

# SOIL SURVEY

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## **Bent County Colorado**

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Issued January 1971

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

Major fieldwork for this soil survey was done in the period 1961-62. Soil names and descriptions were approved in 1965. Unless otherwise indicated, statements in the publication refer to conditions in the county in 1962. This survey was made cooperatively by the Soil Conservation Service and the Colorado Agricultural Experiment Station. It is part of the technical assistance furnished to the Bent County Soil Conservation District.

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

## HOW TO USE THIS SOIL SURVEY

**T**HIS SURVEY contains information that can be applied in managing farms, ranches, and woodlands; in selecting sites for roads, ponds, buildings, or other structures; and in appraising the suitability of tracts of land for farming, industry, or recreation.

### Locating Soils

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

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

### Finding and Using Information

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

Interpretations not included in the text can be developed by grouping the soils according to their suitability or limitations for a particular use. Translucent ma-

terial can be used as an overlay over the soil map and colored to show soils that have the same limitation or suitability. For example, soils that have a slight limitation for a given use can be colored green, those with a moderate limitation can be colored yellow, and those with a severe limitation can be colored red.

*Farmers and ranchers and those who work with them* can learn about use and management of the soils from the soil descriptions and from the discussions of the capability units and the range sites.

*Game managers, sportsmen, and others* can find information about soils and wildlife habitat in the section "Use of the Soils for Wildlife."

*Community planners and others concerned with nonfarm development* can read about the soil properties that affect recreational sites in the section "Use of the Soils for Recreational Developments."

*Engineers and builders* can find under "Use of the Soils in Engineering" tables that describe soil properties that affect engineering and show the relative suitability of the soils for specified engineering purposes.

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

*Newcomers in Bent County* may be especially interested in the section "General Soil Map," where broad patterns of soils are described. They may also be interested in the section "General Nature of the Area."

## Contents

	Page		Page
<b>General nature of the area</b> .....	1	<b>Descriptions of the soils—Continued</b>	
Relief and drainage.....	1	Olney series.....	23
Climate.....	1	Otero series.....	24
Geology.....	2	Penrose series.....	25
<b>How this survey was made</b> .....	3	Pultney series.....	25
<b>General soil map</b> .....	4	Rago series.....	26
1. Stoneham-Vona association.....	4	Rocky Ford series.....	26
2. Wiley-Colby association.....	5	Rough broken land.....	28
3. Manvel-Minnequa-Penrose asso- ciation.....	5	Samsil series.....	28
4. Tivoli association.....	6	Satanta series.....	28
5. Travessilla-Baca association.....	6	Stoneham series.....	29
6. Las-Apishapa-Bankard associa- tion.....	6	Tivoli series.....	30
7. Rocky Ford-Numa association.....	6	Travessilla series.....	30
<b>Descriptions of the soils</b> .....	7	Vona series.....	31
Apishapa series.....	8	Weld series.....	32
Arvada series.....	8	Wiley series.....	33
Baca series.....	10	<b>Use and management of the soils</b> .....	33
Bankard series.....	11	Management of nonirrigated soils.....	33
Cascajo series.....	11	Management of irrigated soils.....	33
Colby series.....	12	Capability groups of soils.....	34
Deertrail series.....	13	Predicted yields.....	41
Dune land.....	14	<b>Use and management of rangeland</b> .....	41
Dwyer series.....	14	Range sites and condition classes.....	41
Glenberg series.....	14	Descriptions of range sites.....	44
Harvey series.....	15	<b>Native woodland and windbreaks</b> .....	46
Kim series.....	15	<b>Use of the soils in engineering</b> .....	46
Kornman series.....	16	Engineering classification systems.....	47
Las series.....	17	Estimated properties.....	47
Las Animas series.....	18	Engineering interpretations.....	54
Limon series.....	18	<b>Use of the soils for wildlife</b> .....	54
Litle series.....	19	<b>Use of the soils for recreational develop-     ments</b> .....	66
Manvel series.....	20	<b>Formation and classification of the soils</b> .....	66
Manzanola series.....	20	Factors of soil formation.....	66
Minnequa series.....	21	Processes of soil formation.....	67
Nepesta series.....	22	Classification of the soils.....	70
Numa series.....	22	<b>Literature cited</b> .....	70
		<b>Glossary</b> .....	70
		<b>Guide to mapping units</b> .....	Following 72



# SOIL SURVEY OF BENT COUNTY, COLORADO

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UNITED STATES DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE, IN COOPERATION WITH THE  
COLORADO AGRICULTURAL EXPERIMENT STATION

**B**ENT COUNTY is in the southeastern part of Colorado (fig. 1). It is 36 miles from east to west and 43 miles from north to south. It has a total land area of 970,880 acres. Approximately 12 percent of this acreage is irrigated and dryfarmed cropland. The rest is rangeland.

The southern part of the county slopes gently northward. The northern part slopes gently southward to the Arkansas River. The overall gradient is less than 1 percent. The elevation is 5,000 feet at the county line on the south, just south of the small settlement of Ninaview, and 3,775 feet where the Arkansas River leaves the county on the east.

In 1960, the population of Bent County was 7,419. Las Animas, the county seat and the only incorporated town, is located at the junction of the Arkansas and the Purgatoire Rivers. Its population is about 3,300. The elevation is 3,893. Fort Lyon, McClave, Hasty, and Caddoa are uninhabited villages within the county.

Cattle and sheep are major sources of income. Sorghum, corn, sugar beets, melons, onions, tomatoes, potatoes, alfalfa, and small grain are the principal irrigated crops. Sorghum and wheat are the principal dryfarmed crops.

The John Martin Reservoir, one of the most important features in the county, is part of a comprehensive system for flood control and development of water resources on

the Arkansas River. The reservoir was completed in 1948. It has a total capacity of 683,260 acre-feet of water. About 402,110 acre-feet of this capacity is available for irrigation, and the rest is reserved for flood control.

## General Nature of the Area

This section describes the relief and drainage, the climate, and the geologic formations in Bent County.

## Relief and Drainage

The Arkansas and the Purgatoire Rivers are the two major streams in Bent County. The Arkansas River flows from west to east across the northern part of the county. The Purgatoire River enters the county on the west, flows in a northeasterly direction, and joins the Arkansas River at Las Animas. The southern part of the county is drained by Rule, Caddoa, and Muddy Creeks. All originate in the county. The rest of the county is drained by very small creeks that drain into the Arkansas and Purgatoire Rivers. The flood plains along the Arkansas River are half a mile to a mile wide.

## Climate<sup>1</sup>

The climate of Bent County is characterized by low and variable precipitation, abundant sunshine, low humidity, a wide range in temperature, and considerable wind. The weather pattern is commonly governed by dry air from the southwest. In winter it is influenced by brief invasions of cold air from the north, which cause sharp drops in temperature. In spring, summer, and fall, it is influenced by moist air from the Gulf of Mexico, which brings above-normal temperatures, higher than average humidity, and most of the growing-season precipitation.

Winters are fairly mild. Although the period December through February is the coldest and driest of the year, temperatures generally rise above freezing during the day and sometimes reach the sixties and seventies. Occasionally, blizzards and cold spells that last 3 to 5 days move into the area from the north. The onset of periods of high winds is frequently late in February.

Skies are cloudier in spring than at any other season. Precipitation increases sharply late in March and in April

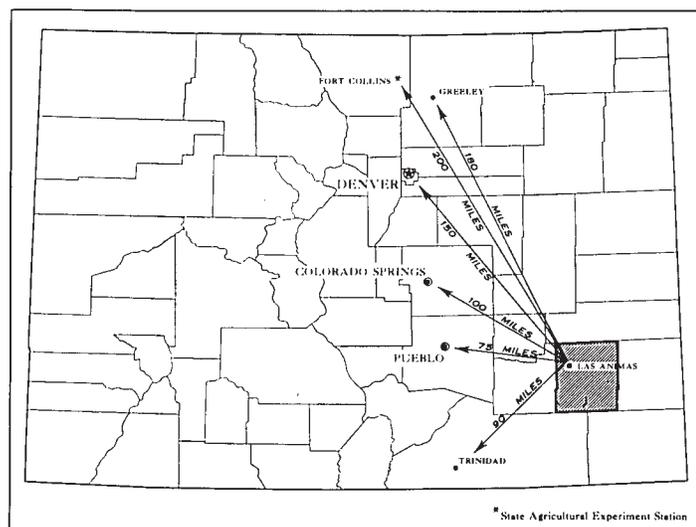


Figure 1.—Location of Bent County in Colorado.

<sup>1</sup> Data furnished by J. W. BERRY, State climatologist, U.S. Weather Bureau, Denver, Colo.

and May. High-velocity winds are common in March and April.

By summertime the sustained high winds have subsided. Short intrusions of air from the Gulf of Mexico increase humidity and shower activity. Through June, July, and August, precipitation is fairly high and temperatures reach 90° F. or above on about 70 percent of the days.

Fall is a transitional period of sunny days and generally mild temperatures. A few thunderstorms persist into September, but precipitation decreases each month and reaches a minimum in November. Freezing nighttime temperatures are frequent late in October and usual in November. Cold air from the north moves in during November. Wind movement is generally light.

Table 1 shows, by months, the average daily maximum temperature, the average daily minimum temperature, and the average precipitation for Bent County. Table 2 shows probabilities of the last freezing temperatures in spring and the first freezing temperatures in fall.

About 75 percent of the annual total precipitation falls during the period March through September, and most of this falls during thunderstorms. The amount varies greatly from storm to storm and from place to place. On July 2, 1961, for example, 3.33 inches of rain fell at John Martin Dam but only 0.25 inch fell at Las Animas. Hailstorms are occasionally severe and damaging, but they are less frequent in Bent County than in higher parts of the

State. Tornadoes are smaller, less damaging, and less frequent than in areas in the eastern part of the State.

## Geology

The geologic formations exposed in Bent County are of sedimentary origin and range in age from Jurassic to Quaternary. The bedrock formations are Jurassic and Cretaceous in age. Rocks of the Jurassic System include the Entrada Sandstone and the Morrison Formation, which are separated by an unnamed unit that contains beds of alabaster gypsum. Rocks of the Cretaceous System include the Purgatoire Formation, Dakota Sandstone, Graneros Shale, Greenhorn Limestone, Carlile Shale, and the Niobrara Formation. The older bedrock formations are exposed in the southwestern part of the county, and the younger in the northern and southeastern parts.

Unconsolidated sand and gravel deposits, possibly of late Tertiary age (Ogallala Formation), occur in a small area in the southeastern corner of the county. Deposits of Pleistocene age include the sandy and gravelly alluvium that covers terraces and high-level erosional surfaces, much of the dune sand south of the Arkansas River, and thin deposits of loesslike material in the northeastern corner and in the central and southeastern parts. Small areas of eolian deposits, probably of recent age, occur in the northern part of the county.

TABLE 1.--TEMPERATURE AND PRECIPITATION DATA

[All data from Las Animas weather station. Elevation 3,893 feet]

Month	Temperature				Precipitation				
	Average daily maximum	Average daily minimum	2 years in 10 will have at least 4 days with--		Average total	2 years in 10 will have--		Average number of days with snow cover	Average depth of snow on days with snow cover
			Maximum temperature equal to or higher than--	Minimum temperature equal to or lower than--		Less than--	More than--		
	°F.	°F.	°F.	°F.	In.	In.	In.		In.
January----	48	13	65	-6	0.48	0.1	0.8	6	3
February---	52	18	71	0	.35	.1	.6	3	4
March-----	62	24	79	5	.68	.3	1.1	2	6
April-----	73	36	88	23	1.20	.3	1.9	(1/)	1
May-----	82	46	96	35	2.09	.8	3.1	0	0
June-----	93	57	104	46	1.45	.5	2.4	0	0
July-----	97	61	105	53	1.83	.6	3.0	0	0
August-----	95	59	103	51	1.70	.5	2.8	0	0
September--	88	50	99	39	.94	.1	1.8	0	0
October----	75	37	89	24	.70	.1	1.3	(1/)	2
November---	59	22	76	7	.48	.1	.8	3	5
December---	51	16	68	2	.35	.1	.7	3	3
Year-----	73	37	2/107	3/-14	12.25	8.6	16.4	17	4

1/  
Less than half a day.

2/  
Average annual highest temperature.

3/  
Average annual lowest temperature.

TABLE 2.--PROBABILITY OF SPECIFIED TEMPERATURES IN SPRING AND FALL

[Based on records at Las Animas]

Probability	Dates for given probability and temperatures				
	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 17	April 25	May 2	May 11	May 23
2 years in 10 later than----	April 10	April 18	April 25	May 4	May 16
5 years in 10 later than----	March 28	April 5	April 12	April 22	May 4
Fall:					
1 year in 10 earlier than---	October 28	October 16	October 7	September 30	September 20
2 years in 10 earlier than---	November 2	October 21	October 12	October 5	September 25
5 years in 10 earlier than---	November 13	November 1	October 23	October 15	October 5

## How This Survey Was Made

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

The soil scientists made comparisons among the profiles they studied, and they compared these profiles with those in counties nearby and in places more distant. They classified and named the soils according to nationwide, uniform procedures. To use this publication 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, the major horizons of all the soils of one series 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. Colby and Stoneham, for example, are the names of two soil series. All the soils in the United States having the same series name are essentially alike in those characteristics that affect their behavior in the natural, undisturbed landscape. Soils of one series can differ somewhat in texture of the surface soil and in slope, stoniness, or some other characteristic that affects use of the soils by man.

Many soil series contain soils that differ in the texture of their surface layer. According to such differences in texture, separations called soil types are made. Within a series, all the soils having a surface layer of the same texture belong to one soil type. Colby fine sandy loam and Colby silt loam are two soil types in the Colby series. The

difference in the texture of their surface layers is apparent from their names.

Some soil types vary so much in slope, degree of erosion, number and size of stones, or some other feature affecting their use, that practical suggestions about their management could not be made if they were shown on the soil map as one unit. Such soil types are divided into soil phases. The name of a soil phase indicates a feature that affects management. For example, Colby silt loam, 1 to 3 percent slopes, is one of several phases of Colby silt loam, a soil type that has a slope range of 0 to 25 percent.

After a guide for classifying and naming the soils had been worked out, the soil scientists drew the boundaries of the individual soils on aerial photographs. These photographs show woodlands, buildings, field borders, trees, and other details that help in drawing boundaries accurately. The soil map at the back of this survey 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 a recognized soil type or soil phase.

In preparing some detailed maps, the soil scientists have a problem of delineating areas where different kinds of soils are so intricately mixed or occur in such small individual tracts that it is not practical to show them separately on the map. They show this mixture of soils as one mapping unit and call it a soil complex. Ordinarily, a soil complex is named for the major kinds of soils in it, for example, Minnequa-Penrose loams, 1 to 9 percent slopes.

Most surveys include areas where the soil material is so rocky, so shallow, or so frequently worked by wind and water that it cannot be classified by soil series. Such an area is shown on the map like other mapping units, but it is given a descriptive name, such as Rough broken land, and is called a land type.

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

But only part of a soil survey is done when the soils have been named, described, and delineated on the map and the laboratory data and yield data have been assembled. The mass of detailed information then needs to be organized in such a way that it is readily useful to different groups of readers, among them farmers, ranchers, managers of woodland, engineers, and homeowners. Grouping soils that are similar in suitability for each specified use is the method of organization commonly used in soil surveys. The soil scientists set up trial groups based on yield and practice tables and other data. They test these groups by further study and by consultation with farmers, agronomists, engineers, and others; then they adjust the groups according to the results of their studies and consultation. Thus, the groups that are finally evolved reflect up-to-date knowledge of the soils and their behavior under present methods of use and management.

## General Soil Map

The general soil map in the back of this publication shows, in color, the soil associations in Bent County. A

soil association is a landscape that has a distinctive proportional pattern of soils. It normally consists of one or more major soils and at least one minor soil, and it is named for the major soils. The soils in one association may occur in another, but in a different pattern.

A map showing soil associations is useful to people who want a general idea of the soils in a county, who want to compare different parts of a county, or who want to know the location of large tracts that are suitable for a certain kind of farming or other land use. Such a map is not suitable for planning the management of a farm or field, because the soils in any one association ordinarily differ in slope, depth, stoniness, drainage, and other characteristics that affect management.

The seven soil associations of Bent County are described in the pages that follow.

### 1. Stoneham-Vona association

*Deep, well-drained, nearly level to moderately sloping loams and sandy loams on uplands*

This association is on the higher parts of the uplands in the northwestern part of the county. It is characterized by nearly level areas, ridges, and drainageways (fig. 2). The total area is about 8 percent of the county.

Stoneham soils make up about half of the association. They are predominant in nearly level areas and adjacent to drainageways. They have a surface layer of loam and a subsoil of clay loam. The underlying material is gravelly loam.

Vona soils make up about 40 percent of the association. They are predominant on the ridges. Both their surface

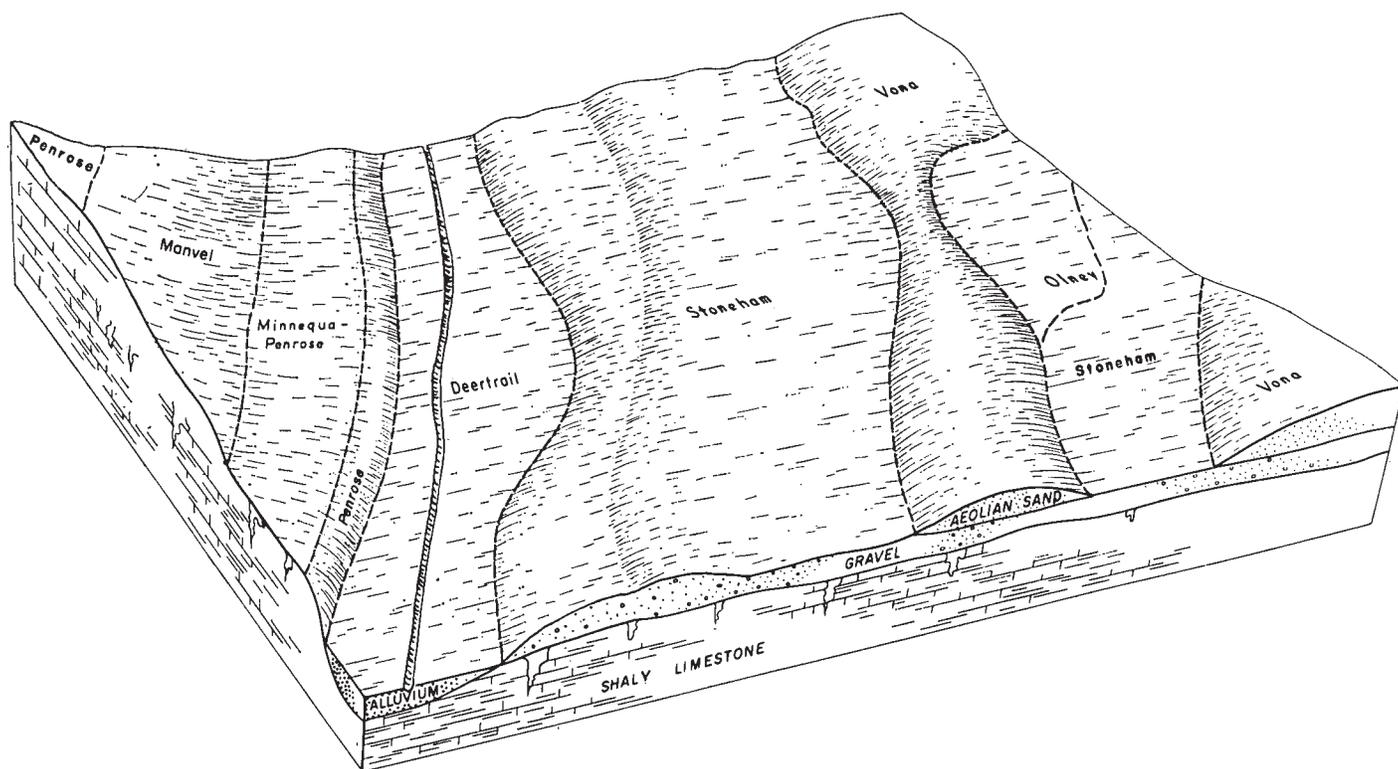


Figure 2.—Representative pattern of soils and underlying material in associations 1 and 3.

layer and their subsoil are sandy loam. The underlying material is sand and loamy sand, presumably wind deposited.

The rest of this association consists of Olney, Wiley, and Deertrail soils. Olney soils, which are sandy loams, occupy small concave or nearly level areas within larger areas of Vona soils. Wiley soils, which are silt loams, occupy small high-lying areas within large areas of Stoneham soils. Deertrail soils, which are clay loams, occur in drainage-ways and swales.

This association is used mostly for grazing. Much of it was once cultivated but then was abandoned as cropland because of droughts and crop failures. A few fields are still used for wheat, but only in the most favorable years are yields more than 10 or 12 bushels per acre. Grass grows well if it is protected against overuse during dry periods. Soil blowing has done serious damage to many old fields where grass has not been reestablished. Most of these seriously eroded areas consist of Vona soils.

## 2. Wiley-Colby association

*Deep, well-drained, nearly level to gently sloping silt loams on loessal uplands*

This association is on the higher, nearly level areas on divides between streams. It is one of little relief other than shallow swales and a few playas. It occurs in all parts of the county except the northwestern and southwestern corners. The total area is about 31 percent of the county.

Wiley soils make up about 60 percent of the association. They are predominantly nearly level. They have a surface layer of silt loam and a subsoil of silty clay loam.

Colby soils make up about 24 percent of the association. They are predominant on slight rises and along the edges of swales and playas. They have a surface layer of silt loam or fine sandy loam and a subsoil of silt loam.

The rest of the association consists of Baca, Weld, and Rago soils. All are silt loams. Baca soils, which make up about 12 percent of the association, are nearly level. Weld soils are nearly level, and Rago soils are slightly concave.

Most of this association is used as range. About a third of it was once cultivated to wheat and grain sorghum but then was abandoned as cropland because of droughts and crop failures. Part of this acreage has reverted to native grass, and the rest has been planted to grass. Soil blowing and water erosion are severe hazards if the soils are cultivated.

## 3. Manvel-Minnequa-Penrose association

*Deep to shallow, well-drained and excessively drained, gently sloping to strongly sloping loams on uplands; underlain by limestone and shale*

This association is at intermediate elevations between the major valleys and the uplands. It is characterized by slopes of less than 10 percent, outcrops of limestone and limy shale, and narrow breaks (fig. 3). The total area is about 18 percent of the county.

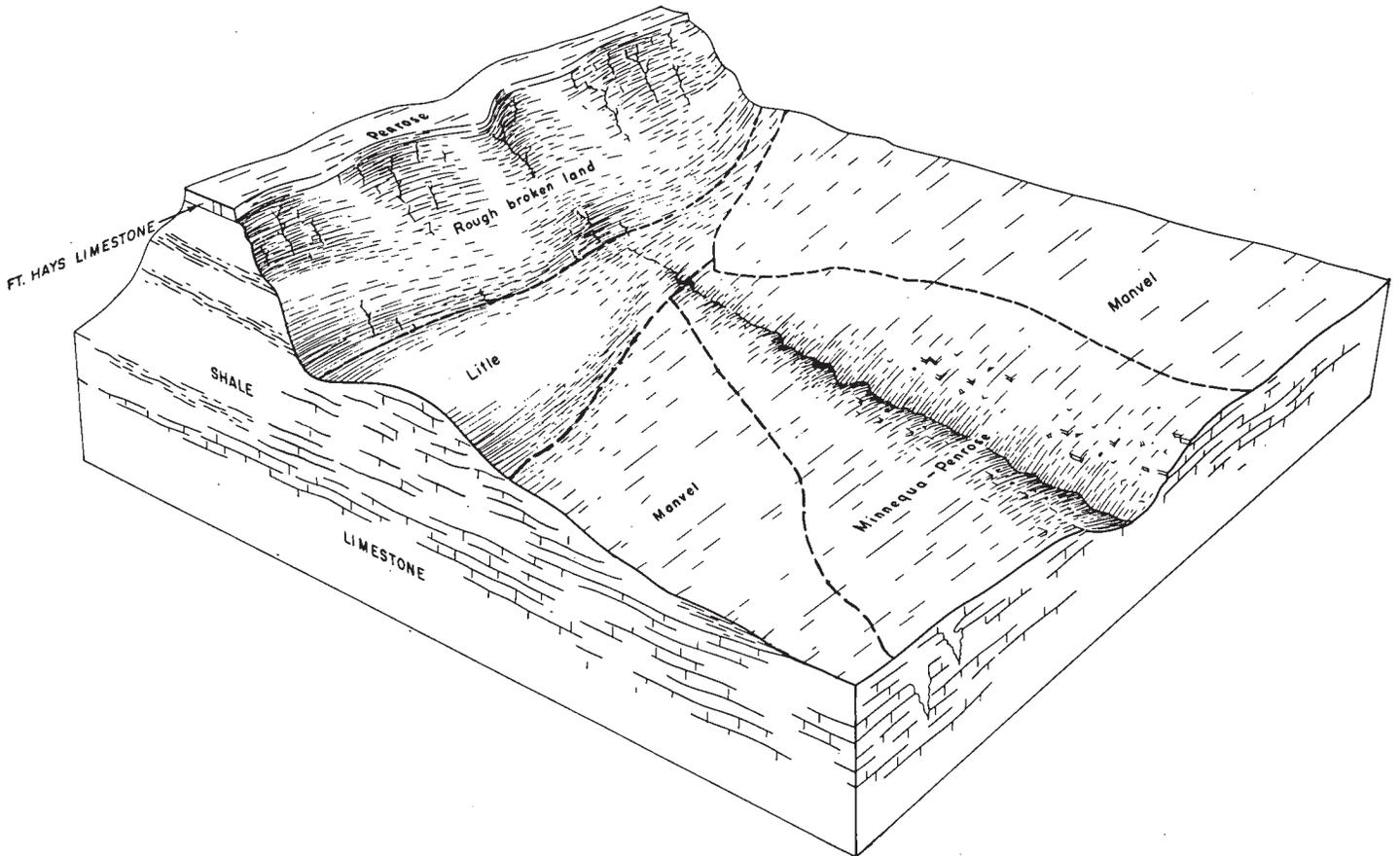


Figure 3.—Representative pattern of soils and underlying material in association 3.

Manvel soils make up about 40 percent of the association. They are deep, highly calcareous loams. They are predominant on the gentle slopes.

Minnequa soils make up about 35 percent of the association. They are on intermediate slopes. They are similar to Manvel soils but are underlain by limestone at a depth of 20 to 40 inches.

Penrose soils make up about 20 percent of the association. They are shallow channery loams.

The rest of the association consists of Deertrail, Litle, Limon, and Arvada soils. All of these soils are clayey. They commonly occur at the lower elevations, along drainageways. Some of the Litle soils are on side slopes where there are strata of limy shale near the surface.

Nearly all of the association is in native grass and is used as range. A few areas of Minnequa soils are irrigated. Some areas of Manvel and Deertrail soils were once plowed and dryfarmed but were abandoned as cropland because of drought and erosion. Most of these areas have reverted to grass and weeds. A few have been planted to grass. The erosion hazard is severe if the vegetative cover is depleted.

#### 4. *Tivoli association*

*Deep, excessively drained, gently rolling to hilly sands on hummocky uplands*

This association occupies an area 1 to 3 miles wide that extends across the county just south of the bottom land along the Arkansas River. The total area is about 4 percent of the county.

Tivoli soils make up about 80 percent of the association. They are deep, loose sands.

The rest of the association consists of Dwyer and Vona soils, sand dunes, and blowouts. Dwyer and Vona soils make up about 10 to 15 percent of the association. Dwyer soils are loose sands, more limy than Tivoli soils. They occur only in areas west of the Purgatoire River. Vona soils occupy low-lying areas, most commonly areas near the boundary between this association and association 2.

All of this association is used as range. It is too sandy and too erodible to be suitable for cultivation. Native grass grows well. If the grass is overgrazed, soil blowing creates dunes and blowouts that are extremely hard to revegetate.

#### 5. *Travessilla-Baca association*

*Shallow to deep, well-drained, nearly level to very steep sandy loams and silt loams on sandstone breaks, uplands, fans, and terraces*

This association extends from the uplands down to the major drainageways. It is in the southern part of the county. The landscape is one of outcrops, escarpments, fans, terraces, and swales (fig. 4). The total area is about 29 percent of the county.

Travessilla soils make up about 50 percent of the association. They are on the higher lying areas near the edges of escarpments and outcrops. They are loamy soils that are shallow over sandstone and commonly have sandstone chips and rocks on the surface.

Baca soils make up about 20 percent of the association. These deep, nearly level silt loams are on the higher areas where deposits of loess have covered the sandstone.

The rest of the association consists of Kim, Olney, Satanta, and Manzanola soils and Rough broken land.

Kim soils, which are deep loams, are on the fans below the escarpments. In places they contain many sandstone chips. Satanta and Manzanola soils are on the terraces and in the swales. Rough broken land, the slopes of which are very steep to nearly vertical, extends downward from the escarpments, in many places for a distance of as much as 200 to 500 feet.

Nearly all of this association is in native grass and is used for grazing. Small acreages of the gently sloping, deep soils are used for crops, mainly wheat and forage sorghum. Some areas that were once cropped have been planted to grass, and others have reverted to grass. Most of these old fields are moderately to severely eroded. The escarpments and outcrops restrict the movement of livestock. Consequently, many of the fans and terraces are overgrazed.

#### 6. *Las-Apishapa-Bankard association*

*Deep, mainly poorly drained and somewhat poorly drained, nearly level clay loams and loams on flood plains and low terraces*

This association is on narrow, low-lying flood plains along the Arkansas River. The landscape is one of very little slope but uneven topography. Many areas have no surface drainage. Most are flooded occasionally; some are flooded frequently. The total area is about 3 percent of the county.

Las soils make up about 40 percent of the association. They are somewhat poorly drained to poorly drained. They have a surface layer of clay loam and a subsoil of clay loam or loam. They contain moderate to large amounts of soluble salts. The water table is within 3 feet of the surface most of the time.

Apishapa soils make up about 20 percent of the association. They have a clayey subsoil and are somewhat poorly drained to poorly drained. They are mostly at slightly higher elevations than the Las and Bankard soils and are flooded less frequently.

Bankard soils make up about 20 percent of the association. They are generally adjacent to the rivers and are flooded frequently. They are excessively drained and have a loamy to sandy surface layer and a sandy subsoil that contains thin lenses of finer textured material.

The rest of the association consists of Las Animas, Glenberg, Rocky Ford, and Kornman soils. Las Animas soils make up about 10 percent of the association. They are more sandy and have a higher water table than Las soils. Glenberg, Rocky Ford, and Kornman soils occupy the narrow, higher lying areas. They are well drained and are seldom flooded.

Most of this association is irrigated cropland. Inadequate drainage is a limitation, and drainage ditches or lines are used extensively, mainly on Las and Apishapa soils. Alfalfa, corn, sugar beets, grain sorghum, melons, onions, and small grain are the main crops. Bankard and Las Animas soils are used as pasture. The vegetation is predominantly saltgrass and sacaton. Willows and cottonwoods thrive in some areas.

#### 7. *Rocky Ford-Numa association*

*Deep, well-drained, nearly level to gently sloping clay loams on terraces and uplands*

This association is on terraces and the lower lying parts of the uplands, just north of the flood plain along the

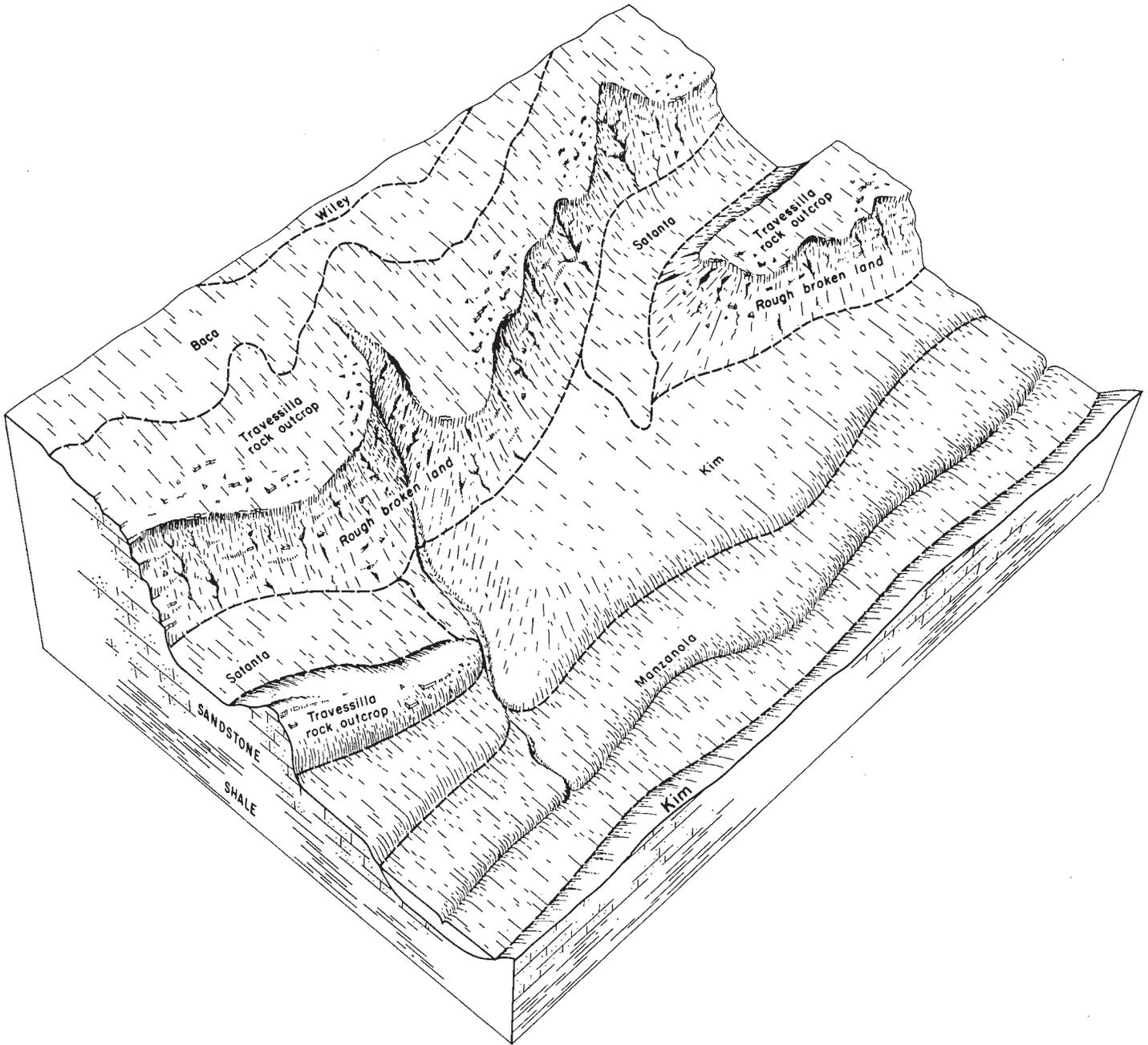


Figure 4.—Representative pattern of soils and underlying material in association 5.

Arkansas River. It is fairly uniform in topography, kinds of soils, and land use. The total area is about 7 percent of the county.

Rocky Ford soils make up about 70 percent of the association. They are deep clay loams and have a subsoil of loam.

Numa soils make up about 20 percent of the association. They are similar to Rocky Ford soils, but they have a subsoil of clay loam and are very limy.

The rest of the association consists of Nepesta soils and small acreages of Cascajo, Glenberg, and Kornman soils. Nepesta soils are deep clay loams.

Nearly all of the acreage is irrigated and is farmed intensively. Alfalfa, sorghum, wheat, barley, onions, melons, and sugar beets are the main crops.

### *Descriptions of the Soils*

This section describes the soil series and mapping units of Bent County. The approximate acreage and the proportionate extent of each mapping unit are given in table 3.

A description of each soil series is given, and it is followed by descriptions of the mapping units in that series.

For full information on any one mapping unit, it is necessary to read the description of the soil series as well as the description of the mapping unit.

Following the name of each mapping unit is a symbol in parentheses. This symbol identifies the mapping unit on the detailed soil map. Listed at the end of the description of each mapping unit are the capability unit and the range site in which the mapping unit has been placed. The page on which each capability unit and each range site is described can be found readily by referring to the "Guide to Mapping Units."

Many terms used in the soil descriptions and other sections of the survey are defined in the Glossary.

## Apishapa Series

The Apishapa series consists of nearly level, deep limy soils that formed in fine-textured, saline alluvium derived from shale. These soils are on bottom lands and low-lying terraces along the Arkansas and Purgatoire Rivers.

In a typical profile the surface layer is grayish-brown clay loam to silty clay loam about 10 inches thick. The uppermost 16 inches of the subsoil is grayish-brown to light yellowish-brown silty clay mottled with gray and yellowish brown. It has medium to coarse, blocky structure. Below this, to a depth of about 60 inches, is massive, gray clay.

Apishapa soils are poorly drained to somewhat poorly drained. They have slow permeability and slow internal drainage. Generally the water table is within a depth of 40 inches. Natural fertility is high if excess water is removed. There is no significant hazard of erosion. The response to management is poor.

Most of the acreage is cultivated.

Typical profile of Apishapa clay loam (450 feet east and 2,100 feet south of NW. corner sec. 9, T. 23 S., R. 52 W.):

- A11—0 to 5 inches, grayish-brown (10YR 5/2) clay loam, very dark grayish brown (10YR 3/2) when moist, dark grayish brown (10YR 4/2) if crushed when moist; weak, fine, granular structure; loose when dry, friable when moist; very strongly calcareous; clear, smooth boundary.
- A12—5 to 10 inches, grayish-brown (10YR 5/2) silty clay loam, dark grayish brown (10YR 4/2) when moist; moderate, fine, subangular blocky structure; very hard when dry, firm when moist; very strongly calcareous; clear, smooth boundary.
- B1g—10 to 17 inches, grayish-brown (2.5Y 5/2) silty clay, dark grayish brown (2.5Y 4/2) when moist; moderate, medium, subangular blocky structure; extremely hard when dry, very firm when moist; very strongly calcareous; common salt spots and many, fine, distinct, gray and yellowish-brown mottles; gradual, smooth boundary.
- B2g—17 to 26 inches, light yellowish-brown (2.5Y 6/3) silty clay, dark grayish brown (2.5Y 4/2) when moist; weak, coarse, subangular blocky structure; slickensides; extremely hard when dry, very firm when moist; strongly calcareous; few salt spots and many, medium, distinct, gray and yellowish-brown mottles; clear, smooth boundary.
- B3g—26 to 60 inches, gray (10YR 5/1) clay, very dark gray (10YR 3/1) when moist; massive; very hard when dry, firm when moist; strongly calcareous; many, fine, yellowish-brown mottles; few salt spots and common, medium, olive mottles; clear, smooth boundary.

The A11 and A12 horizons range from 5 to 10 inches in combined thickness and from clay loam to clay in texture. The Bg horizons range from silty clay loam to clay. In some areas there is a IIC horizon of sand and gravel at a depth of 30 to 40 inches.

Apishapa soils are finer textured and more strongly saline than Las soils. They are much less sandy than Las Animas soils. They are much wetter and finer textured than Rocky Ford soils.

**Apishapa clay loam** (0 to 1 percent slopes) (Ac).—This soil occurs as irregularly shaped areas on bottom land, mainly along the Arkansas River. Most areas are between 20 and 40 acres in size; a few are 100 acres or more. Included in mapping were spots of Las clay loam, generally in slight depressions; small areas of Rocky Ford clay loam, on higher parts of the landscape; and a few 1- or 2-acre areas of Limon clay, on slight ridges.

This soil is difficult to work. It is poorly drained and is slightly to moderately affected by salts. Water intake is slow, and the water-holding capacity is high. Runoff is slow. The erosion hazard is slight.

More than half the acreage is farmed. Alfalfa, sugar beets, barley, onions, and irrigated pasture are the main crops. The rest of the acreage supports saltgrass vegetation and is used as pasture. Drainage, preferably open-ditch drainage, is needed to remove excess subsurface water. (Capability unit IIIw-1, irrigated; capability unit VIw-1, nonirrigated; Salt Meadow range site)

## Arvada Series

The Arvada series consists of nearly level to gently sloping, deep, alkaline soils that formed in clayey material weathered from shale and shaly limestone. These soils are on uplands. They occur as scattered areas throughout the county.

In a typical profile the surface layer is about 2 inches thick. In virgin areas it is light brownish-gray silt loam, and in plowed areas light brownish-gray clay loam. The subsoil is strongly alkaline silty clay about 16 inches thick. It has mainly fine to medium blocky structure. Below the subsoil is about 14 inches of massive silty clay underlain by shale. The shale extends to a depth of 60 inches or more.

Arvada soils are difficult to work. They are naturally well drained. They take in water slowly but have a high water-holding capacity. Runoff is medium to rapid. Natural fertility is low. The erosion hazard is moderate to severe. The response to management is poor.

The entire acreage is used as range.

Typical profile of an Arvada soil (175 feet north and 355 feet east of SW. corner sec. 26, T. 24 S., R. 48 W.):

- A2—0 to 2 inches, light brownish-gray (10YR 6/2) silt loam, dark grayish brown (10YR 4/2) when moist; weak, fine, platy structure to weak, fine, granular; slightly hard when dry, friable when moist; strongly calcareous; abrupt, smooth boundary.
- B21t—2 to 7 inches, brown (10YR 5/3) silty clay, dark brown (10YR 4/3) when moist; weak to moderate, medium, columnar structure to weak to moderate, fine, subangular blocky; very hard when dry, firm when moist; strongly calcareous; thin, nearly continuous clay skins; clear, smooth boundary; some visible bleached sand grains.
- B22t—7 to 12 inches, brown (10YR 5/3) silty clay, dark brown (10YR 4/3) when moist; weak, medium, prismatic structure to moderate, medium and fine, subangular blocky; very hard when dry, firm when moist; strongly calcareous; thin, patchy clay skins; clear, smooth boundary.
- B3caes—12 to 18 inches, pale-brown (10YR 6/3) silty clay, brown (10YR 5/3) when moist; weak, medium, subangular blocky structure; very hard when dry, firm when moist; very strongly calcareous; clear, smooth boundary; some visible gypsum.

BENT COUNTY, COLORADO

TABLE 3.--APPROXIMATE ACREAGE AND PROPORTIONATE EXTENT OF THE SOILS

Soil	Area		Soil	Area	
	Acres	Percent		Acres	Percent
Apishapa clay loam-----	6,131	0.6	Nepesta clay loam, 1 to 3 percent slopes-----	960	0.1
Arvada clay loam, 0 to 3 percent slopes-----	4,810	.5	Numa clay loam, 0 to 1 percent slopes-----	3,620	.4
Arvada and Deertrail soils, eroded-----	2,437	.2	Numa clay loam, 1 to 3 percent slopes-----	6,637	.7
Baca silt loam, 0 to 3 percent slopes-----	56,919	5.9	Numa clay loam, wet, 0 to 3 percent slopes-----	990	.1
Baca silt loam, 3 to 5 percent slopes-----	18,046	1.8	Numa clay loam, sand substratum variant, 0 to 3 percent slopes--	1,540	.2
Bankard soils-----	7,571	.8	Olney sandy loam, 0 to 3 percent slopes-----	11,253	1.1
Cascajo soils and gravelly land---	7,368	.7	Olney soils, 0 to 3 percent slopes, eroded-----	1,765	.2
Colby fine sandy loam, 0 to 3 percent slopes-----	9,651	1.0	Otero loamy sand, 1 to 9 percent slopes-----	4,729	.5
Colby silt loam, 0 to 1 percent slopes-----	9,079	.9	Penrose channery loam, 1 to 25 percent slopes-----	16,653	1.7
Colby silt loam, 1 to 3 percent slopes-----	31,555	3.3	Pultney loam, 1 to 9 percent slopes-----	1,723	.2
Colby silt loam, 6 to 25 percent slopes-----	663	.1	Rago silt loam, 0 to 1 percent slopes-----	515	.1
Deertrail clay loam, 0 to 5 percent slopes-----	33,126	3.4	Rocky Ford clay loam, 0 to 1 percent slopes-----	20,740	2.1
Dune land-----	6,230	.6	Rocky Ford clay loam, 1 to 3 percent slopes-----	17,080	1.8
Dwyer sand-----	2,213	.2	Rocky Ford clay loam, wet, 0 to 1 percent slopes-----	2,700	.3
Glenberg sandy loam, 0 to 1 percent slopes-----	4,597	.5	Rocky Ford clay loam, wet, 1 to 3 percent slopes-----	6,071	.6
Glenberg sandy loam, 1 to 3 percent slopes-----	630	.1	Rocky Ford clay loam, sand substratum variant, 0 to 1 percent slopes-----	930	.1
Glenberg sandy loam, gravel substratum, 0 to 1 percent slopes--	640	.1	Rough broken land-----	13,734	1.4
Harvey loam, 1 to 9 percent slopes-----	9,886	1.0	Samsil soils-----	2,833	.3
Kim loam, 0 to 5 percent slopes---	31,082	3.2	Satanta loam, 0 to 3 percent slopes-----	10,310	1.1
Kornman clay loam, 0 to 1 percent slopes-----	2,150	.2	Stoneham loam, 0 to 3 percent slopes-----	31,450	3.2
Kornman clay loam, 1 to 3 percent slopes-----	870	.1	Stoneham loam, 3 to 9 percent slopes-----	5,021	.5
Las clay loam-----	5,432	.5	Tivoli sand-----	14,842	1.5
Las clay loam, dark variant-----	4,247	.4	Tivoli sand, hilly-----	17,330	1.8
Las clay loam, sand substratum variant-----	1,110	.1	Tivoli-Dune land complex-----	4,789	.5
Las clay loam, sand substratum, dark variant-----	2,660	.3	Travessilla-Olney sandy loams, 1 to 9 percent slopes-----	72,392	7.5
Las Animas soils-----	1,700	.2	Travessilla-Rock outcrop complex--	69,449	7.2
Limon clay-----	3,067	.3	Vona sandy loam, 0 to 5 percent slopes-----	27,484	2.8
Limon clay, alkali-----	800	.1	Vona soils, 0 to 5 percent slopes, eroded-----	3,734	.4
Litle clay loam, 1 to 9 percent slopes-----	5,336	.5	Weid silt loam, 0 to 1 percent slopes-----	7,396	.8
Manvel loam, 1 to 9 percent slopes-----	69,793	7.2	Wiley silt loam, 0 to 3 percent slopes-----	134,812	13.9
Manvel loam, 1 to 9 percent slopes, eroded-----	672	.1	Lakes-----	14,625	1.5
Manzanola clay loam, 0 to 3 percent slopes-----	22,555	2.3	River channels-----	3,828	.4
Minnequa loam, 0 to 5 percent slopes-----	5,381	.5			
Minnequa loam, 1 to 9 percent slopes-----	45,214	4.7			
Minnequa-Penrose loams, 1 to 9 percent slopes-----	23,784	2.4			
Nepesta clay loam, 0 to 1 percent slopes-----	1,540	.2	Total-----	970,880	100.0

- C1caes—18 to 32 inches, pale-brown (10YR 6/3) silty clay, brown (10YR 5/3) when moist; massive; very hard when dry, firm when moist; very strongly calcareous; clear, wavy boundary; many lime and gypsum spots.
- C2—32 to 40 inches, partly weathered, multicolored shale; highly gypsiferous.
- R—40 to 60 inches, shale.

The A2 horizon ranges from 1 to 4 inches in thickness and from fine sandy loam to clay loam in texture. The B2 horizon ranges from 8 to 18 inches in thickness. It is silty clay or clay in texture. The depth to the R horizon (shale) ranges from about 3½ to more than 5 feet.

Arvada soils are more alkaline and finer textured than Manvel soils. They are more alkaline and deeper over shale and shaly limestone than Minnequa soils.

**Arvada clay loam, 0 to 3 percent slopes (ArA).**—This soil occurs as irregularly shaped areas, generally less than 50 acres in size, in slight depressions and in broad swales on uplands. It is mainly in the north-central and east-central parts of the county. The surface layer is mainly clay loam, but in sizable areas it is silt loam. This layer is about 3 inches thick. The subsoil is alkaline silty clay about 15 inches thick. Included in mapping were small eroded areas of this soil; spots of Minnequa loam, on slightly raised parts of the landscape and on the steeper slopes; and a few small areas of Penrose soils, in hilly areas.

The entire acreage is used as range. Deferment and rotation of grazing and seeding of grass help in maintaining and improving the vegetation. Part of the acreage was cultivated, but the fine-textured surface layer made tillage difficult, and the high alkalinity affected yields adversely. Also, soil blowing and water erosion were severe hazards in cultivated areas. (Capability unit VI<sub>s</sub>-1, nonirrigated; Salt Flats range site)

**Arvada and Deertrail soils, eroded (0 to 3 percent slopes) (Av2).**—These soils occur as scattered, nearly level and hummocky areas that were once cultivated but are now idle. Soil blowing and water erosion have been severe. In most areas all of the original surface layer and about a third of the subsoil have been removed. In about 5 to 10 percent of the acreage, all of the subsoil has been removed, and an extremely alkaline, fine-textured material is exposed. Loose, wind-sorted granular material of varying textures is scattered on the surface.

Revegetation is difficult because of alkalinity and erosion. Even areas that have been undisturbed for many years have a poor vegetative cover. (Capability unit VI<sub>s</sub>-1, nonirrigated; Salt Flats range site)

## Baca Series

The Baca series consists of nearly level to gently sloping, deep soils that formed in highly calcareous, silty loess. These soils are on uplands in the eastern part of the county.

In a typical profile the surface layer is grayish-brown silt loam about 2 inches thick. The subsoil is grayish-brown clay loam about 16 inches thick. The structure is weak to strong blocky and moderate prismatic. Below the subsoil is a zone of lime accumulation. The lime spots are about a quarter of an inch in diameter.

Baca soils are naturally well drained. They have medium internal drainage, moderate permeability, and a high water-holding capacity. They are high in natural fertility. Soil blowing and water erosion are hazards unless ade-

quate cover is maintained. The response to range management is good.

Most of the acreage is used as range.

Typical profile of a Baca silt loam (1,050 feet south and 500 feet west of NE. corner sec. 26, T. 27 S., R. 49 W.):

- A1—0 to 2 inches, grayish-brown (10YR 5/2) silt loam, very dark grayish brown (10YR 3/2) when moist; weak, fine, platy structure to weak, fine, granular; soft when dry, very friable when moist; noncalcareous; clear, smooth boundary.
- B1—2 to 4 inches, grayish-brown (10YR 5/2) clay loam, dark grayish brown (10YR 4/2) when moist; weak, fine, subangular blocky structure; slightly hard when dry, friable when moist; noncalcareous; clear, smooth boundary.
- B2t—4 to 8 inches, grayish-brown (10YR 5/2) clay loam, dark grayish brown (10YR 4/2) when moist; moderate, fine, prismatic structure to moderate and strong, fine, subangular blocky; hard when dry, friable when moist; noncalcareous; thin continuous clay skins; clear, smooth boundary.
- B3—8 to 18 inches, grayish-brown (10YR 5/2) clay loam, dark grayish brown (10YR 4/2) when moist; weak, medium, subangular and angular blocky structure; hard when dry, friable when moist; strongly calcareous; thin, patchy clay skins; few calcium carbonate concretions; clear, smooth boundary.
- C—18 to 60 inches, pale-brown (10YR 6/3) silt loam, brown (10YR 5/3) when moist; massive; soft when dry, friable when moist; violently calcareous; common lime spots.

The A1 horizon ranges from 2 to 6 inches in thickness and from silt loam to fine sandy loam in texture. The B2t horizon ranges from 2 to 8 inches in thickness and from clay loam to clay in texture. It has a characteristic strong, well-defined prismatic and angular blocky structure that ranges from medium to fine and from moderate to strong. The depth to calcareous material ranges from 6 to 12 inches.

Baca soils are more strongly developed, have a darker colored subsoil, and are deeper over lime than Wiley and Colby soils. They are not so deeply leached of lime as Weld soils, and they lack the light brownish-gray A2 horizon that is typical of those soils.

**Baca silt loam, 0 to 3 percent slopes (BaA).**—This soil has the profile described as typical for the series. It occurs as irregularly shaped areas 100 acres or more in size. It is mainly in the eastern part of the county. Included in mapping were spots of Wiley silt loam, on the slightly steeper parts of slopes, and a few spots of Colby silt loam, which occur in areas where the slope is more than 3 percent.

This soil takes in water at a moderate rate and has a high water-holding capacity. Runoff is moderate. The erosion hazard is moderate.

Most of the acreage is used as range. Deferring and rotating grazing are important practices in range management. Much of the acreage was once dryfarmed, but dryfarming was abandoned because of low rainfall. Stubble mulching and summer fallowing help to conserve moisture and control erosion if any dryfarming is done. (Capability unit IV<sub>e</sub>-1, nonirrigated; Loamy Plains range site)

**Baca silt loam, 3 to 5 percent slopes (BaC).**—This soil occurs where the loessal uplands slope off toward the sandstone breaks along drainageways. It is mainly in the southern part of the county. The surface layer is about 4 inches thick. The subsoil is clay loam about 8 inches thick. Included in mapping were small areas of Baca silt loam, 0 to 3 percent slopes; a few spots of Kim soils, on the more sloping parts of the landscape; and a few small areas of

the shallow Travessilla soils, where the Baca soil borders the sandstone breaks.

This soil takes in water moderately well and has a high water-holding capacity. Runoff is moderate. The erosion hazard is moderate.

All of the acreage is used as range. Rotating and deferring grazing and providing for good distribution of livestock by proper placement of water and salt are good practices in range management. (Capability unit VIe-1, nonirrigated; Loamy Plains range site)

## Bankard Series

The Bankard series consists of nearly level, calcareous, mainly sandy soils that formed in stratified, limy, sandy alluvium. These soils are adjacent to the main channel of the Arkansas River.

In a typical profile the surface layer is grayish-brown loam about 4 inches thick. The next layer is grayish-brown, limy fine sand about 8 inches thick. In spots it is mottled in the lower part because of a fluctuating water table. The underlying material is sandy alluvium that is dominantly grayish brown. Gravel is at a depth of about 37 inches.

Bankard soils are excessively drained. Internal drainage is very rapid, and the water-holding capacity is low. Runoff is very slow. The water table is high when the water is high in the river, and flooding is a hazard. Natural fertility is low. The erosion hazard is moderate.

Because these soils are sandy and subject to frequent flooding, they are not suitable for cultivation. They are used as pasture, and they supply good grazing throughout the year. Cottonwoods and tamarisk protect cattle during periods of bad weather.

Typical profile of a Bankard loam (1,800 feet north and 330 feet west of SE. corner SW $\frac{1}{4}$  sec. 5, T. 23 S., R. 52 W.):

- A1—0 to 4 inches, grayish-brown (10YR 5/2) loam, dark grayish brown (10YR 4/2) when moist; structure breaks from weak, medium, platy to weak, fine, granular; hard when dry, friable when moist; strongly calcareous; clear, smooth boundary.
- AC—4 to 12 inches, grayish-brown (10YR 5/2) fine sand, dark grayish brown (10YR 4/2) when moist; single grain; slightly firm when dry, loose when moist; strongly calcareous; clear, smooth boundary.
- Cl—12 to 37 inches, loamy fine sand; color dominated by colors of individual grains, generally grayish brown (10YR 5/2) when moist; single grain; loose when dry and moist; strata of loamy sand and sand range in thickness from a fraction of an inch to several inches.
- IIC2—37 to 60 inches, river gravel.

The A1 horizon ranges from 2 to 8 inches in thickness and from loam to loamy sand in texture. The Cl horizon ranges from 20 to 60 inches in thickness. It is light grayish brown or grayish brown in color and in places is mottled in the lower part. It is limy to very strongly limy.

Bankard soils are more sandy than Glenberg soils. They are also more sandy than Las Animas soils, and they lack salts and the other evidences of poor drainage that are typical of those soils.

**Bankard soils** (0 to 1 percent slopes) (Bd).—These soils occur as irregularly shaped areas, 10 to 100 acres in size, on the flood plain adjacent to the main channel of the Arkansas River. The surface layer is loam to loamy sand 2 to 8 inches thick. The next layer is loamy sand to sand about 15 inches thick. This material is highly stratified. In places river gravel occurs at a depth of only about 20 inches. Included in mapping were spots of Glenberg sandy

loam, which occur on the slightly raised parts of the landscape, generally farther away from the river channel than the Bankard soils are; and areas of Las Animas soils, 1 or 2 acres in size, which occur as slight depressions.

These soils are not suited to cultivated crops because they are sandy and subject to flooding. They take in water rapidly but have a low water-holding capacity. They are subject to deposition of sand and silt during floods, and to bank cutting during floods and during periods when the channel changes location. Runoff is very slow. The erosion hazard is moderate.

All of these soils are used as pasture. They supply substantial amounts of usable forage during periods of low water. (Capability unit IVs-2, irrigated; capability unit VIw-2, nonirrigated; Sandy Bottom Land range site)

## Cascajo Series

The Cascajo series consists of strongly sloping to very strongly sloping soils that are shallow over limy, very sandy and gravelly outwash. These soils are mainly in the north-central part of the county, just north of the John Martin Reservoir.

In a typical profile the surface layer is pale-brown gravelly loam about 5 inches thick. The next layer is light brownish-gray gravelly loam that grades to gravel and sand at a depth of about 10 inches. The gravel and sand are very limy. Generally the underside of the gravel (fig. 5) is lime coated.

These soils are too gravelly and too shallow to be suited to cultivated crops. They are naturally well drained. They have rapid internal drainage, rapid permeability, and a low water-holding capacity. Natural fertility is low. There is no significant hazard of soil blowing or of water erosion, because of the very gravelly surface layer.

The entire acreage is used as range.

Typical profile of a Cascajo gravelly loam (60 feet south and 1.5 miles east of road junction, sec. 1, T. 23 S., R. 50 W.):

- A1—0 to 5 inches, pale-brown (10YR 6/3) gravelly loam, dark grayish brown (10YR 4/2) when moist; massive; loose when dry, very friable when moist; noncalcareous; clear, smooth boundary; much fine gravel.
- AC—5 to 10 inches, light brownish-gray (10YR 6/2) gravelly loam, brown (10YR 5/3) when moist; massive; soft when dry, very friable when moist; very strongly calcareous; clear, smooth boundary; many roots; a little lime-coated gravel.
- C1ca—10 to 17 inches, very pale brown (10YR 7/3) limy gravel and sand, pale brown (10YR 6/3) when moist; massive; abrupt, smooth boundary; much coarse, lime-coated gravel, coated mainly on the underside; very strongly calcareous.
- C2—17 to 60 inches, relatively clean gravel and sand; strongly calcareous.

The A1 horizon ranges from 4 to 6 inches in thickness and from gravelly loam to gravelly sandy loam in texture. The AC horizon ranges from 5 to 12 inches in thickness and grades into very limy gravel. These soils become shallower with increasing slope.

Cascajo soils are more gravelly than either Harvey or Stoneham soils.

**Cascajo soils and gravelly land** (5 to 20 percent slopes) (Ca).—This unit is about 60 percent Cascajo soils and about 30 percent very steep, rough, broken areas of gravel. It occurs as elongated, irregularly shaped areas, mainly in the north-central part, just north of the John Martin



Figure 5.—Profile of Cascajo gravelly loam. Lime has accumulated on underside of gravel.

Reservoir, and as scattered small areas throughout the county. These areas are strongly sloping and hilly. Cascajo soils are gravelly loam in texture to a depth of about 15 inches. Their slope is generally less than 12 percent. Included in mapping were spots of Harvey loam, on more level parts of the landscape, and spots of Stoneham loam, on more level parts and also in slight depressions.

These soils take in water readily but have a low water-holding capacity. Runoff is slow to medium. The erosion hazard is slight to moderate.

None of the acreage has ever been cultivated. All of it is used as range. Deferment and rotation of grazing help in improving vegetation and controlling erosion. (Capability unit VII<sub>s</sub>-4, nonirrigated; Gravel Breaks range site)

### Colby Series

The Colby series consists of gently sloping, limy soils that formed in silty, limy loess. These soils occur in all

parts of the county. The largest acreages are in the eastern third.

In a typical profile the surface layer is light brownish-gray to grayish-brown silt loam about 6 inches thick. Below this, to a depth of about 29 inches, is pale-brown silt loam. This material has very weak, coarse, subangular blocky structure and contains a few white lime spots about a quarter of an inch in diameter. The rest of the profile, to a depth of 60 inches, is light yellowish-brown, strongly calcareous, massive silt loam.

Colby soils are naturally well drained. They have slow to medium runoff, moderate permeability, and a high water-holding capacity. They are high in natural fertility. If cultivated or overgrazed, they are susceptible to blowing and to water erosion.

Most of the acreage is used as range. Much of it has been plowed and dryfarmed but has now reverted to grass. Large acreages have been planted to grass.

Typical profile of a Colby silt loam (400 feet east of SW. corner sec. 29, T. 23 S., R. 53 W.) :

A11—0 to 3 inches, light brownish-gray (10YR 6/2) silt loam, dark grayish brown (10YR 4/2) when moist; weak, coarse, platy structure to weak, fine, granular; slightly hard when dry, very friable when moist; strongly calcareous; clear, smooth boundary.

A12—3 to 6 inches, grayish-brown (10YR 5/2) silt loam, dark grayish brown (10YR 4/2) when moist; very weak, coarse, subangular blocky structure; slightly hard when dry, very friable when moist; strongly calcareous; clear, smooth boundary.

AC—6 to 11 inches, pale-brown (10YR 6/3) silt loam, dark grayish brown (10YR 4/2) when moist; very weak, coarse, prismatic structure; slightly hard when dry, very friable when moist; very strongly calcareous; clear, smooth boundary.

C1ca—11 to 29 inches, pale-brown (10YR 6/3) silt loam, brown (10YR 5/3) when moist; very weak, coarse, subangular blocky structure; slightly hard when dry, very friable when moist; clear, smooth boundary; about 5 percent white lime spots.

C2ca—29 to 60 inches, light yellowish-brown (10YR 6/4) silt loam, brown (10YR 5/3) when moist; massive; hard when dry, very friable when moist; strongly calcareous; weak accumulation of calcium carbonate.

The A horizon ranges from 3 to 8 inches in thickness and from silt loam to fine sandy loam in texture. It is generally limy at the surface but in spots is leached to a depth of 2 or 3 inches. The C horizon is uniformly silt loam.

Colby soils have less distinct horizons than Wiley soils. They generally are strongly calcareous throughout the profile, whereas Wiley soils are noncalcareous in the A and B<sub>1</sub> horizons. Colby soils are not so deeply leached as Baca soils. Also, they lack the strong, well-defined structure of those soils. They are more silty than Kim soils.

### Colby fine sandy loam, 0 to 3 percent slopes (CbB).—

This soil is on the uplands in the central part of the county, mainly south of the Arkansas River. It occurs as irregularly shaped areas 100 acres or more in size. The surface layer is about 6 inches thick. The rest of the profile, to a depth of 45 inches or more, is silt loam in texture. Included in mapping were spots of Wiley silt loam, on the less sloping parts of the landscape; a few areas of nearly level Baca soils; and spots of Colby silt loam, 6 to 25 percent slopes, which occur where the uplands slope off toward the drainageways.

This soil takes in water readily and has a high water-holding capacity. Runoff is slow to medium, and the hazard of water erosion is moderate. The hazard of soil blowing is moderate to severe unless a good vegetative cover is maintained.

Most of the acreage is used as range. A small part is farmed to wheat and sorghum. Rotation and deferment of grazing and reseeding of grass help in maintaining vegetation and controlling erosion. (Capability unit VIe-1, nonirrigated; Loamy Plains range site)

**Colby silt loam, 0 to 1 percent slopes (CoA).**—This soil occurs in all parts of the county but is mostly in the southern part. It is on the uplands, on terraces, and along small drainageways. Generally it occurs as irregularly shaped areas 40 to 60 acres or more in size. The texture is silt loam to a depth of about 45 inches or more. The surface layer is about 6 inches thick. Included in mapping were spots of Wiley silt loam, in slightly depressed parts of the landscape, and a few areas of Kim loam, in the more sloping areas.

This soil can be used for all crops grown in the county. It is easy to work. It takes in water at a moderate rate and has a high water-holding capacity. Runoff is medium, and the erosion hazard is moderate. In dryfarmed areas the hazard of soil blowing is severe. In irrigated areas the response to management is good.

Almost all of the acreage is used as range. A small part is irrigated and used for crops. Leveling saves irrigation water and makes uniform application easier. Barnyard manure and green-manure crops replenish the organic-matter content and improve fertility and tilth on the irrigated acreages. (Capability unit I-1, irrigated; capability unit VIe-1, nonirrigated; Loamy Plains range site)

**Colby silt loam, 1 to 3 percent slopes (CoB).**—This soil is mainly in the eastern part of the county. It occurs as irregularly shaped areas 100 acres or more in size. The texture is silt loam to a depth of about 45 inches or more. The surface layer is about 6 inches thick. Included in mapping were spots of the more nearly level Wiley silt loam, small areas of nearly level Baca silt loam, and spots of Colby silt loam, 0 to 1 percent slopes.

This soil has a high level of fertility. It takes in water at a moderate rate and has a high water-holding capacity. Runoff is medium, and the hazard of water erosion is severe. The hazard of soil blowing is moderate to severe unless a vegetative cover is maintained. The response to management is good in irrigated areas.

About all of the acreage is used as range. Wheat is grown in a few places, and part of this acreage is irrigated. Leveling conserves irrigation water and makes uniform application easier. Barnyard manure and green-manure crops replenish the organic-matter content and improve fertility and tilth on irrigated acreages. Rotating and deferring grazing and reseeding grass are important practices in keeping the range productive. (Capability unit IIe-2, irrigated; capability unit VIe-1, nonirrigated; Loamy Plains range site)

**Colby silt loam, 6 to 25 percent slopes (CoE).**—This soil occurs as scattered small areas, elongated in shape, along the edges of drainageways, mainly in the eastern part of the county. The original surface layer, which was about 6 inches thick, has been eroded away in most areas, and there are numerous gullies 2 to 4 feet deep. Included in mapping were small areas of Colby silt loam, 1 to 3 percent slopes.

All of the acreage is used as range. Runoff is rapid, and the erosion hazard is severe. Restriction of grazing would help in maintaining a good grass cover and in controlling erosion. Dams and diversions would prevent the accumula-

tion of excess water. (Capability unit VIe-1, nonirrigated; Loamy Plains range site)

## Deertrail Series

The Deertrail series consists of nearly level to gently sloping, deep, moderately alkaline to strongly alkaline soils that formed in limy, saline alluvium derived from shale and shaly limestone. These soils occur in all parts of the county.

In a typical profile the surface layer is light brownish-gray light clay loam about 6 inches thick. The subsoil is grayish-brown clay loam to pale-brown silty clay loam about 14 inches thick. This layer has prismatic structure that breaks to medium blocky. The substratum is pale-brown silty clay loam to a depth of 60 inches.

These soils are naturally well drained. They have slow to medium runoff, medium internal drainage, moderate permeability, and a high water-holding capacity. Natural fertility is high. The salt content is high enough to affect plants. Soil blowing and water erosion are hazards. The response to range management is good.

The entire acreage is used as range. Some of it was plowed, but farming was extremely difficult because the soils were so highly alkaline. Most of the acreage that was plowed is severely eroded, and the reversion to grass has been very slow.

Typical profile of a Deertrail clay loam (410 feet east and 410 feet south of NW. corner sec. 16, T. 25 S., R. 52 W.):

- A11—0 to 3 inches, light brownish-gray (10YR 6/2) light clay loam, dark grayish brown (10YR 4/2) when moist; weak to moderate, platy structure to weak, fine, granular; slightly hard when dry, friable when moist; calcareous; clear, smooth boundary.
- A12—3 to 6 inches, light brownish-gray (10YR 6/2) light clay loam, dark grayish brown (10YR 4/2) when moist; weak, medium and fine, subangular blocky structure; hard when dry, friable when moist; calcareous; clear, smooth boundary.
- B2t—6 to 13 inches, grayish-brown (10YR 5/2) clay loam, dark grayish brown (10YR 4/2) when moist; weak, medium, prismatic structure to moderate, medium and fine; subangular blocky; very hard when dry, firm when moist; strongly calcareous; thin, patchy clay skins; clear, smooth boundary.
- B3cssa—13 to 20 inches, pale-brown (10YR 6/3) silty clay loam, brown (10YR 5/3) when moist; very weak, coarse, prismatic structure to weak, coarse, subangular blocky structure; hard when dry, friable when moist; strongly calcareous; gradual, smooth boundary; few visible salt and gypsum spots.
- Ccssa—20 to 60 inches, pale-brown (10YR 6/3) silty clay loam, brown (10YR 5/3) when moist; massive; hard when dry; friable when moist; strongly calcareous; gradual, smooth boundary; common salt and gypsum spots.

The A horizon ranges from 4 to 8 inches in thickness and from loam to clay loam in texture. It is moderately limy. The B2t horizon ranges from 6 to 15 inches in thickness, from clay loam to light clay in texture, and from grayish brown to brown in color. Gypsum crystals are visible in the B3 and C horizons.

Deertrail soils are finer textured, contain more salts, and are more deeply developed than Stoneham soils. They have a more clayey subsoil and are deeper over shale and limestone than Minnequa soils. They have a thicker and finer textured subsoil and contain more salts than Wiley soils.

**Deertrail clay loam, 0 to 5 percent slopes (DeB).**—This soil occurs in all parts of the county. Included in mapping were spots of Wiley silt loam, on raised parts of the land-

scape; a few areas of Minnequa loam, on the more sloping parts; and small areas of Arvada clay loam, in slight depressions.

If cultivated, this soil is difficult to manage. Water intake is moderate, but the water-holding capacity is high. Runoff is medium. The hazards of soil blowing and water erosion are moderate. The areas once plowed are eroded.

The entire acreage is used as range. Deferment and rotation of grazing, reseeding, and proper distribution of livestock increase the vigor of the native grass. (Capability unit VIe-2, nonirrigated; Alkaline Plains range site)

## Dune Land

Dune land (Du) consists of deep, loose, windblown sand and loamy sand in blown-out areas and active sand dunes. It consists of areas that were once cultivated and areas where the vegetation has been destroyed. It occurs along the Arkansas River and extends across the county from east to west. Included in mapping were spots of the sandy Tivoli soils, which occur in the less sloping areas.

In its present condition, Dune land is essentially wasteland, suitable only for recreational purposes. Reestablishing vegetation on the dunes would be difficult and expensive. The Tivoli soils support some vegetation. (Capability unit VIIIIs-1, nonirrigated)

## Dwyer Series

The Dwyer series consists of gently sloping to strongly sloping soils that formed in calcareous, windblown sand. These soils are in the sandhills on the west county line, just south of the Arkansas River.

In a typical profile the surface layer is grayish-brown loose sand about 5 inches thick. The next layer is brown loose sand about 11 inches thick. Below this, to a depth of 60 inches or more, is yellowish-brown sand.

Dwyer soils are highly susceptible to blowing. They are excessively drained. Internal drainage is rapid, permeability is rapid, and the water-holding capacity is low. Natural fertility is low.

These soils are not suitable for cultivation. The entire acreage is used as range.

Typical profile of Dwyer sand (345 feet east and 0.8 mile south of NW. corner sec. 30, T. 23 S., R. 53 W.):

- A1—0 to 5 inches, grayish-brown (10YR 5/2) sand, dark grayish brown (10YR 4/2) when moist; single grain; loose when dry, slightly coherent when moist; non-calcareous; clear, smooth boundary.
- AC—5 to 16 inches, brown (10YR 5/3) sand, brown to dark brown (10YR 4/3) when moist; single grain; loose when dry, slightly coherent when moist; noncalcareous; clear, smooth boundary.
- C1—16 to 26 inches, yellowish-brown (10YR 5/4) sand, brown (10YR 5/3) when moist; very soft when dry, slightly coherent when moist; calcareous; clear, smooth boundary.
- C2—26 to 60 inches, light yellowish-brown (10YR 6/4) medium sand, brown (10YR 5/3) when moist; single grain; loose when dry, loose when moist; strongly calcareous.

The A1 horizon ranges from 4 to 8 inches in thickness and from loamy sand to sand in texture. It is lime free. The AC horizon ranges from 8 to 12 inches in thickness and from loamy sand to sand in texture. The depth to lime is 10 to 20 inches.

Dwyer soils are not so deeply leached of lime as Tivoli soils. They are sandier and less limy than Otero soils.

**Dwyer sand** (5 to 20 percent slopes) (Dw).—This soil occurs as gently rolling to strongly sloping, irregularly shaped areas along the western edge of the county, just south of the Arkansas River. Included in mapping were spots of Tivoli sand, on the more nearly level parts of the landscape, and a few small areas of Otero loamy sand, on the more sloping parts.

This soil is highly susceptible to blowing if the vegetation is destroyed. It takes in water very rapidly but has a low water-holding capacity. There is little or no runoff. The hazard of water erosion is slight.

All of the acreage is used as range. (Capability unit VIe-4, nonirrigated; Deep Sand range site)

## Glenberg Series

The Glenberg series consists of nearly level to gently sloping, limy soils that are moderately deep to deep over sand and gravel. These soils are in the valleys, mainly along the Arkansas River.

In a typical profile the surface layer is grayish-brown sandy loam about 6 inches thick. The next layer is brown sandy loam about 5 inches thick. In places it contains pebbles. The underlying material is pale-brown alluvium. The upper part is sandy loam and the lower part is loamy sand.

Glenberg soils are easy to work. They are naturally well drained. Internal drainage is medium to rapid, permeability is moderately rapid, and the water-holding capacity is moderate. Runoff is slow. Natural fertility is moderate. Erosion is a hazard in sloping areas. The response to management is good.

For the most part, these soils are well suited to crops. They are especially well suited to vegetable crops. Most of the acreage is irrigated. Some uncleared areas have stands of grass, tamarisk, cottonwood, and willow. These areas are used as pasture.

Typical profile of a Glenberg sandy loam (300 feet south and 600 feet west of NE. corner NW $\frac{1}{4}$  sec. 24, T. 23 S., R. 52 W.):

- Ap—0 to 6 inches, grayish-brown (10YR 5/2) sandy loam, dark grayish brown (10YR 4/2) when moist; weak, fine, granular structure; slightly hard when dry, friable when moist; strongly calcareous; clear, smooth boundary.
- AC—6 to 11 inches, brown (10YR 5/3) sandy loam, dark brown (10YR 4/3) when moist; massive; slightly hard when dry, friable when moist; strongly calcareous; clear, smooth boundary.
- C1—11 to 17 inches, pale-brown (10YR 6/3) sandy loam, brown (10YR 4/3) when moist; massive; slightly hard when dry, very friable when moist; very strongly calcareous; clear, smooth boundary.
- C2—17 to 40 inches, pale-brown (10YR 6/3) sandy loam, brown (10YR 5/3) when moist; massive; slightly hard when dry, very friable when moist; very strongly calcareous; clear, smooth boundary.
- C3—40 to 60 inches, pale-brown (10YR 6/3) loamy sand, brown (10YR 5/3) when moist; massive; loose; very strongly calcareous.

The A horizon ranges from 4 to 8 inches in thickness and from sandy loam to loam in texture. The AC horizon ranges from 5 to 12 inches in thickness and from brown to dark brown in color. In places the C horizon is mottled below a depth of 30 inches. In places there is a IIC horizon of sand and gravel at a depth of 20 to 60 inches.

Glenberg soils are coarser textured than Colby soils. They are better drained than Las Animas soils. They are less sandy and are deeper over sand and gravel than Bankard soils.

**Glenberg sandy loam, 0 to 1 percent slopes (GbA).**—This soil occurs as irregularly shaped areas, 10 to 100 acres in size, along the Arkansas River and some of the larger streams. It has the profile described as typical for the series. Sand and gravel are generally at a depth between 40 and 60 inches. Included in mapping were spots of Bankard soils, on slightly lower parts of the landscape; a few spots of Las Animas soils, in depressed areas; and small areas of Las clay loam, 0 to 1 percent slopes.

This soil is easy to work. It is particularly well suited to vegetable crops. It takes in water readily and has a moderate water-holding capacity. Runoff is slow. The erosion hazard is slight.

Almost all of the acreage is irrigated. On uncleared areas the vegetation consists of tamarisk, cottonwood, willow, and brush. These areas are used for grazing. (Capability unit IIs-2, irrigated; capability unit VIw-2, non-irrigated; Sandy Bottom Land range site)

**Glenberg sandy loam, 1 to 3 percent slopes (GbB).**—This soil occurs as irregularly shaped areas, generally less than 30 acres in size, along the Arkansas River and some of the other larger drainageways. The surface layer is about 5 inches thick. Gravel and sand are at a depth between 30 and 50 inches. Included in mapping were spots of Bankard soils, on lower parts of the landscape; a few spots of Las Animas soils, in slightly depressed areas; and small areas of Glenberg sandy loam, 0 to 1 percent slopes.

This soil is easy to work. It takes in water readily and has a moderate water-holding capacity. Runoff is slow to medium. The erosion hazard is moderate.

About half the acreage is irrigated. On the rest, the vegetation consists of tamarisk, cottonwood, and willow. This acreage is used for grazing. (Capability unit IIIe-2, irrigated; capability unit VIw-2, nonirrigated; Sandy Bottom Land range site)

**Glenberg sandy loam, gravel substratum, 0 to 1 percent slopes (GeA).**—This soil occurs along the Arkansas River and some of the other large stream bottoms, generally within larger areas of Glenberg sandy loam, 0 to 1 percent slopes. Most areas are 5 to 10 acres in size. A few are larger. The profile of this soil is similar to that described as typical for the series, but gravel and sand generally are at a depth between 20 and 30 inches. Included in mapping were a few spots of Glenberg sandy loam, 1 to 3 percent slopes, and a few spots of Bankard soils, which occur on slightly lower parts of the landscape.

This soil is easy to work. It is used for most crops grown in the area. Because of its moderately coarse texture, it is well suited to the vegetable crops that require a lot of cultivation. It takes in water readily and has a moderate to low water-holding capacity. Runoff is slow. The erosion hazard is slight. Natural fertility is low to moderate.

Most of the acreage is irrigated. The vegetation in the few small uncleared areas consists of tamarisk, cottonwood, and willow. These areas are used for grazing. (Capability unit IIIs-2, irrigated; capability unit VIw-2, nonirrigated; Sandy Bottom Land range site)

## Harvey Series

The Harvey series consists of deep, gently sloping, limy soils. These soils are on uplands north of the Arkansas River.

In a typical profile the surface layer is light brownish-gray loam about 4 inches thick. Below this, to a depth of about 21 inches, is pale-brown to light yellowish-brown loam. This layer has weak blocky to prismatic structure. The underlying material is pale-brown loam and sandy loam. It contains fine gravel.

Harvey soils are naturally well drained. Internal drainage is medium, permeability is moderate, and the water-holding capacity is high. Natural fertility is high. Sloping areas are susceptible to water erosion. The response to management is good.

All of the acreage is used as range.

Typical profile of a Harvey loam (1,800 feet east and 60 feet south of NW. corner sec. 35, T. 22 S., R. 49 W.):

- A—0 to 3 inches, light brownish-gray (10YR 6/2) loam, dark grayish brown (10YR 4/2) when moist; weak, fine, platy structure to weak, fine, granular; slightly hard when dry, friable when moist; calcareous; abrupt, smooth boundary; some fine gravel in profile and on surface.
- AC—3 to 9 inches, pale-brown (10YR 6/3) loam, brown (10YR 5/3) when moist; very weak, medium, subangular blocky structure; hard when dry, friable when moist; very strongly calcareous; clear, smooth boundary; some fine gravel.
- C1ca—9 to 21 inches, light yellowish-brown (10YR 6/4) loam, yellowish brown (10YR 5/4) when moist; very weak, medium, prismatic structure; hard when dry, friable when moist; very strongly calcareous; strong Ca horizon with lime concretions and mycelia visible; smooth boundary; small amount of fine gravel.
- C2ca—21 to 40 inches, very pale brown (10YR 7/3) loam, brown (10YR 5/3) when moist; massive; hard when dry, friable when moist; very strongly calcareous; many lime spots; clear, smooth boundary; some fine gravel.
- C3cacs—40 to 60 inches, pale-brown (10YR 6/3) sandy loam, brown (10YR 5/3) when moist; massive; hard when dry, friable when moist; very strongly calcareous; common seams of calcium carbonate and gypsum.

The A horizon ranges from 3 to 6 inches in thickness and from loam to sandy loam in texture. The AC horizon ranges from 5 to 10 inches in thickness and from brown to pale brown in color. It is 1 to 5 percent gravel. The C horizon is more gravelly in areas adjacent to Cascajo soils.

Harvey soils are more gravelly than Colby soils and have more lime in the C horizon. They are coarser textured and better drained than Las soils. They are less clayey below the surface layer than Stoneham soils.

**Harvey loam, 1 to 9 percent slopes (HcC).**—This soil is mainly in the north-central part of the county, just north of the Arkansas River. The areas are 50 acres or more in size and are generally longer than they are wide. Included in mapping were spots of Colby soils, which are more level, and small areas of Stoneham soils.

This soil takes in water at a moderate rate and has a high water-holding capacity. Runoff is medium. If the vegetation has been depleted, the erosion hazard is moderately severe. A few small fields that were once cultivated are moderately eroded.

All of the acreage is used as range. Deferring and rotating grazing and reseeding grass are important practices. (Capability unit VIe-1, nonirrigated; Loamy Plains range site)

## Kim Series

The Kim series consists of nearly level to strongly sloping, deep, limy soils. These soils occur as scattered areas throughout the southwestern part of the county.

In a typical profile the surface layer is light brownish-gray loam about 4 inches thick. Below this is pale-brown to brown loam that in places contains sandstone chips. The uppermost few inches of this material has weak blocky structure; the rest is massive. Below a depth of about 34 inches is brown clay loam. The sandstone chips increase in number with increasing depth.

Kim soils are well drained. Internal drainage is medium, permeability is moderate, and the water-holding capacity is high. Runoff is medium. Natural fertility is high. Sloping areas are susceptible to water erosion. The response to range management is good.

About all the acreage is used as range. A few fields were plowed and dryfarmed but have been abandoned and have reverted to grass.

Typical profile of a Kim loam (50 feet west and 0.85 mile south of NE. corner sec. 3, T. 26 S., R. 52 W.):

- A1—0 to 4 inches, light brownish-gray (10YR 6/2) loam, dark grayish brown (10YR 4/2) when moist; structure breaks from weak, coarse, platy to weak, fine, granular; slightly hard when dry, very friable when moist; noncalcareous; clear, smooth boundary.
- AC—4 to 11 inches, pale-brown (10YR 6/3) loam, dark brown (10YR 4/3) when moist; very weak, coarse, subangular blocky structure; hard when dry, friable when moist; very strongly calcareous; gradual, smooth boundary.
- C1—11 to 19 inches, brown (10YR 5/3) loam, dark grayish brown (10YR 4/2) when moist; massive; hard when dry, friable when moist; very strongly calcareous; gradual, smooth boundary; few sandstone chips.
- C2—19 to 34 inches, pale-brown (10YR 6/3) loam, brown (10YR 5/3) when moist; massive; hard when dry, friable when moist; very strongly calcareous; gradual, smooth boundary; few sandstone chips.
- C3—34 to 60 inches, brown (10YR 5/3) light clay loam, dark yellowish brown (10YR 4/4) when moist; massive; hard when dry, friable when moist; very strongly calcareous; gradual, wavy boundary; sandstone chips increase in number with increasing depth.

Generally these soils are limy to the surface, but in places they are leached of lime to a depth of 8 inches. The A1 horizon ranges from 3 to 6 inches in thickness and from sandy loam to loam in texture. The C horizon is uniformly loam. The depth to sandstone ranges from 40 to 60 inches or more.

Kim soils are coarser textured than Baca soils. They are less clayey below the surface layer than Manzanola soils. They are much deeper over sandstone than Travessilla soils.

**Kim loam, 0 to 5 percent slopes (KMB).**—This soil is in the southwestern part of the county. It generally occupies foot slopes and fans adjacent to sandstone escarpments and hills. Most areas are between 40 and 100 acres in size; a few are larger. The depth to sandstone is generally more than 40 inches. Sandstone fragments are scattered throughout the profile. Included in mapping were areas of Manzanola clay loam, on lower, more level parts of the landscape; spots of Baca silt loam; and areas of Travessilla sandy loam.

This soil has high natural fertility. It takes in water at a moderate rate and has a high water-holding capacity. Runoff is medium. The erosion hazard is moderate.

The entire acreage is used as range. Deferment and rotation of grazing and reseeding of grass help in maintaining vegetation and controlling erosion. Some fields were plowed and then abandoned and are reverting to grass. (Capability unit VIe-1, nonirrigated; Loamy Plains range site)

## Kornman Series

The Kornman series consists of nearly level to gently sloping, limy soils that formed in stratified alluvium. These soils are on bottom land and low terraces. The texture of the surface layer has been altered by the recent deposition of fine-textured material carried by muddy irrigation water.

In a typical profile the surface layer is grayish-brown, limy clay loam about 11 inches thick. Below this is grayish-brown sandy loam. The uppermost few inches of this layer has weak, blocky structure. The rest is massive. The texture grades to loamy sand at a depth of about 25 inches.

Kornman soils are naturally well drained. Internal drainage is medium to rapid, permeability is moderate, and the water-holding capacity is moderate to high. Natural fertility is moderate. The erosion hazard is slight to moderate. The response to management is good. The fine-textured material deposited by muddy irrigation water is the main limitation. As the surface layer becomes finer textured, it becomes more difficult to work.

The entire acreage is irrigated.

Typical profile of a Kornman clay loam (1,310 feet east and 1,000 feet north of SW. corner sec. 8, T. 23 S., R. 51 W.):

- Ap1—0 to 6 inches, grayish-brown (10YR 5/2) clay loam, very dark grayish brown (10YR 3/2) when moist, dark grayish brown (10YR 4/2) if crushed when moist; structure breaks from weak, fine, subangular blocky to weak, fine, granular; very hard when dry, firm when moist; very strongly calcareous; abrupt, smooth boundary.
- Ap2—6 to 11 inches, grayish-brown (10YR 5/2) clay loam, very dark grayish brown (10YR 3/2) when moist, dark grayish brown (10YR 4/2) if crushed when moist; weak to strong, medium, subangular blocky structure; very hard when dry, firm when moist; strongly calcareous; clear, smooth boundary.
- AC—11 to 17 inches, grayish-brown (10YR 5/2) sandy loam, very dark grayish brown (10YR 3/2) when moist, dark grayish brown (10YR 4/2) if crushed when moist; very weak, coarse, subangular blocky structure to massive; hard when dry, very friable when moist; strongly calcareous; clear, smooth boundary.
- C1—17 to 25 inches, grayish-brown (10YR 5/2) sandy loam, dark grayish brown (10YR 4/2) when moist; massive; slightly hard when dry, very friable when moist; strongly calcareous; abrupt, smooth boundary.
- C2—25 to 60 inches, grayish-brown (10YR 5/2) loamy sand, brown (10YR 4/3) when moist; massive; soft when dry, very friable when moist; highly calcareous.

The A horizon ranges from 8 to 16 inches in thickness and from clay loam to silty clay in texture, depending on the amount of siltation. The AC and C1 horizons are sandy loam. Their total thickness ranges from 10 to 40 inches. The C2 horizon grades from loamy sand to sand and gravel. In places the C horizon is mottled.

Kornman soils have a finer textured surface layer than Glenberg soils. They are coarser textured below the surface layer than Rocky Ford soils. They are coarser textured below the surface layer than Las soils, and they also are better drained.

**Kornman clay loam, 0 to 1 percent slopes (KrA).**—This soil occurs as scattered, irregularly shaped areas, generally less than 80 acres in size, along the Arkansas River valley. It is mainly on first bottoms. It has the profile described as typical for the series. Included in mapping were spots, less than 3 acres in size, of Glenberg soils; a few small areas of Rocky Ford clay loam; and a few spots of Las clay loam, which occur in low-lying areas.

This soil is moderate in natural fertility. It has a moderate water-intake rate and a moderate water-holding capacity. Runoff is slow. The erosion hazard is slight.

The entire acreage is irrigated. Leveling conserves water and makes uniform application easier. Green-manure crops and barnyard manure improve fertility, increase the supply of organic matter, and preserve tilth. (Capability unit II<sub>s</sub>-1, irrigated)

**Kornman clay loam, 1 to 3 percent slopes (Kr<sub>B</sub>).**—This soil occurs as scattered areas along the Arkansas River valley, mainly on first bottoms. The surface layer is about 8 inches thick. Included in mapping were small areas of Kornman clay loam, 0 to 1 percent slopes; a few areas of Rocky Ford clay loam, on slightly lower parts of the landscape; and a few spots of Las clay loam, in slightly depressed areas.

This soil is moderate in natural fertility. It has a moderate water-intake rate and a moderate water-holding capacity. Runoff is medium. The erosion hazard is slight to moderate.

The entire acreage is irrigated. Leveling makes uniform application of irrigation water easier. Green-manure crops and barnyard manure improve fertility, increase the supply of organic matter, and preserve tilth. (Capability unit II<sub>e</sub>-1, irrigated)

## Las Series

The Las series consists of nearly level, limy, moderately saline soils that formed in stratified alluvium. These soils occur on bottom land and low terraces.

In a typical profile the surface layer is light brownish-gray clay loam about 12 inches thick. The subsoil extends to a depth of 60 inches or more. This layer is massive. The upper part is light brownish-gray and light yellowish-brown clay loam mottled with gray and yellowish brown. The lower part is clay loam stratified with thin lenses of sandy loam, loam, and clay and is strongly mottled.

Las soils are somewhat poorly drained to poorly drained. Internal drainage is moderate, and permeability is slow to moderate. The water table is at a depth of 30 to 40 inches. Natural fertility is moderate to high. There is no significant hazard of erosion. The response to management is good.

Most of the acreage is cultivated.

Typical profile of Las clay loam (0.5 mile west and 115 feet north of SE. corner sec. 28, T. 22 S., R. 53 W.):

A11—0 to 4 inches, light brownish-gray (10YR 6/2) clay loam, dark grayish brown (10YR 4/2) when moist; weak, fine, granular structure; hard when dry, firm when moist; strongly calcareous; clear, smooth boundary.

A12—4 to 12 inches, light brownish-gray (10YR 6/2) clay loam, dark grayish brown (10YR 4/2) when moist; massive to very weak, medium, subangular blocky structure; hard when dry, firm when moist; strongly calcareous; clear, smooth boundary.

B1g—12 to 20 inches, light brownish-gray (10YR 6/2) clay loam, dark grayish brown (10YR 4/2) when moist; massive; hard when dry, firm when moist; strongly calcareous; few gypsum crystals; few, fine, distinct, gray and yellowish-brown mottles; clear, smooth boundary.

B21g—20 to 25 inches, light yellowish-brown (2.5Y 6/4) clay loam, light olive brown (2.5Y 5/4) when moist; massive; hard when dry, firm when moist; strongly calcareous; common, fine, distinct, gray and yellowish-brown mottles; few gypsum crystals; gradual, smooth boundary.

B22g—25 to 37 inches, light-gray (2.5Y 7/2) sandy clay loam, grayish brown (2.5Y 5/2) when moist; massive; hard when dry, friable when moist; strongly calcareous; common, medium, distinct, yellowish-brown mottles; gradual, smooth boundary.

B23g—37 to 60 inches, light grayish-brown (2.5Y 6/2) clay loam, grayish brown (2.5Y 5/2) when moist; massive; hard when dry, firm when moist; strongly calcareous; many, medium, prominent, yellowish-brown mottles; many gypsum crystals.

The A1 horizon ranges from 4 to 15 inches in thickness and from loam to silty clay loam in texture. The B horizon is light clay loam stratified with thin lenses of clay loam, loam, sandy loam, and loamy sand. In places the B1 horizon is underlain by sand. The depth to mottling ranges from 12 to 30 inches.

Las soils are finer textured than Glenberg soils and have mottles nearer the surface. They are coarser textured and less saline than Apishapa soils. They have a finer textured subsoil than Kornman soils.

**Las clay loam (0 to 1 percent slopes) (lc).**—This soil occurs as irregularly shaped areas along the Arkansas River. The areas generally are between 20 and 40 acres in size. A few are larger. The surface layer is about 6 inches thick. The subsoil is clay loam about 40 inches thick. Included in mapping were spots of Glenberg sandy loam, small areas of Apishapa clay loam, and a few small areas of Las clay loam, sand substratum variant.

This soil is somewhat difficult to work because of wetness and the texture. It is high in natural fertility. It takes in water at a moderate rate and has a high water-holding capacity. Runoff is medium to slow. The erosion hazard is slight.

This soil has to be drained and leached of salts before it can be farmed satisfactorily. Most of the acreage is irrigated. Some of it is used as saltgrass pasture. (Capability unit II<sub>w</sub>-1, irrigated; capability unit VI<sub>w</sub>-1, nonirrigated; Salt Meadow range site)

**Las clay loam, dark variant (0 to 1 percent slopes) (tc).**—This soil is on first bottoms along the Arkansas River. Its profile is darker colored than the profile described as typical for the series because it contains more organic matter. It also has more prominent mottles and grayer colors, both of which indicate poor drainage. Generally the areas are between 10 and 20 acres in size. Included in mapping were spots, less than 3 acres in size, of Las clay loam and small areas of Kornman clay loam.

This soil is moderately difficult to work because of wetness and the texture. It is high in natural fertility. It takes in water at a moderate rate and has a high water-holding capacity. Runoff is slow. The erosion hazard is slight.

This soil has to be drained and leached of salts before it can be farmed satisfactorily. The entire acreage is irrigated. (Capability unit II<sub>w</sub>-1, irrigated)

**Las clay loam, sand substratum variant (0 to 1 percent slopes) (ld).**—This soil occurs as irregularly shaped areas, generally less than 20 acres in size, along the Arkansas River valley. It is only 20 to 40 inches deep over sand and gravel. Included in mapping were areas of Las clay loam, on lower lying parts of the landscape; spots of Glenberg sandy loam, on slightly raised parts; and spots of Kornman soils.

This soil is somewhat difficult to work because of wetness and the texture. It is moderate in natural fertility. It takes in water at a moderate rate and has a moderate water-holding capacity. Runoff is slow.

This soil has to be drained and leached of salts before it can be farmed satisfactorily. Most of the acreage is irrigated. In undrained, uncleared areas the vegetation consists of saltgrass and tamarisk. These areas are used as pasture. (Capability unit IIIw-2, irrigated; capability unit VIw-1, nonirrigated; Salt Meadow range site)

**Las clay loam, sand substratum, dark variant** (0 to 1 percent slopes) (le).—This soil occurs as irregularly shaped areas, generally less than 30 acres in size, along the Arkansas River valley. It is only 20 to 40 inches deep over sand and gravel. Included in mapping were small areas of Las clay loam, on slightly higher parts of the landscape, and areas of Las clay loam, dark variant, on slightly lower parts.

This soil is somewhat difficult to work. It is moderate in natural fertility. It has a moderate water-intake rate and a moderate water-holding capacity. Runoff is slow. The erosion hazard is slight.

This soil has to be drained and leached of salts before it can be farmed satisfactorily. Most of the acreage is irrigated. In undrained, uncleared areas the vegetation consists of saltgrass and tamarisk. These areas are used as pasture. (Capability unit IIIw-2, irrigated)

## Las Animas Series

The Las Animas series consists of nearly level, limy, strongly saline soils that formed in stratified loamy and sandy alluvium. These soils are in low areas along the Arkansas River.

In a typical profile the surface layer is limy loam or sandy loam about 10 inches thick. It is grayish brown and has a few yellowish-brown mottles in the lower part. The subsoil is loamy sand stratified with lenses of sandy loam and sand. This layer is light brownish gray and has many, distinct, medium-gray and yellowish-brown mottles.

Las Animas soils are poorly drained. Runoff is slow, and permeability is moderate to rapid. Flooding is a hazard. The water table fluctuates. It is always within 30 inches of the surface and is sometimes at the surface. Natural fertility is low to moderate. There is no significant hazard of erosion.

These soils are too wet to be suitable for cultivated crops. Most of the acreage is used as pasture.

Typical profile of a Las Animas loam (1,500 feet west and 1,050 feet south of NE. corner sec. 8, T. 23 S., R. 52 W.):

- A11—0 to 5 inches, grayish-brown (2.5Y 5/2) loam, very dark grayish brown (2.5Y 3/2) when moist; weak, fine, platy structure; hard when dry, friable when moist; strongly calcareous; clear, smooth boundary; few, faint, indistinct mottles.
- A12—5 to 10 inches, light brownish-gray (10YR 6/2) loam, dark grayish brown (10YR 4/2) when moist; massive; hard when dry, friable when moist; strongly calcareous; brown rust spots; visible salt spots; clear, smooth boundary.
- B21g—10 to 37 inches, light brownish-gray (10YR 6/2) loamy sand, dark grayish brown (10YR 4/2) when moist; single grain; very strongly calcareous; common, coarse, yellowish-brown and gray mottles; visible salt spots; clear, smooth boundary.
- B22g—37 to 60 inches, light brownish-gray (10YR 6/2) coarse loamy sand, dark grayish brown (10YR 4/2) when moist; single grain; strongly calcareous; many, coarse, yellowish and gray mottles.

The A1 horizon ranges from 4 to 10 inches in thickness and from clay loam to loamy sand in texture. The B horizon ranges from sandy loam to loamy sand. The depth to sand and gravel ranges from 30 to 60 inches.

Las Animas soils are coarser textured than Las soils and Glenberg soils.

**Las Animas soils** (0 to 1 percent slopes) (lm).—These soils occur as irregularly shaped areas 10 to 50 acres in size, mainly along Horse Creek and the Arkansas River. The surface layer ranges from clay loam to loamy sand in texture and is 4 to 10 inches thick. Included in mapping were spots of Bankard soils, which occur on slightly raised parts of the landscape; small areas of Las clay loam, 0 to 1 percent slopes, which generally occur farther back from the river; and areas of Glenberg soils.

These soils are poorly drained and are subject to flooding. Runoff is slow, and permeability is moderate to rapid. Natural fertility is low to moderate. There is no significant hazard of erosion.

These soils are too wet to be used for farm crops. They are difficult to drain because they lack outlets. If drained, they can be used for salt-tolerant crops like barley and sugar beets. Only a small acreage is farmed. Most of the acreage is native range. The vegetation consists of saltgrass, tamarisk, and cottonwood. (Capability unit IVw-1, irrigated; capability unit VIw-1, nonirrigated; Salt Meadow range site)

## Limon Series

The Limon series consists of nearly level, deep, saline soils that formed in limy material derived mainly from shale. These soils are on old terraces and flood plains in the northwestern and central parts of the county.

In a typical profile the surface layer is grayish-brown and brown clay about 4 inches thick. Below this, to a depth of about 36 inches, is clay or silty clay. The uppermost 10 inches has weak blocky structure. The rest is massive. The underlying material is light olive-brown to light yellowish-brown, massive, limy clay loam.

Except for a few wet spots in the lower part of the substratum, these soils are well drained. Internal drainage is slow, permeability is slow, and the water-holding capacity is high. Natural fertility is high. The erosion hazard is moderate to severe. The response to management is poor.

The entire acreage is used as range.

Typical profile of Limon clay (0.45 mile north and 0.15 mile east of SW. corner sec. 7, T. 21 S., R. 52 W.):

- A1—0 to 2 inches, grayish-brown (2.5Y 5/2) clay, dark grayish brown (2.5Y 4/2) when moist; weak, medium, platy structure to weak, fine, granular; hard when dry, friable when moist; noncalcareous; clear, smooth boundary.
- AC—2 to 4 inches, brown (10YR 5/3) clay, dark brown (10YR 4/3) when moist; weak, fine, subangular blocky structure to weak, fine, granular; hard when dry, very friable when moist; calcareous; clear, smooth boundary.
- C1—4 to 11 inches, grayish-brown (2.5Y 5/2) clay, dark grayish brown (2.5Y 4/2) when moist; weak, coarse, prismatic structure to weak, medium and fine, subangular blocky; very hard when dry, friable when moist; strongly calcareous; slickensides on ped surfaces; clear, smooth boundary.
- C2caes—11 to 14 inches, grayish-brown (2.5Y 5/2) silty clay, dark grayish brown (2.5Y 4/2) when moist; weak, medium and fine, subangular blocky structure; very

hard when dry, very friable when moist; strongly calcareous; clear, smooth boundary; visible salt and gypsum crystals.

- C3cacs—14 to 36 inches, grayish-brown (2.5Y 5/2) silty clay, dark grayish brown (2.5Y 4/2) when moist; massive; very hard when dry, very friable when moist; strongly calcareous; clear, smooth boundary; visible salt and gypsum crystals.
- C4cacs—36 to 43 inches, light olive-brown (2.5Y 5/4) clay loam, olive brown (2.5Y 4/4) when moist; massive; hard when dry, very friable when moist; very strongly calcareous; clear, smooth boundary; few visible salt crystals.
- C5cacs—43 to 60 inches, light yellowish-brown (10YR 6/4) clay loam, yellowish brown (10YR 5/4) when moist; massive; hard when dry, friable when moist; very strongly calcareous; clear, smooth boundary; many visible salt and gypsum crystals.

The A horizon ranges from 2 to 6 inches in thickness and from clay loam to clay in texture. The C horizon is clay loam or clay stratified with silty clay.

Limon soils are finer textured and are deeper over shale and limestone than Minnequa soils. They are finer textured than Deertrail soils. They are finer textured and more strongly saline than Stoneham soils, and they lack the gravel that is characteristic of those soils.

**Limon clay** (0 to 2 percent slopes) (ln).—This soil occurs as irregularly shaped areas generally more than 100 acres in size. It is mainly in the northwestern corner of the county. It has the profile described for the series. Included in mapping were spots of Minnequa soils.

This soil takes in water slowly but has a high water-holding capacity. Runoff is medium to rapid. The erosion hazard is moderate.

The entire acreage is used as range. The vegetation is salt-tolerant native grass. Deferment and rotation of grazing help in maintaining a vegetative cover. (Capability unit VI<sub>s</sub>-1, nonirrigated; Salt Flats range site)

**Limon clay, alkali** (0 to 1 percent slopes) (lo).—One large area of this soil, about 600 acres in size, is in the central part of the county just north of the John Martin Reservoir. There are also a few scattered small areas. The surface layer is light brownish gray and is about 4 inches thick. The next layer is alkaline clay about 10 inches thick. Included in mapping were spots of Minnequa soils, on more sloping parts of the landscape, and a few spots of Limon clay loam, on slightly raised parts.

This soil is difficult to manage. It is very strongly alkaline. It has rapid runoff, takes in water slowly, and has a high water-holding capacity. The erosion hazard is severe.

All of the acreage is used as range. Numerous spots lack vegetation because of the alkali. Small acreages have been plowed and farmed and then abandoned. The fine texture made tillage difficult, and the alkali was toxic to crops. (Capability unit VI<sub>s</sub>-1, nonirrigated; Salt Flats range site)

## Litle Series

The Litle series consists of gently sloping to strongly sloping, saline, alkaline soils that are deep to moderately deep over fine-textured, calcareous shale. These soils occur as scattered areas throughout the southern part of the county.

In a typical profile the surface layer is light brownish-gray to grayish-brown, limy clay loam about 5 inches thick. The subsoil is grayish-brown, very limy, hard clay

about 18 inches thick. Its structure is moderate, coarse, prismatic to moderate, medium, subangular blocky.

Litle soils are naturally well drained. They have rapid runoff, slow permeability, and a high water-holding capacity. They are high in natural fertility but contain enough salts and lime that they are not suited to crops. Water erosion is a hazard, and gullies are common.

The entire acreage is used as native range.

Typical profile of a Litle clay loam (0.25 mile south and 0.2 mile east of NW. corner sec. 7, T. 24 S., R. 53 W.):

- A11—0 to 1 inch, light brownish-gray (2.5Y 6/2) clay loam, dark grayish brown (2.5Y 4/2) when moist; moderate, medium, platy structure to weak, fine, granular; hard when dry, friable when moist; strongly calcareous; abrupt, smooth boundary; scattered limestone chips on the surface.
- A12—1 inch to 5 inches, grayish-brown (2.5Y 5/2) clay loam, dark grayish brown (2.5Y 4/2) when moist; very weak, medium, subangular blocky structure to weak, fine, granular; hard when dry, friable when moist; strongly calcareous; clear, smooth boundary.
- B21—5 to 10 inches, grayish-brown (2.5Y 5/2) clay, olive brown (2.5Y 4/3) when moist; moderate, coarse, prismatic structure to moderate, medium, subangular blocky; very hard when dry, firm when moist; strongly calcareous; thin, patchy clay skins; clear, smooth boundary.
- B22—10 to 14 inches, grayish-brown (2.5Y 5/2) clay, dark grayish brown (2.5Y 4/2) when moist; moderate, coarse, prismatic structure to weak to moderate, medium, subangular blocky; very hard when dry, firm when moist; strongly calcareous; thin, patchy clay skins; clear, smooth boundary.
- B3—14 to 23 inches, grayish-brown (2.5Y 5/2) clay, dark grayish brown (2.5Y 4/2) when moist; weak, coarse, prismatic structure; very hard when dry, firm when moist; very strongly calcareous; few lime spots; gradual, smooth boundary.
- Cca—23 to 35 inches, gray (5Y 5/1) clay, dark gray (5Y 4/1) when moist; massive; very hard when dry, firm when moist; very strongly calcareous; clear, smooth boundary.
- R—35 to 60 inches, very dark gray shale.

The A horizon ranges from 3 to 8 inches in thickness and from clay loam to light clay in texture. It is high in lime. The B2 horizon ranges from 6 to 15 inches in thickness, from clay loam to clay in texture, and from grayish brown to olive brown in color. Crystals of gypsum and salts are visible in the B3 horizon.

Litle soils are finer textured than Minnequa soils. They are deeper over shale than Samsil soils. They are finer textured and more strongly saline than Kim soils.

**Litle clay loam, 1 to 9 percent slopes** (llc).—This soil occurs as scattered areas on foot slopes and fans adjacent to the shale hills in the southern part of the county. Generally the areas are between 40 and 100 acres in size. Included in mapping were small areas of Samsil soils, on raised, slightly steeper parts of the landscape, and spots of Minnequa loam.

This soil takes in water slowly but has a high water-holding capacity. It has slow permeability and slow internal drainage. Runoff is rapid. The erosion hazard is moderate to severe.

The entire acreage is used as native range. Deferring and rotating grazing are good practices in management. Chiseling is beneficial also. Because of the strong alkalinity, salt-tolerant grass should be selected for planting. A few small areas have been plowed and farmed and then abandoned. These areas have reverted to grass. They are moderately to severely eroded. (Capability unit VI<sub>e</sub>-2, nonirrigated; Alkaline Plains range site)

## Manvel Series

The Manvel series consists of nearly level to strongly sloping, deep, limy soils that formed in material presumably weathered from soft limestone. These soils are on uplands, mainly north of the Arkansas River and along the western edge of the county.

In a typical profile the surface layer is light brownish-gray loam about 6 inches thick. The next layer is pale-brown loam about 15 inches thick. It is more limy than the surface layer. It has blocky structure. Below a depth of 21 inches is pale-brown, highly calcareous, massive loam and light clay loam.

Manvel soils are naturally well drained. Internal drainage is medium, permeability is moderate, and the water-holding capacity is high. Natural fertility is high. Soil blowing and water erosion are hazards if vegetation is destroyed.

For the most part, these soils are used as range. Small areas have been dryfarmed.

Typical profile of a Manvel loam (1,225 feet east and 1,848 feet north of SW. corner sec. 35, T. 21 S., R. 53 W.):

- A1—0 to 3 inches, light brownish-gray (10YR 6/2) loam, dark grayish brown (10YR 4/2) when moist; weak, medium, platy structure to weak, fine, granular; soft when dry, very friable when moist; noncalcareous; clear, smooth boundary.
- AC—3 to 6 inches, light brownish-gray (10YR 6/2) loam, dark grayish brown (10YR 4/2) when moist; weak, medium, subangular blocky structure; slightly hard when dry, friable when moist; calcareous; clear, smooth boundary; few limestone chips.
- C1—6 to 10 inches, pale-brown (10YR 6/3) loam, brown (10YR 5/3) when moist; weak, coarse, prismatic structure to weak, medium, subangular blocky; hard when dry, friable when moist; strongly calcareous; clear, smooth boundary; few limestone chips.
- C2—10 to 21 inches, pale-brown (10YR 6/3) loam, brown (10YR 5/3) when moist; weak, medium, subangular blocky structure; hard when dry, friable when moist; violently calcareous; clear, smooth boundary; common lime spots; few limestone chips.
- C3—21 to 34 inches, pale-brown (10YR 6/3) light clay loam, brown (10YR 5/3) when moist; massive; hard when dry, friable when moist; very strongly calcareous; clear, smooth boundary; many limestone chips.
- C4—34 to 60 inches, pale-brown (10YR 6/3) loam, brown (10YR 5/3) when moist; massive; slightly hard when dry, friable when moist; very strongly calcareous; many limestone chips.

The A horizon ranges from loam to sandy loam in texture. The depth to limestone ranges from 40 to more than 60 inches.

Manvel soils are deeper over limestone than Minnequa soils. They are more limy and less sandy than Kim soils. They are coarser textured than Little soils.

**Manvel loam, 1 to 9 percent slopes (MaC).**—This soil occurs as irregularly shaped areas generally more than 100 acres in size. It is on uplands, mainly north of the Arkansas River and along the western edge of the county. It has the profile described for the series. Included in mapping were spots of Minnequa loam, on slightly raised parts of the landscape; a few spots of Penrose channery loam, on the steeper slopes; and a few areas of Little clay loam.

This soil takes in water at a moderate rate and has a high water-holding capacity. Runoff is medium. The erosion hazard is moderate. The hazard of soil blowing is moderate if vegetation is destroyed. The response to management is good.

The entire acreage is used as range. Deferment and rotation of grazing and reseeding of grass help in conserving moisture and controlling erosion. Part of the acreage has been dryfarmed and then abandoned. Some of this has reverted to grass. The rest has been seeded. Most areas that were cultivated are moderately to severely eroded. (Capability unit VIe-1, nonirrigated; Loamy Plains range site)

**Manvel loam, 1 to 9 percent slopes, eroded (MaC2).**—This soil occurs as scattered areas in all parts of the county except the southwestern corner. The acreage is small. The original surface layer was about 4 inches thick. About 25 to 75 percent of it has been removed, mainly through blowing, and the subsoil is exposed in gullies, rills, and thin spots. Most of the gullies are crossable. Generally they are 200 to 300 feet apart. Included in mapping were small, uneroded areas of this soil.

This soil has rapid runoff. The hazards of water erosion and soil blowing are moderately severe.

Some areas have been plowed but are no longer farmed. They are reverting to grass and are used as native range. Reseeding grass and fencing would be beneficial. (Capability unit VIe-1, nonirrigated; Loamy Plains range site)

## Manzanola Series

The Manzanola series consists of nearly level to gently sloping, deep soils that formed in stratified, limy, loamy, old alluvium. These soils are on old alluvial plains and terraces, mainly in the southwestern part of the county.

In a typical profile the surface layer is light brownish-gray clay loam about 6 inches thick. The subsoil is grayish-brown, limy clay loam about 16 inches thick. It is more clayey and more compact than the surface layer. Its structure is coarse prismatic to medium angular blocky.

Manzanola soils are naturally well drained. Internal drainage is medium, permeability is moderate, and the water-holding capacity is high. Natural fertility is high. Soil blowing and water erosion are hazards if the vegetation is destroyed. The response to management is good.

For the most part, these soils are used as range. Small areas in the southwestern part of the county have been cultivated, but most have been abandoned.

Typical profile of a Manzanola clay loam (100 yards north and 0.25 mile west of SE. corner sec. 8, T. 25 S., R. 51 W.):

- A1—0 to 6 inches, light brownish-gray (10YR 6/2) clay loam, dark grayish brown (10YR 4/2) when moist; structure breaks from weak, fine, platy to weak, fine, granular; soft when dry, very friable when moist; strongly calcareous; clear, smooth boundary.
- B2t—6 to 16 inches, grayish-brown (10YR 5/2) clay loam, dark brown (10YR 4/3) when moist; moderate, medium to coarse, prismatic structure to moderate, fine, subangular blocky; hard when dry, friable when moist; very strongly calcareous; thin, patchy clay skins; clear, smooth boundary.
- B3—16 to 22 inches, grayish-brown (10YR 5/2) loam, dark grayish brown (10YR 4/2) when moist; weak, medium, subangular blocky structure; hard when dry, very friable when moist; very strongly calcareous; clear, smooth boundary.
- C1ca—22 to 31 inches, pale-brown (10YR 6/3) loam, dark grayish brown (10YR 4/2) when moist; massive; hard when dry, friable when moist; very strongly calcareous; few lime spots; clear, smooth boundary.
- IIC2ca—31 to 39 inches, pale-brown (10YR 6/3) sandy loam, dark brown (10YR 4/3) when moist; massive; hard when dry, very friable when moist; strongly calcareous; lime spots; clear, smooth boundary.

IIIC3—39 to 60 inches, pale-brown (10YR 6/3) loam, dark brown (10YR 4/3) when moist; massive; soft when dry, very friable when moist; strongly calcareous.

The A1 horizon ranges from clay loam to fine sandy loam in texture. The B2t horizon ranges from loam to light clay loam. Free lime occurs at the surface or within a depth of 8 inches. Lime accumulations begin at a depth between 12 and 24 inches.

Manzanola soils have more distinct horizons than Kim soils. They are lighter colored and shallower over lime than Satanta soils. They formed in mixed alluvium, whereas Baca soils formed in silty loess.

#### **Manzanola clay loam, 0 to 3 percent slopes (McB).—**

This soil is on flood plains. It is mainly in the southwestern part of the county. Included in mapping were spots of Kim soils, which occur on the steeper slopes; areas of Satanta loam; and spots of Baca silt loam, which are more common on upland flats than on flood plains.

This soil is high in natural fertility. It takes in water at a moderate rate and has a high water-holding capacity. Runoff is medium. The hazards of water erosion and soil blowing are moderate.

About all of the acreage is used as range. Deferring and rotating grazing and reseeding grass improve the vegetative cover. Small areas have been dryfarmed. Most of the abandoned fields are moderately eroded. Most have reverted to grass. Some have been reseeded. Stubble mulching and summer fallowing help to conserve moisture and control erosion if any dryfarming is done. (Capability unit IVe-1, nonirrigated; Loamy Plains range site)

#### **Minnequa Series**

The Minnequa series consists of nearly level to strongly sloping soils that are moderately deep over shaly limestone. These soils are on uplands. They occur as scattered areas in all parts of the county except the southwestern corner.

In a typical profile the surface layer is grayish-brown to brown loam about 8 inches thick. The next layer is pale-brown silt loam about 6 inches thick. The underlying material is pale-brown, very limy loam. It contains many limestone chips. Shaly limestone is at a depth of 34 inches.

Minnequa soils are naturally well drained. Internal drainage is medium, permeability is moderate, and the water-holding capacity is moderate. Fertility is moderate. Soil blowing and water erosion are hazards if the vegetation is destroyed.

For the most part, these soils are used as range. They are not suited to crops unless they are irrigated, and if irrigated, they have slow internal drainage because of the underlying shaly limestone.

Typical profile of a Minnequa loam (80 feet west and 2,376 feet south of NE. corner sec. 25, T. 21 S., R. 50 W.):

A11—0 to 4 inches, grayish-brown (10YR 5/2) loam, dark grayish brown (10YR 4/2) when moist; very weak, medium, platy structure to weak, fine, granular; soft when dry, very friable when moist; weakly calcareous; clear, smooth boundary.

A12—4 to 8 inches, brown (10YR 5/3) loam, dark brown (10YR 4/3) when moist; very weak, coarse, prismatic structure to very weak, medium, subangular blocky; slightly hard when dry, friable when moist; very strongly calcareous; clear, smooth boundary.

AC—8 to 14 inches, pale-brown (10YR 6/3) silt loam, brown (10YR 5/3) when moist; very weak, medium, prismatic structure to very weak, medium, subangular blocky; hard when dry, friable when moist; very strongly calcareous; clear, smooth boundary.

C1—14 to 21 inches, pale-brown (10YR 6/3) loam, brown (10YR 4/3) when moist; very weak, medium, subangular blocky structure; hard when dry, friable when moist; very strongly calcareous; clear, smooth boundary; some limestone chips.

C2—21 to 34 inches, very pale brown (10YR 7/3) loam, pale brown (10YR 6/3) when moist; massive; hard when dry, very friable when moist; very strongly calcareous; clear, smooth boundary; many limestone chips.

R—34 to 60 inches, consolidated limestone.

The A1 horizon is either loam or silt loam in texture. The C horizon ranges from 15 to 35 inches in thickness. The depth to limestone ranges from 18 to 40 inches and decreases with increasing slope. The content of salts and gypsum increases with increasing depth.

Minnequa soils are shallower over limestone than Manvel soils. They contain smaller amounts of salts than Pultney soils. They are deeper over limestone than Penrose soils.

**Minnequa loam, 0 to 5 percent slopes (MeB).—**This soil occurs as irregularly shaped areas on uplands, just north of the Arkansas River. Generally the areas are between 50 and 80 acres in size. The surface layer is about 6 inches thick. The next layer is limy loam about 10 inches thick. Otherwise, the profile is similar to that described for the series. Included in mapping were spots of Manvel loam, which occur on the more level parts of the landscape; areas of Litle clay loam; and spots of Penrose soils.

This soil is easy to work. It is moderate in natural fertility. It takes in water at a moderate rate and has a moderate water-holding capacity. Runoff is medium. The erosion hazard is moderately severe.

The entire acreage is irrigated. Irrigation can result in a perched water table, because the impermeable limestone substratum restricts the penetration of water. Barnyard manure and green-manure crops improve fertility, preserve tilth, and replenish the supply of organic matter. (Capability unit IVs-1, irrigated; Loamy Plains range site)

**Minnequa loam, 1 to 9 percent slopes (MeC).—**This soil occurs as scattered, irregularly shaped areas, generally 100 acres or more in size. It occurs on uplands in all parts of the county except the southwestern corner. It has the profile described for the series. Included in mapping were spots of Manvel loam, on the more level parts of the landscape, and spots of Penrose channery loam, on steeper slopes.

This soil takes in water at a moderate rate and has a moderate water-holding capacity. Runoff is medium. The erosion hazard is moderate. Natural fertility is moderate. The response to management is good.

The entire acreage is used as range. A few areas have been plowed and dryfarmed but have been abandoned. Some of these have reverted to grass. Others have been reseeded. Most of the areas that were cultivated are moderately eroded. (Capability unit VIe-1, nonirrigated; Loamy Plains range site)

**Minnequa-Penrose loams, 1 to 9 percent slopes (MpC).—**This complex is approximately 70 percent Minnequa soils and 30 percent Penrose soils. It occurs as scattered, irregularly shaped areas, 100 acres or more in size, in all parts of the county. In the Minnequa soils, limestone is at a depth between 18 and 40 inches. In the Penrose soils, it is within a depth of 18 inches and in places is at the surface. Penrose soils are described under the heading "Penrose Series." Included in mapping were small areas of Manvel loam, which occur in gently sloping areas and

on lower parts of the landscape, and a few spots of Little clay loam.

Runoff is medium. Water intake is moderate. The water-holding capacity is moderate for Minnequa soils and low for Penrose soils. The erosion hazard is moderate. The response to management is good for crops on Minnequa soils, and poor for those on Penrose soils.

The entire acreage is used as range. (Minnequa soils: capability unit VIIIs-1, nonirrigated; Loamy Plains range site. Penrose soils: capability unit VIIIs-1, nonirrigated; Limestone Breaks range site)

## Nepesta Series

The Nepesta series consists of well-drained, nearly level to gently sloping, deep soils that formed in limy, gravelly sediments and windblown material. These soils are north of the Arkansas River.

In a typical profile the surface layer is grayish-brown clay loam about 13 inches thick. The subsoil is brown or light brownish-gray clay loam about 14 inches thick. It has a well-formed blocky structure.

These soils are naturally well drained. Internal drainage is medium, permeability is moderate, and the water-holding capacity is high. Natural fertility is high. There is no significant hazard of erosion. The response to management is good. Fine-textured material deposited by muddy irrigation water is the main limitation. As the surface layer becomes finer textured, it becomes more difficult to work.

The entire acreage is irrigated.

Typical profile of a Nepesta clay loam (500 feet south and 150 feet west of NE. corner sec. 15, T. 21 S., R. 48 W.):

- Ap1—0 to 8 inches, grayish-brown (10YR 5/2) clay loam, very dark grayish brown (10YR 3/2) when moist, dark grayish brown (10YR 4/2) if crushed when moist; weak, fine, granular structure; hard when dry, firm when moist; strongly calcareous; clear, smooth boundary; silted.
- Ap2—8 to 13 inches, grayish-brown (10YR 5/2) clay loam, very dark grayish brown (10YR 3/2) when moist, dark grayish brown (10YR 4/2) if crushed when moist; weak, medium, subangular blocky structure; hard when dry, firm when moist; strongly calcareous; clear, smooth boundary; silted.
- B2t—13 to 18 inches, brown (10YR 5/3) clay loam, dark brown (10YR 4/3) when moist; moderate, medium, prismatic structure to moderate, fine, angular blocky; hard when dry, firm when moist; noncalcareous; thin, continuous clay skins on vertical sides; clear, smooth boundary; worm mixing from upper horizon.
- B3ca—18 to 27 inches, light brownish-gray (10YR 6/2) clay loam, dark grayish brown (10YR 4/2) when moist; weak, medium, prismatic structure to weak to moderate, medium and fine, subangular blocky; hard when dry, firm when moist; strongly calcareous; thin, patchy clay skins; clear, smooth boundary.
- C1ca—27 to 53 inches, light brownish-gray (10YR 6/2) silty clay loam, dark grayish brown (10YR 4/2) when moist; massive; slightly hard when dry, very friable when moist; very strongly calcareous; clear, smooth boundary; common lime spots.
- C2ca—53 to 60 inches, light brownish-gray (10YR 6/2) silt loam, dark grayish brown (10YR 4/2) when moist; massive; slightly hard when dry, very friable when moist; very strongly calcareous.

The A horizon is either clay loam or silty clay loam. It ranges from 8 to 16 inches in thickness. The B2t horizon ranges from 4 to 10 inches in thickness and from clay loam to clay in texture. There are no inhibiting layers of bedrock within a depth of 5 feet.

Nepesta soils have a finer textured subsoil than Kornman soils. They have a finer textured and more strongly developed subsoil than Rocky Ford soils. They do not have the very limy subsoil that is typical of Numa soils.

**Nepesta clay loam, 0 to 1 percent slopes (NeA).**—This soil occurs as irregularly shaped areas, between 20 and 40 acres in size, north of the Arkansas River. Generally it occurs within larger areas of Rocky Ford soils. It has the profile described for the series. Included in mapping were spots of Rocky Ford clay loam, small areas of Numa clay loam, and areas of Nepesta clay loam, 1 to 3 percent slopes.

This soil takes in water at a moderate rate and has a high water-holding capacity. Runoff is slow. The erosion hazard is slight. Natural fertility is high.

The entire acreage is irrigated. Leveling conserves water and makes uniform application easier. Timely cultivation is important in preventing clodding and compaction. Barnyard manure and green-manure crops improve fertility, preserve tilth, and replenish the supply of organic matter. (Capability unit IIs-1, irrigated)

**Nepesta clay loam, 1 to 3 percent slopes (NeB).**—This soil is north of the Arkansas River. The areas are between 15 and 20 acres in size. The surface layer is about 8 inches thick. The subsoil is clay loam about 10 inches thick. Included in mapping were spots of Kornman clay loam, on slightly higher parts of the landscape; a few areas of Rocky Ford clay loam; and small areas of Nepesta clay loam, 0 to 1 percent slopes.

This soil takes in water readily and has a high water-holding capacity. Runoff is medium. The erosion hazard is slight to moderate. Natural fertility is high.

All of the acreage is irrigated. Leveling conserves water and makes uniform application easier. Timely cultivation is important in preventing clodding and compaction. Barnyard manure and green-manure crops improve fertility, preserve tilth, and increase the supply of organic matter. (Capability unit IIE-1, irrigated)

## Numa Series

The Numa series consists of well-drained, nearly level to gently sloping, deep, calcareous soils that formed in stratified, loamy alluvium. These soils are along the Arkansas River.

In a typical profile the surface layer is grayish-brown clay loam about 10 inches thick. The next layer is brown clay loam about 5 inches thick. It has weak blocky structure. Below this is clay loam to loam material.

Numa soils are naturally well drained. They have medium internal drainage and moderate permeability. All except the sand substratum variant have a high water-holding capacity. Natural fertility is high. There is no significant hazard of erosion. The response to management is good. Fine-textured material deposited by muddy irrigation water is the main limitation. As the surface layer becomes finer textured, it becomes more difficult to work.

Most of the acreage is irrigated.

Typical profile of a Numa clay loam (30 feet west and 950 feet south of NE. corner NW $\frac{1}{4}$  sec. 29, T. 22 S., R. 51 W.):

- Ap1—0 to 5 inches, grayish-brown (10YR 5/2) clay loam, very dark grayish brown (10YR 3/2) when moist, dark grayish brown (10YR 4/2) if crushed when moist; structure breaks from weak, coarse, subangular blocky

to moderate, fine, granular; very hard when dry, firm when moist; strongly calcareous; clear, smooth boundary.

- Ap2—5 to 10 inches, grayish-brown (10YR 5/2) clay loam, very dark grayish brown (10YR 3/2) when moist, dark grayish brown (10YR 4/2) if crushed when moist; structure breaks from weak and moderate angular blocky to moderate, fine, subangular blocky; very hard when dry, firm when moist; strongly calcareous; clear, smooth boundary.
- AC—10 to 15 inches, brown (10YR 5/3) clay loam, dark brown (10YR 3/3) when moist, dark brown (10YR 4/3) if crushed when moist; weak, coarse, subangular blocky structure to massive; hard when dry, friable when moist; strongly calcareous; clear, smooth boundary.
- C1—15 to 32 inches, light yellowish-brown (10YR 6/4) clay loam, yellowish brown (10YR 5/4) when moist; hard when dry, friable when moist; very strongly calcareous; clear, smooth boundary; 10 percent of surface white (10YR 8/2) lime spots.
- C2ca—32 to 50 inches, white (10YR 8/2) loam, light yellowish brown (10YR 6/4) when moist; massive; slightly hard when dry, very friable when moist; very strongly calcareous; clear, smooth boundary.
- C3—50 to 60 inches, very pale brown (10YR 7/3) sandy clay loam, brown (10YR 5/3) when moist; massive; hard when dry, friable when moist; very strongly calcareous; few white (10YR 8/2) lime spots.

The A horizon is either clay loam or silty clay loam. It ranges from 8 to 12 inches in thickness. The AC horizon ranges from 5 to 15 inches in thickness. The depth to the white Cca horizon ranges from 15 to 32 inches. There are no inhibiting layers of bedrock within a depth of 60 inches.

Numa soils are finer textured in the C horizon than Kornman soils. They differ from Rocky Ford soils in having a very limy layer in the substratum.

**Numa clay loam, 0 to 1 percent slopes (NmA).**—This soil occurs as areas 100 acres or more in size north of the Arkansas River. It has the profile described as typical for the series. Included in mapping were spots of Nepesta clay loam, areas of Rocky Ford clay loam, and small areas of Numa clay loam, 1 to 3 percent slopes.

This soil is well suited to all crops locally grown. It is high in natural fertility. The water-intake rate is moderate, and the water-holding capacity is high. Runoff is slow. The erosion hazard is slight.

All of the acreage is irrigated. Leveling makes uniform application of irrigation water easier. Timely cultivation is important in preventing clodding and compaction. Barnyard manure and green-manure crops improve fertility, preserve tilth, and replenish the supply of organic matter. (Capability unit IIs-1, irrigated)

**Numa clay loam, 1 to 3 percent slopes (NmB).**—This soil occurs as irregularly shaped areas, generally more than 100 acres in size, north of the Arkansas River. The surface layer is about 8 inches thick. Included in mapping were spots of Nepesta clay loam, on the more nearly level areas; spots of Rocky Ford clay loam, generally on slightly higher parts of the landscape; and areas of Numa clay loam, 0 to 1 percent slopes.

This soil is high in natural fertility. It has a moderate water-intake rate and a high water-holding capacity. Runoff is medium. The erosion hazard is slight to moderate.

All of the acreage is irrigated. Leveling makes uniform application of irrigation water easier. Timely cultivation is important in preventing clodding and compaction. Barnyard manure and green-manure crops improve fertility, preserve tilth, and replenish the supply of organic matter. (Capability unit IIe-1, irrigated)

**Numa clay loam, wet, 0 to 3 percent slopes (NuB).**—This soil occurs as low-lying, irregularly shaped areas, generally less than 40 acres in size, north of the Arkansas River. It receives runoff from surrounding areas. The surface layer is about 8 inches thick. Included in mapping were spots of Rocky Ford clay loam, on slightly higher parts of the landscape, and small areas of Numa clay loam.

This soil is wet and cold and poorly aerated, but it is easy to work and is high in natural fertility. Excess water has increased the salts content.

Most of the acreage is irrigated. Leveling and drainage are needed. (Capability unit IIw-1, irrigated)

**Numa clay loam, sand substratum variant, 0 to 3 percent slopes (NuB).**—This soil occurs as irregularly shaped areas, generally between 20 and 60 acres in size, north of the Arkansas River. The surface layer is about 8 inches thick. The depth to sand ranges from 20 to 40 inches. Included in mapping were spots of Rocky Ford clay loam, on slightly higher parts of the landscape; a few spots of Nepesta clay loam, on nearly level, slightly lower parts; and areas of Numa clay loam, 1 to 3 percent slopes.

This soil is moderate in natural fertility. It has a moderate water-intake rate but, because of the sand substratum, a limited water-holding capacity. Runoff is medium. The erosion hazard is slight to moderate.

The entire acreage is irrigated. Leveling makes uniform application of irrigation water easier. Timely cultivation is important in preventing clodding and compaction. Barnyard manure and green-manure crops improve fertility, preserve tilth, and replenish the supply of organic matter. (Capability unit IIIe-1, irrigated)

## Olney Series

The Olney series consists of nearly level to gently sloping, deep soils that are strongly calcareous below a depth of about 15 to 24 inches. These soils are on uplands in the north-central part of the county.

In a typical profile the surface layer is grayish-brown, lime-free sandy loam about 8 inches thick. The subsoil is brown or pale-brown sandy clay loam about 16 inches thick. It is nonlimy in the upper part and limy in the lower part. It has a distinctive, well-formed, medium, prismatic structure. The underlying material is pale-brown loamy sand to silt loam.

Olney soils are naturally well drained. Internal drainage is rapid, permeability is moderately rapid, and the water-holding capacity is moderate to high. Natural fertility is moderate to high. Water erosion and soil blowing are hazards. The hazard of blowing is particularly serious if the vegetative cover is inadequate.

For the most part, these soils are used as range. Some areas were dryfarmed and then abandoned because of low rainfall. Some have been planted to grass. Others have been neglected, and the vegetation consists mainly of weeds.

Typical profile of an Olney sandy loam (1,320 feet west and 100 feet south of NE. corner sec. 10, T. 21 S., R. 51 W.):

- A1—0 to 4 inches, grayish-brown (10YR 5/2) sandy loam, dark grayish brown (10YR 4/2) when moist; weak, fine, granular structure; soft when dry, very friable when moist; noncalcareous; clear, smooth boundary.

- A3—4 to 8 inches, grayish-brown (10YR 5/2) sandy loam, dark grayish brown (10YR 4/2) when moist; weak, medium, subangular blocky structure to weak, fine, granular; slightly hard when dry, friable when moist; noncalcareous; very thin, patchy clay skins; clear, smooth boundary.
- B21t—8 to 15 inches, brown (10YR 5/3) sandy clay loam, dark brown (10YR 4/3) when moist; moderate, coarse, prismatic structure to moderate to strong, medium to coarse, subangular blocky; hard when dry, friable when moist; noncalcareous; thin, patchy clay skins; clear, smooth boundary.
- B22t—15 to 18 inches, pale-brown (10YR 6/3) sandy clay loam, brown (10YR 5/3) when moist; moderate, medium and coarse, subangular blocky structure; noncalcareous; thin, patchy clay skins; clear, smooth boundary.
- B3ca—18 to 24 inches, pale-brown (10YR 6/3) sandy loam, brown (10YR 5/3) when moist; weak, coarse, subangular blocky structure; slightly hard when dry, friable when moist; strongly calcareous; clear, smooth boundary; few lime spots.
- C1ca—24 to 42 inches, pale-brown (10YR 6/3) loamy sand, brown (10YR 5/3) when moist; single grain; loose when dry, slightly coherent when moist; strongly calcareous; lime spots and streaks; clear, smooth boundary.
- IIC2ca—42 to 60 inches, pale-brown (10YR 6/3) silt loam, brown (10YR 5/3) when moist; massive; slightly hard when dry, friable when moist; very strongly calcareous; clear, smooth boundary; common lime spots.

The A horizon ranges from 4 to 8 inches in thickness and from sandy loam to loamy sand in texture. The B2t horizon ranges from 8 to 12 inches in thickness. The depth to the accumulation of calcium carbonate ranges from 15 to 24 inches.

Olney soils have a more strongly developed and finer textured subsoil than Vona soils. They have a sandier profile and thicker horizons than Stoneham soils.

**Olney sandy loam, 0 to 3 percent slopes (OnA).**—This soil occurs along swales and flood plains that wind through low hills. It is mainly in the north-central part of the county. It has the profile described for the series. Included in mapping were small areas of Vona sandy loam, on higher parts of the landscape, and spots of Stoneham loam, on slightly higher parts.

This soil is moderate in natural fertility. It takes in water readily and has a moderate to high water-holding capacity. Runoff is slow to medium. The hazard of water erosion is slight. The hazard of soil blowing is moderate to severe if the vegetation is destroyed. The response to management is good.

Almost all of the acreage is used as range. Deferment and rotation of grazing and reseeded of grass help in maintaining and improving the vegetative cover. Part of the acreage has been dryfarmed. Most of the cultivated areas are moderately eroded. All cultivated areas that are no longer farmed should be seeded to grass. Stubble mulching, crop residue management, and summer fallowing help to control erosion and conserve water if any dryfarming is done. Listing and chiseling are beneficial if the vegetative cover is inadequate. (Capability unit IVE-2, non-irrigated; Sandy Plains range site)

**Olney soils, 0 to 3 percent slopes, eroded (OsB2).**—These soils were once cultivated and were then abandoned because of soil blowing and crop failures. They are mainly in the north-central part of the county. All of the original surface layer and part of the original subsoil have been removed from 60 to 70 percent or more of the acreage. The texture of the present surface layer ranges from sandy clay loam to loamy sand. Included in mapping were blow-

outs and areas on the downwind side where the blown material has been deposited. The blowouts and dunes make the surface uneven.

These soils take in water readily and have a moderate water-holding capacity. Runoff is medium. The hazard of water erosion is moderate. The hazard of soil blowing is severe in areas where vegetation has not been reestablished. Management is difficult because of the shifting sand.

The entire acreage is used as range. Some of the areas once cultivated have been reseeded to grass. Others have been neglected, and in these the vegetation consists mainly of weeds. (Capability unit VIe-3, nonirrigated; Sandy Plains range site)

## Otero Series

The Otero series consists of gently sloping to strongly sloping soils that are deep and limy. These soils are on uplands. The areas are scattered across the county from east to west, mainly just south of the Arkansas River.

In a typical profile the surface layer is light yellowish-brown loamy sand to pale-brown sandy loam about 9 inches thick. Below this, to a depth of 60 inches or more, is very pale brown to brown, massive sandy loam to silt loam. This material is more limy than the surface layer. In spots sand occurs in the substratum.

Otero soils are well drained to somewhat excessively drained. They have rapid internal drainage, moderately rapid permeability, and a moderate water-holding capacity. They are moderate in natural fertility. They are susceptible to water erosion and highly susceptible to blowing.

For the most part, these soils are used as range. Most areas that have been cultivated are now in grass. Some have reverted to native grass. Others have been seeded.

Typical profile of an Otero loamy sand (350 feet north and 200 feet west of SE. corner sec. 33, T. 22 S., R. 51 W.):

- A11—0 to 4 inches, light yellowish-brown (10YR 6/4) loamy sand, dark yellowish brown (10YR 4/4) when moist; weak, medium, granular structure; soft when dry, very friable when moist; weakly calcareous; clear, smooth boundary; many roots.
- A12—4 to 9 inches, pale-brown (10YR 6/3) sandy loam, dark brown (10YR 4/3) when moist; weak, medium, granular structure; soft when dry, very friable when moist; very strongly calcareous; clear, smooth boundary.
- AC—9 to 15 inches, pale-brown (10YR 6/3) sandy loam, brown (10YR 5/3) when moist; massive; soft when dry, very friable when moist; very strongly calcareous; clear, smooth boundary; some small rocks.
- C1ca—15 to 27 inches, brown (10YR 5/3) sandy loam, dark brown (10YR 4/3) when moist; massive; slightly hard when dry, very friable when moist; very strongly calcareous; clear, smooth boundary; few lime spots.
- C2ca—27 to 37 inches, very pale brown (10YR 7/3) silt loam, pale brown (10YR 6/3) when moist; massive; slightly hard when dry, very friable when moist; very strongly calcareous; clear, smooth boundary; many lime spots.
- C3ca—37 to 60 inches, brown (10YR 5/3) fine sandy loam, dark brown (10YR 4/3) when moist; massive; soft when dry, very friable when moist; very strongly calcareous; few lime spots.

The A1 horizon ranges from 4 to 10 inches in thickness. The A1 and AC horizons tend to be sandier in sloping areas. In places the substratum contains fragments of sandstone and shale.

Otero soils are not so deeply leached of lime as Vona soils, and they have less distinct horizons. They are less sandy than Tivoli soils. They are more sandy than Colby soils.

**Otero loamy sand, 1 to 9 percent slopes (O<sub>t</sub>C).**—This soil occurs as irregularly shaped areas, between 20 and 40 acres in size, in the central part of the county, just south of the Arkansas River. In some areas sand occurs at a depth of 20 to 40 inches. Included in mapping were spots of Vona sandy loam, on more nearly level parts of the landscape; and areas of Tivoli sand, on the higher, more rolling parts.

This soil is moderate in natural fertility. It takes in water readily and has a moderate to low water-holding capacity. Runoff is slow. The hazard of water erosion is slight. The hazard of soil blowing is moderate to severe if the vegetation is depleted. The response to management is good.

The entire acreage is used as range. (Capability unit VIe-3, nonirrigated; Sandy Plains range site)

### Penrose Series

The Penrose series consists of gently sloping to very strongly sloping soils that are shallow over limestone and shaly limestone. These soils occur as scattered areas on uplands throughout the county.

In a typical profile the surface layer is light brownish-gray channery loam about 3 inches thick. It contains many small, flat chips of limestone. The next layer is pale-brown or light yellowish-brown loam about 11 inches thick. Below this is limestone.

Penrose soils are excessively drained. They have a moderate water-intake rate and a low water-holding capacity. If overgrazed, they are susceptible to soil blowing and water erosion. The response to management is poor.

All of the acreage is used as range.

Typical profile of a Penrose channery loam (50 feet north and 0.5 mile west of SE. corner sec. 7, T. 24 S., R. 53 W.):

- A1—0 to 3 inches, light brownish-gray (10YR 6/2) channery loam, dark grayish brown (10YR 4/2) when moist; weak, fine, granular structure; soft when dry, very friable when moist; very strongly calcareous; clear, smooth boundary; many limestone chips on surface.
- C1—3 to 8 inches, pale-brown (10YR 6/3) loam, dark brown (10YR 4/3) when moist; massive; slightly hard when dry, friable when moist; very strongly calcareous; clear, smooth boundary; many limestone chips.
- C2—8 to 14 inches, light yellowish-brown (10YR 6/4) loam, yellowish brown (10YR 5/4) when moist; massive; slightly hard when dry, friable when moist; very strongly calcareous; clear, smooth boundary; many limestone chips.
- R—14 to 60 inches, limestone.

The A1 horizon ranges from 2 to 6 inches in thickness and is loam or channery loam in texture. The depth to bedrock ranges from 4 to 18 inches.

Penrose soils are shallower over bedrock than Minnequa soils. They are coarser textured than Samsil soils and finer textured than Travessilla soils.

**Penrose channery loam, 1 to 25 percent slopes (P<sub>c</sub>D).**—This soil occurs as scattered areas, generally 100 acres or more in size, on uplands in all parts of the county except the southwestern corner. Included in mapping were areas of Minnequa loam, which occur on the more nearly level, lower parts of the landscape; spots of Samsil soils; and areas of limestone outcrops.

This soil has a moderate water-intake rate and a low water-holding capacity. Runoff is medium to rapid, but the erosion hazard is only moderate to slight. Natural fertility is low.

The entire acreage is used as range. (Capability unit VIIs-1, nonirrigated; Limestone Breaks range site)

### Pultney Series

The Pultney series consists of nearly level to strongly sloping, saline soils that are moderately deep over shale. These soils are on uplands in the extreme southwestern corner of the county.

In a typical profile the surface layer is light brownish-gray or brown, limy loam about 5 inches thick. Below this is grayish-brown to pale-brown loam about 11 inches thick. This layer is more clayey than the surface layer. It contains salt crystals that become more abundant with increasing depth. The weathered shale, which is at a depth below 22 inches, becomes more coherent with increasing depth.

Pultney soils are naturally well drained. They have medium internal drainage, moderate permeability, and a high water-holding capacity. The salts content is high enough to be detrimental to plant growth. Soil blowing and water erosion are hazards if the vegetation is destroyed. The response to management is poor.

The entire acreage is used as range.

Typical profile of a Pultney loam (50 yards south and 70 yards west of center sec. 34, T. 27 S., R. 53 W.):

- A11—0 to 3 inches, light brownish-gray (10YR 6/3) loam, dark grayish brown (10YR 4/2) when moist; weak, fine, platy structure to weak, fine, granular; slightly hard when dry, very friable when moist; calcareous; clear, smooth boundary.
- A12—3 to 5 inches, brown (10YR 5/3) loam, dark grayish brown (10YR 4/2) when moist; structure breaks from very weak, coarse, subangular blocky to moderate, fine, granular; hard when dry, friable when moist; strongly calcareous; clear, smooth boundary.
- C1—5 to 10 inches, grayish-brown (10YR 5/2) loam, brown to dark brown (10YR 4/3) when moist; structure breaks from very weak, medium, prismatic to very weak, medium, subangular blocky; hard when dry, friable when moist; very strongly calcareous; clear, smooth boundary.
- C2—10 to 16 inches, pale-brown (10YR 6/3) loam, brown (10YR 5/3) when moist; very weak, medium, prismatic structure; hard when dry, friable when moist; very strongly calcareous; clear, smooth boundary.
- C3cs—16 to 22 inches, grayish-brown (2.5Y 5/2) loam, brown (10YR 5/3) when moist; massive; slightly hard when dry, friable when moist; very strongly calcareous; few lime and gypsum mottles, white (10YR 8/2) when dry; abrupt, wavy boundary.
- C4cs—22 to 40 inches, weathered shale, gray (5Y 6/1) when dry; very strongly gypsiferous.
- R—40 to 60 inches, greenish shale.

The A1 horizon ranges from 3 to 6 inches in thickness and is either loam or silt loam in texture. The depth to shale ranges from 20 to 40 inches. It decreases with increasing slope.

Pultney soils have a less clayey profile and contain more salts than Baca soils. They are coarser textured than Litle soils. They contain more gypsum than Minnequa soils.

**Pultney loam, 1 to 9 percent slopes (P<sub>u</sub>C).**—This soil occurs as irregularly shaped areas, generally between 30 and 50 acres in size, on uplands in the southwestern corner of the county. Included in mapping were small areas of Litle clay loam, on higher parts of the landscape, and spots of Minnequa loam, on lower parts.

This soil is moderate in natural fertility. It has a moderate water-intake rate and a high water-holding capacity. Runoff is medium. The erosion hazard is moderate. The salts content is high enough to hinder plant growth.

The entire acreage is used as range. The stands of native grass are thin, and growth is slow. Rotation of grazing and grazing at the proper season help in maintaining vegetation and controlling erosion. (Capability unit VIe-2, nonirrigated; Alkaline Plains range site)

### Rago Series

The Rago series consists of deep, nearly level soils that occur on the loessal uplands in the northeastern part of the county.

In a typical profile the surface layer is grayish-brown, lime-free silt loam about 5 inches thick. The subsoil is lime-free clay loam about 18 inches thick. It has a strongly defined blocky structure. The underlying material is clay loam.

These soils are high in natural fertility. They are naturally well drained. They have moderately slow internal drainage, moderate permeability, and a high water-holding capacity. There is no significant hazard of soil blowing or water erosion. The response to range management is good.

For the most part, these soils are used as range. Small areas are dryfarmed.

Typical profile of a Rago silt loam (1,600 feet south and 2,620 feet east of NW. corner sec. 5, T. 21 S., R. 49 W.):

- A1—0 to 5 inches, grayish-brown (10YR 5/2) silt loam, very dark grayish brown (10YR 3/2) when moist; weak, fine, granular structure; soft when dry, very friable when moist; noncalcareous; clear, smooth boundary; numerous roots.
- B1—5 to 10 inches, grayish-brown (10YR 5/2) clay loam, very dark grayish brown (10YR 3/2) when moist; weak, medium and fine, subangular blocky structure to fine granular; slightly hard when dry, friable when moist; noncalcareous; thin, patchy clay skins; clear, smooth boundary.
- B21t—10 to 16 inches, grayish-brown (10YR 5/2) clay loam, very dark grayish brown (10YR 3/2) when moist; moderate, medium, prismatic structure to moderate to strong, medium, subangular blocky; hard when dry, friable when moist; noncalcareous; nearly continuous clay skins; clear, smooth boundary.
- B22t—16 to 23 inches, brown (10YR 5/3) clay loam, dark brown (10YR 4/3) when moist; moderate, medium, prismatic structure to strong, medium, subangular blocky; hard when dry, friable when moist; noncalcareous; thin continuous clay skins; abrupt, smooth boundary.
- B23tcab—23 to 30 inches, grayish-brown (10YR 5/2) clay loam, dark gray (10YR 4/1) when moist; strong angular blocky structure; hard when dry, firm when moist; very strongly calcareous; moderate, continuous clay skins; gradual, smooth boundary; common lime spots.
- B24tcab—30 to 60 inches, gray (10YR 5/1) clay loam, dark gray (10YR 4/1) when moist; moderate, fine, prismatic structure to strong, fine, angular blocky; hard when dry, firm when moist; moderate, continuous clay skins; common lime spots.

The A horizon ranges from 4 to 8 inches in thickness. The B21t and B22t horizons combined range from 10 to 20 inches in thickness and are either clay loam or silty clay loam in texture. The depth to the B2tb horizon ranges from 18 to 24 inches.

Rago soils are darker colored, have thicker horizons, and are deeper over lime than Wiley and Baca soils. They do not have the thin, light-colored layer that is typical of Weld soils.

**Rago silt loam, 0 to 1 percent slopes (RcA).**—This soil occurs as irregularly shaped areas, generally between 20 and 40 acres in size, on uplands in the northeastern part of the county. Included in mapping were spots of Baca silt

loam, on the higher, slightly steeper parts of the landscape; and 2- to 4-acre areas of Weld silt loam, on the slightly depressed parts.

This soil has a moderate water-intake rate and a high water-holding capacity. Runoff is slow. The erosion hazard is slight.

About all of the acreage is used as range. Rotation and deferment of grazing, grazing at the proper season, and seeding of native grass are important in range management. If the vegetative cover is inadequate, listing and chiseling are beneficial. Attempts to dryfarm this soil failed because of insufficient rainfall. Soil blowing was a hazard in areas that were cultivated, and most of these areas are now moderately eroded. Stubble mulching, crop residue management, and summer fallowing help to conserve moisture and control erosion if any dryfarming is done. (Capability unit IVe-1, nonirrigated; Loamy Plains range site)

### Rocky Ford Series

The Rocky Ford series consists of nearly level to gently sloping soils that are deep and calcareous. These soils occur along major drainageways.

In a typical profile the surface layer is grayish-brown, limy clay loam and silty clay loam about 12 inches thick. Below this is pale-brown silt loam about 6 inches thick. The underlying material is pale-brown to light brownish-gray, calcareous silt loam.

These soils are generally well drained, but they are affected by a water table at a depth of about 4 feet. Internal drainage is medium, and permeability is moderate. The water-holding capacity is high in all of these soils except the sand substratum variant. There is no significant hazard of water erosion. The main limitation results from the deposition of silt and clay (fig. 6) from muddy irrigation water. The surface layer is becoming thicker and finer textured each year and, consequently, progressively more difficult to work.

Rocky Ford soils are suited to all locally grown crops. All of the acreage is irrigated.

Typical profile of a Rocky Ford clay loam (1,160 feet south and 1,380 feet east of NW. corner sec. 25, T. 22 S., R. 49 W.):

- Ap1—0 to 6 inches, grayish-brown (10YR 5/2) clay loam, very dark grayish brown (10YR 3/2) when moist, dark grayish brown (10YR 4/2) if crushed when moist; weak, medium, subangular blocky structure to weak, fine, granular; very hard when dry, firm when moist; very strongly calcareous; clear, smooth boundary.
- Ap2—6 to 12 inches, grayish-brown (10YR 5/2) silty clay loam, very dark grayish brown (10YR 3/2) when moist, dark grayish brown (10YR 4/2) if crushed when moist; moderate, medium, angular blocky structure to moderate, fine, angular blocky; very hard when dry, firm when moist; strongly calcareous; clear, smooth boundary.
- AC—12 to 18 inches, pale-brown (10YR 6/3) silt loam, brown (10YR 5/3) when moist; weak, coarse, subangular blocky structure; hard when dry, friable when moist; very strongly calcareous; clear, wavy boundary; worm casts.
- C1ca—18 to 32 inches, light brownish-gray (10YR 6/2) silt loam, dark grayish brown (10YR 4/2) when moist; massive; hard when dry, friable when moist; very strongly calcareous; gradual, smooth boundary; common lime spots.



Figure 6.—Profile of Rocky Ford clay loam showing thick, dark-colored surface layer.

C2ca—32 to 60 inches, pale-brown (10YR 6/3) silt loam, brown (10YR 5/3) when moist; massive; hard when dry, friable when moist; very strongly calcareous; few lime spots.

The Ap horizon ranges from 8 to 15 inches in thickness and from clay loam to silty clay in texture. The C horizon has a wide range in thickness. It is generally loamy and high in lime.

Rocky Ford soils are coarser textured, less salty, and better drained than Las soils. They have a darker colored and finer textured surface layer than Colby soils. They are finer textured than Glenberg soils, and generally they are deeper over sand and gravel.

**Rocky Ford clay loam, 0 to 1 percent slopes (RfA).**—This soil occurs as irregularly shaped areas, generally more than 50 acres in size. It is in the eastern part of the irrigated area north of the Arkansas River. The surface layer is about 10 inches thick. Included in mapping were small areas of Numa clay loam, on slightly higher parts of the landscape; a few spots of Kornman soils, on more rolling parts; and spots of Rocky Ford clay loam, 1 to 3 percent slopes.

This soil is moderately easy to work. It takes in water readily and has a high water-holding capacity. Runoff is slow, and the erosion hazard is very slight.

The entire acreage is irrigated. Leveling makes uniform application of irrigation water easier. Timely tillage helps to prevent excessive clodding and compaction. (Capability unit IIs-1, irrigated)

**Rocky Ford clay loam, 1 to 3 percent slopes (RfB).**—This soil occurs as irregularly shaped areas, generally more than 60 acres in size, in the eastern part of the irrigated area just north of the Arkansas River. The surface layer is about 7 inches thick. Included in mapping were small areas of Numa clay loam; spots of Kornman clay loam, which are on slightly higher parts of the landscape; and small areas of Rocky Ford clay loam, 0 to 1 percent slopes.

This soil has a moderate water-intake rate and a high water-holding capacity. Runoff is medium, and the erosion hazard is slight to moderate.

All of the acreage is irrigated. Leveling makes uniform application of irrigation water easier. Timely cultivation is important in preventing clodding and compaction. (Capability unit IIe-1, irrigated)

**Rocky Ford clay loam, wet, 0 to 1 percent slopes (RkA).**—This soil occurs as irregularly shaped areas, between 20 and 30 acres in size, in the eastern part of the irrigated area just north of the Arkansas River. It is in slight depressions where excess water accumulates. The surface layer is about 8 inches thick. Included in mapping were small areas of Rocky Ford clay loam, on slightly raised parts of the landscape, and spots of Rocky Ford clay loam, wet, 1 to 3 percent slopes, in more sloping areas.

This soil is seeped with excess irrigation water. The water table is nearer the surface during the growing season when irrigation water is applied. Runoff is slow, and the erosion hazard is slight. The content of salts is high enough to retard plant growth.

All of the acreage is irrigated. Timely tillage is important in preventing clodding and compaction. Barnyard manure and green-manure crops preserve tilth and improve fertility. A drainage system is needed to remove excess water and salts. (Capability unit IIw-1, irrigated)

**Rocky Ford clay loam, wet, 1 to 3 percent slopes (RkB).**—This soil occurs in the eastern part of the irrigated area north of the Arkansas River, generally at the lower ends of long, gently sloping areas and below irrigation ditches. The areas are between 20 and 30 acres in size. The surface layer is about 6 inches thick. Included in mapping were areas of Rocky Ford clay loam, which are on slightly higher parts of the landscape, and spots of Rocky Ford clay loam, wet, 0 to 1 percent slopes, which are in nearly level or slightly depressed areas.

This soil is seeped with excess irrigation water. During the irrigation season, the water table is high enough to restrict roots. Runoff is medium. The erosion hazard is slight to moderate. The salts content is high enough to retard plant growth. Natural fertility is high.

All of the acreage is irrigated. Leveling makes uniform application of irrigation water easier. Barnyard manure and green-manure crops preserve tilth and improve fertility. A drainage system is needed to remove excess water and salts. (Capability unit IIw-1, irrigated)

**Rocky Ford clay loam, sand substratum variant, 0 to 1 percent slopes (RmA).**—This soil occurs as irregularly shaped areas, between 15 and 20 acres in size, in the

irrigated parts of the county, mostly along the Arkansas and Purgatoire Rivers. The surface layer is about 8 inches thick. Sand or sand and gravel occurs at a depth of 20 to 40 inches. Included in mapping were small areas of Rocky Ford clay loam, generally in slightly depressed parts of the landscape, and spots of Glenberg sandy loam, on more undulating parts.

This soil has a limited root zone because it is only moderately deep over sand and gravel. It is moderate in natural fertility. It has a moderate water-intake rate and a moderate water-holding capacity. Runoff is slow. The erosion hazard is slight. The response to management is good.

All of the acreage is irrigated. Leveling makes uniform application of irrigation water easier. Timely cultivation is important in preventing clodding and compaction. Barnyard manure and green-manure crops preserve tilth and improve fertility. (Capability unit IIIs-1, irrigated)

### Rough Broken Land

Rough broken land (Ro) is made up of very steep hills and vertical cliffs of sandstone, shale, and limestone. Much of it is bare rock. It occurs as scattered areas throughout the county. Most of the acreage is in the southern part.

This land type can be used for hunting and picnicking and other recreational purposes. It furnishes some grazing and shelter for livestock. (Capability unit VIIIs-1, nonirrigated)

### Samsil Series

The Samsil series consists of gently sloping to strongly sloping soils that are shallow over shale. These soils are on uplands, mainly in the southern part of the county.

In a typical profile the surface layer is light brownish-gray silty clay loam about 4 inches thick. The next layer is light brownish-gray silty clay. It is massive or has weak blocky structure. At a depth of 10 inches is shale.

These soils take in water slowly and have a low water-holding capacity. Runoff is rapid, and the erosion hazard is severe.

Samsil soils are suitable only for range and wildlife habitat. None of the acreage is cultivated.

Typical profile of a Samsil silty clay loam (120 feet south and 520 feet east of NW. corner sec. 4, T. 27 S., R. 49 W.):

- A—0 to 4 inches, light brownish-gray (2.5Y 6/2) silty clay loam, dark grayish brown (2.5Y 4/2) when moist; weak, fine, granular structure; hard when dry, firm when moist; strongly calcareous; clear, smooth boundary.
- AC—4 to 10 inches, light brownish-gray (2.5Y 6/2) silty clay, olive brown (2.5Y 4/4) when moist; massive to weak, fine and medium, subangular blocky structure; hard when dry, firm when moist; very strongly calcareous; clear, smooth boundary; visible gypsum crystals.
- R—10 to 60 inches, dark-colored shale.

The A horizon ranges from silty clay loam to clay in texture and from about 2 to 6 inches in thickness. The depth to shale ranges from about 4 to 20 inches.

Samsil soils are shallower and less well developed than the associated Little soils. They are finer textured than Penrose soils and developed from shale instead of limestone. They are not so sandy as Travessilla soils.

**Samsil soils** (3 to 20 percent slopes) (Sc).—These soils occur as irregularly shaped areas, generally less than 30 acres in size, on the foot slopes of upland hills. They are mainly in the southern part of the county. The surface layer ranges from silty clay loam to clay in texture and is 2 to 6 inches thick. Included in mapping were spots of Little clay loam, in less sloping areas, and areas of Minnetonka loam.

These soils take in water slowly and have a low water-holding capacity. Runoff is rapid, and the erosion hazard is severe.

All of the acreage is used as range. The grass cover is sparse, and growth is slow. Rotation and deferment of grazing help in maintaining the vegetation and in controlling erosion. (Capability unit VIIs-2, nonirrigated; Shale Breaks range site)

### Satanta Series

The Satanta series consists of nearly level to gently sloping, deep soils that formed mainly in material weathered from sandstone. They occur in swales and drainage ways, mainly in the southwestern corner of the county.

In a typical profile the surface layer is light brownish-gray, lime-free loam about 9 inches thick. The upper part of the subsoil, which is also lime free, is grayish-brown clay loam and brown loam about 17 inches thick. It has distinct prismatic structure that breaks to well-defined blocky. The underlying material is brown or pale-brown silt loam and contains a few white lime spots.

Satanta soils are high in natural fertility. They are naturally well drained. They have medium internal drainage, moderate permeability, and a high water-holding capacity. They receive excess runoff from surrounding areas and are flooded during heavy rains. Water erosion is a hazard if the vegetative cover is destroyed. The hazard of soil blowing is only slight. The response to management is good.

All of the acreage is used as range.

Typical profile of a Satanta loam (100 feet south and 1,320 feet east of NW. corner sec. 5, T. 27 S., R. 52 W.):

- A11—0 to 5 inches, light brownish-gray (10YR 6/2) loam, very dark grayish brown (10YR 3/2) when moist; weak to moderate, fine, platy structure to weak, fine, granular; slightly hard when dry, very friable when moist; noncalcareous; clear, smooth boundary.
- A12—5 to 9 inches, light brownish-gray (10YR 6/2) loam, very dark grayish brown (10YR 3/2) when moist; weak, medium, subangular blocky structure to weak, fine, granular; slightly hard when dry, very friable when moist; noncalcareous; clear, smooth boundary.
- B21t—9 to 19 inches, grayish-brown (10YR 5/2) clay loam, very dark grayish brown (10YR 3/2) when moist; moderate, medium, prismatic structure to moderate, fine, subangular blocky; hard when dry, friable when moist; noncalcareous; thin, nearly continuous clay skins; clear, smooth boundary.
- B22t—19 to 26 inches, brown (10YR 5/3) loam, dark brown (10YR 4/3) when moist; moderate, medium, prismatic structure to weak, medium, subangular blocky; hard when dry, friable when moist; noncalcareous; thin, nearly continuous clay skins on the vertical faces; clear, smooth boundary.
- B3ca—26 to 36 inches, brown (10YR 5/3) silt loam, dark brown (10YR 4/3) when moist; weak, medium and fine, subangular blocky structure; hard when dry, friable when moist; strongly calcareous; clear, smooth boundary; few lime spots.

Cca—36 to 60 inches, pale-brown (10YR 6/3) silt loam, dark brown (10YR 4/3) when moist; weak, medium and fine, subangular blocky structure; hard when dry, friable when moist; strongly calcareous; clear, smooth boundary; few lime spots.

The A1 horizon ranges from 6 to 12 inches in thickness and from sandy loam to loam in texture. The B2t horizon ranges from 12 to 20 inches in thickness and from loam to clay loam in texture.

Satanta soils are darker colored and have a more clayey subsoil than Kim soils. They are deeper than Baca soils. They are darker colored, coarser textured, and more deeply leached of lime than Manzanola soils.

**Satanta loam, 0 to 3 percent slopes (SnB).**—This soil is in swales and on flood plains in the southwestern corner of the county. The areas are generally 80 acres or more in size. Included in mapping were small areas of Kim loam, Baca loam, and Manzanola clay loam.

This soil is high in natural fertility. It takes in water readily and has a high water-holding capacity. It has only slow to medium runoff, but its position on the landscape makes it susceptible to gully erosion.

All of the acreage is used as range. Deferment and rotation of grazing help in maintaining and improving the vegetative cover. Water spreading, where applicable, is beneficial also. Stubble mulching, summer fallowing, and crop residue management help to conserve moisture and control erosion if any dryfarming is done. (Capability unit IVE-1, nonirrigated; Loamy Plains range site)

## Stoneham Series

The Stoneham series consists of nearly level to strongly sloping soils that are deep. These soils are on uplands, mainly in the northern part of the county. There are a few areas in the southeastern corner.

In a typical profile the surface layer is light brownish-gray, lime-free loam about 3 inches thick. The upper part of the subsoil is grayish-brown, lime-free clay loam about 5 inches thick. The lower part is very limy, pale-brown loam. The subsoil has well-defined blocky structure (fig. 7). At a depth of about 13 inches is limy, pale-brown sandy loam, and below a depth of 32 inches, very pale brown loamy sand.

Stoneham soils are naturally well drained. They have medium internal drainage, moderate permeability, and a high water-holding capacity. They are highly fertile. They are moderately susceptible to soil blowing and water erosion.

For the most part, these soils are used as range. Some areas are dryfarmed, but not successfully because of the dry climate. None of the acreage is irrigated.

Typical profile of a Stoneham loam (150 feet west and 50 feet south of NE. corner sec. 1, T. 21 S., R. 50 W.):

A1—0 to 3 inches, light brownish-gray (10YR 6/2) loam, dark grayish brown (10YR 4/2) when moist; weak, fine, platy structure to weak, fine, granular; slightly hard when dry, friable when moist; noncalcareous; clear, smooth boundary.

B2t—3 to 8 inches, grayish-brown (10YR 5/2) clay loam, dark grayish brown (10YR 4/2) when moist; weak to moderate prismatic structure to moderate, medium, subangular blocky; hard when dry, friable when moist; noncalcareous; thin, continuous clay skins; clear, smooth boundary.

B3ca—8 to 13 inches, pale-brown (10YR 6/3) loam, brown (10YR 5/3) when moist; weak, medium, subangular blocky structure; hard when dry, friable when moist;



Figure 7.—Profile of Stoneham loam, 0 to 3 percent slopes.

very strongly calcareous; clear, smooth boundary; many visible white lime spots.

C1ca—13 to 32 inches, pale-brown (10YR 6/3) sandy loam, brown (10YR 5/3) when moist; massive; hard when dry, friable when moist; very strongly calcareous; gradual, smooth boundary; visible white lime spots.

C2—32 to 60 inches, very pale brown (10YR 7/3) coarse loamy sand, brown (10YR 5/3) when moist; loose; very strongly calcareous.

The A1 horizon ranges from 3 to 5 inches in thickness and from sandy loam to loam in texture. The B2t horizon ranges from 3 to 7 inches in thickness, and from light clay loam to sandy clay loam in texture.

Stoneham soils are more gravelly and more sandy than Wiley soils. They have thinner, less distinct horizons than Olney soils. They are less sandy and are shallower over lime than Vona soils.

**Stoneham loam, 0 to 3 percent slopes (StB).**—This soil occurs as irregularly shaped areas that are generally more than 100 acres in size. It is mainly in the northern part of the county. The surface layer is about 4 inches thick. The subsoil is clay loam about 8 inches thick. Included in mapping were areas of Wiley soils; spots of Vona sandy loam,

on higher parts of the landscape; and areas of Deertrail clay loam, in swales and depressed parts.

This soil takes in water at a moderate rate and has a high water-holding capacity. Runoff is medium, and the erosion hazard is moderate.

Most of the acreage is used as range. Deferred grazing and rotation grazing are important in range management. Dryfarming is still done in a few small areas, but it is not successful because of the dry climate. Contour farming and terracing help to conserve moisture and control water erosion in dryfarmed areas, and stubble-mulch tillage and stripcropping help to conserve moisture and control soil blowing. Plowed fields that are no longer farmed should be planted to grass. (Capability unit IVe-1, nonirrigated; Loamy Plains range site)

**Stoneham loam, 3 to 9 percent slopes (StC).**—This soil is mainly in the northern part of the county. There are some small areas in the southeastern corner. The surface layer is about 3 inches thick. The subsoil is clay loam about 8 inches thick. Included in mapping were areas of Stoneham loam, 0 to 3 percent slopes, which are on the more level, higher parts of the landscape, and small areas of Vona sandy loam.

This soil has a moderate water-intake rate and a moderate to high water-holding capacity. Runoff is medium, and the erosion hazard is moderate.

All of the acreage is used as range. Deferral and rotation of grazing and reseeding of grass are among the effective range management practices. (Capability unit VIe-1, nonirrigated; Loamy Plains range site)

## Tivoli Series

The Tivoli series consists of gently sloping to strongly sloping, deep, sandy, hummocky soils on uplands. These soils extend across the county from east to west, just south of the Arkansas River. They formed in sandy material presumably blown from the riverbed.

In a typical profile the surface layer is pale-brown, lime-free sand about 3 inches thick. Below this, to a depth of about 34 inches, is brown, lime-free sand. It is slightly more clayey than the surface layer. The underlying sand is pale brown. It is strongly calcareous below a depth of about 44 inches.

Tivoli soils are excessively drained. They have very rapid internal drainage, very rapid permeability, and a low water-holding capacity. They are low in natural fertility. They are highly susceptible to blowing. There is no significant hazard of water erosion.

All of the acreage is used as range.

Typical profile of Tivoli sand (0.2 mile east and 0.35 mile south of NW. corner sec. 24, T. 23 S., R. 49 W.):

- A1—0 to 3 inches, pale-brown (10YR 6/3) sand, dark brown (10YR 4/3) when moist; single grain; loose when dry, very friable when moist; noncalcareous; clear, smooth boundary.
- C1—3 to 34 inches, brown (10YR 5/3) sand, brown (10YR 4/3) when moist; very weak, coarse, subangular blocky structure; very soft when dry, very friable when moist; noncalcareous; clear, smooth boundary.
- C2—34 to 44 inches, pale-brown (10YR 6/3) fine sand, dark yellowish brown (10YR 4/4) when moist; single grain; loose when dry, very friable when moist; noncalcareous; clear, smooth boundary.
- C3—44 to 60 inches, pale-brown (10YR 6/3) sand, brown (10YR 5/3) when moist; single grain; loose when dry, very friable when moist; strongly calcareous.

The A1 horizon ranges from 3 to 8 inches in thickness and from loamy sand to sand in texture. In places lime has been leached to a depth of more than 60 inches.

Tivoli soils are sandier than Vona soils. They are more deeply leached of lime than Dwyer soils.

**Tivoli sand (3 to 15 percent slopes) (Td).**—This soil occurs as a narrow band that extends across the county from east to west. It is on uplands, just south of the Arkansas River. Generally the areas are 100 acres or more in size. The surface layer is about 5 inches thick. Included in mapping were a few spots of Dwyer sand; small areas of Vona sandy loam, on lower, more level parts of the landscape; and small areas of Tivoli sand, hilly, on more strongly rolling parts.

This soil has a very rapid water-intake rate and a low water-holding capacity. Runoff is very slow, and the hazard of water erosion is very slight. The hazard of soil blowing is severe if the vegetation is destroyed.

The entire acreage is used as range. Rotation and deferral of grazing and reseeding of grass help in maintaining the vegetative cover and controlling soil blowing. (Capability unit VIe-4, nonirrigated; Deep Sand range site)

**Tivoli sand, hilly (10 to 30 percent slopes) (ThD).**—This soil occurs as a band that extends across the county from east to west. It is on uplands, just south of the Arkansas River. Generally the areas are 100 acres or more in size. The surface layer is about 3 inches thick. Included in mapping were areas of Dwyer sand; a few areas of Tivoli sand, in less rolling areas; and spots of Tivoli-Dune land complex.

This soil has a very rapid water-intake rate and a low water-holding capacity. Runoff is very slow, and the hazard of water erosion is very slight. The hazard of soil blowing is severe unless the vegetative cover is maintained.

All of the acreage is used as range. Rotating and deferring grazing are important practices in management. (Capability unit VIIe-1, nonirrigated; Choppy Sand range site)

**Tivoli-Dune land complex (10 to 30 percent slopes) (Tn).**—This complex occurs as a band that extends across the county from east to west, just south of the Arkansas River. It is about 45 percent Tivoli sand, hilly; about 40 percent Dune land; and about 15 percent Tivoli sand. The individual areas are irregularly shaped and generally are between 20 and 30 acres in size.

This complex is used as range. The dunes are the result of soil blowing following overgrazing or cultivation. Reseeding grass and deferring grazing are practical means of establishing vegetation and controlling soil blowing. (Capability unit VIIe-1, nonirrigated; Choppy Sand range site)

## Travessilla Series

The Travessilla series consists of strongly sloping to very strongly sloping soils that are shallow over sandstone. These soils occur as scattered areas on uplands in the southern part of the county.

In a typical profile the surface layer is pale-brown sandy loam about 5 inches thick. The next layer is about 2 inches thick and is generally limy sandy loam mixed with sandstone chips. Sandstone is at a depth of about 10 inches, and in many places it is at the surface.

Travessilla soils are well drained. They have medium internal drainage, moderately rapid permeability, and a low water-holding capacity. They are low in natural fertility. They are susceptible to blowing and water erosion.

All of the acreage is used as range.

Typical profile of a Travessilla sandy loam (400 feet north and 270 feet east of SW. corner sec. 1, T. 24 S., R. 50 W.):

A1—0 to 5 inches, pale-brown (10YR 6/3) sandy loam, dark brown (10YR 4/3) when moist; weak, fine, granular structure; slightly hard when dry, very friable when moist; calcareous; clear, smooth boundary; sandstone chips and fragments on surface.

AC—5 to 7 inches, pale-brown (10YR 6/3) sandy loam, dark brown (10YR 4/3) when moist; very weak, fine, sub-angular blocky structure; slightly hard when dry, very friable when moist; calcareous; clear, smooth boundary; common sandstone rock fragments.

C—7 to 10 inches, light brownish-gray (10YR 6/2) channery sandy loam, dark grayish brown (10YR 4/2) when moist; massive; slightly hard when dry, friable when moist; strongly calcareous; many sandstone rock fragments.

R—10 to 60 inches, sandstone.

The A1 horizon ranges from 1 inch to 6 inches in thickness and from loam to sandy loam in texture. The AC and C horizons combined, if both are present, range from 1 inch to 6 inches in thickness. The depth to sandstone ranges from 1 inch to 12 inches.

Travessilla soils are shallower than Olney soils and lack the clayey subsoil of those soils. They formed in material weathered from sandstone, whereas Penrose soils formed in material weathered from limestone.

**Travessilla-Olney sandy loams, 1 to 9 percent slopes (ToC).**—These soils occur as scattered areas, 100 acres or more in size, between the uplands and the rough broken areas above drainageways. They are in the southern part of the county. The areas are about 60 percent Travessilla sandy loam, 30 percent Olney sandy loam, and 10 percent rock outcrops. The Travessilla soil in this complex has the profile described for the series. The Olney soil is 30 to 50 inches deep over sandstone. Otherwise, it has the profile described under the heading "Olney Series."

These soils take in water readily. The water-holding capacity is low for the Travessilla soil and moderate for the Olney soil. Runoff is medium, and the erosion hazard is moderate. Many of the drainageways are gullied.

The entire acreage is used as range. Rotation and deferment of grazing help in maintaining and improving vegetation and controlling erosion. (Travessilla soils: capability unit VIIIs-3, nonirrigated; Sandstone Breaks range site. Olney soils: capability unit VIIIs-3, nonirrigated; Sandy Plains range site)

**Travessilla-Rock outcrop complex (5 to 50 percent slopes) (Tr).**—This complex is made up of many vertical cliffs, 50 feet high or more, and many ledges and buttes. It occurs as very rough, broken areas scattered along drainageways in the southern part of the county. It is about 70 percent Travessilla soils and about 30 percent sandstone outcrops. The Travessilla soil has the profile described for the series.

This complex has moderate to rapid runoff. The erosion hazard is moderately severe. Most drainageways are gullied.

This complex has potential for use as recreational areas. It provides some grazing for livestock. Rotation and deferment of grazing help in maintaining and improving

vegetation and controlling erosion. (Travessilla soils: capability unit VIIIs-3, nonirrigated; Sandstone Breaks range site)

## Vona Series

The Vona series consists of deep, nearly level to moderately sloping soils. These soils are on uplands, in the north-central part of the county and just south of the Arkansas River.

In a typical profile the surface layer is grayish-brown and brown, lime-free sandy loam about 8 inches thick. The subsoil is sandy loam about 10 inches thick. It is more clayey than the surface layer. It has a weakly defined, coarse, prismatic and blocky structure (fig. 8). The underlying material is pale-brown, strongly calcareous sandy loam and loamy sand.



Figure 8.—Profile of Vona sandy loam showing coarse prismatic structure in subsoil.

Vona soils are naturally well drained. They have rapid internal drainage, moderately rapid permeability, and a moderate water-holding capacity. They are moderate in natural fertility. They are susceptible to erosion, particularly to blowing.

For the most part, these soils are used as range. Some of the acreage is dryfarmed and is highly susceptible to blowing. None of it is irrigated.

Typical profile of a Vona sandy loam (0.15 mile west and 63 yards north of SE. corner sec. 3, T. 21 S., R. 51 W.) :

- A1—0 to 4 inches, grayish-brown (10YR 5/2) sandy loam, dark grayish brown (10YR 4/2) when moist; weak, coarse, platy structure to weak, fine, granular; soft when dry, friable when moist; noncalcareous; clear, smooth boundary.
- A3—4 to 8 inches, brown (10YR 5/3) sandy loam, dark brown (10YR 4/3) when moist; weak, coarse to medium, subangular blocky structure; slightly hard when dry, friable when moist; noncalcareous; clear, smooth boundary.
- B2t—8 to 15 inches, brown (10YR 5/3) sandy loam, dark brown (10YR 4/3) when moist; weak, coarse, prismatic to moderate, medium, subangular blocky structure; hard when dry, friable when moist; noncalcareous; thin, patchy clay skins; clear, smooth boundary.
- B3—15 to 18 inches, pale-brown (10YR 6/3) sandy loam, brown (10YR 5/3) when moist; weak, coarse, prismatic to weak subangular blocky structure; hard when dry, friable when moist; noncalcareous; clear, smooth boundary.
- C1ca—18 to 24 inches, pale-brown (10YR 6/3) sandy loam, brown (10YR 5/3) when moist; very weak, coarse, subangular blocky structure to massive; strongly calcareous; lime spots; clear, smooth boundary.
- C2ca—24 to 30 inches, pale-brown (10YR 6/3) sandy loam, brown (10YR 5/3) when moist; massive; slightly hard when dry, friable when moist; very strongly calcareous; 10 percent white lime spots; clear, smooth boundary.
- C3—30 to 60 inches, pale-brown (10YR 6/3) loamy sand, brown (10YR 5/3) when moist; single grain; loose; very strongly calcareous.

The A1 horizon ranges from 4 to 8 inches in thickness and from sandy loam to loamy sand in texture. The B2t horizon ranges from 5 to 10 inches in thickness and from sandy loam to loam in texture. The Cca horizon ranges from 10 to 20 inches in thickness. In moderately sloping areas, the soils are shallower over lime and have a less well defined profile than in nearly level areas.

Vona soils are sandier than Olney soils and have a less clayey subsoil. They are coarser textured and deeper over lime than Stoneham soils. They are not so sandy as Tivoli soils.

**Vona sandy loam, 0 to 5 percent slopes (VnB).**—This soil occurs as irregularly shaped areas on uplands. The areas are generally between 40 and 100 acres in size and are mainly in the north-central part of the county. Some are just south of the Arkansas River. This soil has the profile described for the series. Included in mapping were small areas of Olney sandy loam, which occur on more level, lower parts of the landscape, and spots of Stoneham loam.

This soil takes in water readily and has a moderately low water-holding capacity. Runoff is slow. The hazard of water erosion is slight. The hazard of soil blowing is severe if the vegetation is destroyed. The response to management is good.

About all of the acreage is used as range. Rotation and deferment of grazing and reseeding of grass help in maintaining and improving vegetation and controlling erosion.

A few areas have been dryfarmed. Most are moderately eroded. (Capability unit VIe-3, nonirrigated; Sandy Plains range site)

**Vona soils, 0 to 5 percent slopes, eroded (VoB2).**—These soils are in the north-central part of the county. They occur as irregularly shaped areas, between 40 and 80 acres in size, generally within larger areas of Vona sandy loam, 0 to 5 percent slopes. The surface layer ranges from sandy loam to loamy sand. Included in mapping were dunes a few inches to as much as 50 inches high.

Soil blowing has been severe. On about 80 percent of the acreage, most or all of the surface layer has been removed and the subsoil is exposed. In many places part of the subsoil has been removed, and in a few places all of it is gone. Most of these eroded areas were once cultivated.

About all of the acreage is used as range. Deferment of grazing helps in reestablishing grass. Planting is difficult because of the hummocky condition. (Capability unit VIe-3, nonirrigated; Sandy Plains range site)

## Weld Series

The Weld series consists of nearly level soils that are deep and silty. These soils are on the loessal uplands in the northeastern part of the county.

In a typical profile the surface layer is grayish-brown, lime-free silt loam about 7 inches thick. The subsoil is about 19 inches thick. The upper part is dark grayish-brown clay, the middle part is pale-brown silty clay loam, and the lower part is very limy, pale-brown silt loam. This layer has blocky structure. The underlying material is very limy, very pale brown silt loam.

Weld soils are naturally well drained. They have slow internal drainage, moderate permeability, and a high water-holding capacity. They are high in natural fertility. The response to range management is good.

For the most part, these soils are used as range. None of the acreage is irrigated.

Typical profile of a Weld silt loam (100 yards north and 85 yards east of center sec. 22, T. 21 S., R. 50 W.) :

- A1—0 to 6 inches, grayish-brown (10YR 5/2) silt loam, dark brown (10YR 3/3) when moist; weak, coarse, platy structure to weak, fine, granular; soft when dry, very friable when moist; noncalcareous; clear, wavy boundary.
- A2—6 to 7 inches, light brownish-gray (10YR 6/2) silt loam, dark grayish brown (10YR 4/2) when moist; massive; soft when dry, very friable when moist; noncalcareous; abrupt, smooth boundary.
- B21t—7 to 11 inches, dark grayish-brown (10YR 4/2) clay, very dark grayish brown (10YR 3/3) when moist; strong, medium, prismatic structure to strong, fine, subangular blocky; very hard when dry, firm when moist; noncalcareous; medium, continuous clay skins; clear, smooth boundary.
- B22t—11 to 17 inches, pale-brown (10YR 6/3) silty clay loam, dark brown (10YR 4/3) when moist; moderate, medium, prismatic structure to moderate, fine, angular and subangular blocky; hard when dry, firm when moist; calcareous; thin, patchy clay skins; clear, smooth boundary.
- B3ca—17 to 26 inches, pale-brown (10YR 6/3) silt loam, brown (10YR 5/3) when moist; weak, medium, prismatic structure to weak, medium, subangular blocky; slightly hard when dry, friable when moist; violently calcareous; clear, smooth boundary.
- C—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; violently calcareous.

The A1 horizon ranges from 4 to 8 inches in thickness and from silt loam to very fine sandy loam in texture. In spots the A2 horizon is barely visible, and in places it is up to 3 inches thick. The B2t horizon ranges from 8 to 15 inches in thickness and from heavy clay loam to clay in texture.

Weld soils are darker colored, have more distinct and thicker horizons, and are deeper over lime than Baca and Wiley soils. They lack the buried layer that is typical of Rago soils.

**Weld silt loam, 0 to 1 percent slopes (WeA).**—This soil occurs as irregularly shaped areas, generally between 30 and 60 acres in size, in the northeastern corner of the county. Included in mapping were small areas of Baca silt loam, on slightly raised parts of the landscape, and spots of Stoneham loam, on more sloping ridges.

This soil is high in fertility. Runoff is slow, and the hazard of water erosion is slight.

About all of the acreage is used as range. Deferment and rotation of grazing and reseeding of grass help in maintaining the vegetative cover. Some of the acreage has been dryfarmed. Stubble mulching and summer fallowing help to conserve moisture and control soil blowing if any dryfarming is done. (Capability unit IVE-1, nonirrigated; Loamy Plains range site)

## Wiley Series

The Wiley series consists of nearly level to gently sloping soils that are deep and silty. These soils are on uplands, mainly in the eastern part of the county.

In a typical profile the surface layer is light brownish-gray, lime-free to weakly limy silt loam about 3 inches thick. The subsoil is grayish-brown to pale-brown silt loam about 10 inches thick. This layer contains more clay than the surface layer. The structure is weak prismatic to subangular blocky. Below the subsoil, to a depth of 60 inches, is very strongly calcareous, pale-brown, massive silt loam.

Wiley soils are naturally well drained. They have medium internal drainage, moderate permeability, and a high water-holding capacity. They are high in natural fertility. They are susceptible to blowing and to water erosion. The response to management is good.

Most of the acreage is used as range. Some is cultivated, and winter wheat is the main crop. Dryfarming is hazardous because of the dry climate, but none of the acreage is irrigated.

Typical profile of a Wiley silt loam (210 feet south and 580 feet east of NW. corner sec. 18, T. 25 S., R. 49 W.):

- A1—0 to 3 inches, light brownish-gray (10YR 6/2) silt loam, dark grayish brown (10YR 4/2) when moist; weak, fine, granular structure; soft when dry, very friable when moist; noncalcareous; clear, smooth boundary.
- B1—3 to 5 inches, grayish-brown (10YR 5/2) silt loam, dark grayish brown (10YR 4/2) when moist; weak to moderate, fine, subangular blocky structure; hard when dry, friable when moist; noncalcareous; thin, patchy clay skins; clear, smooth boundary.
- B2t—5 to 9 inches, pale-brown (10YR 6/3), fine silt loam, dark brown (10YR 4/3) when moist; weak, medium, prismatic structure to weak, medium, subangular blocky; slightly hard when dry, friable when moist; very strongly calcareous; thin, patchy clay skins; clear, smooth boundary.
- B3ca—9 to 13 inches, pale-brown (10YR 6/3) silt loam, brown (10YR 5/3) when moist; very weak, coarse, prismatic structure; slightly hard when dry, friable when moist; very strongly calcareous; clear, smooth boundary; few lime spots.
- Cca—13 to 60 inches, pale-brown (10YR 6/3) silt loam, brown (10YR 5/3) when moist; massive; slightly hard when

dry, friable when moist; very strongly calcareous; common lime spots.

The A1 horizon ranges from 2 to 6 inches in thickness and from silt loam to very fine sandy loam in texture. The B2t horizon ranges from 4 to 10 inches in thickness and from silt loam to light silty clay loam in texture. The depth to lime ranges from 0 to 6 inches.

Wiley soils are shallower over lime and have less distinct horizons than Baca soils. They are deeper over lime and have more distinct horizons than Colby soils. They developed in loess and therefore lack the gravel content that is typical of Stoneham soils.

**Wiley silt loam, 0 to 3 percent slopes (WIB).**—This is the most extensive soil in the county. It occurs as irregularly shaped areas on uplands, mainly in the eastern part of the county. The areas are generally between 60 and 80 acres in size; some are between 400 and 500 acres. Included in mapping were areas of Baca silt loam, on the smoother parts of the landscape, and areas of Colby silt loam, on the raised, more sloping parts.

This soil is easy to work. It takes in water at a moderate rate and has a high water-holding capacity. Runoff is medium, and the erosion hazard is moderate.

Most of the acreage is used as range. Rotation and deferment of grazing and reseeding of grass help in maintaining a grass cover and controlling erosion. Large acreages have been dryfarmed, and most are now moderately eroded. Stubble mulching and summer fallowing help to conserve moisture and control erosion if any dryfarming is done. If the vegetative cover is inadequate, listing and chiseling are beneficial. (Capability unit IVE-1, nonirrigated; Loamy Plains range site)

## Use and Management of the Soils

The soils of Bent County vary widely in the physical and chemical characteristics that determine their suitability for crops and their management needs. They range from clay to sand in texture. All are low in organic-matter content. Some areas, particularly those irrigated, need artificial drainage if they are to be used for cultivated crops. Most crops need fertilization.

## Management of Nonirrigated Soils

The climate of Bent County is extremely dry. Only the deep, medium-textured, nearly level soils in the eastern half of the county can be used for crops without being irrigated. Conserving moisture and minimizing the hazard of soil blowing are the basic management problems. The amount of rainfall decreases from east to west, and the same kinds of soils that are marginal for dryfarming in the eastern half of the county are too dry in the western half.

Specific management for nonirrigated soils is suggested in the descriptions of the capability units, under the heading "Capability Groups of Soils."

## Management of Irrigated Soils

Irrigation water must be controlled from the time it enters the ditches or pipes, in such a way that the root zone is moistened and the loss of water through runoff or deep percolation is minimized. The method of irrigation depends on the slope.

The quality of water available for irrigation is a major consideration. In this county, the water is affected by dissolved salts and by sediment.

Water from the Arkansas River and from reservoirs, which supply most of the water for the county, contains only small amounts of harmful salts. Seepage water that accumulates in drainage ditches contains large amounts of salts and is not suitable for irrigation. Well water generally is of good to fair quality, but it carries larger amounts of salts than river water.

Canals that originate in the Arkansas River carry large amounts of sediment, and all of the irrigated acreage in the county has been affected by deposition of silt and clay from muddy irrigation water. In areas that have been irrigated for many years, the surface layer is finer textured than it was originally. In places the texture has been changed from sandy loam to clay loam. Most of the silted soils are easily identifiable by the thick deposits of dark-colored material. These deposits are most obvious in the Numa and Kornman soils. As siltation continues, the surface layer becomes hard and crusty and difficult to work, the risk of clodding and compaction after cultivation increases, salts accumulate, and water intake slows down. Moreover, the cost per acre of farming these soils increases. Siltation can be controlled to some extent by protecting the watershed to the west, where the water originates. Run-off in this area and subsequent erosion contribute to the heavy load of silt and clay in the irrigation water.

Depth and texture determine the amount of available moisture that a soil can store. This storage capacity is the basis for determining the frequency of irrigation, the size of streams, and the size of farm laterals. In general, the inches of available moisture that can be stored in 1 foot of soil, by texture, are as follows:

<i>Texture</i>	<i>Inches</i>
Sand -----	0.25 to 0.75
Loamy sand -----	0.75 to 1.25
Sandy loam -----	1.00 to 1.75
Silt loam and loam -----	1.50 to 2.00
Clay loam -----	1.75 to 2.25
Clay -----	2.00 to 3.00

The irrigated soils in this county vary widely in their ability to store water. Glenberg soils, for example, have a low water-holding capacity, and the Rocky Ford and Numa soils have a high water-holding capacity.

The frequency of irrigation and the amount of water to be applied depend on the crop. If the crop is deep rooted and can extract water from a depth of 6 feet, for example, it is more efficient to apply a large amount of water at each irrigation and to irrigate less frequently. Alfalfa penetrates to a depth of 6 feet; corn, sorghum, small grain, and sugar beets to a depth of 4 feet; potatoes, beans, other vegetables, and pasture grasses to a depth of 3 feet; and onions to a depth of 2 feet.

The depth of water required during each irrigation depends on how much water the soil can hold and on how much water is taken from the soil between irrigations. A medium-textured soil normally stores about 2 inches of available water per foot of soil depth. Generally not more than 1 inch is removed before another irrigation is needed if the crop is to grow rapidly. Thus, if the roots of a crop extend to a depth of 3 feet, about 3 inches of water should be stored at each irrigation. Assuming that the irrigation system is 75 percent efficient and that the crop uses 0.2 inch

of moisture per day, the 3 inches stored would last 15 days. Hence, the irrigation interval would be every 2 weeks. Excessive irrigation wastes water and washes away plant nutrients.

The saline-alkali soils and all of the somewhat poorly drained soils have to be drained if they are to be dry enough for seedbed preparation early in spring. If they are waterlogged, subsurface drainage through open ditches or covered tile drains is required. Wet soils have a restricted root zone because of poor aeration. Also they warm up slowly in spring. Some of the somewhat poorly drained Apishapa and Las soils show evidence of such limitations. A drainage system that controls the level of the water table should be considered. The water table must be kept low enough to prevent soluble salts from moving upward into the root zone.

Applying irrigation water without washing away the soil is another serious problem. Choosing a suitable method for distributing the water on sloping soils is most important.

Soils that have a high water table commonly are affected by salts and alkali. The Apishapa, Las, and Las Animas soils in this county, for example, are affected by salts, and the Arvada and Deertrail soils, by large amounts of exchangeable sodium. Saline and alkali soils have to be irrigated more frequently than other soils. They should be used only for salt-resistant crops.

## Capability Groups of Soils

Capability classification is the grouping of soils to show, in a general way, their suitability for most kinds of farming. It is a practical classification based on the limitations of the soils, the risk of damage when they are used, and the way they respond to treatment. The classification does not apply to most horticultural crops or to rice and other crops that have special requirements. The soils are classified according to degree and kind of permanent limitation, but without consideration of major and generally expensive landforming that would change the slope, depth, or other characteristics of the soils; and without consideration of possible but unlikely major reclamation projects.

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

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

- Class I. Soils have few limitations that restrict their use.
- Class II. Soils have moderate limitations that reduce the choice of plants or require moderate conservation practices.
- Class III. Soils have severe limitations that reduce the choice of plants, require special conservation practices, or both.
- Class IV. Soils have very severe limitations that restrict the choice of plants, require very careful management, or both.
- Class V. Soils are subject to little or no erosion but have other limitations, impractical to remove.

that limit their use largely to pasture, range, woodland, or wildlife food and cover. (No class V soils in Bent County.)

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

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

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

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

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

CAPABILITY UNITS are soil groups within the subclasses. The soils in one capability unit are enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity and other responses to management. Thus, the capability unit is a convenient grouping for making many statements about management of soils. Capability units are generally designated by adding Arabic numerals to the subclass symbol, for example, IIe-2 or IIIw-2. Thus, in one symbol, the Roman numeral designates the capability class, or degree of limitation; the small letter indicates the subclass, or kind of limitation, as defined in the foregoing paragraphs; and the Arabic numeral specifically identifies the capability unit.

Most of the soils in the county are classified according to their capacity if not irrigated. Those suitable for irrigation and for which irrigation water is available are also classified according to their capacity if irrigated. In the following pages each of the capability units, both for irrigated and for nonirrigated soils, is described, and suggestions for use and management of the soils are given. The capability unit designations for all the soils in the county can be found in the "Guide to Mapping Units."

#### **Capability unit I-1 (irrigated)**

The one soil in this unit, Colby silt loam, 0 to 1 percent slopes, is deep and well drained. It has a medium-textured subsoil and substratum. Internal drainage is medium, permeability is moderate, and the water-holding capacity is high. Natural fertility is high. The erosion hazard is slight.

This soil is suited to all crops grown in the area and is well suited to vegetable crops. It needs management that

will maintain or improve tilth and fertility and promote efficient use of irrigation water. All crop residue should be incorporated into the soil to replenish the supply of organic matter.

This soil is well suited to irrigation. Leveling, runs of proper length, and adequate heads of water are needed for efficient use of irrigation water and for control of erosion.

#### **Capability unit IIe-1 (irrigated)**

The soils in this unit are nearly level, deep, and well drained. They have a moderately fine textured surface layer and a moderately fine textured to moderately coarse textured subsoil and substratum. Internal drainage is medium to slow, permeability is moderate, and the water-holding capacity is moderate to high. Natural fertility is moderate to high.

These soils are suited to all crops grown in the area. They are not so well suited to vegetable crops as the coarse-textured soils, because they clod and compact more readily. They need management that will maintain or improve tilth and fertility, control erosion, and promote efficient use of irrigation water. Growing alfalfa or an alfalfa-grass mixture part of the time is one method of meeting these needs. Another is applying large amounts of commercial fertilizer and utilizing crop residue. Tilling at the proper time prevents clodding and compaction.

These soils are well suited to irrigation (fig. 9) but are affected by the deposition of silt and clay from muddy irrigation water. Leveling is needed for efficient use of the irrigation water and for good distribution over the fields. Irrigating on the contour helps to conserve water and control erosion.

#### **Capability unit IIe-2 (irrigated)**

The one soil in this unit, Colby silt loam, 1 to 3 percent slopes, is deep and well drained. It has a medium-textured subsoil and substratum. In places it is stratified with coarser textured material. Internal drainage is medium, permeability is moderate, and the water-holding capacity is high. Natural fertility is high.

This soil is suited to all crops grown in the area. It is better suited to vegetable crops than the finer textured soils are. It needs management that will maintain or improve tilth and fertility and promote efficient use of irrigation water. Crop residue should be incorporated into the soil to replenish the supply of organic matter.

This soil is well suited to irrigation. Leveling, runs of proper length, adequate heads of water, and contour irrigation are needed for efficient use of irrigation water and for control of erosion.

#### **Capability unit IIw-1 (irrigated)**

The soils in this unit are nearly level, deep, and somewhat poorly drained. They are medium textured to moderately fine textured throughout the profile. Internal drainage is medium. Permeability is moderate in the surface layer and subsoil and rapid in the substratum. Salinity is slight to moderate. There is no significant hazard of erosion.

If drained and leached, these soils would have moderate to high natural fertility and a high water-holding capacity, and they would be well suited to general crops, including alfalfa, corn, sorghum, sugar beets, small grain, and irrigated pasture, and fairly well suited to vegetable crops.



*Figure 9.*—Irrigated crops on Numa clay loam, 1 to 3 percent slopes.  
Capability unit IIe-1.

Growing alfalfa or a grass-legume mixture, utilizing crop residue, and applying manure would replenish the supply of organic matter and improve tilth and fertility. Nitrogen would be beneficial to grain crops and grasses, and phosphate to legumes.

Leveling would be needed if these soils were irrigated. Irrigation water would have to be applied in amounts large enough to leach the soils below their root zone but not in amounts large enough to cause an accumulation of excess water. The sprinkler, border dike, corrugation, furrow, contour furrow, and controlled flooding methods of irrigation would be suitable.

#### **Capability unit IIs-1 (irrigated)**

The soils in this unit are level, deep, and well drained. They have a moderately fine textured surface layer and a moderately fine textured to coarse-textured subsoil and substratum. Internal drainage is medium to slow, permeability is moderate, and the water-holding capacity is high. There is no significant hazard of erosion.

These soils are suited to all of the crops commonly grown. They are not so well suited to vegetable crops as the coarse-textured soils, because they clod and compact more readily (fig. 10) and are more difficult to work into a seedbed. These soils need management that will maintain

or improve tilth and fertility and promote efficient use of irrigation water. Growing grasses and legumes in the cropping system is one method of meeting these needs.



*Figure 10.*—Clods on Numa clay loam, 0 to 1 percent slopes. Capability unit IIs-1.

Another is utilizing all crop residue. Nitrogen and phosphate should be applied in the amounts indicated by soil tests.

These soils are well suited to irrigation. Leveling and runs of proper length are needed for efficient use of irrigation water (fig. 11) and for control of erosion.

**Capability unit IIs-2 (irrigated)**

The one soil in this unit, Glenberg sandy loam, 0 to 1 percent slopes, is deep and well drained. It has a moderately coarse textured subsoil and a moderately coarse textured or coarse textured substratum. Internal drainage is medium to rapid, permeability is moderately rapid, and the water-holding capacity is moderate. Natural fertility is moderate. The erosion hazard is slight.

This soil is well suited to most of the crops grown in the area and is particularly well suited to vegetable crops. Utilizing crop residue improves tilth and fertility.

This soil is well suited to irrigation. Leveling and runs of proper length promote efficient use of irrigation water. Runs should be shorter on this soil than on the more clayey soils because water intake is more rapid and long runs would result in loss of water through deep percolation.

**Capability unit IIIe-1 (irrigated)**

The one soil in this unit, Numa clay loam, sand substratum variant, 0 to 3 percent slopes, is well drained and

is moderately deep over sand and gravel. It has a medium-textured to moderately fine textured subsoil. Natural fertility is moderate. The water-holding capacity is moderate. Permeability is rapid in the substratum. This soil is affected by the deposition of silt and clay from muddy irrigation water.

This soil is well suited to all the field crops grown in the area and to vegetable crops, including potatoes, melons, onions, and tomatoes. Growing alfalfa and grass-legume mixtures improves tilth and replenishes the supply of organic matter. Utilizing crop residue and applying manure are beneficial. Nitrogen is needed for small grain, grass, and corn, and phosphate is beneficial to all crops, and particularly to legumes. The amounts to be applied should be determined by soil tests.

This soil is well suited to irrigation but requires more careful layout and application of irrigation water than the level, deep soils do. Runs should be short enough to prevent loss of water through deep percolation. Most of the accepted methods of irrigating can be used. The contour furrow method conserves water and controls erosion. Leveling is necessary for irrigation by any method other than sprinkling.

**Capability unit IIIe-2 (irrigated)**

The one soil in this unit, Glenberg sandy loam, 1 to 3 percent slopes, is deep and well drained. It has a mod-



Figure 11.—Rocky Ford clay loam, 0 to 1 percent slopes, leveled and laid out for border irrigation. Capability unit IIs-1.

erately coarse textured subsoil and a moderately coarse textured or coarse textured substratum. Internal drainage is medium to rapid, permeability is moderately rapid, and the water-holding capacity is moderate. The erosion hazard is slight to moderate.

This soil is well suited to all crops grown in the area, and particularly to vegetable crops. Utilizing crop residue and applying manure improve tilth and fertility.

This soil is well suited to irrigation. Leveling, runs of proper length, and timely application promote efficient use of irrigation water. Runs should be shorter on this soil than on the finer textured soils because water intake is more rapid and long runs would result in loss of water through deep percolation. Because of the slope, the water should be controlled so that it will not cause erosion.

#### ***Capability unit IIIw-1 (irrigated)***

The one soil in this unit, Apishapa clay loam, is level, deep, and poorly drained. It has a moderately fine textured surface layer and a moderately fine textured to fine textured subsoil. Internal drainage is slow. Permeability is slow to a depth of 30 inches and slow to moderate below this depth. Fertility is moderate to high.

Wetness and salinity are severe limitations. Artificial drainage has to be installed before crops can be grown.

This soil is suited to sugar beets, small grain, and irrigated pasture. Growing grasses or a grass-legume mixture at least two-thirds of the time reduces salinity and helps to improve fertility, preserve tilth, and increase water intake. Crop residue and barnyard manure replenish the supply of organic matter. Overcultivation or cultivation when the soil is too wet or too dry should be avoided, because the structure and tilth are easily damaged. Nitrogen is needed for grasses and grain crops, and phosphate for legumes.

Irrigating is difficult because of slow permeability, salinity, and the hazard of seepage. The border dike, corrugation, furrow, and controlled flooding methods of irrigating are suitable. Leveling is needed.

#### ***Capability unit IIIw-2 (irrigated)***

The soils in this unit are nearly level, moderately deep, and somewhat poorly drained. They have a moderately fine textured surface layer and subsoil and a coarse-textured substratum. They have a high water table and are naturally wet. Water intake is medium to slow, and the water-holding capacity is moderate. Salinity is slight to moderate.

These soils are moderately difficult to work. They are well suited to sugar beets, sorghum, and truck crops and are very well suited to irrigated pasture. They are not so well suited to alfalfa as the deep soils are. Barnyard manure, crop residue, and green-manure crops should be plowed under to improve tilth and replenish the supply of organic matter.

Where drainage ditches have been established, these soils are well suited to irrigation. Leveling makes uniform application of irrigation water easier. Runs should be shorter on these soils than on the deeper soils because water intake is more rapid and long runs would result in loss of water through deep percolation.

#### ***Capability unit IIIs-1 (irrigated)***

The one soil in this unit, Rocky Ford clay loam, sand substratum variant, 0 to 1 percent slopes, is level, moderately deep, and well drained. It has a moderately fine textured subsoil. Internal drainage is medium in the subsoil and rapid in the substratum. Permeability is moderate in the surface layer and subsoil and rapid in the substratum. The water-holding capacity is moderate. Natural fertility is high. This soil is affected by the deposition of silt and clay from muddy irrigation water.

This soil is suited to all of the crops grown in the area. It needs management that will improve water intake, aeration, and tilth. Growing grasses and legumes is one method of meeting these needs. Another is incorporating crop residue and barnyard manure into the soil. The amounts of nitrogen and phosphate to be applied should be determined by soil tests. Timely cultivation is important. If the soil is cultivated when too wet or too dry, the result is a rough, cloddy seedbed.

This soil is well suited to irrigation. Leveling and runs of proper length are needed for efficient use of irrigation water and for control of erosion.

#### ***Capability unit IIIs-2 (irrigated)***

The soils in this unit are level, moderately deep, and excessively drained. They have a moderately coarse textured to medium-textured surface layer and subsoil and a coarse-textured substratum. Internal drainage is moderately rapid in the subsoil and very rapid in the substratum. Permeability is moderately rapid, and the water-holding capacity is low to moderate. Fertility is low to moderate.

These soils are suited to most of the irrigated crops grown in the area, including alfalfa, small grain, sorghum, and irrigated pasture. They are particularly well suited to vegetable crops. They are not so readily damaged by overcultivation and the use of heavy machinery as the finer textured soils are. Growing alfalfa and grass-legume mixtures improves tilth and fertility and replenishes the supply of organic matter. Utilizing crop residue and applying barnyard manure are beneficial.

Leveling is needed for surface irrigation. Runs should be shorter on these soils than on the finer textured soils because water intake is more rapid and long runs would result in loss of water through deep percolation. Any of the methods of irrigating commonly used are suitable.

#### ***Capability unit IVe-1 (nonirrigated)***

This unit consists of level and nearly level soils that are deep and well drained. These soils have a medium-textured to moderately fine textured surface layer and a moderately fine textured subsoil. They have a high water-holding capacity. They are easily penetrated by water, air, and roots.

Conserving moisture and controlling soil blowing are the main problems. Growing enough vegetation to provide the protection needed is particularly difficult during dry seasons.

These soils are used as cropland and range. They are suited to wheat and sorghum but need to be fallowed every other year because of inadequate rainfall. Sweeps should be used for fallowing; they leave a large amount of vegetation that protects the soil against blowing and water erosion and improves water intake. Crops should be planted

in strips less than 20 rods wide at right angles to the prevailing winds. Stubble mulching and minimum tillage are important. Emergency tillage may be needed during periods of very strong winds. Weeds should be controlled to save moisture.

Practices that conserve moisture and control blowing are also important if these soils are used as range. Rotating and deferring grazing and reseeding grasses help to maintain and improve the vegetative cover. Water spreading is beneficial wherever practical.

#### ***Capability unit IVe-2 (nonirrigated)***

This unit consists of nearly level soils that are deep and well drained. These soils have a moderately coarse textured surface layer and a moderately fine textured subsoil. Internal drainage is medium, permeability is moderately rapid, and the water-holding capacity is high. Natural fertility is high. Blowing is a serious hazard.

These soils are used as cropland and range. Their suitability for dryfarming is marginal because of the dry climate and the hazard of blowing. They are suitable for wheat and sorghum but need to be fallowed every other year because of inadequate rainfall. Sweeps should be used for fallowing; they leave a large amount of vegetation, which protects the soil against blowing and water erosion and improves water intake. Stubble mulching and minimum tillage are important. Crops should be planted in strips less than 20 rods wide at right angles to the prevailing winds. Emergency tillage may be needed during periods of very strong winds.

Management that conserves moisture and controls blowing is also important if these soils are used as range. Rotating and deferring grazing and reseeding grasses help to maintain and improve the vegetative cover.

#### ***Capability unit IVw-1 (irrigated)***

This unit consists of Las Animas soils. These are nearly level, moderately deep to deep, poorly drained soils near streams. They have a high water table and are subject to flooding. They have a medium-textured to moderately coarse-textured surface layer and a coarse-textured subsoil and substratum. Internal drainage is moderately rapid to rapid, and permeability is moderately rapid.

These soils are used mainly as pasture and wildlife habitat. Some areas could be used for crops if outlets for drainage installations were available. If drained, these soils would be suited to most of the crops commonly grown in the county. Crop residue and barnyard manure improve fertility, preserve tilth, and replenish the supply of organic matter.

These soils are not well suited to irrigation, but they would need to be irrigated if they were used for crops. They would be suitable for sprinkler, corrugation, and furrow irrigation. Careful application of water would be necessary to prevent deep percolation, which wastes water and removes plant nutrients. Leveling also would be needed. It would need to be done carefully so as to avoid exposing the sandy and gravelly substratum.

#### ***Capability unit IVs-1 (irrigated)***

The one soil in this unit, Minnequa loam, 0 to 5 percent slopes, is moderately deep and well drained. It has a medium-textured to moderately fine textured subsoil and an impervious substratum. This impervious material is

the main limitation. It creates a perched water table when the soil is irrigated and also limits the depth to which roots can penetrate. The water-holding capacity is moderate. Fertility is moderate.

This soil is suited to corn, sorghum, and small grain but is better suited to grasses and grass-legume mixtures. Utilizing all crop residue and applying barnyard manure improve fertility and tilth and replenish the supply of organic matter. Phosphate is needed for legumes, and nitrogen is beneficial to grasses and grain crops. The amounts to be applied should be determined by soil tests.

This soil needs to be leveled before irrigation, but cuts of more than a foot expose shaly limestone in some places. The sprinkler, border dike, corrugation furrow, and controlled flooding methods of irrigating are suitable. Extreme care is needed. Overirrigation creates a water table above the shaly limestone, and the excess water brings salts to the surface.

#### ***Capability unit IVs-2 (irrigated)***

This unit consists of Bankard soils. These soils are nearly level, excessively drained, and deep to moderately deep over gravel. They have a medium-textured surface layer and a coarse-textured subsoil and substratum. Both the subsoil and substratum are stratified in places. Internal drainage is rapid, permeability is rapid, and the water-holding capacity is low. Natural fertility is low.

Grasses and legumes grown for hay and pasture are the most suitable crops. Corn, sorghum, and some vegetable crops do fairly well if the soils are properly fertilized. A cropping sequence that keeps grass or a grass-legume mixture on the soils most of the time helps in maintaining fertility and controlling erosion.

Irrigating is difficult because of the sandy texture. Extra care is needed to prevent loss of water and plant nutrients. The sprinkler method of irrigation is the most satisfactory. Pipe or concrete-lined field ditches are needed to prevent erosion and excessive loss of irrigation water.

#### ***Capability unit VIe-1 (nonirrigated)***

The soils in this unit are nearly level to gently sloping. They have a medium-textured surface layer, a medium-textured to moderately fine textured subsoil, and a medium-textured to coarse-textured substratum. They are susceptible to erosion unless protected by vegetation. They absorb water well unless the surface layer is sifted and worked by wind and the vegetative cover is destroyed. Most of the water reserve is held in the uppermost few inches.

These soils need management that will maintain and improve the vegetative cover and control erosion. Deferring and rotating grazing and reseeding grasses are important practices. Water spreading is beneficial in places. More information on managing the soils in this unit is given in the section "Use and Management of Rangeland," under the heading "Loamy Plains range site."

#### ***Capability unit VIe-2 (nonirrigated)***

The soils in this unit are nearly level to gently sloping. They have a moderately fine textured surface layer and a moderately fine textured to fine textured subsoil and substratum. In places shale is at a depth of 20 to 36 inches. Internal drainage is moderately slow to slow, and permeability is moderately slow. These soils are susceptible to

blowing and water erosion if the vegetation is destroyed.

None of the acreage is cultivated. The part that once was cultivated has been planted to grasses or has reverted to native range. Deferment and proper distribution of grazing are essential for maintaining an adequate vegetative cover and providing adequate forage for livestock. More information on managing the soils in this unit is given in the section "Use and Management of Rangeland," under the heading "Alkaline Plains range site."

**Capability unit VIe-3 (nonirrigated)**

The soils in this unit are nearly level to gently sloping. They have a moderately coarse textured surface layer, a moderately coarse textured to medium textured subsoil, and a moderately coarse textured to coarse textured substratum. In places they are shallow over sandstone. They have medium to moderately rapid internal drainage and moderate to moderately rapid permeability.

These soils are used as range. They need management that will maintain and improve the vegetative cover and control erosion. Deferring and rotating grazing and re-seeding grasses are essential practices. More information on managing the soils in this unit is given in the section "Use and Management of Rangeland," under the heading "Sandy Plains range site."

**Capability unit VIe-4 (nonirrigated)**

This unit consists of undulating to rolling, deep, loose sands. Water intake is very rapid, and no moisture is lost as runoff. Because these soils are sandy and hold only small amounts of moisture in each foot of soil, moisture penetrates deeply during periods of heavy precipitation. Soil blowing is a serious hazard if the vegetative cover is depleted.

Most of the acreage is used for grazing. None of it is cultivated. Tall, deep-rooted grasses grow well if they are protected during periods of drought. Information on managing the soils in this unit is given in the section "Use and Management of Rangeland," under the heading "Deep Sand range site."

**Capability unit VIw-1 (nonirrigated)**

The soils in this unit are level to nearly level, deep to moderately deep, and poorly drained. They have a moderately fine textured to coarse-textured surface layer and a fine-textured to coarse-textured subsoil. In places sand and gravel are below a depth of 20 inches. The water table is high most of the year, and the soils are moderately to strongly affected by salts. The erosion hazard is slight, unless the vegetation is destroyed.

None of the acreage is drained and cultivated. All of it is used for grazing. Deferment and proper distribution of grazing are essential to provide adequate forage for livestock and an adequate vegetative cover for protection of the soils. More information on managing the soils in this unit is given in the section "Use and Management of Rangeland," under the heading "Salt Meadow range site."

**Capability unit VIw-2 (nonirrigated)**

This unit consists of level to nearly level, deep to moderately deep, somewhat poorly drained soils on bottom land. These soils are subject to flooding during periods of high water. They have a moderately coarse textured surface

layer and subsoil and in places have sand and gravel below a depth of 20 inches. Internal drainage is medium to rapid, and permeability is moderately rapid. Soil blowing becomes a hazard if the vegetation is removed.

These soils are used as range. They need management that will maintain and improve the vegetative cover and control erosion. Deferment and rotation of grazing and proper distribution of livestock are essential. More information on managing the soils of this unit is given in the section "Use and Management of Rangeland," under the heading "Sandy Bottom Land range site."

**Capability unit VIIs-1 (nonirrigated)**

The soils in this unit are nearly level to gently sloping. They are moderately fine textured to fine textured throughout the profile. They are moderately to strongly affected by salts. Internal drainage is moderately slow to slow, and permeability is moderately slow. Soil blowing and water erosion are hazards if the vegetative cover is destroyed.

None of the acreage is cultivated. The part that once was cultivated has been planted to grasses or has reverted to native range. Reseeding grasses and establishing a good stand are difficult because of salinity. Management should include deferred grazing, rotation grazing, and water spreading. More information on managing the soils in this unit is given in the section "Use and Management of Rangeland," under the heading "Salt Flats range site."

**Capability unit VIIe-1 (nonirrigated)**

This unit consists of rolling to hilly, deep, loose sands. Water intake is very rapid, and there is no runoff. Internal drainage is rapid, and the water-holding capacity is low. Water penetrates deeply during periods of heavy rainfall. The vegetation consists dominantly of deep-rooted plants, tall grasses, and sand sage. The hazard of soil blowing is severe.

None of the acreage is cultivated. Most of it is used for grazing. Part of it is bare of vegetation and is actively eroding. The methods of seeding commonly used are not successful in reseeding the eroded areas. Scattering hay or sorghum protects blown areas until the weed or grass seeds germinate and grow. More information on managing the soils in this unit is given in the section "Use and Management of Rangeland," under the heading "Choppy Sand range site."

**Capability unit VIIIs-1 (nonirrigated)**

This unit consists of gently to strongly sloping soils that are shallow over limestone. In some areas limestone is within a depth of 12 inches. In others it crops out or occurs as small ledges. The surface layer is medium textured. Permeability is moderate, and the water-holding capacity is low. Soil blowing and water erosion are hazards if the vegetative cover is depleted.

These soils are used as range. They need management that will maintain or improve the vegetative cover and control erosion. Deferment and proper distribution of grazing are essential. More information on managing the soils in this unit is given in the section "Use and Management of Rangeland," under the headings "Limestone Breaks range site" and "Loamy Plains range site."

**Capability unit VIIs-2 (nonirrigated)**

This unit consists of gently sloping to moderately sloping soils that are shallow over shale. Shale is within a depth of 12 inches. These soils have a moderately fine textured surface layer. They are moderately to slightly affected by salts. Permeability is moderately slow to slow, and the water-holding capacity is low. Erosion is a hazard if the vegetative cover is depleted.

These soils are used only as range. They need management that will maintain or improve the vegetative cover and control erosion. Deferring and rotating grazing and reseeding grasses are important practices. Reseeding is difficult because of shallowness and salinity. More information on managing the soils in this unit is given in the section "Use and Management of Rangeland," under the heading "Shale Breaks range site."

**Capability unit VIIs-3 (nonirrigated)**

This unit consists of gently sloping to steep soils that are shallow over sandstone. In some areas sandstone is within a depth of 12 inches. Outcrops and cliffs are numerous. The surface layer is moderately coarse textured. Permeability is moderate to moderately rapid, and the water-holding capacity is low. Soil blowing and water erosion are hazards.

These soils are suitable only for use as range. They need management that will maintain or improve the vegetative cover and control erosion. Deferment and proper distribution of grazing are essential. More information on managing the soils in this unit is given in the section "Use and Management of Rangeland," under the headings "Sandstone Breaks range site" and "Sandy Plains range site."

**Capability unit VIIs-4 (nonirrigated)**

The soils in this unit are gently sloping to strongly sloping. They have a coarse textured to very coarse textured surface layer and subsoil. Internal drainage is moderately rapid to very rapid, permeability is moderately rapid, and the water-holding capacity is low. Natural fertility is low.

These soils are suitable only for use as range. They need management that will maintain or improve the vegetative cover and control erosion. Deferment and proper distribution of grazing are important. More information on managing the soils in this unit is given in the section "Use and Management of Rangeland," under the heading "Gravel Breaks range site."

**Capability unit VIIIs-1 (nonirrigated)**

This unit consists of Rough broken land and Dune land. These land types are useful for wildlife habitat and recreational purposes. Some areas in which soils are intermixed with the land types are used as range. In these areas grazing should be restricted so as to allow the growth of vegetation that will help to control erosion. Soil material that is washed or blown from these areas damages adjacent soils.

**Predicted Yields**

Predicted yields of the principal crops grown in Bent County, under two levels of management, are shown in table 4. Predictions are made for irrigated soils only. They are based on information obtained from farmers and those

who work with farmers. The acreage dryfarmed is too small to provide reliable yield data.

The "A" columns in table 4 show the yields that can be expected under average management. The "B" columns show the yields that can be expected under improved management. Under improved management—

1. All management is timely.
2. Suitable cropping sequences are used, in order to preserve tilth and replenish the supply of organic matter.
3. Suitable crop varieties are planted.
4. Fertilizer is applied in the amounts indicated by field trials and soil tests.
5. Drainage is provided where needed.
6. Plant diseases, insects, and weeds are controlled.
7. Erosion is controlled.

**Use and Management of Rangeland<sup>2</sup>**

Approximately 86 percent of Bent County is used as range. The southern part of the county is characterized by breaks, a small acreage along the Arkansas River by breaks and rolling plains, and the rest of the county by rolling plains. On the breaks the dominant vegetation is a mixture of mid grasses, including side-oats grama, galleta, and little bluestem. On the rolling plains it is short prairiegrass. On the strongly saline soils, the vegetation is predominantly alkali sacaton.

The dominant grasses in the county are blue grama, buffalograss, side-oats grama, galleta, alkali sacaton, salt-grass, sand dropseed, and three-awn. Less abundant are western wheatgrass, vine-mesquite, sand bluestem, needle-and-thread, little bluestem, switchgrass, sandreedgrass, and blowoutgrass.

The dominant shrubs are greasewood, fourwing salt-bush, sand sagebrush, tamarisk, winterfat, snakeweed, and rabbitbrush.

Mixed with the grasses and shrubs are numerous forbs, including cocklebur, sunflower, Russian-thistle, and Kochiaweed.

Most of the livestock are cows and calves. There are also a few carry-over calves and stockers. Most ranchers rely on native forage supplemented with cake or bundle feed, that is, grain sorghum or forage sorghum.

Distribution of rainfall is erratic. Usually showers are of high intensity, but some are light and ineffective. Drought is common during the growing season.

On rangeland that has been heavily grazed, the vegetation consists predominantly of buffalograss and sodbound blue grama. Sand sagebrush has invaded the heavily grazed sandy areas. Tamarisk covers large acreages on the bottom land along the Arkansas River and its tributaries.

**Range Sites and Condition Classes**

Range sites are kinds of rangeland that differ in the kind or amount of vegetation they can produce. In Bent County the amount of available moisture is a most important factor in determining the kind of vegetation on each range site and the productivity of the site.

<sup>2</sup> By EDWARD C. DENNIS, range conservationist, Soil Conservation Service.

## SOIL SURVEY

TABLE 4.--PREDICTED AVERAGE YIELDS PER ACRE OF PRINCIPAL

[ Figures in columns A indicate yields under average management; figures in columns B not suited to or is not commonly

Soil	Alfalfa		Sorghum			
			Grain		Silage	
	A	B	A	B	A	B
	Ton	Ton	Bu.	Bu.	Ton	Ton
Apishapa clay loam-----	1.5	3.0	45	60	--	--
Bankard soils-----	1.5	2.5	40	55	--	--
Colby silt loam, 0 to 1 percent slopes-----	2.5	5.0	65	90	14	20
Colby silt loam, 1 to 3 percent slopes-----	2.2	4.5	63	88	13	18
Glenberg sandy loam, 0 to 1 percent slopes-----	2.5	3.5	60	80	12	18
Glenberg sandy loam, 1 to 3 percent slopes-----	2.0	3.0	58	70	10	16
Glenberg sandy loam, gravel substratum, 0 to 1 percent slopes-----	1.5	2.5	40	60	9	15
Kornman clay loam, 0 to 1 percent slopes-----	3.0	5.0	60	84	12	18
Kornman clay loam, 1 to 3 percent slopes-----	2.0	3.5	45	60	11	17
Las clay loam-----	2.5	4.0	55	85	12	18
Las clay loam, sand substratum variant-----	2.5	4.0	60	85	14	19
Las clay loam, dark variant-----	2.5	4.0	63	88	12	18
Las clay loam, sand substratum, dark variant-----	2.5	4.0	60	85	14	19
Minnequa loam, 0 to 5 percent slopes-----	1.5	3.0	40	60	8	12
Nepesta clay loam, 0 to 1 percent slopes-----	2.5	5.0	65	90	14	20
Nepesta clay loam, 1 to 3 percent slopes-----	2.0	4.5	62	88	13	18
Numa clay loam, 0 to 1 percent slopes-----	2.5	5.0	65	90	14	20
Numa clay loam, 1 to 3 percent slopes-----	2.0	4.5	60	80	12	16
Numa clay loam, wet, 0 to 3 percent slopes-----	1.0	3.0	25	50	5	16
Numa clay loam, sand substratum variant, 0 to 3 percent slopes-----						
Rocky Ford clay loam, 0 to 1 percent slopes-----	3.0	5.0	65	90	14	20
Rocky Ford clay loam, 1 to 3 percent slopes-----	2.5	4.5	60	85	13	19
Rocky Ford clay loam, sand substratum variant, 0 to 1 percent slopes-----	2.5	4.0	58	81	12	18
Rocky Ford clay loam, wet, 0 to 1 percent slopes-----	1.5	3.5	45	70	10	16
Rocky Ford clay loam, wet, 1 to 3 percent slopes-----	2.5	4.5	63	88	12	18

IRRIGATED CROPS UNDER TWO LEVELS OF MANAGEMENT

indicate yields under improved management. Absence of figure indicates the crop is grown on the soil specified]

Sugar beets		Corn				Wheat		Onions (graded)		Melons		Tomatoes		Pasture	
		Grain		Silage											
A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
Ton	Ton	Bu.	Bu.	Ton	Ton	Bu.	Bu.	50 lb. bag	50 lb. bag	Ton	Ton	Ton	Ton	Head per acre	Head per acre
11	16	30	54	8	13	19	34	350	500	--	--	6	11	1	2
--	--	30	55	7	12	18	32	250	350	4	7	--	--	1	2
14	20	60	90	15	20	27	45	600	800	5	7	11	14	2	3
13	19	57	84	14	19	25	43	560	780	4	6	10	14	2	3
11	17	44	70	9	14	25	40	550	780	5	8	11	14	2	3
9	15	38	68	8	12	19	35	350	690	4	6	9	11	1	2
--	--	35	50	6	10	16	20	350	500	6	8	6	9	1	2
11	17	45	75	9	14	20	40	550	750	6	8	11	14	2	3
10	15	30	54	8	12	17	32	350	500	4	6	9	12	2	3
14	21	55	84	13	17	25	42	450	740	--	--	11	14	2	3
12	18	55	85	12	17	25	45	550	780	--	--	10	13	2	3
14	21	55	84	13	17	25	43	578	790	5	7	11	14	2	3
12	18	55	85	12	17	25	45	550	780	--	--	10	13	2	3
--	--	30	50	7	12	20	31	---	---	--	--	5	10	1	2
14	20	60	90	15	20	27	45	600	800	5	7	11	14	2	3
12	17	55	85	13	17	25	43	550	760	4	6	10	13	2	3
14	20	60	90	15	20	27	45	600	800	5	7	11	14	2	3
13	18	55	80	12	18	25	42	550	700	4	6	9	12	2	3
7	17	20	65	6	16	11	27	---	500	--	--	5	11	1	3
14	20	60	90	15	20	27	45	600	800	5	7	11	14	2	3
13	18	50	85	12	19	26	44	400	770	4	6	9	13	2	3
12	17	45	78	12	19	21	38	500	700	5	7	10	12	2	3
--	--	37	68	9	16	18	29	350	580	4	6	8	11	1	2
13	19	57	83	13	19	25	43	578	790	5	7	11	14	2	3

Range condition is determined mainly by comparing the composition of the vegetative cover with that in the potential native plant cover for the same site. The condition classes generally recognized (3)<sup>3</sup> are excellent, good, fair, and poor. A range is in excellent condition if 76 to 100 percent of the vegetation is like the original plant community on the same site. It is in good condition if the percentage is 51 to 75; in fair condition if the percentage is 26 to 50; and in poor condition if it is 25 or less.

Range that is kept in good or excellent condition provides optimum forage yields and is protected against excessive erosion and loss of water. Heavy grazing during the growing season eventually destroys the taller, more palatable, more productive plants. The plants that decrease if heavily grazed are called *decreasers*. The shorter grasses that increase as the taller plants disappear are called *increasers*. Under continuous heavy grazing, the more palatable increasers are replaced with less palatable increasers, which in turn are replaced with annuals called *invaders*. Generally invaders become established in areas that have been disturbed.

On a site in excellent condition, the vegetation consists largely of decreasers and highly palatable increasers and only a trace of invaders. On a site in good condition, the decreasers are less abundant and the vegetation consists largely of increasers and a trace of invaders. On a site in fair condition, the less palatable increasers make up most of the stand and there is a larger percentage of invaders. On a site in poor condition, the vegetation is a mixture of unpalatable increasers and invaders.

To maintain or improve the quantity and quality of the desirable vegetation, grazing should be controlled so that no more than 50 percent, by weight, of the current year's growth is removed. Fences, stockwater ponds, salt, supplemental feeding, deferred grazing, and herding keep livestock distributed throughout the range and thus help to improve range condition.

Range production varies as much as 100 percent, both from year to year and from site to site within the same growing season, because of differences in the kinds of vegetation and seasonal variations in precipitation.

## Descriptions of Range Sites

The soils of Bent County have been grouped into 12 range sites. Descriptions of the individual sites follow. Each description includes information about the nature of the soils and the composition of the potential plant community on each site. Each also gives estimates of forage yields. The estimates are based partly on records of yields obtained by clipping and weighing and partly on field estimates. The range site classification for each soil in the county is shown in the Guide to Mapping Units.

### Loamy Plains range site

This site, the largest in the county, is approximately 514,500 acres in extent. It consists of medium-textured to fine-textured, generally deep soils.

The potential plant community on this site is approximately 60 percent blue grama and 10 percent galleta. These increasers are mixed with decreasers, among which are western wheatgrass, side-oats grama, needle-and-thread, and Indian ricegrass. There are only small amounts of

three-awn, sand dropseed, wild alfalfa, pricklypear, snake-weed, ring muhly, and rabbitbrush. In areas where moisture is adequate, buffalograss makes up a small percentage of the plant community. Alkali sacaton occurs in a few places.

Optimum density is 35 percent. This much ground cover provides ample amounts of litter and forage residue to protect the soils from blowing and water erosion.

A downward trend in range condition is indicated by an increase in the proportion of buffalograss, galleta, or sodbound blue grama. Further deterioration is indicated by a decrease in density of cover and an increase in the proportion of annuals. Sites that have been stripped of vegetation by overgrazing respond favorably to reseeding and deferment of grazing.

The estimated total annual yield of air-dry forage is 500 to 1,400 pounds per acre.

### Sandy Plains range site

This site is approximately 75,420 acres in extent. It consists of sandy soils that have weak structure, are low in organic-matter content, and are subject to blowing and water erosion. The subsoil of these soils is finer textured than the surface layer.

Blue grama, an increaser, and side-oats grama make up 50 percent of the potential plant community on this site. Important decreasers, such as needle-and-thread, prairie sandreed, sand bluestem, and little bluestem, make up 30 percent of the stand. Less abundant plants are Indian ricegrass, sedge, yucca, buckwheat, and galleta. Except where range condition has deteriorated, sand sagebrush and yucca are less common on this site than on the Deep Sand range site.

A downward trend in range condition is indicated by a decline of side-oats grama and an increase in the proportion of sand dropseed and, in places, of sand sagebrush. If the site is in fair condition, the plant community consists of sand dropseed, three-awn, yucca, blue grama, and cactus.

The estimated total annual yield of air-dry forage is 500 to 1,700 pounds per acre.

### Deep Sand range site

This site is approximately 34,000 acres in extent. It consists of soils that range from loamy sand to very fine sand in texture, have weak structure, and have a high intake rate. Soil blowing is the most serious hazard.

Prairie sandreed, sand bluestem, and big bluestem make up 50 percent of the potential plant community. All are decreasers. Needle-and-thread, side-oats grama, little bluestem, and switchgrass are secondary grasses but are important decreasers also. Forbs, shrubs, and short grasses, such as blue grama and buffalograss, make up no more than a third of the stand.

A downward trend in range condition is indicated by a decline of side-oats grama, sand bluestem, and prairie sandreed. If the range is in poor condition, sand sagebrush, sand dropseed, three-awn, blue grama, and annuals are abundant.

Deferment of grazing and spraying of sand sagebrush help to speed up recovery of this site. Interseeding is the only method of seeding that does not increase the risk of soil blowing.

The estimated total annual yield of air-dry forage is 1,200 to 2,000 pounds per acre.

<sup>3</sup> Italic numbers in parentheses refer to Literature Cited, p. 70.

***Choppy Sand range site***

This site is approximately 4,800 acres in extent. Except for dunes and numerous blowouts, it is similar to the Deep Sand range site. The soils range from loamy sand to very fine sand in texture, have a high water intake, are very low in organic-matter content, and have very weak structure. The topography is hummocky and rolling.

Sandreed, sand bluestem, and switchgrass are the principal decreaseers in the potential plant community. Sand-hill muhly, Indian ricegrass, blowoutgrass, three-awn, and yucca are abundant. Lemon scurfpea is characteristic of this site.

If the range is in poor condition, the dunes are practically bare of vegetation and the rest of the range has an abundance of sand sagebrush. Establishing a cover crop and seeding native grasses when the moisture supply is adequate speed up recovery of the range. Reestablishing vegetation is difficult because of drifting sand. Blowouts should be fenced in and protected from grazing.

The estimated total annual yield of air-dry forage is 1,000 to 1,200 pounds per acre.

***Sandy Bottom Land range site***

This site is approximately 6,600 acres in extent. It occurs along the major drainageways, and it is flooded occasionally. The soils are moderately sandy and are moderately to rapidly permeable.

The potential plant community on this site is a mixture of decreaseers, among which are alkali sacaton, western wheatgrass, switchgrass, indiangrass, and sand bluestem, and small amounts of mid grasses, such as needle-and-thread and Canada wildrye. There are also a few cottonwoods and willows and some tamarisk.

A downward trend in range condition is indicated by increasing abundance of sand dropseed, saltgrass, tamarisk, cottonwoods, and willows.

The estimated total annual yield of air-dry forage is 1,500 to 2,500 pounds per acre.

***Limestone Breaks range site***

This site is approximately 25,700 acres in extent. It consists of medium-textured soils that are generally less than a foot thick over limestone and have a fairly low to low water-holding capacity. The erosion hazard is serious if the range has been misused and is bare of vegetation.

Side-oats grama, little bluestem, needle-and-thread, New Mexico needlegrass, and Indian ricegrass are the principal decreaseers in the potential plant community on this site. Blue grama, hairy grama, galleta, three-awn, and squirreltail are the principal increaseers. Bigelow sagebrush, bush buckwheat, Indian paintbrush, scarlet globe-mallow, and stemless goldenweed are less important plants. Also on this site are cushion plants, such as nailwort, low phlox, and mat loco, which are characteristic of the kind of vegetation that grows on shallow soils.

A downward trend in range condition is indicated by decreasing density of the vegetation, erosion, and the spread of greasewood and nailwort and other cushion plants.

The estimated total annual yield of air-dry forage is 400 to 1,200 pounds per acre.

***Salt Flats range site***

This site is approximately 5,600 acres in extent. It consists of level to gently sloping, moderately fine textured to fine textured soils that are moderately saline to strongly saline. Internal drainage is slow, and permeability is slow to very slow.

Alkali sacaton, a decreaseer, is dominant in the potential plant community. Saltgrass makes up one-tenth of the stand. Western wheatgrass, also a decreaseer, is limited in abundance, but it is an important forage plant. These plants are mixed with smaller amounts of blue grama, galleta, alkaligrass, and fourwing saltbush, and with traces of greasewood, curlycup gunweed, poverty weed, rabbitbrush, alkali muhly, Fremont goldenweed, and snakeweed. Galleta, Fremont goldenweed, and greasewood are increaseers in the potential plant community.

A downward trend in range condition is indicated by the appearance of scattered hummocks of alkali sacaton, by an increase in galleta, Fremont goldenweed, annual saltbush, and greasewood, and by a decrease in density of cover. Reestablishing vegetation is very difficult, and restoring deteriorated areas to good condition takes many years of good management.

The estimated total annual yield of air-dry forage is 800 to 2,000 pounds per acre.

***Salt Meadow range site***

This subirrigated, saline or alkaline site is approximately 15,400 acres in extent. It consists of fine-textured to coarse-textured, subirrigated, poorly drained, saline and alkali soils. Both the surface layer and the subsoil of these soils contain salts. Erosion is not a serious hazard except where the vegetation has been completely destroyed.

The important decreaseers in the potential plant community are switchgrass, alkali sacaton, and western wheatgrass. Increaseers are alkali bluegrass, sedges, and rushes. Less abundant are saltgrass, foxtail barley, wild licorice, and tamarisk.

In poor condition, this site has an abundance of saltgrass and tamarisk. It can be restored to good condition by plowing up the saltgrass and tamarisk, establishing a cover crop of sorghum or small grain, and then reseeding suitable native grasses or tall wheatgrass.

The estimated total annual yield of air-dry forage is 1,500 to 3,000 pounds per acre.

***Shale Breaks range site***

This site is approximately 4,600 acres in extent. It consists of fine-textured soils that are shallow over shale. Permeability and intake are slow. The water-holding capacity is low. Soil moisture is not readily available to plants, because of the generally high content of soluble salts. The erosion hazard is severe.

The potential plant community consists of blue grama, galleta, alkali sacaton, western wheatgrass, Indian ricegrass, and fourwing saltbush. Blue grama and galleta are increaseers. The rest are decreaseers. Other plants in the community are winterfat, pricklypear, cactus, and snakeweed.

A downward trend on this site is indicated by accelerated erosion, declining density of alkali sacaton and other decreaseers, and an increasing proportion of galleta, pricklypear, cactus, and snakeweed.

The estimated total annual yield of air-dry forage is 300 to 1,200 pounds per acre.

#### **Alkaline Plains range site**

This site is approximately 44,900 acres in extent. It consists of gypsum-bearing, strongly saline and strongly alkaline silty clays that were derived from shale. The water-holding capacity is high, and permeability is slow.

Alkali sacaton, the principal increaser, makes up 40 percent of the potential plant community on this site. Galleta, another increaser, makes up 25 percent of the vegetation. Blue grama is a decreaser; it can grow on the saline and alkaline soils only because of the buffering action of the gypsum. Western wheatgrass and fourwing saltbush, although valuable decreaseers, make up only a small part of the plant cover. Forbs, browse, and other grasses are rare.

The presence of Fremont goldenweed, pricklypear, and squirreltail indicate a downward trend in range condition. Greasewood is the principal invader. A large percentage of it in the plant community shows that the range is in poor condition.

The estimated total annual yield of air-dry forage is 400 to 2,000 pounds per acre.

#### **Gravel Breaks range site**

This site consists of Cascajo soils and gravelly land. It is approximately 8,300 acres in extent. The intake rate is high, and the water-holding capacity is low.

Side-oats grama and little bluestem, the principal decreaseers, are dominant in the potential plant community on this site. Less abundant are big bluestem, needle-and-thread, blue grama, hairy grama, and Indian ricegrass. Among the less important but common forbs are hairy goldaster, dotted gayfeather, buckwheat, bigelow sagebrush, and prairie clover. Yucca, snakeweed, sagewort, and sand sagebrush are scarce.

A downward trend in range condition is indicated by declining density of the decreaseers and an increasing proportion of increaseers, such as blue grama and sand dropseed. If the range is in fair or poor condition, the plant community consists dominantly of blue grama, pricklypear cactus, yucca, snakeweed, and galleta.

The estimated total annual yield of air-dry forage is 500 to 1,000 pounds per acre.

#### **Sandstone Breaks range site**

This site is approximately 94,750 acres in extent. It consists of stony sandy loams to light loams that have weak structure, are low in organic-matter content, and have a moderate intake rate. Controlling erosion is the main problem.

This site has good potential for tall, deep-rooted grasses. Sand bluestem, little bluestem, big bluestem, indiangrass, side-oats grama, and junegrass are the principal decreaseers in the potential plant community. These grasses, other tall and mid grasses, and increaseers, such as blue grama, hairy grama, and sand dropseed, make a thick cover on the slopes and between the rocks. The most abundant forbs are prairie clover, globemallow, buckwheat, and loco. Skunkbush, yucca, oak, and juniper form an open overstory.

A downward trend is indicated by declining density of

cover, a declining proportion of decreaseers, and thickening of the overstory.

The estimated total annual yield of air-dry forage is 700 to 1,800 pounds per acre.

## **Native Woodland and Windbreaks**

The native trees in Bent County are mostly in associations 5 and 6. The location of the soil associations is shown on the general soil map at the back of this survey.

Cottonwoods and a few willows and tamarisks grow in soil association 6, mainly on Las and Glenberg soils and along the banks of the Arkansas and Purgatoire Rivers. The trees are generally of little or no commercial value, but they provide shade for livestock in summer and protection during occasional winter blizzards.

In association 5, mainly on Travessilla soils, are thin to dense stands of native juniper. These stands are remnants of woodland that have been largely destroyed by cutting for firewood and fenceposts and by grazing that prevented the reproduction and establishment of seedlings.

Trees are planted mainly to provide windbreaks around farmsteads and feedlots. Trees grow well on irrigated soils in association 6. The water table is not too high, and the soils are free from harmful salts and alkali. Almost any tree suited to the climate will grow. The trees most commonly used in windbreak plantings are the following:

<i>Evergreens</i>	<i>Tall trees</i>	<i>Shrubs</i>
Rocky Mountain juniper	Siberian elm	Squawbush
Eastern redcedar	Cottonless cottonwood	Lilac
Ponderosa pine	White willow	Honeysuckle
Austrian pine	Golden willow	Cotoneaster
Colorado blue spruce	Greenash	Chokecherry
	Honeylocust	American plum
	Catalpa	
	Russian-olive	

Windbreaks should consist of at least three rows of trees and shrubs. The shrubs should be planted on the windward side to keep the wind from sweeping under the trees. One or more rows of evergreens should be used in all windbreaks. Generally evergreens live longer and provide better protection throughout the year than other trees.

Soils that are suited to cereal crops are generally suited to trees, but they have to be summer fallowed before trees are planted. Trees become established more readily if planted in contour rows that are 30 feet apart. Watering and clean cultivation between rows are important also.

The best soils in the county for windbreaks are the Weld and Rago soils, which are in the northeastern part.

Trees are difficult to establish on the uplands where no supplemental water is available. Only the hardiest seedlings should be planted, for example, Rocky Mountain juniper, ponderosa pine, Siberian (Chinese) elm, Russian-olive, lilac, and squawbush. Only potted seedlings of evergreens should be used.

## **Use of the Soils in Engineering<sup>4</sup>**

Some soil properties are of special interest to engineers because they affect the construction and maintenance of

<sup>4</sup>C. H. MITCHELL, State conservation engineer, helped prepare this section.

roads, airports, pipelines, building foundations, facilities for water storage, erosion control structures, drainage systems, and sewage disposal systems. The properties most important to engineers are permeability, shear strength, compaction characteristics, drainage, shrink-swell characteristics, particle size distribution, plasticity, and reaction. Depth to the water table, depth to bedrock, water-holding capacity, and topography also are important.

The information in this publication can be used to—

1. Make preliminary estimates of the engineering properties of soils in planning agricultural drainage systems, farm ponds, irrigation systems, and other structures for conservation of soil and water.
2. Make preliminary evaluations that will aid in selecting locations for highways, airports, pipelines, and cable locations, and in planning detailed investigations at the selected locations.
3. Locate probable sources of sand and gravel and other construction material.
4. Make studies that will aid in selecting and developing industrial, business, residential, and recreational sites.
5. Correlate performance with soil mapping units to develop information that will be useful in planning engineering practices and in designing and maintaining engineering structures.
6. Determine the suitability of soils for cross-country movement of vehicles and construction equipment.
7. Supplement other publications, such as maps, reports, and aerial photographs, that are used in preparation of engineering reports for a specific area.

With the soil map for identification of soil areas, the engineering interpretations reported in tables 5 and 6 can be useful for many purposes. It should be emphasized, however, that these interpretations may not eliminate the need for sampling and testing at the site of specific engineering works involving heavy loads and excavations deeper than the depth of layers here reported.

Some of the terms used by soil scientists have a special meaning in soil science that may not be familiar to engineers. These terms are defined in the Glossary.

## Engineering Classification Systems

The classifications of all the soils in Bent County according to three systems are given in table 5. These are USDA textural classification and the two systems (4) of classifying soils for engineering purposes that are in general use, the Unified system (8) and the AASHTO system (1).

*USDA Textural Classification.*—The textural classification used by the U.S. Department of Agriculture is primarily for agricultural use but is also important in engineering. In this system the texture of the soil is determined according to the proportions of the different sized mineral particles. The sizes are designated as cobbles, gravel, sand, silt, and clay. The textural classes range from the fine-textured clays, silty clays, and sandy clays to the coarse-textured loamy fine sands, loamy sands, sands, and coarse sands.

*Unified System.*—The Unified soil classification system, developed by the U.S. Army Corps of Engineers, is based

on the identification of soils according to their texture, their plasticity and liquid limit, and their performance as engineering construction material. The symbols SW and SP identify clean sands; SM and SC, sands that contain fines; GM and GC, gravel that contains fines; ML and CL, fine-grained material that has a low liquid limit; and MH and CH, fine-grained material that has a high liquid limit. Soils on the borderline between two classifications are given a joint classification; for example, ML-CL.

*AASHTO System.*—The AASHTO classification is based on the bearing strength of soils. In this system soils of about the same general load-bearing capacity are classified into seven basic groups, A-1 through A-7. The best soils for road subgrade, for example, are classified as A-1, the next best A-2, and the poorest A-7.

An A-2 classification means that the material can be up to 35 percent fines, that is, particles that will pass through a No. 200 sieve. An A-3 classification means that the material is no more than 10 percent fines, and classifications of A-4 through A-7 mean that it is at least 36 percent fines.

For more precise classification, groups A-1, A-2, and A-7 are divided into subgroups. Group A-1 is divided into subgroups A-1-a and A-1-b; group A-2 into subgroups A-2-4 through A-2-7; and group A-7 into subgroups A-7-5 and A-7-6. An A-1-a classification means that the material is no more than 15 percent fines and that at least 50 percent of it consists of particles too large to pass through a No. 10 sieve. An A-1-b classification means that the material is no more than 25 percent fines.

The relative engineering value of the soil material within a given group is indicated by a group index number. The numbers range from 0, for the best material, to 20, for the poorest. Laboratory analysis to determine the liquid limit, the plasticity index, and the percentage of fines is needed before soil material can be classified by group index number.

## Estimated Properties

Estimates of soil properties that are significant in engineering are shown in table 5. Depth of soils to bedrock is not shown in this table because it is more than 60 inches in all soils except those of seven soil series. For those seven series, depths to bedrock range as follows: Arvada, 42 to 60 inches; Little, 36 to 60 inches; Minnequa, 18 to 40 inches; Penrose, 4 to 18 inches; Pultney, 20 to 40 inches; Samsil, 4 to 20 inches; and Travessilla, 1 to 12 inches.

Many soils have a high water table during the peak of the irrigation season, and a few are poorly drained and have a high water table throughout the year. The Glenberg, Kornman, Nepesta, Numa, and Rocky Ford soils commonly have a water table that rises high in the root zone during the irrigation season, and in these soils drain lines are needed in many places to assist natural drainage in removing excess water. The Apishapa, Las, and Las Animas soils are wet the year round unless artificially drained. Their water table fluctuates between a depth of 30 inches and the surface.

Nearly all the soil on floodplains and terraces are subject to at least some flooding unless they are protected by a flood-retarding structure or a deep channel. Flooding of Bankard, Glenberg, Las, and Las Animas soils is com-

TABLE 5.--ESTIMATED

Soil series and map symbols	Hydro-logic soil group	Depth from surface	Classification			Percentage passing sieve--		
			Dominant USDA texture	Unified	AASHO	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 200 (0.074 mm.)
		<u>In.</u>						
Apishapa: Ac-----	C	0-10	Clay loam-----	CL	A-6	100	100	75-85
		10-60	Clay-----	MH or CH	A-7	100	100	85-95
Arvada: ArA, Av2----	D	0-2	Clay loam $\frac{1}{2}$					
For Deertrail part of Av2, see Deertrail series.		2-32	Silty clay-----	CL or CH	A-6 or A-7	100	100	95-100
		32	Partly weathered gypsiferous shale.					
Baca: BaA, BaC-----	B	0-2	Silt loam $\frac{1}{2}$					
		2-18	Clay loam-----	ML-CL or CL	A-6, A-4	100	100	90-100
		18-60	Silt loam-----	ML-CL or CL	A-4, A-6	100	100	85-95
Bankard: Bd-----	A	0-4	Loam $\frac{1}{2}$					
		4-37	Loamy fine sand-----	SM	A-1-b	70-95	70-95	10-25
		37-60	Gravelly sand-----	SP	A-1-b	10-35	10-20	5-10
Cascajo: Ca-----	B	0-10	Gravelly loam-----	ML	A-4	60-70	55-65	45-60
		10-60	Gravel and sand-----	GM	A-1-a	10-20	10-20	5-15
Colby: CbB-----	B	0-6	Fine sandy loam-----	SM	A-4, A-2	100	100	30-40
		6-45	Silt loam-----	ML-CL	A-6	100	100	85-95
CoA, CoB, CoE-----	B	0-11	Silt loam-----	ML-CL	A-4	100	100	80-95
		11-60	Silt loam-----	ML-CL	A-6	100	100	85-95
Deertrail: DeB-----	C	0-13	Clay loam-----	CL	A-6	100	100	75-90
		13-60	Silty clay loam-----	CL	A-6	100	100	75-90
Dune land: Du-----	A	0-60	Sand-----	SP	A-1-b	100	100	0-5
Dwyer: Dw-----	A	0-60	Sand or loamy sand-----	SP or SP-SM	A-3 or A-1-b	100	100	0-15
Glenberg: GbA, GbB-----	B	0-40	Sandy loam-----	SM-SC	A-2 or A-4	90-100	80-100	15-40
		40-60	Loamy sand-----	SM	A-2-4	100	100	15-35
GeA-----	B	0-24	Sandy loam-----	SM-SC	A-2-4	90-100	80-100	15-40
		24-60	Sand or gravel-----	SP or GP	A-1-a or A-1-b	50-90	50-90	5-10
Harvey: HaC-----	B	0-40	Loam-----	ML-CL	A-4	90-100	90-100	85-95
		40-60	Loam or clay loam-----	ML-CL	A-4 to A-6	90-100	90-100	90-95
Kim: KmB-----	B	0-56	Loam or clay loam-----	ML	A-4	100	100	65-85
Kornman: KrA, KrB----	B	0-11	Clay loam-----	CL	A-6	100	100	80-95
		11-60	Sandy loam or loamy sand.	SP	A-1-b	60-100	60-90	0-5

See footnotes at end of table.

ENGINEERING PROPERTIES

Permeability	Water-holding capacity	Reaction	Salinity	Dispersion	Shrink-swell potential
<u>In./hr.</u>	<u>In./in. of soil</u>	<u>pH</u>			
0.20-0.5	0.31	7.9-8.4	Moderate to severe--	Moderate-----	Moderate.
0.05-0.2	0.32	8.5-9.0	Moderate to severe--	High-----	Moderately high.
0.05-0.20	0.32	8.5-9.0	Moderate-----	High-----	Moderate to high.
0.20-0.8	0.31	7.9-8.4	None-----	Low-----	Moderate.
0.80-1.5	0.29	7.9-8.4	None-----	Low-----	Moderate.
>5.0	0.08	7.4-7.8	None-----	Low-----	Low.
>5.0	0.04	7.4-7.8	None-----	Low-----	Low.
1.50-5.0	0.14	7.9-8.4	None-----	Low-----	Low.
>5.0	0.07	7.9-8.4	None-----	Low-----	Low.
1.5-2.50	0.15	7.9-8.4	None-----	Low-----	Low.
0.50-0.80	0.30	7.9-8.4	None-----	Moderate-----	Moderate.
0.80-1.5	0.29	7.9-8.4	None-----	Low-----	Low to moderate.
0.50-0.80	0.30	7.9-8.4	None-----	Moderate-----	Moderate.
0.20-0.5	0.31	7.9-9.0	Slight-----	Moderate-----	Moderate.
0.05-0.2	0.32	7.9-9.0	Moderate-----	Moderate-----	Moderate.
>5.0	0.07	7.9-8.4	None-----	Low-----	Low.
>5.0	0.07	7.4-8.4	None-----	Low-----	Low.
2.5-5.0	0.14	7.9-8.4	None-----	Low-----	Low.
0.8-1.5	0.28	7.9-8.4	None-----	Moderate-----	Moderate.
2.5-5.0	0.14	7.9-8.4	None-----	Low-----	Low.
>5.0	0.05	7.4-7.8	None-----	Low-----	Low.
0.80-2.5	0.24	7.6-8.4	None-----	Low-----	Low.
0.20-0.80	0.29	7.8-8.5	None-----	Low-----	Low.
0.8-1.5	0.26	7.9-8.4	None-----	Low-----	Low.
0.50-0.8	0.31	7.9-8.4	None-----	Moderate-----	Moderate.
>5.0	0.06	7.4-7.8	None-----	Low-----	Low.

## SOIL SURVEY

TABLE 5.--ESTIMATED ENGINEERING

Soil series and map symbols	Hydro-logic soil group	Depth from surface	Classification			Percentage passing sieve--		
			Dominant USDA texture	Unified	AASHO	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 200 (0.074 mm.)
		<u>In.</u>						
Las:								
Ld, Le-----	C	0-20	Clay loam-----	CL	A-6	100	100	75-90
		20-60	Loamy sand-----	SP	A-1-a	100	90-100	5-15
La, Lc-----	C	0-60	Clay loam-----	CL	A-6	100	100	75-90
Las Animas: Lm-----	B	0-10	Loam-----	ML-CL	A-4 or A-6	100	100	65-85
		10-60	Sandy loam or loamy sand.	SM or SM-SC	A-2 or A-4	90-100	90-100	15-45
		60	Sand or gravel-----	SP or GP	A-1-a or A-1-b	25-90	25-90	5-15
Limon: Ln, Lo-----	C	0-36	Clay-----	MH or CH	A-7	100	100	85-95
		36-60	Clay loam-----	CL	A-6	100	100	75-90
Litle: LtC-----	D	0-5	Clay loam-----	CL	A-6	100	100	75-90
		5-35	Clay-----	MH or CH	A-7	100	100	85-95
		35	Shale.					
Manvel: MaC, MaC2---	B	0-21	Loam-----	ML	A-4	95-100	95-100	85-95
		21-34	Clay loam-----	CL	A-6	95-100	95-100	85-95
		34-60	Loam-----	ML	A-4	90-100	90-100	80-95
Manzanola: McB-----	B	0-16	Clay loam-----	CL	A-6	100	100	75-90
		16-60	Loam-----	ML	A-4	100	100	65-85
Minnequa: MeB, MeC, MpC.	B	0-34	Loam-----	ML	A-4	95-100	95-100	85-95
		34	Shaly limestone.					
For Penrose part of MpC, see Penrose series.								
Nepesta: NeA, NeB---	B	0-53	Clay loam and silty clay loam.	CL	A-6	100	100	95-100
		53-60	Silt loam-----	ML-CL or CL	A-4, A-6	100	100	85-95
Numa:								
NmA, NmB-----	B	0-10	Clay loam-----	CL	A-6	95-100	95-100	75-90
		10-60	Clay loam-----	ML-CL	A-4 or A-6	75-95	70-90	60-85
NuB-----	B	0-10	Clay loam-----	CL	A-6	95-100	95-100	75-90
		10-60	Clay loam-----	ML-CL	A-4 or A-6	75-95	70-90	60-85
NvB-----	B	0-10	Clay loam-----	CL	A-6	95-100	95-100	75-90
		10-30	Loam-----	ML	A-4	75-90	70-90	50-75
		30-60	Sand or gravel-----	SP or GP	A-1-a or A-1-b	50-90	50-90	15-20

See footnotes at end of table.

PROPERTIES--CONTINUED

Permeability	Water-holding capacity	Reaction	Salinity	Dispersion	Shrink-swell potential
<u>In./hr.</u>	<u>In./in. of soil</u>	<u>pH</u>			
0.20-2.5 >5.0	0.31 0.07	7.9-8.4 7.9-8.4	Moderate----- Moderate-----	Moderate----- Low-----	Moderate. Low.
0.20-0.5	0.31	7.9-9.0	Moderate-----	Moderate-----	Moderate.
0.50-2.5 >2.5 >5.0	0.12-0.28 0.12 0.05	7.9-9.0 7.9-9.0 7.9-9.0	Severe----- Severe----- Moderate-----	Moderate----- Low----- Low-----	Moderate. Low. Low.
0.05-0.2 0.5-0.8	0.32 0.31	8.5-9.0 8.6-9.0	Moderate to severe-- Moderate to severe--	High----- High-----	High. Moderate.
0.5-0.8 0.05-0.2	0.31 0.32	8.6-9.0 8.5-9.0	Moderate to severe-- Moderate to severe--	High----- High-----	Moderate. Moderate to high.
0.80-1.5 0.20-0.8 0.80-2.5	0.25 0.29 0.24	7.9-8.4 7.9-8.4 7.9-8.4	None----- None----- None-----	Low----- Moderate----- Low-----	Low. Moderate. Low.
0.5-0.8 0.8-1.5	0.31 0.26	7.9-8.4 7.9-8.4	None----- None-----	Low----- Low-----	Moderate. Moderate.
0.80-1.5	0.25	7.7-8.4	Slight-----	Low-----	Low.
0.20-0.5	0.32	7.9-8.4	None-----	Low-----	Moderate.
0.80-1.5	0.29	7.9-8.4	None-----	Low-----	Moderate.
0.75-0.9 0.80-1.5	0.31 0.24	7.9-8.4 7.9-8.4	None----- None-----	Moderate----- Moderate-----	Moderate. Moderate to low.
0.50-0.8 0.80-1.5	0.31 0.24	7.9-9.0 7.9-9.0	Moderate to severe-- Moderate to severe--	Moderate----- Moderate-----	Moderate. Moderate.
0.50-0.8 0.80-1.5 >5.0	0.31 0.24 0.05	7.9-8.4 7.9-8.4 7.9-8.4	None----- None----- None-----	Moderate----- Moderate----- Low-----	Moderate. Moderate to low. Low.

TABLE 5.--ESTIMATED ENGINEERING

Soil series and map symbols	Hydro-logic soil group	Depth from surface	Classification			Percentage passing sieve--		
			Dominant USDA texture	Unified	AASHO	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 200 (0.074 mm.)
Olney: OnA, OsB2----	B	In.						
		0-8	Sandy loam-----	SM-SC	A-1-b, A-2, A-4	100	100	25-40
		8-18	Sandy clay loam-----	SC, CL	A-4	100	100	40-60
		18-42	Sandy loam or loamy sand.	SM	A-2-4	100	100	10-20
Otero: OtC-----	B	42-60	Silt loam-----	ML	A-4	100	100	85-95
		0-4	Loamy sand <sup>1/</sup> .					
		4-27	Sandy loam-----	SM-SC	A-1, A-4	90-100	85-95	20-45
Penrose: PcD-----	D	27-60	Silt loam or fine sandy loam.	ML or SM	A-4 or A-1-b	50-95	50-95	25-85
		0-14	Channery loam and loam.	ML	A-4	70-90	75-85	50-75
Pultney: PuC-----	C	14	Limestone.					
		0-22	Loam-----	ML-CL	A-4	100	100	50-70
Rago: RaA-----	B	22	Weathered gypsiferous shale.					
		0-5	Silt loam-----	ML-CL	A-4	100	100	80-95
Rocky Ford: RfA, RkA, RfB, RkB.	C	5-60	Clay loam-----	CL	A-6	100	100	85-100
		0-12	Clay loam and silty clay loam.	CL	A-6	100	100	95-100
RmA-----	C	12-60	Silt loam-----	ML	A-4	95-100	95-100	85-95
		0-12	Clay loam-----	CL	A-6	100	100	90-100
		12-20	Silt loam-----	ML	A-4	100	100	60-75
Rough broken land: Ro <sup>2/</sup> .	D	20-60	Sand or gravel-----	SP or GP	A-1-a or A-1-b	50-90	50-90	5-15
		0-10	Silty clay loam or clay.	CL-CH	A-6	100	100	80-95
Samsil: Sa-----	D	10	Shale.					
Satanta: SnB-----	B	0-9	Loam-----	ML	A-4	95-100	95-100	80-95
		9-19	Clay loam-----	CL	A-6	100	100	75-90
		19-60	Silt loam-----	ML	A-4	100	100	85-95
Stoneham: StB, StC--	B	0-3	Loam <sup>1/</sup> .					
		3-8	Clay loam-----	CL	A-6	90-100	90-100	90-95
		8-32	Sandy loam-----	SM-SC	A-2-4 or A-4	75-95	70-90	25-40
		32-60	Coarse loamy sand-----	SC, SM, GP or SP	A-2-4	40-95	40-90	5-15
Tivoli: Td, ThD, Tn. For Dune land part of Tn, see Dune land.	A	0-60	Sand or loamy sand-----	SP or SP-SM	A-3 or A-1-b	100	100	0-15

See footnotes at end of table.

PROPERTIES--CONTINUED

Permeability	Water-holding capacity	Reaction	Salinity	Dispersion	Shrink-swell potential
<u>In./hr.</u>	<u>In./in. of soil</u>	<u>pH</u>			
2.50-5.0	0.14	7.6-8.4	None-----	Low-----	Low.
1.50-3.0	0.31	7.8-8.4	None-----	Low-----	Low.
2.50-10.0	0.10-0.26	7.9-8.4	None-----	Low-----	Low.
0.80-1.5	0.29	7.9-8.4	None-----	Low-----	Low.
2.50-5.0	0.14	7.9-8.4	None-----	Low-----	Low.
0.80-5.0	0.10-0.26	7.9-8.4	None-----	Low-----	Low.
0.80-1.5	0.16	7.9-8.4	None-----	Low-----	Low.
0.80-1.5	0.28	7.9-8.4	None-----	Low-----	Low.
0.80-1.5	0.29	7.4-7.8	None-----	Low-----	Low.
0.20-0.8	0.31	7.9-8.4	None-----	Low-----	Moderate.
0.20-0.5	0.31	7.9-8.4	None-----	Low-----	Low.
0.20-0.8	0.29	7.9-8.4	None-----	Low-----	Low.
0.20-0.8	0.31	7.9-8.4	None-----	Moderate-----	Moderate.
0.80-1.5	0.25	7.9-8.4	None-----	Low-----	Low.
>5.0	0.05	7.9-8.4	None-----	Low-----	Low.
0.05-0.2	0.32	8.5-9.0	Moderate-----	Moderate-----	Moderate.
0.80-1.5	0.26	7.9-8.4	None-----	Low-----	Low.
0.5-0.8	0.31	7.9-8.4	None-----	Low-----	Moderate.
0.80-1.5	0.28	7.9-8.4	None-----	Low-----	Moderate.
0.20-0.8	0.29	7.9-8.4	None-----	Low-----	Moderate.
0.80-5.0	0.12-0.31	7.9-8.4	None-----	Low-----	Low.
>5.0	0.05	7.9-8.4	None-----	Low-----	Low.
>5.0	0.07	7.4-8.4	None-----	Low-----	Low.

TABLE 5.--ESTIMATED ENGINEERING

Soil series and map symbols	Hydro-logic soil group	Depth from surface	Classification			Percentage passing sieve--		
			Dominant USDA texture	Unified	AASHO	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 200 (0.074 mm.)
Travessilla: ToC, Tr. For Olney part of ToC, see Olney series.	D	<u>In.</u>						
		0-10	Sandy loam-----	SM-SC	A-2-4, A-4	75-95	70-90	25-40
		10	Sandstone.					
Vona: VnB, VoB2-----	B	0-30	Sandy loam-----	SC-SM	A-2-4, A-4	100	100	25-40
		30-60	Loamy sand-----	SM-ML	A-2-4 or A-4	100	100	10-75
Weld: WeA-----	B	0-7	Silt loam-----	ML-CL	A-4	100	100	90-100
		7-17	Silty clay loam-----	ML-CL	A-6 or A-4	100	100	90-100
		17-60	Silt loam-----	ML-CL	A-4	100	100	90-100
Wiley: WLB-----	B	0-60	Silt loam-----	ML-CL	A-4	100	100	90-100

1/

Not rated because layer is too thin to be significant in engineering.-

mon and damaging. Apishapa, Arvada, Kornman, Limon, Manzanola, Nepesta, Numa, and Rocky Ford soils flood infrequently, ordinarily during the most severe storm periods.

The first column in table 5 shows the classification of the soils of the county into four hydrologic groups. The classification is based on runoff potential. The groups are designated as A, B, C, and D. In group A are deep sands that contain little silt and clay and have the lowest runoff potential. In group B are soils that are less permeable than those in group A but have above average infiltration when saturated. In group C are shallow soils and soils that contain considerable clay and colloidal material and have below average infiltration when saturated. In group D are high-swelling clays and shallow soils that are nearly impermeable a few inches below the surface; these soils have the highest runoff potential.

The columns headed "Percentage passing sieve" in table 5 show the percentage of soil material that is smaller in diameter than the openings in the given screen.

The column headed "Permeability" indicates the rate at which water moves through undisturbed soil material. The estimates are based on soil texture, structure, and porosity.

The column headed "Water-holding capacity" gives estimates of the amount of capillary water in soil that is wet to field capacity.

Reaction, which refers to the degree of acidity or alkalinity of a soil, is expressed in pH values. The degrees of acidity or alkalinity are described under "Reaction" in the Glossary.

The estimates of salinity are based on the electrical

conductivity of saturated soil extract as expressed in millimhos per centimeter at 25° C.

Dispersion refers to the degree to which particles smaller than 0.005 millimeter are separated, or dispersed. Such particles exclude the single grain or unaggregated particles, as, for example, clean sands. Dispersed soils are likely to slick over when wet and to crust at the surface when dry. Soils high in sodium, and specifically soils having more than 15 percent exchangeable sodium, are the most likely to be dispersed.

Shrink-swell potential indicates the volume change to be expected in soil material with a change in moisture content. In general, soils classified as CH and A-7 have high shrink-swell potential, and clean, structureless sands and other nonplastic soils have low shrink-swell potential.

## Engineering Interpretations

Estimates of the suitability of the soils for various engineering uses are given in table 6. Features or characteristics that are likely to affect various engineering practices were considered, and evaluations were based on data shown in table 5 and on field performance.

## Use of the Soils for Wildlife<sup>5</sup>

The semiarid climate and the frequent and often severe droughts in Bent County keep the wildlife population

<sup>5</sup> Prepared with the help of ELDIE W. MUSTARD, biologist, Soil Conservation Service.

## PROPERTIES--CONTINUED

Permeability	Water-holding capacity	Reaction	Salinity	Dispersion	Shrink-swell potential
<u>In./hr.</u>	<u>In./in. of soil</u>	<u>pH</u>			
2.50-5.0	0.12	7.4-8.4	None-----	Low-----	Low.
2.50-5.0	0.14	7.9-8.4	None-----	Low-----	Low.
1.50-10.0	0.07-0.25	7.9-8.4	None-----	Low-----	Low.
0.80-1.5	0.29	7.9-8.4	None-----	Low-----	Moderate to low.
0.20-0.80	0.31	7.9-8.4	None-----	Low-----	Moderate.
0.80-1.5	0.29	7.9-8.4	None-----	Low-----	Moderate to low.
0.80-1.5	0.29	7.9-8.4	None-----	Low-----	Moderate to low.

2/

No estimates available.

fairly small. This climatic limitation is modified to some extent by irrigation.

Table 7, p. 68, shows the suitability of the soils, by soil associations, as habitat for the important kinds of wildlife. The general soil map at the back of this survey shows, in color, the location of the soil associations in the county.

Ring-necked pheasant, scaled quail, bobwhite quail, and mourning dove are among the upland game birds in the county.

The only pheasant habitat in the county is in soil associations 6 and 7. Association 6, which is the bottom land along the Arkansas River, provides good brushy cover and has interspersed areas of irrigated cropland where grain is grown. Also, this association is adjacent to the irrigated cropland in association 7. The pheasant population is limited in this county, probably because of the scarcity of permanent cover. Burning weeds along fence lines and in road ditches and irrigation ditches destroys protective and escape cover, as well as nesting cover. Planting grasses in these areas would furnish permanent nesting cover and would also be more effective for control of weeds. Cutting alfalfa at night results in heavy losses of pheasants. Pheasants prefer alfalfa fields for nesting, probably because alfalfa starts growing early in the season and furnishes good nesting cover at a time when little else is available.

All of the soil associations have some potential as habitat for mourning doves. The best potential is in associations 4, 6, and 7, in which there are small grain farms, abandoned cropland that has reverted to weeds, irrigated farms, and stock-watering facilities.

Scaled quail thrive in semiarid regions. They are to be found in all parts of this county. Overgrazing of rangeland, which limits seed production, is seriously detrimental to quail habitat.

Bobwhite quail are not plentiful in southeastern Colorado, because of the limitations imposed by the semiarid climate. Bobwhite require habitat that furnishes brush, water, and a good food supply.

Periodically jackrabbits and cottontails are plentiful. Jackrabbits, which depend on speed for protection and escape, live on the open range, mainly on the soils of associations 1, 2, 3, 4, and 5. Cottontails, which need brushy and herbaceous cover, are most plentiful on the soils of associations 4, 6, and 7, but they are to be found in all parts of the county.

Mule deer are most numerous on the soils of association 6, which provides a mixture of the browse plants that are their main source of food. These bottom-land soils are commonly used as pasture for domestic cattle. Such use destroys the shrubs and undergrowth that furnish cover for deer. Association 5, which has a less adequate mixture of browse plants, supports a small population of mule deer.

Pronghorn antelope are to be found on the extensive rangelands of soil associations 1, 2, 3, 4, and 5. The population is limited, probably because of overuse of the range by domestic stock and extensive periods of drought. On well-managed range, there is little competition between cattle and antelope for food. If range is overgrazed, cattle are forced to eat certain unpalatable weeds and other plants that antelope ordinarily would utilize as food.

Waterfowl hunting, especially goose hunting, is good in Bent County. The Arkansas River and several large reser

Soil series and map symbols	Suitability as source of--				Degree and kind of limitation for--	
	Topsoil	Sand	Gravel	Roadfill	Sewage disposal	Homesites
Apishapa: Ac-----	Fair-----	Unsuitable----	Unsuitable----	Poor-----	Severe: seasonal high water table; slow permeability.	Severe: seasonal high water table.
Arvada: ArA, Av2----- For Deertrail part of Av2, see Deertrail series.	Poor-----	Unsuitable----	Unsuitable----	Poor-----	Severe: shale less than 2 feet below tile floor.	Severe: poor bearing strength; poor stability.
Baca: BaA, BaC-----	Good-----	Unsuitable----	Unsuitable----	Fair-----	Slight-----	Slight-----
Bankard: Bd-----	Poor-----	Good-----	Good-----	Good-----	Severe: high water table; flood hazard.	Severe: flood hazard.
Cascajo: Ca-----	Poor-----	Fair if screened and washed.	Good-----	Good-----	Moderate: slopes.	Moderate: slopes.
Colby: CbB, CoA, CoB, CoE.	Good-----	Unsuitable----	Unsuitable----	Fair-----	Slight-----	Slight-----
Deertrail: DeB-----	Fair-----	Unsuitable----	Unsuitable----	Fair-----	Moderate: moderate permeability.	Moderate: high salt content.
Dune land: Du-----	Poor-----	Good if screened and washed.	Unsuitable----	Fair-----	Severe: pollution hazard to domestic water supply.	Severe: severe erosion hazard.

INTERPRETATIONS

Soil features affecting--					
Highway locations	Dikes and diversions	Farm ponds		Agricultural drainage	Irrigation
		Reservoir area	Embankment		
Seasonal high water table; slow internal drainage; plastic clay; unstable slopes; poor bearing strength; frost heaving; nearly level topography.	Unstable slopes; cracks when dry.	Slow seepage---	Poor bearing strength and stability; large volume change.	Seasonal high water table; few outlets; slow permeability; cracks when dry.	Strong salinity; slow intake; high water table.
Slow internal drainage; poor bearing strength; poor stability.	Severe erosion hazard; poor stability; gypsum strata; cracks badly.	Slow seepage---	Poor stability; cracks badly; severe erosion hazard.	High salt and alkali content; shallow; slow permeability; drainage difficult.	Slow permeability; strong salinity; poor stability.
Fair bearing strength; high silt content; nearly level topography.	Fair stability; slow permeability when packed.	Slow seepage---	Slow permeability when packed.	Not needed-----	Moderate intake.
Flood hazard; good stability; good bearing strength; nearly level topography.	Rapid permeability; erosion hazard; poor compaction.	Rapid permeability.	Rapid permeability.	Not needed-----	Very low water-holding capacity; poor agricultural soil; flood hazard.
Good stability; good bearing strength; hilly topography.	Rapid permeability; stable slopes.	Rapid permeability.	Rapid permeability; stable slopes.	Not needed-----	Very low water-holding capacity; poor agricultural soil; rapid permeability; hilly topography.
Nearly level to gently undulating topography; high silt content; fair bearing strength.	Erosion hazard; slow permeability when packed; fair stability.	Slow seepage---	Fair stability; slow permeability when packed; erosion hazard.	Not needed-----	High water-holding capacity; nearly level to gently rolling topography; moderately slow intake on silty clay loams and silt loams.
Nearly level topography; fair stability; fair bearing strength; erosion hazard.	Slow permeability when packed; fair stability; erosion hazard.	Slow seepage---	Erosion hazard; slow permeability when packed.	Not needed-----	Poor agricultural soil; flood hazard.
Good stability; erosion hazard; rolling topography.	Rapid permeability; erosion hazard.	Rapid permeability.	Rapid permeability.	Not needed-----	Very poor agricultural soil; very low water-holding capacity; very rapid permeability; severe erosion hazard.

## SOIL SURVEY

TABLE 6.--ENGINEERING

Soil series and map symbols	Suitability as source of--				Degree and kind of limitation for--	
	Topsoil	Sand	Gravel	Roadfill	Sewage disposal	Homesites
Dwyer: Dw-----	Poor-----	Good if screened and washed.	Unsuitable----	Fair-----	Severe: pol- lution haz- ard to domes- tic water supply.	Severe: severe ero- sion hazard.
Glenberg: GbA, GbB-----	Fair-----	Fair below a depth of 18 inches if screened and washed.	Fair in places.	Good-----	Severe: flood hazard.	Severe: possible flood hazard.
GeA-----	Fair-----	Good below a depth of 20 inches if screened and washed.	Good below a depth of 20 inches if screened and washed.	Good-----	Severe: flood hazard.	Severe: flood hazard.
Harvey: HaC-----	Good-----	Unsuitable----	Unsuitable----	Good-----	Slight-----	Slight-----
Kim: KmB-----	Good-----	Unsuitable----	Unsuitable----	Fair-----	Severe: bed- rock less than 2 feet below tile floor.	Slight-----
Kornman: KrA, KrB-----	Good-----	Fair below a depth of 30 inches if screened and washed.	Fair in places.	Good-----	Slight-----	Moderate: flood hazard.
Las: La, Lc-----	Fair-----	Unsuitable----	Unsuitable----	Fair-----	Severe: high water table.	Severe: high water table.
Ld, Le-----	Fair-----	Fair-----	Fair-----	Fair-----	Severe: high water table.	Severe: high water table.

## INTERPRETATIONS--CONTINUED

Soil features affecting--					
Highway locations	Dikes and diversions	Farm ponds		Agricultural drainage	Irrigation
		Reservoir area	Embankment		
Good stability; erosion hazard; rolling to hilly topography.	Erosion hazard; good stability; rapid permeability.	Rapid permeability.	Erosion hazard; rapid permeability; good stability.	Not needed-----	Very low water-holding capacity; poor agricultural soil; very rapid permeability; severe erosion hazard.
Good stability; good bearing strength; flood hazard; nearly level topography.	Moderate permeability when packed.	Rapid permeability.	Uppermost 18 inches good fill material; good stability; moderate permeability when packed.	Generally not needed; permeability rapid in substratum.	Rapid permeability; low water-holding capacity; fair agricultural soil; nearly level topography.
Good stability; good bearing strength; flood hazard; nearly level topography.	Rapid permeability.	Rapid permeability.	Permeability rapid below a depth of 20 inches; stability good in uppermost 20 inches.	Generally not needed; permeability rapid in substratum.	Very low water-holding capacity; rapid permeability.
Good stability; good bearing strength; rolling topography.	Slow permeability when packed; good stability.	Slow seepage---	Good stability; slow permeability when packed.	Permeability moderate in substratum.	Moderate to slow permeability; high water-holding capacity.
Rolling topography; good bearing strength; good stability.	Good stability; slow permeability when packed.	Slow seepage---	Slow permeability when packed; good stability.	Not needed-----	Moderate permeability; high water-holding capacity; rolling topography.
Good stability; good bearing strength; possible flood hazard; nearly level topography.	Rapid permeability.	Rapid permeability.	Uppermost 30 inches good fill material; good stability; slow permeability when packed.	Generally not needed; permeability rapid in substratum.	Permeability moderate to slow in surface layer.
Poor drainage; fair bearing strength; frost hazard; nearly level topography.	Fair stability; slow permeability when packed.	Slow seepage---	Fair stability; slow permeability when packed.	Poor drainage; slow permeability; few available outlets.	Poor drainage; strong salinity; slow to moderate permeability and intake.
Poor drainage; fair bearing strength; frost hazard; nearly level topography.	Fair stability; slow permeability when packed.	Rapid seepage--	Fair stability; slow permeability when packed.	Poor drainage; permeability rapid in substratum.	Poor drainage; strong salinity; slow to moderate permeability and intake.

TABLE 6.--ENGINEERING

Soil series and map symbols	Suitability as source of--				Degree and kind of limitation for--	
	Topsoil	Sand	Gravel	Roadfill	Sewage disposal	Homesites
Las Animas: Im-----	Poor-----	Good below a depth of 30 inches.	Good below a depth of 30 inches.	Good below a depth of 30 inches.	Severe: high water table.	Severe: high water table.
Limon: Ln, Lo-----	Fair-----	Unsuitable----	Unsuitable----	Poor-----	Severe: slow permeability.	Severe: poor bearing strength; poor stability.
Litle: LtC-----	Poor-----	Unsuitable----	Unsuitable----	Fair-----	Severe: slow permeability.	Severe: poor bearing strength; poor stability.
Manvel: MaC, MaC2----	Good-----	Unsuitable----	Unsuitable----	Fair-----	Moderate: bedrock less than 2 feet below tile floor.	Slight-----
Manzanola: McB-----	Good-----	Unsuitable----	Unsuitable----	Fair-----	Moderate: moderate per- meability.	Slight-----
Minnequa: MeB, MeC, MpC. For Penrose part of MpC, see Penrose series.	Fair-----	Unsuitable----	Unsuitable----	Fair-----	Severe: bed- rock less than 2 feet below tile floor.	Moderate: bedrock at a depth of 30 inches.
Nepesta: NeA, NeB-----	Fair to poor.	Unsuitable----	Unsuitable----	Surface layer poor; subsurface layer fair.	Moderate: moderate permeability.	Moderate: poor stability.
Numa: NmA, NmB-----	Good-----	Unsuitable----	Unsuitable----	Good-----	Moderate: moderate permeability.	Slight-----
NuB-----	Fair-----	Unsuitable----	Unsuitable----	Good-----	Severe: high water table.	Severe: high water table.

INTERPRETATIONS--CONTINUED

Soil features affecting--					
Highway locations	Dikes and diversions	Farm ponds		Agricultural drainage	Irrigation
		Reservoir area	Embankment		
High water table; poor bearing strength; poor stability; strong salinity; nearly level topography.	Fair stability; rapid permeability; strong salinity.	Rapid permeability.	Fair stability; rapid permeability; strong salinity.	High water table; strong salinity in subsurface; drainage difficult.	Strong salinity; high water table; low water-holding capacity.
Slow internal drainage; plastic clay; unstable slopes; poor bearing strength; nearly level topography.	Unstable slopes; cracks when dry.	Slow seepage---	Cracks when dry; poor bearing strength; poor stability; slow permeability.	Few outlets; slow permeability.	Strong salinity; slow intake.
Poor internal drainage; poor bearing strength; poor stability; gently sloping and rolling topography.	Severe erosion hazard; fair stability; high gypsum content; cracks badly.	Slow seepage---	Poor bearing strength; cracks badly.	Not needed-----	Slow permeability; moderate salinity.
Gently rolling topography; high silt content; fair bearing strength.	Erosion hazard; slow permeability when packed; fair stability.	Slow seepage---	Fair stability; slow permeability when packed; erosion hazard.	Not needed-----	High water-holding capacity; gently rolling topography; moderately slow intake on loams.
Fair bearing strength; nearly level topography.	Slow permeability when packed; fair stability.	Slow seepage---	Slow permeability when packed; fair stability.	Not needed-----	Moderately slow permeability and intake; high water-holding capacity; nearly level topography.
Fair stability; bedrock at a depth of 30 inches; shaly limestone; gently sloping and rolling topography.	Fair stability; slow permeability when packed.	Slow seepage---	Fair stability; slow permeability.	Not needed-----	Moderate permeability; impermeable substratum.
Fair bearing strength; high silt content; nearly level topography.	Fair stability; slow permeability when packed; surface cracks when dry.	Slow seepage---	Poor stability; erosion hazard; surface cracks when dry.	Not needed-----	Slow to very slow permeability and intake.
Good stability; good bearing strength; nearly level topography.	Slow permeability when packed; good stability.	Slow seepage---	Good stability; slow permeability when packed.	Permeability moderate in substratum.	Moderate to slow permeability; high water-holding capacity.
Poor stability; seasonal high water table; frost heave; nearly level topography.	Slow permeability when packed; good stability.	Slow seepage---	Good stability; slow permeability when packed.	Moderate permeability.	Moderate permeability; high water-holding capacity.

TABLE 6.--ENGINEERING

Soil series and map symbols	Suitability as source of--				Degree and kind of limitation for--	
	Topsoil	Sand	Gravel	Roadfill	Sewage disposal	Homesites
Numa--continued: NvB-----	Good-----	Fair below a depth of 30 inches if screened and washed.	Poor-----	Good-----	Slight-----	Slight-----
Olney: OnA, OsB2-----	Good-----	Poor-----	Unsuitable---	Good-----	Slight-----	Slight-----
Otero: OtC-----	Fair-----	Poor below a depth of 25 inches.	Unsuitable---	Good-----	Slight-----	Slight-----
Penrose: PcD-----	Poor-----	Unsuitable---	Unsuitable---	Good-----	Severe: shal- low over bed- rock.	Severe: shal- low over bed- rock.
Pultney: PuC-----	Poor-----	Unsuitable---	Unsuitable---	Poor-----	Severe: mod- erately deep over shale.	Severe: poor bearing strength.
Rago: RaA-----	Good-----	Unsuitable---	Unsuitable---	Fair: high silt con- tent.	Moderate: moderate permeability.	Slight-----
Rocky Ford: RfA, RfB-----	Good-----	Unsuitable---	Unsuitable---	Fair to good.	Moderate: moderate permeability.	Slight-----
RkA, RkB-----	Fair-----	Unsuitable---	Unsuitable---	Good-----	Severe: slow permeability.	Severe: sea- sonal high water table.
RmA-----	Good-----	Good below a depth of 20 inches if screened and washed.	Good below a depth of 20 inches if screened and washed.	Good-----	Severe: flood hazard.	Severe: flood hazard.

INTERPRETATIONS--CONTINUED

Soil features affecting--					
Highway locations	Dikes and diversions	Farm ponds		Agricultural drainage	Irrigation
		Reservoir area	Embankment		
Good stability; good bearing strength; nearly level topography.	Slow permeability when packed; good stability.	Rapid permeability below a depth of 36 inches.	Slow permeability when packed; good stability.	Not needed usually; permeability rapid in substratum.	Permeability rapid in substratum and moderate in rest of profile; moderate water-holding capacity.
Good bearing strength; good stability; nearly level topography.	Good stability; slow permeability when packed.	Moderate seepage.	Good bearing strength; good stability.	Not needed-----	Moderate to moderately rapid intake.
Good stability; good bearing strength; gently rolling topography.	Good stability; moderate to rapid permeability.	Moderate to rapid permeability.	Good stability; moderate to rapid permeability.	Not needed-----	Moderately rapid permeability and intake; low to medium water-holding capacity; variable slopes.
Hilly topography; good stability; stable slopes; limestone at a depth of 10 inches.	Rapid permeability.	Slow seepage---	Rapid permeability; good stability; stable slopes.	Not needed-----	Very shallow over limestone; poor agricultural soil; very low water-holding capacity.
Poor bearing strength; high content of gypsum and shale below a depth of 30 inches; gently sloping and rolling topography.	Poor stability; high gypsum content.	Moderate seepage; gypsum.	Poor bearing strength.	Not needed-----	High gypsum content; moderate salinity; moderate permeability.
Fair stability; high silt content; nearly level topography.	Fair stability; high silt content; moderate compaction.	Slow seepage---	Fair stability; moderate compaction.	Not needed-----	Moderate permeability.
Good stability; good bearing strength; nearly level topography.	Good stability; slow permeability when packed.	Slow seepage---	Fair stability; slow permeability when packed.	Not needed-----	Moderate permeability; high water-holding capacity.
Poor stability; seasonal high water table; frost heave; nearly level.	Good stability; slow permeability when packed.	Slow seepage---	Good stability; slow permeability when packed.	Moderate permeability.	Moderate permeability; seasonal high water-holding capacity.
Good stability; good bearing strength; flood hazard.	Rapid permeability; good stability.	Rapid permeability.	Slow permeability when packed; good stability.	Not needed usually; permeability rapid in substratum.	Permeability rapid in substratum and moderate in rest of profile; moderate water-holding capacity.

TABLE 6.--ENGINEERING

Soil series and map symbols	Suitability as source of--				Degree and kind of limitation for--	
	Topsoil	Sand	Gravel	Roadfill	Sewage disposal	Homesites
Rough broken land: Ro <sup>1/</sup>						
Samsil: Sa-----	Poor-----	Unsuitable----	Unsuitable----	Fair-----	Severe: very shallow over bedrock.	Severe: very shallow over bedrock.
Satanta: SnB-----	Good-----	Unsuitable----	Unsuitable----	Fair-----	Severe: flood hazard.	Severe: flood hazard.
Stoneham: StB, StC----	Good-----	Fair below a depth of 30 inches if screened and washed.	Fair below a depth of 30 inches if screened and washed.	Good-----	Slight-----	Slight-----
Tivoli: Td, ThD, Tn--- For Dune land part of Tn, see Dune land.	Poor-----	Good if screened and washed.	Unsuitable----	Fair-----	Severe: pollution hazard to domestic water supply.	Moderate: low water-holding capacity; erosion hazard.
Travessilla: ToC, Tr-- For Olney part of ToC, see Olney series.	Poor-----	Unsuitable----	Unsuitable----	Bedrock at a depth of 8 to 12 inches.	Severe: bedrock at a depth of 8 to 12 inches.	Severe: bedrock at a depth of 8 to 12 inches.
Vona: VnB, VoB2-----	Fair-----	Fair if screened and washed.	Unsuitable----	Good-----	Severe: pollution hazard to domestic water supply.	Moderate: low water-holding capacity; erosion hazard.
Weld: WeA-----	Good-----	Unsuitable----	Unsuitable----	Fair-----	Moderate: moderate permeability.	Slight-----

See footnote at end of table.

INTERPRETATIONS--CONTINUED

Soil features affecting--					
Highway locations	Dikes and diversions	Farm ponds		Agricultural drainage	Irrigation
		Reservoir area	Embankment		
Hilly topography; fair stability; erosion hazard; fair bearing strength.	Erosion hazard; slow seepage; fair stability.	Slow seepage---	Erosion hazard; slow permeability; fair stability.	Not needed-----	Very slow intake; very shallow over shale; poor agricultural soil.
Fair stability; high silt content; flood hazard; fair bearing strength; nearly level topography.	Slow permeability when packed; fair stability.	Slow seepage---	Fair stability; slow permeability when packed.	Not needed-----	Moderate permeability; high water-holding capacity; nearly level topography; flood hazard.
Rolling topography; good stability; good bearing strength.	Slow permeability when packed; good stability; good bearing strength.	Rapid seepage below a depth of 30 inches.	Slow permeability when packed; good stability; good bearing strength.	Not needed-----	Moderate water-holding capacity; rapid permeability below a depth of 30 inches; rolling topography; moderately rapid intake on sandy loams.
Good stability; erosion hazard; hilly topography in places.	Erosion hazard; good stability; rapid permeability.	Rapid permeability.	Erosion hazard; rapid permeability; good stability.	Not needed-----	Very low water-holding capacity; poor agricultural soil; very rapid permeability; severe erosion hazard.
Good stability; hilly topography; bedrock at a depth of 8 to 12 inches; cliffs.	Rapid permeability; erosion hazard; bedrock at a depth of 8 to 12 inches; hilly topography.	Slow seepage---	Rapid permeability; erosion hazard; bedrock at a depth of 8 to 12 inches.	Not needed-----	Very low water-holding capacity; hilly topography; bedrock at a depth of 8 to 12 inches; poor agricultural soil.
Good stability; good bearing strength; gently rolling topography.	Moderate to rapid permeability when packed; good stability.	Moderate to rapid permeability.	Moderate permeability when packed; good stability.	Not needed-----	Rapid permeability; low water-holding capacity; rolling topography; fair agricultural soil.
Fair bearing strength; high silt content; nearly level topography.	Fair stability; slow permeability when packed.	Slow seepage---	Slow permeability when packed.	Not needed-----	Moderate intake; high water-holding capacity.

TABLE 6.--ENGINEERING

Soil series and map symbols	Suitability as source of--				Degree and kind of limitation for--	
	Topsoil	Sand	Gravel	Roadfill	Sewage disposal	Homesites
Wiley: WLB-----	Good-----	Unsuitable----	Unsuitable----	Fair-----	Moderate: moderate permeability.	Slight-----

<sup>1/</sup>  
Material consists mainly of shale and sandstone.

voirs serve as concentration and resting areas from which waterfowl fly to the surrounding croplands to feed. Because of the very dry climate, the potential for attracting more waterfowl is slight.

Warm-water fish are caught in the larger reservoirs—walleye and channel catfish in Adobe Creek Reservoir (Blue Lakes), and crappie, walleye, and channel catfish in Horse Creek Reservoir. The Arkansas River offers no sport fishing, and farm ponds are few because of the low and uncertain precipitation.

### ***Use of the Soils for Recreational Developments***<sup>6</sup>

The relative severity of the limitations of the soils for recreational developments are shown in table 8, p. 69. The broad classification by soil associations should be noted. Certain locations within an association that generally has severe limitations might be readily adapted to a given recreational use. Conversely, certain locations within an association that generally has only slight limitations might be severely limited for a given use. The general soil map at the back of this survey shows the location of the seven soil associations in the county.

Limiting factors other than soil characteristics were also considered in evaluating the soil associations for recreational enterprises. Among these were long distances from population centers, lack of spectacular scenery, hot summer weather, and frequent and extended droughts.

Improving the waterfowl habitat in areas under irrigation, such as those in soil associations 6 and 7, and then leasing out the rights for hunting ducks and geese probably offers the best potential for development of recreational facilities. Areas to be used for duck hunting must have a gradient of no more than 1 percent, and water must be available for irrigating and flooding. If diked and

<sup>6</sup>Prepared with the help of ELDIE W. MUSTARD, biologist, Soil Conservation Service.

planted in spring and then flooded with a few inches of water in fall, such areas provide excellent facilities for duck shooting. Ducks prefer to feed in flooded areas. Also, certain sites in associations 6 and 7 would be suitable for goose hunting pits.

Good sites for campgrounds can be found on soil associations 6 and 7. The campground on Lake Hasty Recreation Area below the John Martin Reservoir accommodates many tourists.

### ***Formation and Classification of the Soils***

This section describes the major factors of soil formation and some of the soil-forming processes. It also shows how the soils of this county have been classified according to the two systems of classification used in the United States.

#### **Factors of Soil Formation**

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 development have acted on the soil material.

Climate and vegetation are the active factors of soil formation. The effects of climate and vegetation are conditioned by relief. The parent material affects the kind of profile that forms and, in extreme cases, determines it almost entirely. Finally, time is needed for the changing of the parent material into a soil profile. Usually a long time is required for the development of distinct horizons.

The factors of soil formation are so closely interrelated in their effects on the soil that few generalizations can be made regarding the effect of any one factor unless condi-

INTERPRETATIONS

Soil features affecting--					
Highway locations	Dikes and diversions	Farm ponds		Agricultural drainage	Irrigation
		Reservoir area	Embankment		
Nearly level to gently rolling topography; high silt content; fair bearing strength; fair stability.	Slow permeability when packed; erosion hazard; fair stability.	Slow seepage---	Slow permeability when packed; erosion hazard; fair stability.	Not needed-----	Nearly level to gently rolling topography; high water-holding capacity; good agricultural soil; moderate intake.

tions are specified for the other four. Many of the processes of soil formation are unknown.

The five factors of soil formation as they occur in Bent County are described in the paragraphs that follow.

*Parent material.*—The soils in this county formed in a wide variety of parent material, all of which was highly calcareous. Tivoli, Dwyer, and Vona soils formed in recent eolian (windblown) sands. Colby, Wiley, Baca, and Weld soils formed in loesslike sediments. Travessilla soils formed in material weathered from sandstone; Penrose, Minnequa, and Manvel soils in material weathered from limestone; and Samsil, Arvada, and Litle soils in material weathered from shale. Stoneham and Harvey soils formed in gravelly deposits that range in age from Early Tertiary through the Pliocene (Ogallala Formation) and Pleistocene Series. Apishapa, Las, Las Animas, Glenberg, and Bankard soils formed in recent alluvium along the Arkansas River.

*Climate.*—The climate of Bent County is continental and semiarid. The dominant climatic influence on the formation of the soils has been the amount and distribution of precipitation. Water seldom percolates below the root zone of native plants.

*Living organisms.*—Plants, animals, insects, bacteria, and fungi affect the content of organic matter, nitrogen, and plant nutrients and cause changes in structure and porosity. Most of the soils of the county formed under short grasses.

*Relief.*—The topography of the county varies greatly. The recent alluvial and loessal areas are nearly level to gently sloping. Most areas underlain by limestone and shale are gently sloping to strongly sloping; a few are steep. The areas underlain by sandstone are typically very steep hills and breaks and high, flat mesa tops.

*Time.*—The length of time required for the formation of a mature soil depends largely on the other factors involved. The soils that formed in loess are most likely the oldest in this county. The alluvial soils of the river bottoms are the youngest.

### Processes of Soil Formation

Leaching of lime, translocation of clay minerals, accumulation of organic matter, and reduction and transfer of iron have been active processes in the formation of most soils.

While soils are developing, free lime in the soil material is dissolved by water, is carried downward as far as the water can penetrate, and is then redeposited. The depth and degree of leaching help to determine the degree of development that has taken place. The amount of lime left in the soil material and the depth to which it is translocated depend on the amount of lime in the parent material, the permeability of the parent material, the amount of water that percolates through the profile, and the rate at which erosion removes the surface layer of the soil. Leaching of carbonates and bases has occurred in nearly all soils in Bent County, but the amount of rainfall in this county is limited and lime is leached very slowly. Most of the soils are only weakly or moderately leached.

Leaching of lime generally precedes translocation of silicate clay minerals. As weathering continues, clay moves downward from the surface layer and accumulates in the subsoil. It is evidenced by an increase in the proportion of clay particles and the development of clay films on ped surfaces. The effects of this process are noticeable in Baca, Weld, and Olney soils and are slightly noticeable in Vona and Wiley soils.

Accumulation of organic matter has been an important process in horizon development in the soils of this county. The many substances released in the decomposition of organic material greatly increase the rate of weathering and the degree of development that takes place in the mineral part of the soil material.

Reduction and transfer of iron, a process called gleying, is evident in poorly drained soils. Gray colors in the subsoil indicate the reduction and loss of iron. Reddish-brown mottles in some horizons and iron concretions in others indicate the segregation of iron. Apishapa, Las, and Las

## SOIL SURVEY

TABLE 7.--SUITABILITY OF SOIL ASSOCIATIONS FOR WILDLIFE HABITAT

[Dashes in columns stand for "Not applicable"]

Soil associations	Wildlife	Suitability for--				
		Protective and escape cover		Food	Aquatic environment	
		Woody	Herbaceous		Natural	Developed
<b>Nonirrigated:</b>						
1. Stoneham-Vona.	Antelope-----	-----	-----	Good-----	-----	-----
	Jackrabbit-----	-----	-----	Good-----	-----	-----
	Cottontail-----	Poor-----	Fair-----	Fair-----	-----	-----
	Scaled quail-----	Poor-----	Poor-----	Fair-----	-----	-----
	Mourning dove-----	Poor-----	Poor-----	Fair-----	-----	-----
2. Wiley-Colby.	Antelope-----	-----	-----	Good-----	-----	-----
	Jackrabbit-----	-----	-----	Good-----	-----	-----
	Cottontail-----	Poor-----	Fair-----	Fair-----	-----	-----
	Scaled quail-----	Poor-----	Poor-----	Fair-----	-----	-----
	Mourning dove-----	Poor-----	Poor-----	Fair-----	-----	-----
3. Manvel-Minnequa-Penrose.	Antelope-----	-----	-----	Good-----	-----	-----
	Jackrabbit-----	-----	-----	Good-----	-----	-----
	Cottontail-----	Poor-----	Fair-----	Fair-----	-----	-----
	Scaled quail-----	Poor-----	Poor-----	Fair-----	-----	-----
	Mourning dove-----	Poor-----	Poor-----	Fair-----	-----	-----
4. Tivoli.	Antelope-----	-----	-----	Good-----	-----	-----
	Jackrabbit-----	-----	-----	Good-----	-----	-----
	Cottontail-----	Poor-----	Good-----	Good-----	-----	-----
	Scaled quail-----	Poor-----	Good-----	Good-----	-----	-----
	Mourning dove-----	Poor-----	Good-----	Good-----	-----	-----
5. Travessilla-Baca.	Antelope-----	-----	-----	Good-----	-----	-----
	Mule deer-----	Poor-----	-----	Poor-----	-----	-----
	Jackrabbit-----	-----	-----	Fair-----	-----	-----
	Cottontail-----	Poor-----	Fair-----	Fair-----	-----	-----
	Scaled quail-----	Poor-----	Fair-----	Good-----	-----	-----
	Mourning dove-----	Poor-----	Fair-----	Fair-----	-----	-----
	Waterfowl-----	-----	-----	-----	-----	Poor.
	Turkey-----	Poor-----	Fair-----	Fair-----	-----	-----
Fish-----	-----	-----	-----	Poor-----	Poor.	
<b>Irrigated:</b>						
6. Las-Apishapa-Bankard.	Mule deer-----	Good-----	-----	Fair-----	-----	-----
	Cottontail-----	Good-----	Good-----	Good-----	-----	-----
	Pheasant-----	Good-----	Good-----	Fair-----	-----	-----
	Scaled quail-----	Good-----	Good-----	Good-----	-----	-----
	Mourning dove-----	Good-----	Good-----	Good-----	-----	-----
	Bobwhite-----	Good-----	Good-----	Good-----	-----	-----
	Waterfowl-----	-----	-----	Fair-----	Fair-----	Good.
	Fish-----	-----	-----	-----	Poor-----	Fair.
7. Rocky Ford-Numa.	Jackrabbit-----	-----	-----	Good-----	-----	-----
	Cottontail-----	Fair-----	Good-----	Good-----	-----	-----
	Pheasant-----	Fair-----	Good-----	Good-----	-----	-----
	Scaled quail-----	Fair-----	Good-----	Good-----	-----	-----
	Mourning dove-----	Fair-----	Good-----	Good-----	-----	-----
	Waterfowl-----	-----	-----	Good-----	-----	Good.
	Fish-----	-----	-----	-----	-----	Good.

TABLE 8.--DEGREE OF LIMITATIONS OF THE SOIL ASSOCIATIONS FOR RECREATIONAL PURPOSES

Soil associations	Vacation farms (dude ranches)	Picnic and sport areas	Fishing (developed)	Campsites, scenic areas, and nature areas	Hunting areas			Sites for rural cottages, camps, and homesites
					Big game	Upland game	Waterfowl	
Nonirrigated:								
1. Stoneham-Vona-----	Severe--	Very severe--	Very severe--	Severe----	Severe-----	Severe----	Severe-----	Very severe.
2. Wiley-Colby-----	Severe--	Very severe--	Very severe--	Severe----	Severe-----	Severe----	Severe-----	Very severe.
3. Manvel-Minnequa-Penrose--	Severe--	Very severe--	Very severe--	Severe----	Severe-----	Severe----	Severe-----	Very severe.
4. Tivoli-----	Severe--	Very severe--	Very severe--	Moderate--	Moderate----	Moderate--	Very severe--	Very severe.
5. Travessilla-Baca-----	Severe--	Severe-----	Very severe--	Moderate--	Moderate----	Moderate--	Very severe--	Severe.
Irrigated:								
6. Las-Apishapa-Bankard-----	Severe--	Moderate-----	Moderate-----	Moderate--	Moderate----	Slight----	Slight-----	Moderate.
7. Rocky Ford-Numa-----	Severe--	Moderate-----	Moderate-----	Moderate--	Very severe--	Slight----	Slight-----	Moderate.

TABLE 9.--SOIL SERIES CLASSIFIED ACCORDING TO THE CURRENT SYSTEM OF CLASSIFICATION AND THE 1938 SYSTEM, WITH ITS LATER REVISIONS

Series	Current classification			1938 classification
	Family	Subgroup	Order	Great soil group
Apishapa-----	Fine, montmorillonitic, calcareous, mesic.	Vertic Haplaquepts-----	Inceptisols-----	Alluvial soils.
Arvada-----	Fine, montmorillonitic, mesic-----	Ustolic Natrargids-----	Aridisols-----	Solodized Solonetz soils.
Baca-----	Fine, montmorillonitic, mesic-----	Ustolic Haplargids-----	Aridisols-----	Brown soils.
Bankard-----	Sandy, mixed, mesic-----	Typic Torrifuvents-----	Entisols-----	Alluvial soils.
Cascajo-----	Sandy, mixed, mesic-----	Ustolic Calciorthids-----	Aridisols-----	Calcisols.
Colby-----	Fine-silty, mixed, calcareous, mesic-----	Typic Ustorthents-----	Entisols-----	Regosols.
Deertrail-----	Fine, montmorillonitic, mesic-----	Ustolic Natrargids-----	Aridisols-----	Brown soils intergrading to Planosols.
Dwyer-----	Sandy, mixed, mesic-----	Typic Torripsamments-----	Entisols-----	Regosols.
Glenberg-----	Coarse-loamy, mixed, calcareous, mesic.	Typic Torrifuvents-----	Entisols-----	Alluvial soils.
Harvey-----	Fine-loamy, mixed, mesic-----	Ustolic Calciorthids-----	Aridisols-----	Calcisols.
Kim-----	Fine-loamy, mixed, calcareous, mesic-----	Typic Torriorthents-----	Entisols-----	Regosols.
Kornman-----	Coarse-loamy, mixed, calcareous, mesic.	Typic Torrifuvents-----	Entisols-----	Alluvial soils.
Las-----	Fine-loamy, mixed, calcareous, mesic-----	Aquic Ustifuvents-----	Entisols-----	Alluvial soils.
Las Animas-----	Coarse-loamy, mixed, calcareous, mesic.	Fluventic Haplaquepts-----	Inceptisols-----	Alluvial soils.
Limon-----	Fine, montmorillonitic, calcareous, mesic.	Typic Torriorthents-----	Entisols-----	Alluvial soils.
Litle-----	Fine, montmorillonitic, mesic-----	Ustolic Camborhids-----	Aridisols-----	Brown soils.
Manvel-----	Fine, carbonatic, mesic-----	Typic Torriorthents-----	Entisols-----	Regosols.
Manzanola-----	Fine, montmorillonitic, mesic-----	Ustolic Haplargids-----	Aridisols-----	Brown soils.
Minnequa-----	Fine, carbonatic, mesic-----	Typic Torriorthents-----	Entisols-----	Regosols.
Nepesta-----	Fine-silty, mixed, mesic-----	Ustolic Haplargids-----	Aridisols-----	Brown soils.
Numa-----	Fine-loamy, mixed, mesic-----	Ustolic Calciorthids-----	Aridisols-----	Calcisols.
Olney-----	Fine-loamy, mixed, mesic-----	Ustolic Haplargids-----	Aridisols-----	Brown soils.
Otero-----	Coarse-loamy, mixed, calcareous, mesic.	Typic Torriorthents-----	Entisols-----	Regosols.
Penrose-----	Fine, carbonatic, mesic-----	Lithic Torriorthents-----	Entisols-----	Lithosols.
Pultney-----	Fine-loamy, mixed, mesic-----	Ustolic Calciorthids-----	Aridisols-----	Cypsolos.
Rago-----	Fine, montmorillonitic, mesic-----	Pachic Argiustolls-----	Mollisols-----	Chestnut soils.
Rocky Ford-----	Fine-silty, mixed, calcareous, mesic-----	Typic Torriorthents-----	Entisols-----	Alluvial soils.
Samsil-----	Clayey, mixed, calcareous, mesic, shallow.	Typic Ustorthents-----	Entisols-----	Lithosols.
Satanta-----	Fine-loamy, mixed, mesic-----	Typic Argiustolls-----	Mollisols-----	Chestnut soils.
Stoneham-----	Fine-loamy, mixed, mesic-----	Ustolic Haplargids-----	Aridisols-----	Brown soils.
Tivoli-----	Siliceous, nonacid, mesic-----	Typic Torripsamments-----	Entisols-----	Regosols.
Travessilla-----	Loamy, mixed, calcareous, mesic-----	Lithic Torriorthents-----	Entisols-----	Lithosols.
Vona-----	Coarse-loamy, mixed, mesic-----	Ustolic Haplargids-----	Aridisols-----	Brown soils.
Weld-----	Fine, montmorillonitic, mesic-----	Abruptic Paleustolls-----	Mollisols-----	Chestnut soils intergrading to Planosols.
Wiley-----	Fine-silty, mixed, mesic-----	Ustolic Haplargids-----	Aridisols-----	Brown soils.

Animas soils are poorly drained soils affected by this process.

## Classification of the Soils

Classification consists of an orderly grouping of soils designed to make it easier to remember soil characteristics and interrelationships. Classification is useful in organizing and applying the results of experience and research. Soils are placed in narrow classes for discussion in detailed soil surveys and for application of knowledge within farms and fields. The many thousands of narrow classes are then grouped into progressively fewer and broader classes in successively higher categories, so that information can be applied to large geographic areas.

Two systems of classifying soils have been used in the United States in recent years. The older system was adopted in 1938 (2) and revised later (6). The system currently used by the National Cooperative Soil Survey was adopted in 1965. It is under continual study. Readers interested in the development of the system should refer to the latest literature available (5, 7).

The current system of classification has six categories. Beginning with the most inclusive, these categories are the order, the suborder, the great group, the subgroup, the family, and the series. The criteria for classification are soil properties that are observable or measurable, but the properties are selected so that soils of similar genesis are grouped together. The placement of some soil series in the current system of classification, particularly in families, may change as more precise information becomes available.

Table 9 shows the classification of the soil series of Bent County according to the current system. It also shows one category, the great soil group, of the 1938 system.

Following are brief descriptions of each of the categories in the current system.

**ORDER:** In the order, soils are grouped according to properties that seem to result from the same processes acting to about the same degree on soil material. Ten soil orders are recognized in the current system: Entisols, Vertisols, Inceptisols, Aridisols, Mollisols, Spodosols, Alfisols, Ultisols, Oxisols, and Histosols. Entisols, Inceptisols, Aridisols, and Mollisols are recognized in Bent County. Entisols are recent soils that either lack genetic horizons or have only the beginnings of such horizons. Inceptisols have one or more horizons that are believed to have formed in a short time. Aridisols formed in dry climate. They have a B horizon and a light-colored surface layer. Mollisols have a dark-colored surface layer.

**SUBORDER:** Each order is divided into suborders, primarily on the basis of soil characteristics that seem to produce classes having the greatest genetic similarity. The suborder has a narrower climatic range than an order. The criteria for suborders reflect either (1) the presence or absence of waterlogging, (2) differences in climate or vegetation, or (3) extremes in texture or in mineral composition.

**GREAT GROUP:** Each suborder is divided into great groups on the basis of uniformity in kind and sequence of genetic horizons.

**SUBGROUP:** Each great group is divided into subgroups, one representing the central (typic) concept of the group, and others, called intergrades, representing the soils

that have mostly the properties of one great soil group, but also have one or more properties of the soils of another great group, suborder, or order.

**FAMILY:** Families are established within each subgroup, primarily on the basis of properties important to plant growth. Some of the properties considered are texture, mineral composition, reaction, soil temperature, permeability, consistence, and thickness of horizons.

**SERIES:** The series has the narrowest range of characteristics of the categories in the classification system. It is explained in the section "How This Survey Was Made."

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## Glossary

- 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.
- Calcareous soil.** A soil containing enough calcium carbonate (often with magnesium carbonate) to effervesce (fizz) visibly when treated with cold, dilute hydrochloric acid.
- Clay.** As a soil separate, mineral soil particles that are 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.)
- Concretions.** Grains, pellets, or nodules that consist of concentrations of compounds or of soil grains cemented together. They are of various sizes, shapes, and colors. 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.
- Soft.**—When dry, breaks into powder or individual grains under very slight pressure.
- Cemented.**—Hard and brittle; little affected by moistening.
- Emergency tillage.** Cultivation by listing, ridging, duckfooting, chiseling, pitting, basin listing, or other means to roughen the soil surface for temporary control of wind erosion.
- Field moisture capacity.** The moisture content of a soil, expressed as a percentage of the oven-dry weight, after the gravitational, or free, water has been allowed to drain away; the field moisture content 2 or 3 days after a soaking rain; also called normal field capacity, normal moisture capacity, or capillary capacity.
- Horizon, soil.** A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes. These are the major horizons:
- O horizon.** The layer of organic matter on the surface of a mineral soil. This layer consists of decaying plant residues.
- A horizon.** The mineral horizon at the surface or just below an O horizon. This horizon is the one in which living organisms are most active and therefore is marked by the accumulation of humus. The horizons may have lost one or more of soluble salts, clay, or sesquioxides (iron and aluminum oxides).
- B horizon.** The mineral horizon below an A horizon. The B horizon is in part a layer of change from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics caused by (1) accumulation of clay, sesquioxides, humus, or some combination of these; (2) prismatic or blocky structure; (3) redder or stronger colors than the A horizon; or (4) some combination of these. Combined A and B horizons are usually called the solum, or true soil. If a soil lacks a B horizon, the A horizon alone is the solum.
- C horizon.** The weathered rock material immediately beneath the solum. In most soils this material is presumed to be like that from which the overlying horizons were formed. If the material is known to be different from that in the solum, a Roman numeral precedes the letter C.
- R layer.** Consolidated rock beneath the soil. The rock usually underlies a C horizon but may be immediately beneath an A or B horizon.
- Mottling, soil.** Irregular marking with spots of different colors that vary in number and size. Mottling in soils usually indicates poor aeration and lack of drainage. Descriptive terms are as follows: Abundance—*few*, *common*, and *many*; size—*fine*, *medium*, and *coarse*; and contrast—*faint*, *distinct*, and *prominent*. The size measurements are these: *fine*, less than 5 millimeters (about 0.2 inch) in diameter along the greatest dimension; *medium*, ranging from 5 millimeters to 15 millimeters (about 0.2 to 0.6 inch) in diameter along the greatest dimension; and *coarse*, more than 15 millimeters (about 0.6 inch) in diameter along the greatest dimension.
- Permeability.** The capacity of the soil to transmit air or water. Terms used to describe permeability are as follows: *very slow*, *slow*, *moderately slow*, *moderate*, *moderately rapid*, *rapid*, and *very rapid*.
- Profile, soil.** A vertical section of the soil through all its horizons and extending into the parent material.
- Reaction, soil.** The degree of acidity or alkalinity of a soil, expressed in pH values or words as follows:

pH		pH	
Extremely acid....	Below 4.5	Neutral .....	6.6 to 7.3
Very strongly acid..	4.5 to 5.0	Mildly alkaline.....	7.4 to 7.8
Strongly acid.....	5.1 to 5.5	Moderately alkaline...	7.9 to 8.4
Medium acid.....	5.6 to 6.0	Strongly alkaline.....	8.5 to 9.0
Slightly acid.....	6.1 to 6.5	Very strongly alkaline..	9.1 and higher

**Relief.** The elevations or inequalities of a land surface, considered collectively.

**Saline soil.** A soil that contains soluble salts in amounts that impair growth of plants, but that does not contain excess exchangeable sodium.

**Sand.** As a soil separate, individual rock or mineral fragments 0.05 millimeter to 2.0 millimeters in diameter. Most sand grains consist of quartz, but sand may be any mineral composition. As a textural class, soil that is 85 percent or more sand and not more than 10 percent clay. (See also Texture, soil.)

**Silt.** As a soil separate, individual mineral particles that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). As a textural class, soil that is 80 percent or more silt and less than 12 percent clay. (See also Texture, soil.)

**Slickspots.** Small areas in a field that are slick when wet because they contain excess exchangeable sodium, or alkali.

**Soil.** A natural, three-dimensional body on the earth's surface that supports plants and that has properties resulting from the integrated effect of climate and living matter acting upon parent material, as conditioned by relief, over periods of time.

**Soil variant.** A soil having properties sufficiently different from those other known soils to justify establishing a new soil series, but of such limited known area that creation of a new series is not believed to be justified.

**Solum.** The upper part of a soil profile, above the parent material, in which the processes of soil formation are active. The solum in mature soil includes the A and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the underlying material. The living roots and other plant and animal life characteristic of the soil are largely confined to the solum.

**Structure, soil.** The arrangement of primary soil particles into compound particles or clusters that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil particles. The principal forms of soil structure are—*platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular*. *Structureless* soils are (1) *single grain* (each grain by itself, as in dune sand) or (2) *massive* (the particles adhering without any regular cleavage, as in many claypans and hardpans).

**Subsoil.** Technically, the B horizon; roughly, the part of the profile below plow depth.

**Substratum.** Any layer beneath the solum, or true soil; the C or R horizon.

**Surface soil.** The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, about 5 to 8 inches in thickness. The plowed layer.

**Terrace (geologic).** An old alluvial plain, ordinarily flat or undulating, bordering a river, a 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 adding the words “coarse,” “fine,” or “very fine” to the name of the textural class.

**Tilth, soil.** The condition of the soil, especially as to structure, in relation to the growth of plants. 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.

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