Series 1956, No. 11 Issued June 1960

SOIL SURVEY

Cimarron County Oklahoma

OUR SOIL ★ OUR STRENGTH

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

HOW TO USE THE SOIL SURVEY REPORT

THIS SURVEY of Cimarron County will help you plan the kind of ranching and farming that will protect your soils and provide good yields. It describes the soils, shows their location, and tells what they will do under different kinds of management.

Find your property on the map

To use this survey, start by finding your farm or ranch on the soil map that is at the back of this book. This is a large map of the county, on which you can see roads, streams, towns, and other landmarks. The index to map sheets will help you locate your acreage; it shows what part of the county is on each sheet of the soil map.

Learn about your soils

Each kind of soil mapped in the county is identified on the soil map by a symbol.

Suppose you have found on your property an area marked with the symbol Ca. You learn the name of the soil this symbol represents by looking at the map legend. The symbol Ca identifies Carnero loam. To learn how this soil looks in the field and what it can be used for, turn to the section, Descriptions of the Soils, and read the description of Carnero loam.

After you have read the description of the soil, you may want to know what should be done to take care of the soil and get good yields. This is discussed in the section, Use and Management of Soils. To find out how much the soil can be expected to produce, turn to table 6, under the heading, Estimated Yields.

Make a farm plan

Study your soils and see whether you have been cultivating any that do not give good yields or are likely to be damaged by cropping, or whether you have been letting rangeland deteriorate. Then decide whether you need to change your methods. The choice, of course, must be yours. This report will help you plan, but it does not offer a plan of management for any particular farm or ranch. Technical help in planning a conservation program can be obtained from representatives of the Soil Conservation Service and the county agricultural agent. Members of your State experiment station staff and others familiar with farming in your county will also be glad to help.

This soil survey was made as part of the technical assistance furnished by the Soil Conservation Service to the Cimarron County Soil Conservation District. Fieldwork for the survey was finished in 1956. Unless otherwise specified, all statements in the report refer to conditions in the county at the time the fieldwork was in progress.

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Series 1956, No. 11

Issued June 1960

SOIL SURVEY OF CIMARRON COUNTY, OKLAHOMA

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United States Department of Agriculture in Cooperation With Oklahoma Agricultural Experiment Station

General Nature of the County

Cimarron County is at the western end of the Oklahoma Panhandle (fig. 1). It is bounded on the south by Texas, on the west by New Mexico, on the north by Colorado, and on the east by Texas County, Okla. The total area of the county is 1,832 square miles, or 1,172,480

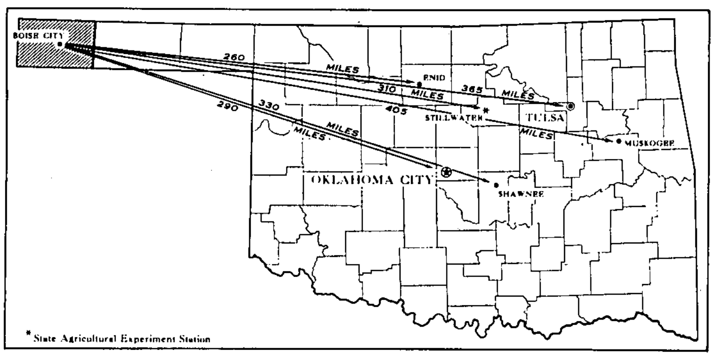

***Figure 1.*—Location of Cimarron County in Oklahoma.**

acres. The distance from the southern boundary to the northern is about 34 miles, and the distance from the eastern boundary to the western is about 54 miles. The average elevation is 4,200 feet.

In 1950, the population of the county was 4,589. Boise City, the county seat, is located 1 mile south of the center of the county and is at an elevation of 4,165 feet. The population of Boise City in 1950 was almost 2,000.

Transportation facilities.—Railroad service in Cimarron County is provided by branch lines of the Santa Fe. One line runs from Dodge City, Kans., to Boise City, and another runs from La Junta, Colo., through Boise City to Amarillo, Tex. Three Federal highways cross the county—U.S. 56, U.S. 64, and U.S. 287. There is regular bus service from Denver through Boise City to Amarillo and from Clayton, N. Mex., and Boise City to Liberal, Kans.

In farm areas, roads are laid out on section lines. Most are graded dirt or gravelled roads. They provide good access to the hard-surfaced roads. A few main roads lead to the larger range areas.

Industries.—Cimarron County is basically agricultural. Wheat and cattle are the principal sources of income. The elevator capacity in Boise City is approximately 775,000 bushels. Keyes and other places each have elevator capacities of 600,000 bushels. Cattle thrive here.

Thus far, more than 100 producing gas wells have been drilled in the basal Pennsylvanian rock formation. The gas field is practically confined to townships 4, 5, and 6, ranges 8 and 9 E., CM. From 1 million to as much as 112 million cubic feet of gas, valued at about 15 cents per thousand, is produced daily. About 2 percent of the volume is helium; this puts this gas field first in the nation as a potential source of helium.

Some oil has been discovered, and further explorations are under way. Approximately 75 percent of the county is now leased for oil and gas production or exploration. Bonuses and rentals account for considerable revenue to the landowners. A 4-inch gasoline line crosses the county enroute to La Junta, Colo. A 20-inch natural-gas line carries gas from Cimarron County to Texas and Colorado.

The county also has some building stone of outstanding color and texture. Little of this, however, has been quarried.

Schools.—The school system of Cimarron County covers both grade and high school levels. At one time there were 55 operating schools and 57 school districts. Improved transportation made it possible to centralize, and a reorganization since 1946 has brought the number of school districts down to seven. With centralization came extra facilities and generally improved conditions in the seven schools now in use.

Physiography and Drainage

Cimarron County is entirely within the Great Plains province. It is all in the High Plains section of this province, except for Black Mesa, which is in the Raton section. The surface of the county is a plain that slopes gently toward the east. This plain is broken by two valleys, one in the northern part of the county and the other in the southern part.

The elevation on Black Mesa is 4,973 feet, and the elevation in the southeastern corner of the county is 3,700 feet. The drop in elevation ranges from 18 to 20 feet per mile.

The two major streams in the county, and their tributaries, flow from west to east. The Cimarron River and its tributaries drain approximately 590 square miles of the county. The tributaries that start in this county average less than 6 miles in length. The longest is Cold Springs Creek, which is approximately 21 miles long.

The North Canadian River (locally called the Beaver River) is formed by the union of Currumpa and Cinequillia Creeks, which enter the county from New Mexico. The total length, in this county, of the North Canadian River and its parent creek is 61 miles. Because this river flows through sandy areas where very little runoff occurs, its tributaries are few and short.

Aqua Frio Creek, which is in the southwestern part of the county, also has only a few short tributaries. This creek drains approximately 17 miles in Cimarron County.

Geologic Formations

Cimarron County lies at the western edge of the High Plains, which is a vast apron of water-deposited materials weathered from the Rocky Mountains, mostly during the Pliocene epoch. These deposits, called Ogallala, are smooth, have a steady slope to the southeast, and rest on red beds. Because the red beds were hilly as a result of previous dissection, the Pliocene deposits are of varying thickness, possibly less than 50 feet in places. They are mostly limy brown silt and sand, with gravel deposits near the bottom. Beds of hardened caliche are very common near and within the breaks of the High Plains.

During the Quaternary period, windblown sands and silty loess were deposited over the Tertiary materials. These deposits vary in thickness from a few inches to many feet, depending upon how close they are to the stream valleys. Generally, the sand deposits are nearer the streams; they are thick and have a hummocky to duny surface. The silt deposits are much thinner, cover much wider areas, and have a smooth surface. Along the main streams and rivers are narrow bodies of silty to sandy recent alluvium.

Sand deposits, loess, and alluvium of the Ogallala formation are at the surface in all of the county except the northwestern quarter, which is adjacent to the Cimarron River and its main southern branches. Here, erosion has stripped away vast deposits of the Ogallala and exposed hard, much older rocks of the Cretaceous, Jurassic, and Triassic systems. The smooth Ogallala formation breaks off sharply into a hilly, dissected sandstone and shale area that extends from a point north of Boise City to a point near Kenton, on Black Mesa, and south to Mexhoma. Black Mesa is a remnant of an olivine basalt lava flow that covered the Ogallala formation late in the Tertiary period. The lava, as well as the volcanic ash in the eastern part of the Panhandle came from volcanoes to the west in New Mexico.

The youngest hard-rock formations exposed are Greenhorn limestone and Graneros shale of the Colorado group. These outcrop in only one sizable area, which is 5 to 13 miles north and east of Wheeless, just below the "breaks in the plains." Below these rocks is the prominent buff to gray Dakota sandstone, which is the material of many of the bizarre sandstone knobs, cliffs, and mesas between Wheeless and Kenton and eastward, both north and south of the Cimarron.

The Purgatoire formation, including Kiowa shale and Cheyenne sandstone, is less extensive. It outcrops just below the Dakota, in a narrow band around the base of Black Mesa and around the rim of each tributary of the Cimarron River as far east as Boise City.

Below the Purgatoire are the brown sandstone and bedded gray, green, and red clay of the Morrison formation and the sandstone of the Exeter formation, which overlie red Triassic sandstone and clay. These red rocks are exposed only in the lowest areas, such as the deep ravines and the low foot slopes near the Cimarron River north of Boise City and around Kenton.

Climate[1]

Weather records for Cimarron County have been kept continuously since 1909, first at Hurley, an early voting precinct near Boise City, and, since 1925, at Boise City.

Cimarron County has a semiarid climate. The average annual rainfall is 16.81 inches at Boise City and 17.11 inches at Kenton. Normally, 75 percent of the rainfall at Boise City occurs during the warm season, from April through September. More than 180 days each year are clear. Because of wind and the high elevation, much of the rainfall evaporates before it can be absorbed.

The length of the growing season averages 180 days. The average date of the first frost in fall is October 19, and the average date of the last in spring is April 22. The earliest frost recorded in fall was on October 6, and the latest in spring was on May 15.

On the average, there are only 4 days a year when the temperature goes below zero. Cold spells are of short duration. Temperatures of over 90° normally occur about 60 days a year, but the heat is seldom oppressive, because of the altitude and the low humidity. Table 1 gives data on precipitation and temperature in the county for the full period for which records are available.

Rainfall.—Wide fluctuations in rainfall occur from year to year. In the past 32 years, annual rainfall has ranged from 8.62 inches to 35.98 inches. Between 1909 and 1925, the annual average was 19.7 inches, but in only 8 years between 1925 and 1957 was as much as 19.7 inches of rainfall recorded at Boise City. In 1913, 1935, and 1955, the total for the year was low; in 1915, it was high.

Apparently, a favorable or unfavorable pattern of precipitation can persist for several years. From 1914 to 1923, the average annual rainfall was 28 inches, 66 percent higher than the current normal rainfall. For the 10 years beginning in 1931, the average was only 13.1 inches, 22 percent less than the current normal. In 1931, there was still enough moisture in the soils so that 6 million bushels of wheat, the largest crop recorded up to that time, was produced. The next year the drought began to take effect, and the total yield for the next 8 years was only 3 million bushels. The 1940's were a period of relatively high rainfall and good yields, but the 1950's brought another series of dry years. In January 1956, the United States Weather Bureau estimated that the drought in Oklahoma was of a severity to be expected only once in 140 years. In each prolonged cycle of dry weather, there are a few complete crop failures.

Some idea of the probability of receiving various amounts of rain through the year and during the growing season can be gained from the data in table 2.

[1] Adapted from material prepared by WENDELL C. JOHNSON, Soil Conservation Service, Lincoln, Nebr.

TABLE 1.—*Temperature and precipitation at Boise City, Cimarron County, Okla.*

[Elevation, 4,170 feet]

Month	Temperature [1]			Precipitation [2]			
	Average	Absolute maximum	Absolute minimum	Average	Driest year (1934)	Wettest year (1919)	Average snowfall
	°F.	°F.	°F.	Inches	Inches	Inches	Inches
December	33. 9	82	−17	0. 58	[3]	0. 40	5. 5
January	33. 5	80	−20	. 30	[3]	. 30	4. 2
February	36. 7	82	−16	. 39	1. 51	1. 88	5. 0
Winter	34. 7	82	−20	1. 27	1. 51	2. 58	14. 7
March	43. 3	88	−12	. 94	. 45	3. 95	5. 5
April	52. 7	94	6	1. 42	. 23	7. 64	2. 2
May	61. 8	100	25	2. 47	. 99	3. 79	. 4
Spring	52. 6	100	−12	4. 83	1. 67	15. 38	8. 1
June	72. 3	107	35	2. 62	1. 66	4. 38	[3]
July	77. 2	108	44	2. 04	. 90	4. 37	0
August	75. 3	107	40	2. 09	1. 31	2. 00	0
Summer	74. 9	108	35	6. 75	3. 87	10. 75	[3]
September	67. 5	102	29	1. 68	1. 23	4. 51	. 1
October	55. 2	91	9	1. 57	. 04	3. 21	. 7
November	42. 9	85	−6	. 71	. 30	2. 54	4. 0
Fall	55. 2	102	−6	3. 96	1. 57	10. 26	4. 8
Year	54. 4	108	−20	16. 81	8. 62	38. 97	27. 6

[1] Average temperature based on a 46-year record, through 1954; highest and lowest temperatures on a 40-year record, through 1952.

[2] Average precipitation based on a 47-year record, through 1955; wettest and driest years based on a 42-year record, in the period 1909–55; snowfall based on a 42-year record, through 1952.

[3] Trace.

During 5 of the 48 years covered by the combined Boise City and Hurley records, more than 33 inches of rain fell. Table 2 shows that this is likely to happen only once in 15 years, or 5 times in the next 75 years. In 1918 and 1919, more than 38 inches of rain fell at the weather station. This much annual rainfall can be expected only twice in the next 80 years. During the past half-century, there have been wet periods that are not likely to be equalled in the 50 years ahead, if the pattern of rainfall is the same in the future as in the past.

High Plains farmers know that there is no way to tell just when a dry or wet period will begin or end. Many say that they farm every year as though it were going to be a dry year. Generally, they figure that the soil should be moist to a depth of 20 to 24 inches to make it worthwhile to plant wheat in the fall. A year of fallow is usually required to store this much moisture before planting time. The season between harvesting and planting is short, and the rainfall then is too scant and too ineffective to restore the moisture used by the last crop.

Wind.—The wind is an important characteristic of the climate in Cimarron County. Part of nearly every day is windy, but the peak blowing seasons are March and April and October. The wind reaches its maximum velocity in the afternoon and dies down at night. The yearly average wind velocity is 16 miles per hour at 3:00 p.m. and only 6 miles per hour between 6:00 a.m. and 3:00 p.m. The spring blowing season follows the two driest months of the year. In dry years, there can be serious damage to the soil and to the wheat crop.

The air flow across the High Plains has definite trends, which differ from winter to summer. In January, dry winds move easterly from the Rocky Mountains and blow across Cimarron County from the southwest. From April through October, moisture-bearing southerly winds blow from the Gulf of Mexico. During the summer of a drought year, the flow of air in the county is from the west, much as in winter. Because it is of continental origin, this air bears little moisture. This was true in the summer of 1934, the driest summer on record, when only 8.62 inches of rain fell.

During dry years, excessive heating of bare soil causes the winds to be abnormally strong and gusty. At such times the soil is very likely to be damaged by blowing, if it is not cloddy and if, because of crop failures, it lacks a good cover of crop residues. During the 1930's there were numerous severe dust storms. On April 14, 1935, the weather observer at Kenton reported zero visibility and midnight darkness at 4:20 p.m., because of dust. In 1936 and again in 1956, the wind erosion hazard was severe to very severe. During the drought of the 1950's, dust storms developed on only a few days. The measures taken by the farmers to control wind erosion are credited with preventing "dusters" like those of the mid thirties.

TABLE 2.—*Probable amounts of precipitation (based on U.S. Weather Bureau records from Hurley and Boise City, 1909–1955)*

Period	Inches (or more) precipitation to be expected 1 year in—						Inches (or less) precipitation to be expected 1 year in—		
	2	3	4	5	10	15	3	4	5
Year	18. 40	21. 60	23. 60	25. 10	29. 60	33. 20	15. 60	14. 20	13. 40
June (wettest spring month)	2. 45	3. 30	[1] 3. 85	4. 30	5. 45	6. 10	1. 75	[1] 1. 35	1. 15
October (wettest fall month)	1. 25	2. 05	2. 55	2. 90	4. 00	4. 60	. 60	. 25	. 05

[1] For example, in 1 year out of 4 there will be 3.85 inches or more of rain in June, and in 1 year out of 4 there will be only 1.35 inches or less in June.

Climate and wheat production

Through the years, wheat has become the major crop in Cimarron County. Yields per acre have ranged from 19.4 bushels in 1931 to practically nothing in 1935, 1937, 1938, 1950, 1953, and 1956. In only one year (1952) during the dry early and mid fifties did yields go above 3.3 bushels per acre.

Yields are adversely influenced by a variety of factors, including drought, very cold weather, diseases, insects, high winds, and hail. These occur in such a variety of combinations that it is hard to find a direct connection between climatic variations and yields. Rainfall seems to have the greatest influence, but results obtained by using data from a single weather station are not reliable because conditions at the station may not be typical of the county.

The proportion of the total acreage in wheat and the proportion left fallow vary each year, depending on rainfall. In 1949, a good year, only 25 percent as many acres were fallow as were in wheat, but in 1954, a dry year, a larger acreage was fallow than was planted to wheat.

Climate and sorghum production

Experiments made at the field station in Dalhart, Tex., have shown that, on soils like those on which sorghum is grown in Cimarron County, yields are closely related to the amount of available moisture in the soil at planting time. During August, the critical month for sorghum, about 0.15 inch of water per day is needed to insure good yields. On the experimental plots at the field station, yields increased 2.18 bushels for each inch of July rainfall.

At the Southern Great Plains Field Station at Woodward, Okla., yields of milo grain were found to be closely related to the rainfall, evaporation, and relative humidity during July and August. Milo needs 0.12 to 0.15 inch of water per day to mature a good crop. Since the sandy soils on which this crop is commonly grown do not store much moisture, rainfall in July and August is especially important. The fact that, in 1 year out of 5, the total rainfall during these two months will probably be only 2.45 inches or less explains why yields of sorghum are erratic.

Water Supply

In parts of Cimarron County, there is an abundant supply of underground water at depths of 50 to 350 feet. In other places, where red beds are relatively near the surface, there is scarcely enough water for domestic use. Many farmers depend on runoff water caught in tanks to water their livestock.

Except for spring-fed Cold Springs Creek, the streams are generally erratic in flow and not dependable. In the river bottoms, however, enough shallow underground water for domestic use and limited irrigation is found. Springs furnish water in some places, but they usually go dry in droughts.

Farmers get most of their water for farm use from wells and stock tanks. Pumps are generally powered by windmills. Water for the towns of Boise City, Felt, and Keyes is also obtained from wells. All of the well water is suitable for drinking.

Irrigation water is obtained from wells or from storage tanks that catch floodwater from the Cimarron River. The pumping capacity of the wells varies from 200 to 1,200 gallons per minute. Only locally is well water unfit for irrigation.

Wildlife

Some of the early settlers recall the days when Cimarron County had large herds of buffalo, antelope, and deer, and flocks of wild turkeys and prairie chickens. Now, there are mule deer in the Kenton area, small herds of antelope, and several flocks of wild turkeys and ring-necked pheasants. The long-billed curlew breeds here in considerable numbers. Waterfowl of many species are common in the vicinity of playa lakes and farm and ranch ponds during the spring and fall migration periods. Cimarron County supports a larger population of blue (scaled) quail than any other county in the State. A few bobwhite quail are found, mostly along the river bottoms.

The pinyon- and juniper-covered mesas near Kenton support a distinctive bird fauna characteristic of the Rocky Mountains and more westerly areas. It includes golden eagles, magpies, house finches, woodhouse's jays, pinyon jays, green-tailed towhees, brown towhees, curved-billed thrashers, and many other western species that are not common in other parts of Oklahoma.

Coyotes, bobcats, badgers, spotted skunks, striped skunks, raccoons, porcupines, gray foxes, and kit foxes are found in varying numbers. Cottontail rabbits, jackrabbits, and prairie dogs are also fairly abundant. A few sunfish, minnows, and catfish live in the small perennial streams.

The large farms and ranches, the many abandoned farmsteads, and the sparse human population are all favorable for wildlife. Farm ponds have improved the distribution of watering sources. Increased irrigation is providing additional cover and food for pheasants and quail. Field borders and irrigation ditches make excellent travel lanes and nesting areas. Much of the sandy area along the Cimarron River is especially adapted to wildlife. It is State owned and eventually may be turned into a small State park or wildlife refuge.

To improve the environment for wildlife, more food and cover are needed, particularly for blue quail and pheasants, which now resort to hiding and nesting in old car bodies and abandoned farm implements.

Studies of habitat requirements and management practices are being conducted in the county by the Oklahoma Cooperative Wildlife Research Unit. The Oklahoma Game and Fish Department is assisting with a program of restoring and restocking wildlife habitats.

Agriculture

Ranching was the earliest type of agriculture in Cimarron County. Possibly, cattle first moved in along the old Santa Fe Trail, which entered the county near Mexhoma and followed the Cimarron River out at the northeastern corner. In 1885 the first settlers moved in and began to break out the bottom lands along the Cimarron River and its tributaries. They grew alfalfa, corn, and feed crops, which were irrigated with water taken from the river.

Actual filing for homesteads began in 1905 and continued until November 1907, the date Oklahoma became a State. Land was later acquired by settlers through two State land sales. The first was in September and October 1913, and the second was in May 1916.

Settlers on uplands began to break out their claims in 1906 and continued until 1913. They were required to cultivate 40 acres of each quarter section. Between 1906 and 1913, many settlers became dissatisfied, sold their equity, and left Cimarron County. Little or no more land was cultivated until 1925, the year the Santa Fe Railroad built its line across Cimarron County, passing through Boise City. A few years later, when the tractor began to take the place of the horse and mule, farmers again put new land into use. The total acreage cultivated at the end of the 1930's was about the same as the acreage now in crops—approximately 440,000 acres.

Crops

The first crops grown on uplands were grain sorghums, broomcorn, corn, and pinto beans. The first wheat grown in Cimarron County was planted in 1909. The average yield in that year was 19 bushels per acre. The major crops now grown in the county are wheat and grain sorghums (table 3). Lesser acreages are in broomcorn, millet, sudangrass, alfalfa, and corn.

TABLE 3.—*Acreage of principal crops in stated years*

Crop	1929	1939	1949	1954
	Acres	*Acres*	*Acres*	*Acres*
Wheat (threshed)	175, 903	60, 467	243, 353	92, 092
Sorghum for grain	27, 438	41, 188	88, 529	100, 159
Sorghum for forage	12, 901	17, 742	10. 968	19, 816

Livestock

Livestock production has been of great importance throughout the history of the county. It began about 1865, when large numbers of sheep were run in the county. During the next 15 years, cattle ranchers displaced the sheep ranchers. Many of the cattle ranchers were, in turn, displaced by homesteaders who began to take up land in the county in 1890. At present about 650,000 acres in the county is used for range, compared to about 440,000 acres that is cultivated.

Beef cattle are the most important class of livestock raised (table 4). The principal breed is Hereford.

There are about 50 ranches and about 50 ranch-and-farm units that are classed as livestock farms. The ranches are up to 40,000 acres in size. Most of them are stocked with grade Herefords of good quality. The general practice is to sell the calves at weaning time. The cows are fed a protein supplement in the winter. Hay is not needed unless there is snow or unless the range is heavily grazed. On many of the livestock farms there are herds of purebred beef cattle. Operators of these units often use steers to graze wheat in the winter.

TABLE 4.—*Number of livestock on farms in stated years*

Livestock	1940	1950	1954
Cattle and calves	[1] 14, 876	35, 077	39, 323
Hogs and pigs	[2] 1, 166	1, 855	1, 016
Horses and mules	[1] 1, 263	902	524
Sheep and lambs	[3] 2, 234	133	9, 111
Chickens	[2] 36, 586	[2] 31, 175	[2] 23, 422

[1] Over 3 months old.
[2] Over 4 months old.
[3] Over 6 months old.

Ranchers who have kept the range moderately grazed over the years have not had to make large reductions in their breeding herds during droughts and have maintained reasonably well their calf crop percentage and weights. In contrast, on heavily grazed ranges the calf crop has decreased and weaning weights have dropped substantially. Also, much supplemental feed is needed.

Farm Tenure and Operation

In 1954 there were 559 farms in Cimarron County. The average size, including farms and ranches, was 1,962.8 acres; most units are more than 1,000 acres in size.

There were 407 farms operated by owners and part owners and 149 farms operated by tenants. There were 3 farms operated by managers. Of the tenants, 109 were share tenants, 19 were share-cash tenants, and 16 were cash tenants.

Under the most common system of rental, the landowner gets one-third of the wheat and one-fourth of the sorghum grain. The landlord furnishes the land, and the tenant furnishes the labor and farm equipment.

Under a share-cropping lease, the landowner furnishes the land, the farm equipment, and one-half of the seed and gets in return one-half of the produce. The farmer does about three-fourths of the work himself and hires other help, as needed, during the seeding and the harvesting seasons.

Normally, labor is plentiful at all times of the year. Laborers usually are paid by the hour. Foremen are usually hired by the month and furnished with a modern house, fuel, a car or pickup, and gasoline.

Soil Survey Methods and Definitions

The scientist who makes a soil survey examines soils in the field and, according to his observations, maps the boundaries of each soil on an aerial photograph or other map.

FIELD STUDY.—The soil scientist bores or digs many holes to see what the soils are like. The holes are spaced irregularly, depending on the lay of the land. Usually they are not more than a quarter of a mile apart, and in many areas they are much closer together. In most soils each boring, hole, or pit reveals several layers, called horizons, which collectively are known as the soil profile. The profile is studied to see how the horizons differ from one another and to learn the things about the soil that influence its capacity to support plants.

Color is usually related to the amount of organic matter. The darker the surface soil, as a rule, the more organic matter it contains. Color is also a clue to the natural drainage conditions. A bright brown subsoil is evidence of good drainage and aeration. Streaks and spots of gray, yellow, and brown show that the soil has a high water table for much of the year and has poor drainage and aeration. A bluish-gray subsoil is characteristic of soils that are waterlogged or covered by water most of the year.

Texture, or the content of sand, silt, and clay, is determined by the way the soil feels when rubbed between the fingers and by laboratory analysis. Texture determines how well the soil retains moisture, plant nutrients, and fertilizer, and whether it is easy or difficult to cultivate.

Structure, which is the way the individual soil particles are arranged in aggregates and the amount of pore space between aggregates, gives clues to the ease or difficulty with which the soil is penetrated by plant roots and by moisture. Soil particles are not ordinarily evenly distributed. Channels have been formed by roots and earthworms, and cracks appear when the soils shrink and swell upon drying and wetting. Thus, the soils are a network of channels filled with air, roots, and water, bounded by the irregular surfaces of the soil particles.

Consistence, or the tendency of the soil to crumble or to stick together, indicates whether it is easy or difficult to keep the soil open and porous under cultivation.

Other characteristics observed in the course of the field survey and considered in study of the soil include the following: The depth of the soil over bedrock or compact layers, the presence of gravel or stones in amounts that will interfere with cultivation, the steepness and pattern of slopes, the degree of erosion, the nature of the parent material from which the soil has developed, and the acidity or alkalinity of the soil as measured by chemical tests.

CORRELATION.—On the basis of the characteristics observed by the soil scientist or determined by laboratory tests, soils are correlated by series, types, and phases.

Soil series.—Soils similar in kind, thickness, and arrangement of layers are normally designated as a soil series. In a given area, a soil series may be represented by only one soil.

Soil type.—Within a series, there may be one or more soil types. The types are differentiated by the texture of the surface layer.

Soil phase.—Soil types are divided into phases because of differences in slope, degree of erosion, or depth of soil over the substratum. The phase (or the type, if it has not been subdivided) is the unit shown on the soil map. It is the unit that has the narrowest range of characteristics. Use and management suggestions, therefore, can be more specific than for soil series or for yet broader groups that contain more variation.

Miscellaneous land types.—Certain types of land are not classified by soil types and series. They are called miscellaneous land types instead of soils and are identified by descriptive names. The only land type in Cimarron County is Rough stony land.

Soil complex.—Two or more kinds of soil that are so closely associated geographically that it is impractical to show them separately on the soil map may be mapped as a single unit and called a complex.

Soil Associations

The five soil associations in Cimarron County are shown on a colored map in the back of this report. Each association is described in the following pages. Figures 2 and 3 show the positions of the soil associations on typical landscapes.

ASSOCIATION 1

Hardlands: Richfield-Portales

The hardlands association occupies large areas on the plain north and east of Boise City, between the Cimarron and the North Canadian Rivers. There is a small area in the southwestern part of the county. This association comprises about 25 percent of the county. The underlying materials are the Ogallala formation and recent loess. The topography is smooth, except for local low humps and shallow basins. Farmers call the hardlands wheat soils.

Richfield clay loam and Richfield loam are the dominant soils in this association. Portales clay loam occupies slight elevations on the plain and the gentle rims around playas or former lakebeds. Near drainageways and along the edges of the sandy plains association, there are inextensive areas of shallow Mansker soils, deeper Dalhart soils, and Richfield fine sandy loam. The soil in the old lakebeds is Randall clay.

The soils and their relations.—Richfield clay loam has 3 to 5 inches of dark-colored, granular surface soil, which grades to coarse granular silty clay loam or light clay. The subsoil becomes browner, lighter colored, and calcareous at depths of 12 to 18 inches. The substratum is pale-brown, floury, highly calcareous, light silty clay loam. Richfield loam is similar, but it has more sand in the surface soil and subsoil. While the Richfield soils are predominantly level, about a tenth of the acreage—the part that borders drainageways and playas—is very gently sloping and has some hazard of water erosion.

Portales clay loam is also dark colored, but it has a less clayey subsoil than the Richfield soils. Its calcareous, dark-brown surface soil is 10 or 12 inches deep over pale-brown, calcareous clay loam, which grades to a nearly white lime layer at depths of 24 to 30 inches. The substratum is pale-brown to reddish-yellow clay loam. Most areas have nearly level, slightly convex slopes that drain well and have more runoff than the Richfield soils. Areas on low swells or on the borders of playas are gently sloping. In these places, caliche fragments are scattered on the surface, the soil is slightly lighter colored than in the nearly level areas, and the lime layer is nearer the surface.

In some parts of the hardlands association, Mansker loam and Dalhart fine sandy loam are mixed together. Mansker loam is a shallow, limy soil. Dalhart fine sandy loam is deeper and more leached and has a subsoil of sandy clay loam. These soils absorb water faster but store less of it than Richfield and Portales soils.

Randall clay is found in the bottoms of playas (intermittent lakes). The characteristics of this soil vary widely from place to place. The color is generally grayish. Most of the acreage is in weeds or grass. Some is cultivated when dry.

Use of soils.—About four-fifths of the hardlands association is cultivated. The soils are mostly deep and well

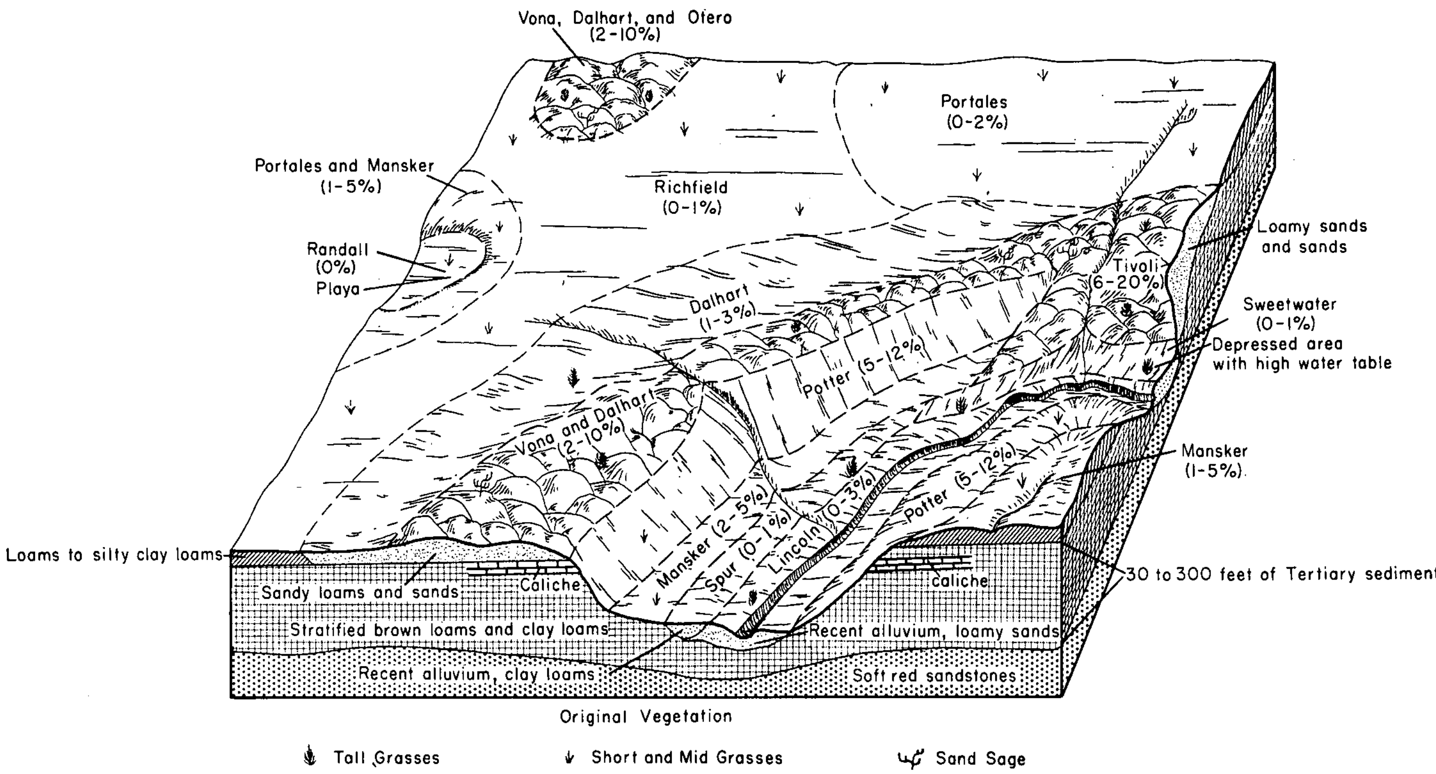

Figure 2.—Typical landscape in the central and eastern part of Cimarron County: Associations 1, 2, 3, and 5.

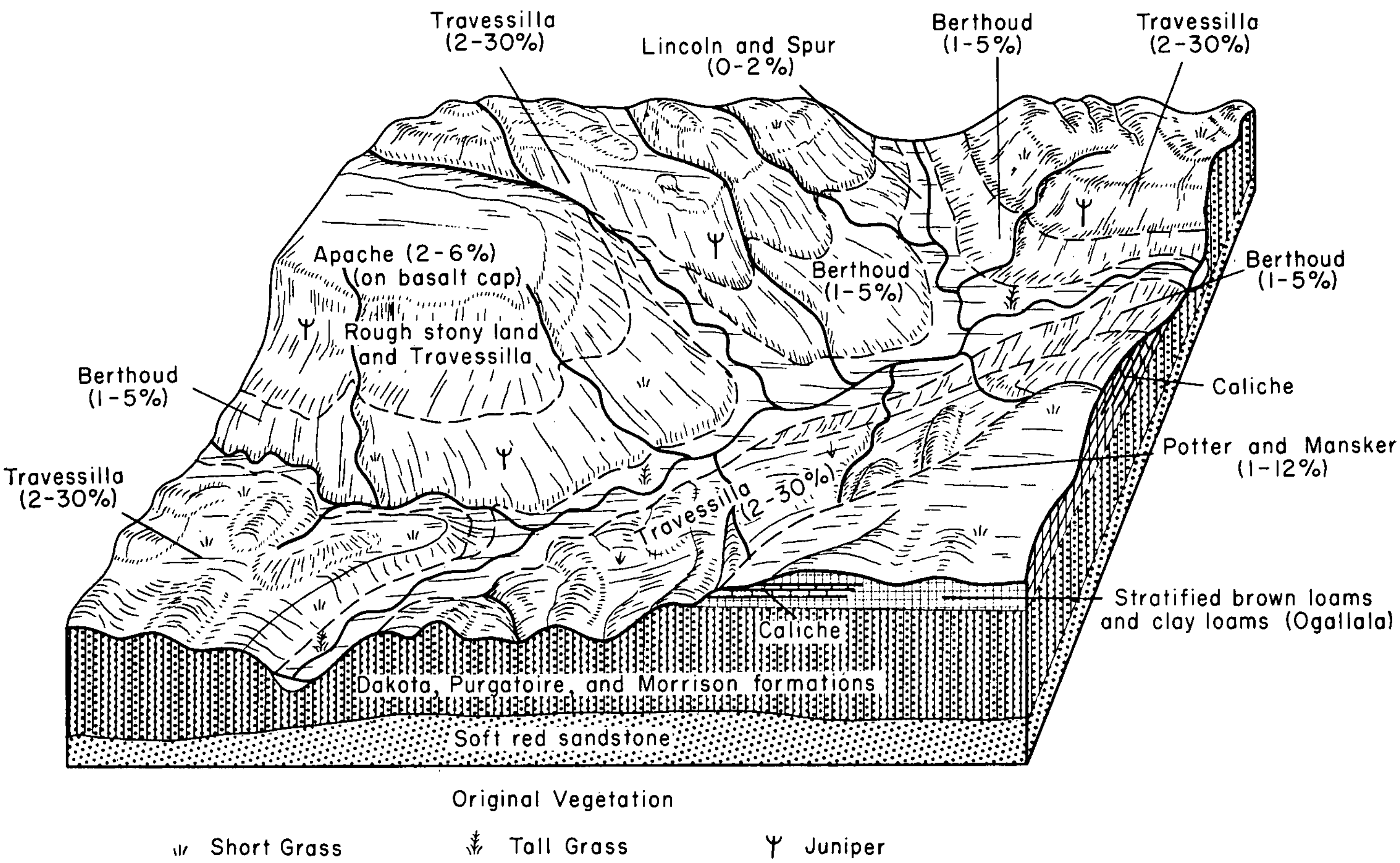

Figure 3.—Typical landscape is the northwestern part of Cimarron County: Associations 3, 4, and 5.

supplied with plant nutrients. They produce as good yields of wheat as any soils in the county. Heavy farm machinery can be used. Grain sorghum is grown only on the sandiest soils in the association, and much of it is grown under irrigation.

A rainfall of less than half an inch does not have much effect during the growing season, but, if there is a heavy rainfall, part of the water is lost through runoff because the soils are slowly permeable. Continued cultivation causes these soils to crust. In dry seasons, wind erosion is a hazard.

Much of the range in this association is overgrazed. The vegetation is principally buffalograss and grama. These soils are likely to compact under heavy grazing.

Most of the drilled water wells in the county are in the soils of this association.

ASSOCIATION 2

Sandy plains: Dalhart-Vona

The sandy plains association occupies a large area south and west of Boise City, on both sides of the North Canadian River, and two smaller areas near the Cimarron River in the northeastern part of the county. It comprises about 41 percent of the county. The soils in this association developed from Quaternary sand that was deposited by the rivers and later reworked by wind. The relief is gently undulating to hummocky, with low dunes here and there.

Dalhart fine sandy loams occur on very slightly undulating terrain in this association, Dalhart loamy fine sands on gently undulating or slight hummocky terrain, and Vona, Tivoli, and Otero loamy fine sands on hummocky to duny landscapes. The Dalhart, Vona, and Otero soils have retentive subsoils; the Tivoli has a coarse, open subsoil. A few small areas of Richfield fine sandy loam are found near the boundary between this association and the hardlands association.

The soils and their relations.—Dalhart fine sandy loam has 8 to 16 inches of dark-brown surface soil. The subsoil is brownish, generally nonlimy sandy clay loam. The substratum is pale-brown, calcareous loam. In Dalhart loamy fine sand, the depth to lime is greater and the subsoil is clayey enough to hold moisture. Otero loamy fine sand is limy to the surface. It has a lighter colored subsoil than Dalhart loamy fine sand and has a gray substratum. Vona loamy fine sand has 6 to 10 inches of brown surface soil. The subsoil is yellowish-brown sandy loam but contains enough clay so that it retains a little moisture. The substratum is very sandy. There is no lime zone, and the soil is about neutral throughout. Tivoli loamy fine sand is nonlimy. The upper few inches are slightly darkened, and the subsoil does not retain moisture. A few active dunes are included. Richfield fine sandy loam has a more clayey subsoil than Dalhart fine sandy loam.

Use of soils.—The Dalhart and Richfield soils in this association are the most drought-resistant soils in Cimarron County. They are the soils most extensively used for growing summer crops. About 45 percent of the acreage is cultivated. Grain sorghums and broomcorn are the main crops. Wheat, millet, and sudangrass are also grown. Crop failures are infrequent, and production costs are low. Smooth areas are well suited to irrigation. The soils are fertile enough to produce good yields of dryland crops but may need some fertilizer if used for irrigated crops. Large or medium-sized farm equipment can be used. Wind erosion is the main hazard.

The Vona, Tivoli, and Otero soils are too sandy and too irregular in topography to be good for crops. Some areas once cultivated are now in grass or weeds.

Although much of the range in this association is overgrazed, it still produces more forage than any other upland range in the county. On the fine sandy loams, the range plants are blue grama, buffalograss, some dropseed, and some sand bluestem. On the loamy fine sands, the cover is largely sand sagebrush, grama, and sand dropseed. Bluestem grows in lightly grazed spots.

ASSOCIATION 3

Breaks and shallow caliche soils: Mansker-Potter

This association occupies separate areas in many parts of the county. It occurs near Beaver Creek in the east-central part of the county, along the North Canadian River in the southeastern part, next to Aqua Frio Creek in the southwestern part, and on the breaks above the Cimarron River in the northeastern and north-central parts. The association comprises 15 percent of the county. The soils developed from Ogallala loams and gravels overlain with Quaternary sand. The topography is rolling to broken or, next to the sandy bottom lands, undulating to duny. Foot slopes below the general level of the hardlands (association 1) are also included.

The Mansker-Potter complex and the Potter-Mansker loams are steep and stony. Mansker loam, Mansker fine sandy loam, and the Mansker-Dalhart loams are on the foot slopes and the irregular plains.

The soils and their relations.—The Potter soils are very shallow, very limy soils that overlie caliche. They are no more than about 10 inches thick. The surface soil is clay loam or stony clay loam. It rests on the hardened, nearly white caliche.

The Mansker soils are also limy. They have a surface soil of grayish-brown or brown loam or fine sandy loam that becomes paler in color at depths of 6 to 8 inches and grades to nearly white chalky silt loam at depths of 12 to 20 inches. They are less deep to the lime layer and more droughty than the Portales soils of the hardlands association.

The Dalhart soils are deeper than the Potter and Mansker soils. They occur near the drainageways, where sediments blown from the sandy bottom lands of association 5 have collected. They are darker colored and less limy than the Mansker soils, with which they are intermixed, and have a retentive subsoil of sandy clay loam. Mansker fine sandy loam is found in transition zones between Dalhart and Mansker loams.

Use of soils.—About a third of the acreage of the more nearly level Mansker loams and Mansker-Dalhart loams is used for wheat or maize (grain sorghum). Yields are generally low. Wind erosion is a constant hazard, and loss of water is serious on slopes of more than 1 percent.

Most of this association is used for range. Many of the smooth areas are overgrazed, but the steeper and less accessible areas have a better cover of grasses. The principal range plants are buffalograss, grama, and sand dropseed. The sandy soils produce the most forage.

ASSOCIATION 4

Stony breaks on hard rock along the Cimarron River: Travessilla-Berthoud

This association is in the northwestern part of the county. It extends from the New Mexico border to a point north of Boise City. It consists of shallow soils and exposed sandstone and shale bedrock of the Dakota and Morrison formations. The association comprises 17 percent of the county. The topography is generally hilly, and there are many knobs, canyons, and mesas. Black Mesa, which is near Kenton, has a cap of basaltic lava. The deepest soils in this association are on the foot slopes below the knobs, ridges, and mesas.

The stony breaks association is dominated by Rough stony land, which is mostly bare rocks, and by the following shallow or very shallow soils: Travessilla stony loam, Carnero loam, Apache stony clay loam, and Vernon clay loam. The soils on the foot slopes are Berthoud loam and Berthoud fine sandy loam.

The soils and their relations.—Rough stony land occupies short steep escarpments on the sides of mesas and canyons and on the sandstone knobs that are common near Kenton. Generally the slopes are very steep, and there is little or no soil.

Travessilla stony loam is light brown. The upper part of it contains many sandstone fragments. Weathered sandstone underlies this soil at depths of 8 to 18 inches.

The Carnero soil occupies smooth ridgetops and is surrounded by Travessilla stony loam. It has a brown, limy surface soil and a paler brown loam subsoil, which grades to brown sandstone at depths of 18 to 30 inches.

Apache stony clay loam is on the gently sloping top of Black Mesa. It has a brown, limy surface layer that grades to pale-brown clay loam. Fractured basalt occurs at depths of 15 to 20 inches.

Berthoud loam has formed in rather deep colluvium on foot slopes below areas of Rough stony land and Travessilla soils. It consists of brown, limy loam over brown clay loam. Berthoud fine sandy loam is similar but is sandier throughout.

The Vernon soil has a surface layer of shallow, limy, brown clay loam over reddish-brown clay and clay loam. It overlies sandstones and red, clayey shales. It occurs on foot slopes and around the edges of canyons. Many of the areas are fairly smooth.

Use of soils.—This association is an area of large ranches. Most of the acreage is used for range. A little of the gently sloping Berthoud soil is used to grow feed crops. A few areas on the bottom lands are irrigated and planted to alfalfa.

Grama and buffalograss are the principal range plants. On the stony soils there is some cane bluestem and silver bluestem. The range is in somewhat better condition in this sparsely settled area than in the associations that are mostly cropland.

ASSOCIATION 5

Bottom lands: Spur-Lincoln

The bottom-lands association consists of areas of recent alluvium on the flood plains of streams. The broadest areas are those along the Cimarron River and its tributaries, in the northern part of the county. The strips along the North Canadian River merge with the hummocky Vona and Tivoli soils and are so narrow that they cannot be shown on the soil association map. Narrow bands of bottom-land soils also are found along Beaver Creek and along shallow drains in the hardlands. This association comprises less than 2 percent of the county.

The association is dominated by the Spur soils, the Lincoln soils, and Sweetwater fine sandy loam. The Spur soils are along streams that drain the hardlands and the breaks, the Lincoln soils are along streams that drain the sandy plains, and the Sweetwater soil is along the Cimarron River.

The soils and their relations.—The Spur soils are limy, dark-brown loams and clay loams to a depth of 2 or 3 feet. The clay loams are the more extensive and are on smoother topography. There are smaller areas of loams and fine sandy loams, many of which are on natural dikes close to stream channels.

The Lincoln soils are light-brown, limy, loose, stratified soils, mostly loamy sands but including some sandy loams and clay loams. The topography is irregular. Many areas have a slightly wavy surface, with the coarsest materials at the crests of the waves. Some areas have been reworked by wind.

The Sweetwater soil is gray to brown fine sandy loam and loam stratified with loam, clay loam, and loamy sand. Generally this soil is high in organic matter. It is limy and, in poorly drained spots, saline. In many places the water table is only 36 inches below the surface.

Use of soils.—About one-third of the Spur soils is cultivated, mostly to irrigated alfalfa, grain sorghums, and corn. Many areas are narrow or of irregular shape and are not well suited to cultivation.

The Lincoln and Sweetwater soils are used almost entirely for range. The Lincoln soils are too sandy to be suited to crops. The Sweetwater soil is often flooded long enough to interfere with cropping, but it is the most productive rangeland in the county.

Descriptions of the Soils

As farmers and ranchers, you are familiar in a general way with the many different kinds of soils on your farm. Experience has taught you many things about your soils. You can point out the places that drain slowly, the fields that drift badly, the limy spots where crops may become yellow and stunted, the soils that have tight subsoils, and the slopes where runoff is great and soils dry out quickly. This report can help each landowner to understand his soils better. It also suggests ways to manage the soils so as to reduce erosion, soil crusting, and blowing-out of young crops.

Brief descriptions of the soils in Cimarron County appear on the following pages. Technical terms used in the descriptions are defined in the glossary. Table 5 gives the approximate acreage and proportionate extent of each of the soils described.

Apache stony clay loam (Aa).—This is a shallow, gently sloping soil that occurs on top of Black Mesa. It developed from weathered olivine basalt. It has a grayish-brown, limy surface soil and a pale-brown, limy clay loam subsoil. The subsoil grades to basaltic lava at

TABLE 5.—*Approximate acreage and proportionate extent of soils*

Soil	Acres	Percent
Apache stony clay loam	904	0. 1
Berthoud fine sandy loam, 2 to 5 percent slopes	6, 856	. 6
Berthoud loam, 0 to 3 percent slopes	6, 999	. 6
Berthoud loam, 3 to 5 percent slopes	48, 898	4. 2
Carnero loam	5, 353	. 5
Dalhart fine sandy loam, 0 to 1 percent slopes	81, 540	6. 9
Dalhart fine sandy loam, 1 to 3 percent slopes	50, 299	4. 3
Dalhart fine sandy loam, 0 to 3 percent slopes, eroded	21, 394	1. 8
Dalhart loamy fine sand, 0 to 3 percent slopes	132, 764	11. 3
Dalhart loamy fine sand, 0 to 3 percent slopes, eroded	7, 707	. 7
Lincoln soils	15, 622	1. 3
Mansker fine sandy loam, 2 to 5 percent slopes	27, 774	2. 4
Mansker loam, 0 to 3 percent slopes	33, 878	2. 9
Mansker loam, 3 to 5 percent slopes	46, 080	3. 9
Mansker-Dalhart loams, 1 to 3 percent slopes	71, 234	6. 1
Mansker-Potter complex, 3 to 12 percent slopes	36, 222	3. 1
Otero loamy fine sand	15, 951	1. 4
Portales clay loam, 0 to 1 percent slopes	39, 824	3. 4
Portales clay loam, 1 to 2 percent slopes	28, 338	2. 4
Potter-Mansker loams, 1 to 3 percent slopes	12, 405	1. 1
Randall clay	3, 891	. 3
Richfield clay loam, 0 to 1 percent slopes	189, 345	16. 1
Richfield clay loam, 1 to 2 percent slopes	3, 927	. 3
Richfield fine sandy loam, 0 to 1 percent slopes	4, 895	. 4
Richfield loam, 0 to 1 percent slopes	81, 089	6. 9
Rough stony land	47, 500	4. 0
Spur soils	19, 747	1. 7
Sweetwater fine sandy loam	1, 349	. 1
Travessilla stony loam	58, 935	5. 0
Vernon clay loam	2, 127	. 2
Vona-Tivoli loamy fine sands	68, 991	5. 9
Water	642	. 1
Total	1, 172, 480	100. 0

depths of 15 to 20 inches. There are stones throughout the profile. The slope range is 0 to 1 percent.

This soil is used for and is suitable only for range. The range generally is in good to fair condition. The native cover consists of side-oats grama, blue grama, buffalograss, and other grasses.

The main problems are maintaining the better grasses and keeping all grasses grazed uniformly. There is a moderate tendency for this soil to blow if the range is badly overgrazed. (Capability unit VIs–1; stony loam range site.)

Berthoud fine sandy loam, 2 to 5 percent slopes (Ba).—This soil is in the northwestern part of the county. It occurs on foot slopes in the stony breaks along the Cimarron River. Shallow sandstone soils lie just above it on the foot slopes. It is also associated with the Berthoud loams.

This soil is deep and permeable. It has a brown surface layer underlain by yellowish-brown, heavy fine sandy loam that is limy at a depth of about a foot. A still deeper layer of light brownish-gray or light yellowish-brown, friable sandy clay loam contains lime and many sandstone fragments at depths of more than 30 inches.

This soil is best suited to range. It is fairly productive, but many areas are overgrazed. The native vegetation consists of grama and some yucca.

Wind erosion is a serious hazard on overgrazed range. Unless the soil is covered, runoff from adjacent higher areas makes water erosion a problem. (Capability unit VIe–1; sandy plains range site.)

Berthoud loam, 0 to 3 percent slopes (Bb).—This soil occurs at the base of long foot slopes, below areas of shallow sandstone soils. It is located along the Cimarron River in the northwestern part of Cimarron County.

This is a deep, permeable soil. It has an 8- to 10-inch surface layer of dark grayish-brown granular loam. The subsoil is limy, light brownish-gray, granular clay loam and reaches a depth of 3 or 4 feet. Fragments of sandstone occur in places.

Most of this soil is in range, to which it is well suited. Some of the gently sloping areas are cropped successfully to wheat, alfalfa, and grain sorghums.

Much water is lost by runoff on the long slopes. Diversion ditches may be needed to protect fields used for crops. There is a moderate hazard of wind erosion on overgrazed or cultivated areas. Cultivated areas may also be damaged by water erosion. (Capability unit IVe–1; hardland range site.)

Berthoud loam, 3 to 5 percent slopes (Bc).—This is a deep, permeable soil that occurs near Berthoud loam, 0 to 3 percent slopes, in the northwestern part of the county.

The dark grayish-brown, granular surface soil is 6 to 8 inches deep. It grades to light brownish-gray, granular, very limy clay loam, which extends to a depth of several feet. Fragments of sandstone occur in places.

Most of this soil is in range consisting of side-oats grama, blue grama, and buffalograss. A few very small areas are cropped to wheat and maize (grain sorghum).

Much water is lost through runoff on these slopes. A good cover of grasses helps to reduce this loss. Diversions are needed above any area used for crops. Severe wind and water erosion are likely on unprotected cropland and overgrazed range. The most serious problem is to keep the range evenly grazed. (Capability unit VIe–1; hardland range site.)

Carnero loam (Ca).—This soil occurs in the stony hardrock breaks along the Cimarron River in the northwestern part of the county. It is on the tops of ridges and mesas, above the shallow Travessilla soil. It has convex slopes of 1 or 2 percent.

The surface layer is brown and is about 8 inches thick. It is underlain by light yellowish-brown, granular clay loam, which is limy at a depth of 16 inches and below and contains numerous sandstone fragments and lime concretions. Light-brown, hard, limy sandstone generally occurs at a depth of about 30 inches.

This soil is not well suited to crops. Most of it is used for range, which is productive if well managed. Side-oats grama and blue grama are the most common grasses. Some bluestem grows in lightly grazed places.

There is a moderate hazard of wind or water erosion if the range is overgrazed. Keeping the grasses uniformly grazed is a problem. (Capability unit VIe–1; hardland range site.)

Dalhart fine sandy loam, 0 to 1 percent slopes (Da).—This soil occurs in the sandy plains in the southern and

Figure 4.—**Thick, tall sorghum stubble protects Dalhart fine sandy loam, 0 to 1 percent slopes, from damage by wind erosion.**

northeastern parts of the county, usually near Dalhart loamy fine sands.

This is a deep, permeable soil that has a good capacity to store moisture. It is brown at the surface but is usually darker colored below plow depth. The subsoil of dark-brown, granular sandy clay loam or light sandy clay loam begins at a depth of 8 to 10 inches. It is limy at depths of 15 to 20 inches and below. The substratum is pale-brown, very limy sandy clay loam. It contains some concretions of calcium carbonate. A buried soil that is dark colored and loamy is found in many places at depths of 30 inches or more.

Nearly half of this soil is in crops, mainly grain sorghums and broomcorn. Yields are good, and crop failures are uncommon. Some of the cropland is irrigated. Yields are materially increased by irrigation.

The range is mostly grama, but some bluestem grows in lightly grazed areas. Buffalograss and yucca invade when the range is overgrazed.

Careful management is needed to protect this soil from damage by wind erosion (figs. 4 and 5). The wind has already winnowed the fine particles from the surface soil. This has not permanently impaired the value of the soil, but it does make the soil blow more easily. (Capability unit IIIe-1; sandy plains range site.)

Dalhart fine sandy loam, 1 to 3 percent slopes (Db).—This soil occurs in gently undulating areas on the sandy plains. Most of it has slopes of 1 or 2 percent; only about 15 percent of the acreage has slopes of 3 percent.

The surface layer of this soil is slightly lighter colored than that of Dalhart fine sandy loam, 0 to 1 percent slopes. It is also coarser textured, because more of the fine particles have been removed by the wind.

Nearly half of this soil is in crops, mainly grain sorghums and broomcorn. Yields of summer crops are usually good. Some of the cropland is irrigated by sprinkler systems. The border method of irrigating is usually not practical because it would require extensive leveling.

The native range is mostly in grama. Some bluestem grows in lightly grazed areas, and some buffalograss and yucca grow in the more heavily grazed places.

Water erosion can occur on the steepest areas of this soil, but since there are no long slopes, it does not do serious damage. Terracing is not practical. Wind erosion is by far the most serious hazard. Careful soil management is needed to keep the soil from blowing. (Capability unit IIIe-1; sandy plains range site.)

Dalhart fine sandy loam, 0 to 3 percent slopes, eroded (Dc).—The surface of this soil is humpy. It is scarred with blowouts and has low dunes where the blown-out soil material has collected. In many places the surface soil is almost as coarse as a loamy fine sand, either because of winnowing or because of deposition of material blown from areas of Dalhart loamy fine sands.

Range is the best long-term use for most of this soil. It is hard to get a good stand of row crops on the blown-out areas, and drifting soil may harm young seedlings. Nevertheless, about two-thirds of the acreage is still used for grain sorghums and broomcorn. Yields are generally lower than on the uneroded Dalhart soils. Crop residues should be left on the surface, to protect the soil and to help the native grasses to become reestablished. Most idle areas are weedy, but some of the blowouts and higher dunes are bare. (Capability unit IVe-2; sandy plains range site.)

Dalhart loamy fine sand, 0 to 3 percent slopes (Dd).—This soil occupies very gently undulating to billowy parts of the sandy plains in the southern and northeastern parts of Cimarron County. It is associated with Dalhart fine sandy loams and Vona loamy fine sand.

This is a deep, rapidly permeable soil that has a moderate capacity for storing water. The brown to light-brown surface soil is 12 to 15 inches deep. It overlies brown sandy clay loam or light sandy clay loam, which grades to pale-brown, limy sandy clay loam at depths of 24 to 30 inches. The subsoil is pale-brown, very limy loam or sandy clay loam. In many places, a buried soil that is darker colored and more loamy underlies this soil at depths of 30 inches or more.

About half of this soil is in crops, chiefly grain sorghums. Broomcorn and feed crops are grown also. Yields of sorghum are variable, but complete crop failures are uncommon.

This is one of the most productive range soils on the uplands. Sand dropseed, side-oats grama, and blue grama are the principal range grasses. Some bluestem grows in lightly grazed places. Grazing should be carefully regulated. Sand sagebrush invades overgrazed range and crowds out the grasses.

Figure 5.—**When sorghum stubble is cut or grazed too closely, the wind can lift the surface soil and cause it to drift. The soil is Dalhart fine sandy loam, 0 to 1 percent slopes.**

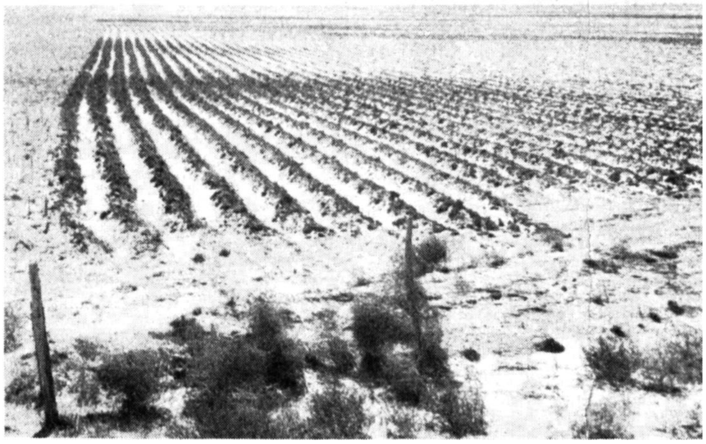

Figure 6.—Dalhart loamy fine sand, 0 to 3 percent slopes, listed across the direction of prevailing winds to prevent excessive wind damage. Note Russian-thistle blown into fence row.

Very careful soil management is needed to protect cultivated areas from wind erosion. Thus far, no permanent damage has been done. Listing (fig. 6) is a common method of checking wind erosion. (Capability unit IVe–2; deep sand range site.)

Dalhart loamy fine sand, 0 to 3 percent slopes, eroded (De).—The surface of this soil is scarred with blowouts and has low dunes where blown-out soil material has accumulated. The sandy clay loam subsoil is exposed in blowouts. Figure 7 shows how erosion begins on unprotected soil.

About 10 percent of this soil is still cropped; the rest is idle or is in weedy pasture. In its present condition and under usual management, this soil returns very little to its owner. It makes a poor seedbed, and young crops are often blown out or damaged by drifting sand. The best long-term use for most of this soil is native grass. (Capability unit VIe–2; deep sand range site.)

Lincoln soils (La).—These are sandy soils that occur most extensively on the flood plains of the North Canadian River (locally called the Beaver River) and the Cimarron River. They are occasionally flooded. The surface is somewhat humpy and irregular.

The surface soil is brown, and the subsoil is pale brown and stratified. The texture of the surface soil is variable. Loamy fine sand predominates, but there is some fine sand and some fine sandy loam. In some low places the texture is clay loam or clay to depths of 10 or 15 inches. Sand and other material deposited during floods modify the surface soil from time to time. The subsoil is uniformly coarse textured. The profile is limy throughout.

These soils produce large quantities of forage consisting mostly of sand bluestem, switchgrass, alkali sacaton, sand dropseed, and hairy grama. They are good sites for wintering cattle; consequently, the range is heavily grazed. Very little, if any, of the acreage is used for crops. Some cottonwoods and willows grow on these soils. (Capability unit VIe–2; sandy bottom-land range site.)

Mansker fine sandy loam, 2 to 5 percent slopes (Ma).—This soil occurs mostly in the northern part of the county, on foot slopes below the margin of the High Plains. It is associated with Dalhart, Potter, and Travessilla soils. The dominant slope is about 3 percent.

The limy surface soil is grayish brown to brown. It overlies pale-brown clay loam or sandy clay loam, which grades to very chalky or limy material at depths of 15 to 20 inches. In places, hardened caliche occurs below depths of 24 to 30 inches.

This soil is droughty, although it absorbs more water than Mansker loam, 3 to 5 percent slopes. It has a sandy, irregular surface. It is not suitable for crops but is good for range. Blue grama and side-oats grama are the principal range grasses. There is some bluestem. Yucca and sand sagebrush have invaded here and there. Grazing should be regulated so that a mulch remains to keep the soil absorptive and to prevent wind and water erosion. (Capability unit VIe–1; sandy plains range site.)

Mansker loam, 0 to 3 percent slopes (Mb).—This soil occurs in the vicinity of Boise City, in the breaks along Beaver Creek and the Cimarron River, and southwest of Felt in the extreme southwestern part of the county. It occupies low rises in the plains and also the margins of depressions in the plains. Associated with it are Potter stony clay loam and Dalhart fine sandy loam. Small areas of Portales clay loam are included.

The surface soil is grayish-brown loam and is 6 to 8 inches deep. The subsoil is pale-brown clay loam. It is underlain at depths of 12 to 20 inches by hardened lime caliche or by chalky, silty material. Fragments of caliche, some brought up by burrowing animals and some exposed by wind erosion, are found on the surface in spots. Although this soil is permeable, it has a low water-holding capacity because of the hard limy layer in the subsoil.

About 40 percent is used for crops, mainly wheat and grain sorghums, but yields are poor. The native range grasses are blue grama, side-oats grama, and buffalograss. In dry years the range is not productive. Enough cover should be left on the soil between grazing seasons to prevent runoff. (Capability unit IVe–1; hardland range site.)

Mansker loam, 3 to 5 percent slopes (Mc).—This soil occurs mostly in the northern part of the county, on

Figure 7.—Not enough stubble remains to protect this field of Dalhart loamy fine sand, 0 to 3 percent slopes, eroded. Drifting sands can be seen in the middle of the picture.

slopes below the margin of the plains. In many places, 10 percent or more of the mapping unit is Potter loam. Little or no Portales clay loam is included.

The surface soil is not so thick as that of Mansker loam, 0 to 3 percent slopes. The depth to the lime zone is more erratic and generally less than in Mansker loam, 0 to 3 percent slopes. Runoff is excessive. The subsoil does not store much moisture; consequently, this soil is droughty in summer.

Little or none of this soil is cultivated. Most of it is used for native range. Blue grama, side-oats grama, and buffalograss are the main grasses. Production of forage is low in most years. Part of every crop should be left on the soil to hold water and prevent erosion. (Capability unit VIe-1; hardland range site.)

Mansker-Dalhart loams, 1 to 3 percent slopes (Md).—This complex occurs on the plain east of Boise City and along the border between the hardlands and the sandy plains in the southern part of the county. The areas vary in size from 15 to 200 acres; the average size is 30 acres. Mansker loam is dominant. Dalhart loam comprises less than 40 percent of most areas. The complex is associated with Richfield loams and with separate units of Dalhart and Mansker soils.

The Mansker soil has grayish-brown surface soil, pale-brown loam at 6 to 8 inches, and a lime layer at 12 to 20 inches. It is very limy throughout and has light-colored spots and caliche pebbles on the surface in some places. The Dalhart soil is dark-brown loam or fine sandy loam and has a nonlimy sandy clay loam subsoil that grades to limy material at 15 to 20 inches. Because of the whitish spots, the Mansker soil appears lighter colored than the Dalhart. The dominant slope is about 2 percent, but about 15 percent of this complex occurs on slopes of 4 percent. The Mansker soil has more runoff than the Dalhart, and is droughtier.

The two soils are used and managed together. Crops occupy about 60 percent of the acreage. Wheat is the main crop; sorghum is second. Yields are only fair but better than on Mansker loam, 0 to 3 percent slopes.

The native grasses are mostly blue grama, side-oats grama, and buffalograss. Some bluestem grows on lightly grazed areas of Dalhart loam.

Preventing wind erosion is the main problem. Grazing should be regulated to maintain a good mulch cover. There is some hazard of water erosion. (Capability unit IVe-1; hardland range site.)

Mansker-Potter complex, 3 to 12 percent slopes (Me).—This complex of limy soils is about 65 percent shallow Mansker soil and 35 percent very shallow Potter soil. It occurs in the caliche breaks along narrow valleys and along the upper rims of breaks from the high plains to the stream valleys.

The Potter soil in this complex is grayish-brown loam or clay loam that is shallow over hardened caliche. In places, the caliche outcrops in rims around the upper slopes. In many places the surface is stony. The Mansker soil has a grayish-brown loam surface soil, a paler clay loam subsoil, and a lime zone at 12 to 25 inches. The Potter soil usually has slopes of 6 to 12 percent; the Mansker soil has slopes of 3 to 6 percent.

These soils are too steep and shallow to crop. They are used for range. The forage is mostly grama and buffalograss. A part of each year's growth should be left to form a mulch. This helps the soils absorb water and prevents damage by water and wind erosion. (Capability unit VIe-1; shallow range site.)

Otero loamy fine sand (Oa).—This soil occurs along the edge of the sandy plains, near the caliche breaks. Like the Vona and Dalhart soils, it has a hummocky surface. The slope range is 2 to 5 percent.

This soil has 6 to 12 inches of light brownish-gray or brown limy surface soil. The subsoil is pale-brown, very limy sandy clay loam that retains water. At depths of 14 to 20 inches, the subsoil grades to a somewhat sandy lime layer. The substratum is hardened caliche in some places and limy clay loam in others.

All of this soil is in native range. Grama and sand dropseed are the principal range plants. Some tall grasses grow in lightly grazed places. Sand sagebrush and yucca have invaded parts of the range and may compete seriously with the grasses. Wind erosion is a serious problem if the surface is exposed as a result of overgrazing. (Capability unit VIe-2; deep sand range site.)

Portales clay loam, 0 to 1 percent slopes (Pa).—This is a deep, fertile soil that is extensive in the hardlands of the High Plains. It commonly occurs next to Richfield soils or between Richfield and Mansker soils. It is shallower than the Richfield soils and has less clay in the subsoil. It is deeper than the Mansker soils and has a more retentive subsoil. Normally it is calcareous to, or nearly to, the surface. Although nearly level, it has enough slope so that it drains well after rains.

This soil has 10 to 14 inches of calcareous, grayish-brown clay loam underlain by pale-brown heavy clay loam. Beginning at depths of 18 to 30 inches is a chalky or floury lime zone that contains a large amount of free calcium carbonate and some concretions of lime. It is underlain by pale-brown clay loam that contains lime but not so much as the layers above. In places this layer is reddish yellow.

About 90 percent of this soil is cultivated. Wheat is the main dryland crop, but some grain sorghum is grown. Under irrigation, alfalfa does well.

A few areas are still in native range, most of which is near buildings and consequently is grazed heavily. The common grasses are grama and buffalograss.

This soil will blow if worked very fine or if overgrazed. Overgrazing may also cause the soil to become compact and to lose moisture by runoff. Generally, runoff is not a problem, since the soil is level or nearly so. (Capability unit IIIc-1; hardland range site.)

Portales clay loam, 1 to 2 percent slopes (Pb).—This is a deep and fertile soil that occurs along shallow drainageways and on rims of depressions in the hardlands. It usually lies next to Portales clay loam, 0 to 1 percent slopes, or one of the Richfield soils, or between Portales or Richfield soils and Mansker soils. It has a profile like that of Portales clay loam, 0 to 1 percent slopes, but is shallower over the lime zone and has slightly less capacity to store water.

About 60 percent of this soil is cultivated; the rest is in range. Wheat is the main crop, but considerable grain sorghum is raised. Yields are fair but not so good as on the more nearly level Portales soil. Drought often harms the summer crops.

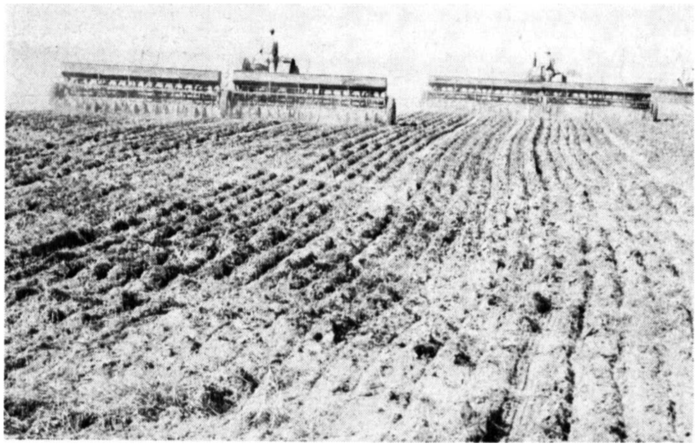

Figure 8.—**Drilling wheat with large equipment on Richfield clay loam. This sight is common early in fall on the High Plains.**

The range acreage of this soil is managed in conjunction with included soils. Grama and buffalograss are the main grasses. Production varies from season to season, depending on the moisture supply.

Erosion is in evidence in many small areas. Light-colored spots on the surface show where the subsoil is reached in plowing. The eroded areas are too small to be mapped separately. A mulch or stubble should be kept on both cultivated areas and range, to prevent further erosion and to help keep the soil from compacting and losing valuable moisture through runoff. (Capability unit IVe–1; hardland range site.)

Potter-Mansker loams, 1 to 3 percent slopes (Pc).—These are shallow or very shallow limy soils that are on the margins of the High Plains, just above the caliche breaks. The complex is about 80 percent Potter soil and about 20 percent Mansker soil.

Hardened caliche is at or near the surface in some areas, and a chalky lime layer is within 18 inches of the surface in other places. The depth to the caliche varies within short distances. The slope range is generally 1 to 3 percent, but the surface is distinctly convex and in places the gradient is 4 or 5 percent. The Potter soil is the more strongly sloping.

The Potter soil is grayish-brown loam or clay loam underlain at depths of less than 10 inches by hardened or partly hardened caliche. The surface is stony in places. Mansker loam is grayish brown. It has a pale-brown subsoil and a layer of chalky lime or hardened caliche at depths of 12 to 25 inches.

Except for a few areas adjacent to Portales and Richfield soils, these soils are too sloping, droughty, and shallow to be used for crops. Most of the acreage is in range consisting of blue grama, side-oats grama, and buffalograss. Production is usually low because these soils do not store enough moisture to supply the plants through summer droughts.

Much water is lost through runoff, and the hazard of both water and wind erosion is great. A good mulch of plant remains helps to keep the soils absorptive and to prevent erosion. More water is lost by runoff and evaporation on overgrazed range than on well-managed range. (Capability unit VIs–1; shallow range site.)

Randall clay (Ra).—This soil occurs on the bottoms of wet-weather lakes that occupy natural depressions on the High Plains. These depressions have no natural outlets and dry out only by evaporation. Some of them receive drainage water from areas several square miles in size. Except during cycles of wet weather, they dry out in summer. Some have been used as sources of irrigation water.

This soil is dark gray. It is somewhat mottled below a depth of 18 inches and becomes browner at depths of 3 to 4 feet. The structure is coarse granular to blocky. Permeability is very slow throughout the profile. The reaction is neutral to calcareous. The characteristics vary widely because several different kinds of material are washed into these depressions.

A few small areas of this soil are cultivated to wheat, but about 95 percent is wasteland or pasture. Grama and western wheatgrass grow on the bottoms of the depressions during cycles of dry weather. These grasses do well if not overgrazed. Many of the areas are not fenced and consequently cannot be used for grazing except when cattle are grazing the stubble in the surrounding wheatfields. (Capability unit Vw–1; hardland range site.)

Richfield clay loam, 0 to 1 percent slopes (Rb).—This is the most extensive level hardland soil on the High Plains. It is deep and fertile and has a clayey, retentive subsoil. It takes in water fairly well and loses little water through runoff. Wind erosion is the main hazard. During periods of drought, growing plants may be slightly damaged by soil shifting.

The surface soil is dark grayish-brown, light clay loam, 3 to 5 inches deep. The subsoil is dark grayish-brown, coarse granular to weak blocky, heavy silty clay loam or clay, which becomes lighter colored and slightly calcareous below a depth of about 14 inches. At depths of 20 to 24 inches there is usually a pale-brown to yellowish-brown lime zone containing soft lime concretions and pockets of chalky lime. The substrata are pale-brown to yellowish-red heavy silt loams or silty clay loams. In many places buried soils, much like the present surface soil, occur at depths of 30 inches or more.

Most of this soil is cultivated. The fields are generally very large. Wheat is the main crop (fig. 8). Grain sorghums are often planted if the wheat crop blows out or is damaged by drought. Yields of dryland sorghum are undependable and are generally low, since this is a poor soil for summer crops. With irrigation, yields of grain sorghums may be very good.

Only a few areas, mostly small pastures near farms, are in native range. The range vegetation consists of grama and buffalograss. Trampling by cattle impairs the ability of this soil to absorb water. Because most of the pastures are overgrazed, little mulch is left to protect the soil from wind erosion. Silt washed from eroding fields nearby may damage the edges of the pastures. (Capability unit IIIc–1; hardland range site.)

Richfield clay loam, 1 to 2 percent slopes (Rc).—This soil occurs along the shoulders of shallow drainageways and around the rims of depressions in the High Plains. Many areas are almost surrounded by Richfield clay loam, 0 to 1 percent slopes, or by Portales clay loam. Some areas slope down to and surround small areas of Randall clay. The slopes are weakly convex, and the dominant gradient is slightly greater than 1 percent.

Only a small acreage has slopes of as much as 2 percent. The surface layer is thinner than that of Richfield clay loam, 0 to 1 percent slopes, and plowing may turn up some of the subsoil.

Most of this soil is cultivated. Wheat is the main crop; sorghum is second. Yields are lower than on Richfield clay loam, 0 to 1 percent slopes, because this soil is more droughty.

As native range, this soil is generally part of areas that include the associated soils. Grama and buffalograss are the common range plants. Many of the stands are poor because drought and overgrazing have thinned and weakened the grasses.

This soil has more runoff and is more likely to be damaged by water erosion than Richfield clay loam, 0 to 1 percent slopes. Unless crops or residues are kept on the surface, wind erosion is a serious hazard. The surface should be kept cloddy between crops or in seasons when the soil is left fallow. (Capability unit IIIe-1; hardland range site.)

Richfield fine sandy loam, 0 to 1 percent slopes (Rd).—This soil occurs in areas between hardlands and sandy plains. It has a sandy surface soil over a subsoil like that of the Richfield clay loams. The sandy material was blown from nearby sandy soils, such as Dalhart. The slopes are slightly convex and have a gradient of between ½ and 1 percent.

The uppermost 5 to 10 inches of this soil is brownish, weak-structured fine sandy loam. This rests on dark-brown heavy clay loam, which grades, at depths of 12 to 18 inches, to lighter colored, normally calcareous clay loam. Below a depth of about 24 inches, there is a light-brown or yellowish-brown limy zone that contains pockets and concretions of calcium carbonate. The substratum consists of clay loam stratified in places with sandy material.

Most of this soil is used for sorghum and wheat. Yields are about the same as on the Dalhart fine sandy loams.

The areas that are in range are generally part of larger areas that include Dalhart and other soils. Grama and buffalograss are the common range plants. Some western wheatgrass and bluestem grow in lightly grazed areas.

Wind erosion is the principal hazard. Enough residue should be left each year to mulch the soil and protect it from wind erosion. (Capability unit IIIe-1; sandy plains range site.)

Richfield loam, 0 to 1 percent slopes (Re).—This is a hardland soil that occurs on level parts of the High Plains. Its parent material was sandier than that of the Richfield clay loams. It is a deep, fertile soil that has a retentive sandy clay subsoil. It absorbs and stores water fairly well and loses little water through runoff. The slopes are generally between ½ and 1 percent.

This soil has 3 to 5 inches of brown loam over dark-brown sandy clay that becomes lighter colored and slightly calcareous below depths of 12 to 15 inches. Beginning at depths of 24 to 30 inches, there is generally a layer that contains chalky masses and concretions of lime. The lower layers are yellowish-brown to pale-brown loam or clay loam. In many places buried soils similar to the Richfield clay loams occur at depths of 30 to 40 inches.

Most of this soil is cultivated. Wheat is the main crop. However, more sorghum is grown on this soil than on the Richfield clay loams, and the yields are better and more consistent.

Only small areas of this soil are used for range, and most of these are used in conjunction with other Richfield soils. Grama and buffalograss are the common range plants. The stands are somewhat better than those on the Richfield clay loams because this soil is less droughty. (Capability unit IIIc-1; hardland range site.)

Rough stony land (Rf).—Most of this land type consists of rock ridges and sandstone escarpments along the breaks in the northwestern part of Cimarron County. The areas are commonly steep and stony. There is little true soil. The slopes range from about 10 percent to nearly vertical. Travessilla and Berthoud soils occur in pockets and in narrow valleys between sandstone knobs.

All of this land type is in native range. The cover of grama, vine-mesquite, and bluestem varies in thickness and in usability. Since many steep slopes are practically inaccessible to cattle, it is hard to keep the range evenly grazed. Overgrazing should be prevented, because wind and water erosion are likely if the surface is exposed. A surface mulch will help keep these areas absorptive.

Figure 9 shows an area of Rough stony land viewed from the bed of the Cimarron River in the northwestern part of the county. Below the sandstone ledges are steep, rocky foot slopes of Travessilla soils. The exposed streambank is composed of Spur soils. (Capability unit VIIs-1; breaks range site.)

Spur soils (Sa).—These soils occur mostly on the flood plains along the Cimarron River and its tributaries. They are dark-colored loamy soils that vary somewhat in surface texture. Clay loam is the dominant texture, but areas of loam and sandy loam also occur. The sandier soils are next to the streams; the finer textured soils are toward the uplands.

The clay loam has 8 to 10 inches of dark grayish-brown, granular surface soil over a layer of brownish heavy clay loam. The second layer is slightly stratified with loam or silty clay loam but is fairly uniform to depths of 5 or 6 feet. The entire profile is calcareous, but there is no definite zone in which lime has accumulated.

These soils are only occasionally flooded and are well suited to crops. Many areas are long and narrow and are consequently not suitable for the extensive wheat farming common on the High Plains. Nevertheless, about a third of the acreage is cultivated. Yields are good under dryland management, and irrigated areas will produce bumper yields of many kinds of crops.

The principal range grasses are western wheatgrass, grama, switchgrass, and buffalograss. If the range is heavily grazed, blue grama and buffalograss increase and silver bluestem and sand dropseed appear. The stands are better than those on the level uplands because the moisture supply is better. A few cottonwoods and willows grow in moist, sandy spots near the stream channels. (Capability unit IIIc-1; loamy bottom-land range site.)

Sweetwater fine sandy loam (Sb).—This is a moderately sandy soil that occurs in level or depressed spots

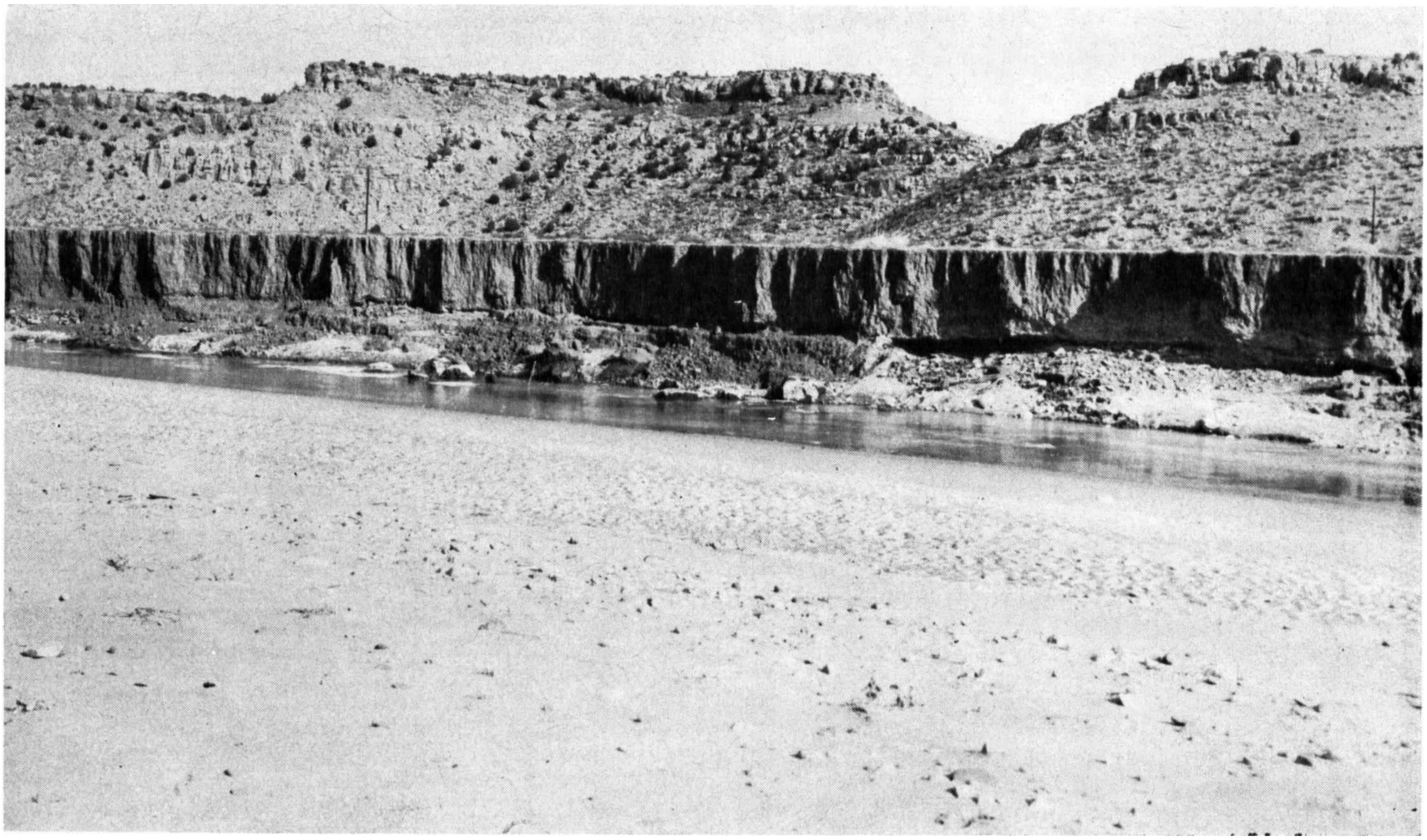

Figure 9.—**Rough stony land on sandstone ledges, Travessilla stony loam on foot slopes, and Spur soils on bottom lands along the Cimmaron River.**

on the bottom lands of the Cimarron River. It is associated with the Lincoln soils.

The surface layer is dark-brown fine sandy loam, 2 feet thick or more. In places this layer is stratified with clay loam, and in places it is covered with a light-colored overwash of sandier material. The substratum is pale-brown loamy sand, stratified with brown sandy loam and loam. It is somewhat mottled in places. The water table is generally not more than 50 or 60 inches below the surface, and it may be only 36 inches below the surface when runoff from the upland is high. Drainage is slow. Some areas have saline spots.

Because it occurs in small bodies and has slow drainage, this soil is not cultivated. It furnishes excellent native range, however. Yields of forage are better than on any other soil in Cimarron County. Switchgrass, sand bluestem, prairie cordgrass, grama, inland saltgrass, and alkali sacaton are the principal range plants. If the range is heavily grazed, the tall grasses decrease and the saltgrass and sacaton increase. Some native hay is cut. (Capability unit Vw–1; subirrigated lowland range site.)

Travessilla stony loam (Ta).—This is a very shallow soil that occurs on the stony breaks along the Cimarron River. It is on slopes below areas of Rough stony land. Many areas slope down to nonstony, gentle foot slopes of Berthoud soil. Carnero loam may occur on the tops of low ridges within areas of this soil.

The light-brown, granular surface layer overlies pale-brown, very limy loam that grades to weathered sandstone at depths of 6 to 18 inches. Sandstone fragments occur on the surface and throughout the soil. Some narrow bands of rock crop out. These rocks are generally coated with lime and are very light colored. The slopes range from gentle to strong, or from 2 to about 12 percent.

This soil is too shallow, droughty, and steep for crops. It is used for range. It has a low water-holding capacity and will produce only sparse stands of native grass. The stands consist of blue grama, black grama, buffalograss, scattered clumps of cactus, and a few juniper shrubs. Some little bluestem, vine-mesquite, and cane bluestem grow on lightly grazed areas.

Since this soil will wash and blow if not protected, grazing should be limited so as to leave a mulch after each growing season. (Capability unit VIs–1; stony loam range site.)

Vernon clay loam (Va).—This soil occupies beds of red Triassic clay in the stony breaks of 15 to 30 percent slopes along the Cimarron River. Most of it is on the lower part of slopes near Kenton. A few areas occur north of Boise City.

The surface soil is calcareous, reddish-brown, granular clay loam, 4 to 8 inches thick. It is underlain by reddish-yellow, coarse, granular clay that contains concretions of lime. The substratum contains bands of sandstone in places. The slopes range from 1 to 6 percent. This soil is dry because runoff is high and water does not normally filter down into the clay beds.

All of this soil is used for range. It supports a fair stand of grama and buffalograss and has a low or moderate carrying capacity. If it is overgrazed, runoff will increase. Enough of each year's growth should be left to provide a mulch and to maintain a good cover of grasses. (Capability unit VIs–1; hardland range site.)

Vona-Tivoli loamy fine sands (Vb).—These soils occupy the sandy plains in the southern and northern parts of the county. They are very sandy and are lighter colored than the associated Dalhart loamy fine sands. Each area of the mapping unit is about two-thirds Vona soils and one-third Tivoli soils. The Tivoli soils occur on low dunes, and the Vona in the hummocky areas between the dunes. The slopes are between 3 and 5 percent.

The surface soil of Vona loamy fine sand is grayish to brownish and is 10 to 15 inches deep. The subsoil is slightly browner fine sandy loam that is limy in places below a depth of 18 inches. This layer is clayey enough to hold some moisture. The lower layers consist of brown or yellowish-brown loamy sand. There are loamy materials at depths of 3 feet or more in some places.

The Tivoli soil, to a depth of 3 feet or more, is light brown or yellowish brown; the uppermost few inches is only slightly darker colored. Blowouts and active dunes are very light colored and resemble "sugar sand." This soil has no layers that hold much moisture.

These soils are too sandy to be suitable for cultivation. Only about 3 percent of the acreage is cultivated, and most of this is next to areas of Dalhart soils or other tillable sandy soils. Grain sorghums are the only crops grown. Yields are very low. Wind erosion is a hazard; often, growing crops are blown completely out of the soil. Crop residues should be left on the soil between seasons.

Although poor for cultivated crops, these soils produce good quantities of forage if used for native range. Sand bluestem, little bluestem, switchgrass, side-oats grama, some blue grama, and some sand dropseed grow on well-managed range. If the range is overgrazed, blue grama and sand dropseed increase. Sand sagebrush is a widespread invader, and yucca invades some areas. Regulation of grazing is needed to protect the better grasses and to maintain a mulch that will protect the soil from wind erosion. (Capability unit VIe–2; deep sand range site.)

Use and Management of Soils

This section has five main parts. The first is a discussion of the most common problems of managing unirrigated cultivated soils in Cimarron County. The second is a description of the system of capability grouping, followed by short discussions of use and management of the soils in each capability unit. The third part concerns irrigation practices in this county. The fourth gives estimates of probable yields of the principal crops. The fifth is a discussion of range management.

Cultivation of Dryland Soils

Soil management in Cimarron County presents problems typical of the southern High Plains: Preventing wind erosion, conserving moisture, and maintaining productivity. These problems are complicated by strong, erosive winds and sparse, erratic rainfall. Drought is an ever-present hazard. The average annual rainfall is 16.8 inches. In 60 percent of the years for which records have been kept, the rainfall has been less than this average. In some years, moreover, 20 percent or more of the rain falls in one storm. Rapid evaporation adds to the difficulty of conserving moisture.

Figure 10.—**Hardland soils that are cultivated intensively become puddled when wet and are easily eroded, then they crack on drying.**

Natural fertility begins to decline as soon as a soil is cultivated, but in this county twice as much of the plant-nutrient supply has been removed by erosion as has been removed by cropping. Continued cultivation is likely to cause deterioration of the soil structure, loss of organic matter, and an increasing hazard of wind and water erosion (fig. 10). Bindweed (*Convolvulus arvensis*), a hardy, trailing, noxious weed, infests thousands of acres of cultivated land and is spreading rapidly. Blueweed and lakeweed are also difficult to control, but they are not so widespread as bindweed and do not spread so rapidly.

Farmers in Cimarron County include in their conservation plans such practices as stubble mulching, utilizing crop residues, growing cover crops, stripcropping, tilling on the contour, seeding the range, establishing perennial vegetation, terracing, summer fallowing, establishing buffer strips, emergency tilling, and deep plowing. The combination of these practices that will most effectively conserve soil and moisture and keep the soil productive

Figure 11.—**Stubble remaining on freshly drilled land tilled since the last year's crop by the stubble mulch method. Wheat drilled in stubble is protected against blowing out during fall windstorms.**

under cultivation depends on the kind of soil, the topography, the climate, the seriousness of the erosion hazard, and the type of farming enterprise. The value of a conservation cropping system depends as much on its potential productivity as on its effectiveness in controlling erosion. The system should be flexible, so that it can be adjusted to varying moisture conditions.

Stubble mulch tillage is no doubt the most important single conservation measure practiced in the county. Emergency tillage, also called wind erosion tillage, is an effective emergency measure.

Stubble mulch tillage.—Stubble mulching is a system of tilling, planting, cultivating, and harvesting in such a way and with such equipment that most of the residue from the previous crop remains undisturbed on the surface (fig. 11). Keeping the mulch on the surface the year 'round helps to control erosion, prevent surface sealing, and improve water intake. It may also reduce the loss of water by evaporation, and it has a favorable effect on soil temperature. Stubble mulching is also called subsurface tillage, subtillage, or undercutting. It should not be confused with chiseling, subsoiling, or deep plowing.

Machinery used to prepare seedbeds by stubble mulching should be (1) designed to leave the residue on the surface but anchored in the soil, (2) capable of operating at controlled and uniform depth, (3) capable of cultivating effectively enough to kill weeds and volunteer crops, (4) of adequate weight and strength to operate when the soil is dry and hard, (5) equipped with V-shaped sweeps, ranging in cutting width from 15 inches to 8 feet, and with rolling coulters to cut residues and weeds ahead of the sweeps, when necessary, to prevent clogging. For working through ordinary amounts of residue, the sweeps should have a minimum cutting width of 24 inches. There should be at least 18 inches clearance between the sweep and the beam.

The first cultivation should be at the greatest depth (4 to 6 inches), and successive cultivations should be at progressively lesser depths. This will insure a firm seedbed. The sweeps should run level.

Special machinery for drill seeding and row planting may be needed on soils tilled by stubble mulch methods, especially if a heavy residue remains.

If combines are used in harvesting, they should have efficient straw spreaders that will not leave straw in the windrows. Sorghum stubble should be left 10 to 16 inches high. Grazing of the stubble or aftermath should be permitted only if the residue is unusually heavy.

Wind erosion tillage.—Wind erosion tillage should be resorted to only in emergencies, when there is inadequate vegetation to control erosion. It is a mechanical practice that can be applied quickly. The objective is to make the surface cloddy. This practice controls wind erosion for a limited time, but it has a detrimental effect on the structure of the soil and it also reduces the supply of available moisture.

Chisels are generally the most effective equipment for emergency tillage of hardlands, and listers are best for emergency tillage of the sandy plains. The effectiveness of wind erosion tillage is influenced by the speed of the equipment, the depth of tillage, the spacing between chisels or listers, and the size of the chisel or lister points. Speeds of 3 to 4 miles an hour are considered the most effective in the High Plains generally. The depth should be sufficient so that clods will be brought to the surface. The looser the soil, the greater the depth that is necessary. Spacing of 27 to 36 inches is most effective, but if the erosion hazard is moderate spacing of 44 to 54 inches is generally adequate. The wider spacing is suitable if an attempt is being made to salvage a wheat crop.

Deep plowing.—If sandy soils are cultivated, the surface layers tend to drift badly, and the fine materials are winnowed out and collect in low dunes and fence rows. Winnowing makes the remaining soil less cohesive and more susceptible to wind erosion, but if the surface can be kept cloddy the force of the wind is reduced. On sandy soils that have clayey subsoils, deep plowing may bring up clod-forming material from the subsoil.

Deep plowing is done by special plows that run deep enough to bring furrow slices of clayey material to the surface, where it mixes with the sand (fig. 12). It is useful only if the clayey subsoil can be reached con-

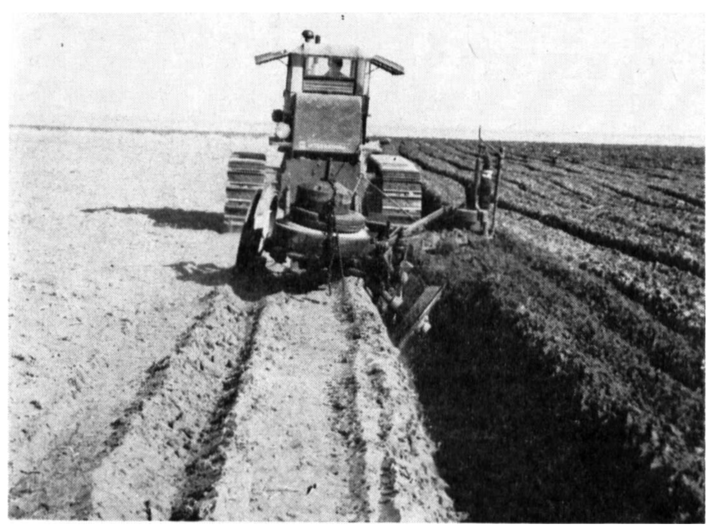

Figure 12.—**Plowing to a depth of 18 inches on Dalhart fine sandy loam.**

sistently. Plowing without reaching clay does no good. The practice in itself will not improve crop yields. It should be supplemented by conservation measures, including growing cover crops, preserving crop residues, and stubble mulching.

Research on deep plowing at the former Soil Conservation Service Experiment Station at Brownfield, Tex., and at the present Sandy Land Station at Mangum, Okla., has produced a general understanding of the needs in deep plowing. While information to date is by no means complete or conclusive, the following requirements and limitations are known.

1. Only moderately coarse textured and coarse textured soils with fine textured subsoils within reach of the plow are suitable for deep plowing.
2. One-fourth to one-third of the furrow slice must be material that is not less than 10 percent clay or not less than 15 percent combined silt and clay. If the plow does not bring up this much fine material, wind erosion will not be appreciably reduced. For example, a soil that is to be plowed 20 to 24 inches deep should not have more than 15 to 18 inches of sandy surface soil over sandy clay loam or heavier material.
3. Slopes of more than 4 percent are not suitable for deep plowing because of the water erosion hazard.
4. The original surface soil should be mixed as thoroughly as possible with the entire plowed layer.
5. Hummocks or accumulations of sandy material in drifts should be smoothed or leveled before deep plowing. Otherwise sandy blow spots will remain in the field after deep plowing.
6. Management of deep-plowed soils should include growing residue-producing crops and cover crops, keeping residues on the surface, and returning or adding large amounts of organic material, such as crop residues or manure.

Deep plowing will be useless and possibly harmful if—

1. The coarse-textured soils are shallow or very shallow over rock.
2. The soils have dispersed or infertile subsoils.
3. The slopes are more than 4 percent.
4. The subsoils are very high or very low in clay.
5. The sandy surface soils are less than 7 inches deep.
6. The subsoils are high in lime.
7. The soils are medium textured or fine textured.

The following soils in Cimarron County are suitable for deep plowing:

	Necessary depth of plowing
Richfield fine sandy loam, 0 to 1 percent slopes	12 inches.
Dalhart fine sandy loam, 0 to 1 percent slopes	12 to 18 inches.
Dalhart fine sandy loam, 1 to 3 percent slopes	12 to 18 inches.
Dalhart fine sandy loam, 0 to 3 percent slopes, eroded	16 to 22 inches (after leveling).
Dalhart loamy fine sand, 0 to 3 percent slopes, eroded	16 to 22 inches (after leveling).
Dalhart loamy fine sand, 0 to 3 percent slopes	20 inches or more.

Capability Groups of Soils

Capability grouping is a system of classifying soils according to their relative suitability for crops, grazing, forestry, or wildlife. It is a practical grouping based on the needs and limitations of the soils, the risk of damage to them, and their response to management. In this report, the soils have been grouped on three levels above the soil mapping unit. These groups are the capability unit, the subclass, and the class.

The capability unit, which can also be called a management group of soils, is the lowest level of capability grouping. Soils in the same capability unit have similar management needs, similar conservation needs, and similar potential for productivity.

The next broader grouping, the subclass, is used to indicate the dominant kind of limitation. The letter symbol "e" means that the main limiting factor is risk of erosion if the plant cover is not maintained. The symbol "w" means that excess water retards plant growth or interferes with cultivation. The symbol "s" means that the soils are shallow, droughty, or low in fertility. Climatic limitations, such as extreme temperatures or lack of moisture, are indicated by the symbol "c." All of the soils in Cimarron County have climatic limitations. The symbol "c" is used only for those that do not have other limitations.

The broadest grouping, the class, is identified by Roman numerals. All the soils in one class have limitations and management problems of about the same degree, but of different kinds as shown by the subclass. The class designation is not necessarily an indication of productivity under practical dryland management. All of the classes except class I may have one or more subclasses.

In classes I, II, and III are soils that are suitable for annual or periodic cultivation of annual or short-lived crops.

Class I soils are those that have the widest range of use and the least risk of damage. They are level or nearly level, productive, well drained, and easy to work. None of the soils in Cimarron County are in class I.

Class II soils can be cultivated regularly, but they do not have quite so wide a range of suitability as class I soils. Some class II soils are gently sloping and consequently need moderate care to prevent erosion. Other soils in class II may be slightly droughty, slightly wet, or somewhat limited in depth. None of the soils in Cimarron County are in class II.

Class III soils can be cropped regularly, but they have a narrower range of use. Because of the climate, the best soils in Cimarron County are in this class.

Soils of class IV should be cultivated only occasionally or only under very careful management. Yields are so low and erosion control and moisture conservation so difficult that the class IV soils in Cimarron County are marginal for cultivation.

In classes V, VI, and VII are soils that normally should not be cultivated for annual or short-lived crops but can be used for pasture, for woodland, or for wildlife shelter.

The class V soils in Cimarron County are level and not extremely erosive. Periodic wetness, unevenness of the surface, or slight salinity limits their use for crops. Because they have a better moisture supply, these soils are better for grazing than the soils in classes III and IV.

Class VI soils are sloping and erosive and have low moisture-storage capacity. Thus, they are not suitable for cultivation in this dry climate, even if they could be irrigated. They give fair yields of forage.

Class VII soils provide only poor to fair yields of forage. They are steep, rocky, and erosive.

Class VIII soils have practically no agricultural use. None of the soils in Cimarron County are in this class.

The management of soils in Cimarron County by capability units is discussed on the following pages.

Capability unit IIIe-1

This unit consists of deep, permeable, nearly level to gently undulating soils of the uplands. Most of the acreage is in grain sorghums. Some is in wheat. A few level areas are irrigated and used for alfalfa. These soils are well suited to cultivation, but they need careful management to preserve their structure and to prevent damaging erosion.

The soils in this unit are—

Dalhart fine sandy loam, 0 to 1 percent slopes.
Dalhart fine sandy loam, 1 to 3 percent slopes.
Richfield fine sandy loam, 0 to 1 percent slopes.
Richfield clay loam, 1 to 2 percent slopes.

The principal problems in managing these soils result from a moderate hazard of wind erosion, a slight hazard of water erosion, the shortage of water, a tendency for the surface to crust temporarily and for plowpans to form, and loss of organic matter in cultivated areas.

Suggestions for Management:

Plant grain sorghums at right angles to the direction of the prevailing wind. Use 20-inch row spacing so the ground will be well protected with stubble and so the growing plants will shade the ground, thus reducing the rate of evaporation and discouraging the growth of weeds. Leave 8 to 12 inches of sorghum stubble.

Till by the stubble mulch method to prepare for seeding wheat or a drilled forage crop. Till only as much as is necessary to prepare the seedbed and control weeds. Avoid using equipment that pulverizes the surface soil.

Delay seedbed preparation in spring so that the soils are covered by residue during as much as possible of the "blow season."

Build diversion terraces to break up concentrations of water on long slopes. Build conservation terraces to prevent loss of moisture.

Use wind erosion tillage as an emergency measure only.

Reestablish grass on areas retired from cultivation.

Many areas of these soils are suited to irrigation, but the level-border method is not suitable unless the irregular surface is leveled. At present, irrigation is mostly by sprinkler systems, although these are not very satisfactory in windy country.

Capability unit IIIc-1

This unit consists of deep, nearly level, fertile soils of the uplands and bottom lands. Most of the acreage is used for growing wheat. Some areas are irrigated and used for alfalfa and other crops. The soils are well suited to cultivation if care is taken to conserve moisture, maintain soil structure, and prevent damaging erosion.

The soils in this capability unit are—

Portales clay loam, 0 to 1 percent slopes.
Richfield clay loam, 0 to 1 percent slopes.
Richfield loam, 0 to 1 percent slopes.
Spur soils.

The principal problems in managing these soils result from a moderate hazard of wind erosion, a slight hazard of water erosion, slow intake of moisture, and a tendency for the surface to crust temporarily and for plowpans to form.

Suggestions for Management:

Grow crops that leave a lot of residue, and protect the residue from grazing. Keep one-fourth to one-half of the acreage in delayed summer fallow, and vary the fallow according to the availability of moisture in the subsoil.

Till by the stubble mulch method to prepare for seeding wheat or a drilled forage crop. Till only as much as is necessary to control weeds and prepare a seedbed. Limit the use of equipment that might pulverize the surface soil.

Build diversion terraces to break up concentrations of water on long slopes, and conservation terraces to prevent the loss of moisture. Cultivate terraced fields on the contour.

Use wind erosion tillage as an emergency measure.

Reestablish grass on areas retired from cultivation.

These soils are generally suited to irrigation. The irregularity of the surface necessitates some leveling before the level-border method of irrigation can be used.

Capability unit IVe-1

This unit consists of shallow and deep, gently sloping or gently undulating soils of the uplands. These soils have moderately clayey subsoils and can hold moderate to good supplies of moisture, but much water is lost through runoff. Most of the cultivated acreage is used for wheat. Some is used for grain sorghums.

These soils are suitable for cultivation only if extreme care is taken to prevent wind and water erosion and to conserve moisture. Much of the acreage is better suited to native grass than to field crops.

The soils in this unit are—

Berthoud loam, 0 to 3 percent slopes.
Mansker loam, 0 to 3 percent slopes.
Mansker-Dalhart loams, 1 to 3 percent slopes.
Portales clay loam, 1 to 2 percent slopes.

The principal problems in managing these soils result from a moderate to severe hazard of wind erosion, a moderate hazard of water erosion, the moderate moisture-holding capacity, the presence of spots of shallow soils that interfere with the use of machinery, and a tendency for the surface to crust and for plowpans to form.

Suggestions for Management:

Grow crops that leave a lot of residue, and protect the residue from grazing. Delayed summer fallow may be advisable on the Portales soil, depending on the supply of moisture in the subsoil. Till by the stubble mulch method to prepare for seeding wheat or a drilled forage crop. Till only enough to prepare a seedbed and control weeds. Avoid using equipment that pulverizes the soil.

Plant sorghums at right angles to the direction of the prevailing wind. Use 20-inch row spacing so the ground will be well protected with stubble and so the growing plants will shade the ground, thus reducing the rate of evaporation and discouraging the growth of weeds. Leave 8 to 12 inches of sorghum stubble.

Use wind erosion tillage as an emergency measure only.

Reestablish grass on areas retired from cultivation.

Many areas probably would give better returns if used for grazing or for seed crops than if used for cultivated crops. Except for a few small spots, these soils are not suitable for irrigation.

Capability unit IVe-2

This unit consists of deep, permeable, nearly level to gently undulating soils of the uplands. These soils have slightly clayey subsoils and hold moderate supplies of moisture. Most of the cultivated areas are in grain sorghums.

These soils are suitable for cultivation only if managed with extreme care. They are already eroded and are particularly subject to further damage by wind erosion. Many areas are better suited to pasture than to crops.

The soils in this unit are—

Dalhart fine sandy loam, 0 to 3 percent slopes, eroded.
Dalhart loamy fine sand, 0 to 3 percent slopes.

The principal problems in managing these soils result from a severe hazard of wind erosion, a moderate hazard of water erosion, loss of water by runoff, low moisture-holding capacity, a tendency for the surface to crust and for plowpans to form, and the difficulty of maintaining a supply of organic matter in the plow layer.

Suggestions for Management:

Grow crops that leave a lot of residue, and protect the residue from grazing.
Till by the stubble mulch method to prepare for seeding wheat or a drilled forage crop. Till only enough to prepare a seedbed and control weeds. Avoid using equipment that pulverizes the soil.
Plant sorghums at right angles to the direction of the prevailing wind. Use 20-inch row spacing so the ground will be well protected with stubble and so the growing plants will shade the ground, thus reducing the rate of evaporation and discouraging the growth of weeds. Leave 8 to 12 inches of sorghum stubble.
Use wind erosion tillage as an emergency measure only.
Reestablish grass on areas retired from cultivation.

Except for a few small areas, these soils are not suited to irrigation.

Capability unit Vw-1

This unit consists of Sweetwater fine sandy loam, which is a deep, loamy, subirrigated soil of the bottom lands, and Randall clay, a deep soil that occurs in playas or enclosed depressions. The Sweetwater soil is good for pasture. The Randall soil is good for pasture in years when there is little rainfall. These soils furnish good cover for wildlife. Some small areas are used occasionally to grow wheat.

The principal problems in managing these soils result from temporary ponding, poor drainage and poor aeration, occasional overflow and a temporary perched water table, slight salinity, and the tendency of the soil to shrink and crack when dry.

Suggestions for Management:

Regulate grazing to protect the native grasses.
Keep water from filling up the enclosed depressions by proper management of watersheds.
Reestablish the native grasses (see Range Management).
Protect wildlife.

Very few areas of these soils are suitable for cultivation. In the long run, the Sweetwater soil is more productive of forage than of any cultivated crop. Randall clay produces good forage if not disturbed during cycles of dry weather. It is completely flooded only in very wet years, and as the water retreats the grass returns.

Capability unit VIe-1

This unit consists of moderately deep to deep, gently sloping to sloping soils of the uplands. These soils have only moderate water-holding capacity. Much water is lost through runoff.

Droughtiness and erodibility make these soils unfit for cultivation. If well managed, they furnish moderate and dependable yields of grass forage and cover for wildlife.

The soils in this capability unit are—

Berthoud fine sandy loam, 2 to 5 percent slopes.
Berthoud loam, 3 to 5 percent slopes.
Carnero loam.
Mansker fine sandy loam, 2 to 5 percent slopes.
Mansker loam, 3 to 5 percent slopes.
Mansker-Potter complex, 3 to 12 percent slopes.

The principal problems in managing these soils result from the generally moderate moisture-holding capacity, the occurrence of spots of shallow soil that have low moisture-holding capacity, the moderate to severe hazard of wind and water erosion, the tendency of the soil to compact in overused areas, and the difficulty of maintaining a surface mulch.

Suggestions for Management:

Retire any areas that are now being cultivated. Reseed these areas and the overgrazed areas of range to suitable grasses (see Range Management).
Manage the native range carefully to protect the grasses. Leave enough residue each year to mulch the surface and to provide cover for wildlife.

Capability unit VIe-2

This unit consists of deep, sandy soils of the uplands and bottom lands. These soils absorb water readily but have low moisture-holding capacity. The bottom-land soils have an irregular surface.

Droughtiness and a severe hazard of wind erosion make these soils unfit for cultivation. If well managed, they furnish low to moderate, but fairly dependable, yields of grass forage. The Lincoln soils of the bottom lands are dependable producers because they receive extra moisture, in the form of runoff and floodwater.

The soils in this capability unit are—

Dalhart loamy fine sand, 0 to 3 percent slopes, eroded.
Lincoln soils.
Otero loamy fine sand.
Vona-Tivoli loamy fine sands.

The principal problems in managing these soils result from the low moisture-holding capacity, the severe hazard of wind erosion, and the need to maintain a surface mulch and to add to the supply of organic matter, in order to protect the soil and make it more absorptive.

Suggestions for Management:

Reseed grazed-out areas to suitable grasses (see Range Management).

Protect blowout spots with mulches, asphalt sprays, or other protective cover.

Regulate grazing so as to allow a vigorous growth of tops and roots. Leave enough residue each year to provide a surface mulch. Defer grazing of small areas, to leave good cover for wildlife. Prevent infestation of the range by sagebrush, either by regulation of grazing or by other means.

Capability unit VIs-1

This unit consists of shallow, stony and nonstony, gently sloping to strongly sloping soils of the uplands. These soils have low moisture-holding capacity. Much water is lost through runoff.

Because they are shallow, droughty, and erodible, these soils are not fit for cultivation. If well managed, they furnish low to moderate amounts of grass forage and cover for wildlife. The yields fluctuate, depending on the amount of rainfall.

The soils in this capability unit are—

Apache stony clay loam.
Potter-Mansker loams, 1 to 3 percent slopes.
Travessilla stony loam.
Vernon clay loam.

The principal problems in managing these soils result from the low moisture-holding capacity, loss of water through runoff, a moderate to severe hazard of wind and water erosion, the tendency of the soil to compact if overgrazed, and the need to maintain a surface mulch.

Suggestions for Management:

Reseed grazed-out areas to suitable grasses (see Range Management).

Regulate grazing so as to allow vigorous growth of both tops and roots. Leave enough residue every year to mulch the surface and provide cover for wildlife.

Capability unit VIIs-1

This unit consists of Rough stony land, which is a land type composed of the steep, very shallow, stony soils in the rough breaks area in the northwestern part of the county. These soils are droughty. They absorb water readily but have low storage capacity. Much water is lost through runoff because of the steep slopes. The deeper soils in pockets are susceptible to wind and water erosion if unprotected.

If well managed, these soils furnish small quantities of forage. Yields fluctuate widely, depending on rainfall.

The principal management problems result from the low water-holding capacity, the moderate to severe hazard of wind and water erosion, and the need to maintain a mulch to protect the soil and make it more absorptive.

Suggestions for Management:

Manage the native range carefully, so as to allow vigorous growth of both tops and roots. Leave enough residue each year to provide a surface mulch and increase permeability.

Reseed grazed-out areas to suitable grasses (see Range Management).

Irrigation

Irrigation has been practiced to some extent since 1889. The first soils to be irrigated were the Spur soils on the flood plains of Cimarron River and its tributaries. The water used in these first irrigation systems was runoff water from higher areas and water from the river and stream channels. The runoff was either diverted from the natural channel direct to the field, or it was collected in manmade lakes and stored for later use (fig. 13). Recently, wells have been drilled to supplement this supply.

The Spur soils that have been irrigated appear to be in excellent physical condition, possibly because plants grow better under irrigation and leave more residue.

The principal crops that are now grown under irrigation on the Spur soils are alfalfa, grain sorghums, corn, sudangrass for supplementary pasture, and truck crops for local use (fig. 14). Yields have been satisfactory. The vegetables are of good quality, but there is practically no outside market for them. Irrigation is also being used to grow hay for winter use and for emergency feed during droughts. Most of those who irrigate acreages on the flood plains of the Cimarron River and its tributaries are ranchers. They usually control large acreages and run large herds of cattle. They use the forage crops as needed and sell the surplus for additional income.

The supply of river water for irrigation is undependable. It is impossible to determine when water will be available from the river, or in what quantity. The heavy load of silt carried by the river complicates distribution. The water moves more slowly in the irrigation ditches than in the river; consequently the silt settles, and this reduces the rate of flow. If the main ditch is broken just before there is a rise in the river, the water is usually lost before the ditch can be repaired. Another disadvantage is that weed seeds are carried in the river water.

Irrigation of upland soils began much later than irrigation of the bottom lands. The first irrigation wells in the uplands were drilled in 1947. Since then, wells have been drilled in practically every part of the county where cultivated crops are grown. The principal upland soils being irrigated are the Richfield and Dalhart soils (figs. 15 and 16). A larger acreage of Richfield soils than of Dalhart soils is irrigated. The Richfield soils take in water more slowly and lose more by evaporation and runoff, but they are more nearly level and consequently easier to irrigate.

The Richfield soils are used to grow grain sorghums, wheat, sudangrass for supplemental pasture, and alfalfa. Under irrigation, these soils have produced 40 to 135 bushels of grain sorghum and 20 to 45 bushels of wheat per acre. Irrigated pastures of sudangrass on these soils will carry 2 to 4 animals per acre for 115 days. Alfalfa will yield 3 to 5 cuttings a year. There is little or no evidence of wind or water erosion on irrigated Richfield soils. Generally, the soils are in good physical condition and have a good cover of stubble or growing vegetation.

Ordinarily, no commercial fertilizer is used on irrigated soils. Those farmers who have used fertilizer do not agree as to its value. Some report slight increases in yields; others say there were no increases.

Figure 13.—Water is diverted from the Cimarron River by small dams like this one and used to irrigate bottom-land soils.

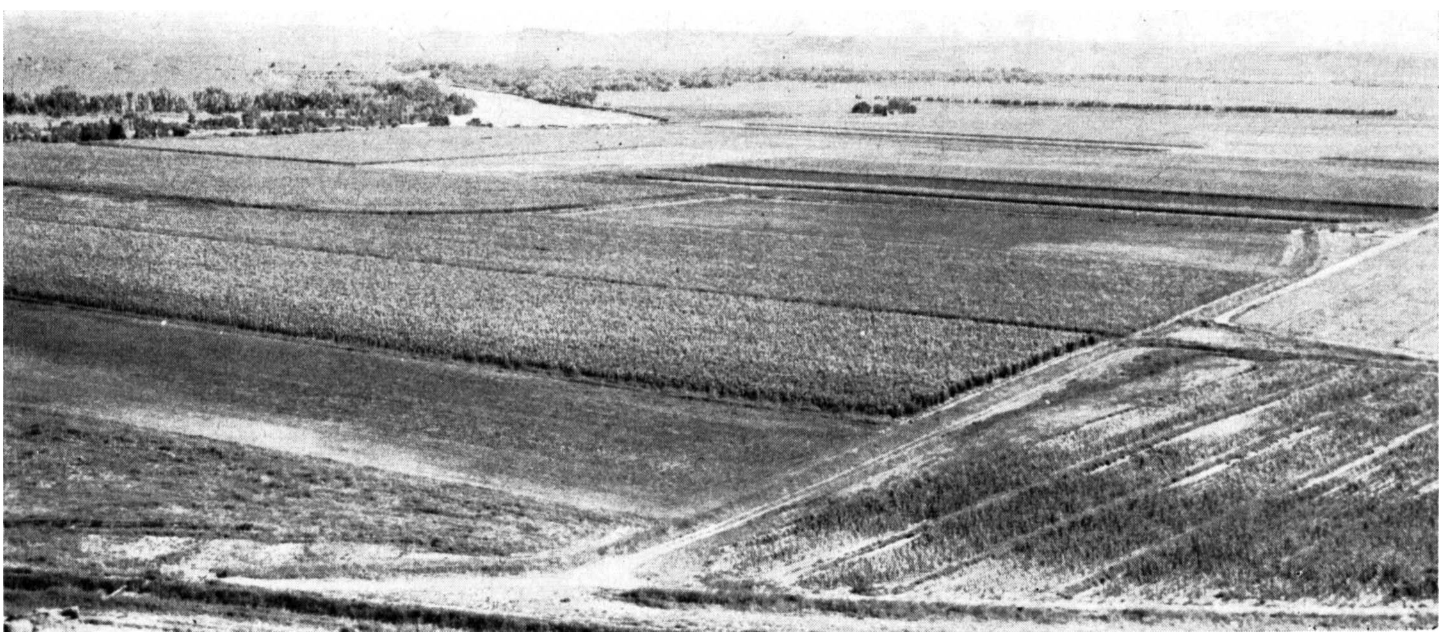

Figure 14.—Irrigated Spur soils can grow a wide variety of crops. Water is diverted from the Cimarron River, or wells are drilled into water-bearing beds along the flood plain.

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Figure 15.—Siphoning water from irrigation lateral to water a grain sorghum crop on Richfield clay loam.

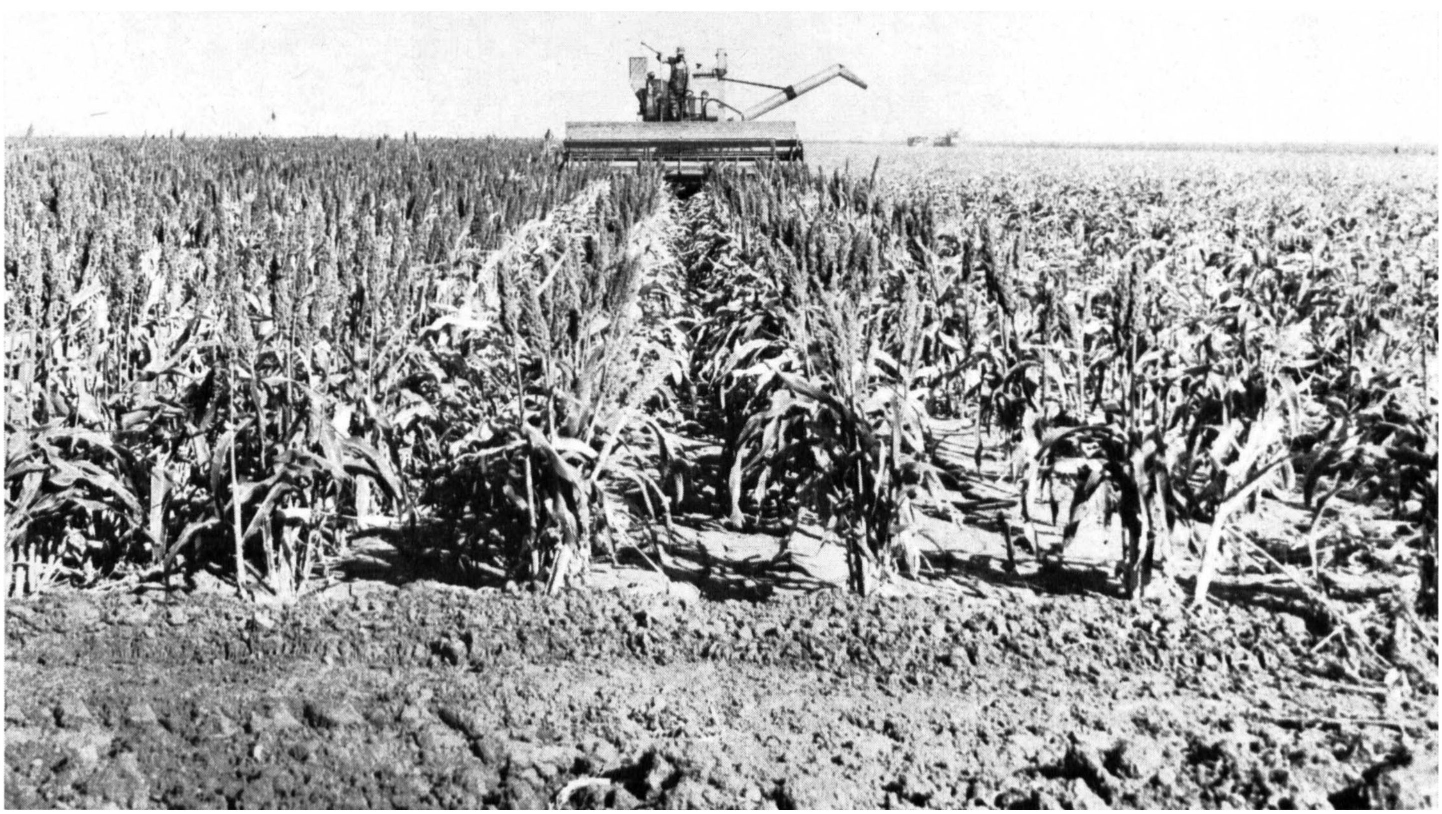

Figure 16.—Irrigated grain sorghums on Richfield clay loam produced over 80 bushels per acre.

Border, row, and overhead systems of irrigation are used on the upland soils. The overhead (sprinkler) system is not well suited to this area, and on the more nearly level areas it is being replaced by row or border systems. It is now more common on the Dalhart soils than on the Richfield, because the Dalhart have a more irregular surface.

New irrigation systems are being installed rapidly. In 1950, there were 1,000 irrigated acres on 20 farms; in 1955, there were 2,800 irrigated acres on 28 farms. At the time this survey was made, a considerably larger acreage was under irrigation and about 100 irrigation wells were being used. It is difficult to estimate how many additional acres will be irrigated, because there is insufficient knowledge of the underground water supply. Also, a weather cycle of adequate rainfall would bring a decrease in interest in irrigation.

The Dalhart soils produce good yields, under irrigation, but they are likely to be damaged by wind erosion. The principal crop is grain sorghum. Alfalfa and sudangrass are also grown. The common sandbur is becoming a pest in many irrigated fields, especially where alfalfa is grown.

The supply of underground water is limited. Some areas seem to have plenty of water for irrigation, while others do not (fig. 17). Some of the best Richfield soils in the county are in the east-central part, in an area where red beds are near the surface and the water supply is barely sufficient for domestic needs. The depth to the static water level in the present irrigation wells varies from 90 feet to 350 feet. For every producing well in the county, approximately two test holes have been drilled that did not show a sufficient depth of water-bearing sand to produce water for irrigation.

Stuart Schoff, in his "Geology of Cimarron County" (Oklahoma University, 1942), gave the approximate location of some underground pretesting streams in which, he predicted, there was water in quantities sufficient for irrigation. Recently drilled wells and test holes have proven this report to be reasonably accurate.

Before an irrigation system is installed, the following questions should be considered:

1. How many acres can be irrigated adequately with the available supply of water?
2. What system is best: Border, row, or overhead?
3. How often should water be applied, and how much should be applied at one time?
4. What practices will be necessary to preserve the soil structure and to maintain fertility?

Farmers planning irrigation systems should consult local agricultural agencies for technical help. Neighbors who have had experience with irrigating can also help. Some suggestions on irrigation structures are given in the section, Engineering Properties of Soils.

Estimated Yields

Table 6 shows the average yields a farmer may expect of wheat and grain sorghums, the two principal cultivated crops, from the arable soils of Cimarron County. The figures in columns A are estimates of the yields that can be expected if the soils are farmed without particular regard to conservation methods. Yields obtained under this level of management may well decrease further. The figures in columns B are estimates of the yields that can be expected if adequate measures are taken to conserve moisture, use crop residues, and control erosion.

The figures in table 6 are averages and reflect the fact that there have been complete crop failures in years of drought.

TABLE 6.—*Estimated average acre yields of principal cultivated crops under two levels of management*

[Yields in columns A are those obtained under ordinary management; yields in columns B are those obtained under improved management]

Soils	Wheat		Grain sorghums	
	A	B	A	B
	Bu.	*Bu.*	*Bu.*	*Bu.*
Berthoud loam, 0 to 3 percent slopes	5. 0	10. 0	13. 0	15. 0
Dalhart fine sandy loam, 0 to 1 percent slopes	2. 5	6. 0	15. 5	19. 5
Dalhart fine sandy loam, 1 to 3 percent slopes	2. 5	6. 0	13. 5	18. 5
Dalhart fine sandy loam, 0 to 3 percent slopes, eroded	1. 5	4. 0	9. 0	16. 0
Dalhart loamy fine sand, 0 to 3 percent slopes	2. 5	5. 0	6. 0	17. 5
Mansker loam, 0 to 3 percent slopes	4. 5	7. 0	7. 0	8. 5
Mansker-Dalhart loams, 1 to 3 percent slopes	4. 0	7. 0	5. 0	13. 5
Portales clay loam, 0 to 1 percent slopes	6. 0	10. 0	9. 0	11. 0
Portales clay loam, 1 to 2 percent slopes	5. 0	7. 0	6. 0	8. 0
Richfield clay loam, 0 to 1 percent slopes	6. 0	11. 5	7. 5	10. 0
Richfield clay loam, 1 to 2 percent slopes	5. 5	8. 0	5. 0	7. 5
Richfield fine sandy loam, 0 to 1 percent slopes	4. 5	7. 5	15. 5	19. 5
Richfield loam, 0 to 1 percent slopes	5. 0	10. 0	13. 0	16. 0
Spur soils	8. 0	11. 5	9. 0	10. 5

Range Management

The shortage of water overshadows all other agricultural problems in Cimarron County, but an abundance of rain would not eliminate the need for good management of the native range. Unless the soil is in good physical condition and the range grasses are growing vigorously, the grasses do not get the full benefit of the available moisture. Soil that has been packed by trampling and that has been continuously and closely grazed has little air space and has lost much of its ability to soak up rain water. It is not a good environment for the earthworms and other organisms that are needed to keep the soil in good condition.

The fact that the soil has never been broken is no assurance that it is in good physical condition. Less water is absorbed by the soils in heavily grazed pastures than by soils used for wheat.

It is certain that the original grasslands had good capacity to absorb water, supported a vigorous growth of range plants, and could maintain cattle the year round without supplemental feed. The objective of range management is to restore the range, as nearly as practicable,

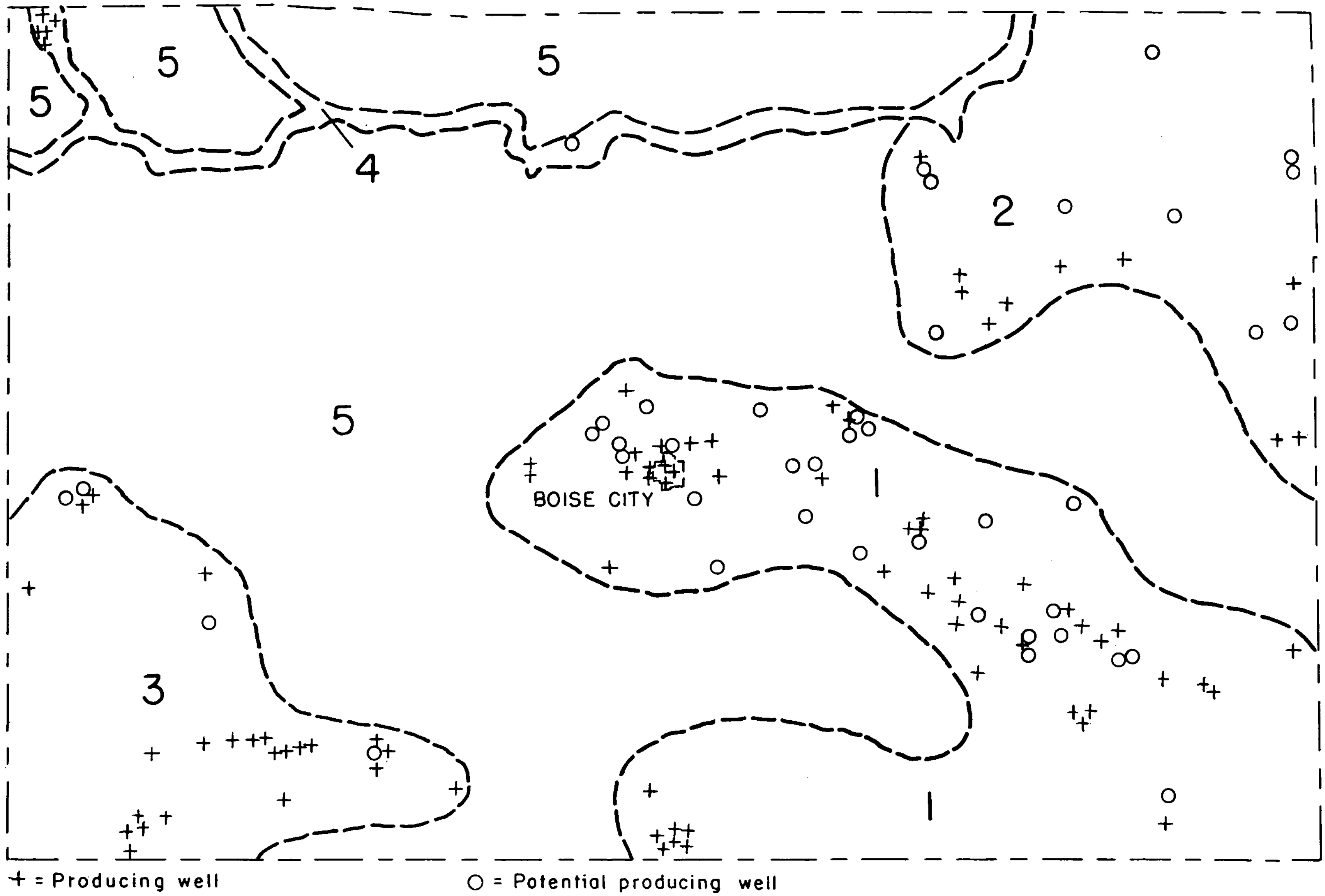

Figure 17.—**Location of producing and potential irrigation wells in Cimarron County, Okla.**

Area	*Depth of wells (Ft.)*	*Production (Gal. per minute)*
1	100 to 1,000	200 to 400
2	250 to 420	100 to 700
3	200 to 500	300 to 1,000
4	30 to 300	800 to 1,600
5	Untested	Untested

to its original condition, by achieving a balance between grass cover, livestock, and other animal life. Regulation of grazing, control of weeds and brush, and reseeding are important practices in the management of the native range.

Regulation of grazing.—This is the surest way to protect or restore the range. A rule of thumb in range management is to allow only half of each year's growth to be grazed off. The grass that is left will supply seed, protect the soil from erosion, and increase its capacity to absorb water. In addition, it forms a reserve of feed that can be used in an emergency.

Because of the erratic climate, plans for regulating grazing must be flexible. By stocking the range lightly with cows and holding over calves or buying stockers to use the grass at times when there is plenty of rainfall, a rancher can maintain a reasonable herd at all times and can lighten the grazing load quickly during a dry spell.

When herds of buffalo, antelope, and deer lived on the plains, their grazing was regulated by nature, and the better range plants were able to thrive. When the grass was grazed short in one place, the animals would move to another range.

With domestic cattle, it is difficult to get even use of forage if the range is partly flat land and partly steep, broken land. The cattle will keep the flat areas heavily grazed, and the breaks are likely to be undergrazed. Fencing between sites is one way of getting even use. Proper location of water and salt also encourages even grazing. Placing salt in lightly grazed areas will attract the cattle. Salt and water need not be near together.

Deferment of grazing is a means of speeding the improvement of an overgrazed range, but it should not be resorted to at the expense of overgrazing other areas. Deferred pastures provide reserves of feed for winter use.

Control of brush and weeds.—On well-managed range, the native grasses will crowd out the weeds. If a cover of sand sagebrush and other woody plants has developed, it is usually profitable to use foliage sprays. Mowing, beating, or one-waying are slower, more expensive, and usually less effective than spraying. Using a big disk one-way does, however, have the advantage of smoothing out the hummocks that have formed around the brush crowns.

Sagebrush provides some forage and gives some protection to sandy soils. If it is removed, the growth of grasses should be encouraged. If the grass is scanty, the areas may be overseeded with suitable native grasses. Whether overseeded or not, they need growing-season rest immediately after the brush is removed, so that the grasses will develop a vigorous stand and produce seed. Moderate grazing during the winter is ordinarily not harmful, since the plants are less likely to be damaged while dormant. In fact, some winter use may help to get the soil in good condition for reseeding.

Reseeding.—Range that has been broken out should be reseeded to suitable native grasses. The shorter native grasses—blue grama and buffalograss—are better suited to the clay loams and loams, and the taller grasses are better suited to the sandy soils. Side-oats grama is better suited to shallow soils than buffalograss and blue grama. A mixture of side-oats grama, blue grama, western wheatgrass, and buffalograss may be seeded on the clay loams and loams. A mixture of little bluestem, sand bluestem, switchgrass, western wheatgrass, blue grama, and side-oats grama is suggested for sandy soils. A dead cover of a crop such as drilled grain, sorghum, or sudangrass makes a good seedbed. The grass seed may be drilled into this stubble without any additional cultivation. The litter will protect the grass seedlings until they are firmly established.

Range condition classes

To select the best methods of improving the range, the operator needs a practical understanding of the important range plants and the combinations in which they grow. He should be able to read the signs that show him whether the range is getting better or worse. Important changes often take place so gradually that they can be overlooked or misunderstood if the operator is not well acquainted with the vegetation and soils. For example, if plant growth has been stimulated by favorable rainfall, it may appear that the range is improving, when the long-time trend actually is toward poorer grasses and lower production. On the other hand, occasional close use that gives the general appearance of degraded range may cause only a temporary setback to healthy and well-managed grassland.

An operator can learn about the local range sites and their vegetation by studying areas that have not been damaged by heavy grazing, fire, or other disturbances. These areas he should compare with similar sites under different methods of grazing. Once he has the ideal examples of the local range sites well in mind, he can estimate the degree of change that has taken place on his range and decide whether it is improving or deteriorating.

Four classes of range condition are defined—excellent, good, fair, and poor. "Excellent" indicates that 75 to 100 percent of the stand consists of the best kinds of native vegetation the site is capable of producing; "good" indicates that the percentage is 50 to 75; "fair," that it is 25 to 50; and "poor," that it is less than 25. The percentages refer to the kinds of vegetation on a given site, not to the density of the grass.

Sometimes the range condition class may be higher or lower for reasons other than kinds of vegetation. For example, a site formerly in poor condition may have recovered to the extent that from 50 to 75 percent of the range cover consists of the best kinds of plants. Normally, this would be judged as range in good condition, but it might be classified as only fair if there is very little litter on the ground, or if the stand is sparse, or if the soil is in poor condition, or if erosion is active.

Range sites

In planning for range management, the kind and quantity of grass that the soils will produce must be considered. Under similar management, a soil with plenty of depth for intake of water and growth of roots will support more vegetation than a shallow soil. Where rainfall is scanty, sandy soils produce more and taller vegetation than hardlands.

A range site is an area of natural grazing land that because of its particular combination of climate, soil, and topography will support a particular type and amount

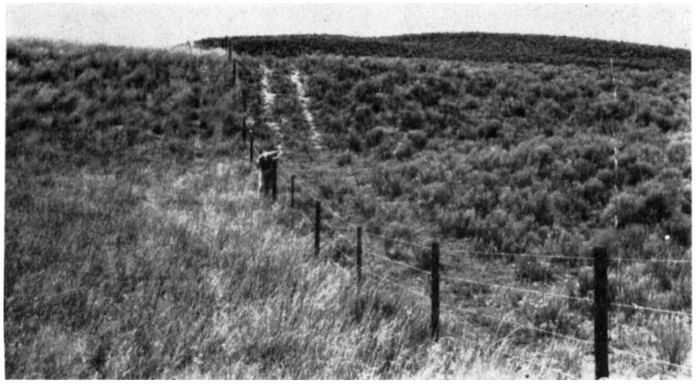

***Figure 18.*—This range is in the deep sand site. The area on the right is infested with sand sagebrush and is in fair condition. Brush was controlled on the area on the left, and range is in excellent condition.**

of natural vegetation. Nine range sites are recognized in Cimarron County. In the following pages, each of these sites is described and some suggestions for management are given. No guides for stocking rates are given, because on one ranch there may be several range sites, and within the same site there may be different classes of range condition. Technical personnel of agricultural agencies can give advice on stocking rates for a particular area of range, but an operator who knows the range sites and understands the signs of improvement or deterioration can generally tell when the range is overstocked and when it is understocked.

SUBIRRIGATED LOWLAND SITE

This site is in the level or lower areas of sandy flood plains, where the soils are permanently moist and ground water is generally within 3 feet of the surface. Some subirrigated soils above the flood plain are included. The principal soil in this site is Sweetwater fine sandy loam.

This site is not extensive, but it is the most productive range site in Cimarron County. In its best condition, it supports a cover of switchgrass, sand bluestem, prairie cordgrass, plains bluegrass, and many other plants. If it is overgrazed, inland saltgrass increases greatly, at the expense of the more palatable and more productive plants. In such cases, improvement might be made by allowing heavy grazing for brief periods late in spring and early in summer, followed by summer deferment. This system makes use of the tough inland saltgrass when it is most palatable and permits recovery of the switchgrass, sand bluestem, and other more desirable grasses.

SANDY BOTTOM-LAND SITE

This site is on uneven, deep, sandy flood plains, principally along the tributaries of the Cimarron and Beaver Rivers and to a lesser extent along the two rivers. The lower areas are subject to flooding and deposition of sand. In some sloughs and low spots the water table is high. Most of this site consists of Lincoln soils.

In productivity, this site is intermediate between the subirrigated lowland site and the deep sand site. The principal grasses are sand bluestem, sandreed, switchgrass, little bluestem, alkali sacaton, and Canada wildrye. Cottonwood and willow trees grow in low spots, and sand sagebrush is prominent on the low dunes. Silver bluestem, sand dropseed, and hairy grama increase if grazing and drought weaken the better grasses.

This site is likely to be heavily grazed because livestock gather here for water, shade, and protection from storms. If water is available elsewhere, this site might be fenced and protected to keep it in the best possible condition.

LOAMY BOTTOM-LAND SITE

This site consists principally of Spur soils. In texture, these soils are similar to many soils in the hardland site, but they are more productive than the hardland soils because they receive runoff water from adjacent higher areas. They are seldom flooded.

The better forage plants include western wheatgrass, vine-mesquite, side-oats grama, Canada wildrye, and switchgrass. Blue grama and buffalograss are present, and they increase under heavy grazing. Other species that tend to replace the better grasses are silver bluestem, sand dropseed, and perennial three-awn.

Only a little of this site is in native grass. Some of it is used for irrigated improved pasture. Management is about like that for the hardland site.

DEEP SAND SITE

This site consists principally of Dalhart loamy fine sand, 0 to 3 percent slopes; Dalhart loamy fine sand, 0 to 3 percent slopes, eroded; Otero loamy fine sand; and Vona-Tivoli loamy fine sands. These are deep sandy soils. The subsoils are permeable but only slightly retentive. Water is absorbed rapidly and is readily available to plants. This permits the growth of the taller range grasses and of palatable legumes.

At present, most of this site is moderately to heavily infested with sand sagebrush (fig. 18). Sand bluestem, little bluestem, switchgrass, needle-and-thread, side-oats grama, and spike dropseed grow in the areas that are in good or excellent condition. The plants that most readily increase or invade under grazing are blue grama and sand dropseed. Other increasers are silver bluestem, hairy grama, sand sagebrush, and numerous annuals.

The grass close to and within the spread of clumps of sand sagebrush is not easily eaten by cattle, but it contributes seed. Signs of heavy use include the breaking open of sagebrush plants by cattle searching for grass, uniformly short stubble of blue grama between the brush clumps, and a scarcity of the taller grasses.

SANDY PLAINS SITE

The principal soils in this site are Berthoud fine sandy loam, 2 to 5 percent slopes; Dalhart fine sandy loam, 0 to 1 percent slopes; Dalhart fine sandy loam, 1 to 3 percent slopes; Dalhart fine sandy loam, 0 to 3 percent slopes, eroded; Mansker fine sandy loam, 2 to 5 percent slopes; and Richfield fine sandy loam, 0 to 1 percent slopes. These soils have more clay in the subsoil than the soils in the deep sand site. Internal drainage is generally moderate. The soils are nearly level to gently undulating.

This site is less productive than the deep sand site, but it is more productive than the hardland site because it has a better supply of moisture. If well managed, it should support a good stand of side-oats grama, little

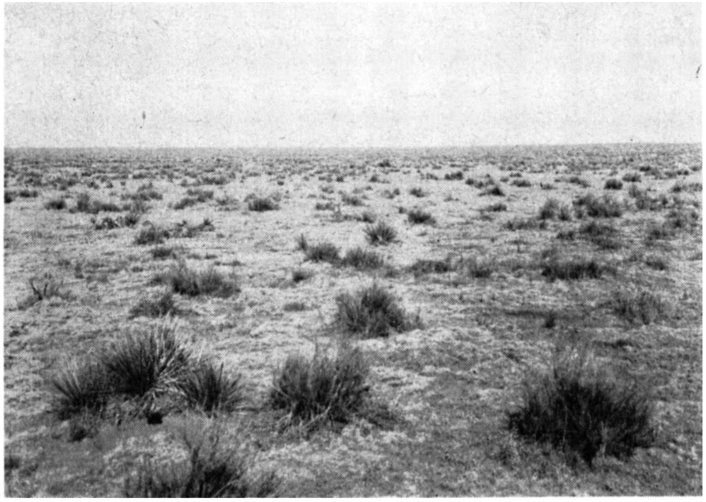

Figure 19.—**Range in fair condition on sandy plains site.**

bluestem, sand bluestem, and blue grama (fig. 19). Western wheatgrass, vine-mesquite, and Canada wildrye grow in some places. If the site is overgrazed, blue grama becomes the dominant grass, and yucca increases. Very little sand sagebrush is found.

Reseeding should be done in a trashy cover, so that the grass seedlings will be protected.

HARDLAND SITE

The principal soils in this site are Berthoud loam, 0 to 3 percent slopes; Berthoud loam, 3 to 5 percent slopes; Carnero loam; Mansker loam, 0 to 3 percent slopes; Mansker loam, 3 to 5 percent slopes; Mansker-Dalhart loams, 1 to 3 percent slopes; Portales clay loam, 0 to 1 percent slopes; Portales clay loam, 1 to 2 percent slopes; Randall clay; Richfield clay loam, 0 to 1 percent slopes; Richfield clay loam, 1 to 2 percent slopes; Richfield loam, 0 to 1 percent slopes; and Vernon clay loam. Except for Randall clay, which is a heavy clay soil, these soils take water fairly well. The topography is nearly level to gently rolling.

In its best condition, this is typically blue-grama country. There is some buffalograss. The taller grasses dominate in the shallow drainageways and in other areas that receive extra moisture. These tall grasses include side-oats grama, vine-mesquite, western wheatgrass, silver bluestem, and galletagrass. Bottlebrush squirreltail is a cool-season grass common on this site. Buffalograss tends to increase if the range is overgrazed, because it can escape destructive grazing. Galletagrass escapes heavy grazing because of its low palatability. Ring muhly (ringgrass), red three-awn, and broom snakeweed also become abundant under heavy use.

Healthy, vigorous individual plants of blue grama and the presence of taller grasses in drainageways are signs of improvement in this site. If heavily grazed, blue grama develops a matlike form and provides less forage (fig. 20).

STONY LOAM SITE

The common soils in this site are Apache stony clay loam and Travessilla stony loam. These soils are associated with Rough stony land, which is in the breaks site in the northwestern part of the county. The slopes range from nearly level to 12 percent. The soils are shallow, and there are some rock outcrops.

This site is somewhat higher in productivity than the shallow site. The better grasses include little bluestem, cane bluestem, vine-mesquite, Arizona cottontop, plains bristlegrass, black grama, and blue grama. Blue grama, black grama, and buffalograss increase under heavy grazing.

SHALLOW SITE

The principal soils in this site are those in the Mansker-Potter complex, 3 to 12 percent slopes, and Potter-Mansker loams, 1 to 3 percent slopes. These soils usually have caliche and gravel on the surface. Bare spots of caliche or sandstone are common. The slopes are strongly rolling.

The gravelly nature of these soils permits fairly good water intake on moderate slopes. Shallowness and low water-holding capacity, however, limit the production of range forage, as compared to the hardland site. It is difficult to maintain a good mulch on this site. In many places, runoff is high and erosion is active.

The principal range grasses, under best conditions, are side-oats grama, little bluestem, and sand bluestem. Hairy grama increases if the range is overgrazed, and blue grama increases in the deeper soil pockets. Red three-awn and ring muhly also increase under heavy grazing.

BREAKS SITE

This site is in the northwestern part of the county (fig. 21). The soils in it are mapped as Rough stony land. Included are areas of very shallow soil and bare rock along the caprock and on valley floors less than 200 feet wide. The steep rocky slopes are underlain by both soft and hard sandstones. Included are many crevices and pockets in which the soils are deep, loamy, and moderately productive. However, steepness and stoniness keep this site from being well utilized, since cattle tend to concentrate on the smoother stony loam site and loamy bottom-land site, which are nearby.

The better grasses on this site include big bluestem, cane bluestem, little bluestem, switchgrass, Indiangrass, New Mexico needlegrass, vine-mesquite, and Arizona cottontop. Common grasses that increase or invade under heavy use include hairy grama, black grama, silver bluestem, wolftail, red three-awn, and rough tridens.

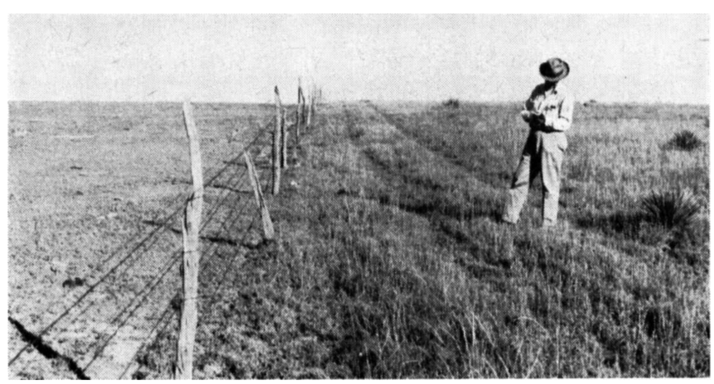

Figure 20.—**The overgrazed pasture on the left is mostly in buffalograss and low, matted blue grama. On the right is side-oats grama and taller blue grama.**

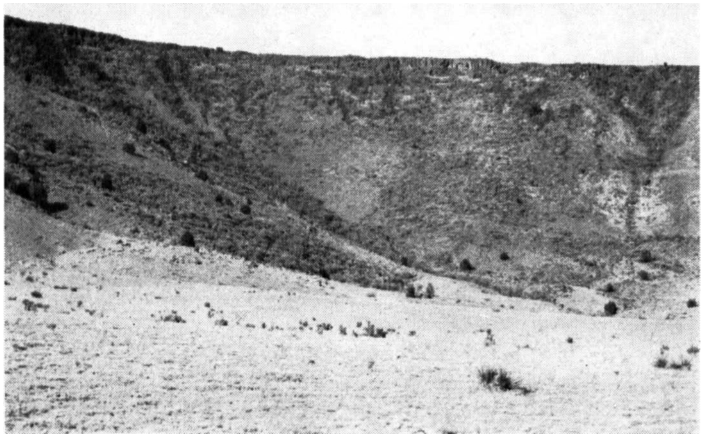

Figure 21.—**An area in the breaks site, on the side of Black Mesa. In the foreground is Berthoud loam, which is in the hardland site.**

Woody species common to the site are mountain-mahogany, Gambel oak, and pinyon pine.

Because it is used less, this range site is apt to be in better condition than nearby, smoother sites. A decrease in bluestems and an increase in gramas is a sign of deteriorating range condition.

How the Soils Are Formed and Classified

Factors of Soil Formation

Soils are developed by the action of soil-forming processes on accumulated materials. The factors that determine the characteristics of the soil at any given place are (1) the kind of parent material, (2) the climate under which the parent material accumulated and has existed since its accumulation, (3) the plant and animal life on and in the soil, (4) the relief, or lay of the land, and (5) the length of time the forces of soil development have acted on the parent material. Climate and living organisms are the active factors of soil formation. Their effect on the accumulated parent material is modified by the relief and by the length of time the parent material has been in place.

Classification of Soils by Higher Categories

Soils are placed in narrow classes for the purpose of organizing and applying knowledge of their behavior within a farm or a county. They are placed in broader categories to facilitate study and comparison of continents or other large areas.

The broadest of these categories are the three soil orders—the zonal, intrazonal, and azonal. Within each order are a number of great soil groups, which are smaller categories consisting of broadly similar soil series.

Zonal soils are those that reflect the predominant influence of climate and living organisms. These soils develop where drainage is good but not excessive and where the parent material has been in place long enough for the soil-forming factors to have full effect.

In the dry climate of Cimarron County, nearly level relief is necessary for the development of zonal soils. Moisture penetrates most deeply and leaches most thoroughly in level areas. Penetration of water encourages penetration of roots and the accumulation of organic matter.

Typical zonal soils in Cimarron County are the Richfield, Dalhart, Vona, and Carnero. These soils occupy most of the level to gently undulating areas where the parent materials have been in place for comparatively long periods. The sandy soils are leached of free calcium to depths of 36 inches. In the clay loams, there is free calcium at depths of 15 to 24 inches. Because it is not moved completely out of the soil, the calcium collects and forms lime zones. These zones vary from indistinct, limy streaks containing pockets and concretions to chalky, nearly white layers.

The zonal great soil groups have fairly definite ranges, but they digress slightly at the edge of the ranges because of local differences in parent material and microclimate. Cimarron County lies near the southern limit of occurrence of the Brown soils and the Chestnut soils and is transitional to the zones of the Reddish Brown soils and Reddish Chestnut soils. The Dalhart and Richfield, which are Chestnut soils, and are in the southwestern part of their range. The Vona are Brown soils and are close to the southeastern limit of their range.

Intrazonal soils are those in which the influence of climate and living organisms is overshadowed by the influence of parent material or relief.

The zonal great soil groups have rather definite ranges, but intrazonal soils can occur over wider areas. The intrazonal soils in Cimarron County are the nearly level Portales and the sloping Mansker, which are both in the Calcisol great soil group, and the Randall, which are in the Grumusol great soil group.

Azonal soils do not have distinct soil profiles. They are much like their parent material, either because this material is resistant to weathering or because it has not been in place long enough for soil development to take place. The azonal soils in this county are limy throughout, but, as in the parent materials, there are no distinct zones of lime accumulation.

The great soil groups of the azonal order may occur in any part of the world. The Alluvial great soil group occupies flood plains and colluvial slopes in all climates. The Alluvial soils in Cimarron County are those of the Lincoln, Sweetwater, Berthoud, and Spur series. Another great soil group, the Regosols, is represented here by the Tivoli on siliceous sands, and by the Vernon on clay beds. Lithosols are shallow soils over hard rock, such as the Travessilla and Apache, or shallow soils over hard caliche, such as the Potter.

Key to Soil Series and Great Soil Groups

Table 7 shows the classification of the soil series of Cimarron County by great soil groups and gives the topographic position, parent material, and dominant relief of each series.

TABLE 7.—*Key to the soil series and great soil groups*

Parent material	Relief			
	Gently sloping to steep or duny	Gently sloping to sloping	Level to gently sloping	Level
SOILS ON UPLANDS				
Weakly consolidated sediments:				
Calcareous clay loam				Randall (*Grumusols*).[1]
Highly limy clay loam with local occurrences of hardened caliche beds.	Potter (*Lithosols*).	Mansker (*Calcisols*).	Portales (*Calcisols*).	
Highly limy sandy loam and loamy sand.		Otero (*Brown soils; intergrades to Calcisols*).		
Calcareous clay loam			Richfield (*Chestnut soils*).	
Moderately to slightly calcareous loamy sand and sandy loam.		Vona (*Brown soils*).	Dalhart (*Chestnut soils*).	
Hard rocks:				
Brown, calcareous, fine-grained sandstone.	Travessilla (*Lithosols*).		Carnero (*Brown soils*).	
Calcareous red clay beds thinly banded with sandstones.		Vernon (*Regosols*).[4]		
Olivine basaltic lava		Apache (*Lithosols*).		
Loose sand and colluvium:				
Siliceous loamy sand, relatively short time in place.	Tivoli (*Regosols*).			
Colluvium from sandstone, relatively short time in place.		Berthoud (*Alluvial soils; intergrades to Brown soils*).		
SOILS ON BOTTOM LANDS				
Unconsolidated alluvium:				
Calcareous clay loam			Spur (*Alluvial soils*).	
Calcareous sandy loam and loamy sand.			Lincoln (*Alluvial soils*).[2]	Sweetwater (*Alluvial soils*).[3]

[1] Sometimes ponded; an atypical Grumusol.
[2] Slightly hummocky in places.
[3] High water table; generally not ponded.
[4] In areas of ledge sandstone, Vernon soils have some characteristics of Lithosols.

Detailed Descriptions of Soils

Detailed descriptions of the soils mapped in Cimarron County are given in this section. Some are descriptions of profiles observed at sites from which samples for laboratory analyses were taken. Others are based on notes made by the field party and the correlators. Colors are given by name and by Munsell designation; they are for dry soil except where moist is specified. Wherever possible, a location where the soil can be examined is given.

Apache stony clay loam.—This is a calcareous Lithosol. It occurs on lava rocks on the top of Black Mesa and is associated with Rough stony land and with Travessilla stony loam. It developed under mixed grasses, is shallow over rock, and has rock fragments throughout the profile.

The following profile is in an area that has a moderately stony surface and a convex slope of about 2 percent.

A 0 to 8 inches, grayish-brown (10YR 5/2; 3/2, moist) clay loam; moderate, medium to fine, granular structure; calcareous; fragments of basalt 10 to 20 millimeters in diameter make up to 20 percent of the soil mass; grades to

C 8 to 16 inches, very pale brown (10YR 7/3; 6/3, moist) clay loam; moderate, medium to fine, granular structure; calcareous; fragments of basalt are more numerous and larger in size (up to 40 millimeters in diameter); grades to fractured, relatively unweathered olivine basalt.

Variations.—Depth to basaltic bedrock normally is 12 to 20 inches, but is more in pockets or small concave spots. Wide variation in the number and size of stone fragments in the profile and on the surface.

Topography.—Convex slopes of 1 to 4 percent.

Present use.—All in native range.

Distribution.—Only on Black Mesa, which is in the northwestern part of the county.

Berthoud loam, 3 to 5 percent slopes.—This is a deep, calcareous Alluvial soil that developed from colluvium derived from fine-grained, brown sandstone. It occurs mostly on well-drained foot slopes below Travessilla stony loam and Rough stony land. The native vegetation was a mixture of grama and buffalograss.

The following profile is in an area that is in native grass and has a concave slope of about 4 percent.

A 0 to 6 inches, dark grayish-brown (10YR 4/2; 3/3, moist) loam or light clay loam; moderate, medium to fine, granular structure; alkaline; grass roots plentiful; grades to

AC 6 to 42 inches, light brownish-gray (10YR 6/2; 5/2, moist) clay loam; weak, granular structure; sticky when wet, hard when dry; calcareous; a few fragments of rocks; grass roots plentiful; grades to

A_b 42 to 58 inches, grayish-brown (10YR 5/3; 3/2, moist) heavy clay loam; medium, granular structure; calcareous; a few grass roots.

Variations.—Chiefly in the number of sandstone fragments and in the color of the lower layers. The A_b horizon appears to be a buried horizon of an older soil. Slightly limy zones in places. A few rock fragments on the surface where this soil adjoins Travessilla soils.

Topography.—Concave foot slopes. Slopes range from 2 to 6 percent, but are mostly about 4 percent.

Present use.—Practically all in native range.

Distribution.—All in the hard-rock area in the northwestern part of the county.

Berthoud loam, 0 to 3 percent slopes.—This soil is like Berthoud loam, 3 to 5 percent slopes, except that it occurs on the lower part of long foot slopes and along the edges of the wider valleys. The slopes probably range only from 1½ to 2 percent. The A horizon is nearly 10 inches deep. The incidence of layers containing sandstone fragments is less than in Berthoud loam, 3 to 5 percent slopes.

Berthoud fine sandy loam, 2 to 5 percent slopes.—This soil is similar to Berthoud loam, except that it is sandier throughout. The following profile is in an area that is in native grass and has a weakly concave slope of about 3 percent.

A 0 to 6 inches, brown (10YR 5/3; 4/3, moist) fine sandy loam; moderate, medium to fine, granular structure; neutral; grades to

AC 6 to 18 inches, yellowish-brown (10YR 5/4; 4/4, moist) heavy fine sandy loam; weak, medium to fine, subangular blocky structure; friable; calcareous; threads of calcium carbonate in lower part; a few rock fragments; grades to

C_1 18 to 30 inches, light brownish-gray (10YR 6/2; 5/2, moist) sandy clay loam; weak, medium to coarse, subangular blocky structure; friable; calcareous; threads of calcium carbonate become numerous with depth; a few irregular-sized rock fragments; grades to

C_2 30 to 52 inches, light yellowish-brown (10YR 6/4; 5/4, moist) clay loam; friable; high in lime; irregular-sized sandstone fragments become more numerous with depth.

Variations.—Chiefly in lime content and number of stone fragments in the substratum. Darker colors in some places may represent buried soils.

Topography.—Gentle to moderate, concave foot slopes, commonly below areas of Rough stony land or Travessilla soils.

Present use.—All in native range.

Distribution.—All in the hard-rock areas in the northwestern part of Cimarron County.

Carnero loam.—This is a moderately deep Brown soil that developed from calcareous brown sandstone. It occupies nearly flat hilltops above areas of Travessilla stony loam. The native vegetation was a mixture of grama, bluestem, and buffalograss.

The following profile is in an area that is in native range and has a weakly convex slope of about 2 percent.

A 0 to 8 inches, brown (7.5YR 5/2; 4/2, moist) loam; moderate, medium to fine, granular structure; neutral to alkaline; grades to

B_2 8 to 16 inches, light yellowish-brown (10YR 6/4; 5/3, moist) clay loam; weak, medium, granular structure; alkaline but noncalcareous; grades to

BC_{ca} 16 to 28 inches, light yellowish-brown (10YR 5/4) clay loam; weak, medium, subangular blocky structure; strongly calcareous; contains fragments of sandstone and small calcium carbonate concretions; grades to

D 28 to 42 inches +, light-brown hard sandstone; calcareous; slightly weathered in upper part.

Variations.—Surface soil is brown or light brown. Depth to bedrock ranges from about 18 to 30 inches. Subsoil is clay loam and sandy clay loam. Variable but not excessive numbers of rock fragments in the substratum.

Topography.—Gentle convex slopes, mostly of about 2 percent. The soil is permeable, but some runoff does occur.

Present use.—All in native range.

Distribution.—All in the sandstone rock area in the northwestern part of Cimarron County.

Dalhart fine sandy loam, 0 to 1 percent slopes.—The Dalhart soils are deep, Chestnut soils. They overlie moderately sandy materials, mostly of the Quaternary period, which were deposited over Tertiary loams on the High Plains. They formed under a mixture of grasses, including grama, buffalograss, and bluestem. The landscape varies from very gently undulating to hummocky; the sandier soils are the most humpy. The Dalhart soils are closely associated with the Richfield, Mansker, and Portales soils.

The following profile of Dalhart fine sandy loam, 0 to 1 percent slopes, is in an area that has a very weakly convex slope of about 1 percent.

A_1 0 to 8 inches, brown (10YR 5/3; 4/3, moist) fine sandy loam; weak, medium to fine, granular structure; noncalcareous; grades to

B_2 8 to 24 inches, dark-brown (10YR 4/3; 4/4, moist) sandy clay loam; strong, medium to fine, granular structure; sticky when wet, hard when dry; calcareous in the lower 4 to 6 inches; grades to

B_3 24 to 35 inches, pale-brown (10YR 6/3; 5/3, moist) sandy clay loam; weak, medium, blocky structure; calcareous; grades to

C_{ca} 35 to 54 inches, very pale brown (10YR 7/4; 6/4, moist) sandy clay loam; strongly calcareous; calcium carbonate concretions are numerous and make up 15 to 30 percent of the soil mass; grades to

C 54 to 74 inches +, pale-brown (10YR 6/3; 5/3, moist) sandy clay loam; moderate, medium, granular structure; sticky when wet; calcareous; contains a few soft calcium carbonate concretions.

Variations.—A_1 horizon varies from light brown to brown in color and from 4 to 10 inches in depth; it is deeper in a few low, drifted areas. Winnowing has changed the uppermost 3 or 4 inches to heavy loamy fine sand in some cultivated areas. Subsoil varies from sandy clay loam to light sandy clay. Depth to the lime zone varies from 24 to 40 inches. Dark-brown, buried soils occur at depths below 30 inches; they are less sandy than the surface soil. Areas next to Dalhart loamy fine sand may be drifted with loamy sand a few inches deep.

Topography.—Very gently undulating, well-drained plains that appear nearly level.

Present use.—About 40 percent cropland; 60 percent is range consisting of grama, bluestem, and buffalograss.

Distribution.—On sandy plains in the southern and northeastern parts of Cimarron County.

Dalhart fine sandy loam, 1 to 3 percent slopes.—This soil occurs with Dalhart fine sandy loam, 0 to 1 percent slopes. It occurs on more undulating landscapes and has both convex and concave slopes. The predominant slope is about 1½ percent, but about 15 percent of this soil has slopes of nearly 3 percent. The soil is so permeable that, in spite of the stronger slopes, it has little more runoff than Dalhart fine sandy loam, 0 to 1 percent slopes.

Some wind erosion has occurred in most areas of this soil. The thickness of the remaining A horizon varies from 3 to about 10 inches. Many small spots of subsoil are exposed, and a few low sand hummocks occur. Nearly half of this soil is cropped, and the rest is in native range. Some areas next to Dalhart loamy fine sand are drifted with loamy sand a few inches deep.

NOTE: The results of mechanical and chemical analyses of two samples of Dalhart fine sandy loam, 1 to 3 percent slopes, are given in tables 8 and 9, which are in the section, Laboratory Analysis.

Dalhart fine sandy loam, 0 to 3 percent slopes, eroded.—The A horizon of this soil varies considerably in thickness. In places it has been completely removed and the clayey subsoil is exposed. Drifts of winnowed loamy sand are common; in fact, the texture over wide areas is almost a loamy sand. Blowout spots and drifted fence rows are common features.

About 70 percent of this soil is cropped; the rest is idle or has reverted to grasses and weeds. Goat head, Russian-thistle, pigweed, and sandbur grow in sandy areas, and blowout spots are bare.

Dalhart loamy fine sand, 0 to 3 percent slopes.—This is a deep, permeable, Chestnut soil. Dalhart loamy fine sands are much like Dalhart fine sandy loams, but they have a sandier A horizon that is 10 to 15 inches deep. Finer textured buried soils are found at depths of 36 inches or more in both types.

This soil is even more erodible than the Dalhart fine sandy loams. Winnowing and shifting of surface layers has been common, and there is considerable range in the thickness of loamy fine sand above the sandy clay loam subsoil.

Because it takes water so well and the subsoil has such good moisture-storage capacity, this soil is very drought resistant and is, consequently, especially valuable for growing summer crops. About half of the acreage is in crops; the rest is in native range. Grama, dropseed, and bluestem are the principal range grasses. Summer forage production is usually high.

Dalhart loamy fine sand, 0 to 3 percent slopes, eroded.—The A horizon of this soil has been shifted and moved by wind so that there are blowout spots, small dunes, and many spots where the sandy clay loam subsoil is exposed.

Eroded areas can be found anywhere within areas of normal Dalhart loamy fine sand. Many start near the crests of low hummocks where blowout spots develop. The shifting sand scours and lifts soil from adjacent land. Small dunes pile up around posts, clumps of tall grass, or any other firm object. Unless stabilized by vegetation, the dunes shift. They may move back and forth over the same area many times.

This soil is hard to farm. About 90 percent of it is now idle or in poor pasture. Thin stands of sand sagebrush, yucca, dropseed, grama, and weeds will, in time, grow up on the idle areas. At present, many areas are unproductive.

Except as noted in this description, this soil is like the uneroded Dalhart loamy fine sand.

Lincoln soils.—These are permeable to rapidly permeable, variously stratified Alluvial soils. They occur on the flood plains of the North Canadian and Cimarron Rivers and the flood plains of creeks that drain the sandy plains. The surface is humpy in many places.

These soils will blow badly if not well covered. They are occasionally flooded and are shifted and sanded to some extent by each major flood. Fresh deposits of lime-rich material keep them calcareous.

These soils are associated with Sweetwater fine sandy loam in slight depressions and with Spur soils on slightly higher, more nearly level areas further back from the streams, where the sediments are finer textured.

The following profile of Lincoln loamy fine sand is on a nearly level bottom land. The area is slightly humpy and has slopes of about 1 percent. The vegetation consists of tall grasses.

- A 0 to 7 inches, brown (10YR 5/3; 4/3, moist) loamy fine sand; single grained; loose; calcareous; grades to
- AC 7 to 15 inches, brown (10YR 5/3; 4/4, moist) loamy sand stratified with brown fine sandy loam; loose; calcareous; grades to
- C_1 15 to 30 inches, very pale brown (10YR 7/4; 5/4, moist) loamy fine sand; loose; calcareous; rests on
- C_2 30 to 72 inches, pale-brown (10YR 6/3; 5/3, moist) fine sand; loose; calcareous.

Variations.—Loamy fine sand is the dominant surface texture, but loam, sandy loam, and clay loam occur in nearly flat places, and clay loams and clays, as much as 15 inches thick, are in low places. Texture of the subsoil ranges from fine sand to fine sandy loam. Surface soils are unstable and may change from time to time.

Topography.—Level to slightly hummocky flood plains; uneven surface.

Present use.—All in range; cover consists of sand bluestem, switchgrass, sacaton, dropseed, and grama. A few cottonwoods grow here, and willows grow in the wetter places.

Distribution.—On flood plains of all streams that drain the soils of the sandy plains.

Mansker loam, 0 to 3 percent slopes.—These are moderately deep Calcisols that have distinct lime zones at depths of 10 to 18 inches. They occur on gentle slopes on the High Plains, among areas of Portales, Dalhart, and Richfield soils, and on stronger slopes in the breaks of the plains, along with Potter and Dalhart soils. The Mansker soils are permeable but have low water-holding capacity. Much water is lost in runoff.

The following profile of Mansker loam, 0 to 3 percent slopes, is in an area that has slightly convex slopes of about 2 percent. The area is used for native pasture of blue grama, side-oats grama, and buffalograss.

- A_1 0 to 7 inches, grayish-brown (10YR 5/2; 4/2, moist) loam or silt loam; strong, medium to fine, granular structure; very friable when moist; calcareous; worm casts numerous; grades to
- AC 7 to 16 inches, pale-brown (10YR 6/3; 5/3, moist) clay loam or heavy silt loam; strong, medium to fine, granular structure; strongly calcareous; a few soft calcium carbonate concretions and rock fragments occur below 12 inches and increase with depth; grades to
- C_{ca} 16 to 38 inches, nearly white (10YR 8/2; 7/3, moist), chalky, very limy material; grades to
- D_r 38 to 46 inches, indurated caliche; small caliche fragments in the upper portion of this layer.

Variations.—Caliche fragments, scattered on surface or in small rings or ovals 20 to 30 feet wide. Caliche layers begin at depths of as little as 10 inches where this soil grades toward the Potter soil or at depths of as much as 20 inches where this soil grades toward Portales soils. Hardened caliche occurs at depths of as little as 18 inches in some places; in other places it is lacking entirely. Caliche stones may have been brought to the surface by rodents, or they may have been exposed by wind or water erosion. Soil becomes particularly loose and susceptible to blowing after cultivation. It may blow out, even in pastures, if not tied down by grasses.

Topography.—Gentle convex slopes, mostly from 1 to 3 percent.

Present use.—About 40 percent cultivated; the rest in native range of grama and buffalograss.

Distribution.—On low rises on the High Plains, on rims around depressions, and in the breaks of the plains; mostly in the eastern, northeastern, and southwestern parts of Cimarron County.

NOTE: The results of chemical and mechanical analyses of samples taken from two profiles of Mansker loam, 0 to 3 percent, are given in tables 8 and 9, which are in the section, Laboratory Analysis.

Mansker loam, 3 to 5 percent slopes.—This soil occurs on the breaks between the plains and the Cimarron River, below areas of Potter soils. In some places it is associated with Dalhart soils. The A horizon is slightly shallower than that of Mansker loam, 0 to 3 percent slopes, and the depth to caliche is only 12 to 15 inches. Drainage is rapid to excessive, and large amounts of water are lost in runoff. Because of the chalky lime zone in the subsoil, the water-holding capacity is low. The slope range is 2 to 6 percent; 4 percent is about average. The slopes are convex to weakly concave.

About 10 percent of this unit consists of small, irregular areas of Potter loam. It was not practical to separate these areas on the map, but they can be recognized by their light-colored, splotchy surface and by caliche flags and pebbles.

Practically all of this soil is in native range. The principal range plants are grama and buffalograss, and there is some three-awn.

Mansker fine sandy loam, 2 to 5 percent slopes.—This soil occurs on foot slopes and gently rolling areas in the breaks of the plains, along with Potter and Dalhart soils and small areas of Travessilla soils. The sandy surface texture results from overblowing with sands from the Cimarron River or from adjacent areas of Dalhart soils.

The following profile is in an area of native range. The surface is convex, and the slope is about 3 percent. The vegetation consists of grama, bluestem, yucca, and sand sagebrush.

A_1 0 to 7 inches, grayish-brown (10YR 5/2; 4/2, moist) fine sandy loam; moderate, medium, granular structure; calcareous; friable; a few calcium carbonate concretions on the surface; grades to

A_3 7 to 14 inches, light brownish-gray (10YR 6/2; 5/2.5, moist) clay loam; strong, medium, granular structure; very friable; strongly calcareous; some concretions of calcium carbonate near the top and increasing in number with depth; many worm casts along with a few roots; grades to

C_1 14 to 22 inches, brown (7.5YR 5/4; 4/4, moist) silty clay loam; strong, fine to medium, subangular blocky and granular structure; many worm casts between peds; the few roots follow natural cleavage lines of the peds: very strongly calcareous; numerous soft to slightly indurated concretions of calcium carbonate that increase in number with depth; grades to

C_{ca} 22 to 30 inches, light-brown (7.5YR 6/4; 5/4, moist) limy clay loam; strong, medium, subangular blocky and granular structure; many worm casts between peds; soft to indurated calcium carbonate concretions throughout; grades to

D_r 30 inches +, semihard caliche, partly fractured at the top; no roots evident.

Variations.—Fine sandy loam varies from a few inches to 10 or 12 inches in thickness. Subsoil is clay loam to sandy clay loam. Limy zones vary from faint (as in above description) to prominent. They are 20 to 30 inches below the surface. Caliche may be at depths of as little as 20 to 24 inches, or may be absent completely.

Topography.—Slightly humpy, irregular slopes, convex in general but locally concave; average gradient about 3 percent.

Present use.—All in range; mostly grama, bluestem, dropseed, sand sagebrush, and yucca.

Distribution.—On slopes below the level plains in the northern part of the county.

Mansker-Dalhart loams, 1 to 3 percent slopes.—This is a complex of Mansker and Dalhart soils that are so closely knit that it is impractical to separate them on the soil map. The areas are 15 to 200 acres in size. The average size is 30 acres. Most areas are about 60 percent Mansker soils and 40 percent Dalhart soils.

The Dalhart soils occur in the lower places. They are deep and have a dark-colored surface soil. The Mansker soils are shallow, light colored, and limy and have caliche spots and surface pebbles.

These soils are associated with Richfield soils and other Mansker soils. They commonly occur in transition areas between soils of the hardlands and soils of the sandy plains.

Topography.—Gently undulating. Slope is commonly about 2 percent, but as much as 15 percent of some areas has slopes of 4 percent.

Present use.—About 60 percent in crops; the rest in native range of grama, buffalograss, and bluestem.

Distribution.—Mostly on the plains east of Boise City, where hardlands and sandy plains merge.

Mansker-Potter complex, 3 to 12 percent slopes.—This is a complex consisting of shallow, limy Mansker loams and of very shallow, limy Potter loams that are stony in many places. It occurs along the breaks of the plains. The two soils are so closely associated that it is impractical to separate them on the soil map.

The proportion of the two soils varies from place to place, but the usual composition is about 65 percent Mansker and 35 percent Potter. The Mansker soils are Calcisols and the Potter soils are Lithosols.

A profile of Mansker loam is described elsewhere in this report.

The following profile of Potter loam is in a native pasture of grama and buffalograss. The slopes are strongly convex, and the gradient is about 8 percent.

0 to 8 inches, grayish-brown (10YR 5/2; 4/2, moist) loam; strong, medium, granular structure; friable; strongly calcareous; fragments of caliche occur throughout the horizon; grades to

8 to 12 inches +, white to light-gray, slightly hard caliche which becomes softer and chalklike below 12 inches.

Variations.—Caliche is normally 8 to 12 inches below the surface but outcrops in some places. Locally, it forms rims just below the break from the level plains. Surfaces are locally flaggy. The fragments range from pebble size to 6 inches in diameter. The surface color is light brownish gray in places.

Topography.—Potter soil on breaks of slopes; slopes are strongly convex, and gradient is 6 to 12 percent. Mansker soil on narrow foot slopes; slopes are concave to weakly convex, and gradient is normally less than 6 percent.

Present use.—All in range of grama and some buffalograss.

Distribution.—Mostly in the northeastern, eastern, and southwestern parts of Cimarron County around the rims of drainageways that cut back into the level plains.

Otero loamy fine sand.—This is a sandy Brown soil that has a limy clay loam substratum. It occurs where the sandy plains overlap the caliche breaks. It has some characteristics of Calcisols. It is associated with Vona, Tivoli, and Dalhart soils. Because of the sandy surface soil, little water runs off and internal drainage is moderate to rapid. The vegetation consists of tall and mid grasses.

The following profile is typical.

A 0 to 6 inches, brown (10YR 5/3; 4/3, moist) loamy fine sand; weak, fine, granular structure; nearly loose; weakly calcareous; grades to

AC 6 to 14 inches, pale-brown (10YR 7/3; 6/3, moist) light clay loam; weak, medium to fine, granular structure; friable; strongly calcareous; grades to

C_{ca} 14 to 50 inches +, light-gray (10YR 7/1; 6/1, moist) limy light clay loam; weak, medium to fine, granular structure; friable.

Variations.—Texture of A horizon ranges from loamy fine sand to fine sandy loam, and color ranges from brown to light brownish gray. Substratum is limy, heavy sandy loam to heavy sandy clay loam and is light brownish gray to light gray in color. Hardened caliche occurs in some places.

Topography.—Hummocky; slopes range from 1 to 5 percent but are mostly more than 2 percent.

Present use.—All in range of grama and some bluestem, sand dropseed, sand sagebrush, and yucca.

Distribution.—Mostly in the northern part of Cimarron County, where sandy plains overlap on caliche breaks.

Portales clay loam, 0 to 1 percent slopes.—Portales soils are moderately deep Calcisols. They are related to the Mansker soils, but they have thicker calcareous A and AC horizons and are deeper to the chalky lime zone. Portales soils occur on level plains and on the margins of depressions, in association with Mansker and Richfield soils. They also occur around bodies of Randall clay.

Most of this soil is nearly level, but it has more slope and faster runoff than the level Richfield soils. The granular structure in the A horizon is more fragile than in Richfield soils. There is less clay and a less pronounced structure in the AC horizon of this soil than in the B horizon of Richfield soils. The depth to a definite lime zone is also less in the Portales soils.

The following profile of Portales clay loam, 0 to 1 percent slopes, is in a cultivated area. The slopes are very weakly convex, and the gradient is about 1 percent.

A 0 to 13 inches, brown (10YR 5/3; 4/3, moist) clay loam; strong, fine and medium, granular structure; the granules are fairly firm when dry and friable when moist; alkaline to slightly calcareous; grades to

AC 13 to 26 inches, very pale brown (10YR 7/3; 6/4, moist) clay loam; strong, medium, granular structure; highly calcareous; some hard lime concretions in the lower 8 inches; a mass of worm casts; some of the darker colored soil in the upper 4 to 6 inches appears to be fillings in insect holes or in channels left by decayed plant roots; grades to

C_{ca} 26 to 50 inches, pink (7.5YR 7/4; 6/6, moist) clay loam; moderate, medium to coarse, granular structure; strongly calcareous; approximately 10 percent hard calcium carbonate concretions more than 10 millimeters in size; grades to

C_u 50 to 72 inches +, pink (7.5YR 7/4; 5/6, moist) sandy clay loam; strong, fine to medium, granular structure; a few lime concretions; more reddish than the horizon above, and less limy; very few roots.

Variations.—Plowed A horizon ranges from brown (10YR 5/3) or grayish brown (10YR 5/2; 3/2, moist) in the most nearly level, least disturbed areas to light brownish gray (10YR 6/2) in the more sloping areas and pale brown (10YR 6/3) in slightly eroded areas. Prevailing color of A horizon below plow depth is dark grayish brown (10YR 4/2). Thickness of A horizon ranges from 6 to 15 inches and averages about 10 inches. Thickness is greatest in the most nearly level areas.

In at least 85 percent of this soil, the A horizon is calcareous and there are scattered fragments of caliche. There is a moderate increase in clay from the A to the C horizons, although the strong granular structure and liminess of the AC layer belie its clay content. The only sharply distinct horizons are the lime zones, which are chalky in places, may contain more than 25 percent free lime in pockets and as concretions, and are very striking in appearance. Depth to the horizon of calcium carbonate ranges from 18 to 30 inches and averages 20 inches.

In transitions to Richfield soils, the plow layer is generally calcareous and the plowsole is noncalcareous. In such places, the horizons of calcium carbonate may contain less than 5 percent free lime and be indistinct. Near areas of moderately sandy soils the texture of A and AC layers ranges to heavy loam.

Inclusions of Mansker soils comprise 5 to 10 percent of the level areas of this soil, and more than that near borders between Portales and Mansker soils. In these included areas, the depth to the calcium carbonate horizon ranges from 12 to 18 inches.

Topography.—Nearly level plains; very weakly convex slopes of ½ to 1 percent. Some areas are slightly elevated within broad, level areas of Richfield soils.

Present use.—About 90 percent cropped; the rest is in native range of grama and buffalograss.

Distribution.—Mostly on plains east of Boise City.

NOTE: The results of mechanical and chemical analyses of samples taken from two profiles of Portales clay loam, 0 to 1 percent slopes, are given in tables 8 and 9, in the section, Laboratory Analysis.

Portales clay loam, 1 to 2 percent slopes.—This inextensive soil occurs mostly near natural drainageways or around the margins of depressions in the plains, within broader areas of level Portales soils. It occurs near Richfield, Dalhart, and Randall soils. It is also closely associated with Mansker soils, which may comprise up to 15 percent of some areas.

Much of this soil has weakly convex slopes of 1 to 1½ percent. A smaller acreage has slopes of 2 percent. The steepest areas are those that slope down to enclosed depressions.

Erosion has been active in most cultivated areas, and there are many light brownish-gray spots (10YR 5.5/2; 4/2, moist) in the normally grayish-brown fields. Caliche fragments are scattered on the surface; they are locally concentrated, as though brought up by the digging of prairie dogs. Some lighter colored spots, representing high-lime variants or soils much like the Colby soils (not mapped in this county), appear even in unplowed pastures. The depth to the lime zone is less than in Portales clay loam, 0 to 1 percent slopes. It ranges from 15 to 24 inches and is normally more than 18 inches.

Topography.—Slight rises on level plains and very gentle slopes going down to enclosed depressions; convex slopes of less than 2 percent.

Present use.—Nearly all cultivated; the rest in native range of grama and buffalograss.

Distribution.—Level plains around and east of Boise City.

Potter-Mansker loams, 1 to 3 percent slopes.—This is a complex of very shallow Potter loams and shallow Mansker loams that are so closely associated that separation is impractical. The proportion of Potter soils (80 percent) is considerably greater than in the Mansker-Potter complex (35 percent). The Potter soils in this complex have slopes of 2 to 5 percent. The Mansker soils are on the gentler slopes and in pockets between areas of Potter soils. In the Mansker soils the depth to caliche is more than 12 inches.

Profiles of both of these soils are described elsewhere in the report.

Variations.—Depth to caliche varies from less than 10 inches to as much as 25 inches within short distances. In places the caliche is indurated or rocklike. Surface is grayish brown to light brownish gray; the lighter colors occur mostly on knobs or in blowouts. The proportion of the two soils varies from place to place.

Topography.—Distinctly convex slopes of 1 to 5 percent but dominantly 2 or 3 percent.

Present use.—Practically all in range, except for a few areas adjacent to cultivated areas of Portales soils. Range is mostly in grama and buffalograss.

Distribution.—On the margins of plains, just above the caliche breaks, mostly in the eastern and central parts of Cimarron County.

Randall clay.—This is a very clayey Grumusol that occurs in playas or other enclosed depressions that are ponded at times. These depressions, into which water drains from wide areas of the nearly level plains, have no outlets; consequently, all drying is by evaporation and by seepage into the substratum. In many years this soil dries out in summertime.

The following profile is in a level area of native grass.

A 0 to 18 inches, dark-gray (5YR 4/1; 3/1, moist) heavy clay; weak, medium and coarse, blocky to massive structure; very sticky when wet, hard when dry; cracks badly upon drying; noncalcareous; grades to

AC 18 to 48 inches, dark-gray (5YR 4/1; 3/1, moist) heavy clay with some faint brown mottles; massive, very hard when dry, very sticky when wet; very slowly permeable; noncalcareous; grades to

C 48 to 72 inches +, light yellowish-brown (10YR 6/4; 5/4, moist) clay mottled with brown; massive to weak blocky structure; iron oxide concretions are common; neutral or slightly calcareous; moisture enters soil chiefly through the large cracks when soil is dry; the cracks close and water penetration is very slow when the soil is wet.

Variations.—Near Dalhart soils, this soil is sandier and more distinctly stratified. Colors are lighter where the most recent sediments are loams or clay loams.

Topography.—Enclosed, undrained depressions.

Present use.—Only a few of the shallower depressions are tillable. Most of the acreage is in native range of grama and western wheatgrass.

Distribution.—On level plains around and east of Boise City, generally within broader areas of Richfield or Portales soils.

Richfield clay loam, 0 to 1 percent slopes.—These are deep, dark-colored, moderately clayey soils of the level plains. They are Chestnut soils, but are at the southern end of the Chestnut range, in an area that is transitional to the zone of Reddish Chestnut soils. They are associated with Portales, Mansker, Dalhart, and Randall soils.

These soils have a slowly permeable B horizon of light clay or heavy clay loam. They are leached of free lime to depths of 18 to 24 inches.

The following profile is in a cropped area that has a slope of one-half percent.

A 0 to 4 inches, brown (10YR 5/3; 4/3, moist) heavy silt loam or clay loam; moderate, fine, granular structure; friable; sticky when wet; noncalcareous; rests on

B_{21} 4 to 15 inches, dark-brown (10YR 4/3; 3/3, moist) light clay or heavy silty clay loam; strong, medium and fine, blocky structure; very sticky when wet; noncalcareous; continuous clay skins; numerous root channels; grades to

B_{22} 15 to 22 inches, brown (10YR 4/3; 4/2, moist) light clay; strong, medium to fine, blocky structure; structure somewhat weaker than in B_{21}; slightly calcareous; a few calcium carbonate concretions; clay skins present but not so pronounced as in B_{21}; grades to

B_3 22 to 32 inches, yellowish-brown (10YR 5/4; 4/4, moist) light clay; weak, medium, granular structure; sticky when wet; calcareous; soft lime concretions that increase in number with depth; some plant roots; grades to

C_{ca} 32 to 65 inches, very pale brown (10YR 8/3; 7/3, moist) silty clay loam; weak, fine, granular structure; highly calcareous; numerous soft calcium concretions; very few plant roots; grades to

C 65 to 75 inches +, light-gray (10YR 7/1; 7/2, moist) silty clay loam; very fine granular structure.

A profile in a level area of cropland half a mile west of Boise City is described as follows.

A_{1p} 0 to 3 inches, brown (10YR 5/3; 4/3, moist) silt loam; very friable; noncalcareous; rests with plow-slice contact on

B_{21} 3 to 12 inches, brown (7.5YR 4/4; 3/3, moist) rather heavy silty clay loam; moderate, very coarse, granular structure or medium to fine, nuciform structure (many-faced peds that are roundish in outline but have angular vertices between faces); firm; noncalcareous; continuous but not pronounced clay skins; moderately numerous rootlet channels; grades to

B_{22} 12 to 16 inches, similar to the B_{21} horizon but brown (7.5YR 4/3, moist) and slightly calcareous; grades to

B_{ca} 16 to 36 inches, brown (7.5YR 4/3 moist) heavy silty clay loam; friable; scattered, soft lime concretions; nearly massive but relatively porous and permeable; discontinuous clay skins below 30 inches; grades to

C_u 36 to 45 inches +, yellowish-red sandy clay loam; calcareous; readily apparent clay skins in the auger core; this appears to be a weak B horizon of a buried soil developed in sandier material.

Variations.—In undisturbed areas of grass away from cultivated fields, the A horizon is heavy silt loam and is 3 to 5 inches deep. In cultivated fields, the upper part of the B horizon has been mixed with the A horizon by plowing. In these places the present surface soil is more clayey and the thickness of the original A horizon is difficult to determine. In eroded spots, the plow layer is lighter colored than the upper part of the B horizon but has the same texture. Surface crusting and a tendency to slake after rains are typical features of eroded areas. The subsoil is about 35 percent clay.

The more nearly level areas are in low but not depressed locations, but they probably receive some drainage water. In such spots the subsoil may be blocky clay like the subsoil of the Pullman soils (not mapped in this county). These areas are generally not large enough to be mapped separately.

The substratum is commonly very pale brown, floury, very friable, highly calcareous, light silty clay loam or heavy silt loam. Dark-colored buried soils are found at depths of more than 30 inches.

Topography.—Level high plains. Slopes average about one-half percent.

Present use.—Nearly all in crops. Range is mostly grama and buffalograss.

Distribution.—On level plains around and east of Boise City.

NOTE: The results of mechanical and chemical analyses of samples taken from a profile of Richfield clay loam, 0 to 1 percent slopes, are given in tables 8 and 9, in the section, Laboratory Analysis.

Richfield clay loam, 1 to 2 percent slopes.—This inextensive soil occurs within broader areas of Richfield clay loam, 0 to 1 percent slopes, and may be near areas of Portales soils. The depth to the lime zone and to the top of the B_{22} layer is a few inches less than in Richfield clay loam, 0 to 1 percent slopes, and the B_{22} horizon is slightly lighter colored than that of the level soil.

Erosion has been active. There are large areas in which the present surface soil is heavy clay loam because the subsoil has been exposed by erosion or brought to the surface by tillage. Near areas of Portales soils, the A horizon is weakly calcareous and the lime zone is nearer the surface.

Topography.—Very gentle convex slopes, mostly about 1 percent, bordering shallow drainageways and playas.

Present use.—Mostly in cropland; the rest in native range of grama and buffalograss.

Distribution.—Entirely on the level plains around and east of Boise City.

Richfield fine sandy loam, 0 to 1 percent slopes.—This soil occurs along boundaries between Richfield and Dalhart soils. It has a 10-inch overblow layer of sandy material blown from the Dalhart soils. It has a darker colored, more clayey B_2 horizon than the Dalhart soils.

The following profile is 46 feet east and 152 feet north of the southwest corner of sec. 12, T. 2 N., R. 3 E., 11 miles west and 4 miles south of Boise City. It is in a nearly level cropped area. The slope is weakly convex, and the gradient is about 1 percent.

0 to 8 inches, light yellowish-brown (10YR 6/4; 4/3; moist) light fine sandy loam; weak, fine, granular structure; slightly sticky when moist; sorghum roots present; noncalcareous; grades to

8 to 17 inches, brown (10YR 5/3; 4/3, moist) clay; weak, medium to coarse, blocky structure; pronounced but not continuous clay skins; very hard when dry, very sticky when moist; noncalcareous; sorghum roots present; grades to

17 to 38 inches, yellowish-brown (10YR 5/4; 4/4, moist) and very pale brown (10YR 8/3; 7/3, moist) heavy clay loam; moderate, medium, granular structure; sticky when wet; strongly calcareous; soft lime concretions; grades to

38 to 56 inches, strong-brown (7.5YR 5/6; 5/4, moist) clay loam; medium to fine, granular structure; sticky when wet; strongly calcareous; numerous soft lime concretions.

56 to 72 inches, dark-brown (7.5YR 4/4; 3/2, moist) heavy clay loam; medium to fine, granular structure; very sticky when wet; strongly calcareous; a few soft lime concretions.

Variations.—The fine sandy loam surface soil ranges from 4 to 12 inches in thickness. In places, as a result of winnowing, the surface soil is almost as coarse as a loamy sand. The texture of the substratum varies considerably; the materials apparently came from several sources and were superimposed at various times. Buried darker colored soils occur at various depths below 30 inches.

Topography.—Nearly level to very gently undulating plains; slopes of about 1 percent.

Present use.—Mostly in cropland. Range consists of grama, bluestem, buffalograss, and western wheatgrass.

Distribution.—Mostly on the level plains around and east of Boise City, near the margins of the sandy plains.

NOTE: The results of mechanical and chemical analyses of samples taken from a profile of Richfield fine sandy loam, 0 to 1 percent slopes, are given in tables 8 and 9, in the section, Laboratory Analysis.

Richfield loam, 0 to 1 percent slopes.—This soil probably formed where the surface of Richfield clay loam, 0 to 1 percent slopes, was covered by a thin overblow layer of loamy loess. It is associated with other Richfield soils, Portales soils, and Dalhart soils.

The following profile is in a nearly level cropped area. The slope is ½ to 1 percent.

A_1 0 to 4 inches, brown (10YR 5/3; 3/3, moist) loam; weak, fine, granular structure; slightly sticky when wet; noncalcareous; grades to

B_{21} 4 to 11 inches, dark-brown (10YR 3/3; 3/2, moist) sandy clay; moderate, medium to fine, subangular blocky structure; firm; crumbly when moist; noncalcareous; grades to

B_{22} 11 to 21 inches, dark yellowish-brown (10YR 3/4; 3/3, moist) heavy clay loam; weak, medium to coarse, subangular blocky structure; slightly calcareous; grades to

B_3 21 to 32 inches, brown (10YR 5/3; 5/2, moist) sandy clay; weak, coarse to medium, granular structure; calcareous; soft calcium concretions become more numerous with increasing depth; grades to

C_{ca} 32 to 53 inches, light yellowish-brown (10YR 6/4; 5/4, moist) sandy clay loam; weak, granular structure; numerous calcium carbonate concretions make up about 30 percent of soil mass; grades to

C 53 to 72 inches, very pale brown (10YR 7/3; 6/3, moist) sandy clay loam or sandy clay; weak, granular structure; strongly calcareous; a few soft lime concretions.

Variations.—The color of the A_1 horizon ranges from dark brown to brown, and the thickness from 3 to 6 inches. The substratum is more sandy than that of Richfield clay loam. Dark-colored buried soils much like the Richfield clay loams occur in places at depths below 30 inches.

Topography.—Nearly level plains; slopes of ½ to 1 percent.

Present use.—Mostly in crops. Grama and buffalograss cover most of the range.

Distribution.—Level plains around and east of Boise City.

Rough stony land.—This land type consists of steep, stony, sandstone areas that have only a little soil covering the rocks in most places. It occupies sandstone escarpments, rock knobs, and mesa sides. The slopes vary from steep to nearly vertical. Most of this unit is on hard rocks in the valley of the Cimarron River and its tributaries, west of United States Highway No. 287 and in the vicinity of Kenton.

Associated soils are the Berthoud, which occur in pockets and narrow valleys between sandstone knobs, and the Travessilla, which are on gentler slopes where some soil has formed in place. Rough stony land is so steep that soil is removed as fast as it forms.

All of this unit is in range, but much is so steep it cannot be reached by cattle.

Spur soils.—These are calcareous, dark-colored loamy Alluvial soils. They occur on fairly stable bottom lands that are flooded only occasionally. Drainage is mostly from Richfield, Portales, Mansker, Travessilla, and Berthoud soils. Surface textures vary from heavy sandy loam to the more prevalent clay loam. Most of the sandier areas occur on the streamward side of the flood plain; the clay loams are nearer the uplands.

The following profile of Spur clay loam is in a cropped area on level bottom land. The surface is weakly convex to plane, and the slope is about one-half percent.

- A_1 0 to 10 inches, dark grayish-brown (10YR 4/2; 3/2, moist) clay loam; moderate, medium to fine, granular structure; firm; sticky when wet, hard when dry; calcareous; grades to
- AC 10 to 50 inches, dark-brown (10YR 3/3; 3/4, moist) heavy clay loam; moderate, medium, granular structure; firm; crumbly when moist, hard when dry; highly calcareous.

Variations.—Depth of A_1 horizon ranges up to 20 inches. The color of the AC horizon varies from dark brown to brown (10YR 3/3 to 5/3). In places, the texture is as coarse as heavy fine sandy loam, although clay loam predominates. In places, the AC horizon is silty clay loam. Buried darker colored soils occur at various depths.

Topography.—Nearly level, well-drained bottom lands that have plane to weakly convex surfaces and slopes of about ½ to 1½ percent.

Present use.—About one-third in cultivation; the rest in range of mixed mid and tall grasses. There may be scattered cottonwood trees.

Distribution.—Mostly on the flood plains of the Cimarron River and its tributaries.

Sweetwater fine sandy loam.—This is a calcareous, slowly drained Alluvial soil. The water table is within 36 inches of the surface during some parts of the year. It occurs in low places within broader areas of Lincoln soils. The soil drains slowly after floods. Saline spots occur in some places.

The following profile is 450 feet south of the road and 630 feet west of a tree line in the SE¼SW¼ sec. 13, T. 6 N., R. 7 E. It is on a level bottom land of the Cimarron River.

- A_{11} 0 to 5 inches, pale-brown (10YR 6/3; 4/3, moist) fine sandy loam; strong, medium to coarse, granular structure; slightly sticky when moist; noncalcareous; numerous grass roots present; grades to
- A_{12} 5 to 11 inches, dark-brown (7.5YR 4/2; 3/2, moist) fine sandy loam; moderate, coarse, granular structure; slightly sticky when wet; noncalcareous; numerous grass roots; grades to
- A_{13} 11 to 16 inches, very dark grayish-brown (10YR 3/2; 2/2, moist) clay loam; strong, medium, granular structure; firm; sticky when moist; noncalcareous; numerous grass roots; grades to
- AC 16 to 23 inches, dark-brown (10YR 4/3; 3/3, moist) fine sandy loam; single grain; slightly sticky when moist; noncalcareous; few grass roots; grades to
- C 23 to 85 inches +, very pale brown (10YR 7/3; 6/4, moist) loamy fine sand; nonsticky; single grain; noncalcareous; a few grass roots above 36 inches; stratified with fine sands and sands; ground water at 50 inches, but water table rises to 36 inches when soil is wet.

Variations.—The dark-colored layers in the A horizon may be fine sandy loams stratified with clay loams and some loamy sands. In the above profile, the A_{11} horizon appears to be a recent overwash. Lower part may have layers of brown sandy loams and loams. The water table may drop to a depth of 60 inches during dry periods. Some subsoil mottling occurs in the zone of water fluctuation. Crusted saline spots occur at the surface of the most slowly drained areas.

Topography.—Slightly depressed areas on irregular-surfaced sandy flood plains; slope is one-half percent or less.

Present use.—In native pasture of switchgrass, sand bluestem, prairie cordgrass, grama, alkali sacaton, and saltgrass.

Distribution.—On the flood plain of the Cimarron River.

Travessilla stony loam.—This soil is a very shallow, stony Lithosol that developed from calcareous brown sandstones. It occurs in the northwestern part of Cimarron County. It sometimes occurs on slopes below areas of Rough stony land. Smoother, deeper soils associated with it are the Carnero loams. The foot slopes below it are usually covered by Berthoud loams. The following profile is in an area of native range. The slopes are convex, and the gradient is about 4 percent.

- A 0 to 6 inches, pale-brown (10YR 6/3; 5/2, moist) stony loam; weak, medium, granular structure; friable; scattered sandstone fragments throughout; a few rocks on the surface; calcareous; grades to
- AC 6 to 15 inches, light-gray (10YR 7/1; 6/2, moist) loam; weak, fine, granular structure; friable; rock fragments throughout; strongly calcareous; grades to
- C 15 to 17 inches, light-gray (10YR 7/2; 6/2, moist) loam in a matrix that is about 40 percent sandstone rock fragments; strongly calcareous.

Variations.—Thickness of the soil over sandstone ranges from 4 to about 15 inches. Deeper pockets are of Berthoud or Carnero loams. There are a few surface stones. Stones on and in the soil mass usually have a light-gray limy coating.

Topography.—Rolling uplands that have convex slopes of about 2 to 12 percent.

Present use.—All in native range of grama, buffalograss, scattered cactus, and shrubby juniper.

Distribution.—Sandstone rock areas in breaks along Cimarron River between Kenton and United States Highway No. 287.

Vernon clay loam.—This is a calcareous, reddish-brown Regosol. It developed mostly in red Triassic clay somewhat bedded with sandstone. It occurs near the valley floors, below areas dominated by Travessilla soils and Rough stony land. Some areas are near ledge sandstone; these have outcrops of rock and have some characteristics of Lithosols.

The following profile is in an area of native range that has convex slopes of about 3 percent.

- A_1 0 to 2 inches, pale-brown (10YR 6/3; 5/3, moist) clay loam; moderate, medium to fine, granular structure; calcareous; grades to
- AC 2 to 9 inches, light reddish-brown (5YR 6/4; 5/4, moist) heavy clay loam; strong, medium to coarse, granular structure; sticky when wet; calcareous; a few small calcium carbonate concretions; grades to
- C 9 to 24 inches, reddish-yellow (5YR 6/6; 5/6, moist) clay; moderate, medium to fine, subangular blocky structure; very sticky when wet; slowly permeable; highly calcareous; a few small calcium carbonate concretions.

Variations.—The uppermost 2 inches of the above profile is probably less red than normal. The A_1 horizon is 2 to 5 inches thick. Total depth to the raw red beds is as much as 20 inches. The lower layers contain bands of red sandstone.

Topography.—Convex to weakly concave slopes of 1 to 6 percent, mostly 2 to 4 percent.

Present use.—All in range, mostly grama and buffalograss.

Distribution.—In the northwestern part of Cimarron County; a few areas are along the Cimarron River north of Boise City.

Vona-Tivoli loamy fine sands.—This complex consists of hummocky Vona soils and duny Tivoli soils that are so closely associated that it is impractical to separate them on the soil map. These soils occur on wavy to duny sandy plains.

The Vona soil in this complex is a loamy sand with a developed subsoil. It is in the Brown great soil group. The Tivoli soil is sandy throughout. It is a Regosol.

This unit occurs near areas of Dalhart soils and, less commonly, near Otero soils. It is about 65 percent Vona and 35 percent Tivoli. In some areas, the soils have been practically destroyed by erosion. Erosion is still active.

Two profiles of Vona loamy fine sand are described in the section, Laboratory Analysis.

In a modal profile of Tivoli loamy fine sand, the A horizon is pale-brown, light yellowish-brown, or light-brown loamy fine sand, 6 to 8 inches deep. The C horizon is light yellowish-brown, light-brown, or yellow loamy fine sand. It is at least 48 inches deep and deeper in many places.

Topography.—The Vona soils occur in hummocky areas and have slopes of about 2 to 5 percent. The Tivoli are in duny areas and have slopes of 6 to nearly 40 percent.

Present use.—All in range of grama, sand dropseed, bluestem, and switchgrass. Range is generally invaded by sand sagebrush.

Distribution.—On the sandy plains southeast, south, and west of Boise City.

Laboratory Analysis

Tables 8 and 9 give data obtained by laboratory analysis of samples taken from 12 profiles representing 7 important soils mapped in Cimarron County. Detailed descriptions of the profiles sampled follow.

Dalhart fine sandy loam, 1 to 3 percent slopes (*Sample No. 55–OK–13–7*).—The following profile was observed 1,840 feet north and 100 feet east of the junction of Keyes Road and United States Highway No. 287, in the SW¼ sec. 31, T. 1. N., R. 8 E., CM. The terrain is gently undulating, the slopes are convex, and the gradient is 2 percent.

A_1 0 to 8 inches, dark-brown (10YR 4/3; 3/3, moist) fine sandy loam; weak, fine, granular structure; very friable or soft when moist; neutral; grades abruptly into

B_{21} 8 to 20 inches, dark yellowish-brown (10YR 4/4; 3/3, moist) sandy clay loam; strong, fine, granular structure resulting from intense insect activity; friable when moist, slightly sticky when wet; no free lime; grades abruptly to

B_{22} 20 to 30 inches, brown (7.5YR 5/4; 4/4, moist) sandy clay loam; strong, fine, granular structure resulting from intense insect activity; friable when moist; strongly calcareous in lower 4 inches; pseudomycelium threads abundant; grades to

C_{ca} 30 to 44 inches, pink (7.5YR 8/4; 7/4, moist) silt loam; strong, medium, granular structure; zone of maximum calcium carbonate accumulation; little evidence of insect activity; grades diffusely to

C 44 to 70 inches +, light-brown (7.5YR 6/4; 5/4, moist) silt loam; strong, medium, granular structure; slightly sticky when wet; strongly calcareous but less calcium carbonate and more silty earth.

Analysis of samples showed the B_{21} horizon and the B_{22} horizon to be fine sandy loams; and the C_{ca} and the C horizons, clay loams.

Dalhart fine sandy loam, 1 to 3 percent slopes (*Sample No. 55–OK–13–8*).—A second profile of this soil was observed 9.1 miles west and 250 feet north of the railroad at the junction of Keyes Road and United States Highway No. 287, in the SE¼ sec. 33, T. 1 N., R. 6 E., CM. The terrain is gently undulating, the slopes are convex, and the gradient is 2 percent.

A_1 0 to 16 inches, brown (10YR 5/3; 4/3, moist) fine sandy loam; loose; nonsticky when wet; neutral; uppermost 2 or 3 inches appears to be an overdeposit of winnowed loamy sand; grades abruptly to

B_2 16 to 28 inches, dark yellowish-brown (10YR 4/4; 4/3, moist) sandy clay loam; strong, fine, granular structure; friable when moist, sticky when wet; neutral but not calcareous; grades to

B_{2ca} 28 to 54 inches, brown (10YR 5/3; 4/3, moist) clay loam; strong, medium, granular structure and weak, coarse, prismatic structure; moderately friable when moist, sticky when wet; strongly calcareous; pseudomycelia in abundance; grades to

C 54 to 65 inches, pale-brown (10YR 6/3; 5/3, moist) loam; strong, very fine, granular structure; weakly calcareous; grades to

C_{bca} 65 to 74 inches +, yellowish-brown (10YR 5/6; 5/4, moist) clay loam; strong, medium, granular structure; strongly calcareous; soft calcium carbonate concretions.

Analysis of samples showed the A_1 layer to be on the loamy sand-sandy loam boundary; the B_{2ca} horizon, on the loam-clay loam boundary; the C horizon, to be a fine sandy loam; and the C_{bca}, a fine sandy loam.

Samples for analysis by the Oklahoma State Highway Department were also collected at this site.

Dalhart loamy fine sand, 0 to 3 percent slopes (*Sample No. 55–OK–13–10*).—The following profile was observed 5½ miles north of the Texas-Oklahoma line, at the east quarter corner of sec. 6, T. 1 N., R. 5 E., CM. The terrain is slightly hummocky, the slopes convex, and the gradient about 3 percent.

A 0 to 12 inches, brown (10YR 5/3; 4/2, moist) loamy fine sand; loose; noncalcareous and neutral; heavy concentration of grass roots; grades to

B 12 to 36 inches, dark-brown (10YR 4/3; 3/3, moist) sandy clay loam; weak, fine, granular structure; weakly columnar when dry; very porous; noncalcareous; neutral; grades to

C 36 to 64 inches +, yellowish-brown (10YR 5/6; 4/4, moist) loamy fine sand; weakly calcareous; a few soft scattered concretions of calcium carbonate.

Analysis of samples showed the B horizon to be on the sandy loam-sandy clay loam boundary.

TABLE 8.—*Particle size distribution for selected soils of Cimarron County, Okla.*

Soil name, sample number, and location	Depth	Particle size distribution										Textural class
		Very coarse sand (2 to 1 mm.)	Coarse sand (1 to 0.5 mm.)	Medium sand (0.5 to 0.25 mm.)	Fine sand (0.25 to 0.10 mm.)	Very fine sand (0.10 to 0.05 mm.)	Silt (0.05 to 0.002 mm.)	Clay (0.002 mm.)	International silt (0.2 to 0.02 mm.)	Fine silt (0.02 to 0.002 mm.)	Coarse silt (0.05 to 0.02 mm.)	
Dalhart fine sandy loam, 1 to 3 percent slopes.												
Sample No. 55-OK-13-7.												
Location: 1,840 ft. N. and 100 ft. E. of the junction of Keyes Rd. and U.S. 287, in the SW¼ sec. 31, T. 1 N., R. 8 E.	*Inches*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	
A_1	0–8	0. 2	5. 3	15. 3	36. 7	19. 5	13. 3	9. 8	52. 4	2. 1	11. 2	Fine sandy loam.
B_{21}	8–20	. 3	8. 6	16. 7	30. 5	12. 6	14. 4	17. 0	40. 6	3. 5	10. 9	Sandy loam.
B_{22}	20–30	. 2	7. 5	18. 0	27. 8	12. 0	15. 7	18. 9	36. 4	6. 4	9. 3	Sandy loam.
C_{ca}	30–44	. 7	4. 0	7. 1	15. 2	11. 0	24. 3	37. 8	30. 1	14. 4	9. 9	Clay loam.
C	44–70+	. 9	4. 3	5. 3	15. 2	11. 2	31. 8	31. 4	35. 2	17. 4	14. 4	Clay loam.
Sample No. 55-OK-13-8.												
Location: 9.1 miles W. and 250 ft. N. of the RR at junction of Keyes Rd. and U.S. 287, in the SE¼ sec. 33, T. 1 N., R. 6 E.												
A_1	0–16	. 1	7. 8	16. 3	35. 7	20. 3	9. 7	10. 1	49. 2	1. 7	8. 0	Loamy sand.
B_2	16–28	. 04	3. 7	8. 1	29. 3	19. 5	15. 6	23. 9	49. 3	5. 3	10. 3	Sandy clay loam.
B_{2ca}	28–54	. 8	1. 4	2. 4	14. 8	24. 1	30. 2	26. 4	53. 8	12. 0	18. 2	Loam.
C	54–65	. 3	8. 6	14. 2	25. 0	14. 0	22. 4	15. 5	44. 4	6. 4	16. 0	Sandy loam.
C_{bca}	65–74+	. 8	8. 9	13. 5	23. 8	18. 3	15. 6	19. 1	43. 4	4. 6	11. 0	Fine sandy loam.
Dalhart loamy fine sand, 0 to 3 percent slopes.												
Sample No. 55-OK-13-10.												
Location: 5½ miles N. of Tex.-Okla. line; E¼ corner sec. 6, T. 1 N., R. 5 E.												
A	0–12	. 2	10. 4	23. 9	36. 0	11. 0	11. 8	6. 6	40. 7	1. 4	10. 4	Loamy sand.
B	12–36	. 0	5. 7	13. 9	27. 6	10. 8	22. 0	19. 9	42. 5	6. 4	15. 6	Fine sandy loam.
C	36–64+	. 0	6. 0	17. 2	41. 9	14. 0	12. 1	8. 9	47. 4	3. 3	8. 8	Loamy fine sand.
Sample No. 55-OK-13-12.												
Location: 4½ miles NW. of the junction of Keyes Rd. and U.S. 287 and 100 ft. E. of U.S. 287; W¼ corner sec. 15, T. 1 N., R. 7 E.												
A_1	0–15	. 0	4. 4	19. 2	54. 9	14. 5	2. 7	4. 3	48. 5	0. 3	2. 4	Loamy fine sand.
B_{21}	15–26	. 0	5. 9	18. 4	37. 5	11. 0	10. 1	17. 1	38. 8	2. 7	7. 4	Fine sandy loam.
B_{22}	26–38	. 0	3. 1	10. 5	25. 2	10. 8	23. 7	26. 8	38. 4	10. 3	13. 4	Sandy clay loam.
A_{1bca}	38–57	. 3	1. 0	2. 0	5. 7	4. 7	52. 8	33. 4	29. 0	32. 2	20. 6	Silty clay loam.
B_{1b}	57–66	. 2	. 7	2. 0	6. 7	5. 4	46. 6	38. 4	30. 1	26. 2	20. 4	Silty clay loam.
B_{2b}	66–75	. 2	. 8	2. 2	7. 9	6. 3	44. 2	38. 5	32. 3	23. 5	20. 7	Silty clay loam.
C_b	75–85+	. 05	. 6	2. 2	8. 2	7. 1	44. 5	37. 4	34. 3	22. 7	21. 8	Silty clay loam.
Mansker loam, 0 to 3 percent slopes.												
Sample No. 55-OK-13-5.												
Location: 550 ft. E. and 50 ft. N. of SW. corner sec. 10, T. 4 N., R. 5 E.												
A_1	0–7	. 7	3. 0	4. 8	9. 5	12. 5	43. 6	26. 0	45. 9	15. 8	27. 8	Loam.
AC	7–16	1. 4	3. 1	4. 6	8. 7	8. 8	35. 3	38. 0	34. 1	15. 0	20. 3	Clay loam.
C_{ca}	16–38	3. 1	5. 0	5. 3	9. 7	9. 4	35. 2	32. 3	27. 7	22. 5	12. 7	Clay loam.
Sample No. 55-OK-13-6.												
Location: 87 ft. E. and 650 ft. NE.												

of SW. corner sec. 15, T. 2 N., R. 9 E.												
A_1	0–7	0.8	3.9	8.4	18.5	19.6	31.0	17.8	52.3	9.1	21.9	Loam.
AC	7–14	2.0	3.6	5.8	12.8	10.9	30.1	34.8	31.1	17.5	12.6	Clay loam.
C_{ca}	14–28+	1.7	2.9	4.2	9.8	9.1	35.3	37.0	25.2	25.1	10.2	Clay loam.
Portales clay loam, 0 to 1 percent slopes.												
Sample No. 55–OK–13–3.												
Location: NW. corner sec. 15, T. 4 N., R. 5 E.												
A	0–13	.2	2.2	4.4	7.5	8.4	42.3	34.9	37.0	17.8	24.5	Clay loam.
AC	13–26	1.3	3.5	5.7	9.1	6.2	30.5	43.6	23.3	18.2	12.3	Clay.
C_{ca}	26–50	2.8	9.1	13.3	16.5	7.3	21.7	29.3	22.6	14.6	7.1	Sandy clay loam.
C	50–72+	.6	9.3	21.3	29.1	8.4	7.1	24.1	27.6	2.2	4.9	Sandy clay loam.
Sample No. 55–OK–13–4.												
Location: 590 ft. E. and 120 ft. N. of SW. corner sec. 4, T. 4 N., R. 6 E.												
A_1	0–12	.2	2.1	3.6	8.5	11.7	47.4	26.6	48.2	16.0	31.4	Loam.
AC	12–26	1.2	1.9	2.3	5.8	7.5	41.6	39.7	39.8	12.9	28.7	Clay loam.
C_{ca1}	26–40	1.1	2.7	3.1	7.4	8.5	34.5	42.7	26.3	21.3	13.2	Clay.
C_1	40–50	1.5	2.7	3.4	7.8	8.4	35.7	40.5	30.3	18.5	17.2	Clay.
C_2	50–62+	1.0	3.1	4.5	9.9	10.1	33.2	38.2	30.1	19.2	14.0	Clay loam.
Richfield fine sandy loam, 0 to 1 percent slopes.												
Sample No. 55–OK–13–1.												
Location: 880 ft. S. and 250 ft. W. of the gas control station along U.S. 64; SW¼ sec. 7, T. 3 N., R. 6 E.												
A_{1p}	0–4	.4	11.9	19.3	21.6	10.3	22.8	13.6	37.0	6.2	16.6	Fine sandy loam.
B_{21}	4–11	.2	4.6	8.7	11.4	8.1	37.3	29.6	38.6	12.4	24.9	Clay loam.
B_{22}	11–23	.5	10.1	14.7	12.0	4.1	26.3	32.3	23.3	12.1	14.2	Clay loam.
B_{uca}	23–35	.9	20.4	32.8	19.9	2.2	11.0	12.8	15.2	4.7	6.3	Sandy loam.
C_{uca}	35–45	.6	19.1	36.0	24.6	3.4	6.3	9.9	17.0	1.4	4.9	Loamy sand.
C_{u1}	45–60	.6	6.3	13.9	16.5	8.0	26.7	28.1	27.6	14.2	12.5	Sandy clay loam.
C_{u2}	60–78	.2	4.0	12.2	20.8	12.8	23.8	26.2	35.3	11.2	12.6	Sandy clay loam.
Richfield clay loam, 0 to 1 percent slopes.												
Sample No. 55–OK–13–2.												
Location: 102 ft. W. and 960 ft. S. of NE. corner sec. 27, T. 4 N., R. 6 E.												
A_{1p}	0–5	.1	1.6	3.6	8.0	9.4	40.2	37.0	38.9	15.2	25.0	Clay loam.
B_2	5–17	.0	1.2	3.3	7.3	7.0	39.8	41.5	34.3	16.5	23.3	Clay.
BC	17–22	.1	1.2	3.6	7.0	4.4	44.0	39.8	30.8	21.0	23.0	Silty clay.
C_{ca1}	22–38	.1	1.8	5.7	11.2	5.5	43.8	32.0	32.9	21.9	21.9	Clay loam.
C_{ca2}	38–60	.3	1.9	6.5	14.1	9.2	40.2	27.8	41.4	15.0	25.2	Clay loam.
C	60–88	.1	1.5	10.0	27.4	14.7	26.0	20.2	47.8	7.1	18.9	Sandy clay loam.
Vona loamy fine sand.												
Sample No. 55–OK–13–9.												
Location: 4½ miles NW. of the junction of Keyes Road and U.S. 287 and 100 ft. E. of U.S. 287; near W¼ corner sec. 15, T. 1 N., R. 7 E.												
A_1	0–11	.5	7.1	21.9	45.0	13.4	3.6	8.6	40.0	1.7	1.9	Loamy sand.
B	11–15	.4	8.1	21.5	37.6	11.7	8.4	12.3	37.7	2.4	6.0	Loamy sand.
BC	15–24	.3	7.2	19.9	38.5	12.8	9.7	11.7	39.2	4.0	5.7	Loamy sand.
C_{ca}	24–33	.3	8.3	20.5	37.8	13.5	9.0	10.6	38.8	4.3	4.7	Loamy sand.
C_1	33–53	.0	5.0	16.3	35.9	15.7	12.6	14.5	43.8	4.6	8.0	Fine sandy loam.
C_2	53–65	.3	2.0	4.6	11.4	9.9	35.5	36.4	31.1	21.2	14.3	Clay loam.
Sample No. 55–OK–13–11.												
Location: 100 yds. S. of the NE. corner sec. 14, T. 6 N., R. 9 E.												
A_1	0–7	1.8	12.9	19.0	46.9	10.6	4.1	4.7	42.0	.3	3.8	Loamy fine sand.
A_{12}	7–19	1.2	10.6	18.0	47.8	11.4	2.3	8.7	42.7	.0	2.3	Loamy fine sand.
C_1	19–29	.7	8.6	16.6	53.3	11.0	3.2	6.5	46.2	.5	2.7	Loamy fine sand.
C_{12}	29–73+	.4	11.4	19.5	50.2	10.0	4.7	3.8	43.4	1.2	3.5	Loamy fine sand.

TABLE 9.—*Chemical properties of selected*

Soil name, sample number, and location	Depth	pH			Organic matter		
		Saturated paste	1:5	1:10	Organic carbon	Nitrogen	C/N
Dalhart fine sandy loam, 1 to 3 percent slopes.							
Sample No. 55–OK–13–7.							
Location: 1,840 ft. N. and 100 ft. E. of junction of Keyes Road and U.S. 287; SW¼ sec. 31, T. 1 N., R. 8 E.	*Inches*				*Percent*	*Percent*	
A_1	0–8	7. 8	8. 2	8. 3	0. 44	0. 059	7. 5
B_{21}	8–20	7. 3	7. 8	7. 8	. 42	. 061	6. 9
B_{22}	20–30	7. 8	8. 3	8. 4	. 22	. 041	5. 4
C_{ca}	30–44	8. 1	8. 6	8. 7	. 23	. 026	8. 8
C	44–70+	8. 4	8. 9	9. 0	. 10	. 015	6. 7
Sample No. 55–OK–13–8.							
Location: 9.1 miles W. and 250 ft. N. of RR at junction of Keyes Road and U.S. 287; SE¼ sec. 33, T. 1 N., R. 6 E.							
A_1	0–16	7. 5	8. 0	8. 1	. 38	. 050	7. 6
B_2	16–28	6. 9	7. 8	7. 9	. 36	. 057	6. 3
B_{2ca}	28–54	7. 8	8. 3	8. 5	. 19	. 038	5. 0
C	54–65	7. 9	8. 5	8. 6	. 10	. 020	5. 0
C_{bca}	65–74+	7. 9	8. 6	8. 8	. 06	. 016	3. 8
Dalhart loamy fine sand, 0 to 3 percent slopes.							
Sample No. 55–OK–13–10.							
Location: 5½ miles N. of Tex.-Okla. line; E¼ corner sec. 6, T. 1 N., R. 5 E.							
A	0–12	7. 5	8. 0	8. 2	. 38	. 049	7. 8
B	12–36	6. 6	7. 9	8. 0	. 34	. 049	6. 9
C	36–64+	7. 7	8. 4	8. 4	. 10	. 019	5. 3
Sample No. 55–OK–13–12.							
Location: 4½ miles NW. of junction of Keyes Road and U.S. 287 and 100 ft. E. of U.S. 287; W¼ corner sec. 15, T 1 N., R. 7 E.							
A_1	0–15	7. 5	7. 0	7. 1	. 20	. 028	7. 1
B_{21}	15–26	7. 4	7. 7	7. 8	. 31	. 051	6. 1
B_{22}	26–38	6. 7	7. 7	7. 8	. 36	. 051	7. 1
A_{1bca}	38–57	7. 3	8. 1	8. 2	. 19	. 043	4. 4
B_{1b}	57–66	7. 4	8. 0	8. 2	. 22	. 046	4. 8
B_{2b}	66–75	7. 5	7. 8	7. 9	. 22	. 044	5. 0
C_b	75–85+	7. 5	8. 1	8. 2	. 22	. 041	5. 4
Mansker loam, 0 to 3 percent slopes.							
Sample No. 55–OK–13–5.							
Location: 550 ft. E. and 50 ft. N. of SW. corner sec. 10, T. 4 N., R. 5 E.							
A_1	0–7	7. 6	8. 1	8. 1	1. 32	. 180	7. 3
AC	7–16	7. 5	8. 0	7. 9	1. 16	. 174	6. 7
C_{ca}	16–38	7. 7	8. 3	8. 5	. 35	. 051	6. 8
Sample No. 55–OK–13–6.							
Location: 87 ft. E. and 650 ft. NE. of SW. corner sec. 15, T. 2 N., R. 9 E.							
A_1	0–7	7. 9	8. 1	8. 1	1. 03	. 118	8. 7
AC	7–14	7. 7	7. 9	8. 0	1. 06	. 147	7. 2
C_{ca}	14–28+	8. 0	8. 3	8. 4	. 28	. 045	6. 2
Portales clay loam, 0 to 1 percent slopes.							
Sample No. 55–OK–13–3.							
Location: 1,029 ft. W. and 546 ft. S. of USGS Station No. 23; NW. corner sec. 15, T. 4 N., R. 5 E.							
A	0–13	7. 4	8. 0	8. 2	1. 12	. 161	7. 0
AC	13–26	7. 7	8. 2	8. 3	. 53	. 078	6. 8
C_{ca}	26–50	7. 7	8. 3	8. 5	. 12	. 023	5. 2
C	50–72+	7. 8	8. 5	8. 6	. 06	. 012	5. 0
Sample No. 55–OK–13–4.							
Location: 590 ft. E. and 120 ft. N. of SW. corner sec. 4, T. 4 N., R. 6 E.							
A_1	0–12	7. 5	8. 0	8. 2	. 85	. 139	6. 1
AC	12–26	7. 7	8. 1	8. 2	. 61	. 100	6. 1
C_{ca1}	26–40	7. 9	8. 6	8. 5	. 14	. 027	5. 2
C_1	40–50	8. 0	8. 5	8. 6	. 12	. 023	5. 2
C_2	50–62+	8. 1	8. 6	8. 7	. 09	. 019	4. 7

soils in Cimarron County, Okla.

Estimated content of salt	Electrical conductivity ($Ec \times 10^3$)	Calcium carbonate equivalent	Cation exchange capacity	Extractable cations				Exchangeable sodium	Saturation extract soluble				Moisture at saturation
				Ca	Mg	Na	K		Na	K	Ca	Mg	
Percent	*Mmho. per cm. at 25° C.*	*Percent*	*Meq./100 gm. of soil*	*Meq./100 gm. of soil*	*Meq./100 gm. of soil*	*Meq./100 gm. of soil*	*Meq./100 gm. of soil*	*Percent*	*Meq./100 gm. of soil*	*Meq./100 gm. of soil*	*Meq./100 gm. of soil*	*Meq./100 gm. of soil*	*Percent*
0.03	0.393	0.0	6.62	7.38	1.31	0.07	0.51	1.06	0.008	0.016	0.076	0.021	27.8
.037	.602	0.0	10.29	9.15	1.50	.09	.39	.87	.015	.013	.175	.057	39.5
.035	.440	4.06	8.67	33.12	1.73	.12	.30	1.38	.017	.010	.194	.061	57.3
.03	.417	35.32	6.51	31.31	5.08	.16	.29	2.46	.021	.012	.081	.101	48.8
.03	.509	24.01	10.91	32.79	10.34	.66	.45	6.05	.191	.013	.019	.098	51.7
.02	.555	0.0	6.67	5.65	.81	.09	.46	1.35	.022	.022	.114	.049	31.1
.032	.694	0.0	13.85	13.40	2.18	.12	.45	.87	.026	.016	.238	.068	43.3
.045	.370	5.43	13.00	34.56	3.94	.18	.49	1.38	.023	.013	.130	.068	49.1
.033	.417	0.0	7.83	19.64	2.74	.26	.41	3.32	.051	.009	.034	.038	29.4
.038	.440	.45	10.33	23.11	4.51	.47	.48	4.55	.092	.011	.034	.049	33.9
.02	.486	0.0	5.89	5.10	1.72	.07	.48	1.19	.014	.023	.085	.028	26.4
.041	.602	0.0	11.27	8.61	1.55	.10	.34	.89	.024	.012	.173	.066	39.9
.02	.602	.54	3.70	20.10	.91	.10	.17	2.70	.023	.009	.134	.033	29.0
.02	.347	0.0	2.89	2.48	.80	.05	.13	1.73	.015	.015	.057	.025	28.7
.02	.347	0.0	9.76	7.91	1.76	.10	.24	1.02	.016	.015	.093	.032	32.7
.03	.324	0.0	15.76	12.75	2.56	.14	.40	.89	.022	.013	.107	.038	46.5
.048	.417	1.93	19.27	33.77	3.85	.46	.72	2.39	.053	.010	.075	.041	45.3
.05	.463	.65	22.76	24.60	4.82	.66	.75	2.90	.087	.013	.118	.061	47.7
.045	.393	0.0	22.90	20.91	4.61	.69	.76	3.01	.108	.013	.052	.045	52.0
.047	.370	0.0	21.86	20.92	4.40	.71	.76	3.25	.113	.013	.065	.045	52.3
.039	.417	14.08	14.45	40.06	1.74	.17	.94	1.18	.010	.023	.173	.014	46.6
.03	.509	53.93	10.98	38.66	1.73	.17	.53	1.55	.016	.017	.225	.035	52.1
.03	.671	63.73	5.21	33.08	2.32	.14	.25	2.69	.028	.007	.224	.064	40.8
.033	.602	12.19	8.14	34.86	1.93	.13	.73	1.60	.014	.034	.163	.047	36.8
.03	.787	49.08	6.66	34.64	1.11	.14	.23	2.10	.020	.011	.286	.052	44.9
.03	.463	57.10	5.66	33.83	1.92	.14	.18	2.47	.021	.011	.136	.058	40.0
.04	.417	12.11	18.14	45.53	2.19	.20	1.00	1.10	.018	.018	.188	.041	52.9
.03	.393	42.07	9.89	37.88	2.96	.19	.50	1.92	.018	.013	.125	.043	45.6
.02	.370	28.59	11.71	37.02	3.89	.27	.46	2.31	.040	.012	.096	.053	46.1
.03	.370	3.00	15.33	28.57	5.19	.36	.52	2.35	.072	.010	.097	.063	56.9
.055	.486	7.64	15.94	41.79	2.38	.24	.98	1.51	.013	.019	.153	.026	50.3
.037	.555	34.98	12.19	38.79	3.90	.17	.42	1.39	.018	.008	.192	.094	51.0
.03	.393	68.38	9.90	32.92	4.67	.21	.27	2.12	.036	.008	.070	.074	41.9
.03	.440	42.86	6.21	34.83	6.54	.53	.43	8.53	.135	.010	.062	.061	51.9
.03	.555	50.52	9.15	34.15	5.90	.62	.38	6.78	.132	.009	.076	.064	46.8

TABLE 9.—*Chemical properties of selected*

Soil name, sample number, and location	Depth	pH			Organic matter		
		Saturated paste	1:5	1:10	Organic carbon	Nitrogen	C/N
Richfield fine sandy loam, 0 to 1 percent slopes. Sample No. 55–OK–13–1. Location: 880 ft. S. and 250 ft. W. of the gas control station along U.S. 64; SW ¼ sec. 7, T. 3 N., R. 6 E.	*Inches*				*Percent*	*Percent*	
A_{1p}	0–4	7.7	8.1	8.2	0.45	0.071	6.3
B_{21}	4–11	7.2	7.7	7.8	.41	.068	6.0
B_{22}	11–23	7.5	7.8	8.0	.29	.061	4.8
B_{uca}	23–35	7.8	8.4	8.6	.15	.036	4.2
C_{uca}	35–45	7.9	8.6	8.7	.07	.023	3.0
C_{u1}	45–60	7.9	8.6	8.7	.06	.018	3.3
C_{u2}	60–78	7.9	8.7	8.8	.03	.012	2.5
Richfield clay loam, 0 to 1 percent slopes. Sample No. 55–OK–13–2. Location: 102 ft. W. and 960 ft. S. of the NE. corner sec. 27, T. 4 N., R. 6 E.							
A_{1p}	0–5	7.4	7.6	7.7	.78	.086	9.1
B_2	5–17	7.2	7.7	8.0	.37	.068	5.4
BC	17–22	7.7	8.2	8.4	.25	.058	4.3
C_{ca1}	22–38	7.8	8.2	8.5	.23	.039	5.9
C_{ca2}	38–60	7.9	8.6	8.7	.10	.030	3.3
C	60–88	7.9	8.6	8.7	.07	.014	5.0
Vona loamy fine sand. Sample No. 55–OK–13–9. Location: 4½ miles NW. of junction of Keyes Road and U.S. 287 and 100 ft. E. of U.S. 287; near W ¼ corner sec. 15, T. 1 N., R. 7 E.							
A_1	0–11	7.7	8.0	8.1	.34	.042	8.1
B	11–15	7.8	8.1	8.2	.39	.057	6.8
BC	15–24	7.9	8.2	8.3	.26	.045	5.8
C_{ca}	24–33	8.0	8.5	8.5	.12	.028	4.3
C_1	33–53	7.8	8.5	8.6	.07	.019	3.7
C_2	53–65	7.9	8.4	8.5	.09	.024	3.8
Sample No. 55–OK–13–11. Location: 100 yds. S. of the NE. corner sec. 14, T. 6 N., R. 9 E.							
A_1	0–7	7.6	8.0	8.1	.19	.036	5.3
A_{12}	7–19	6.4	7.9	8.0	.18	.032	5.6
C_1	19–29	6.6	7.1	7.1	.10	.018	5.6
C_{12}	29–73+	6.7	7.1	7.2	.06	.014	4.3

Dalhart loamy fine sand, 0 to 3 percent slopes (Sample No. 55–OK–13–12).—The following profile has a buried soil in the substratum. The profile was observed 4½ miles northwest of the junction of Keyes Road and United States Highway No. 287 and 100 feet east of United States Highway No. 287, near the west quarter corner of sec. 15, T. 1 N., R. 7 E.

A_1 0 to 15 inches, yellowish-brown (10YR 5/4; 4/3, moist) loamy fine sand; structureless to very weakly crumbly; very friable; rapidly permeable; noncalcareous; grades to

B_{21} 15 to 26 inches, brown to dark-brown (7.5YR 4/4, dry and moist) light sandy clay loam; fine to medium, granular structure or weak, crumb structure; faintly prismatic when dry; friable; noncalcareous; grades to

B_{22} 26 to 38 inches, brown to dark-brown (7.5YR 5/4; 4/2, moist) sandy clay loam; weak to moderate, prismatic structure; breaks to moderately hard subangular blocks and fine and very fine granules; sticky; noncalcareous; weak clay skins; rests on

A_{1bca} 38 to 57 inches, light brownish-gray, when dry, to dark grayish-brown, when moist, (10YR 6/2; 4/2, moist) heavy silt loam; fine to medium blocky structure; calcareous; some very fine streaks of calcium carbonate and very thin deposits on faces of blocks; this is an old buried surface with accumulations of calcium carbonate from more recently deposited material; rests sharply on

B_{1b} 57 to 66 inches, gray (10YR 5/1; 4/2, moist) silty clay loam; hard; fine, blocky structure; crushes to medium to fine granules; sticky; noncalcareous; weak clay skins; grades to

B_{2b} 66 to 75 inches, grayish-brown (10YR 5/2; 4/2, moist) silty clay; very hard; medium to fine, blocky structure; sticky; noncalcareous; very thin, indistinct clay skins; grades to

C_b 75 to 85 inches +, brown to light-brown (10YR 5/3; 4/3, moist) heavy clay loam; hard; fine, blocky structure; breaks to firm, medium granules; slightly calcareous.

Analysis of samples showed the B_{21} horizon to be fine sandy loam; the A_{1bca} to be silty clay loam; and the B_{2b} to be silty clay loam. The buried soil is more silty and clayey than the present soil. Such disconformities are common in the substrata of Dalhart soils.

soils in Cimarron County, Okla.—Continued

Estimated content of salt	Electrical conductivity (Ec × 10³)	Calcium carbonate equivalent	Cation exchange capacity	Extractable cations				Exchangeable sodium	Saturation extract soluble				Moisture at saturation
				Ca	Mg	Na	K		Na	K	Ca	Mg	
Percent	*Mmho. per cm. at 25° C.*	*Percent*	*Meq./100 gm. of soil*	*Meq./100 gm. of soil*	*Meq./100 gm. of soil*	*Meq./100 gm. of soil*	*Meq./100 gm. of soil*	*Percent*	*Meq./100 gm. of soil*	*Meq./100 gm. of soil*	*Meq./100 gm. of soil*	*Meq./100 gm. of soil*	*Percent*
0. 036	0. 648	0. 0	10. 03	10. 98	2. 13	0. 09	0. 73	0. 9	0. 009	0. 020	0. 108	0. 031	25. 0
. 040	. 463	0. 0	19. 79	14. 51	4. 53	. 17	. 76	. 8	. 027	. 011	. 163	. 070	48. 4
. 045	. 440	0. 0	22. 52	16. 56	5. 36	. 17	. 87	. 75	. 023	. 015	. 165	. 085	28. 4
. 03	. 417	1. 47	6. 03	27. 70	2. 73	. 17	. 36	2. 82	. 023	. 010	. 063	. 040	27. 5
. 02	. 417	0. 0	4. 45	9. 65	2. 32	. 09	. 31	2. 02	. 026	. 008	. 035	. 034	22. 8
. 033	. 509	19. 38	11. 45	31. 90	4. 48	. 44	. 57	3. 84	. 123	. 014	. 078	. 057	42. 9
. 033	. 555	16. 25	9. 84	31. 41	5. 49	. 44	. 42	4. 47	. 129	. 011	. 050	. 058	39. 0
. 045	. 463	0. 0	27. 14	17. 70	5. 80	. 09	1. 41	. 33	. 015	. 034	. 177	. 101	57. 4
. 055	. 440	0. 0	28. 36	18. 90	7. 98	. 18	1. 09	. 63	. 027	. 024	. 158	. 123	61. 3
. 051	. 417	8. 88	23. 57	39. 16	8. 78	. 27	1. 06	1. 15	. 035	. 019	. 197	. 122	57. 7
. 040	. 393	10. 94	18. 41	37. 77	7. 70	. 36	. 79	1. 96	. 050	. 018	. 084	. 089	50. 3
. 070	. 440	2. 21	16. 66	34. 19	6. 70	. 89	. 79	5. 34	. 153	. 013	. 030	. 033	44. 7
. 03	. 440	0. 0	12. 24	13. 14	5. 30	. 70	. 57	5. 72	. 122	. 007	. 018	. 025	34. 8
. 02	. 509	0. 0	6. 49	5. 09	. 97	. 06	. 26	. 92	. 017	. 012	. 097	. 026	26. 0
. 02	. 486	. 22	6. 87	23. 25	. 81	. 10	. 32	1. 46	. 013	. 010	. 113	. 028	30. 7
. 02	. 555	4. 56	5. 07	30. 60	. 91	. 12	. 23	2. 37	. 015	. 009	. 139	. 027	31. 4
. 02	. 440	4. 43	4. 11	30. 22	1. 11	. 10	. 18	2. 43	. 010	. 006	. 111	. 024	29. 6
. 033	. 509	1. 72	7. 24	28. 08	2. 14	. 10	. 28	1. 38	. 016	. 009	. 130	. 057	36. 5
. 03	. 347	21. 26	13. 92	39. 51	6. 69	. 24	. 45	1. 72	. 033	. 010	. 099	. 083	57. 8
. 02	. 463	0. 0	3. 82	3. 00	1. 10	. 06	. 23	1. 57	. 017	. 014	. 072	. 034	24. 6
. 02	. 393	0. 0	4. 67	3. 42	. 91	. 08	. 22	1. 71	. 013	. 008	. 094	. 032	25. 1
. 02	. 231	0. 0	3. 70	2. 38	1. 11	. 07	. 17	1. 89	. 008	. 006	. 024	. 020	23. 9
. 02	. 278	0. 0	2. 25	1. 76	. 60	. 07	. 12	3. 11	. 007	. 008	. 052	. 021	23. 5

Mansker loam, 0 to 3 percent slopes (*Sample No. 55–OK–13–5*).—The following profile was observed 550 feet east and 50 feet north of the southwest corner of sec. 10, T. 4 N., R. 5 E., CM.

A_1 0 to 7 inches, grayish-brown (10YR 5/2; 4/2, moist) silt loam; strong, fine, granular structure; very friable or soft when moist; calcareous; many worm casts below 3 inches; grades to

AC 7 to 16 inches, pale-brown (10YR 6/3; 4/2, moist) heavy silt loam containing numerous grayish-brown masses in its upper half; strong, fine and medium, granular structure; the darker colored soil appears to be the result of insect activity and decayed root channels; some soft calcium carbonate concretions in the lower 4 to 6 inches; grades to

C_{ca} 16 to 38 inches, white (10YR 8/2; 7/3, moist) silty chalky earth; dry or nearly so, but other soils in close proximity were moist at the same depth; very few roots of native grass observed in this zone.

D_r 38 inches +, (not sampled) indurated terrestrial limestone or caliche; weakly shattered in the upper part.

Analysis of samples showed the A_1 horizon to be loam the AC, clay loam; and the C_{ca}, clay loam.

Samples for analysis by the Oklahoma State Highway Department were collected nearby.

Mansker loam, 0 to 3 percent slopes (*Sample No. 55–OK–13–6*).—The following profile was observed 87 feet east and 650 feet northeast of the southwest corner of sec. 15, T. 2 N., R. 9 E. Occupies gently sloping upland; convex slopes of about 2 percent.

A_1 0 to 7 inches, grayish-brown (10YR 5/2; 3/2, moist) silt loam to loam; strong, fine, granular structure; very friable when moist; calcareous; many worm casts; grades to

AC 7 to 14 inches, light brownish-gray (10YR 6/2; 4/2, moist) loam; numerous dark grayish-brown masses in the upper half; strong, fine, granular structure; highly calcareous; grades to

C_{ca} 14 to 28 inches +, white (10YR 8/2; 7/3, moist) silty lime that contains a small percentage of silty soil; some hard calcium carbonate concretions; fewer grass roots than in AC horizon.

Analysis of samples showed the A_1 horizon to be loam; the AC horizon, clay loam; and the C_{ca} horizon, clay loam.

Portales clay loam, 0 to 1 percent slopes (*Sample No. 55-OK-13-3*).—The following profile was observed at the northwest corner of sec. 15, T. 4 N., R. 5 E., CM. The slope is less than 1 percent, and the surface is plane to weakly convex.

A 0 to 13 inches, brown (10YR 5/3; 4/3, moist) clay loam; strong, fine and medium, granular structure; fairly firm when dry, friable when moist; strongly calcareous; grades to

AC 13 to 26 inches, very pale brown (10YR 7/3; 6/4, moist) clay loam; strong, medium, granular structure; highly calcareous; some hard lime concretions in the lower 8 inches; a mass of worm casts; darker colored in the upper 4 to 6 inches as a result of insect activity or soil movement through channels left by decayed plant roots; grades to

C_{ca} 26 to 50 inches, pink (7.5YR 7/4; 6/6, moist) clay loam; moderate, medium to coarse, granular structure; strongly calcareous; approximately 10 percent hard calcium carbonate concretions more than 10 millimeters in size; grades to

C 50 to 72 inches, pink (7.5YR 7/4; 5YR 5/6, moist) sandy clay loam; strong, fine to medium, granular structure; a few lime concretions; more reddish than the C_{ca} horizon and contains less lime; very few roots.

The higher calcium carbonate equivalent in the AC horizon than in the C_{ca} is typical of the Portales soils. The C horizon may be unconformable with the layer above.

Samples for analysis by the Oklahoma State Highway Department were collected nearby.

Portales clay loam, 0 to 1 percent slopes (*Sample No. 55-OK-13-4*).—The following profile was observed 590 feet east and 120 feet north of the southwest corner of sec. 4, T. 4 N., R. 6 E., CM. The slope is less than 1 percent, and the surface is weakly convex to plane.

A_1 0 to 12 inches, dark grayish-brown (10YR 4/2; 4/3, moist) clay loam; strong, medium and fine, granular structure; very soft when moist; strongly calcareous; abundant worm casts in the lower 4 inches; grades to

AC 12 to 26 inches, light brownish-gray (10YR 6/2; 5/3, moist) clay loam or light silty clay loam; strong, medium, granular structure; strongly calcareous; approximately 5 percent of the soil mass in the lower 6 inches is soft calcium carbonate concretions and lime streaks; a mass of worm casts; grades to

C_{ca1} 26 to 40 inches, white (10YR 8/2; 7/4, moist) clay loam or light silty clay loam; strong, fine and medium, granular structure; highly calcareous with a floury, silty look and feel when dry; noticeable root restriction; grades with a wavy contact (6 to 12 inch differential) to

C_1 40 to 50 inches, very pale brown (10YR 7/3; 6/3, moist) clay loam or silty clay loam; more soil and less calcium carbonate in this zone; other characteristics same as in horizon above.

C_2 50 to 62 inches +, light yellowish-brown (10YR 6/4; 5/6, moist) clay loam or silty clay loam; about the same characteristics as in C_1 except for less lime and more soil material.

Analysis of samples showed the A_1 horizon to be heavy loam, and the C_{ca1} horizon and C_1 horizon to be light clays.

This profile characterizes the Portales clay loam of Cimarron County better than sample 55-OK-13-3.

Richfield fine sandy loam, 0 to 1 percent slopes (*Sample No. 55-OK-13-1*).—The following profile was observed 880 feet south and 250 feet west of the gas control station along United States Highway No. 64, in the SW¼ sec. 7, T. 3 N., R. 6 E. The slope is about 1 percent and is weakly convex.

A_{1p} 0 to 4 inches, grayish-brown (10YR 5/2; 4/2, moist) fine sandy loam; weak, fine, granular structure; very friable; noncalcareous; sharp abrupt boundary at bottom of plow slice; layer rests on

B_{21} 4 to 11 inches, dark grayish-brown (10YR 4/2; 3/3, moist) clay loam; moderate to weak, medium, blocky structure; sticky when wet, hard when dry; clay skins are pronounced on many of the larger blocks but only faintly observable on the finer blocks; noncalcareous; little evidence of insect activity in this zone; grades to

B_{22} 11 to 23 inches, dark-brown (10YR 4/3; 3/3, moist) silty clay loam; strong, medium, blocky structure; clay skins very pronounced; good sorghum root distribution between blocks; noncalcareous but slightly calcareous in lower few inches on outside of the blocks; grades to

B_{uca} 23 to 35 inches, brown (10YR 5/3; 5/3, moist) sandy loam; weak to moderate, fine, granular structure; contains few soft lime concretions; soil mass highly calcareous.

C_{uca} 35 to 45 inches, reddish-yellow (7.5YR 6/6; 5/6, moist) medium to fine sand; structureless; nonsticky; very few roots; weakly calcareous.

C_{u1} 45 to 60 inches, very pale brown (10YR 7/3; 5/3, moist) sandy clay loam with whitish (10YR 7/2) lime spots; moderate to strong, fine, granular structure. This appears to be a weak B or modified A horizon of a buried soil.

C_{u2} 60 to 78 inches, similar to C_{u1} except for color (10YR 7/2; 6/3, moist).

There is considerable variation in the ratios of the different sizes of sand at 11, 23, and 45 inches. This soil developed in layers of material superimposed at various times.

Richfield clay loam, 0 to 1 percent slopes (*Sample No. 55-OK-13-2*).—The following profile was observed 102 feet west and 960 feet south of the northeast corner of sec. 27, T. 4 N., R. 6 E. The slope is less than one-half percent.

A_{1p} 0 to 5 inches, light brownish-gray (10YR 6/2; 4/2, moist) clay loam; moderate, medium, platy structure that breaks to weak fine granules when moist; winnowed fine and medium sand comprise top one-half inch; grades to

B_2 5 to 17 inches, grayish-brown (10YR 5/2; 3/2, moist) clay; weak, medium to fine, blocky structure; sticky when wet, hard when dry; continuous and pronounced clay skins; good root distribution between the blocks; grades to

BC 17 to 22 inches, pale-brown (10YR 6/3; 4/2, moist) silty clay loam; weak, medium, granular structure to weak, very fine, blocky structure; calcareous; a few soft calcium carbonate concretions in the lower 4 inches; grades to

C_{ca1} 22 to 38 inches, very pale brown (10YR 7/4; 6/4, moist) silty clay loam; moderate, medium to fine, granular structure; strongly calcareous; many soft calcium carbonate concretions, 5 to 10 millimeters in size; grades to

C_{ca2} 38 to 60 inches, similar to the C_{ca1} except the calcium carbonate concretions are absent; grades to

C 60 to 88 inches, reddish-yellow (7.5YR 6/6; 5/4, moist) sandy clay loam; moderate, very fine, granular structure; weakly calcareous in upper part; very few roots.

Mechanical analysis showed the A_{1p} horizon to be 37 percent clay. The B_2 layer is more clayey and blocky than is typical of most of the Richfield clay loam in this county. Probably this profile is gradational toward the Campo series. No Campo soils were mapped in Cimarron County.

Vona loamy fine sand (*Sample No. 55-OK-13-9*).—The following profile was observed 4½ miles northwest of the junction of Keyes Road and United States Highway No. 287 and 100 feet east of United States Highway No. 287, near the west quarter corner of sec. 15, T. 1 N., R. 7 E.

The terrace is hummocky; the slope is about 2 percent and convex.

- A_1 0 to 11 inches, dark-brown (10YR 4/3; 3/2, moist) loamy fine sand; loose; noncalcareous but neutral; heavy concentration of grass roots; grades to
- B 11 to 15 inches, brown (10YR 5/3; 4/3, moist) light sandy clay loam; weak, fine, granular structure; nonsticky when wet; noncalcareous but neutral; heavy concentration of grass roots; permeable; grades to
- BC 15 to 24 inches, yellowish-brown (10YR 5/4; 4/3, moist) loam; strong, fine, granular structure; highly calcareous; some soft concretions of calcium carbonate; pseudomycelia; grades to
- C_{ca} 24 to 33 inches, yellowish-brown (10YR 5/4; 5/3, moist) loamy sand; loose and structureless; strongly calcareous; grades to
- C_1 33 to 53 inches, brown (10YR 5/3; 5/4, moist) loamy sand; other characteristics same as in C_{ca} horizon except this horizon is only weakly calcareous and has no concretions of calcium carbonate.
- C_2 53 to 65 inches, yellowish-brown (10YR 5/6; 5/4, moist) loamy sand; white (2.5YR 8/2; 7/4, moist) calcium carbonate concretions; sand is moderately hard when dry.

Analysis of samples showed the B and BC horizons to be on the loamy fine sand-fine sandy loam boundary; and the C_1 to be a median fine sandy loam.

Samples for analysis by the Oklahoma State Highway Department were collected at this site.

Vona loamy fine sand (Sample No. 55-OK-13-11).— This profile was observed 100 yards south of the northeast corner of sec. 14, T. 6 N., R. 9 E., CM. The relief is hummocky, the slope convex, and the gradient 3 percent.

- A_1 0 to 7 inches, grayish-brown (10YR 5/2; 4/3, moist) loamy fine sand; loose; top inch is dark brown; grades to
- A_{12} 7 to 19 inches, dark yellowish-brown (10YR 4/4; 4/2, moist) loamy fine sand; grades to
- C_1 19 to 29 inches, yellowish-brown (10YR 5/4; 5/3, moist) loamy fine sand.
- C_{12} 29 to 73 inches +, light yellowish-brown (10YR 6/4; 5/3, moist) loamy fine sand.

No segregated lime was observed in this profile. The native vegetation was largely sagebrush and yucca. The native grasses were severely depleted at this site.

Samples for analysis by the Oklahoma State Highway Department were collected nearby.

Engineering properties of Soils [2]

This section records the soil properties important in engineering. It contains information that engineers can use to:

1. Make soil and land use studies that will aid in the selection and development of industrial, business, residential, and recreational sites.
2. Estimate runoff and erosion characteristics for use in designing drainage structures and planning dams and other structures for conserving soil and water.
3. Make reconnaissance surveys of soil and ground conditions that will aid in selecting highway and airport locations and in planning detailed soil surveys for the intended locations.
4. Locate sand and gravel for use in structures and for use as a base for both flexible and rigid pavements.
5. Correlate pavement performance with types of soil and thus develop information that will be useful in designing and maintaining the pavement.
6. Determine the suitability of soil units for cross-country movement of vehicles and construction equipment.
7. Supplement information obtained from other published maps and reports and aerial photographs for the purpose of making soil maps and reports that readily can be used by engineers.
8. Become aware of the hazards or useful properties of various soils when used for highway and earth construction, when definite laboratory data are not available.

The mapping and description of the soils are somewhat generalized, however, and the report therefore should be used only as a preliminary to more detailed field surveys to determine the in-place condition of the soil material at the site proposed for engineering construction.

Soils in Highway Construction

Among those who find a constantly increasing use for soils information are the engineers who plan and construct foundations and embankments for highways. Highways are extensive and are laid out on many kinds of soils. Engineers engaged in constructing highways need information on soils covering large areas.

Engineering tests and estimates

Valuable as the agricultural soil surveys have been in the past, their use to engineers has been somewhat restricted by the lack of a method of translating soils information into engineering language. The soils language of the engineer consists principally of numbers representing the results of laboratory tests of soil samples. Some engineering tests are made to determine the particle size distribution of the grains in a soil. Other tests are made to determine the effect of water on the consistency of the soil.

To determine the size of the grains present in a particular soil, a sieve analysis is used for the larger grains and a hydrometer is used to determine the size of the smaller particles retained in suspension with water. Particles are classed in four principal groups: Gravel, sand, silt, and clay.

The tests commonly made to determine the effect of water on the consistency of a soil are the liquid-limit (LL) and the plastic-limit tests. The result of the liquid-limit test shows the moisture content at which a mixture of soil and water changes from a plastic to a liquid state. The plastic limit is the moisture content at which the soil changes from a solid or semisolid state to a plastic state.

If the moisture content of a liquid soil is reduced to the liquid limit percentage, the soil becomes plastic and the volume decreases in proportion to the volume of the water removed. The soil will continue to decrease in volume as the water content is reduced to approximately the plastic limit. The plastic limit subtracted from the liquid limit gives the plasticity index (PI) of a soil. It indicates the range in moisture content through which a soil is plastic.

The American Association of State Highway Officials (AASHO) has approved a system of classifying soils

[2] This section was prepared with the help of R. A. HELMER, highway research engineer, Oklahoma State Highway Department.

by the results of laboratory soil tests. This system has been used extensively by the Bureau of Public Roads. In this system, there are seven primary groups of soils. For some of the primary groups a further characterization is accomplished by means of group index numbers. The suitability of a soil for engineering purposes can be estimated from the classification group and group index number. The lower the number of the soil group and the lower the group index number within the same soil group, the better the rating of the soil.

Table 10 gives the essentials of the classification system used by the AASHO. It also lists the stability properties of the several classes of material.

The values of the group index are based on particle size gradation, liquid limit, and plasticity index and are computed according to the following formula:

Group index=0.2a+0.005ac+0.01bd, where—

a=that portion of percentage passing No. 200 sieve greater than 35 percent and not exceeding 75 percent, expressed as a positive whole number (1 to 40);

b=that portion of percentage passing No. 200 sieve greater than 15 percent and not exceeding 55 percent, expressed as a positive whole number (1 to 40);

c=that portion of the numerical liquid limit greater than 40 and not exceeding 60, expressed as a positive whole number (1 to 20);

d=that portion of the numerical plasticity index greater than 10 and not exceeding 30, expressed as a positive whole number (1 to 20).

Table 11 gives engineering data obtained by laboratory tests of some of the principal soils in Cimarron County and the AASHO classifications based on these tests.

The California bearing ratio (CBR) given in this table is a test of the load-supporting value of a soil. It is a punching shear test on confined samples compacted at optimum moisture percent. The formula is as follows:

$$\text{CBR}=\frac{\text{Force needed to push piston into compacted soil 0.1 inch}}{\text{Force needed to push piston into well-graded and compacted crushed stone 0.1 inch}}$$

The information in this table is limited. It is assumed that it will be supplemented by further sampling and testing.

Table 12 shows the criteria used for estimating ratings for the soil characteristics important to engineering.

Engineering tests were made on only the major soils. For soils not tested, the quality of soil materials and their suitability for construction purposes are inferred by comparison with physically similar soils. Estimates of the engineering qualities of the soils in Cimarron County are given in table 13.

For the A horizons, suitability for seeding and sodding was judged from the expected performance of each soil as a medium for plant growth. Organic-matter content, soil granulation, and the ability of material to absorb and store moisture were considered. Because of this, A horizons have seeding and sodding ratings different from those of B and C horizons, even though all layers have similar engineering test values.

Soil complexes are judged according to the series having the largest acreage. Of course, the proportion is not constant from place to place. An idea of the range of composition in each complex can be obtained from the descriptions in other parts of this report.

Fortunately the soils mapped as complexes are not generally highly contrasting, and the qualities of the complex are much like those of the individual soils. Qualities of the complexes, estimated from data in table 13, are listed below.

Mansker-Dalhart loams. Complex is 60 percent Mansker and 40 percent Dalhart. The Dalhart are the better soils for roadbuilding. They support loads better and swell and shrink less. They are darker colored and appear to be more uniform than the Mansker, which have light-colored limy spots throughout the upper 2 or 3 feet. Engineers can use Dalhart soils as borrow in crossing these areas.

Mansker-Potter complex. This complex is 35 percent Potter soils. The Potter soils occupy breaks and steep ridges. They may have caliche slabs on the surface and in the soil. They have better load-supporting ability than the Mansker, and they shrink less. Also, they have better qualities for other uses. They are identified rather readily by their position on steep slopes and by their stony surface (caliche).

Potter-Mansker loams. This complex is similar to the Mansker-Potter complex, except that it is on gentler slopes and has a greater portion of Potter soil (80 percent). It occurs on edges of plains above the breaks. Select material of hardened caliche may be obtained from many of the Potter areas.

Vona-Tivoli loamy fine sands. The Vona soils are on low, wavy terrain; the Tivoli are on the dunes. The two soils have similar characteristics. Both support loads well if confined. Neither one swells or shrinks, but the high sand content makes these soils hard to use. Drifting into roads and bare ditches is a problem. Materials suitable for blending with or replacing these sands may be available in nearby areas of Dalhart fine sandy loam.

The three bottom-land soils are quite different in engineering characteristics. The Spur soils are clay loams and are not desirable for roadbuilding. Sweetwater fine sandy loam has vari-textured layers, mixtures of which may be superior to the Spur soils and might be blended successfully with them to get better road material. The Lincoln soils also vary but are consistently very sandy. They may be useful for blending with Spur soils.

Richfield and Portales soils are extensive and level, but their layers do not have good properties for roadbuilding. The B and C horizons of the Richfield soils are satisfactory as topdressing to prevent ditch erosion. Dalhart soils, which commonly occur next to Richfield and Portales soils, have considerably better roadbuilding properties. Ditches and slopes, however, are hard to stabilize on Dalhart soils. Borrow from Dalhart soils may improve the properties of Richfield and Portales soils for load supporting and may lessen swelling and shrinkage. Borrow from Richfield subsoils may be used to prevent erosion of ditches and slopes in Dalhart and Portales areas.

Conservation Engineering

The qualities that affect the suitability of soils for highway engineering are also important in conservation

TABLE 10.—*Essentials of soil classification system of the American Association of State Highway Officials* [1]

General classification	Granular materials (35 percent or less passing No. 200 sieve [2])							Silt-clay materials (more than 35 percent passing No. 200 sieve [2])				
Group classification	A-1		A-3	A-2				A-4	A-5	A-6	A-7	
	A-1-a	A-1-b		A-2-4	A-2-5	A-2-6	A-2-7				A-7-5	A-7-6
Sieve analysis: Percent passing—												
No. 10	50 maximum.											
No. 40	30 maximum.	50 maximum.	51 minimum.									
No. 200	15 maximum.	25 maximum.	10 maximum.	35 maximum.	35 maximum.	35 maximum.	35 maximum.	36 minimum.	36 minimum.	36 minimum.	36 minimum.	36 minimum.
Characteristics of fraction passing No. 40 sieve—												
Liquid limit			[3] NP	40 maximum.	41 minimum.	40 maximum.	41 minimum.	40 maximum.	41 minimum.	40 maximum.	41 minimum.	41 minimum.
Plasticity index	6 maximum.	6 maximum.	[3] NP	10 maximum.	10 maximum.	11 minimum.	11 minimum.	10 maximum.	10 maximum.	11 minimum.	11 minimum.[4]	11 minimum.[4]
Group index [5]	0	0	0	0	0	4 maximum.	4 maximum.	8 maximum.	12 maximum.	16 maximum.	20 maximum.	20 maximum.
Stability properties	Highly stable at all times.		Highly stable when confined.	Stable when dry; ravels and is easily worn away by traffic.		Good stability.		Stable when dry; loses stability when wet.	Stability variable; hard to compact.	Fair stability when properly compacted.	Fair stability if properly compacted and kept free of moisture.	

[1] Based on STANDARD SPECIFICATIONS FOR HIGHWAY MATERIALS AND METHODS OF SAMPLING AND TESTING (pt. 1; ed. 7); The Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes, AASHO Designation: M 145–49.

[2] The 200-mesh sieve separates soil fractions at about the middle of the range of very fine sand, based on the classification used by the United States Soil Conservation Service, Soil Survey Division.

[3] NP—Nonplastic.

[4] Plasticity index of A-7-5 subgroup is equal to or less than LL minus 30. Plasticity index of A-7-6 subgroup is greater than LL minus 30.

[5] General evaluations of subgrades in terms of group index are as follows: 0-1, good; 2–4, fair; 5–9, poor; 10–20, very poor. The procedure for calculating the group index is explained under Designation M 145–49 of the reference cited in footnote 1.

TABLE 11.—*Engineering test data for important soils*

[Samples are from profiles described in the section, Laboratory Analysis, except for the sample of Potter loam, which was taken in Texas County, Okla.]

Soil	Horizon	Depth	AASHO classification	California bearing ratio	Liquid limit	Plasticity index	Percentage of material passing—	
							No. 40 sieve	No. 200 sieve
		Inches						
Berthoud loam	A	0–14	A–4(4)	7.0	27	9	99	54
	B	16–30	A–6(9)	8.3	33	12	99	73
	C	30–60	A–4(8)	6.7	25	8	99	83
Dalhart fine sandy loam	A	0–14	A–2(0)	8.3	21	2	91	24
	B	16–28	A–2–4(0)	9.3	26	8	92	28
	C_{ca}	28–54	A–6(5)	5.3	32	13	93	55
Dalhart loamy fine sand	A	0–10	A–2–4	13.0	[1]NP	[1]NP	94	14
	B	11–24	A–4(1)	10.0	29	10	97	42
	C	33–53	A–6(7)	5.0	35	15	94	62
Mansker loam	A	0–7	A–6(5)	3.0	34	11	92	59
	C_{ca}	16–38	A–6(7)	9.0	15	11	93	71
Portales clay loam	A	0–13	A–4(6)	4.7	33	9	96	66
	AC	13–26	A–6(3)	1.7	28	11	95	51
	C_{ca}	30–50	A–6(10)	7.0	35	14	94	74
Potter loam	A	0–8	A–2–4(0)	22.6	34	7		21
	C	8–30	A–4(2)	30.6	22	3		45
Richfield clay loam	A	0–5	A–6(10)	2.0	36	16	98	82
	B	8–22	A–7–6(15)	4.0	48	23	99	89
	C	24–60	A–6(9)	4.7	34	12	99	74
Spur soils	A	0–20	A–6(10)	6.7	37	15	96	80
	C	20–60	A–6(10)	4.7	35	14	97	74
Travessilla stony loam	[2]AC	0–8	A–4(3)	2.0	27	9	97	52
Vona loamy fine sand	A	0–16	A–2(0)	5.5	20	1	91	16
	C	20–73	A–3(0)	8.7	[1]NP	[1]NP	87	5

[1] Nonplastic.
[2] Sample did not include any stones or pebbles.

engineering. Building terraces and ponds involves moving large quantities of earth. To be sure the results will justify the expense, it is important to plan such structures carefully and to build them in suitable soil materials.

The estimates in table 10 can be applied to conservation engineering as well as to roadbuilding. Volumetric shrinkage is important in locating and building diversion ditches and water-impounding terraces. Load-supporting ability is important in locating farm and ranch roads. Suitability as erosion control material indicates how good a soil will be as topdressing for completed earth structures. A soil that is suitable material for seeding and sodding will probably support a good protective cover. Soil stability is important in building terraces and diversion structures, as well as in selecting sites for farm ponds. Unstable materials are likely to drift and fill in the water channels. In windy Cimarron County, sandy soils should not be terraced. Conservation terraces are not common, even on the clay loams and loams, since they are not generally needed to control water erosion. A large proportion of the cropland is so level that it absorbs most of the normal rainfall. However, a good bit of valuable water is lost each year by runoff from the steeper areas. This runoff water might be captured and stored in suitable adjacent soils. Saving 2 or 3 inches of water may make the difference between crop failure and success.

Water-impounding terraces can be built on nearly level or very gently sloping soils (slopes up to 2 percent). Such terraces are made by pushing soil up from the downslope side to form a ridge. The area above the ridge is leveled for about two-thirds of the way to the next ridge. Water from the unleveled third runs onto the leveled part. These terraces are not graded, and the ends are left blocked so water is trapped. If necessary, the ends can be opened to drain away excess water. Water-impounding terraces are most effective on permeable and slowly permeable soils, such as Dalhart fine sandy loam and the Richfield, Portales, and Spur soils.

Diversions are large, graded, channel-type terraces that have a high ridge and a channel adequate to carry as much runoff water as is expected. They may be used to divert runoff that would damage crops on lower lying areas. Usually, diversions are designed to carry water to natural drainageways or to large stock reservoirs.

A great deal of moisture may be saved so that it can be used by crops if this diverted water is spread over lower lying croplands or pastures. Irrigation water from wells costs as much as $10 to $15 per acre-foot. It is often possible to collect, by the use of diversions and water-spreading terraces, enough water to grow crops without irrigation.

Diversions are most useful in catching water from sloping and steep loams and clay loams. They are most commonly needed and most useful in the breaks along the stream valleys, where they catch runoff from steep, shallow soils such as the Potter, Mansker, Vernon, and Travessilla, and from sloping soils of the Mansker, Potter, and Berthoud series. Often this water can be spread on more gently sloping areas of Portales, Berthoud, or Spur soils. A few areas of Richfield clay loam are so located that they may benefit from diverted water.

Since conservation structures are costly and must be very accurately designed to accomplish the desired results, they should be laid out by trained persons who are familiar with the soils and the runoff pattern. Farmers can get help from representatives of the Soil Conservation District.

Bibliography

Harper, W. G.
1957. MORPHOLOGY AND GENESIS OF CALCISOLS. Soil Sci. Soc. Amer. Proc. 21: 420–424.

Templin, E. H., Mowery, I. C., and Kunze, G. N.
1956. HOUSTON BLACK CLAY, THE TYPE GRUMUSOL: I. FIELD MORPHOLOGY AND GEOGRAPHY. Soil Sci. Soc. Amer. Proc. 20: 88–90.

Thorp, James, and Smith, Guy D.
1949. HIGHER CATEGORIES OF SOIL CLASSIFICATION: ORDER, SUBORDER, AND GREAT SOIL GROUP. Soil Sci. 67: 117–126.

United States Department of Agriculture.
1938. SOILS AND MEN. U.S. Dept. Agr. Ybk. 1938, 1232 pp., illus.

——— 1951. SOIL SURVEY MANUAL. U.S. Dept. Agr. Handbook 18. 503 pp., illus.

Table 12.—*Criteria for determining shrinkage characteristics and construction suitability*

Shrinkage characteristics and suitability classes for earth construction	Percentage passing 200 screen	California bearing ratio	Liquid limit	Plasticity index
Load supporting ability for subgrade:				
Good	Less than 15	More than 10	Less than 35	Less than 12.
Fair	15 to 35	5 to 10	35 to 45	12 to 20.
Poor	More than 35	Less than 5	More than 45	More than 20.
Volumetric shrinkage:				
Low	(1)	(1)	Less than 35	Less than 12.
Medium	(1)	(1)	35 to 40	12 to 20.
High	(1)	(1)	More than 40	More than 20.
Soil binder:				
Yes	Less than 50	(1)	(1)	10 to 25.
No	50 or more	(1)	(1)	Less than 10 and more than 25.
Soil stabilization for base:				
Yes	15 to 50	(1)	(1)	Less than 10.
No	Less than 15 and more than 50.	(1)	(1)	10 or more.
Shoulder construction:				
Good	15 to 30	(1)	(1)	6 to 15.
Fair	31 to 50	(1)	(1)	3 to 5, 16 to 20.
Poor	Less than 15 and more than 50.	(1)	(1)	Less than 3 and more than 20.
Prevention of slope and ditch erosion:				
Good	More than 50	(1)	(1)	More than 20.
Fair	35 to 50	(1)	(1)	15 to 20.
Poor	Less than 35	(1)	(1)	Less than 15.
Seeding and sodding:				
Good	10 to 50	(1)	(1)	6 to 15.
Fair	5 to 9, 51 to 90	(1)	(1)	1 to 5, 16 to 25.
Poor	Less than 5 and more than 90.	(1)	(1)	NP[2] and more than 25.

[1] Column heading not applicable. [2] Nonplastic.

TABLE 13.—*Estimated qualities of soil materials and suitability for various construction purposes*

Soil type	Horizon	Depth	Soil quality		Suitability for—				
			Load-supporting ability	Volumetric shrinkage	Soil binder	Soil stabilization	Shoulder construction	Prevention of slope and ditch erosion	Seeding and sodding
		Inches							
Apache stony clay loam (see Berthoud loam).									
Berthoud fine sandy loam (see Berthoud loam).									
Berthoud loam	A	0–14	Poor	Low	No	No	Poor	Poor	Fair.
	B	14–30	Poor	Low	No	No	Poor	Poor	Fair.
	C	30–60	Poor	Low	No	No	Poor	Poor	Fair.
Carnero loam (see Berthoud loam).									
Dalhart fine sandy loam	A	0–14	Fair	Low	No	No	Poor	Poor	Fair.
	B	14–28	Fair	Low	No	No	Poor	Poor	Fair.
	C	28–54	Poor	High	No	No	Poor	Poor	Fair.
Dalhart loamy fine sand	A	0–10	Fair	Low	No	No	Poor	Poor	Poor.
	B	11–24	Poor	Low	No	No	Good	Poor	Fair.
	C	33–53	Poor	High	No	No	Poor	Fair	Fair.
Lincoln soils (see Vona loamy fine sand).									
Mansker fine sandy loam (see Mansker loam).									
Mansker loam	A	0–7	Poor	High	No	No	Poor	Poor	Fair.
	C_{ca}	7–38	Poor	High	No	No	Poor	Poor	Fair.
Mansker-Dalhart loams (see Mansker loam).									
Mansker-Potter complex (see Mansker loam).									
Otero loamy fine sand (see Mansker loam).									
Portales clay loam	A, AC	0–25	Poor	High	No	No	Poor	Poor	Fair.
	C_{ca}	25–40	Poor	High	No	No	Poor	Poor	Fair.
Potter-Mansker loams (tests are for Potter which comprises about 80 percent of complex).	A	0–8	Fair	Low	Yes	Yes	Good	Poor	Good.
	C	8–30	Poor	Medium	Yes	Yes	Fair	Poor	Fair.
Randall clay (see Richfield clay loam).									
Richfield clay loam	A	0–5	Poor	High	No	No	Poor	Poor	Fair.
	B	8–22	Poor	High	No	No	Poor	Good	Fair.
	C	24–60	Poor	High	No	No	Poor	Fair	Fair.
Richfield fine sandy loam (see Richfield clay loam).									
Richfield loam (see Richfield clay loam).									
Rough stony land (see Travessilla stony loam).									
Spur soils	A	0–20	Poor	High	No	No	Poor	Fair	Fair.
	C	20–60	Poor	High	No	No	Poor	Poor	Fair.
Sweetwater fine sandy loam (see Dalhart fine sandy loam).									
Travessilla stony loam	AC	0–8	Poor	High	No	No	Poor	Poor	Fair.
Vernon clay loam (see Richfield clay loam).									
Vona-Tivoli loamy fine sands (tests are for Vona loamy fine sand which comprises about 65 percent of complex).	A	0–16	Fair	Low	No	Yes	Good	Poor	Fair.
	C	20–73	Poor	Low	No	No	Poor	Poor	Poor.

Glossary

Alluvial soils.—An azonal great soil group. Soils developed from transported and relatively recently deposited material (alluvium); soils are characterized by a weak modification (or none) of the original material by soil-forming processes.

Alluvium.—Fine material, such as sand, mud, or other sediments, deposited on land by streams.

Association, soil.—A group of soils, with or without common characteristics, geographically associated in an individual pattern.

Bedrock.—The solid rock underlying soils and other earthy surface formations.

Bottom land.—*See* flood plain.

Brown soils.—A group of zonal soils of arid to semiarid regions having a brown surface soil grading into a whitish calcareous horizon 1 to 3 feet from the surface.

Calcareous.—Containing sufficient calcium carbonate (often with magnesium carbonate) to effervesce visibly to the naked eye when treated with hydrochloric acid. Alkaline in reaction, because of the presence of free calcium carbonate.

Calcisols.—An intrazonal great soil group. Soils of arid and semiarid regions, developed in highly calcareous parent materials; includes soils in which a prominent horizon of calcium carbonate has formed.

Caliche.—A more or less cemented deposit of calcium carbonate or of mixed calcium and magnesium carbonates, characteristic of soils of warm or hot desert or semiarid regions.

Chestnut soils.—A zonal great soil group. Soils have a dark-brown surface horizon that grades into lighter colored soil and finally to a horizon of lime accumulation; developed under mixed tall and short grasses in a temperate to cool, subhumid to semiarid climate.

Clay.—Mineral soil grains less than 0.002 mm. in diameter.

Colluvium.—Heterogeneous mixtures of rock fragments and soil material, moved by gravity and deposited at the base of strong slopes.

Complex, soil.—A soil association mapped as a single unit because the series, types, or phases are so intricately mixed that they cannot be shown separately on maps of the scale used in the soil survey reports.

Concretions.—Local concentrations of certain chemical compounds, such as calcium carbonate or compounds of iron, that form hard grains or nodules of mixed composition and of various sizes, shapes, and coloring.

Flood plain.—A nearly flat area that is close to a stream course. The lower part is flooded occasionally and is called a first bottom; the higher part, above overflow, is called a second bottom.

Friable.—Easily crumbled in the fingers; nonplastic.

Grumusols.—An intrazonal great soil group. Dark-colored, mostly calcareous clay soils that are high in montmorillonite, have a thick solum without textural or other pronounced horizonation, and have a marked tendency to contract and crack on drying.

Igneous rock.—A rock produced by the cooling of melted mineral material.

Lithosols.—An azonal great soil group. Soils have an incomplete solum or no clearly expressed soil morphology; they consist of a freshly and imperfectly weathered mass of hard rock or hard rock fragments; largely confined to steeply sloping land.

Massive.—Structureless but cohesive, sometimes with irregular cleavage.

Phase, soil.—A subdivision of the soil type based on characteristics significant to use but not to the genesis of the soil. The variations are chiefly in such external characteristics as relief, stoniness, or accelerated erosion. They may be of great practical importance in land use.

Plastic.—Capable of being molded without rupture; not friable.

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 the soil mass, expressed in pH values or in words, as follows:

	pH
Extremely acid	Below 4.5
Very strongly acid	4.5 to 5.0
Strongly acid	5.1 to 5.5
Medium acid	5.6 to 6.0
Slightly acid	6.1 to 6.5
Neutral	6.6 to 7.3
Mildly alkaline	7.4 to 7.8
Moderately alkaline	7.9 to 8.4
Strongly alkaline	8.5 to 9.0
Very strongly alkaline	9.1 and higher

Strict neutrality is precisely pH 7.0.

Reddish-Brown soils.—A zonal great soil group. Soils have brown or reddish-brown surface soils and heavier subsoils that grade to whitish calcareous horizon. They develop under mixed grasses and shrubs in a temperate to hot, semiarid climate.

Reddish Chestnut soils.—A zonal great soil group. Soils have slightly reddish surface soils, heavier reddish-brown subsoils, and lime accumulation at 2 feet or more. They develop under mixed grasses and shrubs in a warm-temperate to hot, semiarid climate.

Regosols.—An azonal great soil group. Soils consist of deep, unconsolidated rock (soft mineral deposits) in which few or no clearly expressed soil characteristics have developed.

Relief.—The elevations or inequalities of a land surface, considered collectively.

Silt.—Small grains of mineral soil 0.05 mm. to 0.002 mm. in diameter (or 0.02 mm. to 0.002 mm. in the international system).

Single grain.—Structureless; each grain by itself, as in dune sand.

Slope, soil.—The rise or fall in feet per 100 feet of horizontal distance, expressed in percentages or words, as follows: Level, 0 to ½ percent; nearly level, ½ to 1 percent; gentle, 1 to 3 percent; sloping, 3 to 5 percent; strongly sloping, 5 to 8 percent; steep, 8 to 12 percent +.

Soil separates.—The individual size groups of soil particles: Sand, silt, and clay.

Solum.—The upper part of the soil profile, above the parent material, in which the processes of soil formation are taking place. In mature soils this includes the A and B horizons. The character of the material may be, and usually is, greatly unlike that of the parent material beneath. The area of living roots and life processes.

Structure.—The morphological aggregates in which the individual soil particles are arranged. The following are the principal types of soil structure observed in Cimarron County.

Blocky (angular).—Generally flat-sided blocklike aggregates.

Granular.—Hard or soft, but firm, small aggregates, angular or rounded, as in the A horizon of many Reddish Chestnut soils.

Fragmental.—Hard or soft, but firm, irregular aggregates, angular or subangular, as in many young soils developed from silty or clayey alluvium.

Prismatic.—Blocky, with the vertical axis of the blocks longer than the horizontal, as in the B horizon of many Reddish Chestnut soils.

Subangular blocky.—Mixed rounded and plane faces with rounded vertices; somewhere between blocks and granules.

Subsoil.—The zone of accumulation (highest clay content) in soils with distinct profiles. On the average, it begins 4 to 12 inches below the surface. In a soil without a distinct profile, the subsoil may begin just below plowing depth. That part of the solum below plow depth.

Substratum.—Any layer beneath the solum, either C or D horizons.

Surface soil.—That part of the upper layers of arable soils commonly stirred by tillage implements, or an equivalent depth (5 to 8 inches) in nonarable soils.

Texture, soil.—The relative proportion of the various size groups of individual soil grains. The principal textural classes, in increasing order of the content of the finer separates, are as follows: sand, loamy sand, sandy loam, loam, silt loam, clay loam, and clay. These may be modified, depending on the relative size of the coarser particles, to fine sand, loamy fine sand, fine sandy loam, sandy clay, stony clay loam, silty clay, and so on.

Topsoil.—A general term applied to the uppermost part of the soil; average plow depth (surface soil), or the A horizon, where this is deeper than plow depth. Topsoil cannot be precisely defined as to depth or productivity except in reference to a particular soil type.

Type, soil.—A group of soils having horizons similar as to texture and arrangement in the soil profile, and developed from a particular type of parent material.

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