitable the 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 VIII. 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 as many as 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 a 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 have little or no susceptibility to 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-4. The capability units are not numbered consecutively in Finney County, because not all of the capability units used in Kansas are in this county.

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, when the soils are grouped for dryland farming, are described in the list that follows.

Class I. Soils that have few limitations that restrict their use. (None in Finney County, because of climatic limitations)

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

Subclass IIe. Soils subject to moderate erosion if they are not protected.

Unit IIe-1. Deep, gently sloping silt loams.

Unit IIe-3. Deep, nearly level fine sandy loams.

Subclass IIs. Soils that have moderate limitations of moisture capacity or tilth.

Unit IIs-3. Deep, nearly level silty clay loams that are limited mainly by a compact subsoil.

Subclass IIc. Soils that have moderate limitations, mainly because of low rainfall.

Unit IIc-1. Deep, nearly level silt loams, loams, and clay loams, mainly on uplands.

Unit IIc-2. Deep, nearly level silt loams formed in alluvium on flood plains or low stream terraces.

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 sloping, calcareous silt loams and loams.

Unit IIIe-4. Deep, gently sloping, eroded silty clay loams.

Unit IIIe-6. Deep, undulating fine sandy loams.

Subclass IIIw. Soils that have severe limitations because of excess water.

Unit IIIw-3. Deep, nearly level, imperfectly drained clay loams formed in alluvium.

Subclass IIIs. Soils that have severe limitations of salinity or tilth.

Unit IIIs-4. Deep, nearly level, saline silt loams.

Class IV. Soils that have very severe limitations that restrict the choice of plants, that 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, undulating loamy fine sands.

Unit IVe-2. Deep, sloping, calcareous silt loams.

Unit IVe-3. Complexes of deep, undulating fine sandy loams and loams.

Unit IVe-10. Deep, gently sloping, calcareous clays.

Subclass IVw. Soils that have very severe limitations for cultivation because of excess water.

Unit IVw-1. Deep clay loams in slight depressions where they receive runoff from surrounding areas.

Unit IVw-2. Moderately deep, nearly level, imperfectly drained clay loams and sandy loams formed in alluvium.

Subclass IVs. Soils that have very severe limitations of salinity or tilth.

Unit IVs-3. Deep, nearly level, saline and saline-alkali soils.

Class V. Soils not likely to erode but that have other limitations, impractical to remove, 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. Nearly level, poorly drained clay loams formed in alluvium.

Class VI. Soils that have severe limitations that make them generally unsuitable for 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. Moderately steep, calcareous clay loams formed in plains outwash and nearly level, loamy soils formed in alluvium.

Unit VIe-2. Deep loamy fine sands in areas of low dunes.

Unit VIe-3. Deep, moderately steep, calcareous fine sandy loams.

Unit VIe-4. Moderately steep, calcareous loams that are moderately deep or shallow over caliche.

Unit VIe-6. Steep, calcareous sandy loams and gravelly loamy sands.

Subclass VIw. Soils severely limited by excess water and generally unsuitable for cultivation.

Unit VIw-1. Loamy soils formed in alluvium on narrow flood plains.

Unit VIw-2. Poorly drained, compact clays in upland depressions.

Subclass VIIs. Soils generally unsuitable for cultivation and limited for other uses by their limited root zone, low moisture capacity, or other features.

Unit VIIs-2. Nearly level, imperfectly drained loamy sands formed in alluvium.

Class VII. Soils that have very severe limitations that make them unsuitable for cultivation 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 fine sands in areas of steep, dune topography.

Subclass VIIw. Soils very severely limited by excess water.

Unit VIIw-1. Unstable soils subject to recurrent flooding.

Subclass VIIs. Soils very severely limited by a shallow root zone, low moisture capacity; stones, or other soil features.

Unit VIIs-2. Shallow, steep, loamy soils and limestone outcrops.

Unit VIIs-3. Steep, clayey soils that are shallow over shale.

Class VIII. Soils and landforms that 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 Finney County)

Management of dryland soils by capability units

In this section the soils of this county are grouped in capability units for dryland farming. The significant features of the soils in each capability unit, together with their hazards and limitations, are described. Suggestions for use and management of the soils of each unit are also given.

DRYLAND CAPABILITY UNIT IIc-1

Only Richfield silt loam, 1 to 3 percent slopes (Rn), is in this capability unit. It is deep, gently sloping, and permeable, but the surface tends to seal during heavy rains if this soil is not protected. Conserving moisture and controlling erosion by wind and water are other problems.

Terracing, contour farming, and good management of crop residue will help to control erosion and to prevent runoff. Keeping plant residue on the surface will supply protection from erosion when the soil is not protected by a growing crop. Contour stripcropping is another practice that effectively controls erosion and conserves moisture.

Wheat and grain sorghum are the principal crops grown on this soil. The best cropping system is a flexible one that includes summer fallow. This soil is well suited to the native grasses.

DRYLAND CAPABILITY UNIT IIc-3

Manter fine sandy loam, level (Mn), is the only soil in this capability unit. It is a deep, nearly level, fertile soil, and it has moderate moisture-holding capacity. This soil takes water readily and releases a large part of it for the use of plants. The surface layer is sandy and blows easily when it is dry and unprotected. Conserving moisture and controlling wind erosion are problems.

Good management of plant residue is the most effective way of conserving moisture and protecting this soil from erosion. A cover of plant residue on the surface will give protection from wind erosion. Contour farming, stripcropping, and terracing also help to control erosion and conserve moisture.

Wheat and grain sorghum are the principal crops grown on this soil. The best cropping system is a flexible one that includes summer fallow. This soil is well suited to the native grasses.

DRYLAND CAPABILITY UNIT IIc-3

Spearville silty clay loam, 0 to 1 percent slopes (Sp), is the only soil in this capability unit. It is a deep, nearly level, fertile soil. The moisture-holding capacity is high, but this soil has a compact subsoil that takes water slowly and releases it slowly to plants. Also, the soil material in the surface layer tends to run together and seal over during rains. Conserving moisture and controlling wind erosion are other problems.

Good management of plant residue is the most effective way of conserving moisture and protecting this soil from erosion. A cover of plant residue on the surface will provide protection from wind erosion, improve the ability of the soil to take in moisture, and protect the soil from the beating action of raindrops. Contour farming and stripcropping are other desirable practices. Terraces are effective for conserving moisture, but the many depressions make terraces difficult to construct.

Because of its compact, droughty subsoil, this soil is better suited to wheat than grain sorghum. The best cropping system is a flexible one that includes summer fallow. This soil is well suited to the native grasses.

DRYLAND CAPABILITY UNIT IIc-1

In this capability unit are deep, nearly level silt loams, loams, and clay loams, mainly on uplands. These soils are—

Bridgeport clay loam (Bp).

Harney silt loam, 0 to 1 percent slopes (Ha).

Keith loam, 0 to 1 percent slopes (Ka).

Richfield silt loam, 0 to 1 percent slopes (Rm).

Richfield-Spearville complex, 0 to 1 percent slopes (Rs).

Ulysses silt loam, 0 to 1 percent slopes (Ua).

These are fertile soils, and they have high moisture-holding capacity. They are permeable to roots, water, and air. When these soils are not protected, their surface layer tends to seal, and a crust forms after rains. Conserving moisture and controlling wind erosion are also problems.

Keeping plant residue on the surface will provide protection from wind erosion when these soils are not protected by a growing crop. The plant residue breaks the impact of raindrops, helps to prevent crusting of the surface layer, and improves the ability of the soils to take in moisture. Other practices that help to control erosion and improve the ability of the soils to take in moisture are contour farming, stripcropping, and terracing.

Wheat and grain sorghum are the principal crops grown on these soils. The best cropping system is a flexible one that includes summer fallow. These soils are well suited to the native grasses.

DRYLAND CAPABILITY UNIT IIc-2

Deep, nearly level silt loams on flood plains or low stream terraces make up this capability unit. These soils formed in alluvium. These soils are—

Humbarger silt loam (Hu).

Roxbury silt loam (Rx).

These are fertile soils, and they have high moisture-holding capacity. They are permeable, but if they are not

protected, the surface tends to seal and a crust forms after rains. Conserving moisture and controlling wind erosion are also problems.

Keeping plant residue on the surface will provide protection from wind erosion when these soils are not protected by a growing crop. The plant residue breaks the impact of raindrops, helps to prevent crusting of the surface layer, and improves the ability of the soils to take in moisture. Stripcropping is also a practice that will help to conserve moisture and protect the soils from erosion. Contour farming and terracing are other desirable practices if the site is suitable.

Wheat and grain sorghum are the principal crops grown on these soils, but alfalfa is also grown (fig. 13). Once a stand of alfalfa is established, this deep-rooted crop obtains moisture from the water table, which is generally 10 to 15 feet below the surface. The best cropping system is a flexible one that includes summer fallow. These soils are well suited to the native grasses.

DRYLAND CAPABILITY UNIT IIIe-1

Deep, gently sloping, calcareous silt loams and loams are in this capability unit. These soils are—

- Ulysses-Colby silt loams, 1 to 3 percent slopes, eroded (Ue).
- Ulysses loam, undulating (Ud).
- Ulysses silt loam, 1 to 3 percent slopes (Ub).

These soils are permeable and have high moisture-holding capacity. If they are not protected, however, the surface tends to seal, and a crust forms after rains. Conserving moisture and controlling erosion by water and wind are other problems. The eroded soils need careful management that will prevent further erosion and deterioration.

Terraces, contour farming, and good residue management will conserve moisture and help to protect these soils from erosion. Terracing and contour farming are generally not practical on the undulating Ulysses soils, but stripcropping can be used. It is effective in conserving moisture and controlling erosion.

Wheat and grain sorghum are the principal crops. The best cropping system is a flexible one that includes summer fallow. These soils are well suited to the native grasses.

DRYLAND CAPABILITY UNIT IIIe-4

Only Spearville complex, 1 to 3 percent slopes, eroded (Sr), is in this capability unit. It consists of deep, gently sloping, eroded silty clay loams that have high moisture-holding capacity. Erosion has thinned the surface layer of these soils to such an extent that plowing has mixed in some material from the more clayey subsoil. The soils take water slowly and tend to seal over when it rains. Conserving moisture and controlling erosion by water and wind are other problems.

Terraces, contour farming, and good management of plant residue will help to protect these soils. Plant residue on the surface not only provides protection against erosion but also increases the intake of moisture. Stripcropping also helps to control runoff.

Wheat is better suited to these soils than grain sorghum because of the droughty subsoil. The best cropping sys-



Figure 13.—Dryland alfalfa on a field of Roxbury silt loam.

tem is a flexible one that includes summer fallow. The soils are well suited to the native grasses.

DRYLAND CAPABILITY UNIT IIIe-6

Deep, undulating fine sandy loams are in this capability unit. These soils are—

- Bayard fine sandy loam (Bo).
- Las-Bayard sandy loams (Lc).
- Manter fine sandy loam, undulating (Mr).

These are fertile soils that are easily penetrated by plant roots, water, and air. They have moderate moisture-holding capacity. The surface layer is sandy, and it blows easily when dry and not protected. Conserving moisture and controlling wind erosion are other problems.

Keeping plant residue on the surface will help to protect these soils from wind erosion. Stripcropping is another desirable practice that can be used. Contour farming and terracing are generally impractical, because of the complex slopes, but they may be beneficial in some places.

Wheat and grain sorghum are grown on these soils. The best cropping system is a flexible one that includes summer fallow. These soils are well suited to the native grasses.

DRYLAND CAPABILITY UNIT IIIw-3

Only Las clay loam, deep (lb), is in this capability unit. It is a deep, nearly level, imperfectly drained soil formed in alluvium.

This soil is permeable and has high moisture-holding capacity. Its productivity is affected by a fluctuating water table and associated slight to moderate salinity. Conserving moisture and controlling wind erosion are additional problems.

Good management of plant residue is the most effective practice that can be used on this soil for conserving moisture and controlling erosion. The plant residue on the surface gives protection from wind erosion and increases the intake of moisture. Stripcropping is another desirable practice.

Wheat and grain sorghum are the principal crops grown on this soil. The best cropping system is one that includes summer fallow. This soil is well suited to the native grasses.

DRYLAND CAPABILITY UNIT IIIs-4

Deep, nearly level, saline silt loams make up this capability unit. These soils are—

Richfield silt loam, saline (R₀).

Ulysses silt loam, saline, 0 to 1 percent slopes (U_s).

These soils are permeable and have high moisture-holding capacity. Salinity has a slight to moderate effect on the growth of crops. The growth of crops is uneven, because the degree of salinity varies from place to place. Conserving moisture and controlling wind erosion are additional problems.

Good management of plant residue will help to control erosion and conserve moisture. The plant residue on the surface helps to prevent surface sealing by reducing the impact of raindrops. Contour farming, stripcropping, and terracing are additional practices that will help to control erosion and conserve moisture.

Wheat and grain sorghum are grown on these soils. The best cropping system is a flexible one that includes summer fallow. These soils are well suited to the native grasses.

DRYLAND CAPABILITY UNIT IVe-1

Only Vona loamy fine sand (V₀) is in this capability unit. It is a deep, undulating soil.

This soil takes water rapidly, but its surface layer is loose and blows easily. The soil is low in fertility. Wind erosion is a severe hazard.

This soil is better suited to native grasses than to field crops. It can be cultivated, however, if practices are used to protect it from wind erosion. If it is cultivated, continuous grain sorghum is the best cropping system. Summer fallow is not practical, because of the hazard of wind erosion and the restricted moisture-holding capacity.

Good management of plant residue will help to protect this soil from erosion. Keeping plant residue on the surface helps to break the force of the wind and holds the soil material in place.

DRYLAND CAPABILITY UNIT IVe-2

Deep, sloping, calcareous silt loams are in this capability unit. These soils are—

Ulysses silt loam, saline, 1 to 3 percent slopes (U₁).

Ulysses silt loam, 3 to 5 percent slopes (U_c).

Ulysses-Colby silt loams, 3 to 5 percent slopes, eroded (U_m).

These soils are permeable and have high moisture-holding capacity. If they are not protected, however, their surface layer tends to seal, and a crust forms after rains. Conserving moisture and controlling erosion by wind and water are problems. The salts in the saline Ulysses soil have a slight to moderate effect on the growth of crops. On the eroded soils careful management is needed to prevent further erosion and deterioration.

These soils are better suited to native grasses than to cultivated crops. They can be used for cultivated crops, however, if good management is practiced. The principal crops grown are wheat and grain sorghum. If these soils are used for cultivated crops, the best cropping system is one that includes summer fallow.

Terraces, contour farming, and good management of crop residue will help to conserve moisture and to protect these soils from erosion. Keeping plant residue on the surface breaks the impact of raindrops. This helps to pre-

vent surface crusting and increases the intake of moisture. Stripcropping is another desirable practice.

DRYLAND CAPABILITY UNIT IVe-3

In this capability unit are complexes of deep, undulating fine sandy loams and loams. These soils are—

Manter-Otero fine sandy loams, undulating (M₁).

Otero-Ulysses complex, undulating (O_y).

These soils take water readily and release a large part of it for plants. The surface layer is sandy and blows easily when these soils are dry and not protected. Conserving moisture and controlling wind erosion are problems.

These soils are better suited to native grasses than to cultivated crops. If good management is used, however, they can be used for cultivated crops. Wheat and grain sorghum are the principal crops grown where these soils are cultivated. The best cropping system is a flexible one that includes summer fallow.

Good management of plant residue will help to conserve moisture and protect these soils from erosion. Stripcropping is another good practice. Contour farming and terracing may be beneficial in some places, but they are generally impractical, because of the complex slopes.

DRYLAND CAPABILITY UNIT IVe-10

Only Promise clay, 1 to 3 percent slopes (P_c), is in this capability unit. It is a deep, gently sloping, calcareous soil.

This soil is compact. It takes water slowly and releases it slowly to plants. If not protected, the surface layer tends to seal and a crust forms after rains. Conserving moisture and controlling erosion by water and wind are other problems.

This soil is better suited to the native grasses than to cultivated crops. It can be cultivated, however, if good management is used. Because of the droughty subsoil, wheat is better suited to this soil than grain sorghum. The best cropping system is a flexible one that includes summer fallow.

Terraces, contour farming, and good management of plant residue will help to protect this soil and control runoff. Plant residue on the surface helps to provide protection from erosion and increases the intake of moisture. Stripcropping is an additional practice that can be used for conserving moisture and controlling erosion.

DRYLAND CAPABILITY UNIT IVw-1

Only Lofton clay loam (L₀) is in this capability unit. It is a deep soil in slight depressions.

This soil is fertile and receives runoff from surrounding areas. Its subsoil is compact and takes water slowly. The water that ponds on the surface is harmful to growing crops. The surface layer is subject to wind erosion when it is dry and unprotected.

This soil is better suited to native grasses than to cultivated crops, but it can be used for cultivated crops if good management is practiced. Wheat and grain sorghum are the crops that are grown.

Good management of crop residue helps to conserve moisture and to protect this soil from wind erosion when no crop is growing. Using practices to divert runoff from surrounding areas will help to reduce the amount of ponding by holding the raindrops where they fall.

DRYLAND CAPABILITY UNIT IVw-2

This capability unit consists of moderately deep, nearly level, imperfectly drained clay loams and sandy loams formed in alluvium. These soils are—

- Las clay loam, moderately deep (Lc).
- Las-Las Animas complex (Ld).
- Las Animas sandy loam (Lk).

These soils are permeable and have moderate moisture-holding capacity. Their productivity is affected by a fluctuating water table and the associated slight to moderate salinity. Conserving moisture and controlling wind erosion are additional problems.

These soils are better suited to the native grasses than to cultivated crops. They can be used for cultivated crops, however, if good management is practiced. Where these soils are cultivated, the principal crops are wheat and grain sorghum. The best cropping system is a flexible one that includes summer fallow.

Good management of plant residue will help to control erosion and conserve moisture on these soils. Keeping plant residue on the surface breaks the force of the wind and increases the intake of moisture. Stripcropping is another desirable practice.

DRYLAND CAPABILITY UNIT IVs-3

Deep, nearly level, saline and saline-alkali soils are in this capability unit. These soils are—

- Church silty clay loam (Ch).
- Colby loam, saline (Cs).
- Drummond silt loam (Dr).

These soils are permeable and have high moisture-holding capacity. They are moderately well drained; the water table is generally 4 to 10 feet below the surface. During periods of excessive rainfall, however, the water table sometimes rises to within 2 feet of the surface. Salinity and excessive sodium have a moderate to severe effect on the growth of crops. Crops make uneven growth, because the degree of salinity varies from place to place. Conserving moisture and controlling wind erosion are additional problems.

These soils are better suited to the native grasses than to cultivated crops. They can be cultivated, however, if good management is used. Wheat and grain sorghum are the principal crops grown on the Church and Colby soils. Wheat does better than grain sorghum on the Drummond soil. The best cropping system is a flexible one that includes summer fallow.

Good management of plant residue will help to control erosion and conserve moisture. Other desirable practices are contour farming and stripcropping.

DRYLAND CAPABILITY UNIT Vw-1

Sweetwater clay loam (Sw) is the only soil in this capability unit. It is nearly level and poorly drained, and it formed in alluvium.

This soil has a water table within 3 feet of the surface. Salinity is slight to moderate.

Because it is wet, this soil is more suitable for grazing and meadow than for cultivated crops. It is among the most productive soils used for range in the county. Grazing at a rate that will allow the most desirable grasses to maintain or improve their vigor is important on this soil. Deferred grazing or rotation deferred grazing can be used along with a proper stocking rate to improve the vigor

and composition of the grasses. If reseeding is necessary, native grasses that are adapted to this land should be used. Among the adapted grasses are switchgrass, alkali sacaton, Indiangrass, and western wheatgrass.

Management practices discussed in the section "Management of Rangeland" will help to maintain the native grasses. This soil is in the Saline Subirrigated range site.

DRYLAND CAPABILITY UNIT VIe-1

Only Mansic complex (Mh) is in this capability unit. The soils are moderately steep, calcareous clay loams formed in plains outwash and nearly level, loamy soils formed in alluvium.

Deep, permeable, well-drained clay loams that are moderately steep occupy about 80 percent of the complex. The rest of the complex consists of nearly level, well-drained, loamy soils on narrow valley floors. Erosion is a severe hazard where the soils are moderately steep. The soils on narrow valley floors are subject to flooding and erosion.

Because of the severe hazard of erosion, the soils of this complex are best suited to range. Regulating grazing so that the most desirable native grasses will maintain or improve their vigor is among the most important practices needed. This consists of stocking the range at a proper rate and distributing livestock so that the range will be grazed uniformly. Locating fences, salt, and water properly will help to distribute livestock over the range.

Deferred grazing or rotation deferred grazing can also be used to improve the vigor of the grasses. If reseeding is necessary, native grasses should be used. Among the native grasses suited to these soils are blue grama, buffalograss, western wheatgrass, side-oats grama, and little bluestem.

Management practices discussed in the section "Management of Rangeland" will help to maintain the native grasses on these soils. The soils are in the Loamy Upland range site.

DRYLAND CAPABILITY UNIT VIe-2

Only Tivoli-Vona loamy fine sands (Tv) is in this capability unit. It consists of deep loamy fine sands in areas of low dunes.

The soils of this complex are sandy and take water rapidly, but they have low moisture-holding capacity. Wind erosion is a severe hazard.

Because of the hazard of erosion, these soils are best suited to range. Regulating grazing so that the most desirable native grasses will maintain or improve their vigor is one of the most important practices needed. This consists of stocking the range at a proper rate and distributing livestock so that the range will be grazed uniformly. Locating fences, salt, and water properly will help to distribute livestock over the range.

If the range is in poor condition, brush is likely to be a problem on these soils. The brush can be controlled by chemicals or by mechanical means. Deferred grazing or rotation deferred grazing can be used along with a proper stocking rate to improve the vigor of the grasses. If reseeding is necessary, adapted native grasses should be used. Among the native grasses adapted to these soils are sand bluestem, little bluestem, switchgrass, side-oats grama, and blue grama. Blowout areas ought to be fenced to keep

livestock out. Then establish a protective cover of sorghum or weeds, and seed to native grasses when the cover is established.

Management practices needed to maintain the native grasses are discussed in the section "Management of Rangeland." These soils are in the Sands range site.

DRYLAND CAPABILITY UNIT VIe-3

Only Otero fine sandy loam, 5 to 15 percent slopes (Ot), is in this capability unit. It is a deep, moderately steep, calcareous fine sandy loam.

This soil is well drained and takes water readily. It has moderate moisture-holding capacity. Erosion is a severe hazard.

This soil is best suited to range. Regulating the rate of grazing so that the most desirable native grasses will maintain or improve their vigor is one of the most important practices needed. Deferred grazing or rotation deferred grazing can also be used to improve the range.

Brush may be a problem in some places, but it can be controlled by chemicals or by mechanical methods. If reseeding is necessary, adapted native grasses should be used. Among the adapted native grasses are sand bluestem, little bluestem, switchgrass, side-oats grama, and blue grama.

Management practices discussed in the section "Management of Rangeland" will help to maintain the native grasses. This soil is in the Sandy range site.

DRYLAND CAPABILITY UNIT VIe-4

Only Mansker-Potter complex (Mm) is in this capability unit. It consists of moderately steep, calcareous loams that are moderately deep or shallow over caliche.

The soils of this complex have limited moisture-holding capacity and a limited root zone. Surface runoff is rapid. Erosion is a severe hazard if the native vegetation is not maintained.

These soils are best suited to range. Regulating grazing so that the most desirable grasses will maintain or improve their vigor is one of the most important practices needed. Deferred grazing or rotation deferred grazing can be used along with a proper stocking rate to improve the composition and vigor of the grasses.

Locating water, fences, and salt properly will help to distribute livestock over the range. This will prevent overuse in some areas and underuse in other areas. Suitable management practices are discussed in the section "Management of Rangeland."

Generally, about 55 percent of this complex is Mansker loams in the Limy Upland range site; about 28 percent is Potter soils in the Rough Breaks range site; and 17 percent is Mansic clay loams in the Loamy Upland range site.

DRYLAND CAPABILITY UNIT VIe-6

Only Otero gravelly complex (Ox) is in this capability unit. It consists of steep, calcareous sandy loams and gravelly loamy sands.

These soils are moderately deep over a variable substratum of coarse sand, gravel, and caliche. They take water readily, but they have low moisture-holding capacity. Erosion is a severe hazard if the native grasses are not maintained.

Because of the limitations of the soils, the steep slopes, and the hazard of erosion, this complex is best suited to range. Regulating grazing so that the most desirable

native grasses will maintain or improve their vigor is among the most important practices needed. This consists of stocking the range at a proper rate and distributing livestock so that the range will be grazed uniformly. Locating fences, salt, and water properly will help to distribute livestock over the range.

Deferred grazing or rotation deferred grazing can also be used to improve the vigor of the grasses. Where brush is a problem, it can probably be controlled most easily by chemicals because of the rough topography. If reseeding is necessary, adapted native grasses should be used. Among the native grasses suited to these soils are sand bluestem, side-oats grama, little bluestem, and blue grama.

Management practices are discussed in the section "Management of Rangeland." Generally, about 65 percent of this complex consists of gravelly loamy sands in the Gravelly Hills range site; about 20 percent is Otero soils in the Sandy range site; and about 15 percent is Mansker soils in the Limy Upland range site.

DRYLAND CAPABILITY UNIT VIw-1

Only Alluvial land (An) is in this capability unit. It is loamy and is on the narrow flood plains of local intermittent streams. This land type is subject to flooding and the resulting erosion and deposition. Meandering stream channels have cut through Alluvial land and have formed isolated areas of soils that generally are not suitable for cultivation, because they are too small and inaccessible.

This land is best suited to range. Regulating grazing so that the most desirable grasses will maintain or improve their vigor is important. Deferred grazing or rotation deferred grazing can also be used, along with a proper stocking rate, to improve the vigor and composition of the grasses.

In many places weeds are a problem on this land. They can be controlled by mechanical or chemical means. If reseeding is necessary, adapted native grasses should be used. Among the native grasses suited to this land are switchgrass, big bluestem, Indiangrass, Canada wildrye, little bluestem, and western wheatgrass.

Management practices suitable for range are discussed in the section "Management of Rangeland." This land is in the Loamy Lowland range site.

DRYLAND CAPABILITY UNIT VIw-2

Randall clay (Rc) is the only soil in this capability unit. It is a poorly drained, compact, clayey soil in upland depressions.

This soil receives runoff from surrounding areas. Water is frequently ponded on it long enough to damage growing plants. Wind erosion is a hazard when this soil is dry and unprotected.

The depressions where Randall clay occurs are generally farmed along with the adjoining soils. Crops are frequently drowned out, however, or the areas are too wet to plant. Practices used to conserve moisture and control erosion on surrounding areas will help by holding the moisture where it falls.

Randall clay is not a true range site, because the vegetation is too unstable. Also, the composition and density of the plant cover vary because the soil is wet for long periods and dry for long periods. The vegetation is dominantly Pennsylvania smartweed, bur-ragweed, cocklebur, sedges, and rushes.

DRYLAND CAPABILITY UNIT VI_s-2

Only Las Animas-Lincoln loamy sands (Ll) is in this capability unit. The soils are nearly level and imperfectly drained, and they formed in alluvium.

These soils take water rapidly, but they have low moisture-holding capacity, and low fertility. The water table fluctuates between a depth of 3 and 7 feet. Salinity is slight to moderate.

These soils are best suited to range. Regulating grazing is important so that the most desirable grasses will maintain or improve their vigor. This consists of stocking the range at a proper rate and distributing the livestock so that the range will be grazed uniformly. Locating fences, salt, and water properly will help to distribute livestock over the range.

Deferred grazing or rotation deferred grazing can be used along with a proper stocking rate to improve the vigor and composition of the grasses. If reseeding is necessary, adapted native grasses should be used. Among the native grasses suited to these soils are switchgrass, alkali sacaton, Indiangrass, and western wheatgrass.

In some places brush and trees are a problem on these soils. They can be controlled by chemicals or by mechanical means. Management practices are discussed in the section "Management of Rangeland." These soils are in the Saline Subirrigated range site.

DRYLAND CAPABILITY UNIT VII_s-1

In this capability unit are deep fine sands in areas of steep, dune topography. These soils are—

- Active dunes (Ad).
- Tivoli fine sand (Tf).
- Tivoli-Dune land complex (Tx).

These soils take water rapidly but are low in fertility. They are highly susceptible to wind erosion.

Because of the severe hazard of erosion, these soils are best suited to range. Regulating grazing so that the most desirable native grasses will maintain or improve their vigor is among the most important management practices. This consists of stocking the range at a proper rate and distributing the livestock so that the range will be grazed uniformly. Locating fences, salt, and water properly will help to distribute livestock over the range.

If the range is in poor condition, brush is generally a problem on these soils. It can be controlled by using chemicals or by mechanical means. Deferred grazing or rotation deferred grazing can be used along with a proper stocking rate to improve the vigor of the grasses. If reseeding is necessary, adapted native grasses should be used. Among the native grasses suited to these soils are sand bluestem, switchgrass, little bluestem, and big sandreed. Blowout spots and areas of Active dunes need special treatment. It is best to fence such areas to keep livestock out. Then establish a protective cover of sorghum or weeds, and seed to native grasses when the cover is established.

Management practices suitable for these soils are discussed in the section "Management of Rangeland." These soils are in the Choppy Sands range site.

DRYLAND CAPABILITY UNIT VII_w-1

In this capability unit are unstable soils subject to recurrent flooding. These soils are—

- Broken land (Bx).
- Lincoln soils (Lm).

The recurrent flooding subjects the soils to erosion and deposition of new material. These are not true range sites, because the soil material and vegetation are unstable.

Broken land occupies the steep, broken banks of creeks. The vegetation is primarily annuals and trees. The mapping unit Lincoln soils consists of sandy soils that lie next to the Arkansas River. The vegetation consists primarily of cottonwood trees, tamarisk, sand willow, and annual plants.

DRYLAND CAPABILITY UNIT VII_s-2

Only Rock land (Rw) is in this capability unit. It consists of outcrops of limestone and of steep, loamy soil material that is shallow over bedrock. Surface runoff is rapid, and the moisture-holding capacity is low.

This land type is better suited to range than to other uses. Grazing at a rate that will allow the most desirable grasses to maintain or improve their vigor is important. Deferred grazing or rotation deferred grazing can be used along with a proper stocking rate to improve the composition and vigor of the grasses.

Locating water, fences, and salt properly will help to distribute livestock over the range. If livestock are distributed properly, they will not overuse some areas and underuse others.

Management practices suitable for this land type are discussed in the section "Management of Rangeland." Among the adapted native grasses are little bluestem, side-oats grama, and blue grama. This land type is in the Rough Breaks range site.

DRYLAND CAPABILITY UNIT VII_s-3

Lismas clay (Ln) is the only soil in this capability unit. It is a steep, clayey soil that is shallow over shale.

Surface runoff is rapid on this soil, and the moisture-holding capacity is low. It is difficult for water and plant roots to penetrate the dense, platy shale.

This soil is best suited to range. Grazing at a rate that will allow the most desirable grasses to maintain or improve their vigor is important. Deferred grazing or rotation deferred grazing can be used along with a proper stocking rate to improve the composition and vigor of the grasses.

Locating water, fences, and salt properly will help to distribute the livestock over the range. If livestock are distributed properly, they will not overuse some areas and underuse others. This soil has some good sites for ponds.

Management practices suitable for this soil are discussed in the section "Management of Rangeland." Among the adapted native grasses are little bluestem, side-oats grama, switchgrass, western wheatgrass, and blue grama. This soil is in the Shale Breaks range site.

Predicted Yields of Crops (Dryland)

Table 2 gives predicted average yields per seeded acre of dryland wheat and sorghum for the soils suitable for cultivation. The yields are based on common and on improved management. Information on which to base precise estimates is limited, however, because no longtime, accurate records of yields are available. Also, yields fluctuate greatly, mainly as the result of differences in the

amount of precipitation. Yields of both wheat and sorghum range from none to more than 30 bushels per acre, depending on the amount of available moisture. Figure 14 gives some information on the number of acres of wheat seeded during the period from 1921 to 1959 and shows the acreage where the crop failed to produce a profitable yield. Besides lack of moisture, other factors that influence yields are diseases, insects, the supply of plant nutrients in the soils, and management.

TABLE 2.—*Predicted longtime average yields per acre of seeded wheat and sorghum grown on the arable soils under two levels of management*

Yields in columns A are those to be expected under common management, and yields in columns B are those to be expected under improved management. Absence of yield data indicates that the soil is not suited to the crop. The wheat yields reflect the general use of summer fallow]

Soil	Wheat		Sorghum	
	A	B	A	B
Bayard fine sandy loam.....	Bu. 11	Bu. 15	Bu. 18	Bu. 23
Bridgeport clay loam.....	16	20	21	26
Church silty clay loam.....	10	13	12	16
Colby loam, saline.....	10	13	13	17
Drummond silt loam.....	9	12	---	---
Harney silt loam, 0 to 1 percent slopes.....	17	21	21	26
Humbarger silt loam.....	16	20	21	26
Keith loam, 0 to 1 percent slopes.....	18	22	21	26
Las Animas sandy loam.....	11	14	17	22
Las-Bayard sandy loams.....	13	16	17	22
Las clay loam, moderately deep.....	13	16	15	20
Las clay loam, deep.....	14	17	17	22
Lofton clay loam.....	12	16	17	22
Manter fine sandy loam, level.....	15	20	25	31
Manter fine sandy loam, undulating.....	13	17	23	29
Manter-Otero fine sandy loams, undulating.....	11	15	19	24
Otero-Ulysses complex, undulating.....	11	16	21	26
Promise clay, 1 to 3 percent slopes.....	12	16	12	16
Richfield silt loam, 0 to 1 percent slopes.....	17	21	21	26
Richfield silt loam, 1 to 3 percent slopes.....	15	19	17	24
Richfield silt loam, saline.....	15	19	13	18
Roxbury silt loam.....	20	23	21	26
Spearville silty clay loam, 0 to 1 percent slopes.....	15	19	15	20
Spearville complex, 1 to 3 percent slopes, eroded.....	14	18	13	18
Ulysses silt loam, 0 to 1 percent slopes.....	16	20	21	26
Ulysses silt loam, 1 to 3 percent slopes.....	14	18	17	23
Ulysses silt loam, 3 to 5 percent slopes.....	12	16	15	21
Ulysses-Colby silt loams, 1 to 3 percent slopes, eroded.....	13	17	16	22
Ulysses-Colby silt loams, 3 to 5 percent slopes, eroded.....	11	15	14	20
Ulysses loam, undulating.....	14	18	17	23
Ulysses and Richfield soils, silted, 0 to 1 percent slopes.....	16	20	17	22
Ulysses silt loam, saline, 0 to 1 percent slopes.....	14	18	14	19
Ulysses silt loam, saline, 1 to 3 percent slopes.....	12	16	11	16
Vona loamy fine sand.....	10	15	17	23

Estimates of yields were based on data obtained from farmers and on information obtained from the Kansas Agricultural Experiment Station. They were also based on observations of the soil survey party and on observa-

tions of other agricultural workers who are familiar with the soils.

Estimated average yields of wheat and sorghum to be expected over a long period under the prevailing, or most common, management practiced in the county are shown in columns A. Yields that may be obtained by using an improved system of management are shown in columns B.

Common management.—Under the prevailing, or most common, system of management, the following practices are used in producing wheat and sorghum:

1. Tillage is done in straight lines, generally parallel to the boundaries of fields.
2. The soils are tilled frequently; tillage equipment is used that eliminates the protective cover of crop residue and leaves the soils bare.
3. The cropping system used is generally alternate wheat and fallow. However, since controls have been placed on the acreage of wheat grown, a larger acreage has been fallowed and used for sorghum. As a result, wheat-sorghum-fallow is the cropping system sometimes used. Where the cropping system consists of alternate wheat and fallow, winter wheat is seeded on soils that have been left idle and kept free of weeds during one growing season. If a satisfactory stand of wheat is not obtained, or if the wheat is blown out, the soils are planted to sorghum.
4. Crop residue is grazed if it is available. Usually, the wheat, both seeded and volunteer, is grazed during fall and winter.

Improved management.—Under improved management for wheat and sorghum, the following practices are used:

1. Practices are used that will conserve moisture and protect the soils from erosion. These include terracing and contour farming.
2. Tillage is held to a minimum and is done in a way that will leave the crop residue on the surface. Tillage is performed only when it is necessary to kill weeds or to prepare a seedbed.
3. The cropping system is flexible. Wheat or sorghum is grown, or the soils are left fallow, depending on the amount of moisture in the soil.
4. A proper seeding rate is used.
5. Grazing of crop residue is controlled so that the soils are protected at all times.

Irrigation in Finney County

Finney County has about 100,000 acres under irrigation. The largest irrigated area is the broad tableland north of the Arkansas River and west of the Scott-Finney depression. Most of the cultivated acreage in the valley of the Arkansas River is under irrigation. Irrigation is most extensive on the north side of the river, but much of the acreage of loamy soils south of the sandhills is also irrigated. East of the Scott-Finney depression, irrigation is less extensive. Only a small acreage is irrigated in the area drained by the Pawnee River.

Sources of irrigation water.—Water for irrigation comes from two major sources—formations of Pliocene and Pleistocene age, and alluvial sands and gravel in the valley of the Arkansas River. The formations of Pliocene and

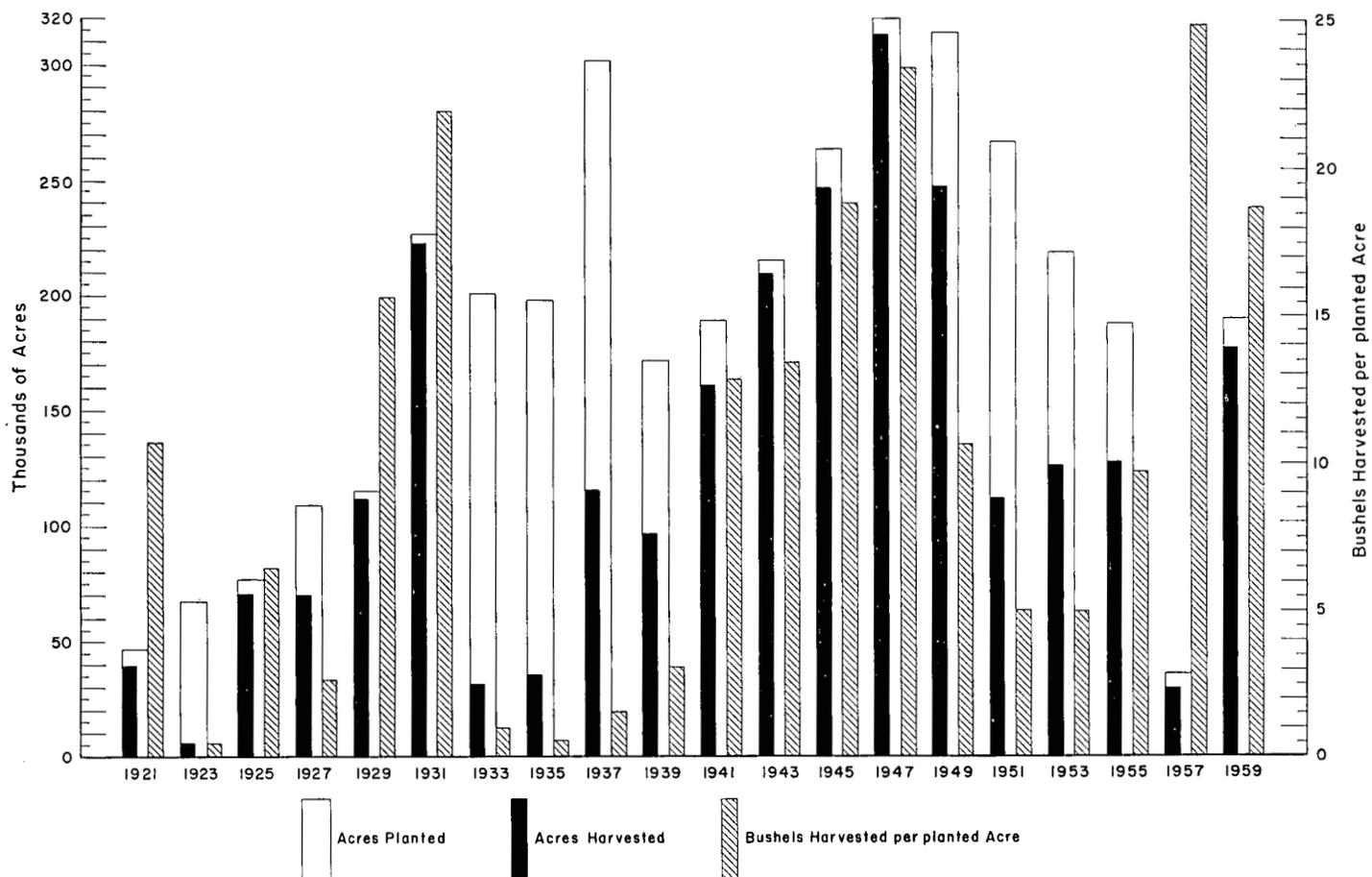


Figure 14.—Acreage of wheat planted, the acreage harvested, and the yield per planted acre in given years.

Pleistocene age underlie all of the county, except the area drained by the Pawnee River. The material in these formations is chiefly silt, sand, and gravel, but there is a small amount of clay. It is poorly sorted and its composition varies widely within short distances. The material of Pleistocene age is thicker in the Scott-Finney depression than in other parts of the county. It is more than 160 feet thick in the depression.

The alluvial sands and gravel in the valley of the Arkansas River are more permeable than the formations of Pliocene and Pleistocene age, and they yield a large amount of water for irrigation. They are about 30 to 60 feet thick over sand and gravel of the Pleistocene formations.

When irrigation was begun in the county, water for irrigation was taken from the Arkansas River. Now, few farmers depend entirely on water from that river. Most of them have wells in addition to their ditch rights. Much of the irrigation water for the broad tableland north of the Arkansas River comes from deep wells (fig. 15) or is brought in from the Arkansas River through a ditch. A ditch is also used to bring in water from Lake McKinney, in Kearny County. That lake also receives its supply from the Arkansas River.

Near the Arkansas River, water is obtained directly from the river or is pumped from shallow wells in the thick deposits of alluvium. In the area south of the sandhills, water is pumped from deep wells. Several ponds supply

water for the small acreage under irrigation in the basin of Pawnee River.

The county has about 550 irrigation wells. Most of the wells in the upland in the northern part of the county are 200 to 360 feet deep, but a few are less than 200 feet deep. The wells in the valley of the Arkansas River are generally only 30 to 50 feet deep, but a few are more than 50



Figure 15.—A typical installation used for pumping water from a deep well. The turnout box directs the flow of water into the irrigation ditch.

feet deep. Irrigation wells vary widely in the amount of water they yield. Only a few wells yield less than 500 gallons of water per minute, and a few yield more than 3,000 gallons per minute.

General management of irrigated soils

If soils are irrigated, it is necessary to maintain their fertility and tilth, apply enough water to meet the needs of the crop to be grown, and apply the water in such a way that the soils will be protected from erosion. The things to be considered in each of these various categories are discussed in the following paragraphs. Also discussed are the quality of the water used, and soil factors that affect suitability for irrigation.

Maintaining fertility.—The fertility of the soils must be high if maximum returns are to be realized from irrigation. Growing irrigated crops year after year removes a large amount of plant nutrients from the soils. Under dryland farming the natural supply of plant nutrients is reduced rather slowly, but it decreases faster after irrigation is begun. Table 3 shows the approximate amount of plant nutrients removed each year by various irrigated crops.

TABLE 3.—Approximate amount of plant nutrients removed by specified crops under irrigation

Crop	Yield	Pounds per acre of—		
		Nitrogen (N)	Phosphorus (P ₂ O ₅)	Potassium (K ₂ O)
Sorghum.....	80 bushels....	76	32	26
Wheat.....	40 bushels....	46	22	14
Sugar beets.....	15 tons.....	76	23	60
Alfalfa for hay.....	4 tons.....	180	43	178

Commercial fertilizer, manure, and legumes are sources of plant nutrients. The amount and kinds of commercial fertilizer to apply depend on the natural fertility of the soil and on the needs of the crop to be grown. Nitrogen is generally needed for maximum yields on all the soils. Application of a fertilizer high in phosphate has also increased yields on some soils, particularly on the Las and Las Animas soils in the valley of the Arkansas River. The Kansas Agricultural Experiment Station maintains laboratories at Garden City and Manhattan for testing soils to determine the kind of fertilizer needed.

Where a commercial fertilizer is applied, the time of application is important. The plant nutrients must be available when they are needed. For the soils that are in the valley of the Arkansas River and that have a limited root zone, care must be taken to avoid loss of plant nutrients through leaching. Adding plant nutrients as a side dressing is best on those soils so that the crop can use the nutrients before they are leached from the soil.

Manure is low in plant nutrients, but it supplies organic matter, which improves the structure of the soils and encourages the growth of micro-organisms. Manure is especially beneficial in cut areas where the supply of organic matter is low and the soils do not have good natural structure.

Legumes supply nitrogen. The amount of nitrogen furnished depends on how well the crop grows and how much of it is kept as plant residue.

Maintaining tilth.—The tilth of the soils is important because a compact layer in the soil restricts the depth to which water and roots can penetrate. Good tilth is also important for a good seedbed.

Plowing under plant residue improves the soil tilth and increases the content of organic matter. Plant residue worked into the surface soil also helps to prevent surface crusting. It keeps the soil open and porous so that water and roots can penetrate easily. This is especially important in clayey soils, which are more susceptible to compaction than other kinds of soils. Legumes that have roots that penetrate to a great depth increase the percolation of water and the movement of air in the lower layers. Plowing crops under as green manure is an effective way of adding organic matter to the soils.

Methods of applying water.—The crop to be grown, the kinds of soils, and the degree of slope influence the method of applying water. Furrow irrigation is suitable for sorghum, sugar beets, corn, soybeans, many kinds of vegetables, and most other cultivated crops (fig. 16). Border irrigation is ideal for alfalfa, small grains, and other close-growing crops. Where the border type of irrigation is used, some land leveling is generally needed so that the water will be distributed evenly. Sprinkler irrigation is best suited to soils that have a high intake rate and that are in areas of uneven topography. It is used in some undulating areas of sandy soils that lie south of the sandhills.

Crops vary greatly in their water requirements. Alfalfa, for example, uses a large amount of water. This is because it grows mainly in hot weather and needs a large amount of water each day, and because it has a long growing season. Crops such as wheat, on the other hand, grow mostly during the cooler part of the year when less moisture is required.

The frequency of irrigation depends on the amount of water needed each day by the crop and on the moisture-holding capacity of the soil. The amount of moisture needed each day by a given crop varies as the result of differences in the stage of growth, the temperature, movement of the wind, humidity, and proportion of daylight



Figure 16.—Field of Ulysses silt loam, 0 to 1 percent slopes, that has been furrow irrigated. The crop is potatoes.

hours in relation to darkness. The yield and quality of the crop is seriously affected if the plants lack moisture just once during the growing season. It is best to start irrigating when about half of the available moisture has been used. This allows enough time to cover the entire field before all of the moisture has been used and the crop is injured.

The rate at which irrigation water can be applied without causing excessive erosion depends on the degree and length of the slopes and on the kind of crop that is irrigated. The rate at which water can be applied decreases as the degree of slope and the length of slope increases. Irrigation on the contour decreases the degree of slope. Land leveling is necessary in many places to eliminate excessive slopes. Close-growing crops slow the flow of irrigation water and thus help to control erosion. Irrigating close-growing crops requires less care than irrigating clean-tilled crops because a close-growing crop provides more protection from erosion.

Drop structures can be used to control erosion in irrigation ditches. Underground pipelines eliminate erosion in the irrigation ditches and eliminate loss of water through seepage.

Growing a combination of crops whose demands for water come at different seasons of the year makes for the most efficient use of the irrigation system. Part of the acreage can be irrigated in winter when crops under full

irrigation require only a small amount of water. If this is done, the amount of moisture stored in the root zone may be great enough so that the yield of the next crop is as high as that obtained when the crop is planted after summer fallow. Some soils can store as much as 10 inches of water for plants if water is applied during the off season. If the root zone is deep enough, moisture is not lost when the soil is wet to a depth of 5 or 6 feet. It is stored, ready to be used by plants.

Water quality and soil factors.—The quality of the irrigation water varies as the result of differences in the source. Water from the Pliocene and Pleistocene deposits is of excellent quality. However, water from the Arkansas River and from shallow wells in the valley of that river contains a higher concentration of salts. The water from all sources needs to be tested before it is used for irrigation. Several different soils must be tested before the quality of the water can be evaluated. The quality of the water that can be safely used for irrigation, the suitability of the soil for irrigation, and the way the soil should be irrigated depend on several factors. The main factors to be considered are (1) the available water holding capacity, (2) the depth of the root zone, (3) the water-intake rate, (4) the drainage, and (5) the salinity or alkalinity of the soil.

Table 4 shows the depth of the root zone in the soils in Finney County, the approximate available water holding capacity at stated depths, and the approximate water-

TABLE 4.—Factors that affect irrigation of Finney County soils

Irrigated capability unit and mapping units	Depth of root zone	Approximate available water holding capacity				Approximate water-intake rate	Drainage, salinity, and alkalinity
		Per foot	Total to a depth of 3 feet	Total to a depth of 6 feet	Total in root zone		
Unit I-1: Deep, nearly level silt loams, loams, and clay loams.							
	<i>Feet</i>	<i>Inches</i>	<i>Inches</i>	<i>Inches</i>	<i>Inches</i>	<i>Inches per hour</i>	
Bridgeport clay loam.....	8	2.2	6.6	13.2	17.6	0.4 to 0.6	Well drained; no salinity or alkalinity.
Harney silt loam, 0 to 1 percent slopes.....	8	2.2	6.4	13.0	17.4	0.2 to 0.4	
Humbarger silt loam.....	8	2.2	6.6	13.2	17.6	0.8 to 1.2	
Keith loam, 0 to 1 percent slopes.....	8	2.2	6.6	13.2	17.6	0.4 to 0.6	
Richfield silt loam, 0 to 1 percent slopes.....	8	2.2	6.6	13.2	17.6	0.2 to 0.4	
Richfield-Spearville complex, 0 to 1 percent slopes.....	8	2.2	6.4	13.0	17.4	0.15 to 0.3	
Richfield and Ulysses complexes, bench leveled.....	8	2.2	6.6	13.2	17.6	0.4 to 0.6	
Roxbury silt loam.....	8	2.2	6.6	13.2	17.6	0.4 to 0.6	
Ulysses silt loam, 0 to 1 percent slopes.....	8	2.2	6.6	13.2	17.6	0.4 to 0.6	
Unit IIe-2: Deep, undulating fine sandy loams and loams.							
Manter fine sandy loam, undulating.....	8	1.5	4.5	9.0	12.0	0.8 to 1.2	Well drained; no salinity or alkalinity.
Otero-Ulysses complex, undulating.....	8	1.5	4.5	9.0	12.0	0.8 to 1.2	
Unit IIe-4: Deep, gently sloping silt loams and loams.							
Richfield silt loam, 1 to 3 percent slopes.....	8	2.2	6.6	13.2	17.6	0.2 to 0.4	Well drained; no salinity or alkalinity.
Ulysses loam, undulating.....	8	2.0	6.0	12.0	17.6	0.8 to 1.2	
Ulysses silt loam, 1 to 3 percent slopes.....	8	2.2	6.6	13.2	17.6	0.4 to 0.6	
Ulysses-Colby silt loams, 1 to 3 percent slopes, eroded.....	8	2.2	6.6	13.2	17.6	0.4 to 0.6	
Unit IIw-1: Deep, imperfectly drained clay loams formed in alluvium.							
Las clay loam, deep.....	4	2.2	6.6	8.8	8.8	0.2 to 0.4	Imperfectly drained, because of the fluctuating water table; slight to moderate salinity.

TABLE 4.—Factors that affect irrigation of Finney County soils—Continued

Irrigated capability unit and mapping units	Depth of root zone	Approximate available water holding capacity				Approximate water-intake rate	Drainage, salinity, and alkalinity
		Per foot	Total to a depth of 3 feet	Total to a depth of 6 feet	Total in root zone		
Units IIs-1: Deep, nearly level fine sandy loams and sandy loams.							{The Bayard and Manter soils are well drained and have no salinity or alkalinity. The Las soil is imperfectly drained and has slight to moderate salinity.
Bayard fine sandy loam.....	5	1.5	4.5	7.0	7.0	1.3 to 1.7	
Las-Bayard sandy loams.....	5	1.5	4.5	7.0	7.0	0.8 to 1.2	
Manter fine sandy loam, level.....	8	1.5	4.5	9.0	12.0	0.8 to 1.2	
Unit IIs-2: Deep, nearly level silty clay loams.							{Well drained; no salinity or alkalinity.
Spearville silty clay loam 0 to 1 percent slopes.	8	2.2	6.2	12.8	17.2	0.05 to 0.2	
Ulysses and Richfield soils, silted, 0 to 1 percent slopes.	8	2.2	6.2	12.8	17.2	0.05 to 0.2	
Unit IIs-4: Deep, nearly level, saline silt loams.							{Well drained; slight to moderate salinity.
Richfield silt loam, saline.....	8	2.2	6.6	13.2	17.6	0.2 to 0.4	
Ulysses silt loam, saline, 0 to 1 percent slopes.	8	2.2	6.6	13.2	17.6	0.4 to 0.6	
Ulysses and Richfield complexes, saline, bench leveled.	8	2.2	6.6	13.2	17.6	0.4 to 0.6	
Unit IIIw-1: Moderately deep, imperfectly drained clay loams and sandy loams formed in alluvium.							{Imperfectly drained, because of the fluctuating water table; slight to moderate salinity.
Las clay loam, moderately deep.....	2.5	2.2	5.0	5.0	5.0	0.2 to 0.4	
Las-Las Animas complex.....	2.5	2.0	4.5	4.5	4.5	0.3 to 0.5	
Unit IIIw-2: Moderately deep, imperfectly drained sandy loams formed in alluvium.							{Imperfectly drained, because of the fluctuating water table; slight to moderate salinity.
Las Animas sandy loam.....	2.5	1.5	4.0	4.0	4.0	1.3 to 1.7	
Unit IIIs-2: Deep, nearly level, saline soils that are moderately well drained.							{Moderately well drained because of the fluctuating water table; salinity is slight to moderate.
Church silty clay loam.....	8	2.2	6.6	13.2	17.6	0.2 to 0.4	
Colby loam, saline.....	8	2.2	6.6	13.2	17.6	0.4 to 0.6	
Unit IVe-7: Deep, undulating loamy fine sands.							{Well drained; no salinity or alkalinity.
Vona loamy fine sand.....	8	1.0	3.5	6.0	8.0	1.8 to 2.2	
Unit IVs-2: Deep, nearly level, saline-alkali soils that are moderately well drained.							{Moderately well drained because of the fluctuating water table; salinity and alkalinity are severe.
Drummond silt loam.....	8	2.2	6.6	13.2	17.6	0.15 to 0.3	

¹ Variations in the approximate available water holding capacity at a stated depth are caused by variations in the clay content of the soil horizon.

intake rate. It also gives some facts about drainage and about the salinity and alkalinity of the soils. In table 4 the soils are grouped by capability units. A discussion of each capability unit is given in the section "Management of Irrigated Soils by Capability Units."

The Garden City Experiment Station and the Kansas State University at Manhattan will help in testing the water and soils. For assistance in planning the irrigation system and in evaluating the suitability of the soils and of the supply of water for irrigation, consult a technician of your local Soil Conservation Service office or a member of the experiment station staff.

The depth of the root zone determines the depth to which roots can penetrate to obtain plant nutrients and

water. If the root zone is favorable, the roots of alfalfa penetrate to a depth of 8 feet or more; the roots of wheat and sorghum, to a depth of at least 6 feet; the roots of sugar beets, to a depth of about 5 feet; and the roots of grasses, to a depth of about 3 feet. Some soils have a root zone that is too limited for these various crops; in such soils the growth of the roots, and often the growth of the entire plant, is restricted.

The available water holding capacity refers to the amount of water that the soil can hold available for plant use. It depends largely on the texture of the soil and on the thickness of the soil material. Silty and clayey soils hold more water available for plants than do sandy soils. Soils that are shallow over coarse sand or gravel have

lower water-holding capacity than soils that have finer textured material to a depth of many feet. The water-holding capacity of the soil affects the frequency of irrigation and the amount of time needed to fill the root zone to the desired moisture content.

The water-intake rate depends largely on the texture and tilth of the surface layer and on the permeability of the subsoil. Sandy soils take water more rapidly than finer textured soils. In general, the intake rate decreases as the content of clay increases. A compact surface layer that has unfavorable structure restricts the penetration of water. In places the permeability of the subsoil determines the rate of water intake. The permeability of the subsoil depends on the texture and structure of the soil material in that layer. Sandy soils that have granular structure in the subsoil are the most permeable, and clayey soils that have blocky structure in the subsoil are the least permeable.

Soils must have adequate surface drainage and subsurface drainage if the irrigation system is to be successful. Surface drainage is needed to dispose of excess irrigation water and water from precipitation. Subsurface drainage must be adequate to keep salts from accumulating in the root zone and to prevent the buildup of a damaging water table. If salts are not leached from the root zone, they accumulate until a damaging level is reached. The soils that in many places do not have adequate natural subsurface drainage are Church silty clay loam, Drummond silt loam, the Las clay loams, Las Animas sandy loam, and Colby loam, saline.

The degree of salinity or alkalinity of a soil determines the amount of leaching necessary and the quality of irrigation water that can be used. Water that contains some salts or alkali can be used more readily on well-drained soils that contain no salts or alkali than on soils that have restricted drainage and some degree of salinity or alkalinity. Some of the irrigation water must pass through the root zone in saline and alkali soils to leach out the excess salts and sodium. The amount of leaching required depends on the degree of salinity and alkalinity of the soil and on the quality of the water. The soils that contain harmful salts or alkali are Drummond silt loam, Church silty clay loam, the Las clay loams, Las Animas sandy loam, and saline Richfield silt loam, the saline Ulysses silt loams, and saline Colby loam. Special precautions should be taken when irrigating these soils to insure that water of good quality is used and that subsurface drainage is adequate for removing the excess salts.

Capability Groups of Soils for Irrigation

The soils of the county have been grouped in capability units to show their suitability for irrigation farming. The capability classes, subclasses, and units for irrigation farming are described in the list that follows.

Class I. Soils that have few limitations that restrict their use.

Unit I-1. Deep, nearly level silt loams, loams, and clay loams.

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

Subclass IIe. Soils subject to moderate erosion if they are not protected.

Unit IIe-2. Deep, undulating fine sandy loams and loams.

Unit IIe-4. Deep, gently sloping silt loams and loams.

Subclass IIw. Soils that have moderate limitations because of excess water.

Unit IIw-1. Deep, imperfectly drained clay loams formed in alluvium.

Subclass IIs. Soils that have moderate limitations of moisture capacity or tilth.

Unit IIs-1. Deep, nearly level fine sandy loams and sandy loams.

Unit IIs-2. Deep, nearly level silty clay loams.

Unit IIs-4. Deep, nearly level, saline silt loams.

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

Subclass IIIw. Soils that have severe limitations because of excess water.

Unit IIIw-1. Moderately deep, imperfectly drained clay loams and sandy loams formed in alluvium.

Unit IIIw-2. Moderately deep, imperfectly drained sandy loams formed in alluvium.

Subclass IIIs. Soils that have severe limitations because of salinity or tilth.

Unit IIIs-2. Deep, nearly level, saline soils that are moderately well drained.

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-7. Deep, undulating loamy fine sands.

Subclass IVs. Soils that have very severe limitations as the result of salinity, alkalinity, or tilth.

Unit IVs-2. Deep, nearly level, saline-alkali soils that are moderately well drained.

Management of irrigated soils by capability units

In the following pages the management practices suitable for the soils in each irrigated capability unit are discussed. Information about planning an irrigation system can be obtained from a local technician of the Soil Conservation Service.

IRRIGATED CAPABILITY UNIT I-1

Deep, nearly level silt loams, loams, and clay loams make up this capability unit. These soils are—

- Bridgeport clay loam (Bp).
- Harney silt loam, 0 to 1 percent slopes (Ha).
- Humbarger silt loam (Hu).
- Keith loam, 0 to 1 percent slopes (Ka).
- Richfield silt loam, 0 to 1 percent slopes (Rm).
- Richfield-Spearville complex, 0 to 1 percent slopes (Rs).
- Richfield and Ulysses complexes, bench leveled (Ru).
- Roxbury silt loam (Rx).
- Ulysses silt loam, 0 to 1 percent slopes (Uo).

These are fertile, well-drained soils that have high moisture-holding capacity. They are permeable to roots, water, and air.

Good management of these soils consists of using practices that maintain or improve the fertility and tilth of

the soils. Such practices are (1) use of a cropping sequence that includes a deep-rooted legume, (2) managing crop residue so as to maintain the content of organic matter and the structure of the surface layer, and (3) applying commercial fertilizer as needed. Wheat, sorghum, sugar beets, alfalfa, corn, and other adapted crops can be grown on these soils under irrigation.

Use practices that will conserve and make the most efficient use of the irrigation water. The soils are well suited to flood irrigation, but many areas will need leveling so that water will be distributed uniformly. A system for disposing of excess irrigation water and water from precipitation is essential.

IRRIGATED CAPABILITY UNIT IIc-2

In this capability unit are deep fine sandy loams and loams that are undulating. These soils are—

Manter fine sandy loam, undulating (Mr).
Otero-Ulysses complex, undulating (Oy).

These are fertile, well-drained soils, easily penetrated by roots, water, and air. Their moisture-holding capacity is moderate, and they readily release moisture for the use of plants.

Controlling erosion by wind and water and using irrigation water efficiently are problems on these sandy, sloping soils. These soils are better suited to sprinkler irrigation than to other types of irrigation because of their irregular slopes. They can be leveled, but deep cuts and fills are necessary because of the irregular topography. Where areas are leveled, small sand pockets are sometimes encountered. These areas may require backfilling with less sandy material to prevent them from being droughty. In many places in these sandy soils, drop structures are necessary to control erosion in the irrigation ditches. Underground pipelines will reduce losses of water.

Good management of these soils consists of using practices that maintain or improve the fertility and tilth of the soils. Such practices are (1) use of a cropping sequence that includes a deep-rooted legume, (2) managing crop residue so as to maintain the content of organic matter and the structure of the surface layer, and (3) applying commercial fertilizer as needed. If good management is used, wheat, sorghum, sugar beets, alfalfa, and other adapted crops can be grown on these soils under irrigation.

IRRIGATED CAPABILITY UNIT IIc-4

Deep, gently sloping silt loams and loams are in this capability unit. These soils are—

Richfield silt loam, 1 to 3 percent slopes (Rn).
Ulysses loam, undulating (Ud).
Ulysses silt loam, 1 to 3 percent slopes (Ub).
Ulysses-Colby silt loams, 1 to 3 percent slopes, eroded (Ue).

These are fertile, well-drained soils that have high moisture-holding capacity. They are permeable to roots, water, and air.

Controlling erosion and using irrigation water efficiently are problems on these sloping soils. Good management consists of using practices that maintain the fertility and tilth of the soils. Managing plant residue well is important, and commercial fertilizer should be applied as needed. A deep-rooted legume will help to maintain the fertility and good tilth of the soils. Wheat, sorghum, sugar beets, alfalfa, corn, and other adapted crops can be grown under irrigation if these soils are properly managed.

Land leveling or irrigating on the contour minimizes erosion and increases the efficiency with which water is used. Small sand pockets occur in some places in the undulating Ulysses soils. In areas where pockets occur backfilling with less sandy material may be required to prevent the soils from being droughty. The other soils generally have no limiting layers that affect land leveling. Drop structures may be necessary to control erosion in the irrigation ditches. Underground pipelines reduce losses of water and eliminate troublesome ditches.

IRRIGATED CAPABILITY UNIT IIw-1

Only Las clay loam, deep (lb), is in this capability unit. It is a deep, imperfectly drained soil formed in alluvium.

This soil has somewhat restricted moisture-holding capacity. Its productivity is slightly to moderately affected by a fluctuating water table and by the associated salinity.

Good management of this soil consists of using practices that maintain or improve the fertility and tilth and that make efficient use of the irrigation water. Work crop residue into the soil to maintain the content of organic matter and to improve the tilth of the surface layer. A deep-rooted legume improves the fertility and tilth. Use commercial fertilizer as needed. Wheat, sorghum, sugar beets, alfalfa, and other adapted crops can be grown under irrigation.

Use practices that will conserve water and distribute it evenly. The depth of the root zone is limited by coarse sand and gravel, which is 40 to 60 inches beneath the surface. Therefore, when leveling, keep the depth of the cut to a minimum.

Applying water properly is important on this soil. Light irrigation is not desirable, because it favors the accumulation of harmful salts in the root zone. Excessive irrigation, on the other hand, leaches plant nutrients from the soil. Testing the soil and the water for salinity and alkalinity will help to determine the amount of water to apply.

IRRIGATED CAPABILITY UNIT IIw-1

Deep, nearly level fine sandy loams and sandy loams are in this capability unit. These soils are—

Bayard fine sandy loam (Bo).
Las-Bayard sandy loams (Lc).
Manter fine sandy loam, level (Mn).

These are fertile soils, and they have moderate moisture-holding capacity. They are easily penetrated by roots, water, and air. These soils readily release moisture for the use of plants. The Bayard and Manter soils are well drained. The Las soils are imperfectly drained.

Good management of these soils consists of using practices that maintain or improve the fertility and tilth. Such practices are (1) using a cropping sequence that includes a deep-rooted legume, (2) managing crop residue so as to maintain the content of organic matter and the structure of the surface layer, and (3) applying commercial fertilizer as needed. If good management is used, wheat, sorghum, sugar beets, alfalfa, and other adapted crops can be grown on these soils under irrigation.

Use practices that will conserve moisture and make the most efficient use of the irrigation water. In many places land leveling is necessary so that water will be distributed uniformly. Sand pockets are sometimes encountered when leveling; where they occur, backfilling with less sandy material may be necessary to prevent the area from being

droughty. Avoid deep cuts in the Las soil because that soil is underlain by coarse sand and gravel at a depth of 3 to 6 feet. Underground pipelines or drop structures in ditches may be necessary in some places.

IRRIGATED CAPABILITY UNIT II_s-2

In this capability unit are deep, nearly level silty clay loams. These soils are—

Spearville silty clay loam, 0 to 1 percent slopes (Sp).
Ulysses and Richfield soils, silted, 0 to 1 percent slopes (Ux).

These soils are compact and clayey. They have high moisture-holding capacity, but they take up water slowly. Careful management is required to maintain favorable soil structure and good tilth.

Working crop residue into the soils and using a cropping sequence that includes a deep-rooted legume will help to improve soil tilth. Organic matter worked into the surface layer helps to prevent crusting and improves the moisture relationships of the soils. Use commercial fertilizer, as needed, for good yields. Wheat, sorghum, sugar beets, alfalfa, corn, and other adapted crops can be grown on these soils under irrigation.

Use practices that will conserve moisture and make the most efficient use of the irrigation water. In many places land leveling is needed so that water will be distributed uniformly. These soils contain no limiting layers that affect land leveling. A disposal system for the removal of excess irrigation water and runoff from precipitation is essential.

IRRIGATED CAPABILITY UNIT II_s-4

Deep, nearly level, saline silt loams are in this capability unit. These soils are—

Richfield silt loam, saline (Ro).
Ulysses silt loam, saline, 0 to 1 percent slopes (Us).
Ulysses and Richfield complexes, saline, bench leveled (Uv).

These are permeable, well-drained soils that have high moisture-holding capacity. Salinity has a slight to moderate effect on crops that are grown on them.

Good management of these soils consists of using practices that maintain or improve the fertility and tilth. Such practices are (1) using a cropping sequence that includes a deep-rooted legume, (2) managing crop residue so as to maintain the content of organic matter and the structure of the surface layer, and (3) applying commercial fertilizer as needed. If good management is used, wheat, sorghum, sugar beets, alfalfa, corn, and other adapted crops can be grown under irrigation.

Apply enough water to leach the excess salts from the root zone. Testing the soils and water for salinity and alkalinity will help to determine the amount of leaching necessary. Use practices that conserve moisture and make the most efficient use of the irrigation water. Land leveling helps to get uniform distribution of water. Keep the depth of the cut to a minimum so that the saline horizons will not be closer to the surface than necessary. A disposal system is essential for removing excess irrigation water and excess water from precipitation.

IRRIGATED CAPABILITY UNIT III_w-1

Moderately deep, imperfectly drained clay loams and sandy loams formed in alluvium make up this capability unit. These soils are—

Las clay loam, moderately deep (Lc).
Las-Las Animas complex (Ld).

These soils have low moisture-holding capacity. Their productivity is slightly to moderately affected by a fluctuating water table and the associated salinity.

Manage these soils so that their fertility and tilth are maintained or improved and irrigation water is used efficiently. Work crop residue into the soil to improve tilth and to maintain the content of organic matter. Use commercial fertilizer as needed. Wheat, sorghum, sugar beets, alfalfa, and other adapted crops can be grown on these soils under irrigation.

Use practices that will conserve water and distribute it evenly. The depth to which roots penetrate is limited by coarse sand and gravel that is 20 to 40 inches beneath the surface. Therefore, when leveling is done, the depth of the cut should be kept to a minimum.

Applying water properly is important on these soils. Light irrigation is not desirable, because it favors the accumulation of harmful salts in the root zone. Excessive irrigation, on the other hand, leaches plant nutrients from the soil. Testing the soils and the water for salinity and alkalinity will help to determine the amount of water to apply.

IRRIGATED CAPABILITY UNIT III_w-2

Only Las Animas sandy loam (Lk) is in this capability unit. It is a moderately deep, imperfectly drained soil formed in alluvium.

This soil has low moisture-holding capacity. Its productivity is slightly to moderately affected by a fluctuating water table and the associated salinity. Work crop residue into the surface to build up the content of organic matter, and apply commercial fertilizer as needed. Wheat, sorghum, and sugar beets are the crops best adapted to this soil under irrigation.

Use practices that will conserve water and distribute it evenly. The depth of the root zone is limited by coarse sand and gravel, which are 24 to 40 inches beneath the surface. Therefore, when leveling is done, keep the depth of the cut to a minimum.

Applying water properly is important on this soil. Light irrigation is not desirable, because it favors the accumulation of harmful salts in the root zone. Excessive irrigation, on the other hand, leaches plant nutrients from the soil. Testing the soil and the water for salinity and alkalinity helps to determine the amount of water to apply.

IRRIGATED CAPABILITY UNIT III_s-2

Deep, nearly level, saline soils that are moderately well drained make up this capability unit. These soils are—

Church silty clay loam (Ch).
Colby loam, saline (Cs).

These are permeable soils that have high moisture-holding capacity. Salinity has a moderate effect on crops that are grown on them. Their subsurface drainage is somewhat restricted.

Good management of these soils consists of using practices that maintain or improve the soil fertility and tilth. These practices are (1) including a deep-rooted legume in the cropping sequence, (2) managing crop residue so as to maintain the content of organic matter and the structure of the surface layer, and (3) applying commercial fertilizer as needed. If good management is used, wheat, sugar beets, and alfalfa are the crops best adapted for irrigation.

Apply enough water to leach the excess salts from the root zone. Testing the soils and water for salinity and alkalinity will help to determine the amount of leaching necessary. Subsurface drainage must be provided where the present drainage is not adequate to provide for continued leaching of the root zone.

Use practices that will conserve water and distribute it evenly. In many places land leveling is needed so that water will be distributed uniformly. Keep the depth of the cut to a minimum so that the saline horizons will not be closer to the surface than necessary. A disposal system is essential for removing the excess irrigation water and water from precipitation.

IRRIGATED CAPABILITY UNIT IVe-7

Only Vona loamy fine sand (Vo) is in this capability unit. It is a deep, undulating soil.

This soil takes water rapidly, but it blows easily. It has low moisture-holding capacity. Fertility is low.

Controlling wind erosion and using irrigation water efficiently are problems on this soil. This soil is better suited to sprinkler irrigation than to other types because of the sandy surface layer and irregular slopes.

Good management of this soil consists of using practices that maintain or improve the soil fertility and tilth. Such practices are (1) using a cropping sequence that includes a deep-rooted legume, (2) managing crop residue so as to maintain the content of organic matter and the structure of the surface layer, and (3) applying commercial fertilizer as needed. If good management is used, wheat, sorghum, and alfalfa can be grown on this soil under irrigation.

IRRIGATED CAPABILITY UNIT IVs-2

Drummond silt loam (Dr) is the only soil in this capability unit. It is a deep, nearly level, saline-alkali soil, and it is moderately well drained.

Crops grown on this soil are affected severely by salinity and alkalinity. This soil has high moisture-holding capacity. Its subsurface drainage is somewhat restricted.

Good management of this soil consists of using practices that maintain or improve the fertility and tilth. Such practices are (1) using a cropping sequence that includes a deep-rooted legume, (2) managing crop residue so as to maintain the content of organic matter and structure of the surface layer, and (3) applying commercial fertilizer as needed. The best adapted crops to grow under irrigation are wheat, sugar beets, and alfalfa.

Apply enough water to leach the excess salts and sodium from the root zone. Testing this soil and the water for salts and alkali will help to determine the amount of leaching necessary. Subsurface drainage must be supplied where drainage is not adequate to provide for continued leaching of the root zone. Only water of excellent quality should be used.

Use practices that conserve water and distribute it evenly. In many places land leveling is needed so that the water will be distributed evenly. Keep the depth of the cut to a minimum so that the saline and alkali horizons will not be closer to the surface than necessary. A disposal system for removing excess irrigation water and excess water from precipitation is essential.

Predicted Yields of Crops (Irrigated)

Methods of managing irrigated soils vary. Therefore, predictions of yields to be obtained from irrigated crops grown on the soils of this county were not made. The following figures for expected acre yields of various crops grown under good irrigation management were taken from information published by the Garden City Experiment Station, Branch of Kansas State University (6).²

Crop:	Expected acre yield
Alfalfa.....	5 to 7 tons
Barley (winter).....	40 to 50 bushels
Corn grown for grain.....	75 to 115 bushels
Corn grown for silage.....	15 to 25 tons
Sorghum grown for forage.....	16 to 26 tons
Sorghum grown for grain.....	75 to 125 bushels
Wheat.....	35 to 55 bushels

These yields were obtained when a correct seeding rate was used, a suitable variety was planted, and seeding was done at the right time. Also, enough water was applied to meet the needs of the crop, and fertilizer was properly used.

Yields of 20 to 25 tons of sugar beets per acre are not uncommon on these soils, and the beet tops can be used for livestock feed. The green weight of the tops, including the crown, is about one-half that of the beets.

Besides the grain obtained when wheat is harvested, additional returns are gained by pasturing irrigated wheat and sorghum stubble. A large number of cattle and sheep graze the irrigated wheat each winter.

Management of Rangeland³

Rangeland makes up about 36 percent of the total acreage in Finney County. It is scattered throughout the county, but some areas are concentrated in the sandhills south of the Arkansas River and adjacent to that river. Generally, this rangeland is not suitable for cultivation.

The raising of livestock is the second largest agricultural enterprise in this 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

² Italic numbers in parentheses refer to Literature Cited, p. 89.

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

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, 50 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; consequently, they are 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.

Descriptions of range sites

The range sites in Finney County are the Saline Subirrigated, Saline Lowland, Loamy Lowland, Loamy Upland, Limy Upland, Clay Upland, Saline Upland, Sandy, Sands, Choppy Sands, Gravelly Hills, Rough Breaks, and Shale Breaks. Because of differences in the soils, the range sites vary greatly in the amount of forage produced. The total yield of forage varies also from year to year because of differences in the amount of precipitation, in the amount of grazing in past years, and in relief. In addition, trampling or the activities of rodents and insects may damage the forage plants or cause them to disappear. The following listing gives estimates of the total top growth of forage for the range sites in excellent condition where there has been an average amount of rainfall:

Range site:	Air-dry weight (<i>Lb. per acre</i>)
Saline Subirrigated.....	4,000 to 6,000
Saline Lowland.....	3,000 to 4,000
Loamy Lowland.....	2,000 to 3,000
Loamy Upland.....	1,250 to 2,000
Limy Upland.....	1,500 to 2,250
Clay Upland.....	750 to 1,500
Saline Upland.....	1,500 to 2,250
Sandy.....	1,500 to 2,000
Sands.....	2,000 to 2,500
Choppy Sands.....	1,250 to 1,750
Gravelly Hills.....	1,500 to 2,000
Rough Breaks.....	1,250 to 1,750
Shale Breaks.....	1,000 to 1,500

The range sites in this county are described in the following pages. The description of each site includes the name and map symbol of each soil in the site, and the dominant vegetation when the site is in excellent condition.

SALINE SUBIRRIGATED SITE

This range site is made up of nearly level, somewhat poorly drained, saline soils of the Arkansas River bottom lands. The soils have a surface layer of clay loam to loamy sand. They receive extra moisture from flooding and from

the high water table. Following are the soils in this range site and the map symbol of each:

- Las Animas sandy loam (Lk).
- Las Animas-Lincoln loamy sands (Ll).
- Las-Las Animas complex (Ld).
- Sweetwater clay loam (Sw).

The climax plant cover is a mixture of switchgrass, alkali sacaton, Indiangrass, western wheatgrass, and other decreasers. These grasses make up at least 80 percent of the total cover, and perennial grasses and forbs make up the rest. Switchgrass and alkali sacaton are the dominant decreasers. Increasers, mainly saltgrass, make up as much as 20 percent of the climax vegetation. Common invaders are alkali muhly, western ragweed, foxtail barley, and tamarisk.

SALINE LOWLAND SITE

In this range site are nearly level, somewhat poorly drained, saline soils on low terraces in the valley of the Arkansas River. The soils have a surface layer of loam to clay loam. They receive extra moisture from occasional flooding or from run-in. Following are the soils in this range site and the map symbol of each:

- Las clay loam, moderately deep (ta).
- Las clay loam, deep (tb).
- Las-Bayard sandy loams (Las soil only) (Lc).

The climax plant cover is a mixture of such decreaser grasses as switchgrass, alkali sacaton, and western wheatgrass. These grasses make up at least 70 percent of the total cover, and other perennial grasses and forbs make up the rest. Alkali sacaton and western wheatgrass are the dominant decreasers. Increasers, mainly saltgrass, make up as much as 30 percent of the climax vegetation. Common invaders are western ragweed and tamarisk.

LOAMY LOWLAND SITE

The soils in this range site are deep, permeable, and loamy. They have high moisture-holding capacity and receive extra moisture from occasional flooding or from run-in. Following are the soils in this range site and the map symbol of each:

- Alluvial land (An).
- Humbarger silt loam (Hu).

The climax plant cover is a mixture of such decreaser grasses as switchgrass, big bluestem, Indiangrass, Canada wildrye, and little bluestem. These grasses make up at least 55 percent of the total cover, and other perennial grasses and forbs make up the rest. In places increasers make up as much as 45 percent of the climax vegetation. The increasers are mainly western wheatgrass, blue grama, and buffalograss.

LOAMY UPLAND SITE

In this range site are well-drained, nearly level to steep soils of the upland. These soils have a surface layer and subsoil of silt loam to clay loam. They are moderately permeable and have high moisture-holding capacity. Following are the soils in this range site and the map symbol of each:

- Bridgeport clay loam (Bp).
- Harney silt loam, 0 to 1 percent slopes (Ha).
- Keith loam, 0 to 1 percent slopes (Ka).
- Mansic complex (Mh).
- Otero-Ulysses complex, undulating (Ulysses soil only) (Oy).
- Richfield silt loam, 0 to 1 percent slopes (Rm).
- Richfield silt loam, 1 to 3 percent slopes (Rn).

Richfield-Spearville complex, 0 to 1 percent slopes (Richfield soil only) (Rs).
 Richfield and Ulysses complexes, bench leveled (Ru).
 Roxbury silt loam (Rx).
 Ulysses loam, undulating (Ud).
 Ulysses silt loam, 0 to 1 percent slopes (Ua).
 Ulysses silt loam, 1 to 3 percent slopes (Ub).
 Ulysses silt loam, 3 to 5 percent slopes (Uc).

The climax plant cover is a mixture of such grasses as blue grama, buffalograss, western wheatgrass, side-oats grama, and little bluestem. Buffalograss is the main increaser under grazing pressure, but blue grama and buffalograss are the dominant grasses under present grazing use (fig. 17). Annuals are the principal invaders; pricklypear is the common invader in droughty years.

LIMY UPLAND SITE

This range site consists of gently sloping and sloping, well-drained soils of the upland. The soils have a surface layer and subsoil of calcareous silt loam. They are permeable and have high moisture-holding capacity. Following are the soils in this range site and the map symbol of each:

Mansker-Potter complex (Mansker soil only) (Mm).
 Ulysses-Colby silt loams, 1 to 3 percent slopes, eroded (Ue).
 Ulysses-Colby silt loams, 3 to 5 percent slopes, eroded (Um).

The climax plant cover is a mixture of such grasses as little bluestem, side-oats grama, blue grama, hairy grama, and buffalograss. The dominant decreasers are little bluestem and side-oats grama. The dominant increasers are buffalograss, broom snakeweed, and other grasses that form a mat.

CLAY UPLAND SITE

In this range site are nearly level and gently sloping soils that have a surface layer and subsoil of silty clay loam to clay. These soils are on the upland. They are slowly permeable and are very droughty. Following are the soils in this range site and the map symbol of each:

Lofton clay loam (Lo).
 Promise clay, 1 to 3 percent slopes (Pc).
 Richfield-Spearville complex, 0 to 1 percent slopes (Spearville soil only) (Rs).
 Spearville silty clay loam, 0 to 1 percent slopes (Sp).
 Spearville complex, 1 to 3 percent slopes, eroded (Sr).
 Ulysses and Richfield soils, silted, 0 to 1 percent slopes (Ux).

The climax plant cover is a mixture of such decreaser grasses as western wheatgrass, side-oats grama, big blue-



Figure 17.—An area of the Loamy Upland range site, where blue grama and buffalograss are the dominant vegetation.

stem, and switchgrass. The dominant increaser grasses are buffalograss and blue grama. Annuals are the principal invaders; pricklypear is the common invader in droughty years.

SALINE UPLAND SITE

Deep, nearly level and gently sloping, saline and saline-alkali soils of the Scott-Finney depression make up this range site. The texture of the surface layer ranges from loam to silty clay loam. Permeability is moderate to slow, and the soils have high moisture-holding capacity. Following are the soils in this range site and the map symbol of each:

Church silty clay loam (Ch).
 Colby loam, saline (Cs).
 Drummond silt loam (Dr).
 Richfield silt loam, saline (Ro).
 Ulysses silt loam, saline, 0 to 1 percent slopes (Us).
 Ulysses silt loam, saline, 1 to 3 percent slopes (Ut).
 Ulysses and Richfield complexes, saline, bench leveled (Uv).

The climax plant cover is a mixture of such decreaser grasses as alkali sacaton and western wheatgrass. These grasses make up at least 70 percent of the total cover, and other perennial grasses and forbs make up the rest. In places increasers, mainly saltgrass, make up as much as 30 percent of the climax vegetation. Common invaders on this site are tumblegrass and annuals.

SANDY SITE

Deep, nearly level to moderately steep soils of the upland make up this range site. The soils have a surface layer and subsoil of fine sandy loam. They have moderately rapid permeability and moderate moisture-holding capacity. Following are the soils in this range site and the map symbol of each:

Bayard fine sandy loam (Ba).
 Las-Bayard sandy loams (Bayard soil only) (Lc).
 Manter fine sandy loam, undulating (Mr).
 Manter fine sandy loam, level (Mn).
 Manter-Otero fine sandy loams, undulating (Mt).
 Otero-Ulysses complex, undulating (Otero soil only) (Oy).
 Otero fine sandy loam, 5 to 15 percent slopes (Ot).
 Otero gravelly complex (Otero soil only) (Ox).

The climax plant cover is a mixture of such decreaser grasses as sand bluestem, little bluestem, switchgrass, and side-oats grama. In places these dominant climax grasses make up as much as 55 percent of the total cover, and perennial forbs and grasses make up the rest. The dominant increaser grasses are blue grama, buffalograss, sand dropseed, and sand paspalum. The dominant woody increasers are sand sagebrush and small soapweed. Common invaders are perennial three-awns and windmillgrass.

SANDS SITE

This range site consists of deep, rapidly permeable soils that have a surface layer of loamy fine sand and a subsoil of fine sand to fine sandy loam. The soils are in undulating areas or in areas of low dunes. Following are the soils in this range site and the map symbol of each:

Tivoli-Vona loamy fine sands (Tv).
 Vona loamy fine sand (Vo).

The climax plant cover is a mixture of such decreaser grasses as sand bluestem, little bluestem, switchgrass, side-oats grama, and big sandreed. In places these climax grasses make up as much as 65 percent of the total cover, and perennial grasses and forbs make up the rest. The

dominant increaser grasses are blue grama, sand dropseed, and sand paspalum. Sand sagebrush is the principal woody increaser. Common invaders are false buffalograss, purple sandgrass, and red lovegrass.

CHOPPY SANDS SITE

In this range site are deep fine sands in areas of steep, dune topography. Blowouts are numerous in some areas. The soils are rapidly permeable and somewhat excessively drained. Following are the soils in this range site and the map symbol of each:

- Active dunes (Ad).
- Tivoli fine sand (Tf).
- Tivoli-Dune land complex (Tx).

The climax plant cover is a mixture of such decreaser grasses as sand bluestem, switchgrass, little bluestem, and big sandreed. In places these dominant climax grasses make up as much as 60 percent of the total cover, and other perennial grasses and forbs make up the rest. The dominant increaser grasses are sand dropseed and sand paspalum. Sand sagebrush is the principal woody increaser. Blowoutgrass and big sandreed are the first perennial grasses to stabilize blowouts or dunes. Common invaders are false buffalograss and purple sandgrass.

GRAVELLY HILLS SITE

Only the gravelly soils of Otero gravelly complex (Ox) are in this range site. The complex consists of gravelly, calcareous sandy loams and loamy sands that are moderately deep over a variable substratum of coarse sand, gravel, and caliche. Permeability is rapid, and the moisture-holding capacity is low.

The climax plant cover is a mixture of such decreaser grasses as little bluestem, side-oats grama, and sand bluestem. The dominant increaser grasses are blue grama, hairy grama, and sand dropseed. The dominant woody increasers are sand sagebrush and small soapweed. Common invaders are tumblegrass and grasses that form a mat.

ROUGH BREAKS SITE

This range site consists of soils on steep, somewhat broken slopes. The soils are loamy and are shallow over caliche or limestone. They are well drained, but they have a shallow root zone and low moisture-holding capacity. Following are the soils in this range site and the map symbol of each:

- Mansker-Potter complex (Potter soil only) (Mm).
- Rock land (Rw).

The climax plant cover is a mixture of such decreaser grasses as little bluestem and side-oats grama. In places these climax grasses make up as much as 60 percent of the total cover, and other perennial grasses and forbs make up the rest. The dominant increasers are blue grama, hairy grama, and sand dropseed. Broom snakeweed is a common invader.

SHALE BREAKS SITE

Only Lismas clay (Ln) is in this range site. It is on steep, somewhat broken slopes and is shallow over shale. This soil is well drained. It has a shallow root zone and low moisture-holding capacity.

The climax plant cover is a mixture of such decreaser grasses as little bluestem, side-oats grama, switchgrass, and western wheatgrass. These climax grasses make up

50 percent of the plant cover, and other perennial grasses and forbs make up the rest. The dominant increasers are blue grama, buffalograss, and saltgrass. Annuals are common invaders.

UNSTABLE SITES

Because the soils and the vegetation are unstable, the following soils are not true range sites:

- Broken land (Bx).
- Lincoln soils (Lm).
- Randall clay (Rc).

Broken land consists of loamy soils on steep, broken slopes along creeks throughout the county. The soils are frequently disturbed by floodwaters that quickly recede. The cover of plants varies as the result of scouring and cutting. The vegetation is primarily annuals and trees.

The Lincoln soils are very sandy and gravelly. They are in nearly level, channeled areas along the Arkansas River. The plant cover is unstable and sparse, but the density and composition of the cover varies during the periods between floodings, deposition, and shifting of the stream channel. The vegetation consists primarily of cottonwoods, tamarisk, sand willow, and annuals.

The Randall soil is in undrained depressions where runoff from surrounding areas is ponded. This soil is clayey and is very slowly permeable. The plant cover is unstable and varies in density and composition because the soil is sometimes wet or dry for a long period. The vegetation is mainly Pennsylvania smartweed, bur-ragweed, cocklebur, sedges, and rushes.

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 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. Climax vegetation is the best kind of cover for controlling erosion.
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 the need for forced 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.
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 areas should not be grazed for at least 2 years, so that the plants have time to become firmly established (fig. 18).

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 to achieve uniform use of the range. Generally, wells, ponds, and dugouts supply water for livestock, but in some areas water must be hauled. 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 are fenced separately. This is done when the areas differ greatly and are large enough for fencing to be practical.
7. *Salting* is necessary on rangeland to supplement the native forage. Proper distribution of salt is used to improve the distribution of grazing.



Figure 18.—An area of the Sands range site that was reseeded to a mixture of native grasses by using the furrow method.

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 livestock easier to handle (fig. 19).

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 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

Finney County has no native forests or large areas of woodland, although some areas on the flood plains of the Arkansas River support a mixed stand of cottonwood, tamarisk, and willow. Because of the limited supply of moisture, trees have been planted only for windbreaks, shade, or ornamental purposes.

Windbreak plantings reduce soil blowing and help to protect farmsteads and livestock. They also improve the appearance of the farmstead, increase the value of the property, and provide food and cover for wildlife.

Windbreaks can be successfully established and maintained if they are planned and cared for properly. On upland sites the growth and longevity of the trees can be increased by diverting runoff water into the windbreak. Where irrigation water is available, the growth of the trees in the windbreak can be increased markedly, as shown in table 5.

During the early life of all windbreaks, it is necessary to cultivate often enough to keep weeds under control. On upland sites, however, it is necessary to cultivate for weed control during the whole life span of the windbreak. The trees also need protection from fire, livestock, insects, rabbits, and rodents.

In table 5 the soils suitable for growing trees have been placed in windbreak suitability groups. The species most suitable for use in windbreaks and the kinds of trees that appear best adapted to the soils of each group are given. Also given are the approximate average heights that are likely to be attained after 10 years' growth on dryland and on irrigated soils. In this county the trees that are the most tolerant of drought are eastern redcedar, Rocky Mountain juniper, Siberian elm, and Osage-orange.



Figure 19.—Aerial spraying with 2, 4-D to control sand sagebrush on the Sands range site.

Each soil type listed in table 5 includes all the slope phases, depth phases, and erosion phases shown on the soil map. The following soils and miscellaneous land types, however, are not well suited to trees and were not placed in a windbreak suitability group: Active dunes, Broken land, Lincoln soils, Lismas clay, Lofton clay loam, Mansker-Potter complex, Promise clay, Otero gravelly complex, Randall clay, Rock land, Tivoli fine sand, and Tivoli-Dune land complex. The data given in table 5 were obtained from studies on the growth of trees in Hodgeman, Ford, Gove, Stevens, Morton, and Edwards Counties.

No data are available for the soils listed for the Saline Upland windbreak suitability group. The degree of salinity and alkalinity of any of these soils varies from place to place, in many areas within a short distance. This may cause a variation in the growth of the trees within the windbreak.

More information on the planting of trees, such as the species and spacing for windbreak development, can be obtained from a local technician of the Soil Conservation Service or from the county agricultural extension agent.

Management for Wildlife ⁵

Soils influence wildlife, primarily through the kind of vegetation they produce. The carrying capacity of an area for wildlife is largely determined by the kind, amount, and distribution of this vegetation.

Soil characteristics, such as fertility and moisture-holding capacity, also have their effect on wildlife. Fertile soils are capable of producing greater numbers of wildlife than less fertile soils, and waters that drain from fertile soils generally produce more fish than waters that drain from infertile soils. Soils that have high moisture-holding capacity lend themselves to development of aquatic and semiaquatic habitats for waterfowl and for some species of furbearers.

Topography affects wildlife through its influence on the way the land is used. Where the topography is rough and rolling, many of the areas have an irregular shape. These

⁴F. DEWITT ABBOTT, State soil conservationist in Kansas, Soil Conservation Service, helped to prepare this section.

⁵By CHARLES V. BOHART, conservation biologist, Soil Conservation Service, Lincoln, Nebr.

TABLE 5.—Soils grouped into windbreak suitability groups (tree planting sites), trees suitable for the soils of each site, and the average height attained by the trees after 10 years of growth on dryland and on irrigated soils

Windbreak suitability groups and included soil types	Best adapted species	Approximate average height attained in 10 years			
		Dryland	Irrigated soils		
Silty Upland:					
Bridgeport clay loam.....	Siberian elm..... Mulberry..... Honeylocust..... Eastern redcedar..... Russian-olive.....	<i>Feet</i>	<i>Feet</i>		
Colby silt loam.....				22	32
Harney silt loam.....				15	20
Keith loam.....				14	23
Mansic clay loam.....				10	18
Richfield silt loam.....				12	22
Roxbury silt loam.....					
Spearville silty clay loam.....					
Ulysses loam and silt loams.....					
Ulysses and Richfield soils, silted.....					
Sandy Upland:					
Bayard fine sandy loam.....	Siberian elm..... Mulberry..... Honeylocust..... Eastern redcedar..... Russian-olive.....				
Las-Bayard sandy loams.....				25	35
Manter fine sandy loam.....				17	24
Otero fine sandy loam.....				16	26
Tivoli loamy fine sand.....				12	20
Vona loamy fine sand.....				13	22
Lowland:					
Alluvial land.....	Siberian elm..... Mulberry..... Honeylocust..... Eastern redcedar..... Russian-olive.....				
Humbarger silt loam.....				27	32
				17	24
				16	23
				13	18
	14	22			
Saline Lowland:					
Las Animas sandy loam.....	Cottonwood..... Siberian elm..... Mulberry..... Russian-olive.....				
Las Animas-Lincoln loamy sands.....				30	35
Las clay loam.....				24	30
Sweetwater clay loam.....				16	22
	14	22			
Saline Upland:¹					
Church silty clay loam.....	Tamarisk..... Russian-olive..... Siberian elm..... Ponderosa pine..... Eastern redcedar.....				
Colby loam, saline.....					
Drummond silt loam.....					
Richfield silt loam, saline.....					
Ulysses silt loam, saline.....					

¹ Species named as best adapted to this site are listed in order of tolerance to salt. Tamarisk is the most tolerant of salt, and eastern redcedar is the least tolerant. No information is available as to the approximate average height attained in 10 years by trees on the Saline Upland site.

areas are often difficult to farm or to fence for livestock, and they can be developed for wildlife. The undisturbed vegetation in many such areas is valuable for wildlife.

The characteristics of the soils and the topography were considered in preparing table 6. That table shows the potential of the soil associations in the county for producing habitats for the more important species of wildlife. The column titled "Food" shows, by means of ratings, the capacity of the soil associations to provide the kinds of food plants needed by the kind of wildlife specified. The ratings of *low*, *medium*, and *high* in the other columns indicate the potential of the associations for developing the type of habitat indicated. The soil associations are described in the section "General Soil Map," and the location of each is shown on the general soil map at the back of the report. A detailed description of the individual soils in each association is given in the section "Descriptions of the Soils." Information about the use and man-

agement of the soils and about the kinds of vegetation they are capable of producing is given in the section "Use and Management of Soils."

Some species of wildlife now in the county were not present when the county was first settled. Pheasants are important game birds in the county, and raccoons and opossums are fairly important animals. Buffalo, elk, and antelope have disappeared, but deer are frequently seen along the Arkansas River. The coyote, weasel, mink, muskrat, skunk, cottontail rabbit, jackrabbit, and smaller animals have also found suitable habitats in the county.

Many different kinds of birds make the county their home. Waterfowl and shore birds use the Arkansas River, intermittent lakes, and farm ponds during their annual migrations in spring and fall. Birds that require a woody habitat make their homes along streams and around field and farmstead windbreaks. Some prairie chickens and bobwhite quail nest in suitable areas.

TABLE 6.—*Potential of the soil associations for providing habitats required by some of the more important kinds of wildlife*

Soil association	Species	Potential for producing, for species of wildlife named—			
		Woody cover	Herbaceous cover	Aquatic habitat	Food
Richfield-Ulysses.	Pheasant.....	-----	High.....	-----	High.
Spearville-Harney.	Pheasant.....	Low.....	Medium.....	-----	Medium.
	Dove.....	Low.....	Medium.....	-----	Medium.
	Cottontail rabbit.....	Low.....	Low.....	-----	Low.
Richfield-Ulysses-Mansic.	Pheasant.....	Low.....	Medium.....	-----	Medium.
	Dove.....	Low.....	Medium.....	-----	Medium.
	Quail.....	Low.....	Low.....	-----	Low.
	Cottontail rabbit.....	Low.....	Low.....	-----	Low.
	Fish.....	-----	-----	Medium.....	-----
Las-Las Animas.	Pheasant.....	Medium.....	Medium.....	-----	Medium.
	Dove.....	Medium.....	Medium.....	-----	Medium.
	Quail.....	Medium.....	Medium.....	-----	Medium.
	Cottontail rabbit.....	Medium.....	Medium.....	-----	Medium.
	Deer.....	Medium.....	Medium.....	-----	Low.
	Fish.....	-----	-----	Medium.....	-----
	Waterfowl.....	-----	-----	Low.....	Low.
Furbearers.....	-----	Low.....	Low.....	Low.	
Ulysses, saline-Richfield, saline-Drummond.	Pheasant.....	-----	High.....	-----	High.
	Furbearers.....	-----	Low.....	Low.....	Low.
	Waterfowl.....	-----	Low.....	High.....	Medium.
	Fish.....	-----	-----	Low.....	-----
Tivoli-Vona.	Prairie chicken.....	-----	High.....	-----	Low.
	Dove.....	Low.....	Medium.....	-----	Low.
Manter-Keith.	Pheasant.....	-----	Low.....	-----	Low.
	Prairie chicken.....	-----	Low.....	-----	Medium.
	Dove.....	Low.....	Low.....	-----	Low.

Channel catfish are the most important species of fish in the Arkansas River. Bass, bluegill, and channel catfish can be produced in ponds.

Use of the soils for agriculture has many effects on wildlife because of the cover of vegetation it creates or removes. Where grassland is converted to cropland, some kinds of wildlife lose their protective cover. In turn, an improved supply of food and new types of cover are made available to other species. Proper use of native grass range is important to a number of species, especially to the prairie chicken.

In the early days, wildlife was an important source of food. Also, at times both the meat and pelts provided a source of cash income. Wildlife resources continue to be important in this county. Perhaps their greatest value at the present time is in the recreational opportunities they provide for hunting and fishing. In addition some species of wildlife are beneficial because they control undesirable insects and pests.

Developing a specific habitat for wildlife requires that the kind of plant cover the soils are capable of producing be properly located. On-site technical assistance in planning developments for wildlife and in determining which species of vegetation to plant can be obtained from the district office of the Soil Conservation Service. Additional information and assistance can be obtained from the Ex-

tension Service, from the Bureau of Sports, Fisheries, and Wildlife, and from the Kansas Forestry, Fish and Game Commission.

Engineering Properties of Soils⁶

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.

Soil properties frequently influence design, construction, and maintenance of engineering structures. The properties most important to the engineer are permeability to water, shear strength, compaction characteristics, texture, plasticity, and reaction. However, depth of unconsolidated material, depth to the water table, and topography are also important.

The information in this report can be used to—

1. Make soil and land use studies that will aid in selecting and developing sites for industries, businesses, residences, and recreational purposes.

⁶ CARL L. ANDERSON, civil engineer, Soil Conservation Service, assisted in the preparation of this section.

2. Make preliminary estimates of the engineering properties of soils that will help in planning agricultural drainage systems, farm ponds, terraces, waterways, dikes, diversions, irrigation canals and irrigation systems.
3. Make preliminary evaluations of soil and ground conditions that will aid in selecting locations for highways and airports and in planning detailed investigations of the selected locations.
4. Locate probable sources of gravel, sand, and other construction material.
5. Correlate performance of engineering structures with soil mapping units, and thus develop information that will be useful in maintaining the structures. The information may also prove useful as a guide in future planning.
6. Determine the suitability of soil units for cross-country movement of vehicles and construction equipment.
7. Supplement information obtained from other published maps, reports, and aerial photographs for the purpose of making maps and reports that will be more useful to engineers.
8. Develop other preliminary estimates for construction purposes pertinent to the particular area.

This report will not eliminate the need for, or take the place of, on-site sampling and testing of soils for design and construction of specific engineering works. It may be useful, however, in planning more detailed field surveys to determine the in-place condition of the soil at the site of the proposed construction.

Some of the soil science terminology used in agriculture may have a different meaning from that used in engineering. Some of the terms used with reference to agriculture are defined in the Glossary in the back of the report. Terms used in engineering are defined in the following pages.

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. These are the systems used by the American Association of State Highway Officials (AASHO) and the Unified system. These systems are explained briefly in the following paragraphs. The explanations are taken largely from the PCA Soil Primer (9).

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 the groups, 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 indexes range from 0 for the best material to 20 for the poorest. Increasing values of group indexes 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. The plasticity index refers to the numerical difference between the liquid limit and the plastic limit. The liquid limit is the moisture content, expressed as a percentage of the oven-dry weight of the soil, at which the soil material passes from a plastic to a liquid state. The plastic limit is the moisture content, expressed as a percentage of the oven-dry weight of the soil, at which the soil material passes from a semisolid to a plastic state.

Unified Soil 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 (15). 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 Finney 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.

After an engineer has been trained and has obtained experience, he can make an approximate classification of soils, based on visual field inspection and observation. Exact classification, however, must be based on the review and application of complete laboratory analysis data. Field classifications are useful in determining when and upon which soils laboratory analyses should be made.

Soil engineering interpretations

Two tables are given in this section. In the first (table 7) the soils are briefly described and their physical properties important to engineering are estimated. In the second (table 8) the suitability of the soils for various engineering uses is indicated. No test data were available for the soils in Finney County. The data given in table 7 are based on laboratory testing of soils in Ford, Logan, and Morton Counties; on the results of tests made by the State Highway Commission of Kansas at the site of construction; on experience with the same kind of soils in other counties; and on information given in other parts of this report.

The properties described in table 7 are for a typical profile. Therefore, some variation from these values should be anticipated. In the column that gives a description of the soil and site, the significant layers in each kind of soil are described. A more complete description of a profile that is typical for each series is given in the section "Genesis, Classification, and Morphology of Soils." Table 7 also gives classifications for each significant layer,

according to the textural classes of the U.S. Department of Agriculture, as well as estimates of the Unified and AASHO classifications.

In table 7 depth to ground water or to bedrock is mentioned only where the water table or bedrock is within 10 feet of the surface. For more information about the ground water and bedrock in this county, the reader can refer to the section "Irrigation in Finney County" and to State Geologic Survey of Kansas Bulletin No. 55 (?), which gives facts about the geology and ground water of this county.

In the columns that show percentage of material passing sieves of various sizes, the separation between the coarse-textured and fine-textured soils is shown. Also shown is the percentage of soil material that is smaller in diameter than the openings in a given screen.

Soil permeability is the ability of the soil to transmit water or air. It is measured in terms of the rate at which water passes through the soil profile. The column that shows permeability gives the estimated probable rate of water percolation through a soil that is not compacted, expressed in inches per hour.

In the column that shows available water capacity are estimates, in inches per inch of soil material, of the capillary water in the soil when that soil is wet to field capacity. When the soil is air dry, this amount of water will wet the soil material to a depth of 1 inch without deeper percolation.

The salinity of the soils is estimated according to the electrical conductivity of the soil saturation extract, expressed in millimhos per centimeter. The following defines the relative terms used to rate salinity: *None*—less than 2 millimhos per centimeter; *slight*—2 to 4 millimhos per centimeter; *moderate*—4 to 8 millimhos per centimeter; *severe*—8 to 16 millimhos per centimeter; and *very severe*—more than 16 millimhos per centimeter. Salinity tests have been run on only a few of the soils in this county. For the other soils, the salinity was estimated.

Alkalinity was not estimated in table 7. It is a measure of the amount of sodium in the soil and is expressed as the percentage of exchangeable sodium in relation to exchangeable cations. A percentage of more than 15 is considered excessive. Drummond silt loam is the only soil in the county that consistently shows an excess of sodium. Church silty clay loam, Richfield silt loam, saline, Sweetwater clay loam, and the Las clay loams, however, contain excessive sodium in some places. In addition to containing excessive sodium, the Drummond soil is saline and has a concentration of gypsum at a depth of 12 to 60 inches.

The column that shows shrink-swell potential indicates the volume change in a soil when the content of water changes. It gives estimates of how much a soil shrinks when it is extremely dry and of how much it swells when it is extremely wet. Randall clay is an example of a soil that has high shrink-swell potential. This soil shrinks greatly when dry and swells when wet. The Tivoli soils are examples of soils that have low shrink-swell potential. A knowledge of this potential is important in planning the use of a soil for building roads and other engineering structures.

Estimates of shrink swell are based on the liquid limit of the soil. The shrink-swell potential of the soils of the

county is indicated by the relative terms *low*, *moderate*, *high*, and *very high*. The soils that have a liquid limit of 25 or less are given a rating of low; those that have a liquid limit of 25 to 40 are given a rating of moderate; those that have a liquid limit of 40 to 60 are given a rating of high; and those that have a liquid limit of more than 60 are given a rating of very high.

In table 7 the reaction of the soils of this county is not given, but the reaction of the soils ranges from neutral to moderately alkaline. The pH of the surface layer and subsoil ranges from 7.0 to 8.5. The substratum of most of the soils is moderately alkaline and has a pH of 7.9 to 8.5.

Dispersion is also not indicated in table 7, but it may be a problem in some of the soils of the county. As used in this report, the term "dispersion" refers to the degree that particles smaller than 0.005 millimeter are separated or dispersed. This is to be distinguished from the single grain or unaggregated condition common to clean sands. Dispersed soils are often slick when wet, and they have a crust on the surface when they are dry. Soils high in sodium, especially those that contain more than 15 percent exchangeable sodium, are likely to be dispersed. Dispersion may be a problem in the Drummond soil because of the content of sodium in that soil. In some places dispersion may be a problem in the Church and Sweetwater soils.

The suitability of the soils of this county for various engineering uses is indicated in table 8. In that table are also given soil features that affect the use of the soils for highway construction and for agricultural engineering. The miscellaneous land types Active dunes, Alluvial land, Broken land, and Rock land are not listed in table 8, because the material is variable or is not suited to engineering work.

The suitability of the soils as a source of topsoil is indicated by the terms *good*, *fair*, or *poor*, or if the soils are not suitable, that fact is indicated. This information is important because topsoil is needed for growing vegetation that will control erosion on embankments, the shoulders of roads, ditches, and cut slopes. For these estimates, each layer of the soil profile was considered as a possible source of topsoil, although only one rating is shown in the table; the subsoil may have a different rating than the surface layer because of its different characteristics. It may, for example, be more sandy or more clayey than the surface layer, or it may contain caliche. Whether it is still in place or has been moved, some part of the soil material can be used as topsoil in many areas, as on embankments and on cut slopes.

The silty soils on cut slopes can usually be seeded without adding a layer of topsoil. The Tivoli, Vona, and other sandy soils, however, are not suitable as a source of topsoil. If vegetation is to be grown on cut slopes of the Tivoli, Vona, and similar soils, a layer of suitable topsoil must be added.

As indicated in table 8, many of the soils are not suitable as a source of sand and gravel, but pockets of sand and gravel occur in some soils. These pockets are in the gravelly terraces along the south side of the valley of the Arkansas River, next to the sandhills. Otero gravelly complex, along the north side of the valley of the Arkansas River and east of Garden City, is another source of sand and gravel. The Tivoli soils are a source of a large amount of fine quartz sand.

TABLE 7.—*Brief description of the soils of Finney County,*

Map symbol	Soil name	Description of soil and site	Depth from surface
Ad	Active dunes.	Bare, shifting sand dunes; the soil material has no definable soil profile.	<i>Inches</i> 0-60
An	Alluvial land.	Stratified, loamy soils formed in alluvium on the flood plains of intermittent streams; subject to flooding and deposition.	(³)
Ba	Bayard fine sandy loam.	Fine sandy loam that contains thin layers of clay loam and loamy sand and is 36 to 48 inches thick over coarse-textured material. On alluvial fans where the slopes are between 0 and 2 percent. Well drained, but there is some local flooding of short duration.	0-36 36-60
Bp	Bridgeport clay loam.	Nearly level clay loam 12 to 30 inches thick over loam. Formed in alluvium on terraces and fans. Well drained; the water table is seldom within 10 feet of the surface.	0-18 18-60
Bx	Broken land.	Steep, broken banks of intermittent streams. Subject to flooding, erosion, and deposition.	(³)
Ch	Church silty clay loam.	Nearly level silty clay loam formed in lacustrine material on lake benches. This soil has a variable amount of gypsum in the subsoil. It is moderately well drained; the water table is generally 5 to 10 feet below the surface.	0-92
Cs	Colby loam, saline.	Nearly level or gently undulating, loamy soil formed in wind-deposited material; this soil is moderately well drained; the water table is generally 4 to 10 feet below the surface. This soil has a variable amount of gypsum in the subsoil.	0-60
Dr	Drummond silt loam.	Nearly level silt loam 4 to 10 inches thick over silty clay loam that is 24 to 30 inches thick; underlain by silt loam formed in silty plains sediment. Has a large amount of gypsum between a depth of 12 and 60 inches. Moderately well drained; the water table is generally 6 to 12 feet below the surface.	0-5 5-30 30-90
Ha	Harney silt loam, 0 to 1 percent slopes.	Silt loam 5 to 10 inches thick over heavy silty clay loam that is 20 to 34 inches thick and is underlain by silt loam. Formed in loess. Well drained.	0-7 7-18 18-26 26-60
Hu	Humbarger silt loam.	Weakly stratified silt loam and loam formed in alluvium on flood plains where the slope is between 0 and 3 percent. Good internal drainage, but subject to infrequent flooding of short duration.	0-60
Ka	Keith loam, 0 to 1 percent slopes.	Loam 10 to 18 inches thick over light clay loam that is 8 to 14 inches thick; underlain by silt loam. Formed in loess. Well drained.	0-15 15-24 24-60
Lb	Las clay loam, deep.	Nearly level clay loam 40 to 60 inches thick over sand and gravel. Formed in alluvium on low stream terraces. Imperfectly drained; the water table is generally 6 to 12 feet below the surface.	0-48 48+
La	Las clay loam, moderately deep.	Nearly level clay loam 20 to 40 inches thick over sand and gravel. Formed in alluvium on low stream terraces. Imperfectly drained; the water table is generally 6 to 12 feet below the surface.	0-26 26+

See footnotes at end of table.

Kans., and their estimated properties

Classification			Percentage passing sieve—			Permeability ²	Available water capacity	Salinity	Shrink-swell potential
USDA texture	Unified ¹	AASHO	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 200 (0.42 mm.)				
Fine sand	SP-SM	A-2 or A-3		100	5-15	Inches per hour 5+	Inches per inch of soil 0.04	None	Low.
(³)	(³)	(³)	(³)	(³)	(³)	(³)	(³)	(³)	(³)
Fine sandy loam	SM	A-2	95-100	95-100	20-35	0.8-1.5	.12	None	Low.
Fine sand	SP-SM	A-2		100	5-15	2.0-5.0	.04	None	Low.
Clay loam	CL	A-6		100	75-90	0.3-0.5	.18	None	Moderate.
Loam	ML-CL	A-6		100	60-75	0.3-0.5	.18	None	Moderate.
(³)	(³)	(³)	(³)	(³)	(³)	(³)	(³)	(³)	(³)
Silty clay loam	CL	A-7		100	90-100	0.1-0.3	.18	Slight to moderate.	High.
Loam	ML-CL	A-4 or A-6		100	60-75	0.4-0.6	.18	Slight to moderate.	Moderate.
Silt loam	ML-CL	A-4 or A-6		100	85-95	0.2-0.5	.18	None	Moderate.
Silty clay loam	CL	A-7-6		100	90-100	0.05-0.2	.18	Severe to very severe salinity and alkalinity.	High.
Silt loam	ML-CL	A-6 or A-7		100	90-100	0.2-0.5	.18	Severe to very severe salinity and alkalinity.	Moderate.
Silt loam	ML-CL	A-4 or A-6		100	90-100	0.2-0.3	.18	None	Moderate.
Silty clay loam	CL	A-7		100	90-100	0.2-0.3	.18	None	High.
Silty clay	CH	A-7		100	90-100	0.1-0.2	.18	None	High.
Silt loam	ML-CL	A-6 or A-7		100	90-100	0.2-0.4	.18	None	Moderate.
Silt loam	ML-CL	A-4 or A-6		100	85-95	0.6-1.0	.18	None	Moderate.
Loam	ML-CL	A-4 or A-6		100	75-90	0.5-1.0	.18	None	Low.
Light clay loam	CL	A-6 or A-7		100	80-95	0.2-0.5	.18	None	Moderate.
Silt loam	ML-CL	A-6 or A-7		100	90-100	0.2-0.5	.18	None	Moderate.
Clay loam	CL	A-7	95-100	95-100	75-90	0.2-0.4	.18	Slight to moderate.	High.
Sand and gravel	SP-SM	A-1	85-95	85-95	0-10	5+		None	Low.
Clay loam	CL	A-7	95-100	95-100	75-90	0.2-0.4	.18	Slight to moderate.	High.
Sand and gravel	SP-SM	A-1	85-95	85-95	0-10	5+		None	Low.

TABLE 7.—*Brief description of the soils of Finney County,*

Map symbol	Soil name	Description of soil and site	Depth from surface
Lc	Las-Bayard sandy loams.	This complex is about 55 percent Las sandy loam and 35 percent Bayard sandy loam. The soils are undulating and formed in alluvium on stream terraces. Depth to sand and gravel is 3 to 7 feet. The Las soil is imperfectly drained and the Bayard is well drained; the water table is 7 to 12 feet below the surface. The estimated properties given in the columns to the right are those of the Las soil. See Bayard fine sandy loam for estimated properties of the Bayard soil.	<i>Inches</i> 0-10 10-18 18-48 48-60
Ld	Las-Las Animas complex.	This complex is about 55 percent Las soils and 30 percent Las Animas soils. The soils are nearly level and formed in alluvium on flood plains. Depth to sand and gravel is 20 to 40 inches. The soils are imperfectly drained; the water table is generally 3 to 6 feet below the surface. For estimated properties of the Las soils, see the Las clay loams. For estimated properties of the Las Animas soils, see Las Animas sandy loam.	-----
Lk	Las Animas sandy loam.	Sandy loam 24 to 40 inches thick over sand and gravel. In places the subsoil contains clayey layers. Formed in alluvium on nearly level flood plains. Imperfectly drained; the water table is generally 3 to 7 feet below the surface.	0-30 30+
Li	Las Animas-Lincoln loamy sands.	This complex is about 55 percent Las Animas soils and about 35 percent Lincoln soils. The soils formed in alluvium. In places the surface layer is clayey or the subsoil contains clayey layers. Imperfectly drained; the water table is 3 to 7 feet below the surface.	Las Animas loamy sand: 0-14 14-30 30+ Lincoln loamy sand: 0-24 24+
Lm	Lincoln soils.	Stratified fine sand and loamy fine sand 10 to 18 inches thick over coarse sand and gravel. The soils contain clayey layers in some places. On low flood plains next to the channel of the Arkansas River. Subject to frequent flooding and to erosion and deposition.	0-10 10+
Ln	Lismas clay.	Clay 2 to 12 inches thick over bedded clay shale. The slopes are steep and broken.	0-5 5+
Lo	Lofton clay loam.	Nearly level or gently sloping clay loam 5 to 10 inches thick over clay that is 12 to 30 inches thick; underlain by about 17 inches of silty clay loam over silt loam. On benches around undrained depressions where runoff from surrounding areas is ponded.	0-6 6-19 19-36 36-62
Mh	Mansic complex.	A complex of steep Mansic soils on the side slopes of valleys and of loamy soils formed in alluvium on the floors of valleys. The soils on the floors of valleys make up about 20 percent of the acreage, and Mansic and included soils make up the rest. The estimated properties given in the columns to the right are those of Mansic clay loam.	0-46 46-60
Mm	Mansker-Potter complex.	A complex of Mansker and Potter loams and clay loams formed in plains outwash. About 55 percent of the acreage consists of Mansker soils that are 12 to 36 inches deep over caliche, and 28 percent consists of Potter soils that are less than 12 inches deep over caliche. These soils are on the steep sides of drainageways.	Mansker loam: 0-15 15-31 31+ Potter loam: 0-10 10+

See footnotes at end of table.

Kans., and their estimated properties—Continued

Classification			Percentage passing sieve—			Permeability ²	Available water capacity	Salinity	Shrink-swell potential
USDA texture	Unified ¹	AASHO	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 200 (0.42 mm.)				
Sandy loam.....	SM.....	A-2.....	95-100	95-100	20-35	<i>Inches per hour</i> 0.5-1.0	<i>Inches per inch of soil</i> 0.12	None.....	Low.
Sandy clay loam....	CL, ML-CL....	A-4, A-6....	95-100	95-100	70-80	0.2-0.5	.18	Slight to moderate.	Moderate.
Clay loam.....	CL.....	A-7.....	95-100	95-100	75-90	0.2-0.4	.18	Slight to moderate.	High.
Sand and gravel....	SP or SP-SM..	A-1.....	85-95	85-95	0-10	5+	-----	None.....	Low.

Sandy loam.....	SM.....	A-2.....	95-100	95-100	20-35	1.0-1.5	.12	Slight to moderate.	Low.
Sand and gravel....	SP or SP-SM..	A-1.....	85-95	85-95	0-10	5+	-----	None.....	Low.
Loamy sand.....	SM.....	A-2.....	95-100	95-100	15-25	2.0-5.0	.06	None to slight..	Low.
Sandy loam.....	SM.....	A-2.....	95-100	95-100	20-35	1.0-1.5	.12	None to slight..	Low.
Sand and gravel....	SP or SP-SM..	A-1.....	85-95	85-95	0-10	5+	-----	None.....	Low.
Loamy sand.....	SM.....	A-2.....	95-100	95-100	15-25	2-5	.06	None to slight..	Low.
Sand and gravel....	SP or SP-SM..	A-1.....	85-95	85-95	0-10	5+	-----	None.....	Low.
Fine sand.....	SP-SM, SM....	A-2.....	95-100	95-100	5-15	2.0-5.0	.04	None to slight..	Low.
Coarse sand and gravel.	SP or SP-SM..	A-1.....	85-95	85-95	0-10	5+	-----	None to slight..	Low.
Clay.....	CH.....	A-7.....	-----	100	90-100	(⁴)	.18	None to slight..	High.
Clay shale.....	CH.....	A-7.....	-----	100	90-100	(⁴)	.18	None to slight..	High.
Clay loam.....	CL.....	A-6.....	-----	100	75-90	0.2-0.5	.18	None.....	High.
Clay.....	CH.....	A-7.....	-----	100	90-100	0.05-0.2	.18	None.....	High.
Silty clay loam....	CL.....	A-7.....	-----	100	90-100	0.2-0.5	.18	None.....	High.
Silt loam.....	ML-CL.....	A-6 or A-7..	-----	100	90-100	0.2-0.5	.18	None.....	Moderate.
Clay loam.....	CL.....	A-6.....	95-100	85-95	75-90	0.2-0.5	.18	None.....	High.
Loam.....	CL.....	A-6.....	95-100	85-95	70-80	0.2-0.5	.18	None.....	Moderate.
Loam.....	CL.....	A-6.....	95-100	85-95	50-70	0.2-0.5	.18	None.....	Moderate.
Loam that contains more than 30 percent lime.	CL.....	A-6.....	95-100	85-95	50-70	0.2-0.5	.18	None.....	Moderate.
Caliche.....	CL.....	A-6.....	95-100	85-95	50-70	0.2-0.5	.18	None.....	Moderate.
Loam.....	CL.....	A-6.....	95-100	85-95	50-70	0.2-0.5	.18	None.....	Moderate.
Caliche.....	CL.....	A-6.....	95-100	85-95	50-70	0.2-0.5	.18	None.....	Moderate.

TABLE 7.—*Brief description of the soils of Finney County,*

Map symbol	Soil name	Description of soil and site	Depth from surface
Mn Mr	Manter fine sandy loam, level. Manter fine sandy loam, undulating.	Fine sandy loams underlain by loam or silt loam at variable depths, generally at a depth between 24 and 60 inches. Formed in windblown material. Well drained.	<i>Inches</i> 0-45 45-60
Mt	Manter-Otero fine sandy loams, undulating.	About 50 percent of this complex is Manter fine sandy loam, and about 30 percent is Otero fine sandy loam. The soils formed in windblown material. They generally have thin layers of loam at variable depths. The slopes are undulating and are between 1 and 4 percent. For estimated properties of the Manter soils, see the Manter fine sandy loams. For estimated properties of the Otero soils, see Otero fine sandy loam, 5 to 15 percent slopes.	-----
Ot	Otero fine sandy loam, 5 to 15 percent slopes.	Fine sandy loam that contains some thin layers of loam and loamy sand. Formed in windblown material. Well drained.	0-60
Ox	Otero gravelly complex.	A complex consisting of about 20 percent Otero sandy loam and 65 percent gravelly, coarse-textured soils that are stratified and vary in texture. The soils are on broken slopes of 5 to 15 percent, where they formed in Pleistocene sands and gravel. The estimated properties given in the columns to the right are those of Otero sandy loam. The properties of the gravelly soils are too varied to estimate.	0-20 20-40
Oy	Otero-Ulysses complex, undulating.	A complex consisting of about 60 percent Otero fine sandy loam and 25 percent Ulysses loam formed in windblown material. The slopes are undulating and are between 0 and 5 percent. For estimated properties of the Otero soils, see Otero fine sandy loam, 5 to 15 percent slopes. For estimated properties of the Ulysses soils, see Ulysses loam, undulating.	-----
Pc	Promise clay, 1 to 3 percent slopes.	Clay 12 to 48 inches thick over clay loam; has occasional layers of sandy loam in the substratum. Formed in stratified alluvium washed from shale. The clay impedes internal drainage and the penetration of moisture	0-32 32-60
Ra	Randall clay.	Silty clay 24 to 48 inches thick over a thin horizon of silty clay loam underlain by silt loam. In undrained depressions where runoff from surrounding areas is ponded. Poorly drained; no surface drainage, and very slow internal drainage.	0-30 30-62
Rm Rn	Richfield silt loam, 0 to 1 percent slopes. Richfield silt loam, 1 to 3 percent slopes.	Silt loam 5 to 10 inches thick over silty clay loam that is 18 to 30 inches thick; underlain by silt loam formed in loess. Well drained.	0-6 6-34 34-60
Ro	Richfield silt loam, saline.	This soil has a profile the same as that of the Richfield silt loams, except for slight to moderate salinity at depths ranging from 16 inches to more than 5 feet below the surface. Has an accumulation of calcium sulfate in the substratum.	0-6 6-34 34-60
Rs	Richfield-Spearville complex, 0 to 1 percent slopes.	A complex of about 55 percent Richfield silt loam and 30 percent Spearville silty clay loam. Formed in loess. For estimated properties of the Richfield soils, see the Richfield silt loams. For estimated properties of the Spearville soils, see the Spearville soils.	-----
Ru	Richfield and Ulysses complexes, bench leveled.	Complexes of Richfield, Ulysses, Colby, and Keith soils that have been leveled for irrigation. Throughout much of the acreage, cutting and filling have mixed the soil material so that the individual soils cannot be identified.	(3)
Rw	Rock land.	About 45 percent of this land type consists of soils that are shallow over limestone, 30 percent is limestone outcrops, and 15 percent is deep soils formed in colluvium on foot slopes. Mansic clay loam and Lismas clay make up the other 10 percent. On broken slopes of 10 to 20 percent.	(3)

See footnotes at end of table.

TABLE 7.—*Brief description of the soils of Finney County,*

Map symbol	Soil name	Description of soil and site	Depth from surface
Rx	Roxbury silt loam.	Silt loam 8 to 14 inches thick over about 30 inches of silty clay loam underlain by light clay loam. Formed in alluvium on nearly level stream terraces. Well drained.	<i>Inches</i> 0-8 8-35 35-60
Sp	Spearville silty clay loam, 0 to 1 percent slopes.	Silty clay loam 5 to 10 inches thick over 8 to 14 inches of silty clay; underlain by about 10 inches of silty clay loam over silt loam. Formed in loess. Well drained.	0-6
Sr	Spearville complex, 1 to 3 percent slopes, eroded.		16-26 26-60
Sw	Sweetwater clay loam.	Clay loam 15 to 24 inches thick over coarse sand and gravel. Formed in alluvium on nearly level flood plains. Poorly drained. The water table is generally at a depth between 10 and 36 inches.	0-15 15+
Tf	Tivoli fine sand.	Fine sand in areas of choppy dune topography. The slopes are between 8 and 20 percent. Internal drainage is excessive.	0-60
Tx	Tivoli-Dune land complex.	From 60 to 80 percent of this complex is Tivoli fine sand, and 20 to 40 percent is Active dunes. The complex occupies areas of choppy dune topography. The slopes are between 8 and 20 percent.	0-60
Tv	Tivoli-Vona loamy fine sands.	About 50 percent of this complex is Tivoli loamy fine sand, and 30 percent is Vona loamy fine sand. The areas are undulating and the slopes are between 3 and 8 percent. For estimated properties of the Tivoli soils, see Tivoli fine sand. For estimated properties of the Vona soil, see Vona loamy fine sand.	-----
Ua	Ulysses silt loam, 0 to 1 percent slopes.	Silt loam 4 to 8 inches thick over light silty clay loam that is 5 to 10 inches thick and is underlain by silt loam. Formed in loess.	0-6
Ub	Ulysses silt loam, 1 to 3 percent slopes.		6-11
Uc	Ulysses silt loam, 3 to 5 percent slopes.	Well drained.	11-60
Ue	Ulysses-Colby silt loams, 1 to 3 percent slopes, eroded.	A complex of about 50 to 60 percent Ulysses silt loam and 25 to 40 percent Colby silt loam on weakly convex slopes. The estimated properties in the columns to the right are those of Colby silt loam. For estimated properties of the Ulysses soils, see the Ulysses silt loams.	0-60
Um	Ulysses-Colby silt loams, 3 to 5 percent slopes, eroded.		
Ud	Ulysses loam, undulating.	An undulating, loamy soil that has thin layers of sandy loam in the substratum. The slopes are between 0 and 3 percent. Formed in windblown material. Well drained.	0-60
Us	Ulysses silt loam, saline, 0 to 1 percent slopes.	The profile of these soils is the same as the one described for the Ulysses silt loams, except for slight to moderate salinity at depths ranging from 24 inches to more than 5 feet. Has an accumulation of calcium sulfate in the substratum below a depth of 20 inches.	0-6 6-11
Ut	Ulysses silt loam, saline, 1 to 3 percent slopes.		11-60
Uv	Ulysses and Richfield complexes, saline, bench leveled.	Complexes of Ulysses and Richfield soils that have been leveled for irrigation and have a saline substratum. Cutting and filling have mixed the soil material.	(³)
Ux	Ulysses and Richfield soils, silted, 0 to 1 percent slopes.	Silty clay loam or light silty clay 5 to 12 inches thick. This material has been deposited over the subsoil of the Ulysses and Richfield soils. It came from muddy irrigation water.	(³)
Vo	Vona loamy fine sand.	Loamy fine sand 6 to 18 inches thick over fine sandy loam. Formed in windblown material. Has slopes of 1 to 5 percent. Well drained.	0-8 8-60

¹ The Soil Conservation Service and Bureau of Public Roads have agreed to consider that all soils having plasticity indexes within two points from A-line are to be given a borderline classification. Examples of borderline classifications obtained by this use are SP-SM, ML-CL, and SM-SC.

Kans., and their estimated properties—Continued

Classification			Percentage passing sieve—			Permeability ²	Available water capacity	Salinity	Shrink-swell potential
USDA texture	Unified ¹	AASHO	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 200 (0.42 mm.)				
Silt loam	ML-CL	A-4 or A-6		100	90-100	<i>Inches per hour</i> 0.3-0.5	<i>Inches per inch of soil</i> 0.18	None	Moderate.
Silty clay loam	CL	A-7		100	90-100	0.3-0.5	.18	None	Moderate.
Light clay loam	CL	A-6		100	80-90	0.3-0.5	.18	None	Moderate.
Silty clay loam	CL	A-7		100	90-100	0.2-0.5	.18	None	Moderate.
Silty clay	CH	A-7		100	90-100	0.05-0.2	.18	None	High.
Silty clay loam	CL	A-7		100	90-100	0.2-0.5	.18	None	High.
Silt loam	ML-CL	A-6 or A-7		100	90-100	0.2-0.5	.18	None	Moderate.
Clay loam	CL	A-6		100	75-90	0.2-0.5	.18	Slight to severe	Moderate.
Coarse sand	SP or SM	A-1	85-95	85-95	0-10	5+		None	Low.
Fine sand	SP-SM	A-2 or A-3		100	5-15	5+	.04	None	Low.
Fine sand	SP-SM	A-2 or A-3		100	5-15	2.0-5.0	.04	None	Low.
Silt loam	ML-CL	A-4 or A-6		100	90-100	0.2-0.5	.18	None	Moderate.
Light silty clay loam	ML-CL	A-6 or A-7		100	90-100	0.2-0.5	.18	None	Moderate.
Silt loam	ML-CL	A-6 or A-7		100	90-100	0.2-0.5	.18	None	Moderate.
Silt loam	ML-CL	A-6		100	85-95	0.2-0.5	.18	None	Moderate.
Loam	ML-CL	A-4 or A-6		100	65-80	0.6-1.0	.18	None	Moderate.
Silt loam	ML-CL	A-4 or A-6		100	90-100	0.2-0.5	.18	Slight to moderate salinity at depths ranging from 24 inches to more than 5 feet.	Moderate.
Light silty clay loam	ML-CL	A-6 or A-7		100	90-100	0.2-0.5	.18		Moderate.
Silt loam	ML-CL	A-6 or A-7		100	90-100	0.2-0.5	.18		Moderate.
(³)	(³)	(³)	(³)	(³)	(³)	(³)	(³)	(³)	(³)
(³)	(³)	(³)	(³)	(³)	(³)	(³)	(³)	(³)	(³)
Loamy fine sand	SM	A-2		100	10-20	1.0-2.0	.06	None	Low.
Fine sandy loam	SM	A-2		100	20-35	0.5-1.0	.12	None	Low.

² Based on observations of soil structure, texture, and porosity. A measure of the rate of percolation of water through a unit cross section of saturated soil under gravity with a 1/2-inch head.

³ Variable.

⁴ Less than 0.05.

TABLE 8.—*Interpretation of engineering*

Soil series and map symbol	Suitability as source of—					Soil features affecting engineering practices	
	Topsoil	Sand	Gravel	Road fill ¹	Subgrade ¹	Highway location	Dikes and canals
Bayard (Ba)-----	Fair-----	Poor-----	Not suitable, but occasional pockets.	Good-----	Fair-----	Moderate erodibility.	Well graded; moderate stability and shear strength.
Bridgeport (Bp)-----	Good-----	Not suitable--	Not suitable--	Good-----	Fair-----	(³)-----	Moderate stability and shear strength.
Church (Ch)-----	Fair-----	Not suitable--	Not suitable--	Fair-----	Poor-----	Fluctuating water table at a depth of 5 to 10 feet; highly plastic.	High plasticity and shrink-swell potential; poor stability and compaction.
Colby (the non-saline Colby soils occur only in complexes with Ulysses soils).	Good-----	Not suitable--	Not suitable--	Good-----	Good-----	Erodible-----	Moderate erodibility; low to moderate shear strength and stability.
Colby loam, saline (Cs).	Fair-----	Not suitable--	Not suitable--	Good-----	Good-----	Fluctuating water table at a depth of 4 to 10 feet.	Moderate erodibility; low to moderate shear strength and plasticity.
Drummond (Dr)-----	Fair-----	Not suitable--	Not suitable--	Fair-----	Poor-----	Fluctuating water table at a depth of 6 to 12 feet.	(²)-----
Harney (Ha)-----	Good-----	Not suitable--	Not suitable--	Fair-----	Poor-----	Well drained; highly plastic subsoil.	Moderate shear strength and stability.
Humbarger (Hu)-----	Good-----	Not suitable--	Not suitable--	Good-----	Good-----	Infrequently flooded; good internal drainage.	Moderate shear strength and stability.
Keith (Ka)-----	Good-----	Not suitable--	Not suitable--	Good-----	Fair-----	Well drained----	Moderate shear strength and stability.

See footnotes at end of table.

properties of soils in Finney County, Kans.

Soil features affecting engineering practices—Continued					
Farm ponds		Agricultural drainage	Irrigation	Terraces and diversions	Waterways
Reservoir area	Embankment				
Occasional pockets of gravel; moderately rapid permeability.	Well graded; moderate shear strength and stability.	Well drained; moderately rapid permeability.	Deep; moderate water-holding capacity; moderately rapid intake rate; contains sand pockets.	(?)-----	Friable; moderate stability and erodibility.
Moderate permeability.	Moderate shear strength and stability; fair compaction; medium to high compressibility.	Well drained; moderate permeability.	Deep; high water-holding capacity; moderate intake rate.	Soil properties favorable; no limitations.	Deep; friable; fertile; low erodibility.
(?)-----	(?)-----	Fluctuating water table at a depth between 5 and 10 feet; slow permeability.	Deep; high water-holding capacity; slow intake rate; slight to moderate salinity; fluctuating water table.	(?)-----	(?).
Moderate permeability.	Moderate to low stability, shear strength, and plasticity; medium to high compressibility; fair compaction.	Well drained; moderate permeability.	Deep; high water-holding capacity; moderate intake rate.	Moderate erodibility.	Deep; friable; sloping; moderate erodibility.
(?)-----	(?)-----	Moderately well drained; fluctuating water table at a depth of 4 to 10 feet.	Deep; high water-holding capacity; moderate intake rate; saline; fluctuating water table at a depth of 4 to 10 feet.	Moderate erodibility.	Sloping; slight to moderate salinity; moderate erodibility.
(?)-----	(?)-----	Moderately well drained; fluctuating water table at a depth of 6 to 12 feet.	Deep; high water-holding capacity; fluctuating water table; severe salinity and alkalinity.	Severe salinity and alkalinity in subsoil and substratum.	(?).
Moderately slow permeability.	Moderate shear strength and stability; low to moderate shrink-swell potential and plasticity; medium to high compressibility; fair compaction.	Well drained; moderately slow permeability.	Deep; high water-holding capacity; moderate intake rate.	Soil properties favorable; no limitations.	(?).
Moderate permeability.	Moderate shear strength, stability, and plasticity; medium to high compressibility; fair compaction.	Infrequently flooded; well drained; moderate permeability.	Deep; high water-holding capacity; moderate intake rate.	(?)-----	Deep; friable; low to moderate erodibility; occasional flooding.
Moderate permeability.	Moderate shear strength, stability, and plasticity; medium to high compressibility; fair compaction.	Well drained; moderate permeability.	Deep; high water-holding capacity; moderate intake rate.	Soil properties favorable; no limitations.	(?).

TABLE 8.—*Interpretation of engineering properties*

Soil series and map symbol	Suitability as source of—					Soil features affecting engineering practices	
	Topsoil	Sand	Gravel	Road fill ¹	Subgrade ¹	Highway location	Dikes and canals
Las (La, Lb) -----	Good above a depth of 20 to 40 inches; not suitable below that depth.	Good below a depth of 30 to 60 inches.	Poor; occasional pockets.	Good -----	Fair -----	Fluctuating water table at a depth of 6 to 12 feet.	Moderate stability and shear strength.
Las Animas (Lk) -- --	Sandy loam, fair; loamy sand, poor.	Good below a depth of 30 inches.	Poor; occasional pockets.	Good -----	Poor to good.	Fluctuating water table at a depth of 3 to 7 feet.	Well graded; moderate shear strength and stability.
Lincoln (Lm) -----	Not suitable --	Good; poorly graded.	Poor; localized pockets.	Fair to good.	Poor to good.	High water table; flooding hazard.	Unstable -----
Lismas (Ln) -----	Not suitable --	Not suitable --	Not suitable --	Poor -----	Poor -----	Unstable slopes.	(²) -----
Lofton (Lo) -----	Good -----	Not suitable --	Not suitable --	Poor -----	Poor -----	Occasional ponding of runoff water; highly plastic.	Low to moderate shear strength and stability.
Mansic (Mh) -----	Good -----	Not suitable --	Not suitable --	Good -----	Fair -----	(³) -----	Moderate shear strength and stability.
Mansker (occurs only in a complex with Potter soils).	Surface layer good; not suitable below a depth of 12 inches.	Not suitable --	Good source of caliche below a depth of 30 inches.	Good -----	Poor -----	Caliche at a depth of 12 to 36 inches.	Moderate shear strength and stability.
Manter (Mn, Mr) -- --	Fair -----	Poor -----	Not suitable --	Good -----	Good -----	(³) -----	Low compressibility; good compaction.
Otero ⁴ (Ot) -----	Fair -----	Poor -----	Not suitable --	Good -----	Good -----	(³) -----	Moderate shear strength and stability.

See footnotes at end of table.

of soils in Finney County, Kans.—Continued

Soil features affecting engineering practices—Continued					
Farm ponds		Agricultural drainage	Irrigation	Terraces and diversions	Waterways
Reservoir area	Embankment				
(?)-----	(?)-----	Imperfectly drained; fluctuating water table at a depth between 6 and 12 feet; moderate permeability.	Moderately deep to deep; limited water-holding capacity; imperfectly drained; slight to moderate salinity.	Surface layer favorable; limited depth.	Outlets remotely situated.
(?)-----	(?)-----	Imperfectly drained; fluctuating water table at a depth between 3 and 7 feet; rapid permeability.	Moderately deep; low water-holding capacity; imperfectly drained; moderately rapid intake rate.	(?)-----	Moderate stability and erodibility.
(?)-----	(?)-----	Frequent flooding; fluctuating water table; rapid permeability.	(?)-----	(?)-----	High erodibility; unstable banks; low fertility.
Shallow; slow permeability.	High shrink-swell potential, plasticity, and compressibility; low shear strength; poor stability and compaction.	Well drained-----	(?)-----	(?)-----	(?).
Slow permeability---	Moderate to high shrink-swell potential and plasticity; high compressibility; low to moderate shear strength and stability; poor to fair compaction.	Runoff is ponded on this soil; permeability is slow.	Deep; high water-holding capacity; slow intake rate.	Slow permeability---	(?).
Moderate permeability.	High compressibility; moderate stability, shrink-swell potential, shear strength, and permeability.	Well drained-----	(?)-----	Steep; soil properties favorable.	Good structure, stability, and fertility.
Moderate permeability; caliche below depth of 12 to 36 inches.	High compressibility; moderate stability, shrink-swell potential, shear strength, and permeability.	Well drained-----	(?)-----	(?)-----	Moderately shallow; moderate stability; low erodibility.
Moderately rapid permeability.	Well graded; low compressibility; good compaction; slight piping potential.	Well drained-----	Deep; moderate water-holding capacity; moderately rapid intake rate.	(?)-----	Deep; friable; moderate stability and erodibility.
Moderately rapid permeability.	Low plasticity and shrink-swell potential; moderate shear strength and stability; good compaction.	Well drained-----	Deep; moderate water-holding capacity; moderately rapid intake rate.	(?)-----	Limited water-holding capacity.

TABLE 8.—*Interpretation of engineering properties*

Soil series and map symbol	Suitability as source of—					Soil features affecting engineering practices	
	Topsoil	Sand	Gravel	Road fill ¹	Subgrade ¹	Highway location	Dikes and canals
Potter (occurs only in a complex with Mansker soils).	Not suitable--	Not suitable--	Good source of caliche.	Good-----	Poor-----	Caliche at a depth of 12 inches or less.	(²)-----
Promise (Pc)-----	Fair-----	Not suitable--	Not suitable--	Poor-----	Poor-----	Highly plastic---	Poor stability and compaction.
Randall (Ra)-----	Fair-----	Not suitable--	Not suitable--	Poor-----	Poor-----	Frequent ponding of runoff from surrounding areas; highly plastic.	(²)-----
Richfield (Rm, Rn, Ro).	Good-----	Not suitable--	Not suitable--	Fair to good.	Poor to fair.	(³)-----	Moderate shear strength and stability.
Roxbury (Rx)-----	Good-----	Not suitable--	Not suitable--	Good-----	Fair-----	(³)-----	Moderate shear strength and stability.
Spearville (Sp, Sr)---	Good-----	Not suitable--	Not suitable--	Fair-----	Poor-----	Moderately plastic to highly plastic soils.	Moderate shear strength and stability.
Sweetwater (Sw)---	Poor-----	Good below a depth of 15 inches.	Poor; localized pockets.	Fair-----	Poor to fair--	High water table.	Moderate shear strength and stability.
Tivoli (Tf)-----	Poor-----	Good (fine sand).	Not suitable--	Good if confined.	Good if confined.	High erodibility--	(²)-----

See footnotes at end of table.

of soils in Finney County, Kans.—Continued

Soil features affecting engineering practices—Continued					
Farm ponds		Agricultural drainage	Irrigation	Terraces and diversions	Waterways
Reservoir area	Embankment				
Shallow over caliche; some sand pockets.	Material above the caliche has moderate shear strength, shrink-swell potential, stability, and plasticity; compaction fair to good; caliche high in calcium carbonate.	Well drained-----	(?)-----	(?)-----	Shallow over caliche; steep.
Slow permeability---	High compressibility, plasticity, and shrink-swell potential; poor stability and compaction.	Well drained-----	(?)-----	Slow permeability---	(?).
(?)-----	(?)-----	Depressional areas where water is ponded.	(?)-----	(?)-----	(?).
Moderately slow permeability.	Moderate shear strength and stability; low to moderate shrink-swell potential and erodibility; fair to good compaction.	Well drained-----	Deep; high water-holding capacity; moderate intake rate; Richfield silt loam, saline, is slightly to moderately saline below a depth of 16 inches.	Soil properties favorable; no limitations.	Deep; friable; moderate stability; low to moderate erodibility.
Moderate permeability.	Moderate shear strength and stability; low to moderate shrink-swell potential and erodibility.	Well drained-----	Deep; high water-holding capacity; moderate intake rate.	Soil properties favorable; no limitations.	Deep; high water-holding capacity.
Slow permeability---	Low to moderate shear strength and stability; high compressibility; poor to fair compaction; moderate to high shrink-swell potential and plasticity.	Well drained-----	Deep; high water-holding capacity; slow intake rate.	Slow permeability---	(?).
(?)-----	(?)-----	Poorly drained; fluctuating water table; drainage difficult to establish.	(?)-----	(?)-----	Sandy substratum allows seepage; saline.
(?)-----	(?)-----	Well drained-----	(?)-----	(?)-----	(?).

TABLE 8.—*Interpretation of engineering properties*

Soil series and map symbol	Suitability as source of—					Soil features affecting engineering practices	
	Topsoil	Sand	Gravel	Road fill ¹	Subgrade ¹	Highway location	Dikes and canals
Ulysses (Ua, Ub, Uc, Ud, Us, Ut).	Good.....	Not suitable..	Not suitable..	Good.....	Fair to good.	(³).....	Low to moderate shear strength and stability.
Vona (Vo).....	Poor.....	Fair (fine sand).	Not suitable..	Good.....	Good.....	High erodibility..	(²).....

¹ These columns prepared with the assistance of C. W. HECKATHORN, field soils engineer, and HERBERT E. WORLEY, soils research engineer, Kansas State Highway Commission, under a cooperative agreement with U.S. Department of Commerce, Bureau of Public Roads.

² Practice was not considered, because of location of the soil or physiographic position.

The soils in some soil complexes may give trouble if they are used as subgrade for highways because of the differences in the characteristics of the soils. The complexes that may cause difficulty are Las-Bayard sandy loams, Las-Las Animas complex, and Otero-Ulysses complex, undulating. Information about the characteristics of the soils in these complexes is given in the section "Descriptions of the Soils."

The Randall soils are in undrained depressions and often have water ponded on the surface. The Lofton and Church soils are on lake benches, and water occasionally ponds on them. If a highway is to be constructed across areas where any of the soils occur, it should be constructed on an embankment to keep the roadway above the level reached by the water.

Sites where a pond is to be constructed need special investigation to determine if there are any sand pockets in the soils. Where sand pockets occur, there may be excessive seepage, or the structure may fail.

Features that affect the suitability of the soils for irrigation are given in table 8. Additional facts about the suitability of the soils is given in the section "Irrigation in Finney County."

Genesis, Classification, and Morphology of Soils

The purpose of this section is to show the outstanding morphologic characteristics of the soils of Finney County and to relate them to the factors of soil formation. Information about the physical and chemical characteristics of these soils is limited, and the discussion of soil genesis and morphology is therefore incomplete. The first part of the

section deals with the environment of the soils; the second, with their classification; and the third, with their morphology.

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 into a soil profile. It 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.

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 of them unless conditions are specified for the other four. Many of the processes of soil formation are complex and are difficult to understand.

of soils in Finney County, Kans.—Continued

Soil features effecting engineering practices—Continued					
Farm ponds		Agricultural drainage	Irrigation	Terraces and diversions	Waterways
Reservoir area	Embankment				
Moderate permeability.	Low to moderate shear strength, shrink-swell potential, stability, erodibility, and plasticity; fair to good compaction.	Well drained-----	Deep; high water-holding capacity; moderate intake rate; Ulysses silt loams, saline, (Us Ut) have slight to moderate salinity below a depth of 24 inches.	Soil properties favorable; no limitations.	Deep; friable; low to moderate stability and erodibility.
(?)-----	(?)-----	Well drained-----	Deep; moderate water-holding capacity; moderately rapid intake rate.	(?)-----	(?).

³ No detrimental features affecting the location of highways.

⁴ Otero gravelly complex (Ox) was not included, because the soil material is too variable.

Parent material

The soils of the county formed in several different kinds of parent material. The principal kinds are loess, sandy eolian material, alluvium, plains outwash, material weathered from shale of Cretaceous age, and lacustrine silts and clays.

Loess is the predominant parent material of the soils on the High Plains tableland. The loess is calcareous and porous, and more than 50 percent of it is silt. It was deposited in late Pleistocene time. The loess on the High Plains is approximately 10 to 30 feet thick over the calcareous silt, sand, and gravel of the Ogallala formation. In the drainage area of the Pawnee River, loess caps the divides, but the mantle of loess is thinner on the divides than on the plains. In about 60 percent of the county, the soils formed in loess.

Eolian sand is the major parent material of the soils of the sandhills. Most of the sand was deposited during Recent time after the loess was deposited. In the large areas of sandhills south of the valley of the Arkansas River, the soils are noncalcareous fine sands and the topography is steep and dunny. The sand is deepest and coarsest next to the valley. To the south, the mantle of soil material is thinner and the sand contains an increasing amount of silt and clay.

Sandy eolian material lies around the perimeter of the sandhills and in other small areas in the county. This material is calcareous and is a mixture of locally reworked sand, silt, and clay. It is the parent material of the moderately coarse textured soils of the upland.

The alluvium in the county has been deposited in Recent time. It is the most variable of all the parent material in the county. Variations in the texture of the alluvial sediments and in drainage are responsible for most of the differences in the soils formed in alluvium. The most sandy

soils formed in alluvium occupy a narrow band along both sides of the channel of the Arkansas River. The soils on the broad flood plains and low terraces in the valley of the Arkansas River are less sandy. Along the sides of the valley are high terraces and alluvial fans consisting of local alluvium washed from the adjoining upland. Most of the alluvium in the valley of the Pawnee River came from the silty loess that mantles the upland.

Plains outwash consists of unconsolidated loamy and clayey sediments that are probably of upper Pliocene age. The material was deposited by widely shifting streams that originated in the Rocky Mountains. The sediment is less silty than the loess. It is the parent material of the Mansic, Mansker, and Potter series. The Mansic soils formed in sediments that are generally more than 3 feet deep over consolidated material, such as the thick beds of caliche of the Ogallala formation. The Mansker soils formed in plains outwash that is about 12 to 36 inches deep over caliche. The Potter soils formed in sediments that are less than 12 inches deep over the beds of caliche.

Limestone and shale of Cretaceous age are exposed along the valleys of the Pawnee River and its tributaries. The upper formation exposed is the Fort Hays limestone; the lower one is Carlile shale. The Lismas soils formed in material weathered from Carlile shale. The Promise soils formed in alluvium washed from the Fort Hays and Carlile formations.

Lacustrine silts and clays are the parent material of the soils in the shallow basins that dot the surface of the Scott-Finney depression. Soils formed in lacustrine material occupy only a small part of the acreage in the county.

Climate

Finney County has a temperate, semiarid climate. The average annual precipitation is about 19 inches. A large

part of the precipitation falls during the growing season. Evaporation is high, however, because of the warm temperature and strong winds. The amount of moisture available for plants and for soil leaching is limited.

The effect that climate has had on the soils of this county varies according to the kind of parent material, the lay of the land, and the time the forces of soil formation have had to act. None of the soils have been excessively leached of plant nutrients. Few soils have been leached of lime to a depth greater than 30 inches. Except for soils formed in noncalcareous fine sand and some young soils formed in alluvium, most of the soils have an accumulation of calcium carbonate within 30 inches of the surface. The cation-exchange capacity of the various soils depends more on the kind of parent material than on the amount of leaching that has occurred.

The Richfield soils are an example of the influence of climate on the formation of soils. They are on smooth, gentle slopes where the surface drainage is neither restricted nor excessive. These soils formed in pale-brown, calcareous loess that is about 20 to 25 percent clay and is high in weatherable minerals. They have a well-developed profile and are mature. The forces of soil formation are assumed to have had sufficient time to exert their full influence on the profile of the soils. Leaching and the weathering of minerals have caused the development of a dark grayish-brown eluvial horizon, about 5 to 10 inches thick, and an illuvial horizon about 7 to 14 inches thick. The illuvial horizon has a clay content of about 33 to 40 percent and is high in exchangeable cations.

The Richfield soils are leached of free carbonates to a depth of 12 to 20 inches. Below that depth is a zone where calcium carbonate has accumulated. Below a depth of 30 inches, these soils have been little affected by the processes of soil formation, except for some accumulation of calcium carbonate.

Plant and animal life

Plants and animals are important to the formation of soils, chiefly because they affect horizon differentiation. Plants largely determine the kinds and amounts of organic matter that go into the soil. They also govern the way the organic matter is added, whether as leaves and twigs on the surface or as fibrous roots within the soil.

All of the soils in the county formed under grass. Under virgin conditions the upper few inches contained many fibrous roots. Decomposed organic matter darkened the soils and influenced the development of soil structure. Plant growth and the accumulation of organic matter is greatest in nearly level areas where the most benefit is derived from the available moisture. As a result, these nearly level soils are darkened by organic matter to a greater depth than the more sloping soils.

Bacteria and fungi live mainly on plant and animal residue. They break down complex compounds into simpler forms, as in the decay of organic matter. The simpler compounds supply nutrients for the growth of plants. Substances produced by micro-organisms act as binding agents in the formation of structural peds. Some micro-organisms fix nitrogen from the atmosphere and add it to the soil when they die. Burrowing animals and earthworms have influenced the formation of soils by mixing the organic and mineral parts of the soil. The dis-

tinctly granular structure of the Ulysses soils is the result largely of the numerous worm casts in the soil.

Relief

Relief, or the lay of the land, affects runoff and drainage. This modifies the effect of climate on the parent material. Other things being equal, with an increase in slope there is a corresponding increase in runoff, less moisture gets into the soil, and erosion is greater. As a result, with increase in slope, soil development is less rapid.

The relationship of the Randall, Richfield, and Ulysses soils is an example of the effect of relief on the formation of soils. The parent material of the soils in these three series was similar, and most of the differences in profile characteristics are the result of differences in relief.

Randall soils are in undrained depressions that receive runoff from adjacent areas. The clayey texture and gray color of the Randall soils show the effects of additional moisture and poor drainage. The Richfield soils are on smooth, gentle slopes and have neither restricted nor excessive surface drainage. Of all the soils, they most nearly reflect the full influence of the climate on the parent material. The Richfield soils are less clayey and are better drained than the Randall soils. They are more clayey than the Ulysses soils and are leached of lime to a greater depth. The Ulysses soils are in more sloping, weakly convex areas. Runoff is greater on these soils and erosion has been greater than on the more gentle, smoother slopes. The weakly developed profile of the Ulysses soils reflects the influence of relief on the moisture regime of the soil.

Time

Time is necessary for the forces of soil formation to develop soil horizons through their action on the parent material. The parent sediments of such soils as the Bayard, which formed in alluvium, were deposited in recent time. These soils have weakly developed soil horizons. At the other extreme are soils, such as the Harney and Keith, whose parent material has been in place long enough for distinct soil horizons to be developed.

Differences in the soils of several series in this county have been caused mainly by differences in the time that the processes of soil development have had to act on the parent material. For example, the Manter and Otero soils formed in similar material in areas of similar topography. The Manter soils have been generally leached of lime and darkened by organic matter to a depth of about 20 inches, whereas the Otero soils are generally calcareous to the surface and have been darkened by organic matter only in the uppermost few inches. The parent material of the Roxbury and Humbarger soils is nearly uniform, but the more mature Roxbury soils reflect the longer time the parent material has been subject to soil-forming processes.

Classification and Morphology of Soils

Soils are placed in narrow classes for the organization 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. Soil series, type, and phase are defined in the section "How This Soil Survey Was Made." Subdivision of soil types into phases provides finer distinctions significant to soil use and management.

Classes in the highest category of the classification scheme are the zonal, intrazonal, and azonal orders (11).

In the zonal order are soils with evident, genetically related horizons that reflect the predominant influence of climate and living organisms in their formation. In the intrazonal order are 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. In the azonal order are soils that lack distinct, genetically related horizons, commonly because of youth, resistant parent material, or steep topography. Table 9 shows the three orders, lists the great soil groups in each, and names the series in each group. A profile that is considered typical for each series is described in alphabetic order in the section "Descriptions of Soil Series."

No mechanical or chemical analyses were made of the soils of Finney County. The Colby, Richfield, and Ulysses

TABLE 9.—Soil series arranged by higher categories, and some important characteristics of each series

ZONAL ORDER					
Great soil group and series	Horizon characteristics		Depth to calcareous layer	Parent material	Relief and position
	Color and texture of A horizon	Color and texture of B horizon or subsoil			
			<i>Inches</i>		
Brown: Vona.....	Grayish-brown loamy fine sand.	Grayish-brown fine sandy loam.	14 to 30	Sandy windblown material.	Undulating upland.
Chernozem: Harney.....	Dark grayish-brown silt loam.	Dark grayish-brown silty clay loam.	18 to 30	Loess.....	Nearly level upland.
Spearville....	Dark grayish-brown silty clay loam.	Dark grayish-brown silty clay.	12 to 20	Loess.....	Nearly level and gently sloping upland.
Chestnut: Keith.....	Dark grayish-brown loam.	Grayish-brown light clay loam.	15 to 30	Loess.....	Nearly level upland.
Lofton.....	Dark grayish-brown clay loam.	Gray clay.....	15 to 30	Silty material.....	Weakly concave areas.
Mansic ¹	Dark grayish-brown clay loam.	Brown clay loam.....	0 to 10	Plains outwash.....	Moderately steep upland.
Manter.....	Dark grayish-brown fine sandy loam.	Brown fine sandy loam...	12 to 48	Sandy windblown material.	Nearly level and undulating upland.
Richfield.....	Dark grayish-brown silt loam.	Dark grayish-brown silty clay loam.	12 to 20	Loess.....	Nearly level and gently sloping upland.
Ulysses ¹	Dark grayish-brown silt loam.	Dark grayish-brown light silty clay loam.	0 to 15	Loess.....	Nearly level to sloping upland.
INTRAZONAL ORDER					
Calcisol: Mansker.....	Dark grayish-brown loam.	Grayish-brown light clay loam.	(²)	Plains outwash.....	Sloping upland.
Grumusol: Randall.....	Gray silty clay.....	Mixture of gray and brown silty clay.	0 to 48	Silty material.....	Undrained depressions.
Humic Gley: Sweetwater ..	Gray clay loam.....	Mixture of gray and very dark gray clay loam.	(²)	Alluvium.....	Nearly level flood plains.
Solonetz (solodized): Drummond..	Grayish-brown silt loam..	Dark-gray silty clay loam.	9 to 17	Silty sediment of the plains.	Nearly level upland.

See footnotes at end of table.

TABLE 9.—*Soil series arranged by higher categories, and some important characteristics of each series—Continued*

AZONAL ORDER

Great soil group and series	Horizon characteristics		Depth to calcareous layer	Parent material	Relief and position
	Color and texture of A horizon	Color and texture of B horizon or subsoil			
Alluvial:			<i>Inches</i>		
Bayard-----	Grayish-brown fine sandy loam.	Pale-brown sandy loam--	0 to 8	Alluvium-----	Nearly level and gently sloping alluvial fans.
Bridgeport--	Dark grayish-brown clay loam.	Brown clay loam-----	0 to 12	Alluvium-----	Nearly level terraces.
Humbarger--	Grayish-brown silt loam--	Light brownish-gray silt loam.	0 to 6	Alluvium-----	Nearly level flood plains.
Las-----	Grayish-brown clay loam.	Light brownish-gray clay loam.	(²)	Alluvium-----	Nearly level flood plains.
Las Animas--	Grayish-brown sandy loam.	Brown sandy loam-----	(²)	Alluvium-----	Nearly level flood plains.
Lincoln-----	Pale-brown fine sand-----	Pale-brown coarse sand--	0 to 48	Alluvium-----	Nearly level flood plains.
Roxbury-----	Dark grayish-brown silt loam.	Dark grayish-brown silty clay loam.	0 to 12	Alluvium-----	Nearly level stream terraces.
Lithosol:					
Lismas-----	Grayish-brown clay-----	Mixture of very dark gray and dark grayish-brown (moist) clay shale.	(³)	Material weathered from shale.	Steeply sloping upland.
Potter-----	Grayish-brown loam-----	Thick beds of caliche--	(²)	Plains outwash-----	Moderately steep upland.
Regosol:					
Church-----	Dark grayish-brown silty clay loam.	Gray or light-gray silty clay loam.	0 to 6	Lacustrine-----	Nearly level lake benches.
Colby-----	Grayish-brown silt loam--	Pale-brown silt loam-----	0 to 5	Loess-----	Nearly level and gently sloping upland.
Otero-----	Brown fine sandy loam--	Brown fine sandy loam--	0 to 10	Sandy eolian material.	Undulating and moderately steep upland.
Promise-----	Dark grayish-brown clay	Grayish-brown clay-----	(²)	Local alluvium-----	Gently sloping upland.
Tivoli-----	Brown fine sand-----	Light yellowish-brown fine sand.	(³)	Sandy eolian material.	Steeply sloping upland.

¹ Intergrading toward Regosol great soil group.² At the surface.³ Noncalcareous.

soils of this county, however, are similar to the Colby, Richfield, and Ulysses soils of Hamilton County. Results of analyses of these soils in Hamilton County are given in the soil survey of Hamilton County (12).

In Finney County the soils of the zonal order are those of the Brown, Chernozem, and Chestnut great soil groups. The Brown great soil group consists of soils that have a brown A horizon of moderate thickness and a lighter colored B or C horizon. Commonly these soils have an accumulation of lime at a depth of 1 to 3 feet. They formed under short grasses, bunch grasses, and shrubs in a semiarid, temperate to cool-temperate climate. The only Brown soils in this county are those of the Vona series.

The Chernozems are a group of soils that have a thick, dark to nearly black A horizon rich in organic matter; a brown transitional B horizon that may contain more clay than the A horizon; and a light-colored C horizon with an accumulation of lime at a depth of 1½ to 4 feet. These soils formed under tall grasses or a mixture of tall and short grasses in a subhumid, temperate to cool-temperate climate. In this county the Harney and Spearville soils are in the Chernozem great soil group.

The Chestnut soils have a dark-brown surface layer that grades to lighter colored horizons. They have accumulated lime at a depth of 1 to 4 feet. These soils formed under mixed tall and short grasses in a subhumid to semi-

arid, temperate to cool-temperate climate. In this county the soils of the Keith, Lofton, Manter, and Richfield series are typical Chestnut soils. The Mansic and Ulysses soils are also in the Chestnut great soil group, but they have some characteristics of Regosols.

The soils of the intrazonal order are those of the Calcisol, Grumusol, Humic Gley, and Solonetz (solodized) great soil groups. Calcisols have an A horizon that varies in thickness and color, a prominent deeper horizon of lime accumulation, and parent material with a high to very high content of carbonates. The Mansker are the only soils of the Calcisol great soil group in this county.

Grumusols have a profile rather high in content of clay, relatively uniform in texture, and marked by signs of local soil movement resulting from shrinking and swelling as the soils wet and dry. Many of these soils have a thick, dark A horizon over a limy C horizon; others are uniform in general appearance, except for the signs of churning. These soils formed in parent material having a high content of clay or of alkaline earth elements, or from rocks that provided abundant clay and alkaline earth elements upon weathering. Soils of this group occur chiefly in a tropical or subtropical climate where wet and dry seasons alternate. The Randall soils are the only Grumusols in this county. In the Humic Gley great soil group are poorly drained or very poorly drained soils that have a thick, black A horizon, high in content of organic matter,

over a gray or mottled B or C horizon. These soils formed under marsh plants or swamp forest in a subhumid, cool-temperate to warm-temperate climate. The only Humic Gley soils in this county are those of the Sweetwater series.

Solonetz soils have a friable surface layer of variable thickness that is underlain by dark, hard, clayey soil material, ordinarily of columnar structure. These soils are generally highly alkaline. They formed under grass or shrub vegetation, mainly in a subhumid or semiarid climate. Where a light-colored, leached layer overlies the hard, clayey layer, the soils are called solodized Solonetz. In this county only the soils of the Drummond series are in the Solonetz (solodized) great soil group.

The soils of the azonal order in this county are those of the Alluvial, Lithosol, and Regosol great soil groups. Alluvial soils consist of transported and relatively recently deposited material. They are characterized by a weak modification, or no modification, of the original material by soil-forming processes. The soils of this county in the Alluvial great soil group are those of the Bayard, Bridgeport, Humbarger, Las, Las Animas, Lincoln, and Roxbury series.

Lithosols are a group of soils having no clearly expressed soil morphology and consisting of a freshly and imperfectly weathered mass of rock fragments. These soils are mainly on steep slopes. The soils in the Lithosol great soil group in this county are those of the Lismas and Potter series.

Regosols are a group of soils lacking definite genetic horizons and developing from deep unconsolidated or soft, rocky deposits. The Regosols in this county are those of the Church, Colby, Otero, Promise, and Tivoli series.

Descriptions of 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.

Bayard Series

In the Bayard series are grayish-brown, calcareous fine sandy loams formed in sandy alluvium. The soils are deep and well drained. The native vegetation was grass.

The Bayard soils are better drained than the Las Animas, and they lack the mottling in the subsoil that is typical of the Las Animas soils. The Bayard soils are less clayey than the Bridgeport soils.

Typical profile of Bayard fine sandy loam under native grass (790 feet east and 100 feet north of the southwestern corner of sec. 30, T. 24 S., R. 31 W.) :

- A1—0 to 6 inches, grayish-brown (10YR 5/2) fine sandy loam; very dark grayish brown (10YR 3.5/2) when moist; weak, granular structure; soft when dry, very friable when moist; calcareous; clear boundary.
- C1—6 to 36 inches, pale-brown (10YR 6/3) sandy loam; brown (10YR 5/3) when moist; massive; soft when dry, very friable when moist; few worm casts; calcareous and contains small lime concretions; gradual boundary.
- IIC2—36 to 60 inches, very pale brown (10YR 7/3) fine and medium sand; pale brown (10YR 6/3) when moist; calcareous and contains few lime concretions.

In general, the texture of the solum ranges from fine sandy loam to light loam, but thin layers of clay loam and of loamy sand are common in the profile. In places the soils contain scattered pebbles. These soils are generally

calcareous from the surface downward, but they are non-calcareous to a depth of 8 inches in some places.

Bridgeport Series

The Bridgeport series consists of well-drained, calcareous clay loams. These soils are deep. They formed in calcareous, silty alluvium under grass.

The Bridgeport soils have a deeper root zone and a better drained subsoil than the Las soils. They are more clayey than the Bayard soils.

Typical profile of Bridgeport clay loam in a cultivated field (330 feet east and 730 feet south of the northwestern corner of sec. 7, T. 24 S., R. 34 W.) :

- Alp—0 to 6 inches, grayish-brown (10YR 5/2) light clay loam; very dark grayish brown (10YR 3/2) when moist; weak granular structure; slightly hard when dry, friable when moist; worm casts; calcareous; abrupt boundary (plow slice).
- A1—6 to 11 inches, dark grayish-brown (10YR 4/2) light clay loam; very dark grayish brown (10YR 3/2) when moist; moderate, fine, granular structure; slightly hard when dry, friable when moist; numerous worm casts; weakly calcareous; clear, smooth boundary.
- AC—11 to 18 inches, brown (10YR 5/3) light clay loam; dark grayish brown (10YR 4/2) when moist; moderate, fine, granular structure; slightly hard when dry, friable when moist; numerous worm casts; calcareous and contains threads of lime; gradual, smooth boundary.
- Cca—18 to 60 inches, pale-brown (10YR 6/3) loam; dark grayish brown (10YR 4.5/2) when moist; massive; porous; slightly hard when dry, friable when moist; calcareous and contains threads of lime.

The texture of the solum is generally between heavy loam and clay loam, but there are thin layers of sandy loam in the subsoil in some places. When the soils are dry, the color of the A horizon ranges from grayish brown to dark grayish brown. The thickness of the A horizon ranges from 6 to 12 inches. These soils are generally calcareous to the surface, but the A horizon is noncalcareous in some places.

Church Series

The Church series consists of moderately well drained, saline soils that have a surface layer and subsoil of silty clay loam to light clay. The soils are deep and calcareous. They formed in light-colored lacustrine material under grass.

The Church soils lack a B horizon and the columnar structure in the subsoil that is typical of the Drummond soils. Also, their subsoil is calcareous instead of noncalcareous. The Church soils are more clayey and are less well drained than the Ulysses soils.

Typical profile of Church silty clay loam under native grass (410 feet north and 1,080 feet east of the west quarter corner of sec. 14, T. 21 S., R. 33 W.) :

- A1—0 to 6 inches, dark grayish-brown (10YR 4/2) silty clay loam; very dark grayish brown (10YR 3/2) when moist; moderate, fine, granular structure; hard when dry, friable when moist; numerous worm casts; calcareous; clear boundary.
- AC1—6 to 12 inches, gray (10YR 5/1) silty clay loam; very dark gray (10YR 3/1) when moist; moderate, fine, granular and weak, fine, subangular blocky structure; hard when dry, firm when moist; numerous worm casts; calcareous; clear boundary.
- AC2—12 to 22 inches, light-gray (10YR 6/1) silty clay loam; dark grayish brown (10YR 4/2) when moist; moderate, fine, granular and weak, fine, subangular blocky structure; hard when dry, firm when moist; calcareous; gradual boundary.

- C1—22 to 33 inches, light brownish-gray (10YR 6/2) silty clay loam; grayish brown (10YR 5/2) when moist; moderate, fine, subangular blocky structure; hard when dry, firm when moist; calcareous and contains a few threads of lime; gradual boundary.
- Clcs—33 to 54 inches, same as C1 horizon, except that it contains numerous crystals of calcium sulfate; gradual boundary.
- C2—54 to 78 inches, light brownish-gray (10YR 6/2), mixed with light-gray (10YR 6/1), silty clay loam; weak, granular structure; hard when dry, friable when moist; lower part of horizon is peppered with black concretions about 1 millimeter in diameter; calcareous; contains a few crystals of calcium sulfate; diffuse boundary.
- C3—78 to 92 inches, white (2.5Y 8/2), mixed with light brownish-gray (10YR 6/2), silty clay loam; weak, granular structure; hard when dry, friable when moist; calcareous.

The A horizon ranges in color from dark grayish brown to gray in the 10YR hue; material that has a hue ranging from 1Y to 5Y is at a depth of 2 to 7 feet. These soils are generally calcareous to the surface, but the uppermost few inches is noncalcareous in some places. Salinity ranges from slight to moderate. The amount and location of the excessive concentration of soluble salts in the soil profile vary.

Colby Series

In the Colby series are calcareous soils that have a weakly developed profile. These soils are on the upland. They lack a B horizon, but their A horizon is grayish-brown silt loam, and their C horizon is pale-brown, calcareous silt loam. The maximum thickness of the A horizon is 5 inches. These soils formed in pale-brown, calcareous, silty loess under mixed grasses.

The Colby soils are lighter colored and more calcareous than the Ulysses soils. Also, their profile is less well developed.

Typical profile of Colby silt loam in a cultivated field (300 feet east and 300 feet south of the northwestern corner of sec. 7, T. 21 S., R. 34 W.):

- A1p—0 to 4 inches, grayish-brown (10YR 5/2) silt loam; dark grayish brown (10YR 4/2) when moist; weak, granular structure; slightly hard when dry, friable when moist; few worm casts; calcareous; abrupt boundary (plow slice).
- AC—4 to 8 inches, brown (10YR 5.5/3) silt loam; dark brown (10YR 4/3) when moist; moderate, very fine, granular structure; slightly hard when dry, friable when moist; calcareous; clear, smooth boundary.
- Cca—8 to 30 inches, pale-brown (10YR 6/3) silt loam; brown (10YR 5/3) when moist; weak, granular structure; slightly hard when dry, friable when moist; calcareous; contains weak films of lime; gradual, smooth boundary.
- C—30 to 60 inches, pale-brown (10YR 6/3) silt loam; brown (10YR 5/3) when moist; massive; calcareous.

The color of the A horizon ranges from dark grayish brown to pale brown. The texture of the A and C horizons ranges from silt loam to loam. These soils are generally calcareous to the surface, but the uppermost few inches is noncalcareous in some places.

Drummond Series

This series consists of soils that have an A1 horizon of grayish-brown silt loam and a B horizon of dark-gray silty clay loam. The B horizon has columnar structure. In places these soils have a thin, weakly defined A2 horizon. They are deep and moderately well drained, and they have

an excessive concentration of sodium and soluble salts in the B and C horizons. The Drummond soils formed in calcareous, silty plains sediment under grass.

The well-defined B horizon that is noncalcareous and has columnar structure distinguishes the Drummond from the Church soils. The columnar structure in the B horizon and the high content of sodium and soluble salts distinguish the Drummond soils from the Richfield.

Typical profile of Drummond silt loam in an area of native grass (1,010 feet west and 600 feet south of the north quarter corner of sec. 35, T. 22 S., R. 33 W.):

- A1—0 to 3½ inches, grayish-brown (10YR 5/2) silt loam; very dark grayish brown (10YR 3/2) when moist; weak, granular structure; slightly hard when dry, friable when moist; noncalcareous; abrupt, smooth boundary.
- A2—3½ to 5 inches, light brownish-gray (10YR 6/2) silt loam; very dark grayish brown (10YR 3/2) when moist; weak, granular structure; slightly hard when dry, friable when moist; noncalcareous; abrupt, smooth boundary.
- B21t—5 to 9 inches, dark-gray (10YR 4/1) heavy silty clay loam; very dark grayish brown (10YR 3/2) when moist; moderate, medium, columnar structure that breaks to moderate, fine, blocky and subangular blocky; very hard when dry, firm when moist; continuous clay films; noncalcareous; clear, smooth boundary.
- B22t—9 to 13 inches, grayish-brown (10YR 5/2) heavy silty clay loam; dark grayish brown (10YR 4/2) when moist; moderate, fine, subangular blocky structure; very hard when dry, firm when moist; continuous clay films; noncalcareous; clear, smooth boundary.
- B3cs—13 to 32 inches, light brownish-gray (10YR 6/2) light silty clay loam; dark grayish brown (10YR 4/2) when moist; moderate, fine, subangular blocky structure; hard when dry, friable when moist; calcareous; numerous crystals of calcium sulfate; gradual, smooth boundary.
- Ccs—32 to 56 inches, very pale brown (10YR 7/3) silt loam; brown (10YR 5/3) when moist; weak, granular structure; slightly hard when dry, friable when moist; calcareous; crystals of calcium sulfate less numerous than in B3cs horizon; diffuse boundary.
- C—56 to 90 inches, very pale brown (10YR 7/3) silt loam; brown (10YR 5/3) when moist; weak, granular structure; slightly hard when dry, friable when moist; calcareous.

The A1 horizon ranges from 3 to 6 inches in thickness, and the A2 horizon from 1 to 4 inches. Where these soils have been cultivated, plowing has mixed the soil material in the two horizons so that the A2 can no longer be recognized. The color of the B horizon ranges from dark gray to brown. The structure of the B horizon is typically columnar and breaks to blocky or subangular blocky, but the columnar structure is lacking in places. Depth to calcareous material ranges from 9 to 17 inches.

Harney Series

Soils of the Harney series have an A horizon of dark grayish-brown or grayish-brown silt loam that grades to light silty clay with blocky or subangular blocky structure in the lower part of the B horizon. These soils are deep and well drained. They formed in pale-brown, calcareous, silty loess under grass.

In the Harney soils the lower part of the B horizon is more clayey than in the Richfield soils. The Harney soils have a slightly thicker A horizon and less clay in the upper part of the B horizon than the Spearville soils. They also lack the abrupt boundary between the A and B horizons that is typical of the Spearville soils.

Typical profile of Harney silt loam in a cultivated field (510 feet south and 240 feet west of the northeastern corner of sec. 29, T. 23 S., R. 27 W.):

- A1p—0 to 4 inches, grayish-brown (10YR 5/2) silt loam; very dark grayish brown (10YR 3/2) when moist; weak, granular structure; slightly hard when dry, friable when moist; noncalcareous; abrupt boundary (plow slice).
- A1—4 to 7 inches, dark grayish-brown (10YR 4/2) silt loam; very dark grayish brown (10YR 3/2) when moist; moderate, fine, granular structure; slightly hard when dry, friable when moist; noncalcareous; clear, smooth boundary.
- B1—7 to 13 inches, dark grayish-brown (10YR 4/2) light silty clay loam; very dark grayish brown (10YR 3/2.5) when moist; moderate, fine, granular structure; hard when dry, friable when moist; numerous worm casts; noncalcareous; clear, smooth boundary.
- B21t—13 to 18 inches, dark grayish-brown (10YR 4.5/2) silty clay loam; very dark grayish brown (10YR 3/2) when moist; moderate, fine, subangular blocky structure; hard when dry, firm when moist; apparent clay films; noncalcareous; clear, smooth boundary.
- B22t—18 to 26 inches, dark grayish-brown (10YR 4.5/2) light silty clay; very dark grayish brown (10YR 3/2) when moist; moderate, fine, prismatic and moderate, fine, blocky structure; very hard when dry, firm when moist; distinct clay films; noncalcareous; clear, smooth boundary.
- B2ca—26 to 31 inches, grayish-brown (10YR 5/2) heavy silty clay loam; dark grayish brown (10YR 4/2) when moist; moderate, fine, subangular blocky structure; hard when dry, firm when moist; patchy clay films; calcareous; contains soft concretions and threads of lime; clear, smooth boundary.
- B3ca—31 to 36 inches, pale-brown (10YR 6/3) silty clay loam; dark grayish brown (10YR 4/2) when moist; weak, subangular blocky structure; slightly hard when dry, friable when moist; calcareous, soft concretions and threads of lime; gradual, smooth boundary.
- Cca—36 to 60 inches, very pale brown (10YR 7/3) silt loam; brown (10YR 5/3) when moist; massive; porous; slightly hard when dry, friable when moist; calcareous; contains concretions and threads of lime.

The A horizon ranges from 5 to 10 inches in thickness. The transitional horizon (B1 horizon) between the A horizon and the B horizon ranges from 5 to 10 inches in thickness. The color of the B horizon ranges from dark grayish brown to brown, and the thickness of that horizon, from 12 to 18 inches. Depth to calcareous material ranges from 18 to 30 inches.

Humbarger Series

The soils of the Humbarger series are deep, well-drained, grayish-brown silt loams. They formed in calcareous, silty alluvium under grass.

The Humbarger soils are less clayey than the Roxbury soils and have not been darkened by organic matter to so great a depth. Also they do not have a well-defined B horizon.

Typical profile of Humbarger silt loam in a cultivated field (500 feet north and 120 feet east of the southwestern corner of sec. 9, T. 22 S., R. 28 W.):

- A1p—0 to 5 inches, grayish-brown (10YR 5/2) silt loam; very dark grayish brown (10YR 3/2) when moist; weak, granular structure; slightly hard when dry, friable when moist; worm casts; calcareous; abrupt boundary (plow slice).
- A1—5 to 10 inches, grayish-brown (10YR 5/2) silt loam; very dark grayish brown (10YR 3/2) when moist; weak, granular structure; slightly hard when dry, friable when moist; worm casts; calcareous; clear boundary.

AC—10 to 16 inches, grayish-brown (10YR 5/2.5) silt loam; dark grayish brown (10YR 4/2) when moist; weak, granular structure; slightly hard when dry, friable when moist; worm casts; calcareous; gradual boundary.

C—16 to 60 inches, light brownish-gray (10YR 6/2.5), weakly stratified silt loam and loam; dark grayish brown (10YR 4/2) when moist; massive; porous; slightly hard when dry, friable when moist; calcareous.

The color of the A horizon ranges from dark grayish brown to brown. The texture of the surface layer and subsoil is generally between loam and light silty clay loam, but there are thin layers of sandy loam in the subsoil in places. These soils are generally calcareous to the surface, but they are noncalcareous to a depth of 6 inches in some places.

Keith Series

The Keith series consists of deep, well-drained soils that have an A horizon of dark grayish-brown loam. The B horizon is light clay loam with subangular blocky structure. These soils formed in pale-brown, calcareous, loamy loess under grass.

The Keith soils are less clayey than the Richfield soils. They have been darkened to a greater depth by organic matter, they have a more strongly defined subsoil, and they are leached of lime to a greater depth than the Ulysses soils.

Typical profile of Keith loam in a cultivated field (690 feet north and 50 feet east of the southwestern corner of sec. 16, T. 26 S., R. 32 W.):

- A1p—0 to 7 inches, dark grayish-brown (10YR 4/2) loam; very dark grayish brown (10YR 3/2) when moist; weak, granular structure in upper part of plow layer and weakly platy in lower part; slightly hard when dry, friable when moist; noncalcareous; abrupt boundary (plow slice).
- A1—7 to 10 inches, dark grayish-brown (10YR 4/2) loam; very dark grayish brown (10YR 3/2) when moist; moderate, fine, granular structure; slightly hard when dry, friable when moist; worm casts; noncalcareous; clear, smooth boundary.
- AB—10 to 15 inches, dark grayish-brown (10YR 4/2) heavy loam; very dark grayish brown (10YR 3/2) when moist; moderate, fine, granular structure; slightly hard when dry, friable when moist; numerous worm casts; noncalcareous; clear, smooth boundary.
- B21t—15 to 20 inches, grayish-brown (10YR 5/2) light clay loam; very dark grayish brown (10YR 3/2) when moist; moderate, fine, granular and weak, fine, subangular blocky structure; hard when dry, firm when moist; patchy clay films; pockets of worm casts; noncalcareous; clear, smooth boundary.
- B22t—20 to 24 inches, brown (10YR 5/3) light clay loam; dark brown (10YR 3.5/3) when moist; moderate, fine, subangular blocky structure; hard when dry, firm when moist; clay films; noncalcareous; clear, smooth boundary.
- Cca—24 to 60 inches, pale-brown (10YR 6/3) silt loam; brown (10YR 5/3) when moist; weak, subangular blocky structure; slightly hard when dry, friable when moist; calcareous; contains numerous concretions and threads of lime.

The A horizon ranges from 6 to 12 inches in thickness, and the transitional horizon from the A to the B horizon (AB horizon) ranges from 4 to 8 inches in thickness. The B horizon ranges from dark grayish brown to brown in color and from 8 to 14 inches in thickness. Depth to calcareous material ranges from 15 to 30 inches.

Las Series

Soils of the Las series are calcareous, imperfectly drained clay loams that have a weakly defined profile. They formed in clayey alluvium in the valley of the Arkansas River. The native vegetation was grass.

The Las soils have a more clayey, more coherent subsoil than the Bayard soils; they are less well drained and have a shallower root zone than the Bridgeport soils; and they are better drained and are lighter colored than the Sweetwater soils.

Typical profile of Las clay loam in a cultivated field (340 feet south and 610 feet west of the center of sec. 8, T. 24 S., R. 34 W.):

- A1p—0 to 5 inches, grayish-brown (10YR 5/2) clay loam; very dark grayish brown (10YR 3/2) when moist; weak, granular structure; hard when dry, firm when moist; numerous worm casts; few small pebbles; calcareous; abrupt boundary (plow slice).
- A1—5 to 8 inches, grayish-brown (10YR 5/2) clay loam; very dark grayish brown (10YR 3.5/2) when moist; moderate, fine, granular structure; hard when dry, firm when moist; worm casts; few small pebbles; calcareous; clear boundary.
- AC—8 to 19 inches, light brownish-gray (10YR 6/2) clay loam; dark grayish brown (10YR 4/2) when moist; moderate, fine, granular structure; hard when dry, firm when moist; worm casts; calcareous; clear boundary.
- C1—19 to 26 inches, light-gray (10YR 6/1) light clay loam; dark grayish brown (10YR 4/2) when moist; weak, granular structure; slightly hard when dry, friable when moist; calcareous; gradual boundary.
- IIC2—26 to 31 inches, light brownish-gray (10YR 6.5/2) sandy loam; grayish brown (10YR 5/2) when moist; massive; soft when dry, very friable when moist; common, distinct, strong-brown mottling; calcareous; the mass is streaked with lime; gradual boundary.
- IIIC3—31 to 48 inches, light yellowish-brown (10YR 6/4) when dry fine sand and gravel; noncalcareous; diffuse boundary.
- IIIC4—48 to 60 inches, pale-brown (10YR 6/3) when dry coarse sand and gravel streaked with mottlings of strong brown; noncalcareous.

The color of the A horizon ranges in value from 4 to 6 where the soils are dry, and from 3 to 5 where they are moist. The chroma ranges from 1.5 to 3. In general, the texture of the surface layer and subsoil ranges from heavy loam to clay loam or sandy clay loam, but thin layers of more sandy and more clayey material are common.

Las Animas Series

The soils of the Las Animas series are calcareous sandy loams and loamy sands that have a weakly defined profile. They are moderately deep and are imperfectly drained. These soils formed in calcareous, sandy alluvium under grass.

The Las Animas soils are more sandy than the Las soils, but they have a less sandy, more coherent subsoil than the Lincoln soils. The Las Animas soils are less well drained than the Bayard soils.

Typical profile of Las Animas sandy loam (860 feet south and 150 feet east of the northwestern corner of sec. 18, T. 24 S., R. 33 W.):

- A1—0 to 6 inches, grayish-brown (10YR 5/2) sandy loam; very dark grayish brown (10YR 3/2) when moist; weak, granular structure; soft when dry, very friable when moist; numerous worm casts; calcareous; clear boundary.

- C1—6 to 14 inches, grayish-brown (10YR 5.5/2) sandy loam; dark grayish brown (10YR 4/2) when moist; weak, granular structure; soft when dry, very friable when moist; worm casts; calcareous; clear boundary.
- C2—14 to 18 inches, light brownish-gray (10YR 6/2) loam; dark grayish brown (10YR 4/2) when moist; weak, granular structure; slightly hard when dry, friable when moist; calcareous; contains threads of crystalline salts; clear boundary.
- C3—18 to 30 inches, brown (10YR 5/3) sandy loam; dark brown (10YR 3.5/3) when moist; weak, granular structure; soft when dry, very friable when moist; common, fine, distinct, strong-brown mottling; calcareous; gradual boundary.
- IIC4—30 to 36 inches, pale-brown (10YR 6/3) fine sand streaked with strong-brown mottling; noncalcareous; gradual boundary.
- IIIC5—36 to 60 inches, light yellowish-brown (10YR 6/4) sand and gravel streaked with strong-brown mottling; noncalcareous.

The texture of the A horizon ranges from light loam to loamy sand. The C horizon is dominantly sandy loam, but it contains layers of clay loam, loam, and loamy sand. The color of the A horizon ranges from dark grayish brown to pale brown. Depth to strong-brown mottling ranges from 16 to 40 inches.

Lincoln Series

The Lincoln series consists of stratified loamy fine sands and fine sands. The soils have a weakly defined profile and formed in recent, coarse-textured alluvium. The native vegetation is variable but ranges from a sparse stand of mixed grasses to mixed grasses, tamarisk, and cottonwoods.

The Lincoln soils are more sandy than the Las Animas soils. Also their subsoil is not mottled.

Typical profile of Lincoln sand under native grass (1,020 feet north and 200 feet east of the southwestern corner of sec. 22, T. 24 S., R. 32 W.):

- A1—0 to 10 inches, pale-brown (10YR 6/3) fine sand covered by a thin layer of calcareous loam; dark brown (10YR 4/3) when moist; single grain; loose; noncalcareous; gradual boundary.
- IIC—10 to 48 inches, pale-brown (10YR 6/3) coarse sand that contains numerous pebbles; brown (10YR 5/3) when moist; single grain; loose; noncalcareous.

Fine sand and loamy fine sand are dominant in these soils, but layers of more loamy material are common in the profile. The number of pebbles in the profile varies from place to place. The material is noncalcareous in some places, calcareous in others. In most places these soils are unmottled, but there are some faint mottles in the loamy layers.

Lismas Series

In the Lismas series are noncalcareous soils that have a grayish-brown, clayey A horizon and are shallow over shale. These soils formed in noncalcareous, gypsiferous clay shale under grass.

Typical profile of Lismas clay under native grass (790 feet north and 530 feet east of the west quarter corner of sec. 13, T. 22 S., R. 29 W.):

- A1—0 to 5 inches, grayish-brown (2.5Y 5/2) clay; dark grayish brown (2.5Y 4/2) when moist; moderate, fine, granular structure; very hard when dry, very firm when moist; noncalcareous; small pebbles are scattered throughout the horizon; gradual boundary.

C—5 to 48 inches, thinly bedded clay shale that is mainly very dark gray (N 3/0) and dark grayish brown (2.5Y 4/2) when moist but contains thin layers of yellowish brown (10YR 5/6) and light yellowish brown (2.5Y 6/4); few, soft, black concretions; noncalcareous; thin seams and crystals of calcium sulfate.

The main variation in these soils is in the thickness of the profile over shale. The maximum thickness is 12 inches, and the minimum thickness is only 1 to 2 inches of slightly darkened, weathered material over shale. The upper part of the shale contains septarium concretions. Concretions as much as 3 feet in diameter are scattered over the surface. Thin plates of gypsum that remain after the shale is completely weathered are also scattered over the surface.

Lofton Series

This series consists of deep soils in weakly concave areas where runoff from surrounding soils is ponded. The soils have a grayish-brown or dark grayish-brown A horizon and a gray, clayey B horizon. The structure of the A horizon is granular, and that of the B horizon is blocky. The soils formed in light-colored, calcareous, silty material under grass.

The Lofton soils are less clayey and less compact than the Randall soils. They have a well-defined B horizon that is lacking in the Randall soils.

Typical profile of Lofton clay loam in a cultivated field (760 feet west and 420 feet north of the southeastern corner of sec. 28, T. 22 S., R. 31 W.):

- Ap—0 to 6 inches, dark grayish-brown (10YR 4/2) clay loam; very dark grayish brown (10YR 3/2) when moist; weak, granular structure; hard when dry, friable when moist; noncalcareous; abrupt boundary (plow slice).
- B2t—6 to 19 inches, gray (10YR 5/1) clay; very dark gray (10YR 3/1) when moist; grades to light clay in the lower part of the subsoil; moderate, fine, blocky structure; very hard when dry, very firm when moist; prominent, continuous clay films; shot-size iron-manganese concretions; few, fine, distinct mottles; noncalcareous; clear, smooth boundary.
- B3—19 to 23 inches, light brownish-gray (1Y 6/2) light clay loam; grayish brown (1Y 5/2) when moist; weak, fine, subangular blocky structure; hard when dry, friable when moist; brown stains of organic matter in root channels; calcareous; clear, smooth boundary.
- Cca—23 to 36 inches, light-gray (1Y 7/2) light silty clay loam; grayish brown (1Y 5/2) when moist; weak, fine, subangular blocky structure; hard when dry, friable when moist; brown stains of organic matter in root channels; calcareous; contains threads of lime; gradual boundary.
- C—36 to 62 inches, light-gray (1Y 7/2) heavy silt loam; grayish brown (1Y 5/2) when moist; massive; slightly hard when dry, friable when moist; calcareous.

The thickness of the A horizon ranges from 5 to 10 inches. The color of the B horizon ranges from gray to dark gray. The degree of mottling in the B and C horizons ranges from none to distinct. The color of the C horizon ranges from brown to light gray in hues 7.5YR to 2.5Y. Depth to calcareous material ranges from 15 to 30 inches.

Mansic Series

This series consists of dark grayish-brown, deep, well-drained clay loams that have granular structure in the upper part of the profile. These soils lack a B horizon. They formed in calcareous Plains outwash under grass.

The Mansic soils lack the strong lime accumulation that is characteristic of the Mansker soils.

Typical profile of Mansic clay loam under native grass (1,190 feet north and 130 feet west of the southeastern corner of sec. 21, T. 22 S., R. 30 W.):

- A1—0 to 10 inches, dark grayish-brown (10YR 4/2) clay loam; very dark grayish brown (10YR 3/2) when moist; moderate, very fine, granular structure; slightly hard when dry, friable when moist; noncalcareous; clear, smooth boundary.
- ACca—10 to 18 inches, brown (10YR 4/3) clay loam; dark brown (10YR 3/3) when moist; moderate, very fine, granular structure; hard when dry, friable when moist; few small pebbles; calcareous; contains threads and concretions of lime; gradual, smooth boundary.
- C1ca—18 to 30 inches, brown (10YR 5/3) clay loam; dark brown (10YR 4/3) when moist; weak, fine, subangular blocky and weak, granular structure; hard when dry, firm when moist; few small pebbles; calcareous; segregated lime makes up about 10 percent of the soil mass; gradual boundary.
- C2ca—30 to 46 inches, very pale brown (10YR 7/3) light clay loam; brown (10YR 5.5/3) when moist; massive; hard when dry, firm when moist; calcareous; contains numerous threads and coatings of lime; gradual boundary.
- C3ca—46 to 60 inches, pale-brown (10YR 6/3) loam; dark brown (10YR 4/3) when moist; massive; slightly hard when dry, friable when moist; calcareous; contains fine threads of lime.

The texture of the A horizon ranges from heavy loam to clay loam. The A horizon is calcareous in some places, but not everywhere. The hue of the C horizon ranges from 10 YR to 7.5 YR.

Mansker Series

The Mansker soils are moderately deep and loamy, and they have a strong lime accumulation within 18 inches of the surface. The A horizon has granular structure and is dark grayish brown. These soils formed in strongly calcareous plains outwash under grass.

The Mansker soils have more lime in the subsoil and are less deep over caliche than the Mansic soils. They are deeper over caliche and are less sloping than the Potter soils.

Typical profile of Mansker loam under native grass (1,080 feet south of the northwestern corner of sec. 33, T. 23 S., R. 29 W.):

- A1—0 to 6 inches, dark grayish-brown (10YR 4/2) loam; very dark grayish brown (10YR 3/2) when moist; moderate, fine, granular structure; hard when dry, friable when moist; numerous worm casts; calcareous; small pebbles are scattered throughout the horizon; clear boundary.
- AC—6 to 15 inches, grayish-brown (10YR 5/2) light clay loam; dark grayish brown (10YR 4/2) when moist; weak, granular structure; slightly hard when dry, friable when moist; numerous worm casts; calcareous; many of the granules are coated with lime; small fragments of caliche are scattered throughout the horizon; clear boundary.
- Cca—15 to 31 inches, white (10YR 8/2) loam; very pale brown (10YR 7/3) when moist; massive; very hard when dry, firm when moist; penetrated by roots; strongly calcareous; fragments of caliche are scattered throughout the horizon; gradual boundary.
- C—31 inches +, thick caliche beds.

The texture of the A horizon ranges from loam to light clay loam, and the color of the A horizon, from dark

grayish brown to grayish brown. The number of pebbles and of fragments of caliche in the profile varies.

Manter Series

In the Manter series are deep, noncalcareous soils that have an A horizon of dark grayish-brown fine sandy loam. The subsoil is weakly defined and is brown fine sandy loam. These soils formed under grass in calcareous, windblown, sandy material. Below the sandy material, generally within 5 feet of the surface, is calcareous silt loam and loam.

The Manter soils are darker colored and less calcareous than the Otero soils. They have a darker colored, less sandy surface layer than the Vona soils.

Typical profile of Manter fine sandy loam in a cultivated field (100 feet west and 380 feet north of the south quarter corner of sec. 30, T. 26 S., R. 31 W.) :

- A1—0 to 8 inches, dark grayish-brown (10 YR 4/2) fine sandy loam; very dark grayish brown (10YR 3/2) when moist; weak, granular structure; soft when dry, very friable when moist; worm casts; noncalcareous, abrupt boundary (plow slice).
- B2—8 to 28 inches, brown (10YR 4/3) fine sandy loam; dark brown (10YR 3/3) when moist; slightly lighter colored in the lower 8 inches; weak, granular structure; soft when dry, very friable when moist; worm casts; clear, smooth boundary.
- C1ca—28 to 45 inches, pale-brown (10YR 6/3) fine sandy loam; brown (10YR 4.5/3) when moist; massive; soft when dry, very friable when moist; calcareous; contains threads of lime; boundary 2 inches or less wide.
- IIC2—45 to 60 inches, very pale brown (10YR 7/3) silt loam; brown (10YR 5/3) when moist; weak, granular structure; slightly hard when dry, friable when moist; calcareous; contains concretions and threads of lime.

The thickness of the A horizon and the depth to free carbonates vary as a result of differences in the shape and degree of slope. Depth to calcareous material ranges from 12 inches on convex ridgetops to 48 inches on concave slopes between the ridges. The degree of development of the B horizon ranges from negligible to the least that will qualify for a textural B horizon. The texture of the subsoil ranges from fine sandy loam to light loam.

Otero Series

The Otero soils are calcareous, brown fine sandy loams. They are deep soils formed on the upland in calcareous, sandy, windblown material under grass.

The Otero soils are lighter colored and more calcareous than the Manter soils. They are more calcareous and have a less sandy surface layer than the Vona soils.

Typical profile of Otero fine sandy loam in a cultivated field (200 feet north and 340 feet east of the west quarter corner of sec. 9, T. 26 S., R. 33 W.) :

- Ap—0 to 5 inches, brown (10YR 5/3) fine sandy loam; dark grayish brown (10YR 4/2) when moist; weak, granular structure; soft when dry, very friable when moist; worm casts; calcareous; abrupt boundary (plow slice).
- C—5 to 60 inches, brown (10YR 5/3) fine sandy loam; dark grayish brown (10YR 4/2) when moist; massive; soft when dry, very friable when moist; porous; pockets of worm casts above a depth of 30 inches; calcareous; contains a few threads of lime above a depth of 15 inches; this horizon has weak bedding planes where there are thin bands of slightly more silty and slightly more sandy material.

The dry color of the A horizon ranges from grayish brown to pale brown. The thickness of the A horizon ranges from 4 to 10 inches. The A horizon is generally calcareous, but it is noncalcareous in places. The subsoil contains thin layers of loam and loamy sand.

Potter Series

The Potter series consists of calcareous, grayish-brown loams that have a weakly developed profile. The soils are shallow over thick beds of caliche. The native vegetation is grass.

The Potter soils are less deep over caliche than the Mansker soils. They also have stronger slopes.

Typical profile of Potter loam under native grass (1,060 feet south of the northwestern corner of sec. 33, T. 23 S., R. 29 W.) :

- A1—0 to 5 inches, grayish-brown (10YR 5/2) loam; very dark grayish brown (10YR 3/2) when moist; moderate, fine, granular structure; hard when dry, friable when moist; numerous worm casts; calcareous; pebbles are scattered throughout the horizon; clear boundary.
- AC—5 to 10 inches, grayish-brown (10YR 5/2) light clay loam; dark grayish brown (10YR 4/2) when moist; weak, granular structure; hard when dry, friable when moist; numerous worm casts; calcareous; pebbles and fragments of caliche are scattered throughout the horizon; clear boundary.
- C—10 inches +, thick caliche beds.

The surface layer ranges from 4 to 12 inches in thickness over the beds of caliche. Its texture ranges from loam to silt loam, and there are varying amounts of pebbles and fragments of caliche.

Promise Series

This series consists of deep, calcareous soils that have a dark grayish-brown, clayey A horizon. The soils lack a B horizon, but below the surface layer is grayish-brown, clayey soil material that has blocky structure. These soils formed on the upland in local alluvium from shale. The native vegetation was grass.

Typical profile of Promise clay under native grass (70 feet south and 1,320 feet west of the east quarter corner of sec. 2, T. 22 S., R. 29 W.) :

- A1—0 to 2 inches, dark grayish-brown (10YR 4/1.5) light clay; very dark grayish brown (10YR 3/1.5) when moist; moderate, fine, granular structure; hard when dry, firm when moist; worm casts; weakly calcareous; clear boundary.
- AC—2 to 18 inches, grayish-brown (2.5Y 5/2) clay; dark grayish brown (2.5Y 4/2) when moist; moderate, fine and medium, blocky structure; very hard when dry, very firm when moist; worm casts; calcareous; small pebbles are scattered throughout the horizon; clear boundary.
- C1—18 to 32 inches, grayish-brown (1Y 5/2) clay; dark grayish brown (1Y 4/2) when moist; weak, subangular blocky structure; very hard when dry, very firm when moist; calcareous; contains numerous threads and a few hard crystals of calcium sulfate; more pebbles than the AC horizon, and the pebbles are in layers; gradual boundary.
- IIC2—32 to 52 inches, grayish-brown (10YR 5/2) heavy clay loam; dark grayish brown (10YR 4/2) when moist; weak, granular structure; hard when dry, firm when moist; calcareous; contains threads and seams of calcium sulfate; scattered small pebbles; gradual boundary.
- IIC3—52 to 60 inches, pale-brown (10YR 6/3) clay loam; brown (10YR 5/3) when moist; massive; calcareous; contains less calcium sulfate than the IIC2 horizon; few small pebbles.

The color of the A horizon ranges from dark grayish brown to grayish brown. In places the structure of the material below the surface layer is blocky, and in other places it is subangular blocky. The clayey material is 12 to 48 inches thick over stratified material that ranges from clay loam to coarse sandy loam in texture.

Randall Series

This series consists of deep, gray, compact silty clays in undrained depressions. The soils formed in calcareous, silty material where the drainage was poor.

The Randall soils are more clayey and more compact than the Lofton soils, and they are less well drained. Unlike the Lofton soils, they lack a B horizon.

Typical profile of Randall silty clay in a cultivated field (one-fourth mile north and 530 feet east of the southwestern corner of sec. 35, T. 23 S., R. 31 W.):

A11—0 to 24 inches, gray (10YR 5/) silty clay; very dark gray (10YR 3/1) when moist; weak, fine, blocky structure; very hard when dry, very firm when moist; the surfaces of the peds are shiny; contains iron-manganese concretions less than 2 millimeters in diameter; noncalcareous; clear boundary.

A12—24 to 30 inches, silty clay with a mixture of gray (10YR 5/1) or very dark gray (10YR 3/1) when moist and brown (10YR 5/3) changing to dark brown (10YR 4/3) when moist; the gray color is predominant in the upper part of the horizon, and the brown color is more prevalent in the lower part; weak, fine, blocky structure; very hard when dry, very firm when moist; the soil material becomes more friable with increasing depth; the surfaces of the peds are shiny; contains iron-manganese concretions less than 2 millimeters in diameter; noncalcareous; has few soft lime concretions in lower half of horizon; clear boundary.

ACca—30 to 35 inches, brown (10YR 5/3), calcareous silty clay loam with vertical streaks of noncalcareous, gray (10YR 5/1) material; dark grayish brown (10YR 4/2) when moist; the noncalcareous gray material is apparently fill from the A12 horizon in root channels and worm channels; weak, subangular blocky and weak, granular structure; hard when dry, friable when moist; contains iron-manganese concretions less than 2 millimeters in diameter; contains threads and concretions of lime; clear boundary.

Cca—35 to 62 inches, pale-brown (10YR 6/3) silt loam; brown (10YR 5/3) when moist; weak, granular structure; slightly hard when dry, friable when moist; calcareous; contains threads and concretions of lime.

The thickness of the clayey solum ranges from 24 to 48 inches over less clayey material. The reaction ranges from calcareous to the surface to noncalcareous to a depth of 48 inches. The C horizon ranges in texture from loam to silty clay loam, and in color, from hue 7.5YR to 2.5Y.

Richfield Series

The Richfield series consists of deep, well-drained soils of the upland. These soils have an A horizon of dark grayish-brown silt loam and a B horizon of silty clay loam. The lower part of the B horizon has subangular blocky structure. These soils formed in pale-brown, calcareous, silty loess under grass.

The Richfield soils have a less clayey, less compact subsoil than the Spearville soils. They are more clayey and have a more strongly developed profile than the Ulysses soils. Their subsoil is more clayey than that of the Keith soils. The lower part of their subsoil is less clayey than that of the Harney soils.

Typical profile of Richfield silt loam in a cultivated field (500 feet west and 90 feet south of the north quarter corner of sec. 3, T. 22 S., R. 34 W.):

Ap—0 to 6 inches, dark grayish-brown (10YR 4.5/2) silt loam; very dark grayish brown (10YR 3/2) when moist; weak, granular structure; slightly hard when dry, friable when moist; noncalcareous; abrupt boundary (plow slice).

B1—6 to 10 inches, dark grayish-brown (10YR 4/2) light silty clay loam; very dark grayish brown (10YR 3/2) when moist; moderate, fine, granular structure; hard when dry, friable when moist; worm casts; noncalcareous; clear, smooth boundary.

B2t—10 to 18 inches, dark grayish-brown (10YR 4/2) silty clay loam; very dark grayish brown (10YR 3/2) when moist; weak, fine, prismatic and moderate, very fine, subangular blocky structure; hard when dry, firm when moist; noncalcareous; clear, smooth boundary.

B3ca—18 to 34 inches, light brownish-gray (10YR 5.5/2) light silty clay loam; dark grayish brown (10YR 4/2) when moist; weak, fine, subangular blocky structure; hard when dry, friable when moist; calcareous; contains soft concretions and threads of lime; gradual, smooth boundary.

Cca—34 to 60 inches, pale-brown (10YR 6/3) silt loam; brown (10YR 5/3) when moist; massive; slightly hard when dry, friable when moist; porous; calcareous; contains soft concretions and threads of lime.

The A horizon ranges from 5 to 10 inches in thickness. The transitional layer between the A horizon and the B horizon (B1 horizon) ranges from 2 to 6 inches in thickness. The B2t horizon ranges from 8 to 14 inches in thickness. Depth to calcareous material ranges from 12 to 20 inches.

Roxbury Series

The Roxbury series consists of deep, well-drained soils that have an A horizon of dark grayish-brown or grayish-brown silt loam. These soils lack a B horizon, but below the A horizon is dark grayish-brown silty clay loam that has subangular blocky structure. These soils formed in calcareous, silty alluvium under grass.

The Roxbury soils are more clayey than the Humbarger soils. Also, organic matter has darkened their profile to a great depth.

Typical profile of Roxbury silt loam in a cultivated field (290 feet west and 150 feet south of the north quarter corner of sec. 10, T. 22 S., R. 29 W.):

A11p—0 to 8 inches, grayish-brown (10YR 5/2) heavy silt loam; very dark grayish brown (10YR 3/2) when moist; weak, granular structure; slightly hard when dry, friable when moist; calcareous; clear, smooth boundary.

A12—8 to 14 inches, dark grayish-brown (10YR 4/1.5) light silty clay loam; very dark grayish brown (10YR 3/2) when moist; moderate, fine, granular structure; slightly hard when dry, friable when moist; numerous worm casts; calcareous; clear boundary.

AC1—14 to 21 inches, dark grayish-brown (10YR 4/2) silty clay loam; very dark grayish brown (10YR 3/2) when moist; moderate, fine, subangular blocky structure; hard when dry, firm when moist; calcareous; gradual boundary.

AC2—21 to 28 inches, grayish-brown (10YR 5/2) silty clay loam; dark grayish brown (10YR 3.5/2) when moist; moderate, fine, subangular blocky structure; hard when dry, firm when moist; calcareous; contains a few threads of lime; gradual boundary.

ACca—28 to 35 inches, light brownish-gray (10YR 6/2) clay loam; dark grayish brown (10YR 4/2) when moist; moderate, fine, subangular blocky structure; slightly hard when dry, friable when moist; calcareous; contains numerous threads of lime in rootlet channels; gradual boundary.

Cca—35 to 60 inches, pale-brown (10YR 6/3) light clay loam; brown (10YR 5/3) when moist; weak, granular structure; slightly hard when dry, friable when moist; calcareous; contains threads of lime.

The texture of the A horizon ranges from silt loam to loam. The color of the solum ranges from dark grayish brown to grayish brown. Below the surface layer, the structure of the soil material ranges from subangular blocky to granular. Depth to calcareous material ranges from 0 to 12 inches.

Spearville Series

In the Spearville series are deep, well-drained soils of the upland. These soils have an A horizon of dark grayish-brown silty clay loam and a B horizon that is silty clay and has blocky structure. They formed in pale-brown, calcareous, silty loess under grass.

The Spearville soils have a more clayey, more compact subsoil than the Richfield soils. The upper part of their subsoil is more clayey than that of the Harney soils, and they have an abrupt boundary between the A and B horizons.

Typical profile of Spearville silty clay loam in a cultivated field (480 feet north and 660 feet east of the west quarter corner of sec. 36, T. 23 S., R. 27 W.):

- Ap—0 to 6 inches, dark grayish-brown (10YR 4/2) silty clay loam; very dark grayish brown (10YR 3/2) when moist; weak, granular structure; hard when dry, friable when moist; noncalcareous; abrupt boundary (plow slice).
- B21t—6 to 10 inches, dark grayish-brown (10YR 4/2) silty clay; very dark grayish brown (10YR 3/2) when moist; moderate, fine, prismatic and moderate, very fine, blocky structure; very hard when dry, very firm when moist; distinct, continuous clay films; noncalcareous; clear, smooth boundary.
- B22t—10 to 16 inches, dark grayish-brown (10YR 4/2) silty clay; very dark grayish brown (10YR 3/2.5) when moist; moderate, fine, blocky structure; very hard when dry, very firm when moist; distinct, continuous clay films; noncalcareous; clear, smooth boundary.
- B3ca—16 to 26 inches, grayish-brown (10YR 5/2) heavy silty clay loam; dark grayish brown (10YR 4/2) when moist; moderate, fine, subangular blocky structure; hard when dry, firm when moist; calcareous; contains lime concretions; clear, smooth boundary.
- Cca—26 to 60 inches, very pale brown (10YR 7/3) silt loam; brown (10YR 5/3) when moist; massive; slightly hard when dry, friable when moist; calcareous; contains concretions and threads of lime.

The A horizon ranges from 5 to 10 inches in thickness. The color of the B horizon ranges from dark grayish brown to brown. Depth to calcareous material ranges from 12 to 20 inches.

Sweetwater Series

In the Sweetwater series are poorly drained, calcareous clay loams formed in alluvium. Below the surface layer, the soil material is strongly mottled. These soils formed in calcareous, loamy alluvium under grass.

The Sweetwater soils are darker colored and more poorly drained than Las soils. They are darker colored, more clayey, and more poorly drained than the Las Animas soils.

Typical profile of Sweetwater clay loam under native grass (460 feet west and 70 feet north of the south quarter corner of sec. 14, T. 25 S., R. 31 W.):

A1—0 to 8 inches, gray (10YR 5/1) clay loam; very dark gray (10YR 3/1) when moist; moderate, medium, granular structure; hard when dry, firm when moist; calcareous; gradual boundary.

AC—8 to 15 inches, light clay loam with a mixture of colors ranging from gray (10YR 5/1) or very dark gray (10YR 3/1) when moist, to very dark gray (10YR 3/1) or black (10YR 2/1) when moist; many, fine, distinct mottles of strong brown; moderate, fine and medium, granular structure; hard when dry, firm when moist; few small pebbles; calcareous; gradual boundary.

IIC—15 to 36 inches, pale-brown (10YR 6/3) coarse sand streaked with strong brown; noncalcareous; saturated with water at a depth of 24 inches.

In most places the texture of the solum is between clay loam and loam, but thin layers of more sandy material are common. Depth to coarse sand and gravel is generally less than 24 inches. The water table fluctuates and is at a depth of 10 to 36 inches.

Tivoli Series

The Tivoli series consists of deep, noncalcareous fine sands that have a weakly developed profile. The only evidence of profile development is the slightly darkened A horizon. These soils formed in noncalcareous fine sand that was deposited by wind. The native vegetation was grass.

The Tivoli soils are more sandy than the Vona soils. They also lack the B horizon that is characteristic of the Vona soils.

Typical profile of Tivoli fine sand under native grass (1,160 feet east and 190 feet north of the center of sec. 12, T. 25 S., R. 33 W.):

- A1—0 to 4 inches, brown (10YR 5/3) fine sand; dark grayish brown (10YR 4/2) when moist; single grain; loose; noncalcareous; clear, smooth boundary.
- C—4 to 48 inches, light yellowish-brown (10YR 6/4) fine sand; brown (10YR 4.5/3) when moist; single grain; loose; noncalcareous.

The A horizon ranges from brown to pale brown in color and from 2 to 8 inches in thickness. The color of the subsoil ranges from brown to very pale brown.

Ulysses Series

The Ulysses series consists of dark grayish-brown silt loams that have granular structure throughout the profile. These soils are deep and well drained. They formed in pale-brown, calcareous, silty loess under grass.

The Ulysses soils are less clayey and have a less strongly defined B horizon than the Richfield soils. They are not darkened to so great a depth by organic matter, and they do not have so well-defined a B horizon as the Keith soils. They are darker colored, less calcareous, and show more profile development than the Colby soils.

Typical profile of Ulysses silt loam in a cultivated field (390 feet west and 400 feet south of the northeastern corner of sec. 3, T. 24 S., R. 32 W.):

- Ap—0 to 6 inches, dark grayish-brown (10YR 4.5/2) silt loam; very dark grayish brown (10YR 3/2) when moist; weak, granular structure; slightly hard when dry, friable when moist; noncalcareous; abrupt boundary (plow slice).
- B2—6 to 11 inches, dark grayish-brown (10YR 4/2) light silty clay loam; very dark grayish brown (10YR 3/2.5) when moist; moderate, fine, granular structure; hard when dry, friable when moist; worm casts; noncalcareous; clear, smooth boundary.

- B3—11 to 17 inches, grayish-brown (10YR 5/2) heavy silt loam; dark grayish brown (10YR 4/2) when moist; weak, granular structure; slightly hard when dry, friable when moist; numerous worm casts; calcareous; gradual, smooth boundary.
- B3ca—17 to 34 inches, light brownish-gray (10YR 6/2) silt loam; dark grayish brown (10YR 4/2) when moist; weak, granular structure; slightly hard when dry, friable when moist; calcareous; contains soft concretions and threads of lime; gradual, smooth boundary.
- Cca—34 to 60 inches, very pale brown (10YR 7/3) silt loam; brown (10YR 5/3) when moist; massive; slightly hard when dry, friable when moist; calcareous; contains small concretions and threads of lime.

The A horizon ranges in thickness from 4 to 8 inches. Where the Ulysses soils are associated with more sandy soils, the texture of the surface layer is loam, and that of the subsoil is loam or light clay loam. The degree of development of the B horizon ranges from negligible to the least that will qualify for a textural B horizon. The structure of the subsoil ranges from granular to subangular blocky. Depth to calcareous material ranges from 0 to 15 inches.

Vona Series

The Vona series consists of deep, noncalcareous soils that have an A horizon of grayish-brown loamy fine sand and a B horizon of grayish-brown fine sandy loam. These soils are well drained and formed in calcareous, wind-deposited, sandy material under grass.

These soils have a lighter colored, more sandy surface layer than the Manter soils. They are more sandy and less calcareous than the Otero soils. The Vona soils are less sandy than the Tivoli soils, and they have a distinct B horizon that is lacking in the Tivoli soils.

Typical profile of Vona loamy fine sand in a cultivated field (1,600 feet east and 180 feet south of the northwest corner of sec. 2, T. 26 S., R. 33 W.) :

- Ap—0 to 8 inches, grayish-brown (10YR 5/2) loamy fine sand; dark grayish brown (10YR 4/2) when moist; single grain; loose; noncalcareous; clear, smooth boundary.
- B2t—8 to 22 inches, grayish-brown (10YR 5/2) fine sandy loam; dark grayish brown (10YR 4/2) when moist; weak, granular structure; soft when dry, very friable when moist; porous; worm casts; noncalcareous; clear, smooth boundary.
- Cca—22 to 58 inches, pale-brown (10YR 6/3) light fine sandy loam; brown (10YR 5/3) when moist; massive; soft when dry, very friable when moist; porous; calcareous; contains soft concretions and threads of lime.

The A horizon of loamy fine sand ranges from 6 to 18 inches in thickness. The color of the solum ranges from grayish brown to brown. Depth to calcareous material ranges from 14 to 30 inches.

Climate ⁷

Because of its location in the southern part of the Great Plains, Finney County has a distinct continental type of climate. About half the time, the annual precipitation is similar to that in an area where the climate is semiarid. The rest of the time, it is similar to that in an area where the climate is dry subhumid (8).

To a great extent, the amount of rainfall depends on the supply of moisture from the Gulf of Mexico. The Rocky

Mountains to the west prevent an inflow of moist air from the Pacific Ocean. Most of the precipitation falls during the warm season. The summers are warm, and the winters are cold but not rigorous. The abundant sunshine and the constant movement of the wind are probably the two most noticeable characteristics of the climate. Marked and significant differences in daily temperature occur in the colder part of the year.

In addition to the fluctuations in daily, seasonal, and annual temperature and precipitation that occur within a short period in this county, there are longer climatic trends. At times, there are longer than average periods of low rainfall and high temperatures. Again, there may be longer than average periods of favorable temperature and precipitation.

Tables 10, 11, 12, and 13 give facts about temperatures and precipitation in the county. The information given was taken mainly from records of the U.S. Weather Bureau at Garden City and from records kept by voluntary observers since 1889. A few facts are from records of the U.S. Weather Bureau at Dodge City in Ford County.

TEMPERATURE.—Table 10 shows the average daily maximum and minimum temperatures for each month and for the year. It also gives probabilities that, 2 years in 10, specified temperatures will be received. The many sunny days and the pronounced radiation at night cause temperatures to vary widely in this county over a 24-hour period. The days are warm and the nights are cool. The average (mean) maximum temperature is about 29° higher than the average minimum for the year. The range between absolute monthly extremes, however, increases from 69° in July (the difference between the maximum extreme of 113° and the minimum extreme of 44°) to 120° in March (the difference between the maximum extreme of 98° and the minimum extreme of -22°). These extremes of temperature are shown in table 11.

Winter temperatures sometimes linger in this county, and occasionally spring temperatures arrive early. The highest temperature recorded for March, 98°, was on a date only 8 days later than the one on which the lowest temperature on record occurred. Another fact that emphasizes the wide range in temperature is that a temperature of 100° or higher has been recorded almost 2 weeks earlier in spring than the date of the last freezing temperature of 32° or lower. Similarly, the date of the first freeze in fall is 5 days earlier than the date on which a temperature of 100° or higher occurred. Figure 20 gives the dates of the means and extremes of temperature for this county.

The extremes of temperature that are experienced in a locality are of interest to many people. At Garden City, the highest temperature on record is 113°, which occurred on July 13, 1934. The coldest temperature on record is -32°, which occurred on February 12, 1899. The monthly extremes of temperature and precipitation and the date they occurred are shown in table 11.

In only 2 months has the average maximum temperature been above 100°. The first time was July 1901, when the average maximum temperature for the month was 101.5°, and the second time was July 1934, when the average maximum temperature for the month was 104.1°. The temperature rose to 100° or higher on 44 days during the summer of 1901; on 58 days during the summer of 1934; and on 39 days during the summer of 1936. In July 1934 the temperature rose to 100° or higher during two protracted

⁷ By A. D. ROBB, State climatologist, U.S. Weather Bureau, Topeka, Kans.

TABLE 10.—*Temperature and precipitation*

[From records kept at the U.S. Weather Bureau station at Garden City]

Month	Temperature				Precipitation				
	Average daily maximum ¹	Average daily minimum ¹	Two years in 10 will have at least 4 days with—		Average total ¹	One year in 10 will have—		Days with snow cover of 1 inch or more ³	Average depth of snow on days with snow cover ³
			Maximum temperature equal to or higher than ² —	Minimum temperature equal to or lower than ¹ —		Totals less than ¹ —	Totals more than ¹ —		
°F.	°F.	°F.	°F.	Inches	Inches	Inches	Number	Inches	
January.....	45.1	16.7	65	2	0.40	(⁴)	1.08	5	3.7
February.....	49.2	19.9	70	6	.75	0.07	1.46	5	3.8
March.....	57.9	27.6	79	15	1.06	.12	2.20	2	3.9
April.....	68.7	38.6	86	28	1.94	.40	4.52	(⁵)	2.6
May.....	77.6	49.3	94	38	2.64	.67	5.30	0	0
June.....	87.7	59.4	102	50	3.01	.94	5.57	0	0
July.....	93.3	64.4	104	58	2.61	.65	5.68	0	0
August.....	92.3	63.5	104	56	2.29	.66	4.23	0	0
September.....	84.3	54.5	98	40	1.75	.26	3.39	0	0
October.....	72.3	41.0	88	29	1.31	.08	2.90	(⁵)	1.0
November.....	57.8	27.0	75	17	.74	(⁴)	1.72	(⁵)	1.9
December.....	46.8	18.9	66	6	.58	.01	1.30	5	3.9
Year.....	69.4	40.1	⁶ 105	⁷ -10	19.08	12.81	27.21	18	2.9

¹ For period 1898-1962.

² For period 1922-1946.

³ For period 1899-1923.

⁴ Trace.

⁵ Less than 1 day.

⁶ Average annual highest temperature.

⁷ Average annual lowest temperature.

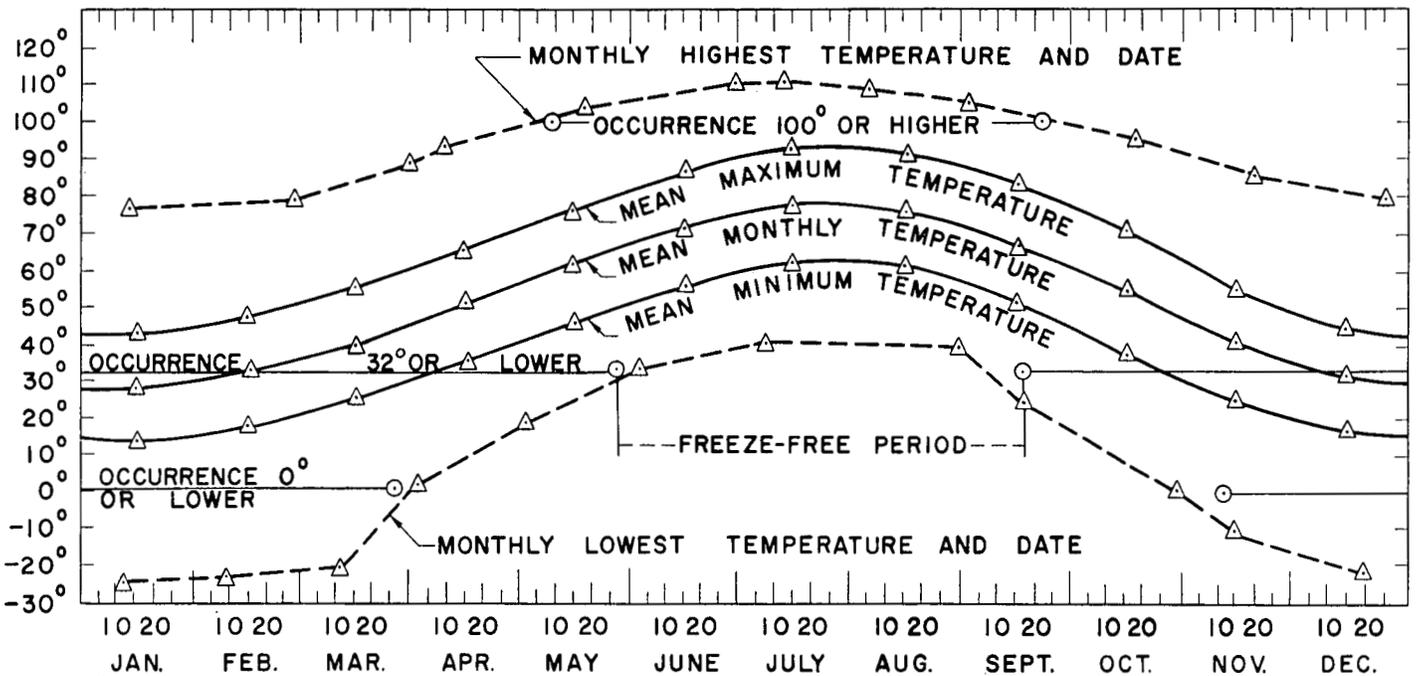


Figure 20.—Means and extremes in temperature, as recorded at the U.S. Weather Bureau station near Garden City.

TABLE 11.—*Monthly extremes of temperature and precipitation and date of occurrence*

[From records kept at Garden City from 1889 through 1962]

Month	Temperature				Precipitation			
	Maximum		Minimum		Least		Greatest	
	° F.	Day and year	° F.	Day and year	Inches	Year	Inches	Year
January	79	¹ 12/53	-23	12/12	0	¹ 1938	2. 18	1944
February	86	25/05	-32	12/99	0	¹ 1917	4. 45	1903
March	98	19/07	-22	11/48	(²)	¹ 1930	4. 95	1957
April	97	28/10	7	2/36	(²)	1935	6. 03	1944
May	106	26/53	22	1/09	0. 13	1927	8. 49	1923
June	110	¹ 24/53	36	¹ 13/47	(²)	1952	7. 89	1891
July	113	13/34	44	10/05	. 11	1946	8. 04	1950
August	112	20/02	40	30/15	. 15	1892	7. 68	1915
September	107	6/22	22	29/95	0	¹ 1956	5. 63	1923
October	97	17/26	8	29/17	0	1922	6. 09	1946
November	91	5/24	-6	22/29	0	¹ 1943	3. 93	1946
December	83	24/55	-17	28/94	0	1889	4. 60	1918
Year	113	7/13/34	-32	2/12/99	6. 54	1956	34. 81	1923

¹ Also in earlier years.

² Trace.

TABLE 12.—*Probabilities of last freezing temperatures in spring and first in fall*

[From records kept at Garden City from 1891 to 1958]

Probability	Dates for given probability and temperature				
	16° F. or lower	20° F. or lower	24° F. or lower	28° F. or lower	32° F. or lower
Spring:					
1 year in 10 later than	April 8	April 12	April 17	April 28	May 13
2 years in 10 later than	April 2	April 6	April 12	April 23	May 8
5 years in 10 later than	March 21	March 27	April 3	April 13	April 28
Fall:					
1 year in 10 earlier than	November 1	October 26	October 20	October 11	October 3
2 years in 10 earlier than	November 7	October 31	October 24	October 16	October 7
5 years in 10 earlier than	November 19	November 11	November 3	October 25	October 17

TABLE 13.—*Probabilities of receiving specified amounts of rainfall during stated time intervals at Garden City*

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	0. 9	1. 2	1. 3	1. 4	1. 6	1. 7	1. 9
2	1. 1	1. 5	1. 6	1. 8	1. 9	2. 2	2. 4
5	1. 6	2. 0	2. 2	2. 3	2. 7	3. 0	3. 3
10	1. 9	2. 4	2. 7	2. 8	3. 2	3. 5	4. 0
25	2. 2	2. 8	3. 2	3. 3	3. 8	4. 2	4. 3
50	2. 5	3. 2	3. 5	3. 8	4. 1	4. 4	5. 3
100	2. 7	3. 5	3. 9	4. 3	4. 8	5. 2	5. 9

¹ Expresses probability of receiving specified inches of rainfall at given time interval. For example, 0.9 inch of rain can be expected to fall in 30 minutes once in every year (100 percent probability), but 2.7 inches can be expected to fall in 30 minutes once in 100 years (1 percent probability).

periods of consecutive days. The first of these periods lasted 17 days, or from July 7 through July 23; and the second lasted 15 days, or from July 29 through August 12. During these two periods, no rain fell.

The summer of 1941 is the only one on record when the temperature did not rise to 100° or higher. In contrast, during five summers the temperature has reached 100° or higher on 1 or more days in each of the 6 months from May through September.

Temperatures during the cold season are less extreme in this county than those during the warm season. In no month has the average minimum temperature been below zero, but the average minimum was 10° or lower in six Januarys and four Februarys. In this county the lowest average minimum temperature for any month on record was 4.4° for February 1899. January 1912 had the greatest number of days when the temperature was zero or lower. It had a total of 13 such days, and January 1930 and February 1899 were next with 12 days each.

A total of 16 consecutive days when the temperature was zero or lower occurred between December 29, 1912 and January 13, 1913. From February 2 to February 13, 1913, there were 11 consecutive days on which temperatures of zero or lower were recorded. In each of the periods between January 14 and 22, 1930, and January 18 and 26, 1940, there were 9 consecutive days with minimum readings of zero or lower. On only 3 days has the temperature failed to rise above zero. These were January 6, 1912, when the temperature was -2° , and February 11, 1899, and January 7, 1912, when the temperature was zero.

Three periods of 4 months each—one period of November through February, and two of December through March—have had temperatures of zero or lower each month. In each of the 5 months from November 1947 through March 1948, there was a cold spell, when the temperature dropped to zero or below.

The scarcity of days with such extremes of temperatures indicates that more comfortable temperatures prevail in this county most of the time. Table 10 gives probabilities that either high or low temperatures of specified values will occur on at least 4 days in 2 years out of 10. It does not show the highest and lowest temperatures on record. For example, it does not show the extreme high of 113° that occurred on July 13, 1934. A more likely high temperature to be experienced in July is 104° , which may be expected on at least 4 days of the month about 2 years in 10. Again, a reading of -23° has been made in January (see table 11), and a reading of -32° has been made in February, but these extremes are not shown in table 10. Instead table 10 indicates that a low temperature of 2° is more likely on at least 4 days in January about 2 years in 10. A low temperature of 6° may be expected on at least 4 days in February, although February has a colder extreme.

Freezing temperatures.—Aside from the damage it does to some early or late vegetables, frost is, as a rule, not much of a hazard to the adapted crops grown in this county. Wheat is occasionally damaged in fall if it has not had an opportunity to harden before unseasonably low temperatures occur. Similarly, severe damage may be caused in spring by freezing temperatures after a warm period, or late-planted grain sorghum may fail to mature in fall if freezing temperatures arrive early.

Figure 21 indicates the probabilities that temperatures of 16° , 20° , 24° , 28° , or 32° will occur in spring at Garden City after the dates indicated or in fall before the dates indicated. Because of the location of Garden City in the valley of the Arkansas River, temperatures are likely to be lower in that area than in the higher areas to the north and south (3).

The probabilities that a damaging freeze will occur by the dates indicated in spring or fall are also given in table 12 by specified temperatures. Probabilities for intervening dates may be determined from figure 20.

PRECIPITATION.—The average annual precipitation in this county is 19.08 inches (see table 10), but the amount of precipitation varies greatly from year to year. A total of 34.81 inches was received in 1923, but only 6.54 inches was received in 1956. Fortunately, 75 percent of the year's total precipitation falls during the time when moisture is most needed by crops. Snow contributes about $2\frac{1}{2}$ inches to the year's total precipitation.

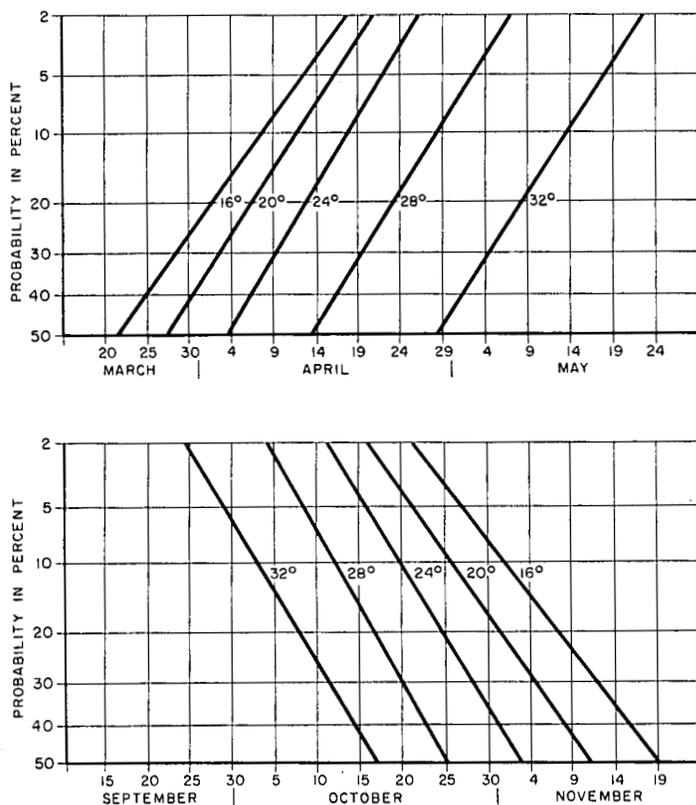


Figure 21.—Probabilities that temperatures of 16° , 20° , 24° , 28° , or 32° will occur in spring after the indicated dates or in fall before the indicated dates.

Although the amount of precipitation is generally lower than needed in this county, occasionally it is excessive. Problems less serious than that of the amount are the distribution, frequency, and intensity of rainfall. The balance between the amount of moisture gained through precipitation and the amount lost through evaporation is a deciding factor in the growth of crops. In this area the amount of moisture added by precipitation is overbalanced by the direct loss of moisture from the soil by evaporation from the surface and through transpiration from plants—that is, evapotranspiration.

Thorntwaite and Mather (10) have estimated that the average amount of precipitation needed annually in this area is about 30 inches, about 11 inches more than the present average annual precipitation. Near the valley of the Arkansas River, the extra water that is needed can be added by irrigating crops. In other parts of the county, the only ways of compensating to some extent for the lack of moisture are growing crops that resist drought and using farming practices that conserve moisture.

Farmers or others concerned with agriculture are interested primarily in the amount of rainfall received in summer. By studying figure 22, they can gain an idea of the amount of rainfall received annually, as well as the amount received during the growing season of April to September. The information in figure 22 is based on records kept at Garden City from 1898 to 1962. It also shows the periods when precipitation was near average or above average and the periods when precipitation was below average. Rainfall was favorable during the period

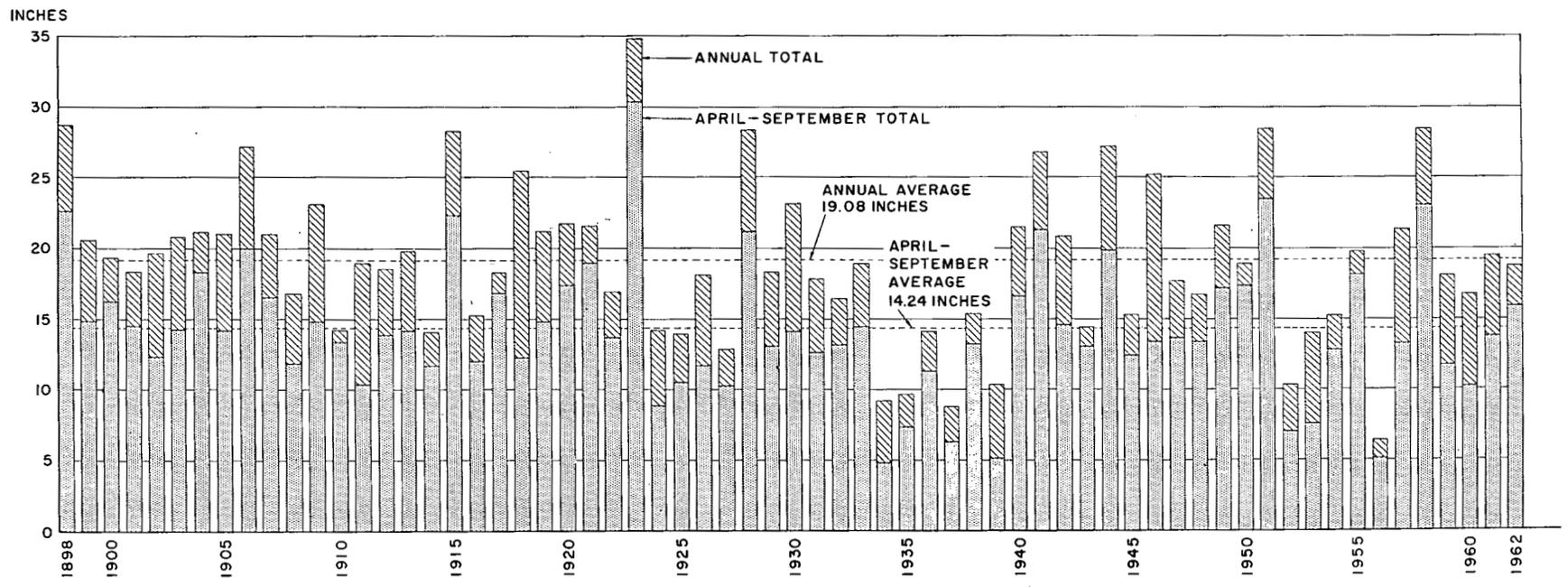


Figure 22.—Annual and April to September precipitation at Garden City from 1898 to 1962.

from 1898 through 1923, and this no doubt attracted many people to this area. The greater number of dry years from 1924 through 1939, and again from 1952 through 1961, revealed the need for irrigation, which was readily available in part of the county.

Figure 23 shows the probabilities of receiving specified amounts of precipitation during the period between April and September. It shows that in half the summers approximately 10 to 14 $\frac{1}{4}$ inches of rainfall is received. In about one summer in four, there is less than 9 inches, and in about one summer in four there is more than 14 $\frac{1}{4}$ inches. The benefit that crops derive from rainfall in the period April to September depends on the frequency of the rainfall, as well as on the amount and timeliness of each rain, all of which are variable.

The average amount of monthly precipitation increases from 0.40 inch in January to 3.01 inches in June. After June, the average amount of monthly precipitation decreases. Figure 24 shows the probabilities, in percent, of receiving at least the specified amount of precipitation in a 7-day period (4). It shows in slightly more detail than figure 22 the probability of receiving a specified amount of precipitation. Figure 23, for example, shows a marked increase in the amount of precipitation received from February through April; then an even more rapid decline in precipitation from the first week in August through September. It also shows that during the latter part of June and extending through much of July, the probability of receiving a weekly total of less than 2 inches decreases sharply.

The rapid decline in the probability of receiving an adequate supply of rainfall during the latter part of June, through most of July, and during the early part of August is a definite limitation on the production of crops. That is the season when the weather is the hottest and when crops require the most moisture.

The information given in figure 23 is not accurate enough for use in selecting a particular date or time for a special farming operation. It can be used, however, to show seasonal patterns of rainfall.

The intensity, or rate of fall, of rains is a governing factor in planning engineering projects, such as culverts, the capacity of dams, and the capacity and type of water-

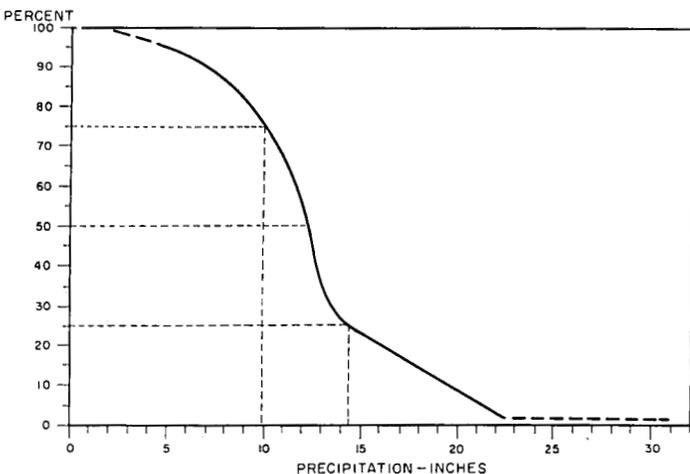


Figure 23.—Probabilities of receiving specified amounts of precipitation at Garden City from April to September.

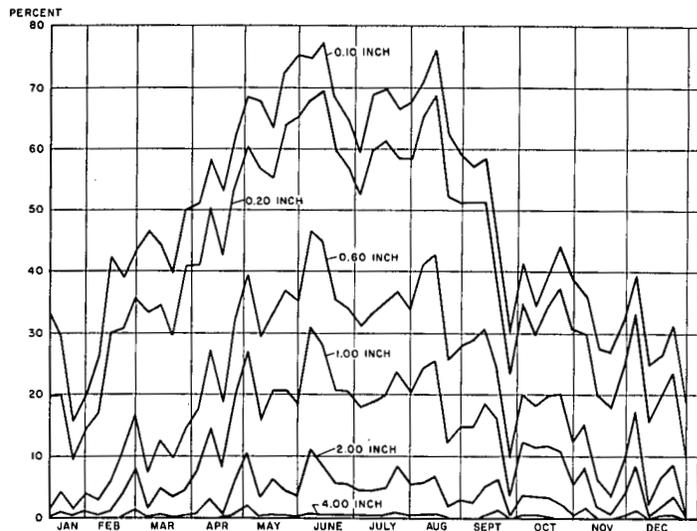


Figure 24.—Probabilities of receiving at least the indicated amount of precipitation weekly.

ways. Heavy downpours usually come in summer. For Garden City, table 13 shows the frequency of rainfalls of the specified duration for return periods of 1 year, 2 years, 5 years, 10 years, 25 years, 50 years, and 100 years. A 30-minute rain of 0.9 inch or more, for example, will occur practically every year, but a 30-minute deluge of 2.7 inches will occur only once in a century (13). Again, a total of 1.9 inches of rainfall is received during a 24-hour period once every year. In contrast, a total of 5.3 inches or more is received during a 24-hour period only once in 50 years, and a total of 5.9 inches is received during a 24-hour period only once in a hundred years.

Wet and dry years differ, not only in the amount of rainfall received but also in the distribution of rainfall. In 1915, 1923, and 1951, for example, the total amount of rainfall was 2 inches or more for each month from April through September. Also, in 1923, the wettest year of record at Garden City, October with 3.29 inches of rainfall was the seventh consecutive month in which 2 inches or more of rainfall was recorded. In contrast, during the years of 1893 and 1934, not a single month had as much as 2 inches of rainfall. In 1923, the wettest year on record at Garden City, more than five times as much rain fell as in 1956, the driest year on record.

The periods of high and of low precipitation in summer are fairly obvious. From 1898 through 1910, the amount of precipitation received in summer was approximately normal. From 1924 through 1939, most of the summers had below normal rainfall. Then, in 1940, there was a trend toward more abundant rainfall, when rainfall was more favorable for 12 consecutive summers. These 12 years were followed by 10 more years of favorable and of less favorable rainfall. During the years of 1952 through 1962, rainfall was below average in most summers.

Figure 22 shows that in about one summer in eight, 20 inches or more of rainfall is received, and that in about one summer in eight, less than 10 inches of rainfall is received. Summers when rainfall is favorable have been fairly evenly scattered throughout the 65 years during which records were kept, but the dry summers tend to occur in groups.

Snowfall is a most unreliable weather factor in this area. It cannot be counted on to supply moisture. Yet, there may be enough snow to be hazardous to livestock and to traffic on the highways. The average amount of snowfall received each year is about 19 inches. Less than 10 inches has been received in 14 out of 60 years, however, and 30 inches or more has been received in 8 out of 60 years.

The beneficial effects of snow are determined largely by the extent of the accompanying winds. Much of the time, high winds blow the snow from the fields. As a result, the moisture is lost that would have been obtained from the melted snow, and the snow blocks highways or is a hazard to livestock. The rare occasions when several inches of snow falls at a time when there is no wind and the temperature is a few degrees below freezing are a boon to wheat.

The least amount of snow received during an entire winter was 2.5 inches in 1895-96. The most was 51.7 inches in 1902-03. The greatest amount for any 1 month, 34 inches, fell in February 1903.

On the average the first day in winter with 1 inch of snowfall is December 2. January and February each have an average of 5 days with a snow depth of 1 inch or more (14). From December through March, the average depth of snow on the days when there is snow cover is about 3.8 inches.

STORMS.—Occasionally, violent hailstorms, severe windstorms, tornadoes, duststorms, and blizzards occur in this county. Most of these are of relatively short duration. The duststorms and blizzards may last for 24 hours or more, but their effects last longer. Railroads and highways have been left impassable by drifted snow. Each strong wind raises some dust. The major duststorms, however, occur after long periods of deficient rainfall when there is little or no cover of vegetation. They are likely to be more long lasting in their effect.

Tornadoes occur about once a year in this county. Any one point in the county is likely to be subjected to hailstorms and windstorms about four times each year. Such storms are generally local, and the resulting damage is spotty and variable. May and June are the most likely months for the occurrence of hail. Thunderstorm squalls and shifts in wind direction produce the highest wind gusts. These gusts reach 75 to 80 miles per hour.

Additional Facts About the County

In this section the physiography, relief, and drainage of the county are discussed. Facts are also given about the early history, the agriculture, and the social and industrial development of the area, and information is given about the Garden City Branch Experiment Station. Unless otherwise indicated, the statistics used are from records of the U.S. Bureau of the Census.

Physiography, Relief, and Drainage

Most of Finney County is in the High Plains section of the Great Plains physiographic province (7). The northeastern, or panhandle, part of the county is in the Plains Border section. The highest altitude, about 3,090 feet, is in the northwestern corner of the county. The lowest al-

titude, about 2,450 feet, is at the point where the Pawnee River leaves the county. Locally, differences in relief do not exceed 300 feet.

Within the county are five well-defined physiographic areas. These are the High Plains tableland, the Pawnee River drainage area, the Scott-Finney depression, the valley of the Arkansas River, and the sandhills.

The High Plains tableland occurs predominantly in the northwestern and north-central parts of the county, north of the valley of the Arkansas River. It is divided by the Scott-Finney depression and is bordered on the east by the area drained by the Pawnee River. The topography of this area is nearly level to gently rolling. The land slopes gently toward the east with a drop of about 7½ feet to the mile.

The tableland consists of windblown deposits classified as Peorian loess, which is of early Wisconsinian age (5). The loess is approximately 10 to 30 feet thick over calcareous silt, sand, and gravel of the Ogallala formation of Tertiary age. The material that makes up the Ogallala formation was deposited by widely shifting streams that originated in the Rocky Mountains.

A common feature of the High Plains tableland is the shallow, undrained basins that hold water after rains. These form temporary lakes. Short tributaries lead into some of the depressions; otherwise, the area has no defined drainage pattern.

The Pawnee River drainage area occupies most of the panhandle of Finney County. The surface of this area was at one time continuous with that of the High Plains tableland. Recent dissection has produced rolling topography and local differences in relief of more than 250 feet. Erosion has exposed deposits of Tertiary age (Ogallala formation). It has also exposed deposits of limestone (Niobrara formation) and shale (Carlile) of Cretaceous age.

The exposed Tertiary and Cretaceous sediments form bluffs and breaks along the valley of the Pawnee River and its tributaries. Silty loess caps the divides between the drainageways. Sandy windblown material of local origin causes the topography to be undulating in a few areas.

The valley of the Pawnee River proper ranges in width from about a quarter of a mile to a mile. Many short, narrow tributary valleys branch out from the main valley.

The Scott-Finney depression is a broad, shallow basin. It extends from the valley of the Arkansas River, at a point just east of Garden City, northward into Scott County. The east side of the depression is abrupt in most places. It is marked by a conspicuous escarpment, 50 feet or more in height. There is no sharp limit to the depression on the west. Its sides slope gradually upward to merge with the surface of the High Plains tableland. Short streams that flow southeastward from Kearny County into this county gradually disappear on the western slope of the depression.

The Scott-Finney depression resulted from folding of strata during the early part of the Tertiary period. The basin was buried beneath sediments of the Ogallala formation but was subject to renewed downwarping during late Pliocene or early Pleistocene time. At the same time, the lowland area south of the Arkansas River was produced by subsidence. During Pleistocene time, the two

areas were filled by sediments laid down by water. This period was probably followed by a period when renewed downwarping took place.

The valley of the Arkansas River includes the present flood plains and the terraces that border the flood plains. The Arkansas River originates in the Rocky Mountains of central Colorado and flows eastward through the eastern part of Colorado and the western part of Kansas. It enters Finney County about 16 miles north of the southwestern corner, flows east-southeastward through the county, and leaves the county about 9 miles north of the southeastern corner. The average drop of the riverbed is about 7 feet to the mile.

Thick deposits of terrace gravel of Pleistocene age lie beneath the sandhills south of the present valley of the Arkansas River. These indicate that the course of the ancestral river during late Pleistocene time was far to the south of the present course of the Arkansas River. At one time the river probably flowed within a few miles of the southern edge of the sandhills. As a result of subsidence, it migrated northward until it reached its present position.

The north side of the valley is marked by a pronounced bluff. Sand and gravel of the Ogallala formation are exposed along the wall of the valley, several miles east of Garden City.

Most of the sandhills are in a broad band along the south side of the valley of the Arkansas River. In the southwestern part of Finney County, this band extends down into Haskell County, but it is only about 3 miles wide along the southeastern edge of the county. The sandhills cover a lowland that is about halfway between the level of the river valley on the north and the plains on the south. The area is characterized by typical sand dune topography. Some of the hills are as high as 50 feet or more. There is no established drainage system in this area.

Early History of the County

Bat Masterson's in town! And for a good reason. The voters are well armed. An election is being held to decide whether Ravanna or Eminence will be the county seat of Garfield County.

That was the setting in Ravanna on November 8, 1887. Supporters of Eminence hired Bat Masterson to come over from Dodge to keep the peace. All the trouble began when a committee was appointed to select a county seat for Garfield County, now the northeastern part, or panhandle, of Finney County. Instead of choosing Ravanna, a town of more than seven hundred, the committee laid out the new town of Eminence. The election was held to settle the dispute.

Ravanna won by a vote of 467 to 432. The town prospered and grew. In 1889, a \$10,000 courthouse and a two-story schoolhouse of native limestone were built (fig. 25). The city once had two parks.

But the Eminence supporters wouldn't give up. They declared that 46 Ravanna votes were illegal, and the Supreme Court upheld them. The Eminence people had another fight on their hands to get possession of the records. One evening, just after dark, they sneaked the records out of the courthouse, threw them in their wagon, and lit out for Eminence. The Ravannans took off in hot pursuit but lost them in the dark.



Figure 25.—All that remains of the courthouse at Ravanna.

The people of Ravanna were not through. They had the county resurveyed and found it contained but 430½ square miles, 1½ square miles less than the 432 necessary to qualify for a county. That was the end of Garfield County, for in 1893 its territory was annexed to Finney County. It was also the end of Eminence and Ravanna. Soon these were ghost towns.

The organization of the rest of Finney County was less stormy. Although the county was organized in 1884, its present boundaries were not established until several years later. In 1885 Finney County was described as the largest county in Kansas with a total area of 2,808 square miles, or 1,797,120 acres. It was also described as being in the southwestern part of the State, "one county north of Indian territory and one east of Colorado, and divided by the Arkansas River into two nearly equal parts." During each session of the Kansas legislature in the 1870's and 1880's, counties throughout the State were dissolved, renamed, and boundaries revised. Today the county contains 833,280 acres.

When Finney County was organized in 1884, its population was 15,000. The population had dropped to 3,172 by 1902, but by 1930 it was almost 11,000. In 1961 it was 16,412.

Agriculture

The raising of livestock was the first major agricultural enterprise in Finney County. The firm of Barton Brothers introduced the cattle industry into the area in 1872. In February of that year the Barton Brothers left Texas with 3,000 head of longhorns and headed for the Arkansas River in Western Kansas. They established the headquarters of their ranch in dugouts in the bank of the Arkansas River at Pierceville. Their cattle ranged over the prairie without the restriction of a single fence.

Cattlemen had the area to themselves until 1878, but the land was open for homesteading, and moisture was plentiful that spring. Lured by the cheap, fertile land, the settlers came. By the spring of 1885, settlers were coming in so fast that the range was broken up. Managing large herds was no longer possible. The terrible blizzard

of 1886 was the last blow to the free-range cattle industry. Thousands of cattle died in the blinding snowstorm.

Among the families who settled in the area were the Goodmans, who came from Illinois by covered wagon in 1885. John Goodman and his pioneer father broke the sod on their claim with a bull ox and a buffalo cow hitched to a walking plow. During the boom years, the overwhelming number of settlers completely routed the open-range cattlemen. But in 1888 the hot winds began to blow. Crops were a complete failure and people began leaving. When asked why he didn't migrate with the others when times got tough, Mr. Goodman replied, "I did get packed to leave one time, but didn't have enough axle grease to grease the wagon, so I had to stay."

Soon all that remained at the site of many homesteads were slight depressions or piles of sod that marked the spots where dugouts and shanties had stood. The people who stayed could buy land by paying the taxes on it. They began to buy larger tracts and turned to raising livestock. This new crop of cattlemen soon had control of large holdings of land.

About 222,206 acres was in grass in this county in 1959. The large area of sandhills south of the Arkansas River is now used exclusively for grazing. Some of the wet bottom lands along the Arkansas River provide wintering areas and meadow to supplement the vast ranges in the sandhills.

The most rolling land in the eastern, or panhandle, part of the county is still in native grass, and a large number of cattle graze there each summer. In winter the cattle are moved to areas where they can graze wheat and sorghum stubble. Some farmers also grow alfalfa on the bottom lands of the Pawnee River, and use the alfalfa for winter feed.

Each winter large numbers of cattle and sheep are brought into the county to graze on the dryland and irrigated wheat. A large feedyard, just north of Garden City, has facilities for as many as 11,000 head of cattle. Hundreds of other cattle are finished out at smaller feedyards. All types of grain and feed are available from the immediate area. Irrigation insures an abundant supply of grain sorghum, forage sorghum, alfalfa, and corn for ensilage.

The few acres that a pioneer could cultivate no more than met the needs of his family and provided winter feed for his livestock. In 1893 only about 48,000 acres of field crops was harvested in this county. Field crops were never harvested on more than 65,000 acres until 1903, when the figure jumped to about 140,000 acres. An increasingly large acreage of sod was plowed, as wheat became more important as a cash crop and tractor power became available. In 1959 a total of 329,829 acres of crops was harvested in the county. Table 14 lists the acreage used for various crops in stated years.

Wheat and grain sorghum are the major dryland crops grown in the county. Wheat is usually grown on land that has been fallowed. During the fallow period, the land is kept free of weeds and volunteer wheat so that moisture will be stored for the crop that follows. The fallow period is usually one growing season, but it is sometimes stretched to two seasons if the supply of moisture is low. Since acreage controls have been established for wheat, the production of grain sorghum has increased

considerably. Only a minor acreage is used for small grains other than wheat.

TABLE 14.—Acreages of the principal crops in stated years¹

Crop	1921	1930	1940	1950	1959
Wheat.....	46,646	157,398	148,000	241,000	189,000
Sorghum:					
Grain.....	8,262	14,541	69,140	64,130	122,000
Forage.....	13,098	8,296	29,980	17,330	2,000
Barley.....	14,333	21,469	28,050	15,800	9,900
Alfalfa.....	7,673	12,769	6,660	8,670	9,800
Sugar beets.....	4,235	3,933	5,928	4,770	3,140
Corn.....	8,944	30,157	1,100	400	2,000
Rye.....	2,335	201	50	770	2,300
Oats.....	3,527	1,491	1,240	500	100

¹ Based on reports of the Kansas State Board of Agriculture.

The first irrigation ditch constructed in the western part of Kansas, the Garden City Ditch, was built in 1880. It extends from Lakin to a point near Garden City. The location for the ditch was surveyed by using a plow and a yoke of oxen. Then a group of farmers began to plow a furrow north and east from a point in the sand beside the Arkansas River near Lakin. When they had finished, they had a ditch that ran from Lakin to 2 miles north of Garden City.

Now about 100,000 acres is irrigated in this county. Most of the present water supply is from deep wells. Wheat and grain sorghum are the major crops grown under irrigation, but sugar beets, alfalfa, corn, and forage sorghum are grown on a smaller acreage. Some vegetable crops, such as onions, beans, and potatoes, are also grown.

Livestock has always been a major source of income for the farmers of this county. Table 15 lists the numbers and kinds of livestock in stated years.

TABLE 15.—Numbers of livestock on farms and ranches in stated years¹

	1921	1930	1940	1950	1959
Horses and mules..	8,769	6,842	2,000	970	430
Milk cows.....	2,701	3,164	3,290	1,840	1,000
Other cattle.....	27,919	19,835	8,160	26,360	38,000
Sheep.....	568	1,088	6,650	36,010	42,100
Swine.....	3,005	5,330	4,000	4,350	3,600
Chickens.....	(²)	60,892	63,010	64,700	19,000

¹ Based on reports of the Kansas State Board of Agriculture.

² Figures not available.

The trend is toward larger farms in this county. In 1930 there were 971 farms in the county and the average size of farms was 668 acres. By 1959 the number of farms had dropped to 682, but the average size of farms had increased to 1,138 acres, almost double that in 1930. Of the farms in the county in 1959, 63 contained less than 100 acres, 208 contained from 100 to 500 acres, 164 contained from 500 to 1,000 acres, and 247 contained more than 1,000 acres.

In 1959 there were 420 cash-grain farms in the county, 15 farms where other field crops were the main source of

farm income, 10 dairy farms, 127 livestock farms other than dairy and poultry, 14 livestock ranches, and 18 general farms. The rest were miscellaneous and unclassified.

The irrigated acreage in this county has almost doubled since 1954, when there were 293 farms with 54,778 acres under irrigation. A total of 100,749 acres, on 324 farms, was irrigated in 1959.

In 1959, 436 farm operators resided on the farm they owned. Another 205 persons operated farms but did not reside on the farm.

Tillage and harvesting are performed with mechanically powered equipment. Large, standard wheel-type tractors are generally used on dryland farms, and general-purpose tractors are used on irrigated farms. Wheat and grain sorghum are harvested with large, self-propelled combines. Most farmers own enough equipment for tillage and planting, but many hire part or all of their grain combined. Custom operators from outside the area commonly furnish much of the labor and the equipment needed for the harvest.

The demand for farm labor is seasonal. The local labor supply is generally adequate for planting and tilling, but transient labor is needed for harvesting. Each spring, a large number of transient workers are employed to thin the stand of sugar beets in the fields.

Garden City Branch Experiment Station ⁸

For more than 50 years, the Garden City Experiment Station, a branch of Kansas State University, has served the people of Kansas. It was established near Garden City in June 1907. This station has helped fill the need for obtaining more information about dryland and irrigation farming. In December 1911, the Garden City Industrial Club raised \$6,200 to begin irrigation at the experiment station.

In 1912 the Finney County commissioners obtained a 99-year lease on 320 acres of land for use for experimental purposes. This land was about 5 miles northeast of Garden City. The lease was signed on June 21, 1912, and was then presented to the State Board of Regents. It covers the period from June 14, 1907, to June 14, 2006. The land leased was the east half of section 3, T. 24 S., R. 32 W.

In July 1937 another 99¼ acres was purchased from George Gano for \$2,000. This tract was in the west half of section 3. Two years later, in April 1939, still another tract was purchased, this time from Pete Meekma for \$2,992. That tract consisted of 136 acres in the northeast quarter of section 10. An additional 80-acre tract, in the south half of SW¼ (26-23-34), 2 miles north and 1½ miles west of Holcomb, was provided by the Garden City Company for experimental work, starting in 1948.

In 1908 the following report was written by H. R. Reed, who was superintendent of the station at that time: "The lay of the land comprising the station is variable, ranging from that located in the shallow-water area, which is adapted especially to crops having deep root systems, to the upland, which is representative of the larger area of the surrounding country.

"The equipment with which the station is provided is limited. One building furnishes shelter for the tools and

a lodging place for the man in charge. The implements on hand consist of a plow, a disk-harrow, a smoothing harrow, a grain drill, a hand corn planter, a one-horse cultivator, a subsoiler, and a light farm wagon. There are two horses. No scales are available with which to determine yields.

"For proper development of the station," Superintendent Reed added, "a set of buildings consisting of a house, a barn (including a seedroom), an implement shed, and a windmill should be provided, and a binder, a gasoline engine, a small-size thresher, a lister, a corn planter, and some wagon scales are needed."

A conservative estimate of the investment that was made in equipment at that time would exceed \$100,000. Replacing, at current prices, all the land, buildings, livestock, and equipment now being used, however, would require more than \$1 million.

The early scientists understood many of the problems that still confront farmers in the county. Among the work they planned were (1) experiments to study the results when crops are grown year after year if current methods are used and new methods devised; (2) experiments to study the results of alternate cropping and summer fallow or other crops; and (3) experiments to learn methods of conserving moisture and preventing blowing. Superintendent Reed reported that the depth of rooting of the various crops should be determined, as well as the extent to which plants exhaust the supply of moisture in the soils, and the amount of water needed by plants to produce a given weight of dry matter.

Although many of the questions of those days still remain unanswered, progress has been made. New varieties have been developed, and better machinery has been invented. There is now a more complete understanding of the relationship between moisture, soils, and crops, and great advances have been made in the use of chemicals for diseases and for insect control. Improved fertilizers are now available, and hormones and antibiotics are now being used. The Garden City Experiment Station has helped to make this progress possible. The persons who have taken part in this work can be proud of their results.

In 1914 fewer than 50 plots were planted to winter wheat, and only three varieties of wheat were grown. In contrast, as many as 2,000 plots have been used for studying wheat in recent years. As the result of numerous studies of the rates of seeding and of the proper seeding dates, valuable information has been obtained. In the early days of the station, wheat was generally seeded at the rate of 1 bushel per acre. Today the maximum yields on dryland are produced when only one-half bushel or less is seeded. Yields of sorghum are generally best when not more than 2 pounds per acre are planted. The most desirable seeding dates, for both wheat and sorghum, are later than those used in the early days.

The early settlers in the western part of Kansas realized that a home, whether in town or on the farm, should be attractive. They knew that trees, grass, shrubs, and gardens help to make the farmstead attractive. Therefore, since the early days of the station, plants for beautifying the farmstead have received attention. No elaborate horticultural tests have been conducted, but hundreds of species of ornamentals have been grown for observation.

Eight different projects are now carried on at the experiment station, each under the supervision of a trained

⁸ By ANDREW B. ERHART, superintendent, Garden City Branch, Kansas Agricultural Experiment Station.

technician. Some projects deal with the management of dairy cattle and the feeding of lambs. Others consist of testing crops grown under dryland and irrigated farming. Experiments have been made with varieties of 30 different crops. They include studies of ways to prepare the seedbed, the best dates and rates of seeding, methods of irrigation, control of insects and diseases, rotation of crops, various phases of fertilizer application, and the relationship of the soils, moisture, and crops.

Social and Industrial Development

Garden City has educational facilities ranging from kindergarten through junior college. In the school year that began in September 1960, the six elementary schools in the city had a total enrollment of about 2,270. Another 855 students were enrolled in elementary schools in Holcomb, Friend, Kalvesta, Pierceville, and five rural schools in the county. Besides the junior high school and other high schools in Garden City, Holcomb and Pierceville both have high schools that offer a 4-year course of study.

Twenty-eight churches are located in Garden City, and there are churches in Pierceville, Holcomb, and Kalvesta. In addition, a rural church is south of Garden City and another, between Garden City and Kalvesta, serve the people in the county.

Garden City has two public parks. Finnup Park has facilities for picnicking, a large zoo, a swimming pool, and ball diamonds. Stevens Park, located near the center of the town, has a band shell, where the city band holds concerts on summer evenings.

A civic center, which provides recreation for persons of all ages is located in Garden City. The activities at the center range from little-league baseball to recreation for older persons. A public library is located near the center of the town.

Markets and transportation.—Facilities for marketing and storing grain are located at several points in the county. Garden City is the principal marketing and storage point, but there are also elevators at Pierceville, Kalvesta, and Friend. In addition, two elevators are along the Santa Fe Railroad between Garden City and Friend, and two are along the Garden City Western Railroad, north and west of Garden City.

Dehydrating plants provide a local market for alfalfa. Some alfalfa, is also marketed at the local feed yards, along with other forage crops and grain. Sugar beets are shipped by railway to a processing plant in the eastern part of Colorado. A livestock auction, held weekly in Garden City, provides a market for livestock raised in the county.

U.S. Highway No. 50 crosses the county from east to west and passes through Pierceville, Garden City, and Holcomb. U.S. Highway No. 156 extends east from Garden City through Kalvesta, and U.S. Highway No. 83 crosses the county from north to south and passes through Garden City. Kansas State Highway No. 23 crosses the panhandle of the county from north to south. Garden City is served by buslines that follow U.S. Highway No. 50.

The Santa Fe Railroad crosses the county from east to west, roughly paralleling U.S. Highway No. 50. A branch line extends north from Garden City to Scott City. The

branch line provides railway facilities to two country elevators and to the elevator at Friend. The Garden City Western Railroad is completely within Finney County. Its 14 miles of track extend north and west from Garden City and end at the Kearny County line. The Garden City Western Railroad serves two elevators, a plant where alfalfa is processed, and loading stations for sugar beets.

Regularly scheduled air service is available from the airport about 10 miles east of Garden City. This airport is along U.S. Highway No. 50.

Industries.—About two-thirds of the industries in the county are engaged in processing agricultural products, in producing materials needed by agriculture, or in supplying services to agriculture. The rest supply goods and services used by nonagricultural as well as agricultural workers. About 54 percent of the industries employ fewer than 15 persons each, 57 percent employ between 15 and 50 persons, and about 10 percent employ more than 50 persons.

The largest industry in the county is concerned with the collection and transportation of natural gas and oil. Natural gas and oil are the principal nonagricultural resources in the county. There are more than 1,200 gas wells and about 160 producing oil wells in the county.

Other industries consist of quarrying for sand and gravel, which are taken from pits along the Arkansas River. The sand and gravel are used mainly for the surfacing of roads.

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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*.)
- Caliche.** A more or less cemented deposit of calcium carbonate in many soils of warm-temperate areas, as in the Southwestern States. The material may consist of soft, thin layers in the soil or of hard, thick beds just beneath the solum, or it may be exposed at the surface by erosion.
- 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 particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt. (See also *Texture, soil*.)
- Clay film.** A thin coating of clay on the surface of a soil aggregate. Synonyms: Clay coat, clay skin.
- Clay loam.** Soil textural class that contains 27 to 40 percent clay and 20 to 45 percent sand. (See also *Texture, soil*.)
- Colluvium.** Soil material, rock fragments, or both, moved by creep, slide, or local wash and deposited at the base of steep slopes.
- 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 to pull free from other material.
- Hard.*—When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Consistence, soil—Continued

- Soft.*—When dry, breaks into powder or individual grains under very slight pressure.
- Deep soil.** Generally, a soil deeper than 40 inches to rock or other strongly contrasting material. Also, a soil that has a thick, black surface layer; or a soil in which the total depth of unconsolidated material, whether true soil or not, is about 40 inches or more.
- Eolian soil material.** Soil parent material accumulated through wind action; commonly refers to sandy material in dunes.
- Erosion, accelerated.** Erosion of soil resulting from disturbance of the natural landscape, usually by man.
- Horizon, soil.** A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes.
- Loam.** A textural class name for soils that contain a moderate amount of sand, silt, and clay. Loam contains 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. (See also, *Texture, soil*.)
- Loess.** Geologic deposit of relatively uniform, fine material, mostly silt, usually transported by wind.
- Moisture capacity.** The capacity of a soil to hold water in a form available to plants. Amount of moisture held in a soil between field capacity, or about one-third atmosphere of tension, and the wilting coefficient, or about 15 atmospheres of tension. Also called available moisture capacity and available water capacity.
- 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*.
- Plowpan.** A compacted layer formed in the soil immediately below the plowed layer.
- 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 degree of acidity or alkalinity are expressed thus:
- | <i>pH</i> | | <i>pH</i> | |
|------------------------|------------|-----------------------|------------|
| Extremely acid..... | Below 4.5 | Mildly alkaline..... | 7.4 to 7.8 |
| Very strongly acid.... | 4.5 to 5.0 | Moderately alkaline.. | 7.9 to 8.4 |
| Strongly acid..... | 5.1 to 5.5 | Strongly alkaline.... | 8.5 to 9.0 |
| Medium acid..... | 5.6 to 6.0 | Very strongly alkala- | |
| Slightly acid..... | 6.1 to 6.5 | line..... | 9.1 and |
| Neutral..... | 6.6 to 7.3 | | higher |
- Saline-alkali soil.** A soil having a combination of a harmful quantity of salts and either a high degree of alkalinity or a high amount of exchangeable sodium, or both, so distributed in the soil profile that the growth of most crop plants is less than normal.
- Saline soil.** A soil that contains soluble salts in amounts large enough to impair the growth of plants but that does not contain excess exchangeable sodium.
- Sand.** Individual rock or mineral fragments in soils 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*.)
- Sandy clay.** Soils of this textural class contain 35 percent or more clay and 45 percent or more sand. (See also, *Texture, soil*.)
- Sandy clay loam.** Generally, soil material having 20 to 35 percent clay, less than 28 percent silt, and 45 percent or more sand. (See also, *Texture, soil*.)
- Sandy loam.** As used in this report, a soil that contains 50 percent sand and less than 20 percent clay. Also used as a general term for a small group of textural classes of soils, including sandy loam and fine sandy loam. (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*.)

Silt loam. Soil material having 50 percent or more silt and 12 to 27 percent clay, or 50 to 80 percent silt and less than 12 percent clay. (See also, Texture, soil.)

Silty clay. Soil material having 40 percent or more clay and 40 percent or more silt. (See also, Texture, soil.)

Silty clay loam. Soil of this textural class contains 27 to 40 percent clay and less than 20 percent sand. (See also, Texture, soil.)

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.

Structure, soil. The arrangement of primary soil particles into compound particles or clusters that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil particles. The principal forms of soil structure are—*platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular*. Structureless soils are (1) *single grain* (each grain by itself, as in dune sand) or (2) *massive* (the particles adhering together without any regular cleavage, as in many claypans and hardpans).

Substratum. Any layer lying beneath the solum, or true soil; the C or D horizon.

Surface soil. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, about 5 to 8 inches in thickness. Also called *surface layer*.

Terrace. An old alluvial plain, ordinarily flat or undulating, bordering a river, lake, or the sea. Stream terraces are frequently called second bottoms, as contrasted to flood plains, and are seldom subject to overflow. Marine terraces were deposited by the sea and are generally wide.

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."

Tilth, soil. The condition of the soil in relation to the growth of plants, especially soil structure. Good tilth refers to the friable state and is associated with high noncapillary porosity and stable, granular structure. A soil in poor tilth is nonfriable, hard, nonaggregated, and difficult to till.

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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