

Series 1961, No. 34

Issued June 1965

SOIL SURVEY

Gaines County, Texas



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

HOW TO USE THIS SOIL SURVEY REPORT

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

Locating the Soils

At the back of this report is an index map and a soil map consisting of many sheets. The index map is numbered to correspond to the sheets of the soil map so that the sheet showing any area can be located easily. On each map sheet, the soil boundaries are outlined and there is a symbol for each kind of soil. All areas marked with the same symbol are the same kind of soil. The soil symbol is inside the area if there is enough room; otherwise, it is outside the area and a pointer shows where it belongs. For example, an area on the map has the symbol AmB. The legend for the set of maps shows that this symbol identifies Amarillo loamy fine sand, 0 to 3 percent slopes. That soil and all others mapped in the county are described in the section "Descriptions of the Soils."

Finding Information

In the "Guide to Mapping Units, Capability Units, and Range Sites" at the back of this report, each soil is listed in the alphabetic order of its map symbol. This guide gives the page where each soil is described, and the page for the capability unit and range site in which the soil has been placed.

Farmers and ranchers and those who work with them can learn about the soils in the section "Descriptions of the Soils" and then turn to the section "Use and

Management of the Soils." In this way they first identify the soils on their farm or ranch and then learn how these soils can be managed and what yields can be expected. The soils are grouped by capability units, that is, groups of soils that need similar management and respond in about the same way. For example, Amarillo loamy fine sand, 0 to 3 percent slopes, is in dryland capability unit IVE-1 in climatic zone 1 and VIe-5 in climatic zone 2. It is in irrigated capability unit IIIe-3. The capability units are discussed in the section "Use and Management of the Soils."

Engineers and builders will find in the section "Use of the Soils for Engineering" tables that (1) give engineering descriptions of the soils in the county and (2) name soil features that affect engineering practices and structures.

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

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

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

* * * * *

Fieldwork for this survey was completed in 1961. Unless otherwise indicated, all statements in the report refer to conditions in the county at the time the survey was in progress. The soil survey of Gaines County was made as part of the technical assistance furnished by the Soil Conservation Service to the Gaines-Andrews Soil Conservation District.

Cover picture: Hereford cattle on range improved by spraying to control brush. The soil is Amarillo loamy fine sand, and the range site is Sandy Land.

Contents

	Page		Page
How this soil survey was made	1	Use and management of the soils—Continued	
General soil map	2	General management of cropland—Continued	
1. Brownfield association.....	2	Use of crop residue.....	16
2. Brownfield-Tivoli association.....	3	Tillage.....	16
3. Portales association.....	3	Contour farming and terraces.....	17
4. Amarillo-Arvana association.....	4	Use of commercial fertilizer.....	17
5. Simona-Kimbrough-Potter association.....	4	Capability groups of soils.....	17
6. Arch-Drake-Potter association.....	5	Management by dryland capability units.....	18
Descriptions of the soils	5	Management by irrigated capability units.....	23
Amarillo series.....	5	Yield predictions.....	27
Arch series.....	8	Use of the soils for range.....	28
Arvana series.....	8	Range sites and condition classes.....	28
Berthoud series.....	9	Descriptions of range sites.....	29
Brownfield series.....	9	Practices for rangeland.....	31
Drake series.....	10	Use of the soils for engineering.....	33
Gomez series.....	10	Engineering classification systems.....	33
Kimbrough series.....	11	Engineering interpretations of the soils.....	33
Lubbock series.....	11	Genesis, classification, and morphology of soils	39
Portales series.....	11	Factors of soil formation.....	40
Potter series.....	12	Classification of soils by higher categories.....	41
Randall series.....	12	Zonal order.....	41
Simona series.....	12	Intrazonal order.....	41
Springer series.....	12	Azonal order.....	42
Spur series.....	13	Morphology of soils.....	42
Stegall series.....	13	General nature of the county	50
Tivoli series.....	14	Geology.....	50
Zita series.....	14	Climate.....	51
Use and management of the soils	14	Natural resources.....	52
Wind erosion and its control.....	15	Social and industrial development.....	52
Effects of wind erosion.....	15	Agriculture.....	53
General management of cropland.....	15	Wildlife.....	53
Cropping systems.....	15	Glossary	53
Stripcropping.....	16	Guide to mapping units, capability units, and range sites	55

SOIL SURVEY OF GAINES COUNTY, TEXAS

BY WILLIAM H. DITTEMORE, JR., CAREY MAY, WILLIS L. De LOZIER, DONALD L. McCLENNON, AND HAROLD W. HYDE,
SOIL CONSERVATION SERVICE

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

GAINES COUNTY is in the extreme southern part of the High Plains (Llano Estacado) in the Great Plains area of the northwestern part of Texas (fig. 1). The county is rectangular, and has a total area of 1,479 square miles, or 946,560 acres. The town of Seminole, along U.S. Highway No. 180, is the county seat.

Since the early thirties, the increasing use of irrigation wells in this county has brought about a gradual change in land use from ranching to farming. Huge cattle ranches have been broken up, and agriculture is now the main enterprise. Cotton and grain sorghum are the main cash crops. In 1962 about 426,400 acres was used for cultivated crops, and more than 40 percent of the cropland was irrigated. About 481,300 acres was used for native range. Crop yields may be above average in years when rainfall is ample, but in periods of drought, crops are produced on only the most productive soils and only under good management. Farmers cannot rely on continuous high yields under dryland farming, because the climate is semiarid and much of the cropland is susceptible to wind erosion. If these soils are irrigated properly and adequately fertilized, however, they will generally produce high yields. Some of the acreage used for cultivated crops would be better used for permanent pasture.

How This Soil Survey Was Made

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

They went into the county knowing they likely would find many soils they had already seen, and perhaps some they had not. As they traveled over the county, they observed steepness, length, and shape of slopes; kinds of native plants or crops; kinds of rock; and many facts about the soils. They dug or bored many holes to expose soil profiles (fig. 2). A profile is the sequence of natural layers, or horizons, in a soil; it extends from the surface down into the parent material that has not been changed much by leaching or by roots of plants.

The soil scientists made comparisons among the profiles they studied, and they compared these profiles with those in counties nearby and in places more distant. They classified and named the soils according to nationwide, uniform procedures. To use this report efficiently, it is necessary to know the kinds of groupings most used in a local soil classification.

Soils that have profiles almost alike make up a soil series. Except for different texture in the surface layer, all the soils of one series have major horizons that are similar in thickness, arrangement, and other important characteristics. Each soil series is named for a town or other geographic feature near the place where a soil of that series was first observed and mapped. Amarillo and Brownfield, for example, are the names of two soil series. All the soils in the United States having the same series name are essentially alike in those characteristics that go with their behavior in the natural, untouched landscape. Soils of one series can differ somewhat in texture of the surface layer and in slope, stoniness, or some other characteristic that affects use of the soils by man.

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

Some soil types vary so much in slope, degree of erosion, number and size of stones, or some other feature affecting their use, that practical suggestions about their management could not be made if they were shown on the soil map as one unit. Such soil types are divided into phases. The name of a soil phase indicates a feature that affects man-

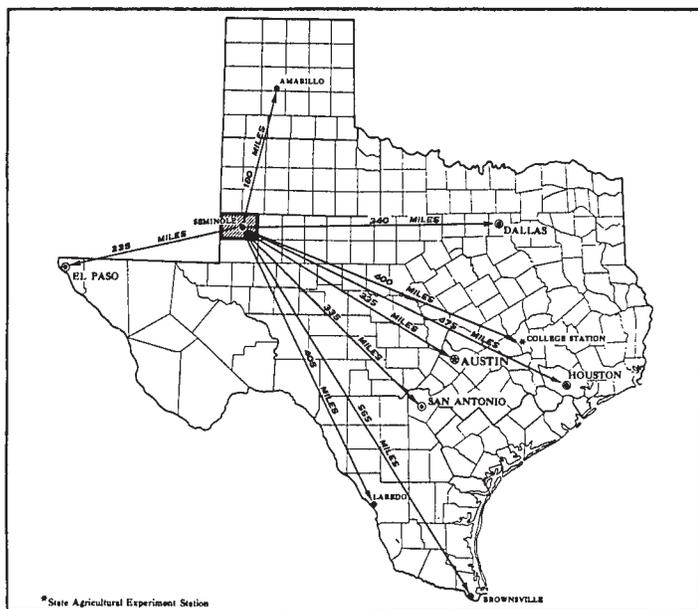


Figure 1.—Location of Gaines County in Texas.



Figure 2.—Some of the equipment used by a soil scientist to make a soil survey. The pickup truck carries a hydraulic soil sampler. Leaning against the truck, from left to right, are a sharpshooter spade, a 1-inch soil tube, a 2-inch soil tube, and a 3-inch bucket auger. Propped against the wheel is a folder containing field sheets, which will be used to prepare the descriptive legend of the soils. On the fender, from left to right, are an Abney level used to determine slope, and a book of color samples. Back of the color samples and the level is a mounted aerial photograph of the area.

agement. For example, Amarillo fine sandy loam, 1 to 3 percent slopes, is one of two phases of Amarillo fine sandy loam, a soil type that ranges from nearly level to gently sloping.

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

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

In preparing some detailed soil maps, the soil scientist has a problem of delineating areas where different kinds of soils are so intricately mixed, and so small in size, that it is not practical to show them separately on the map. Therefore, he shows this mixture of soils as one mapping unit and calls it a soil complex. Ordinarily, a soil complex is named for the major kinds of soil in it, for example, Tivoli-Potter complex.

If two or more soils that normally do not occur in regular geographic associations are mapped together, the unit is called an undifferentiated mapping unit and is named for its major soils. An example in Gaines County is Springer and Brownfield soils, moderately deep.

While a soil survey is in progress, samples of soils are taken, as needed, for laboratory measurements and for engineering tests. Laboratory data from the same kinds of soils in other places are assembled. Data on yields of

crops under defined practices are assembled from farm records and from field or plot experiments on the same kinds of soils. Yields under defined management are estimated for all the soils.

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

General Soil Map

After the study of soils in a locality and the way they are arranged, it is possible to make a general map that shows several main patterns of soils, called soil associations. Such a map is the colored soil map in the back of this report. Each soil association, as a rule, contains a few major soils and several minor soils in a pattern that is characteristic although not strictly uniform.

The soils within any one association are likely to differ greatly among themselves in some properties; for example, slope, depth, stoniness, or natural drainage. Thus, the general soil map shows, not the kind of soil at any particular place, but several distinct patterns of soils.

Each soil association is named for the major soil series in it, but as already noted, soils of other series may also be present. The major soils of one association may also be present in another association, but in a different pattern.

The general map is useful to people who want a general idea of the soils, who want to compare different parts of a county, or who want to know the possible location of good-sized areas suitable for a certain kind of farming or other land use.

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

1. Brownfield Association

Deep, moderately permeable, sandy soils

The soils of this association (fig. 3) are gently sloping or nearly level. They are mainly fine sands, but some are loamy fine sands. The association occupies approximately 582,000 acres, or more than 60 percent of the county.

Brownfield fine sand, thin surface, is the main soil. Its surface layer is fine sand, 10 to 18 inches thick, and its subsoil is red, noncalcareous sandy clay loam. Springer loamy fine sand and Amarillo loamy fine sand

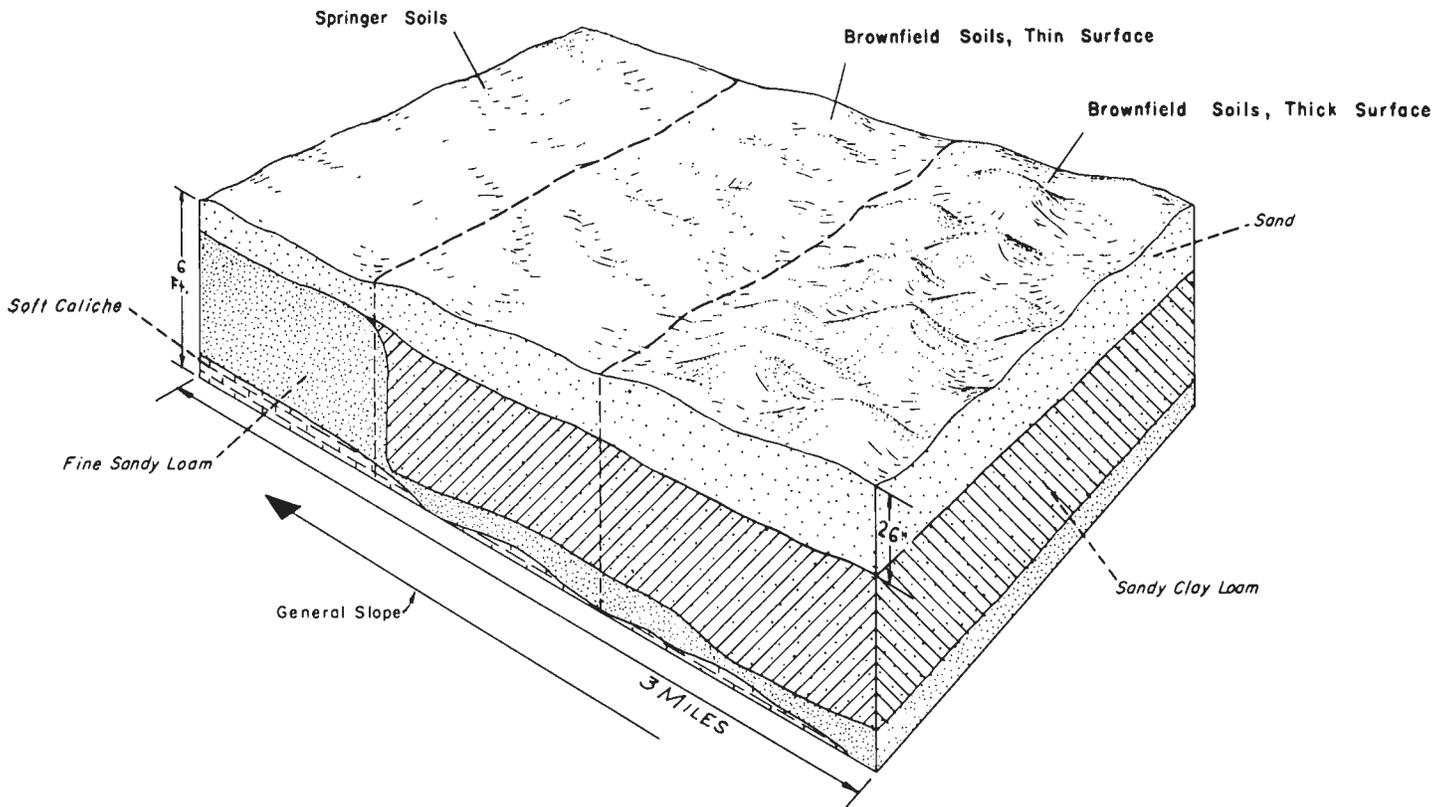


Figure 3.—Diagram showing an area typical of the Brownfield association. Brownfield fine sand, thick surface, is part of the adjoining Brownfield-Tivoli association.

are also in this association. The Springer soils have a red subsoil of fine sandy loam. The Amarillo soils are underlain by soft caliche.

About 35 percent of this association is cultivated; the rest is in range. The main cash crops are grain sorghum and cotton. About 34,000 acres in the cultivated area is irrigated by sprinklers that receive water from wells yielding 200 to 1,200 gallons per minute. At the time of the survey, the rangeland was in poor to fair condition. The native vegetation on most of the soils consists mainly of thick stands of shin (shinnery) oak and scattered plants of sand dropseed and three-awn.

The sandy surface layer of the soils in this association is highly susceptible to wind erosion. Good management is needed to maintain a cover of protective grasses.

2. Brownfield-Tivoli Association

Deep, moderately or rapidly permeable, sandy, undulating soils

The soils of this association (fig. 4) are gently sloping to undulating. They are mainly fine sands, but some are loamy fine sands. This association occupies approximately 187,000 acres.

Brownfield fine sand, thick surface, is the major soil in this association. It is noncalcareous, and its surface layer is fine sand, 18 to 40 inches thick. The subsoil is red, noncalcareous sandy clay loam. Tivoli fine sand occupies a small acreage in this association. It consists of loose,

dunelike sand to a depth of many feet. Small areas of Gomez fine sand and Springer loamy fine sand are also in this association. The Gomez soils have a surface layer of fine sand, 10 to 24 inches thick, and a subsoil of calcareous fine sandy loam. This sandy surface layer is highly susceptible to wind erosion. The Springer soils have a surface layer of loamy fine sand, 10 to 18 inches thick, and a subsoil of red, noncalcareous fine sandy loam.

This association is used mostly for range; it is not suited to cultivated crops. The native vegetation on most of the soils consists mainly of thick stands of shin oak and scattered plants of sand bluestem, sand dropseed, and three-awn.

These soils are highly susceptible to wind erosion if the plant cover is reduced or destroyed. Good range management is needed to maintain a cover of protective grasses.

3. Portales Association

Moderately deep, calcareous, loamy soils

The soils of this association (fig. 5) are on nearly level plains throughout the county. They occupy areas ranging from 5,000 to 12,000 acres in size. The association comprises approximately 53,000 acres.

This association consists mainly of moderately deep, calcareous Portales fine sandy loam, Portales loam, and Arch soils, but a few small areas of Zita fine sandy loam, Drake fine sandy loam, and Stegall loam are included.

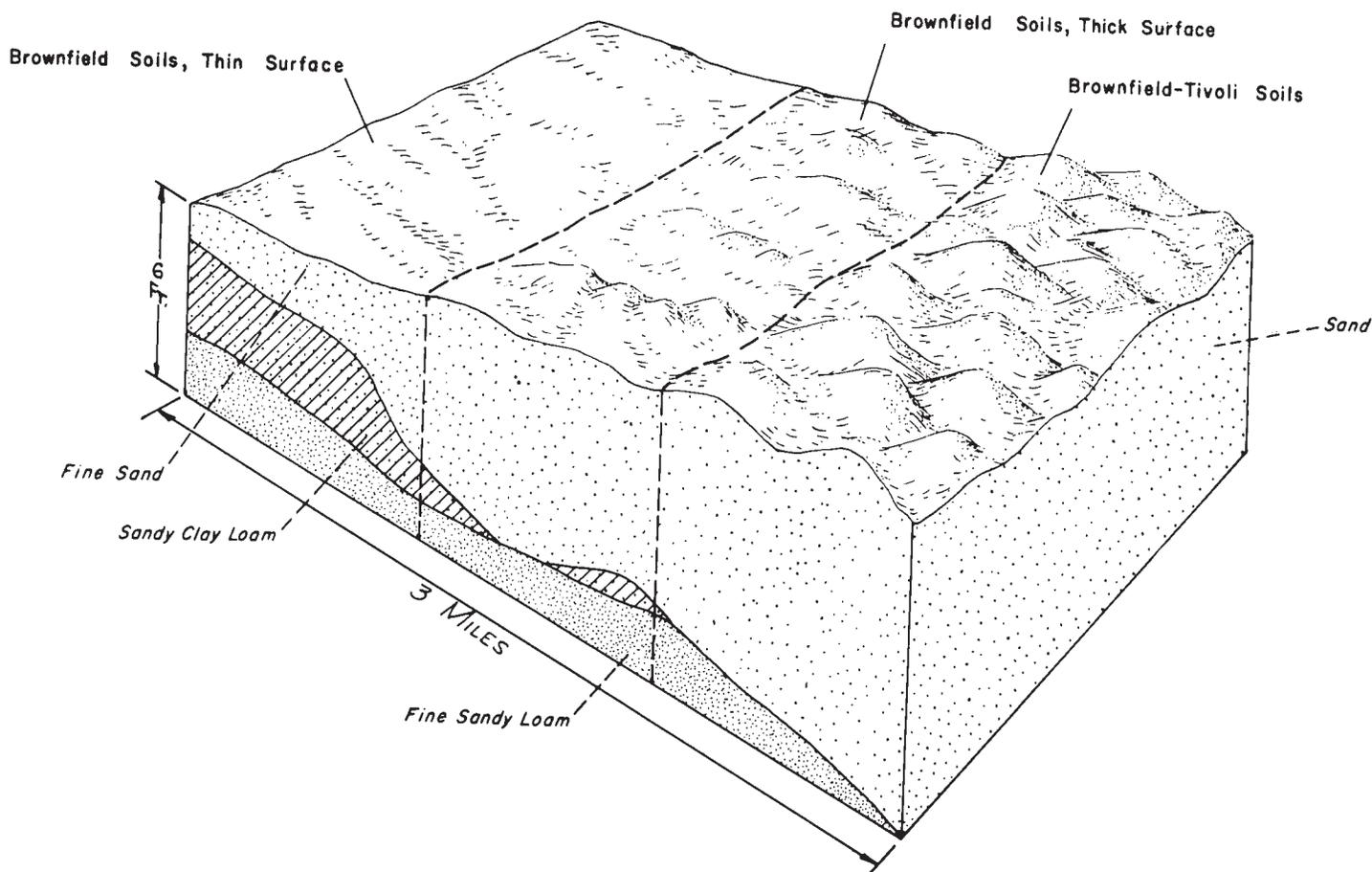


Figure 4.—Diagram showing an area typical of the Brownfield-Tivoli association. Brownfield fine sand, thin surface, is part of the adjoining Brownfield association.

The Zita and Stegall soils have a noncalcareous surface layer. The Drake soils are moderately deep and calcareous. They occupy areas ranging from 20 to 600 acres in size and contain more lime than the more gently sloping Portales soils. The Drake soils are in crescent-shaped, sloping areas on the eastern and northeastern edges of the salt lakes.

Most of this association is used for cultivated crops, mainly cotton and grain sorghum, and most of the cultivated areas are irrigated. The rest of the acreage is range and has a cover of native plants. Good stands of sideoats grama, blue and black grama, and buffalograss grow on the soils of this association.

4. Amarillo-Arvana Association

Deep and moderately deep, loamy soils

The soils of this association occupy nearly level to gently sloping plains. They are in small areas in the northern half of the county and comprise approximately 44,000 acres.

This association consists mainly of Amarillo fine sandy loam and Arvana fine sandy loam. These soils have a surface layer of fine sandy loam and a subsoil of reddish, noncalcareous sandy clay loam. The underlying material

of the Amarillo soils is soft caliche. Arvana soils, shallower than the Amarillo, are underlain by hard rock at a depth of 10 to 36 inches. The Amarillo soils make up about 60 percent of the association. They are very productive. The Arvana soils are shallow to moderately deep and occupy small ridges within larger areas of Amarillo soils.

About 10 percent of this association is used for range. The rest is used for cotton and grain sorghum, and most of the cultivated areas are irrigated. The native vegetation is a thick stand of mesquite and a fair cover of blue and black grama, sideoats grama, buffalograss, and three-awn.

5. Simona-Kimbrough-Potter Association

Shallow or very shallow, loamy soils over hard caliche

This association (fig. 6) is in Seminole Draw, Wordswell Draw, and other long, narrow draws in the county. It occupies about 75,000 acres.

This association consists of Simona fine sandy loam, Kimbrough soils, Potter soils, and a small acreage of Spur fine sandy loam, Spur clay loam, Berthoud soils, and Portales soils. The Simona soil is calcareous and is shallow over strongly cemented caliche. The Kimbrough

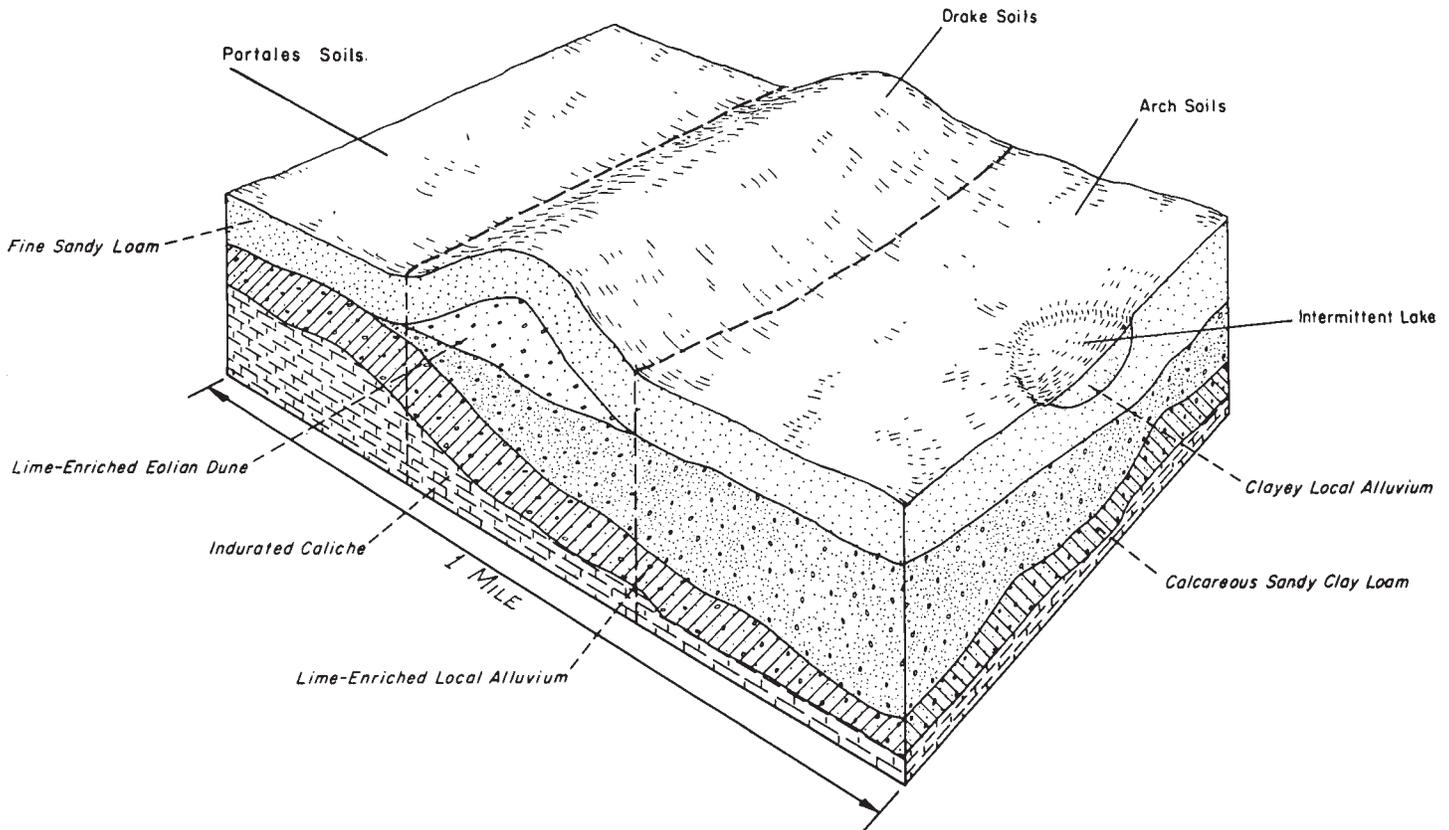


Figure 5.—Diagram showing the pattern of soils typical of the Portales association.

soils are nearly level to gently sloping, noncalcareous, and very shallow over hard caliche. The Potter soils are calcareous and are shallow over strongly cemented caliche. On the foot slopes, below the Potter soils and above the Spur soils, are the Berthoud soils. The Spur soils, which are deep and calcareous, are in the small, narrow bottoms. Some areas of Portales soils also occur in the draws.

Most of this association is in native range, but a few small areas are used for grain sorghum and cotton. The vegetation includes three-awn, black grama, and broom snakeweed. Some vine mesquite grows in the bottoms of the draws.

6. Arch-Drake-Potter Association

Soils bordering salt lakes

This association (fig. 7) consists of McKenzie and Cedar Lakes, which fluctuate from year to year according to the amount of rainfall, and soils bordering the lakes. In periods of normal rainfall, McKenzie Lake occupies approximately 1,500 acres, and Cedar Lake, approximately 3,500 acres.

Around the lakes are the calcareous, shallow Potter soils on the west, and the Arch and Drake soils on the southeast, east, and north. Various salt-tolerant sedges and alkali sacaton grow around the lakes. The soils on the lake bottoms are strongly affected by alkali and cannot be used for agriculture.

Descriptions of the Soils

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

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

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

Amarillo Series

Soils of the Amarillo series are deep, reddish, moderately permeable, noncalcareous, and nearly level to gently sloping. They are among the most extensive soils in the county.

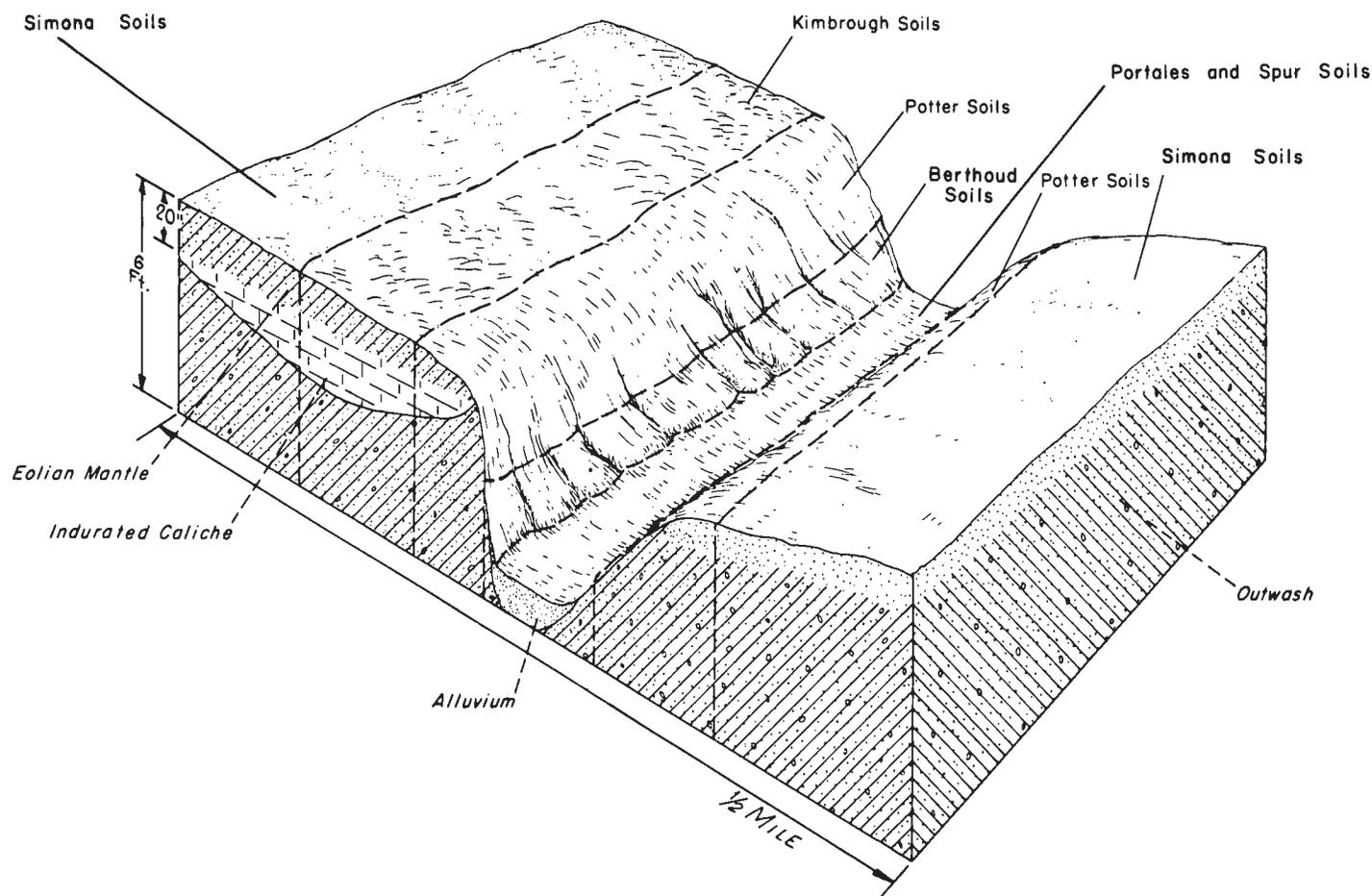


Figure 6.—Diagram showing an area typical of the Simona-Kimbrough-Potter association.

The surface layer is reddish-brown to reddish-yellow or yellowish-red fine sandy loam to loamy fine sand, 8 to 16 inches thick. This layer is friable and easily worked; it takes water readily.

The subsoil, 24 to 48 inches thick, is a reddish-brown to yellowish-red sandy clay loam that is moderately permeable. The extensive network of tubes and pores left in it by decaying roots allows movement of air and water. In most places the subsoil contains worm channels, cavities, and dark-colored stains caused by organic matter. The underlying material is pink, soft caliche.

These soils have high natural fertility. Yields are moderate to high when rainfall is adequate. The soils are susceptible to erosion by both wind and water.

Amarillo soils occur with the Arvana, Brownfield, and Portales soils. They are less sandy and less reddish than the Brownfield soils, and they have a horizon of calcium carbonate that is lacking in those soils. The Amarillo soils are redder than the Portales soils and are noncalcareous. The areas of Amarillo soils are also slightly higher than those occupied by the Portales soils. Generally, the Portales soils are more nearly level than the Amarillo soils.

The Amarillo soils are cultivated under both dryland and irrigated farming, and large areas are in native range.

Where these soils are used as range, they have a cover of blue grama, sideoats grama, and some buffalograss. Catclaw, mesquite, and shin oak are invading shrubs.

Amarillo loamy fine sand, 0 to 3 percent slopes (AmB).—This is the most sandy Amarillo soil in the county. The areas are 40 to 80 acres in size and are mostly in the northern half of the county. The slopes are long and convex, and generally no steeper than 2 percent. This soil is in a broad transitional area between the Amarillo fine sandy loams and the thin-surface phase of the Brownfield fine sands. Where this soil occurs with the sandy Brownfield soils, it occupies the smoother, lower lying slopes. In some areas of this soil where wind erosion has been active, there are low dunes along fence rows.

In areas of this soil used for range, the surface layer is reddish brown to yellowish red and is 10 to 16 inches thick. In cultivated areas most of this soil has been plowed to a depth of 16 to 24 inches. As a result of this deep plowing, some of the sandy clay loam from the subsoil has been mixed with the sandy material in the surface layer. The clayey material added to the plow layer makes more effective the tillage practices used to control wind erosion.

In spring when wind erosion is most active, the soil material in the surface layer is shifted when this soil is not protected by a cover of plants. This is evidenced by the

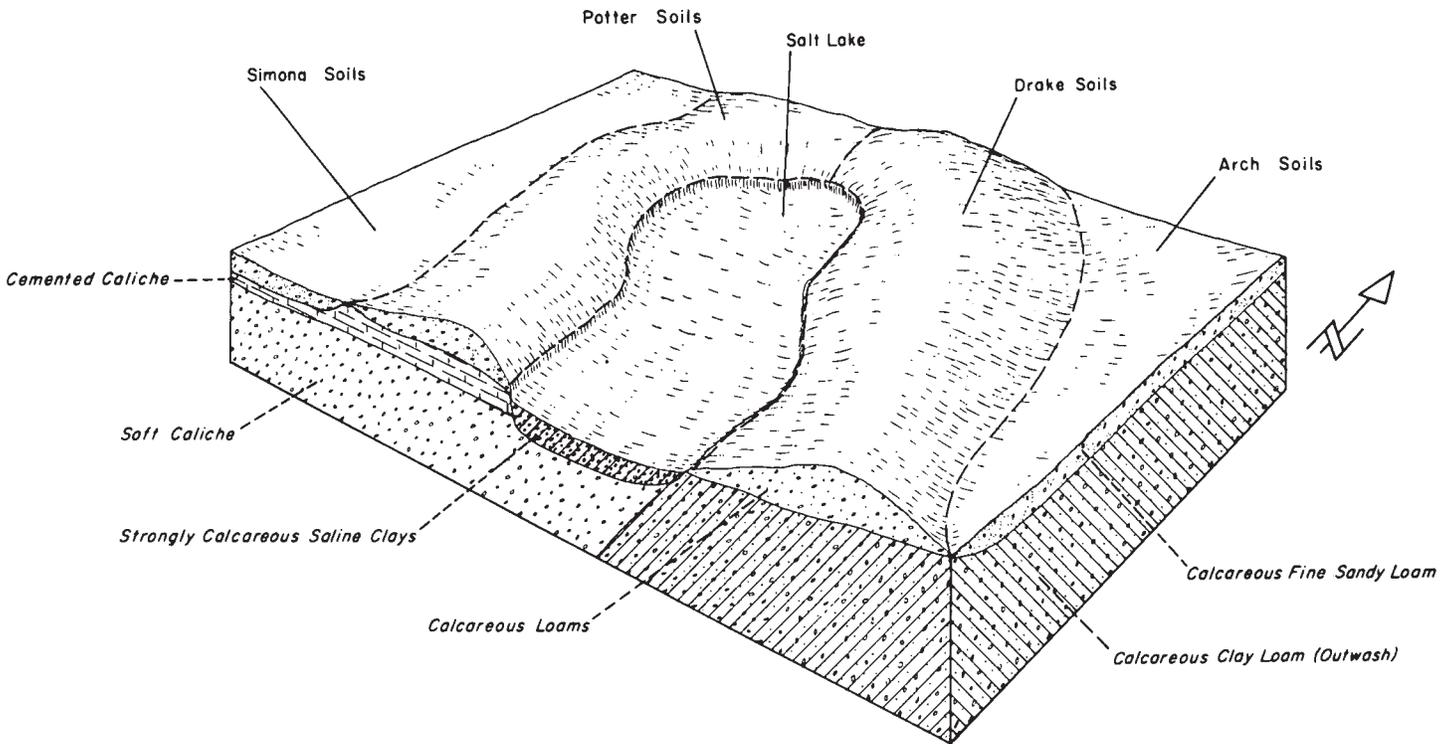


Figure 7.—Diagram showing salt lakes and surrounding soils in the Arch-Drake-Potter association.

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

Soil	Acres	Per-cent
Amarillo loamy fine sand, 0 to 3 percent slopes	50, 930	5. 4
Amarillo fine sandy loam, 0 to 1 percent slopes	24, 950	2. 6
Amarillo fine sandy loam, 1 to 3 percent slopes	5, 540	. 6
Arch soils	1, 830	. 2
Arvana fine sandy loam, 0 to 1 percent slopes	12, 140	1. 3
Arvana fine sandy loam, 1 to 3 percent slopes	4, 740	. 5
Arvana fine sandy loam, shallow, 0 to 3 percent slopes	7, 060	. 7
Berthoud-Potter complex	6, 720	. 7
Brownfield fine sand, thick surface	180, 280	19. 0
Brownfield fine sand, thin surface	451, 660	47. 7
Brownfield soils, severely eroded	6, 120	. 6
Drake soils, 1 to 3 percent slopes	1, 630	. 2
Drake soils, 3 to 5 percent slopes	2, 710	. 3
Drake soils, 5 to 30 percent slopes	1, 040	. 1
Gomez fine sand	5, 960	. 6
Gomez loamy fine sand	10, 010	1. 1
Kimbrough soils	24, 230	2. 6
Lubbock and Randall soils	240	(¹)
Portales fine sandy loam, 0 to 1 percent slopes	23, 810	2. 5
Portales fine sandy loam, 1 to 3 percent slopes	5, 400	. 6
Portales loam, 0 to 1 percent slopes	2, 830	. 3
Portales and Spur soils	6, 490	. 7
Simona fine sandy loam	31, 470	3. 3
Springer loamy fine sand	3, 530	. 4
Springer and Brownfield soils, moderately deep	50, 690	5. 4
Springer and Brownfield soils, shallow	10, 400	1. 1
Stegall loam, 0 to 1 percent slopes	510	(¹)
Tivoli fine sand	990	. 1
Tivoli-Potter complex	8, 270	. 9
Zita fine sandy loam, 0 to 1 percent slopes	4, 380	. 5
Total	946, 560	100. 0

¹ Less than .0.1 percent.

filling of the furrows in areas that have been listed. This evidence of erosion is erased when the seedbed is prepared and planting and cultivation take place.

A few small areas of Brownfield fine sand, thin surface, and minor areas of Springer and Brownfield soils, moderately shallow, that are not mapped separately in this county are included in the mapping. These included soils occupy less than 5 percent of the acreage.

This Amarillo soil is productive, but it is highly susceptible to wind erosion. Most of the acreage is cultivated. The principal crops are cotton and grain sorghum, grown both under dryland farming and under irrigation. Sparse stands of shin oak generally grow on the areas in native range. The present cover on most of the range consists mainly of blue grama, three-awn, and sand dropseed. (Dryland capability unit IVe-1, climatic zone 1, and VIe-5, climatic zone 2; irrigated capability unit IIIe-3; Sandy Land range site)

Amarillo fine sandy loam, 0 to 1 percent slopes (AfA).—This soil has a surface layer of reddish-brown fine sandy loam, 8 to 16 inches thick.

Mapped with this soil are small, circular, lower lying areas of Zita fine sandy loam, 0 to 1 percent slopes; of Portales fine sandy loam, 0 to 1 percent slopes; and of Arvana fine sandy loam, 0 to 1 percent slopes.

Some areas of this Amarillo soil have been cultivated longer than areas of some of the more sandy soils in the county. Consequently, many of these areas have been winnowed by wind to such an extent that much of the clay and silt in the plow layer has been blown away. In the uppermost 4 to 8 inches of the surface layer, the soil material is more sandy than it was originally.

Under good irrigation management, this soil is among the most productive in the county. Good yields can be

expected from irrigated cotton, grain sorghum, legumes, and small grains. Soil tests show, however, that this soil is low in nitrogen and phosphorus. (Dryland capability unit IIIe-1, climatic zone 1, and IVe-4, climatic zone 2; irrigated capability unit IIe-3; Mixed Land range site)

Amarillo fine sandy loam, 1 to 3 percent slopes (A₈B).—This soil is on low ridges, slopes, and knolls within larger areas of Amarillo fine sandy loam, 0 to 1 percent slopes. It is slightly redder than that soil and has a thinner surface layer and subsoil.

If this soil is cultivated, sheet erosion, gully erosion and wind erosion are moderate hazards. (Dryland capability unit IIIe-1, climatic zone 1, and IVe-4, climatic zone 2; irrigated capability unit IIIe-1; Mixed Land range site)

Arch Series

Soils of the Arch series are grayish brown and highly calcareous. They are on high-lime flats or in depressions and are shallow over old alluvium. They formed in old lake sediments that have been enriched with lime from ground water or from runoff from adjacent limy areas.

The surface layer is grayish brown, strongly calcareous, and 4 to 10 inches thick. The subsoil is chalky clay loam that is nearly structureless and contains many rounded, soft lumps of pure lime in the uppermost 4 to 20 inches. The root zone is mainly within the dark-colored surface layer.

Arch soils occur with Simona and Portales soils, but they are lighter colored than either. They contain more lime and are shallower than the Portales soils.

Arch soils (0 to 3 percent slopes) (Ar).—The Arch soils in this county are mapped together as a single unit. Their high content of lime makes them highly susceptible to wind erosion when they are cultivated. Clods that resist wind erosion are not readily formed in a soil having a high content of lime, so emergency tillage usually is not effective on Arch soils. The farmer must rely on a good cover of plants to control wind erosion. Where these soils have been eroded by wind, the fine soil material has been winnowed out and the texture of the present surface layer is more sandy than that of the original one.

If this soil is irrigated and fertilizer is applied, it produces moderate yields of cotton. Grain sorghum generally shows chlorosis, or yellowing of the leaves. Chlorosis is a symptom of iron deficiency, which reduces yields. A few areas of this soil are irrigated for cultivated crops, but most of the acreage is in native pasture. The present vegetation is mainly alkali sacaton, inland saltgrass, and blue grama. (Dryland capability unit IVes-1, climatic zone 1, and VIes-1, climatic zone 2; irrigated capability unit IIIes-1; High Lime range site)

Arvana Series

In the Arvana series are reddish, moderately sandy, noncalcareous soils that are shallow to moderately deep over hard, platy caliche. The soils are moderately permeable and are well drained. They developed in a thin mantle of sandy material that was deposited by wind over caliche. The tops of the hard fragments of caliche are smooth and rounded, but the bottoms are concretionary or knobby. These soils are nearly level or gently sloping and are on plains throughout the county.

The surface layer is reddish-brown to dark-brown fine sandy loam about 8 inches thick. This layer is very friable, is easily worked, and takes water readily.

The subsoil is red to yellowish-red sandy clay loam that is noncalcareous and moderately permeable. It is 8 to 20 inches thick. The underlying material is hard, platy caliche.

These soils have high natural fertility, but they are susceptible to erosion by both wind and water. Their capacity to hold water is good.

The Arvana soils are associated with the Amarillo and Kimbrough soils. They are shallower than the Amarillo soils and are deeper and redder than the Kimbrough soils.

These soils are used for both dryland and irrigated farming. Large areas are in native range.

Arvana fine sandy loam, 0 to 1 percent slopes (A_vA).—This soil occurs throughout the county in areas 40 to 80 acres in size. It is associated with Amarillo fine sandy loam, 0 to 1 percent slopes.

The surface layer is dark-brown to reddish-brown fine sandy loam and is about 8 inches thick. Depth to hard rock ranges from 20 to 36 inches. Where this soil occurs with the Amarillo fine sandy loams and has been cultivated for a long time, much of the clay and silt has been blown away and the plow layer is coarser than it was originally. Small areas of Arvana fine sandy loam, shallow, 0 to 3 percent slopes, are mapped with this soil.

This is a productive soil when irrigated. Tests show, however, that it is low in nitrogen and phosphorus. Its water-holding capacity is limited because of the depth to indurated caliche. Good yields of cotton, grain sorghum, legumes, and small grains can be expected under either dryland or irrigated farming. The soil is moderately susceptible to wind erosion. (Dryland capability unit IIIe-1, climatic zone 1, and IVe-4, climatic zone 2; irrigated capability unit IIe-3; Mixed Land range site)

Arvana fine sandy loam, 1 to 3 percent slopes (A_vB).—This soil occupies low ridges within larger areas of Arvana fine sandy loam, 0 to 1 percent slopes. In most places the slopes are about 2 percent, but the range is from 1 to 3 percent. In some places the surface layer is thinner than that of less sloping Arvana soils, and the profile is slightly lighter colored and slightly shallower, or 24 to 30 inches thick.

If this soil is cultivated, the hazards of sheet, gully, and wind erosion are moderate. (Dryland capability unit IIIe-1, climatic zone 1, and IVe-4, climatic zone 2; irrigated capability unit IIIe-1; Mixed Land range site)

Arvana fine sandy loam, shallow, 0 to 3 percent slopes (A_wB).—The profile of this soil is like that of Arvana fine sandy loam, 0 to 1 percent slopes, but hard caliche is at a depth of about 14 to 20 inches. Many scattered stones are on the surface.

The caliche near the surface limits the capability of this soil. Often the soil does not hold all the rain that falls. Some of the water runs off, and some enters cracks in the hard caliche and passes out of reach of the roots of most cultivated crops. Irrigation costs more on this soil than on the other Arvana soils because smaller, more frequent waterings are needed.

If it is cultivated, this soil is highly susceptible to wind erosion. Crop residue left on the soil will protect it during the critical spring season. (Dryland capability

unit IVe-3, climatic zone 1, and VIe-7, climatic zone 2; irrigated capability unit IIIe-5; Mixed Land range site)

Berthoud Series

The soils of this series are brown to dark grayish brown, moderately deep, and moderately permeable. They occupy long, narrow areas on foot slopes along the draws, below the higher lying Potter soils. Berthoud soils follow the contour of the slope and lie just above the Spur soils, which are on the floors of the draws. Berthoud soils developed in material washed down from higher areas.

The surface layer is brown to dark grayish-brown loam or fine sandy loam, 8 to 12 inches thick. The subsoil is light yellowish-brown to brown clay loam that contains free lime.

Berthoud soils occur with the Potter and Spur soils. They are deeper than the Potter soils and are lighter colored and shallower than the Spur soils. In this county the Berthoud soils are mapped only in a complex with the Potter soils.

Berthoud-Potter complex (5 to 12 percent slopes) (Be).—The soils of this complex are so intermingled that it was not feasible to map them separately. They are brown to dark grayish brown and are moderately deep to very shallow over soft to hard caliche. These soils occupy the steep slopes of the draws that cross the county. The slopes range from 5 to 12 percent but are generally about 8 percent.

Small areas of Arvana and Kimbrough soils are mapped with the soils of this complex. In most places the included areas have been moderately eroded by both wind and water.

In this complex the Berthoud soils occupy the lower lying foot slopes and the less sloping sides of tributary drainageways. They make up about 50 percent of the acreage in the complex. The Potter soils are in the steeper areas and on the narrow ledges of caliche caps near the tops of the slopes. In most places they make up about 45 percent of the acreage. Arvana and Kimbrough soils make up about 5 percent of the acreage.

Within this complex are shallow gullies and alluvial fans at the base of slopes. Water erosion has formed small gullies and has removed soil around clumps of vegetation to leave small stools or "pedestals." The vegetation consists of sparse stands of short grasses and moderate stands of broom snakeweed.

These soils are not suited to cultivated crops, because of their thin solum, steep slopes, and high susceptibility to wind and water erosion. They are best suited to perennial grasses and are not suitable for irrigation. (Dryland capability unit VIe-4, climatic zones 1 and 2; Mixed Plains range site for Berthoud soils and Shallow Land range site for Potter soils)

Brownfield Series

In the Brownfield series are deep, noncalcareous, moderately permeable, sandy soils that are nearly level to gently rolling or undulating. These soils occur throughout the county and are the most extensive of the soils mapped.

The surface layer is reddish-brown to reddish-yellow fine sand, 10 to 40 inches thick. This layer is very friable

and loose, is easily worked, and takes water readily.

The subsoil is reddish, friable, moderately permeable, noncalcareous sandy clay loam, 20 to 50 inches thick.

The substratum is reddish, noncalcareous light sandy clay loam to loamy fine sand. These soils do not have distinct horizons of calcium carbonate, but they are underlain by soft caliche in some places. This underlying caliche is thought to be a relict layer of calcium carbonate, upon which windblown material was deposited.

The Brownfield soils occur with the Amarillo, Gomez, and Tivoli soils. They occupy gently rolling areas above the smoother Amarillo and Gomez soils and below the Tivoli soils on dunes. In this county they are also mapped in undifferentiated units with the Springer soils, which have a subsoil of loam to fine sandy loam.

The Brownfield soils are deeper and more sandy than the Amarillo soils, and they do not have an accumulation of calcium carbonate in the profile. They are redder and more clayey than the Gomez soils. Their subsoil of sandy clay loam distinguishes them from the Tivoli soils, which have more sand throughout the profile.

Cultivated areas of Brownfield soils are highly susceptible to wind erosion. Unless these areas are protected by vegetation, the topmost few inches of the surface layer is continually shifted by wind. The wind winnows out a small amount of the silt, clay, and organic matter. As a result, the soils become more sandy and less fertile each year. Brownfield soils are used for both cultivated crops and range.

Brownfield fine sand, thick surface (0 to 3 percent slopes) (Br).—This soil occurs in areas 400 to 600 acres in size, mainly in the southern half of the county. It occupies about 19 percent of the county. It is more susceptible to wind erosion than Brownfield fine sand, thin surface.

The surface layer is reddish-yellow fine sand that ranges from 18 to 40 inches in thickness but is generally less than 30 inches thick.

Mapped with this soil are a few small, low dunes occupied by Tivoli fine sand. Also included in the mapping are small areas of Brownfield fine sand, thin surface, on ridgetops and on west-facing slopes.

The surface in cultivated areas is uneven, because Brownfield fine sand, thick surface, is highly susceptible to wind erosion. The effects of this erosion can be partly erased by normal tillage. Deep plowing is impractical; the sand is so thick in most places that not enough clayey material that will form clods and protect the soils can be brought up from the subsoil and mixed with the sandy surface layer. During the season when wind erosion is most critical, it is almost impossible to keep enough crop residue on the surface to control erosion. Sandy soil material accumulates in lister furrows, in roadside ditches, around plants, and in large dunes along fence rows.

The only effective way of controlling erosion is to maintain a continuous cover of growing plants or stubble. (Dryland capability unit VIe-2, climatic zones 1 and 2; irrigated capability unit IVe-2; Deep Sand range site)

Brownfield fine sand, thin surface (0 to 3 percent slopes) (Bs).—This is the most extensive soil in the county. It has a surface layer of reddish-brown to reddish-yellow fine sand, 10 to 18 inches thick. A few small areas of

Brownfield fine sand, thick surface, are mapped with this soil.

This soil is productive, but it is highly susceptible to wind erosion. The wind fills furrows on listed land, fills roadside ditches, and piles soil material against fence rows. Normal seedbed preparation, planting, and cultivation obliterate such evidence of erosion.

For several years, farmers have deep-plowed this soil. This plowing mixes the sandy clay loam from the subsoil with the fine sand in the surface layer. Along with other good management practices, it helps to reduce or control wind erosion. Sprinkler irrigation is the only efficient way of applying water to this soil. (Dryland capability unit IVe-2, climatic zone 1, and VIe-6, climatic zone 2; irrigated capability unit IIIe-4; Sandy Land range site)

Brownfield soils, severely eroded (0 to 3 percent slopes) (Bt3).—These soils are of minor extent and occur in abandoned fields throughout the county. Wind erosion has removed all of the surface layer in as much as 80 percent of the acreage and has exposed the subsoil of red sandy clay loam.

Blowout holes, where all of the surface layer and part of the subsoil has been removed, are common. In places dunes and hillocks have formed that are as much as 6 feet high and 10 to 50 feet in diameter at the base. Some dunes 10 to 15 feet high and 50 to 100 feet wide line the boundaries of fields. In some places two or three fences, one above the other, are covered by these dunes. Other areas consist of a complex of blowouts and dunes; the dunes are circular and occupy as much as 20 percent of the area. Most of the dunes have a sparse cover of shin oak and a few tall grasses, but some of them are bare and are actively moving from the southwest toward the northeast. In many places the swept-off areas are bare, except in local low spots that receive extra water. Hard caliche is exposed in some areas.

These soils are not suitable for cultivation. Extensive leveling and redistribution of the sand can be done, but this is costly. Establishing perennial grass, though difficult, is the best treatment and the best use for these areas. The soils are not suitable for irrigation. (Dryland capability unit VIe-2, climatic zones 1 and 2; Sandy Land range site)

Drake Series

In the Drake series are light-colored, strongly calcareous soils that have moderately rapid permeability. These soils are highly susceptible to wind erosion and developed in material blown from the strongly calcareous dry playas. They make up the dunes on the east and northeast sides of these ancient lakes. In this county prominent dunes are locally called chalk hills.

The surface layer is gray to very pale brown loam or fine sandy loam, 6 to 12 inches thick. The subsoil is white, strongly calcareous, soft and chalky material.

The Drake soils are associated with the lower lying Arch and Portales soils. They are steeper than the Arch soils and are lighter colored and more strongly calcareous than the Portales soils.

Drake soils, 1 to 3 percent slopes (DrB).—These soils have crescent-shaped slopes that are generally steeper than 2 percent. They are highly susceptible to wind erosion; some particles of silt and clay they originally contained

have blown away. The soils are moderately susceptible to water erosion, and in some places small gullies and rills form after a heavy rain.

The smaller areas of these soils are associated with less sloping and more productive soils, and consequently, they are often cultivated. Tillage to form clods will not control erosion effectively, because the high content of lime prevents enough stable clods from forming. Chlorosis is a problem. (Dryland capability units IVes-1, climatic zone 1, and VIes-1, climatic zone 2; irrigated capability unit IIIes-1; High Lime range site)

Drake soils, 3 to 5 percent slopes (DrC).—These soils contain much lime and are highly susceptible to both wind and water erosion. Some of the particles of silt and clay they originally contained have blown away. Water erosion causes gullies and rills after a heavy rain. Even where there is a cover of native plants, small gullies have formed. In many places these gullies follow tracks made by livestock and vehicles.

The surface layer has a wider range in texture than that of the more gently sloping Drake soils; the texture ranges from light clay loam to fine sandy loam. The use of these soils is limited by the high content of lime and by the hazard of erosion. The soils are best suited to perennial grasses and are not suitable for irrigation. (Dryland capability unit VIe-3, climatic zones 1 and 2; High Lime range site)

Drake soils, 5 to 30 percent slopes (DrD).—These steep soils are strongly calcareous. Practically all of the acreage is on slopes that border the two large salt lakes in the eastern part of the county. The slopes range from 8 to 30 percent, but are about 15 percent in most places.

Many gullies have formed as the result of runoff from higher areas. Some of these gullies are stabilized with native grasses. Some of the particles of silt and clay that were originally in these soils have blown away. Wind and water erosion has also removed much of the soil material around clumps of grass, and the clumps have been left on small stools of soil 1 to 4 inches high and 4 to 8 inches in diameter.

These soils are not suitable for irrigation. Because of these steep slopes, they can be used only for range. (Dryland capability unit VIe-3, climatic zones 1 and 2; High Lime range site)

Gomez Series

In the Gomez series are moderately deep, calcareous, sandy soils that developed in wind-deposited material. These soils have concave slopes of less than 2 percent.

The surface layer is pale-brown to dark grayish-brown loamy fine sand or fine sand, 10 to 24 inches thick. This layer is very friable and easily worked; it takes water readily.

The subsoil is grayish-brown to pale-brown, calcareous fine sandy loam that takes water readily and is 6 to 24 inches thick.

The underlying material is white to light brownish-gray, very strongly calcareous fine sandy loam.

The Gomez soils are associated with the Portales soils but are more sandy than those soils. They are also associated with the Amarillo and Brownfield soils but have a slightly coarser textured subsoil than those soils.

Gomez soils are used for both dryland and irrigated farming.

Gomez fine sand (0 to 3 percent slopes) (Gf).—The surface layer of this soil is fine sand, 18 to 24 inches thick. The soil is calcareous to the surface if it is cultivated, and it is highly susceptible to wind erosion. Surface roughening alone will not control wind erosion. The clods are not stable, because the content of lime is high and the texture is sandy.

After a windstorm, this soil is hummocky and the lister rows and roadside ditches are filled with material from the surface layer. Low dunes occur along fence rows. This soil is best suited to perennial grasses. (Dryland capability unit VIe-1, climatic zones 1 and 2; irrigated capability unit IVe-2; Sandy Land range site)

Gomez loamy fine sand (0 to 3 percent slopes) (Gl).—The surface layer of this soil is thinner, darker colored, less sandy, and less calcareous than that of Gomez fine sand. This soil is highly susceptible to wind erosion.

Surface roughening alone is not sufficient to prevent damage by wind erosion. After a windstorm, this soil is hummocky and the lister rows and roadside ditches are filled with loamy fine sand from the surface layer. Low dunes occur along fence rows. (Dryland capability unit IVe-1, climatic zone 1, and VIe-5, climatic zone 2; irrigated capability unit IIIe-3; Sandy Plains range site)

Kimbrough Series

Soils of the Kimbrough series are very dark grayish brown to dark grayish brown and noncalcareous. They are 2 to 14 inches deep over a thick, hard, platy layer of caliche.

The surface layer of these soils is a loam, gravelly loam, or, in some places, fine sandy loam or light clay.

Kimbrough soils are darker colored and less calcareous than the Potter soils, and they are underlain by harder caliche. They are less reddish and are shallower over caliche than the Arvana soils. They are also shallower than the Stegall soils. Kimbrough soils are not suitable for cultivation.

Kimbrough soils (0 to 3 percent slopes) (Km).—These are the only Kimbrough soils mapped in this county. They are too shallow over caliche for crops to be grown successfully. Many small, hard stones are on the surface in areas where cultivation has been attempted. These soils are not suitable for irrigation. (Dryland capability unit VIIs-1, climatic zones 1 and 2; Shallow Land range site)

Lubbock Series

The Lubbock series consists of well-drained soils in small depressions, 2 to 10 acres in size. The soils are not extensive. They developed in moderately fine textured alluvial or windblown sediments. These sediments are similar to the material underlying the Amarillo soils, but generally the material is more highly calcified and more compact. The Lubbock soils receive runoff from the surrounding higher lying soils.

The surface layer is brownish and ranges from clay loam to sandy clay loam in texture. It is 8 to 12 inches thick.

The subsoil is grayish-brown to gray clay loam to light clay, 22 to 36 inches thick.

The underlying material is whitish, strongly calcareous clay loam or light clay.

The Lubbock soils are less clayey than the Randall soils and are browner and more clayey than the Amarillo soils.

In this county the Lubbock soils are mapped only with the Randall soils as an undifferentiated unit.

Lubbock and Randall soils (0 to 1 percent slopes) (lr).—These are the only Lubbock or Randall soils mapped in this county. About 60 percent of the acreage is Lubbock clay loam, and about 40 percent is Randall clay. These soils occur together in such an intricate pattern that it was not practical to map them separately. The slopes are generally less than 1 percent. Gilgai, or buffalo-wallow, relief is common where these soils are in native range.

At times these soils can be cultivated during dry years, or if water is drained off or diverted from them. Some areas are farmed, and yields are good in years when moisture is adequate but not excessive. The soils are often either too dry or too wet, however, and they are hard to work. Use of these soils is extremely limited because of flooding and drowning of crops. The soils are not suitable for irrigation. (Capability unit VIw-1, climatic zones 1 and 2; small areas are included in the Mixed Plains range site)

Portales Series

In the Portales series are moderately dark colored, calcareous soils that have moderately rapid permeability. The soils are friable and moderately deep. They occur throughout the county in areas 20 to 200 acres in size. Slopes range from 0 to 3 percent but are normally less than 2 percent.

The surface layer is brown to dark grayish-brown, calcareous fine sandy loam or loam, 6 to 18 inches thick.

The subsoil is calcareous clay loam, 12 to 24 inches thick; it is lighter in color than the surface layer.

The underlying material is pink to light brownish-gray, very strongly calcareous clay loam at a depth of 22 to 36 inches.

The Portales soils are deeper and less limy than the Arch soils. They are shallower and less reddish than the Amarillo soils and are calcareous rather than noncalcareous. Portales soils are lighter colored and more calcareous than Zita soils; they are darker colored than the Spur soils.

Portales fine sandy loam, 0 to 1 percent slopes (PfA).—The surface layer of this soil is grayish-brown to dark grayish-brown fine sandy loam. The underlying material is white to very pale brown, very strong calcareous clay loam, at a depth of 24 to 36 inches.

In some places the plow layer contains 3 to 6 inches of loamy fine sand. This is probably caused by the removal of particles of silt and clay by wind erosion or by the addition of particles of sand that have blown from higher lying, more sandy areas into the slight depressions occupied by this soil.

This soil is used for cotton and grain sorghum under both dryland and irrigated farming. It has moderate fertility and moisture-holding capacity. The hazard of

wind erosion is moderate. (Dryland capability unit IIIe-2, climatic zone 1, and IVe-5, climatic zone 2; irrigated capability unit IIe-4; Mixed Plains range site)

Portales fine sandy loam, 1 to 3 percent slopes (Pfb).—The surface layer of this soil is thinner, lighter colored, and more calcareous than that of the less sloping Portales fine sandy loam. Most of the areas have slopes of less than 2 percent. In some places small gullies have formed. (Dryland capability unit IIIe-2, climatic zone 1, and IVe-5, climatic zone 2; irrigated capability unit IIIe-2; Mixed Plains range site)

Portales loam, 0 to 1 percent slopes (PmA).—This smooth, nearly level soil occurs throughout the county. It occupies areas from 20 to 200 acres in size. The surface layer is brown, calcareous loam, 6 to 12 inches thick. The subsoil is lighter colored and more calcareous than the surface layer and is 8 to 14 inches thick. The substratum is white to light-gray, very strongly calcareous, soft and chalky material.

Under dryland farming this soil tends to be droughty, and its content of lime increases the hazard of erosion. If the soil is properly fertilized and irrigated, however, good yields are obtained. (Dryland capability unit IIIe-2, climatic zone 1, and IVe-2, climatic zone 2; irrigated capability unit IIe-2; Mixed Plains range site)

Portales and Spur soils (0 to 1 percent slopes) (Ps).—These soils occur in small areas in the bottoms of draws. They are so similar that it was not practical to map them separately. About 80 percent of the acreage is divided nearly equally between Spur fine sandy loam and Portales fine sandy loam. The rest of the acreage is Spur clay loam. The hazard of wind erosion is moderate.

In some areas the plow layer contains a layer of loamy fine sand, 3 to 6 inches thick, that has accumulated as a result of wind winnowing in nearby cultivated areas. The subsoil is calcareous and has moderate to moderately rapid permeability.

These soils are fertile and receive water from adjoining areas. They have moderate capacity to hold plant nutrients. Yields of cotton, grain sorghum, and grasses are good. If these soils are used for irrigated farming, crops grown on them respond well to additions of nitrogen and phosphate. (Dryland capability unit IIIe-1, climatic zone 1, and IVe-4, climatic zone 2; irrigated capability unit IIe-4; Bottom Land range site)

Potter Series

This series consists of grayish-brown, calcareous soils that are shallow over beds of soft or slightly hard caliche. The soils are steep and are on the sides of draws that cross the county.

The surface layer is brownish, calcareous loam, 2 to 10 inches thick. It rests on a bed of slightly hardened caliche.

The Potter soils are similar to the Kimbrough and Simona soils. They are calcareous, however, and are lighter colored. They are underlain by softer caliche than the Kimbrough soils and are shallower than the Simona soils.

In this county the Potter soils are mapped only in complexes with the Berthoud and Tivoli soils.

Randall Series

The Randall series consists of poorly drained, dark-gray to grayish-brown, clayey soils on the floors of small playas, or lake basins. These soils occupy small areas, 2 to 10 acres in size, in association with the more clayey soils of the county.

The surface layer is dark-gray to grayish-brown clay, 10 to 30 inches thick. The subsoil is very dark gray, tough, plastic clay.

The Randall soils are more clayey than the Lubbock soils and are grayer and more clayey than the Amarillo soils. They are normally cultivated along with the surrounding soils. Associated soils are the Kimbrough, Arvana, and Amarillo soils.

In this county the Randall soils are mapped only in an undifferentiated unit with the Lubbock soils.

Simona Series

This series consists of strongly calcareous, nearly level to gently sloping soils that have moderately rapid permeability and are shallow over caliche. These soils are mostly in the western half of the county and occupy areas 40 to 200 acres in size.

The surface layer is dark grayish-brown to pale-brown fine sandy loam, 6 to 12 inches thick.

The subsoil is strongly calcareous, brown to pale-brown fine sandy loam, 4 to 12 inches thick.

The underlying material consists of a thick bed of strongly cemented fragments of caliche, 1 to 2 inches thick and 2 to 8 inches in diameter. Some fine soil material is between the fragments.

Closely associated are the Kimbrough, Arvana, and Potter soils. The Simona soils are calcareous rather than noncalcareous like the Kimbrough and Arvana soils. They are deeper than the Kimbrough and Potter soils; they are less reddish and have a less clayey subsoil than the Arvana soils.

The Simona soils are used for both dryland and irrigated farming. Large areas are in range.

Simona fine sandy loam (0 to 3 percent slopes) (Sc).—This is the only Simona soil mapped in this county. It is nearly level or gently sloping and occupies broad areas, mostly in the western part of the county. It is associated with deeper soils.

If this soil is cultivated, it is susceptible to severe wind erosion. The caliche near the surface limits the capacity of the soil to hold water and plant nutrients and restricts the development of roots. Irrigation is expensive because applications of water must be small and frequent to maintain adequate moisture. (Dryland capability unit IVe-3, climatic zone 1, and VIe-7, climatic zone 2; irrigated capability unit IIIe-5; Mixed Plains range site)

Springer Series

The soils of the Springer series are loose, sandy, and noncalcareous, and they have moderately rapid permeability. They occur throughout the county.

The surface layer is reddish brown to reddish yellow, is noncalcareous, and is 10 to 30 inches thick.

The subsoil is red to reddish-yellow fine sandy loam to loam, 6 to 40 inches thick.

The underlying material is pink, soft caliche to white, hard caliche and is at a depth of 16 to 60 inches.

Some shallower areas of Springer soils are mapped in an undifferentiated unit with the Brownfield soils. The Springer soils have a less clayey subsoil than the Brownfield soils.

The Springer soils are associated with the Tivoli soils but are less sandy than those soils. They are also associated with the Gomez soils, but they are more reddish than those soils and have a noncalcareous subsoil.

If cultivated, these soils are highly susceptible to wind erosion. Unless the areas are protected by vegetation, the topmost few inches is subject to continual shifting by wind. These soils are used for cultivated crops and range. In irrigated areas sprinkler irrigation is the most efficient way of applying water.

Springer loamy fine sand (0 to 3 percent slopes) (Sp).—This soil is highly susceptible to wind erosion. Deep-plowing is not practical; the subsoil does not contain enough clay to stabilize the surface.

In spring, when wind erosion is most active, the soil material in the surface layer is shifted unless this soil is protected by a cover of plants. This is evidenced by the filling of furrows in areas that have been listed, by the filling of roadside ditches, and by the building up of low dunes along fence rows. The evidence of erosion is partly erased when the seedbed is prepared and planting and cultivation take place.

This soil is better suited to range than to cultivated crops because of the severe hazard of wind erosion. If the soil is irrigated, a sprinkler system is the only efficient way to apply water. (Dryland capability unit VIe-1, climatic zones 1 and 2; irrigated capability unit IVe-2; Sandy Land range site, climatic zone 1, and Sandy Plains range site, climatic zone 2)

Springer and Brownfield soils, moderately deep (0 to 3 percent slopes) (Sm).—These soils occupy areas 40 to 160 acres in size throughout the county, mostly on ridges above Brownfield fine sand, thin surface. They occur together in such an intricate pattern that it was not practical to map them separately. The soils resemble Brownfield fine sand, thin surface, but they are underlain by hard caliche at a depth of 20 to 36 inches. Also, some of the areas have a subsoil of fine sandy loam. Included in the mapping are areas of Springer loamy fine sand and Brownfield fine sand, thin surface.

These soils are productive, but the hazard of wind erosion is serious. In spring when wind erosion is most active, some of the finer textured, more fertile particles of silt and clay are lost and the soil material in the surface layer is shifted unless this soil is protected by a cover of plants. This is evidenced by the filling of furrows in areas that have been listed, by the filling of roadside ditches, and by the building up of low dunes along fence rows. This evidence of erosion is partly erased when the seedbed is prepared and planting and cultivation take place.

These soils are closely associated with Brownfield fine sand, thin surface, and Springer and Brownfield soils, shallow.

The soils are underlain by hard rock, and if they are deep plowed, the work must be done carefully. If the

soils are irrigated, the only efficient way of applying water is by sprinkler irrigation. (Dryland capability unit IVe-2, climatic zone 1, and VIe-6, climatic zone 2; irrigated capability unit IIIe-4; Sandy Land range site)

Springer and Brownfield soils, shallow (0 to 3 percent slopes) (Sb).—These soils occupy small areas within larger areas of Springer and Brownfield soils, moderately deep. Unlike those soils, they are underlain by hard caliche at a depth of 16 to 20 inches.

These shallow soils have been deep plowed along with the surrounding deeper soils, and consequently, flat, rocklike fragments of caliche are on the surface.

These soils are highly susceptible to wind erosion. In spring when wind erosion is most active, the soil material in the surface layer is shifted unless this soil is protected by a cover of plants. This is evidenced by the filling of furrows in areas that have been listed, by the filling of roadside ditches, and by the building up of low dunes along fence rows. The evidence of erosion is partly erased when the seedbed is prepared and planting and cultivation take place. (Dryland capability unit VIe-1, climatic zones 1 and 2; irrigated capability unit IVe-1; Sandy Land range site)

Spur Series

In the Spur series are brown to dark grayish-brown, calcareous, friable soils formed in alluvium. These soils are on the floors of ancient draws that cross the county from the northwest to the southeast. These draws drain to the headwaters of the Colorado River, but they do not now carry runoff.

The surface layer is dark grayish-brown to pale-brown clay loam to fine sandy loam, 8 to 24 inches thick.

The subsoil is very pale brown to dark grayish-brown, calcareous fine sandy loam or clay loam. It is friable, moderately permeable, and 20 to 50 inches thick.

The underlying material is white to very pale brown, very strongly calcareous clay loam.

The principal associated soils are the very shallow Potter soils, which occupy the steep slopes at the edges of the draws, and the moderately deep Berthoud soils, also on the edges of draws.

In this county the Spur soils are mapped only in an undifferentiated unit with the Portales soils.

Stegall Series

This series consists of very dark grayish-brown to brown, moderately deep, slowly permeable soils that are noncalcareous. These soils developed over hard, rocklike caliche that is at a depth of 24 to 40 inches.

The surface layer is very dark grayish-brown to brown, noncalcareous loam, 4 to 12 inches thick.

The subsoil is very dark grayish-brown to brown, noncalcareous heavy clay loam, 20 to 28 inches thick. It has blocky structure and is slowly permeable. The movement of air and water through the soil is slow, and root penetration is restricted.

These soils are less permeable and less reddish than the Arvana soils.

Stegall loam, 0 to 1 percent slopes (StA).—This is the only Stegall soil mapped in the county. It is moderately deep and is underlain by hard, rocklike caliche at a depth

of 24 to 40 inches. This soil occupies small areas in low swales throughout the county. It is surrounded by the higher lying Kimbrough, Portales, and Zita soils.

This soil is fertile and produces good yields of cotton and grain sorghum, except when water is scarce. Because the soil is slowly permeable and does not supply water to the roots rapidly enough in dry weather, crops are likely to wilt.

Under irrigation this soil is productive, and crops grown on it respond well to applications of nitrogen and phosphate. The hazard of wind erosion is moderate. The rate of water intake is low but can be increased by maintaining a high content of organic matter. (Dryland capability unit IIIce-1, climatic zone 1, and IVce-1, climatic zone 2; irrigated capability unit IIe-1; small areas are included in the Mixed Land range site)

Tivoli Series

The soils of the Tivoli series are deep, light-colored, loose sands that were deposited by wind. They are in the northeastern part of the county and in the extreme southwestern corner. The Tivoli soils are undulating to billowy, or occupy stabilized dunes that are 2 to 12 feet high and as much as 200 feet in diameter at the base.

The surface layer is brown to very pale brown, loose fine sand, 2 to 10 inches thick; it takes water rapidly.

The underlying material is very pale brown to pale brown fine sand, 30 to more than 60 inches thick.

These soils are adjacent to the Brownfield soils. They are less smooth and occupy higher areas than the Brownfield soils.

The Tivoli soils are not suited to cultivation, because the hazard of wind erosion is high.

Tivoli fine sand (0 to 15 percent slopes) (Tv).—Areas of this soil consist of a mixture of dunes and blowouts. The blowouts and some of the dunes are not stabilized by vegetation. In some areas, ranging from 1 or 2 acres to as much as 10 acres in size, there are one to a few clumps of grass in places that are otherwise bare and sandy.

The surface layer is brown to very pale brown fine sand that has been slightly darkened by organic matter. It is 2 to 10 inches thick and is underlain by pale brown to very pale brown, loose fine sand that extends to a depth of many feet.

This soil is not suited to cultivation. The hazard of wind erosion is high, and the capacity to hold water and plant nutrients is low. The soil is best used as range, seeded to perennial grasses. It is not suitable for irrigation. (Dryland capability unit VIIe-1, climatic zones 1 and 2; Deep Sand range site)

Tivoli-Potter complex (0 to 15 percent slopes) (Tx).—The soils of this complex are so intermingled that it was not feasible to map them separately. They are on the side slopes of ancient drains. About 75 percent of the acreage is Tivoli fine sand that has accumulated over Potter soil material, about 20 percent consists of Potter soils, and the rest is Berthoud fine sandy loam. The accumulations of fine sand are 2 to 4 feet thick. They are in areas covered by native vegetation and adjoin areas of cultivated sandy soils. In cultivated areas the deposits of sand are mostly on north-facing slopes. In other places, mostly on the south-facing slopes, the soil is eroded and the underlying caliche is exposed.

The soils in this complex are associated with the coarse-textured Brownfield, Amarillo, and Gomez soils.

Most areas of this complex have been eroded by both wind and water. Water erosion has formed small gullies and has removed soil around clumps of vegetation to leave small stools or "pedestals."

These soils are not suited to cultivated crops, because of their thin solum, steep slopes, and high susceptibility to wind and water erosion. They are best suited to perennial grasses and are not suitable for irrigation. (Dryland capability unit VIIe-1, climatic zones 1 and 2; Deep Sand range site for Tivoli soils and Shallow Land range site for Potter soils)

Zita Series

The soils of the Zita series are brown, moderately deep, moderately permeable, and noncalcareous. They are nearly level and occupy small areas within larger areas of Amarillo and Portales soils.

The surface layer is brown to dark grayish-brown fine sandy loam, 8 to 16 inches thick. It has subangular blocky structure and is noncalcareous.

The subsoil is dark grayish-brown to brown, calcareous clay loam, 6 to 12 inches thick.

The underlying material is mostly pink to pale-brown, strongly calcareous clay loam.

The Zita soils are shallower and less reddish than the Amarillo soils. They are darker than the Portales soils and do not have a calcareous surface layer. Most areas of the Zita soils are used for cultivated crops.

Zita fine sandy loam, 0 to 1 percent slopes (ZfA).—The surface layer of this soil is generally friable, porous fine sandy loam, 8 to 16 inches thick. In many areas, however, the plow layer contains 2 to 6 inches of loamy fine sand. The subsoil is calcareous, lighter colored, and more clayey than the surface layer.

This soil produces good yields of cotton and grain sorghum. It is susceptible to moderate wind erosion, and it normally receives runoff from the surrounding, slightly higher lying soils. If this soil is irrigated, crops respond well to applications of nitrogen and phosphorus. (Dryland capability unit IIIe-1, climatic zone 1, and IVe-4, climatic zone 2; irrigated capability unit IIe-3; Mixed Land range site)

Use and Management of the Soils

In this section wind erosion and its control are discussed in relation to the use and management of the soils, and general management practices are described that help to control erosion, conserve moisture, and maintain fertility in the soils. The capability grouping used by the Soil Conservation Service is also explained, and the use and management of the soils in each dryland capability unit are discussed. Then a brief discussion is given of irrigation in the county, the use and management of the soils in each irrigation unit are described, and predicted average yields are given that are obtained under dryland farming and under irrigated farming. Finally, the use and management of the soils for range and for highways and other engineering uses are discussed.

Wind Erosion and Its Control

Wind erosion is a major hazard to farming in Gaines County, and its control is a serious problem. Wind erosion results when strong winds blow unanchored particles of soil about. These winds move small particles of soil or grains of sand across the surface in a series of bounces, or cause them to roll or creep. Where these particles strike unprotected soil, they loosen and free more particles. The finer silts and clays, in the form of dust, are carried high into the air and sometimes float for days before they settle. Strong blowing is most likely late in winter and early in spring when the soil has the least vegetation and is the most susceptible.

Soil erodes, mainly because it lacks a cover of plants to hold it in place. Drought is the primary cause of the lack of vegetation, but poor management is also a factor. For example, a large acreage of soils suited only to permanent grasses has been cultivated. As a result, the soils are bare and subject to severe erosion much of the time, and they provide only low income from cultivated crops grown on them. Another example of poor management is the use of unsuitable tillage implements that have increased the erodibility of the soils by depleting the vegetation. Frequent, shallow plowing increases the hazard of erosion. Also, the high temperatures and long, dry spells that prevail in this area contribute to conditions favorable to wind erosion.

Management practices are needed that will best control wind erosion. It is wiser to use planned soil-protecting practices than to delay until emergency practices are necessary. The use of a plant cover and crop residue, and of tillage that roughens the surface, are important practices that help to control wind erosion.

Practices needed to control erosion on the individual soils are discussed under the capability units for each soil, both under dryland and irrigated farming. A representative of the Soil Conservation Service should be consulted for more specific and detailed information about the control of wind erosion.

Effects of wind erosion

Although in this survey only the soils in one mapping unit are named as eroded, all of the cultivated soils and some of the soils used only for grazing have been altered by the action of wind. Wind erosion is the major hazard to agriculture in this county, and the soils must be managed to prevent rapid and lasting damage. In cultivated areas wind erosion may remove as much as half of the material in the original surface layer, including some of the organic matter, silt, and clay in the plow layer. On the other hand, wind may also cause the accumulation of 4 to 6 inches of sandy material. The hazard of wind erosion is least on the noncalcareous loams, but it becomes greater in direct relation to the proportion of sand or lime in the subsoil.

The loams and other fine-textured soils are least affected by wind erosion because tillage generally roughens them and makes them cloddy so that they resist blowing. In most areas, however, wind winnowing has removed enough of the organic matter, silt, and clay from the surface layer to make the soil coarser textured and somewhat lighter colored than it was when first put into cultivation. Thus,

susceptibility to erosion increases, and the capacity to hold water and plant nutrients decreases.

The fine sandy loams are moderately susceptible to wind erosion and have been greatly altered by the action of wind. The most damaging effect of blowing is probably the removal of organic matter, silt, and clay from the plow layer of these soils. In some small areas nearly all of the original surface layer has been removed by wind. The remaining sandy layer is practically sterile and is highly susceptible to wind erosion. The reduced fertility and lower moisture-holding capacity are reflected in lower yields of crops. To offset the effects of wind erosion, farmers have plowed deeper to bring to the surface the more clayey material that underlies the sand.

The coarse-textured loamy fine sands and fine sands show the most severe effects of wind erosion. In cultivated areas of these soils, dunes as much as 10 feet high are common along fence rows. Often, farm buildings are nearly surrounded by dunes; roads may be closed by drifting sand during one hard blow. Farmers often must plant their crops three or four times because of shifting sand in the early spring blows. In places the soils in abandoned fields have lost all of the thick, sandy surface layer. The blowing of sterile sand from these areas to adjoining areas of more productive soils is especially damaging. Extensive reclamation is necessary to level the dunes.

Rangeland also shows the effects of wind erosion. Although some of the soil is shifted about or removed, generally, the wind deposits sand and soil material from cultivated areas onto the rangeland. In some places several acres are covered by sand that is 6 inches to 3 feet deep. This sand smothers the good grasses, and weeds and brush get a start.

One of the least noticed, yet most damaging, effects of wind erosion results from the blowing of clay and silt from cultivated land onto rangeland. Small particles are picked up by wind from areas used for crops and are carried many miles before being deposited on rangeland in a mantle $\frac{1}{8}$ to $\frac{1}{4}$ inch thick. The crust formed by these particles reduces the intake of water and increases runoff and water erosion. The good grasses are thus robbed of greatly needed moisture.

General Management of Cropland

The main objectives of the management practices discussed in the following pages are controlling soil erosion, conserving moisture, and maintaining the fertility of the soils. The practices described to attain these objectives are use of a suitable cropping system, stripcropping, use of crop residue, use of deep plowing or of tillage to roughen the surface, contour farming and terraces, and use of commercial fertilizer. Generally, a combination of several of these practices is needed to conserve moisture and to protect the soils from wind and water erosion. Additional information about use of these practices on specific soils is given in the section "Capability Group of Soils."

Cropping systems

In planning a cropping system, the soil properties that need the most careful attention should be considered. This will insure more efficient production over a period of years. The limitations of a soil will determine what kind

of crops can be grown and how frequently a specific crop can be included in the cropping system.

The cropping system should include crops that (1) conserve the soil; (2) use available moisture efficiently; (3) protect the soil from wind and water erosion; (4) maintain or improve tilth and fertility and provide a suitable environment for micro-organisms and other kinds of life in the soil; (5) help to control weeds, insects, and diseases; and (6) fit into a long-time plan of land use that is economically sound and feasible.

In this county the cropping system should include crops that provide maximum protection of the soil when the risk of wind erosion is greatest. Although cotton is the most common cash crop, it leaves little residue after harvest, and therefore the soil is not adequately protected in critical periods of blowing.

Generally, grasses, legumes, sorghum, and small grains should be grown more often than cotton in the cropping system. They will decrease the hazards of soil erosion and soil deterioration.

Stripcropping

Stripcropping is a system of growing crops in alternate strips, or bands, at right angles to the natural slope and at right angles to the direction of the prevailing winds. These strips provide barriers to wind and water erosion. Stripcropping helps to protect cotton from the blasting of sand during windstorms and protects the soil from wind erosion after the crops are harvested. The main crops grown in protective strips are grain sorghum, forage sorghum, and tall perennial grasses. Cotton is the main cash crop grown in those areas that need protection by stripcropping.

Sorghum successfully competes with cotton for water, and consequently, the rows of cotton next to the sorghum will not get enough moisture from the soil. This can be compensated for by leaving one blank row on either side of each two rows of cotton.

Use of crop residue

Soil is protected from erosion by growing plants and by the residue from crops. Generally, vegetation and crop residue have a greater capacity for trapping moving soil than a rough or cloddy surface. Crop residue or stubble left in the field after harvest will protect the soil from damaging winds during the critical blowing seasons in winter and in spring, and it will also maintain or improve the tilth, and the environment for micro-organisms and other forms of life.

Tall stubble reduces the surface velocity of the wind more effectively than short stubble. Stalks of grain sorghum 10 feet high are generally used to protect the soil, either in closely spaced rows or in rows 40 inches apart. The rest of the stalk, which has been through a combine, is left on the ground.

Grass is one of the best plant covers because it has a relatively large protective surface above ground and a well-anchored root system. Crops of small grain, winter peas, and vetch, and the residue from grain sorghum also provide good protection from wind erosion.

Stubble mulching.—Stubble mulching (fig. 8) is a year-round system of farming designed to keep vegetation on the surface until the next crop is seeded. Tilling, plant-



Figure 8.—Stubble mulching with grain sorghum on or near the surface.

ing, cultivating, and harvesting must be planned; special equipment is required for stubble mulching.

Stubble mulching is an excellent practice on all soil types. It (1) controls erosion by wind and water; (2) improves the tilth and chemical condition of the soil, and provides a good environment for minute forms of animal life; (3) conserves moisture and reduces surface evaporation; and (4) reduces the rate of decrease of organic matter.

Application of cotton burs.—Cotton burs, spread evenly and worked in, control erosion on cropland that did not produce enough cover the previous season. They shield the soil from the wind. Burs also protect freshly plowed fields and "blown-out" areas. They increase yields and improve soils that are in poor tilth. The use of cotton burs (1) increases the rate of infiltration of water; (2) reduces runoff; (3) returns nitrogen, phosphorus, and potassium to the soil; and (4) improves the soil as an environment for minute forms of animal life by adding organic matter.

A minimum of 3 tons per acre of dry burs is needed for dryland farming; the best results are obtained by using 4 to 5 tons. If the soils are irrigated, 3 to 12 tons per acre can be applied, but the most efficient amount is about 8 tons. Twenty pounds of nitrogen per ton of burs should be added to irrigated cropland.

Tillage

The purposes of tillage are to prepare the seedbed, to control weeds, and to manage crop residue. All of the tillage operations should help produce and maintain good tilth in the surface soil. In this county tillage is the principal means by which a farmer carries out his soil management program.

Excessive tillage, or continued tillage without crop residue on the surface, causes the exposed soil aggregates to break down into fine particles or single grains that are highly susceptible to blowing. These fine particles of silt and clay fill the pores and channels through which water and air move. Improper tillage impairs soil tilth

and causes the formation of a dense, hard crust on the surface.

Minimum tillage should be used to prepare the seedbed, conserve moisture, control weeds, and maintain roughness and cloddiness of the surface soil. Fields should be tilled across the direction of the prevailing wind, and tillage should be begun at the windward edge of an area subject to blowing.

Deep plowing.—If sandy, erodible soils are dry farmed, it is nearly impossible to grow crops that leave enough residue on the surface to control wind erosion. Deep plowing is now widely used on the fine sands and loamy fine sands in this county to reduce susceptibility to wind erosion. It brings 4 to 6 inches of clayey material from the subsoil to the surface in the furrow slice, and the plow layer can then be roughened to form stable clods that will not blow easily. Deep plowing alone is not enough, however, and should be combined with proper use of crop residue and with tillage that roughens the surface.

According to the results of a field study made of wind erosion in the western part of Texas,¹ the main significance of deep plowing is that it increases the productivity of the soils by bringing up clayey soil material from below. A clayey soil will no doubt remain more cloddy and maintain a less erodible structure in the surface layer if no soil drifting occurs. However, if the surface layer is not kept stable after deep plowing, the beneficial results do not last long. If drifting of the surface soil continues, the clayey material is eventually so far from the surface that it can no longer be reached by deep plowing. The resulting deep mantle of sand then tends to be more hazardous to surrounding areas than the shallower mantle.

Tillage to roughen the surface.—A rough surface is more resistant to wind erosion than a smooth one. It slows the surface velocity of the wind and traps particles blown from more exposed areas. Listing, or other tillage that roughens the surface, is effective on soils that have a surface layer of loam or finer textured material. Emergency tillage is largely ineffective or at best is effective for only a short time on the fine sandy loams and loamy fine sands.

Often, the only practical way to roughen the surface is to use a tillage implement that turns up as many clods as possible, even if the clods are not of an ideal size. Clods reduce susceptibility to wind erosion because they are too large to be moved about by wind. The degree of protection, however, depends on their size, stability, and number. Clods as small as an alfalfa seed (0.84 millimeter, or $\frac{1}{32}$ of an inch in diameter) are large enough to resist wind erosion. Larger clods are less effective than smaller ones because they have less surface area in proportion to their weight.

The formation of clods is determined by the texture of the soil. Clay binds the particles of sand and silt together, and clods form more readily if the soil contains as much as 20 to 35 percent clay. Also, the stability of the clods is affected by the percentage of clay in the soil. Lime reduces the stability of the clods.

Contour farming and terraces

In Gaines County much of the rainfall comes rapidly; sometimes 1 to 2 inches fall in an hour. Contour farming and terraces help to store much of the moisture in the subsoil for future crops. In contour farming, the plowing, planting, and other cultivation practices follow the natural contour of the land, established terraces, or contour strips.

Terraces check the runoff from rainfall and spread the water so that most of the moisture is available to plants. They should be supplemented, however, by a well-planned cropping system. Fine sands and loamy fine sands are not stable enough to be used for terraces.

Use of commercial fertilizer

Lack of moisture is the limiting factor on most soils that are dryfarmed. Farmers have noticed, however, that yields decline in areas that have been irrigated for 3 or 4 years.

Most of the irrigated soils in this county need nitrogen and phosphorus, and some of the soils need potassium. The use of commercial fertilizer is increasing each year. At present, fertilizer is applied to cotton in all irrigated areas and to much of the cotton in dry-farmed areas. If fertilizer is correctly applied on irrigated soils, yields of cotton can be expected to increase by $\frac{1}{3}$ to $\frac{1}{2}$ bale per acre, and yields of grain sorghum, by 1,500 pounds to 2,500 pounds per acre. The amount and kind of fertilizer used varies according to the season, the needs of the crop to be grown, the kind of soil, and the kind of crop previously grown. The farmer should apply fertilizer in accordance with the needs shown by the results of soil tests.

The county agent or a representative of the Soil Conservation District will furnish information on the use of commercial fertilizer, new experiments run each year, and progress made. The soil maps at the back of this report will help in selecting sites from which to take samples for soil testing.

Capability Groups of Soils

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

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

The subclasses indicate major kinds of limitations within the classes. Within most of the classes there can be up to four subclasses. The subclass is indicated by adding a small letter *e*, *w*, *s*, or *c*, to the class numeral, for example IIIe. The letter *e* shows that the main limitation is risk of erosion unless close-growing plant cover is maintained; *w* means that water in or on the soil will interfere with plant

¹ CHEPIL, W. S., WOODRUFF, N. P., AND ZINGG, A. W. FIELD STUDY OF WIND EROSION IN WESTERN TEXAS. U.S. Dept. Agr. SCS-TP-125, 60 pp., illus. 1955.

growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c*, used in only some parts of the country, indicates that the chief limitation is climate that is too cold or too dry.

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

Within the subclasses are the capability units, groups of soils enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity and other responses to management. Thus, the capability unit is a convenient grouping for making many statements about management of soils. Capability units are generally identified by numbers assigned locally, for example, IIe-1 or IIIe-2.

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

Many of the soils of Gaines County are put in a different capability unit if they are irrigated than if they are dryfarmed. Consequently, two sets of capability units are described. In the first, all the soils of the county are classified according to their capability under dryland farming. In the second, the soils suitable for irrigation are classified according to their capability when irrigated.

Management by dryland capability units

The soils of Gaines County have been placed in capability units for management under dryland farming. All the soils in one capability unit need about the same kind of management and respond to management in about the same way. The soils are grouped according to climatic limitations and the hazards of wind and water erosion.

In this county strong winds for prolonged periods in spring cause loss of soil through blowing and loss of moisture through evaporation. The hazard of wind erosion is least on the noncalcareous loams, and it increases as the content of sand or lime increases in the surface layer. Management practices suggested for controlling wind erosion are designed to supply cover for the soils or to make the surface rough or cloddy, to help get water into the soils, and to prevent loss of moisture through evaporation. Practices that control wind erosion also increase yields in most years.

Management of dry-farmed soils is affected by the two climatic zones that divide the county diagonally from northwest to southeast, generally along the Wordswell and Seminole Draws. The northeastern part of the county, in climatic zone 1, receives more rainfall than the southwestern part, in climatic zone 2 (fig. 9). Because less rainfall is received in climatic zone 2, yields are lower in that zone and crop failures and serious wind erosion are more common than on the same soils in climatic zone 1.

A soil may be in more than one climatic zone, and consequently, in more than one capability unit. Also, the

transitional area between the zones is several miles wide, and a soil in the transitional zone may be placed in a specific capability unit for reasons other than climate and soil characteristics. The climatic zones are not significant if a soil is irrigated.

The capability units assigned are shown in the "Guide to Mapping Units, Capability Units, and Range Sites" in the back of the report. The eight classes in the capability system, and the subclasses and dryland units in this county, are described in the list that follows. Following the list are descriptions of the units, including suggestions for managing the soils for dryland farming.

Class I.—Soils that have few limitations that restrict their use. (None in this county)

Class II.—Soils that have some limitations that reduce the choice of plants or require moderate conservation practices. (Grouped under irrigated capability units in this county)

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

Subclass IIIe.—Soils subject to severe erosion if they are cultivated and not protected.

Unit IIIe-1.—Deep and moderately deep, reddish-brown to dark grayish-brown, moderately permeable fine sandy loams to clay loams that are nearly level to gently sloping.

Unit IIIe-2.—Moderately deep, calcareous, brown to dark grayish-brown fine sandy loams that are nearly level to gently sloping and have moderately rapid permeability.

Subclass IIIc.—Soils that have severe climatic limitations caused by low rainfall and that are subject to severe erosion if they are cultivated and not protected.

Unit IIIc-1.—Moderately deep, very dark grayish-brown to brown, slowly permeable, nearly level loams.

Unit IIIc-2.—Moderately deep, calcareous, very dark grayish-brown to brown, moderately permeable, nearly level loams.

Class IV.—Soils that have very severe limitations that restrict the choice of plants, require very careful management, or both.

Subclass IVe.—Soils subject to very severe erosion if they are cultivated and not protected.

Unit IVe-1.—Deep to moderately deep, pale-brown to dark grayish-brown and reddish-brown to yellowish-red loamy fine sands.

Unit IVe-2.—Deep to moderately deep, reddish-brown to reddish-yellow, nearly level to gently sloping fine sands.

Unit IVe-3.—Reddish-brown to dark-brown, nearly level to gently sloping fine sandy loams that are shallow over caliche and have moderate to moderately rapid permeability.

Unit IVe-4.—Deep and moderately deep, reddish-brown to dark grayish-brown, moderately permeable fine sandy loams to clay loams that are nearly level to gently sloping.

Unit IVe-5.—Moderately deep, calcareous, brown to dark grayish-brown fine sandy loams that are nearly level to gently sloping and have moderately rapid permeability.

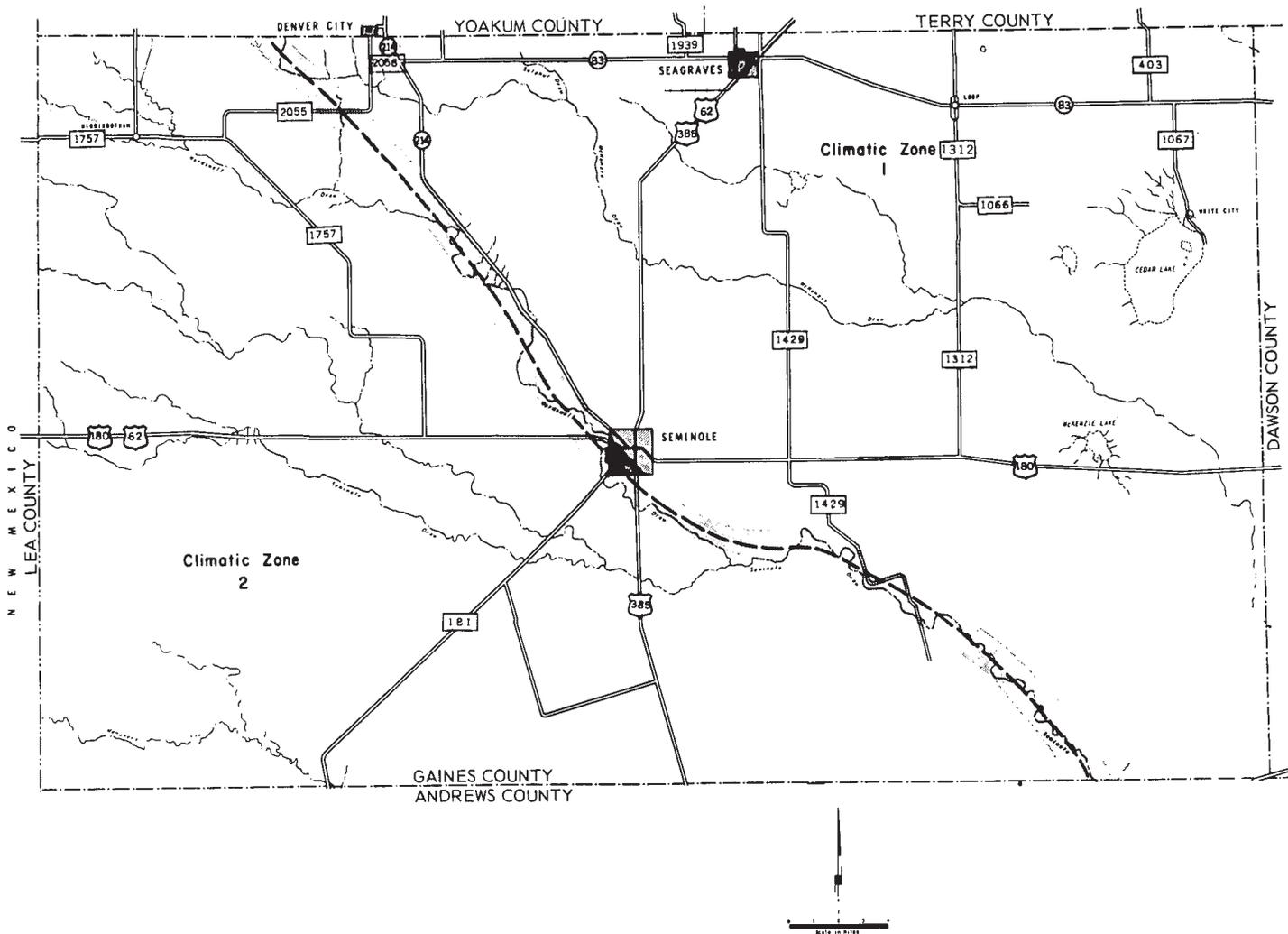


Figure 9.—The two climatic zones in Gaines County.

Subclass IVes.—Soils that have very severe limitations if they are cultivated and not protected and that are strongly calcareous.

Unit IVes-1.—Shallow to deep, light-gray, nearly level to gently sloping soils that have slow to moderately rapid permeability.

Subclass IVce.—Soils that have a severe climatic limitation caused by low rainfall, and a very high susceptibility to wind erosion.

Unit IVce-1.—Moderately deep, very dark grayish-brown to brown, slowly permeable, nearly level loams.

Unit IVce-2.—Moderately deep, calcareous, very dark grayish-brown to brown, moderately permeable, nearly level loams.

Class V.—Soils not likely to erode, but that have other limitations, impractical to remove without major reclamation, that limit their use largely to pasture or range, woodland, or wildlife food and cover. (None in this county)

Class VI.—Soils that have severe limitations that make them generally unsuitable for cultivation and that limit

their use largely to pasture or range, woodland, or wildlife food and cover.

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

Unit VIe-1.—Shallow to moderately deep, reddish-yellow to dark grayish-brown sandy soils that have moderate to moderately rapid permeability.

Unit VIe-2.—Deep, reddish-brown to reddish-yellow, moderately permeable, nearly level to gently sloping soils.

Unit VIe-3.—Moderately deep, light-gray, gently sloping to steep light clay loams to fine sandy loams that have moderately rapid permeability.

Unit VIe-4.—Very shallow to moderately deep, dark grayish-brown to brown loams or fine sandy loams on the sides of draws.

Unit VIe-5.—Deep to moderately deep, pale-brown to dark grayish-brown and reddish-brown to yellowish-red loamy fine sands.

Unit VIe-6.—Deep to moderately deep, reddish-brown to reddish-yellow, nearly level to gently sloping fine sands.

Unit VIe-7.—Reddish-brown to dark-brown, nearly level to gently sloping fine sandy loams that are shallow over caliche and have moderate to moderately rapid permeability.

Unit VIes-1.—Shallow to deep, light-gray, nearly level to gently sloping soils that have slow to moderately rapid permeability.

Unit VIw-1.—Deep, dark-gray to grayish-brown, very slowly permeable, poorly drained soils in small playas.

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

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

Unit VIIe-1.—Shallow to deep, rapidly permeable, grayish-brown to pale-brown, undulating to steep soils.

Subclass VIIs.—Soils very severely limited by moisture capacity, stones, or other soil features.

Unit VIIs-1.—Dark grayish-brown to brown, nearly level to sloping soils.

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

**DRYLAND CAPABILITY UNIT IIIe-1, CLIMATIC ZONE 1,
AND IVe-4, CLIMATIC ZONE 2**

These two units consist of deep and moderately deep, reddish-brown to dark grayish-brown, moderately permeable fine sandy loams to clay loams that are nearly level to gently sloping. In climatic zone 2, because of less rainfall, lower average yields, greater risk of crop failure, and more serious erosion, they are in unit IVe-4. The soils of this group are—

Amarillo fine sandy loam, 0 to 1 percent slopes.

Amarillo fine sandy loam, 1 to 3 percent slopes.

Arvana fine sandy loam, 0 to 1 percent slopes.

Arvana fine sandy loam, 1 to 3 percent slopes.

Portales and Spur soils.

Zita fine sandy loam, 0 to 1 percent slopes.

These soils are moderately susceptible to wind erosion, and they are slightly to moderately susceptible to water erosion. Their capacity to hold water and plant nutrients is moderate.

Cotton and grain sorghum are the main cash crops, but small grains may also be grown as a cash crop. Use a cropping system that provides residue to protect the soils. Such a system can be 1 year of cotton, followed by 2 years of grain sorghum or a small grain. If stripcropping is practiced, use alternate strips of cotton and grain sorghum or of a small grain. Each year rotate the strips until the grain sorghum or the small grain has been grown on all of the cropland.

Leaving residue on the surface during periods when erosion is critical is an important practice. Tillage that roughens the surface should be used to help control erosion in years when the residue produced is not adequate for protection.

**DRYLAND CAPABILITY UNIT IIIe-2, CLIMATIC ZONE 1,
AND IVe-5, CLIMATIC ZONE 2**

These two units consist of moderately deep, calcareous, brown to dark grayish-brown fine sandy loams. The soils are nearly level to gently sloping and have moderately rapid permeability. In climatic zone 2, because of less rainfall, lower average yields, greater risk of crop failure, and more serious erosion, they are in unit IVe-5. The soils of this group are—

Portales fine sandy loam, 0 to 1 percent slopes.

Portales fine sandy loam, 1 to 3 percent slopes.

These soils are moderately susceptible to wind erosion, and they are slightly to moderately susceptible to water erosion. Their capacity to hold water and plant nutrients is moderate. Because of their high content of lime, these soils have lower water-holding capacity and are more susceptible to wind erosion than the soils in capability unit IIIe-1. Chlorosis may be a problem.

Cotton and grain sorghum are the main cash crops, but small grains may also be grown as a cash crop. Use a cropping system that provides residue to protect the soil. Such a system can be 1 year of cotton, followed by 2 years of grain sorghum or a small grain. If stripcropping is practiced, use alternate strips of cotton and grain sorghum or of a small grain. Each year rotate the strips so that all parts of the field can benefit from the greater amount of residue produced by the grain sorghum or small grain.

Leaving residue on the surface during periods when wind erosion is critical is an important practice. Tillage that roughens the surface, such as listing or chiseling, should be used to help control wind erosion in years when the residue produced is not adequate for protection.

**DRYLAND CAPABILITY UNIT IIIce-1, CLIMATIC ZONE 1,
AND IVce-1, CLIMATIC ZONE 2**

The only soil in these capability units is Stegall loam, 0 to 1 percent slopes. It is a nearly level, moderately deep, very dark grayish-brown to brown soil that is slowly permeable.

This soil is highly susceptible to wind erosion. Its capacity to hold water and plant nutrients is high, but lack of moisture limits its productivity.

Cotton and grain sorghum are the main cash crops. Use a cropping system that provides enough residue to protect the soil. Such a system can be 1 year of cotton, followed by 1 year of grain sorghum or a small grain.

Crop residue that is turned under helps to maintain the content of organic matter in this soil. If left on the surface, it helps to control erosion by providing cover during periods when wind erosion is critical. If the residue is not adequate to control blowing in periods of drought, this soil should be chiseled or listed so that the surface will be cloddy and rough.

**DRYLAND CAPABILITY UNIT IIIce-2, CLIMATIC ZONE 1,
AND IVce-2, CLIMATIC ZONE 2**

The only soil in these capability units is Portales loam, 0 to 1 percent slopes. It is a moderately deep, calcareous, very dark grayish-brown to brown, nearly level soil that is moderately permeable.

This soil is highly susceptible to wind erosion. Its capacity to hold water and plant nutrients is high. Because of its high content of lime, this soil has lower water-hold-

ing capacity and is more susceptible to wind erosion than the soil in capability unit IIIc-1. Chlorosis may be a problem.

Cotton is the main cash crop. Among the other cash crops are grain sorghum and small grain. Use a cropping system that provides residue to protect the soil. Such a system can be 2 years of cotton, followed by 3 years of grain sorghum or small grain.

Leaving residue on the surface during periods when erosion is critical helps to control wind erosion. Tillage that leaves the surface cloddy or rough, such as chiseling or listing, should be used during or following dry years, when only a small amount of crop residue is produced.

**DRYLAND CAPABILITY UNIT IVe-1, CLIMATIC ZONE 1,
AND VIe-5, CLIMATIC ZONE 2**

In these units are deep to moderately deep, pale-brown to dark grayish-brown and reddish-brown to yellowish-red loamy fine sands. Permeability is moderate to moderately rapid, and the soils are nearly level to gently sloping. In climatic zone 2, these soils are in capability unit VIe-5. Generally, these soils are not suited to dryland cultivation, because of inadequate rainfall, low average yields, high risk of crop failure, and serious erosion. The soils of this group are—

Amarillo loamy fine sand, 0 to 3 percent slopes.
Gomez loamy fine sand.

Because the climate is dry and the soils are sandy, susceptibility to wind erosion is severe. On the steeper slopes susceptibility to water erosion is slight. The rate of water intake is high.

If these soils are protected from wind erosion, they can be used for cultivated crops, but they are best suited to perennial vegetation. Cotton and grain sorghum are the main cash crops. When cotton is grown, however, the soil is without cover much of the time.

In areas where these soils are deep plowed successfully and sandy clay loam is turned up on the surface, use a cropping system that provides residue to protect against erosion. Such a system can be 1 year of cotton followed by 3 years of grain sorghum or a small grain.

The Gomez soil cannot be deep plowed successfully. It needs a cropping system that provides residue for protection against erosion. Grain sorghum or a small grain must be grown each year. The crop residue should be left on the surface to be most effective in controlling wind erosion. If enough residue is not produced to control wind erosion, tillage, such as chiseling or listing, should be used.

**DRYLAND CAPABILITY UNIT IVe-2, CLIMATIC ZONE 1,
AND VIe-6, CLIMATIC ZONE 2**

These units consist of deep to moderately deep, reddish-brown to reddish-yellow fine sands. Permeability is moderate to moderately rapid, and the soils are nearly level to gently sloping. In climatic zone 2, these soils are in capability unit VIe-6 and are not generally suited to dryland cultivation. The rainfall is less, average yields are lower, the risk of crop failure is greater, and erosion is more serious than on the same kinds of soils in climatic zone 1. The soils of this group are—

Brownfield fine sand, thin surface.
Springer and Brownfield soils, moderately deep.

These soils are highly susceptible to wind erosion, and control is difficult. The capacity of the sandy surface layer to hold water and plant nutrients is low. Even when moisture is adequate, plant growth is often limited by the low fertility of these soils.

Grain sorghum is the main cash crop, but some cotton is grown. Cotton stubble provides little protective cover, and areas that are planted to cotton, especially those that are dry farmed, are usually the first to start blowing in spring. These soils are best suited to perennial grasses.

If cash crops are grown in areas where the soils can be deep plowed effectively, the cropping system should include crops that provide enough residue to protect the soil. Such a system can be 1 year of cotton, followed by 3 years of grain sorghum or small grain. If stripcropping is practiced, use alternate strips of cotton and grain sorghum or a small grain. The strips of cotton should be only one-third as wide as the strips of grain sorghum or small grain. Each year rotate the strips so that the soils in all parts of the field will benefit from the greater amount of residue produced by the grain sorghum or small grain.

If the soil is not deep plowed, grain sorghum or small grain should be grown on all of the cropland year after year. The crop residue should be left on the surface to be most effective in controlling wind erosion. If enough residue is not produced to control wind erosion, tillage, such as chiseling or listing, should be used.

**DRYLAND CAPABILITY UNIT IVe-3, CLIMATIC ZONE 1,
AND VIe-7, CLIMATIC ZONE 2**

These units consist of reddish-brown to dark-brown, nearly level to gently sloping fine sandy loams that are shallow over caliche and have moderate to moderately rapid permeability. The Simona soil is strongly calcareous; the Arvana soil is noncalcareous above the caliche. In climatic zone 2, these soils are in unit VIe-7 and are not generally suited to dryland cultivation. The rainfall is less, average yields are lower, crop failures are more common, and erosion is more serious than in climatic zone 1. The soils of this group are—

Arvana fine sandy loam, shallow, 0 to 3 percent slopes.
Simona fine sandy loam.

These soils are highly susceptible to wind erosion, and they are moderately susceptible to water erosion in areas where the slope is 1 to 3 percent. These soils have a moderate capacity to hold water and plant nutrients; they are often droughty, however, because they are shallow, and crops grown on them frequently produce too little residue to control wind erosion effectively.

Grain sorghum is the main cash crop, but these soils are best suited to permanent vegetation. Use a cropping system that provides residue to protect the soil. Such a system can be 1 year of cotton, followed by 3 years of grain sorghum or small grain. If stripcropping is practiced, use alternate strips of cotton and grain sorghum or of a small grain. The strips of cotton should be only one-third as wide as the strips of grain sorghum or small grain. The crop residue should be left on the surface to help control wind erosion. In years when inadequate residue is produced, chiseling or other tillage that roughens the surface will also help to control erosion.

**DRYLAND CAPABILITY UNIT IVes-1, CLIMATIC ZONE 1,
AND VIes-1, CLIMATIC ZONE 2**

These units consist of shallow to deep, light-gray, nearly level to gently sloping soils that have slow to moderately rapid permeability. The Arch soils are shallow over chalky clay loam. In climatic zone 2, these soils are in capability unit VIes-1 and are not generally suited to dryland cultivation. Rainfall in climatic zone 2 is less, average yields are lower, crop failures are more frequent, and risk of erosion is more serious than in climatic zone 1. The soils of this group are—

Arch soils.

Drake soils, 1 to 3 percent slopes.

These soils are highly susceptible to wind erosion; the Drake soils are also moderately susceptible to water erosion. The soils have moderate water-storage capacity. They contain a large amount of free lime, which slows the release of plant nutrients and frequently causes the leaves of grain sorghum to turn yellow.

These soils are best suited to grass. If cash crops are grown, use a cropping system that provides enough residue to protect the soil. Such a system can be 1 year of cotton, followed by 3 years of grain sorghum or small grain. If stripcropping is practiced, the strips of cotton should be only one-fourth as wide as the strips of grain sorghum or small grain. Four rows of cotton and twelve rows of grain sorghum should provide enough residue to protect the soil. A good alternative cropping system is one that provides for such crops as grain sorghum or small grain each year.

Crop residue should be left on the surface to give maximum protection from wind erosion. In years when inadequate residue is produced, tillage that roughens the surface, such as chiseling or listing, will also help to control wind erosion.

DRYLAND CAPABILITY UNIT VIe-1, CLIMATIC ZONES 1 AND 2

In this unit are shallow to moderately deep, reddish-yellow to dark grayish-brown, sandy soils that have moderate to moderately rapid permeability. The Springer and Brownfield soils are shallow over hard caliche. The Gomez soil is underlain by fine sandy loam. The soils are nearly level to gently sloping. The soils of this group are—

Gomez fine sand.

Springer and Brownfield soils, shallow.

Springer loamy fine sand.

These soils are highly susceptible to wind erosion and are not suited to cultivated crops. Those areas that have been used for cultivated crops should be reseeded to tall native grasses. Careful management is needed to protect the areas from fire and overgrazing and to help control wind erosion. Practices needed are proper range use, deferred grazing, range seeding, and control of brush. More information on the use and management of these soils is given in the section "Use of the Soils for Range."

DRYLAND CAPABILITY UNIT VIe-2, CLIMATIC ZONES 1 AND 2

In this unit are deep, reddish-brown to reddish-yellow, moderately permeable, nearly level to gently sloping soils. The soils of this group are—

Brownfield fine sand, thick surface.

Brownfield soils, severely eroded.

These soils are highly susceptible to wind erosion. Their capacity to hold water and plant nutrients is low. The surface layer is thick and sandy, and deep plowing that will increase the content of clay in the uppermost few inches is not practical.

These soils are not suitable for cultivation under dryland farming. They should be seeded to tall native grasses and given proper rangeland treatment. Careful management is needed to protect the areas from fire and overgrazing and to help control wind erosion. Practices needed are proper range use, deferred grazing, range seeding, and control of brush. More information on the use and management of these soils is given in the section "Use of the Soils for Range."

DRYLAND CAPABILITY UNIT VIe-3, CLIMATIC ZONES 1 AND 2

This unit consists of moderately deep, light-gray, gently sloping to steep light clay loams to fine sandy loams that have moderately rapid permeability. The soils of this group are—

Drake soils, 3 to 5 percent slopes.

Drake soils, 5 to 30 percent slopes.

These soils are highly susceptible to wind and water erosion. They have moderate water-storage capacity. The soils contain a large amount of free lime, which slows the release of plant nutrients and frequently causes the leaves of grain sorghum to turn yellow.

These soils are best suited to permanent vegetation. Careful management is needed to protect them from fire and overgrazing and to help control wind erosion. Practices needed are proper range use, deferred grazing, and seeding to suitable perennial grasses. More information on the use and management of these soils is given in the section "Use of the Soils for Range."

DRYLAND CAPABILITY UNIT VIe-4, CLIMATIC ZONES 1 AND 2

Only the mapping unit Berthoud-Potter complex is in this capability unit. These soils are very shallow to moderately deep, dark grayish-brown to brown loams or fine sandy loams on the sides of draws. The Potter soils are shallow over slightly hardened caliche.

These soils are highly susceptible to wind and water erosion and are either too shallow or too steep to cultivate. Careful management is needed to control erosion if the soils are used for range. In areas where the grass has been killed out by overgrazing, reseed to suitable perennial grasses. Newly seeded areas need protection from grazing for at least one season to allow the plants to become well established.

Good management is needed to protect the soils from fire and overgrazing and to help control wind erosion. Practices needed are proper range use, deferred grazing, and range seeding. More information on use and management of these soils is given in the section "Use of the Soils for Range."

DRYLAND CAPABILITY UNIT VIw-1, CLIMATIC ZONES 1 AND 2

In this county only the Lubbock and Randall soils, mapped as an undifferentiated unit, are in this capability unit. The soils are deep, dark gray to grayish brown, very slowly permeable, and poorly drained. They are nearly level and occur in small playas. Their horizons are weakly defined.

These soils are frequently flooded by runoff from higher lying soils and are difficult to drain. The hazard of flooding limits their use.

In long dry periods the Lubbock and Randall soils are farmed where they are surrounded by other soils used for crops. In wet years annual weeds and grasses grow in these areas. If these soils are used for range, the areas provide water for livestock from time to time. Careful management is needed to protect the soils from fire and overgrazing and to help control wind erosion. Practices needed are proper range use, deferred grazing, and range seeding. More information on the use and management of these soils is given in the section "Use of the Soils for Range."

DRYLAND CAPABILITY UNIT VIIe-1, CLIMATIC ZONES 1 AND 2

This unit consists of shallow to deep, rapidly permeable, grayish-brown to pale-brown, undulating to steep soils. The Potter soils are shallow over slightly hardened caliche. The soils of this group are—

- Tivoli fine sand.
- Tivoli-Potter complex.

These soils are highly susceptible to wind and water erosion. They are not suited to cultivation. If they are used for range, the soils need careful management to control erosion.

Areas of these soils that have been used for cultivated crops should be reseeded to native grasses. Grazing should be limited to maintain a cover of plants; otherwise, these areas will become severely eroded or active dunes. Pastures that have been overgrazed should be rested to allow recovery of the grass. Seedings of new grass will need to be left ungrazed for 1 to 2 years to allow the grass to become well established. Practices needed are proper range use, deferred grazing, and range seeding. More information on the use and management of these soils is given in the section "Use of the Soils for Range."

DRYLAND CAPABILITY UNIT VIIe-1, CLIMATIC ZONES 1 AND 2

Only the mapping unit, Kimbrough soils, is in this capability unit. The soils are dark grayish brown to brown and are nearly level to sloping. They are shallow over caliche.

Because of the caliche near the surface, these soils are not suited to cultivation. The native vegetation is sparse.

Even when they are used for range, careful management of these soils is needed to prevent erosion. Overgrazed pastures need to be rested 2 to 3 years to allow recovery of the native grasses. Always manage grazing so that at least half of the current year's growth is left on the ground. This helps to control erosion and to form a mulch that allows more water to enter the soils. Practices needed are proper range use, deferred grazing, and range seeding. More information on the use and management of these soils is given in the section "Use of the Soils for Range."

Management by irrigated capability units

Irrigated farming in Gaines County has expanded rapidly since World War II. Water available for irrigation occurs in spots throughout the county, but does not occur in a definite pattern. The most plentiful supply is near the community of Higginbotham.

In this county water for irrigation is taken from wells that are 100 to 200 feet deep. The wells pump 200 to 800

gallons of water per minute, and the quality of the water is good.

If additional wells are planned, they should be spaced far enough apart to prevent interference between wells. Water moves slowly through the water-bearing formation, so that an inverted cone of water depletion temporarily occurs beneath a well that has been pumping. The depth of this depletion below the level of the static water table is known as drawdown. If the wells are too close together, the inverted cones overlap and the yields of both wells are greatly reduced.

The irrigation system must be designed to distribute water evenly over the field without causing erosion or excessive loss of soil. The water applied should be the amount the soil will hold in the root zone of the crop to be grown. Most irrigation in this county is by the sprinkler system, but a few flood-type systems are used in nearly level areas where the soils are clayey. These systems are being rapidly replaced, however, by sprinkler systems. Sprinkler systems are more practical than other irrigation systems on sandy soils that cannot be leveled economically. Surface-flow methods require a level or nearly level, uniform grade for soils that have a low rate of water intake.

A conservation irrigation system is important to the farmer because it saves water and makes crop production economical. The county agricultural extension agent or technicians of the Soil Conservation Service will help design an irrigation system that is suited to the soils, water supply, and crops. The system should—

1. Use rainfall and irrigation water efficiently.
2. Maintain or increase the productivity of the soils.
3. Control erosion.
4. Prevent excessive leaching of plant nutrients.
5. Dispose of excess water without causing significant erosion.
6. Prevent waterlogging and the accumulation of harmful salts.
7. Permit uniform growth of crops without plants going into stress from lack of moisture.
8. Permit maximum production of crops.
9. Maintain a high level of moisture at all times.

It is most important to maintain or increase soil productivity. Unless the soil is managed well, the best system for controlling and distributing water will be unsuccessful. Among the things that must be considered in designing a system for conservation irrigation are—

1. The quality and quantity of available water.
2. How fast the soil will take water and how much it will hold.
3. The quantity of water needed by the crop to be grown.
4. The topography.

The soils of Gaines County have been placed in capability groups for irrigated farming. The classes, subclasses, and units for irrigated soils are briefly described in the list that follows; the other classes and the dryland subclasses and units in this county are described in the section "Management by Dryland Capability Units."

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

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

Unit IIe-1.—Moderately deep, very dark grayish-brown, nearly level soils that are slowly permeable.

Unit IIe-2.—Moderately deep, calcareous, dark grayish-brown, moderately permeable, nearly level soils.

Unit IIe-3.—Deep and moderately deep, reddish-brown to dark grayish-brown, moderately permeable fine sandy loams that are nearly level.

Unit IIe-4.—Moderately deep, brown to grayish-brown, calcareous, nearly level soils that have moderately rapid permeability.

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

Subclass IIIe.—Soils subject to severe erosion if they are cultivated and not protected.

Unit IIIe-1.—Deep to moderately deep, reddish-brown, moderately permeable fine sandy loams that are gently sloping.

Unit IIIe-2.—Moderately deep, calcareous, brown to grayish-brown soils that have moderately rapid permeability.

Unit IIIe-3.—Deep to moderately deep, brown to dark grayish-brown, nearly level to gently sloping soils that have moderate to moderately rapid permeability.

Unit IIIe-4.—Deep to moderately deep, reddish-brown to reddish-yellow, nearly level to gently sloping soils that have moderate to moderately rapid permeability.

Unit IIIe-5.—Reddish-brown to dark-brown, nearly level to gently sloping soils that are shallow over caliche and have moderate to moderately rapid permeability.

Subclass IIIes.—Soils subject to severe erosion if they are cultivated and not protected, and that have severe limitations of moisture capacity or tilth.

Unit IIIes-1.—Shallow to deep, light-gray, nearly level to gently sloping soils that have slow to moderately rapid permeability.

Class IV.—Soils that have very severe limitations that restrict the choice of plants, require very careful management, or both.

Subclass IVe.—Soils subject to very severe erosion if they are cultivated and not protected.

Unit IVe-1.—Reddish-yellow to reddish-brown, permeable, nearly level to gently sloping soils that are shallow over caliche.

Unit IVe-2.—Deep to moderately deep, reddish-brown to dark grayish-brown, nearly level to gently sloping soils that have moderate to moderately rapid permeability.

IRRIGATED CAPABILITY UNIT IIe-1

The only soil in this capability unit is Stegall loam, 0 to 1 percent slopes. It is moderately deep, very dark grayish brown, nearly level, and slowly permeable.

This soil is moderately susceptible to wind erosion and slightly susceptible to water erosion. Its capacity to hold water and plant nutrients is high.

The main cash crops are cotton and grain sorghum. Other suitable crops are vetch, Austrian winter peas, small grain, and cowpeas, used as winter cover crops. This soil is very productive if it is irrigated. Use a cropping system that provides residue to protect the soil. Such a system can be 1 year of cotton, followed by 2 years of grain sorghum or small grain. A deep-rooted legume or other soil-improving crop may be grown in the rotation to maintain or improve tilth.

If plants do not supply enough cover to control wind erosion, chiseling or similar emergency tillage should be used. Chiseling may also increase the intake of water and temporarily increase the quantity of moisture stored.

Commercial fertilizer can be added to maintain good crop yields. This soil can be irrigated by a level-border, level-furrow, graded furrow, or sprinkler system.

IRRIGATED CAPABILITY UNIT IIe-2

The only soil in this capability unit is Portales loam, 0 to 1 percent slopes. It is a moderately deep, calcareous, dark grayish-brown soil that is moderately permeable and nearly level.

This soil is moderately susceptible to wind erosion. Its capacity to hold water and plant nutrients is high. Because of its high content of lime, this soil has lower water-holding capacity and is more susceptible to wind erosion than the Stegall soil in irrigated capability unit IIe-1. Also, its use of phosphorus from fertilizer is less efficient. Chlorosis may be a problem.

Cotton is the main cash crop. Among the other cash crops are grain sorghum and small grain. Austrian winter peas, cowpeas, and vetch may be included in the cropping system. Use a cropping system that provides residue to protect the soil. Such a system can be 2 years of grain sorghum or a small grain, followed by 3 years of cotton. The soil-improving crops may be a deep-rooted legume or a small grain. If grain sorghum is grown, it should be fertilized enough to promote an abundance of top growth.

Crop residue should be left on the surface to help control wind erosion. Chiseling or other tillage that roughens the surface should be used to help control wind erosion in years when the amount of residue produced is not adequate for protection. Chiseling may also increase the intake of water.

Commercial fertilizer can be added to maintain high crop yields. This soil can be irrigated by a sprinkler, level-border, or level-furrow system.

IRRIGATED CAPABILITY UNIT IIe-3

This unit consists of deep and moderately deep, reddish-brown to dark grayish-brown, moderately permeable fine sandy loams that are nearly level. The soils of this group are—

Amarillo fine sandy loam, 0 to 1 percent slopes.

Arvana fine sandy loam, 0 to 1 percent slopes.

Zita fine sandy loam, 0 to 1 percent slopes.

These soils are susceptible to moderate wind erosion and to slight water erosion. Their capacity to hold water and plant nutrients is moderate.

Cotton and grain sorghum are the main cash crops. Among the other cash crops are small grain and alfalfa. The soils are productive if irrigated. Use a cropping system that provides enough residue to protect them.

Such a system can be 1 year of cotton followed by 2 years of grain sorghum or small grain. A rotation consisting of cotton and of grain sorghum that has been fertilized to promote an abundance of top growth will produce enough residue to control erosion. A deep-rooted legume or other soil-improving crop may be grown in the rotation.

Crop residue should be left on the surface during periods when wind erosion is critical. If not enough residue is produced to control wind erosion, chiseling or similar tillage may be necessary. Chiseling may also increase the intake of water and temporarily increase the quantity of water stored.

Commercial fertilizer will help to maintain high crop yields. Grasses and alfalfa or other deep-rooted legumes help to improve or maintain tilth.

IRRIGATED CAPABILITY UNIT IIe-4

This unit consists of moderately deep, brown to grayish-brown, calcareous soils that are nearly level and have moderately rapid permeability. The soils of this group are—

Portales fine sandy loam, 0 to 1 percent slopes.
Portales and Spur soils.

These soils are moderately susceptible to wind erosion and slightly susceptible to water erosion. Their capacity to hold water and plant nutrients is moderate. Because of their high content of lime, these soils have lower water-holding capacity and are more susceptible to wind erosion than the noncalcareous Stegall soil in irrigated capability unit IIe-1. Also, their use of phosphorus from fertilizer is less efficient. Chlorosis may be a problem.

Cotton and grain sorghum are the main cash crops, but small grains and alfalfa are grown. Use a cropping system that provides enough residue to protect the soils. Such a system can be 1 year of cotton, followed by 1 year of grain sorghum or small grain. Deep-rooted legumes or other soil-improving crops will improve tilth and increase fertility.

Crop residue should be left on the surface to be most effective in controlling wind erosion. Emergency tillage may be used to roughen the surface in years when the residue produced is not adequate for protection.

Commercial fertilizer may be applied to maintain high crop yields. These soils can be irrigated by a level-furrow, level-border, or sprinkler system.

IRRIGATED CAPABILITY UNIT IIIe-1

In this unit are deep to moderately deep, reddish-brown, moderately permeable fine sandy loams that are gently sloping. The soils of this group are—

Amarillo fine sandy loam, 1 to 3 percent slopes.
Arvana fine sandy loam, 1 to 3 percent slopes.

These soils are highly susceptible to wind and water erosion if they are cultivated. Their capacity to hold water and plant nutrients is moderate.

Cotton is the main cash crop. Among the other cash crops are grain sorghum and small grain, which supply residue that helps to control wind erosion. Use a cropping system that provides enough residue to protect the soil. Such a system can be 1 year of cotton, followed by 2 years of grain sorghum or small grain. A deep-rooted legume or other soil-improving crop may be grown in the rotation.

Crop residue should be left on the surface during periods when wind erosion is critical. If not enough residue is produced to control wind erosion, chiseling, listing, or similar tillage may be necessary.

Use a commercial fertilizer to improve crop yields. Sprinkler irrigation is the best method of applying water to these soils.

IRRIGATED CAPABILITY UNIT IIIe-2

The only soil in this capability unit is Portales fine sandy loam, 1 to 3 percent slopes. It is a moderately deep, calcareous, brown to grayish-brown soil that has moderately rapid permeability. It is gently sloping.

If this soil is cultivated, it is highly susceptible to wind erosion and moderately susceptible to water erosion. Its capacity to hold water and plant nutrients is moderate. Because of the high content of lime, this soil has lower water-holding capacity and is more susceptible to wind erosion than the soils in irrigated capability unit IIIe-1. Also, its use of phosphorus from fertilizer is less efficient. Chlorosis may be a problem.

Cotton is the main cash crop. Among the other cash crops are grain sorghum and small grain, which supply residue that helps to control wind erosion. Use a cropping system that provides residue to protect the soil. Such a system can be 3 years of grain sorghum, followed by 2 years of cotton. A deep-rooted legume or other soil-improving crop may be grown in the rotation.

Crop residue should be left on the surface during periods when wind erosion is critical. If not enough residue is produced to control wind erosion, chiseling, listing, or similar tillage may be necessary.

Use a commercial fertilizer to improve crop yields. Sprinkler irrigation is the best method of applying water to this soil.

IRRIGATED CAPABILITY UNIT IIIe-3

This unit consists of deep to moderately deep, brown to dark grayish-brown, nearly level to gently sloping soils that have moderate to moderately rapid permeability. The soils of this group are—

Amarillo loamy fine sand, 0 to 3 percent slopes.
Gomez loamy fine sand.

These soils are highly susceptible to wind erosion and moderately susceptible to water erosion. The surface layer is sandy, and its capacity to hold water and plant nutrients is low. Even if these soils are irrigated, growth of plants is slower than on less sandy soils because the fertility is low. These soils may be used for cultivated crops if they are protected from wind erosion, but they are better suited to perennial vegetation.

Cotton and grain sorghum are the main cash crops. Cotton, however, leaves the soil without cover much of the time. Small grain is grown successfully in irrigated areas. A deep-rooted legume or other soil-improving crop may also be grown in the cropping system.

Where the soils have been deep plowed successfully, the cropping system should include crops that will provide residue to protect against erosion. Such a system can be 1 year of grain sorghum or small grain, followed by 1 year of cotton. In areas where the soils have not been deep plowed successfully, grain sorghum or a small grain should be grown for 2 years and cotton for 1 year.

Crop residue should be left on the surface to help control wind erosion. Deep plowing makes emergency tillage more effective in the control of wind erosion.

The addition of fertilizer improves crop yields. Sprinkler irrigation is the only type that can be used successfully on these soils.

IRRIGATED CAPABILITY UNIT IIIe-4

The soils in this unit are deep to moderately deep, reddish brown to reddish yellow, and nearly level to gently sloping. Permeability is moderate to moderately rapid. The soils of this group are—

Brownfield fine sand, thin surface.
Springer and Brownfield soils, moderately deep.

These soils are highly susceptible to wind erosion, and control of erosion is difficult. The capacity of the sandy surface layer to hold water and plant nutrients is low. Grain sorghum is the main cash crop, but some cotton is grown. The cotton provides only a small amount of protective stubble. The areas planted to cotton are usually the first to start blowing in spring. These soils are best suited to perennial grasses. Plant growth is often limited by the low fertility of the soils, even if adequate moisture is received.

Where the soils have been deep plowed successfully, the cropping system should include crops that will provide residue to protect against erosion. Such a system can be 1 year of grain sorghum or a small grain, followed by 1 year of cotton. In areas where the soils have not been deep plowed successfully, grain sorghum or a small grain should be grown each year. A deep-rooted legume or other soil-improving crop may be used in the rotation.

Crop residue should be left on the surface during periods when erosion is critical. If not enough residue is produced to control wind erosion, tillage, such as chiseling or listing, may be necessary.

Commercial fertilizer is effective in improving crop yields. Sprinkler irrigation is the only type suited to these soils.

IRRIGATED CAPABILITY UNIT IIIe-5

This unit consists of reddish-brown to dark-brown, nearly level to gently sloping soils that are shallow over caliche. Permeability is moderate to moderately rapid. The soils of this group are—

Arvana fine sandy loam, shallow, 0 to 3 percent slopes.
Simona fine sandy loam.

These soils are highly susceptible to wind erosion, and those areas where the slope is not greater than 1 percent are slightly susceptible to water erosion. The hazard of water erosion is moderate in other areas. These soils have moderate capacity to hold water and plant nutrients. They are shallow, however, and in many places they are droughty. Frequently, not enough residue is produced to control wind erosion.

These soils are best suited to permanent vegetation. Grain sorghum and cotton are the main cash crops. Use a cropping system that provides enough residue to protect the soil. Such a system can be 2 years of grain sorghum or small grain, followed by 1 year of cotton. A deep-rooted legume or other soil-improving crop may be grown in the rotation.

Crop residue should be left on the surface during periods when wind erosion is critical. If not enough residue is

produced to control wind erosion, chiseling or similar tillage may be necessary. Commercial fertilizer should be added.

These soils are more costly to irrigate than other soils because small, frequent applications of water are required. Sprinkler irrigation is the best method of applying water.

IRRIGATED CAPABILITY UNIT IIIes-1

This unit consists of shallow to deep, light-gray, nearly level to gently sloping soils that have slow to moderately rapid permeability. The Arch soils are shallow over chalky clay loam. The soils of this group are—

Arch soils.
Drake soils, 1 to 3 percent slopes.

These soils are highly susceptible to wind erosion. They have moderate water-storage capacity but contain a large amount of free lime. The lime slows the release of plant nutrients, especially iron, and the deficiency frequently causes the leaves of grain sorghum to turn yellow.

These soils are best suited to permanent vegetation, but grain sorghum and some of the small grains are also suited. If the soils are irrigated, cotton, sweetclover, vetch, Austrian winter peas, cowpeas, and guar can be grown successfully. Use a cropping system that provides residue to protect the soils. Such a system can be 2 year of grain sorghum or small grain, followed by 1 year of cotton.

Crop residue should be left on the surface during periods when wind erosion is critical. If not enough residue is produced to control wind erosion, chiseling or similar tillage may be helpful.

The addition of commercial fertilizer will improve yields and increase the amount of residue produced. Deep-rooted legumes and grasses help to improve or maintain crop yields and productivity. Sprinkler irrigation is the best method of applying water to these soils.

IRRIGATED CAPABILITY UNIT IVe-1

Only one mapping unit, Springer and Brownfield soils, shallow, is in this capability unit. The soils are reddish yellow to reddish brown, permeable, and nearly level to gently sloping. They are shallow over caliche.

These soils are highly susceptible to wind erosion and slightly susceptible to water erosion. They have low capacity for holding water and plant nutrients. Because caliche is near the surface, care should be taken if the soils are deep plowed.

If these soils are irrigated, a limited amount of grain sorghum, small grain, and perennial grasses can be grown in drilled or closely spaced rows. Use a cropping system that provides enough residue to protect the soils. Such a system can be grain sorghum planted in closely spaced rows or small grain grown continuously. A deep-rooted legume or other soil-improving crop may be grown on half of the acreage each year in rotation with another crop.

Crop residue should be left on the surface to help control erosion. Emergency tillage, such as listing, may be needed to control wind erosion.

The application of fertilizer is effective in maintaining yields. Sprinkler irrigation is the only type that can be used successfully on these soils.

IRRIGATED CAPABILITY UNIT IVe-2

This unit consists of deep to moderately deep, reddish-brown to dark grayish-brown soils that have moderate to moderately rapid permeability. The soils are nearly level to gently sloping. The soils of this group are—

- Brownfield fine sand, thick surface.
- Gomez fine sand.
- Springer loamy fine sand.

These soils are highly susceptible to wind erosion and slightly susceptible to water erosion. They have low capacity for holding water and plant nutrients. Deep plowing is not practical, because the surface layer is deep and sandy.

If these soils are irrigated, a limited amount of grain sorghum, small grain, and perennial grasses can be grown in drilled or closely spaced rows. Use a cropping system that provides enough residue to protect the soils. Such a system can be grain sorghum planted in closely spaced rows or small grain grown continuously. A deep-rooted legume or other soil-improving crop may be included in the rotation.

Crop residue should be left on the surface to help control erosion. Emergency tillage, such as chiseling, may be needed to control wind erosion.

The application of fertilizer is effective in maintaining yields. Sprinkler irrigation is the only type that can be used successfully on these soils.

Yield Predictions

The yields obtained on a soil reflect the quality of management the soil has had. If yields have been consistently high, the soil probably has been properly managed. In addition to keeping yields high, good management conserves the soil and may even improve it. The farmers of Gaines County manage their soils differently, and consequently, yields on the different soils vary from farm to farm.

Table 2 shows estimated yields per acre of cotton and grain sorghum on the soils under two levels of management. If soils are both dry farmed and irrigated, expected yields are given for each method. If only one method is practical, yields for that method are given. The larger part of the estimates of average yields under dryland farming are for soils in climatic zone 1, that is, for soils in the northeastern half of the county. Dry-farming is not practiced extensively in the southwestern part, because rainfall is less favorable.

The yield predictions are based on information furnished by farmers and agricultural workers, on observations and comparisons made by people familiar with the soils, and on results obtained at various agricultural experiment stations in the area. Yields are about the same for the individual soils in a soil complex or other multiple mapping unit. Although many crops in addition to cotton and grain sorghum are grown in this county, yields for those crops are not listed, because their acreage is small and reliable yield data are not available.

TABLE 2.—Yield predictions per acre under two levels of management

[Yields in columns A can be expected under a common level of management; yields in columns B can be expected under a high level of management. Soils that ordinarily are not used for cotton or sorghum are not shown in this table]

Symbol	Soil	Cotton lint				Grain sorghum			
		Dryland ¹		Irrigated		Dryland ¹		Irrigated	
		A	B	A	B	A	B	A	B
		<i>Lb.</i>	<i>Lb.</i>	<i>Lb.</i>	<i>Lb.</i>	<i>Lb.</i>	<i>Lb.</i>	<i>Lb.</i>	<i>Lb.</i>
AmB	Amarillo loamy fine sand, 0 to 3 percent slopes.....	120	160	500	700	700	1,000	1,500	3,500
AfA	Amarillo fine sandy loam, 0 to 1 percent slopes.....	140	150	500	750	800	1,200	2,000	4,000
AfB	Amarillo fine sandy loam, 1 to 3 percent slopes.....	130	150	425	700	700	1,000	1,700	3,400
AvA	Arvana fine sandy loam, 0 to 1 percent slopes.....	125	150	450	700	700	1,100	1,800	3,800
AvB	Arvana fine sandy loam, 1 to 3 percent slopes.....	125	140	450	650	600	900	1,600	3,400
AwB	Arvana fine sandy loam, shallow, 0 to 3 percent slopes.....	55	175	275	250	800	600	1,200	2,000
Bs	Brownfield fine sand, thin surface.....	110	165	375	550	600	900	1,400	3,000
Br	Brownfield fine sand, thick surface.....	75	120	300	300	350	450	1,200	2,000
Gf	Gomez fine sand.....	80	125	300	400	400	800	1,200	2,000
Gl	Gomez loamy fine sand.....	100	150	375	500	600	1,000	2,000	3,600
Km	Kimbrough soils.....	50	75	100	200	250	400	500	600
PfA	Portales fine sandy loam, 0 to 1 percent slopes.....	135	160	450	650	750	1,000	1,700	3,600
PfB	Portales fine sandy loam, 1 to 3 percent slopes.....	125	160	450	650	600	1,000	1,700	3,600
PmA	Portales loam, 0 to 1 percent slopes.....	125	160	500	650	650	1,000	1,700	3,600
Ps	Portales and Spur soils.....	150	250	600	700	750	850	2,400	3,600
Sa	Simona fine sandy loam.....	55	100	200	200	500	600	1,200	2,000
Sp	Springer loamy fine sand.....	100	150	350	500	600	1,000	2,000	3,600
Sm	Springer and Brownfield soils, moderately deep.....	110	160	375	700	650	900	1,500	2,800
Sb	Springer and Brownfield soils, shallow.....	55	100	150	300	350	550	800	1,800
StA	Stegall loam, 0 to 1 percent slopes.....	100	125	450	700	450	1,000	1,500	3,000
ZfA	Zita fine sandy loam, 0 to 1 percent slopes.....	160	200	500	800	900	1,000	2,000	4,000

¹ Dryland yields are for climatic zone 1, in the northeastern part of the county. Yields from dryland farming are generally lower in the southwestern part of the county (climatic zone 2) because rainfall is less favorable.

The predicted yields given in table 2 can be expected if the following management practices are used:

Common level of management:

Dryland—

1. Water is not conserved properly.
2. Soil-improving crops are not included in the rotation.
3. Tillage alone is used to control wind erosion.

Irrigated—

1. Water is not conserved properly.
2. Irrigation is erratic.
3. Crop residue is plowed under.
4. Fertilizer either is not applied or is applied haphazardly.
5. Tillage alone is used to control erosion.

High level of management:

Dryland—

1. Rainfall is conserved.
2. Soil-improving crops and crops that produce a large amount of residue are grown in the cropping system and are used to conserve moisture and improve the soil.
3. Crop residue is used to help control wind erosion.

Irrigated—

1. Rainfall is saved, and crops are watered according to need.
2. Fertilizer is used according to crop needs, as determined by soil analysis.
3. Crop residue is used to help control wind and water erosion.
4. Soil-improving crops and crops that produce a large amount of residue are used in the cropping system.

Use of the Soils for Range ²

The use of native grassland in Gaines County and the range condition classes are discussed in this section. Also described are the range sites and general practices of management appropriate for rangeland.

The raising of livestock is a major enterprise in this county; slightly more than half of the agricultural land in the county was in range in 1962. The success of the enterprise depends on how efficiently the range is managed, for the forage produced on the range is marketed through the sale of livestock and livestock products. The livestock are mainly cows and calves, but they include some winter stockers or carry-over calves, which graze small grain. Also, many ranchers allow livestock to graze sudangrass and sorghum stubble. They thus supplement the supply of forage obtained from the mid and short grasses that make up the main cover on the range.

Before livestock were brought into the area, the vegetation on the sandy soils was little bluestem, sand bluestem, giant dropseed, sideoats grama, and shin oak. The sandy loams and the limy soils had good stands of sideoats grama, blue grama, black grama, and buffalo-grass. Overgrazing and drought, however, have caused undesirable invaders to increase. Shin oak has replaced many of the tall and mid grasses on the sandy soils. Mes-

quite and annuals have replaced the mid and short grasses on the sandy loams, and broom snakeweed has replaced the mid and short grasses on the limy soils.

The extreme variability of the climate has considerable effect on the production of forage. Rainfall is erratic; most of it occurs in May, June, September, and October. Many of the rains in those months are of high intensity and of short duration, and some are ineffective showers. Drought is common in midsummer and may last from 30 to 90 days. The long dry spells retard the growth of plants and prevent the natural spread of desirable range plants. The hot winds of high velocity favor excessive evaporation and transpiration.

Native grasses grow best from mid-April through October. In nearly every year, however, recurrent drought results in some dormancy during July. If enough moisture is available, the grasses begin to grow again about the middle of August and continue to grow until the end of October. Late in fall they become semidormant. Frequently, lack of moisture in winter and early spring retards the early growth.

Range sites and condition classes

Soils differ in their capacity to produce grass and other plants suitable for grazing. The soils that produce about the same kind and amount of climax vegetation on areas of range that are in similar condition make up what is called a range site. *Climax vegetation* refers to the stabilized plant community on a particular site; it reproduces itself and does not change so long as the environment does not change. Throughout most of the areas of plains, the climax vegetation consists of the plants that grew there when the area was first settled. Generally, the climax vegetation is the most productive combination of forage plants that will grow on a range site.

Decreasers are species in the climax vegetation that tend to decrease under close grazing. They are generally the tallest and most productive of the perennial grasses and forbs and are the most palatable to livestock.

Increasers are species in the climax vegetation that tend to increase as the more desirable plants are reduced by close grazing. They are commonly shorter than the decreaseers, and some of them are less palatable to livestock.

Invaders are kinds of plants that cannot withstand the competition of the climax vegetation for moisture, plant nutrients, and light. Hence, they thrive only after the climax vegetation has deteriorated. Many invaders are annual weeds. Some are shrubs that provide a small amount of forage, but other invaders have little or no value for grazing.

Four range condition classes are used to indicate the degree to which the native or climax vegetation has been changed by grazing or other use. They show the present condition of the native vegetation on the site in relation to the native vegetation that could be grown. A range is in *excellent* condition if 76 to 100 percent of the present vegetation is the same kind that grew on it originally. It is in *good* condition if the percentage is between 51 and 75, in *fair* condition if the percentage is between 26 and 50, and in *poor* condition if the percentage is less than 25.

The potential production of forage on a range site depends largely upon the kinds of soil in the site. The actual production of forage depends largely upon the con-

² By ALTON T. WILHITE, range conservationist, Soil Conservation Service, Pecos, Tex.

dition of the range and the amount of moisture available to plants during the growing season.

Good range management requires that the range be maintained in *excellent* or *good* condition. This conserves water, maintains or improves yields, and protects the soils. A major problem in managing the range, however, is recognizing important changes in the kind of plant cover. These changes take place so gradually that they are easily overlooked or misinterpreted. Rapid growth that has been encouraged by a heavy rainfall may cause the appearance of the range to be good when the cover is actually weedy and the potential production is in a downward trend. On the other hand, areas that have been closely grazed for a relatively short period under the supervision of a careful manager may have a deteriorated appearance that temporarily conceals the quality of the range and the ability to recover.

Descriptions of range sites

In this section the several range sites in the county are described, and the soils in each site are listed. Also the plants in the climax vegetation are named, the principal invaders are mentioned, and the potential yield of herbage for each site is given.

BOTTOM LAND SITE

Only the mapping unit Portales and Spur soils is in this range site. The soils are in narrow draws within flats or are in nearly level areas.

These soils are deep and fertile. They receive runoff from adjoining range sites, even when the rainfall is light. This is considered to be one of the better range sites because of the extra moisture. In dry periods it may provide the only green forage on the range.

About 60 to 70 percent of the climax vegetation consists of decreaseers, mainly sideoats grama, cane bluestem, white tridens, vine-mesquite, and plains bristleggrass. The major increaseers are blue grama and buffalograss. Common invaders are mesquite and annuals. Any deterioration of this site results in the rapid increase of mesquite. After the site has deteriorated, water erosion becomes severe.

In the northeastern part of the county, the potential yield per acre of air-dry herbage on this site ranges from 2,500 pounds in unfavorable years to 3,000 pounds in favorable years. In the southwestern part, the yield ranges from 2,000 pounds per acre in unfavorable years to 2,500 pounds per acre in favorable years.

DEEP SAND SITE

The soils of this site occur mainly in the southern and southwestern parts of the county. The site consists of large sand dunes and of the lower lying, nearly level to gently sloping areas between dunes. The dunes are as much as 20 feet high, and they have choppy slopes of about 40 percent in most places. The soils in this site are—

- Brownfield fine sand, thick surface.
- Tivoli fine sand.
- Tivoli-Potter complex (Tivoli soils only).

Included in this site are small areas of Brownfield soils, severely eroded. A separate range site is not designated for these included soils, because the acreage is limited and the soils occur with other soils.

The soils of this range site are deep and coarse textured. Permeability is moderate to rapid, and roots penetrate easily or fairly easily. The capacity for holding water and plant nutrients is low. If the soils are not protected, they are highly susceptible to wind erosion. They produce a good stand of mid and tall grasses if they are properly managed.

In both the northeastern and southwestern parts of the county, about 60 percent of the climax vegetation on this site consists of decreaseers, mainly sand bluestem, giant dropseed, and little bluestem. The major increaseers are sand dropseed, perennial three-awn, and Havard oak. Common invaders are false buffalograss and annuals.

Any deterioration in this site results in the rapid increase of woody plants. As deterioration progresses, shin oak and other woody plants displace nearly all the better grasses by shading them and by using all of the available moisture.

If this site is maintained in good or excellent condition, it is capable of high production. Few of the grasses have intermediate value for grazing, however, and production drops rapidly once the climax vegetation has been overgrazed. Recovery is rapid if brush is controlled and grazing is deferred because a source of seed is usually present.

In the southwestern part of the county, the potential yield per acre of air-dry herbage ranges from 650 pounds in unfavorable years to 900 pounds in favorable years. In the northeastern part, the yield ranges from 750 pounds in unfavorable years to 1,000 pounds in favorable years.

HIGH LIME SITE

The soils of this site are on the lower, convex slopes of dunes, generally on the east and northeast sides of ancient lakebeds. The soils in this site are—

- Arch soils.
- Drake soils, 1 to 3 percent slopes.
- Drake soils, 3 to 5 percent slopes.
- Drake soils, 5 to 30 percent slopes.

These soils are deep and highly calcareous. They are highly susceptible to wind and water erosion if they are not protected by a cover of plants. About 60 percent of the climax vegetation consists of decreaseers, mainly sideoats grama, blue grama, vine-mesquite, and plains bristleggrass. The major increaseers are black grama, sand dropseed, and slim tridens. Common invaders are annuals and broom snakeweed.

Identification of the climax vegetation was not possible in some areas adjacent to salt lakes, because of the active erosion and salinity. Salinity is generally variable in those areas; therefore, communities of vegetation are variable. Adjacent to the salt lakes, only salt-tolerant vegetation is likely to grow, but as the distance from the lake increases, the number of plants less tolerant of salt increases.

Any deterioration in this site results in the rapid increase of broom snakeweed. Recovery is slow because seed plants of desirable varieties are lacking. Also, crusting is severe on these soils.

In the southwestern part of the county, the potential yield per acre of air-dry herbage on this site ranges from 750 pounds in unfavorable years to 1,000 pounds in favorable years. In the northeastern part, the yield

ranges from 850 pounds in unfavorable years to 1,100 pounds in favorable years.

MIXED LAND SITE

The soils of this site (fig. 10) are in nearly level to gently rolling uplands throughout the county. The soils in this site are—

- Amarillo fine sandy loam, 0 to 1 percent slopes.
- Amarillo fine sandy loam, 1 to 3 percent slopes.
- Arvana fine sandy loam, 0 to 1 percent slopes.
- Arvana fine sandy loam, 1 to 3 percent slopes.
- Arvana fine sandy loam, shallow, 0 to 3 percent slopes.
- Zita fine sandy loam, 0 to 1 percent slopes.

Included in this site are small areas of Stegall loam, which is normally in a Deep Hardland site. The acreage is small, however, and for that reason a description of the Deep Hardland site is not given.

These soils are shallow to deep and are moderately coarse textured. Permeability is moderate, and the capacity for holding water is moderate.

In the southwestern part of the county, about 50 percent of the climax vegetation on this site consists of decreasers, and in the northeastern part, about 70 percent is decreasers. The major decreasers are sideoats grama, blue grama, cane bluestem, and Arizona cottontop. The increasers are mainly black grama, hooded windmillgrass, buffalograss, and perennial three-awn. Common invaders are mesquite and annuals.

If this site is kept in good condition, it is capable of good production of forage. Any deterioration in the vegetation results in an immediate decrease in sideoats grama. If the range is continuously overgrazed, the vegetation soon consists of three-awn, annuals, and mesquite. After the range has deteriorated, recovery is slow because viable seeds of the better grasses are lacking. In some areas recovery is slow because a crust forms on the surface.

In the southwestern part of the county, the potential yield per acre of air-dry herbage on this site ranges from 750 pounds in unfavorable years to 1,000 pounds in favorable years. In the northeastern part, the yield ranges from 850 pounds in unfavorable years to 1,100 pounds in favorable years.



Figure 10.—An area of the Mixed Land range site in fair condition.

MIXED PLAINS SITE

The soils of this site are on broad, level or nearly level plains. The soils in this site are—

- Berthoud-Potter complex (Berthoud soils only).
- Portales fine sandy loam, 0 to 1 percent slopes.
- Portales fine sandy loam, 1 to 3 percent slopes.
- Portales loam, 0 to 1 percent slopes.
- Simona fine sandy loam.

Included in this site are small areas of Lubbock and Randall soils, which are normally assigned to a Deep Hardland site. The acreage is small, however, and for that reason a description of the Deep Hardland site has not been given.

These calcareous soils are shallow to deep and are medium textured to moderately coarse textured. Permeability is moderate to moderately rapid, and the capacity for holding water is moderate. The drainage pattern is immature; most areas drain into ancient lakes.

About 60 percent of the climax vegetation on this site consists of decreasers, mainly sideoats grama, cane bluestem, blue grama, and vine-mesquite. The major increasers are black grama, sand dropseed, and perennial three-awn. Common invaders are sand mulhly, ring mulhly, broom snakeweed, and annuals.

Any deterioration in this site results in the rapid increase of broom snakeweed. Recovery is slow because seed plants of desirable varieties are lacking. Also, a crust forms on the surface of the soils.

In the southwestern part of the county, the potential yield per acre of air-dry herbage on this site ranges from 700 pounds in unfavorable years to 950 pounds in favorable years. In the northeastern part, the yield ranges from 800 pounds in unfavorable years to 1,050 pounds in favorable years.

SANDY LAND SITE

The soils of this site are nearly level to gently sloping and occur throughout the county. The soils in this site are—

- Amarillo loamy fine sand, 0 to 3 percent slopes.
- Brownfield fine sand, thin surface.
- Brownfield soils, severely eroded.
- Gomez fine sand.
- Springer and Brownfield soils, moderately deep.
- Springer and Brownfield soils, shallow.
- Springer loamy fine sand (climatic zone 1).

These soils are deep and coarse textured. Permeability is moderate to rapid, and roots penetrate easily. The capacity of these soils for holding water and plant nutrients is limited. These soils are highly susceptible to wind erosion if they are not protected by a cover of plants. If properly managed, they produce a good stand of mid grasses. About 65 percent of the climax vegetation on this site consists of decreasers, mainly little bluestem, giant dropseed, mesa dropseed, and plains bristlegrass. The major increasers are hooded windmillgrass, fallwitchgrass, sand dropseed, perennial three-awn, and shin oak. The common invaders are annuals.

Any deterioration in this site results in the rapid increase of shin oak, which will dominate the site unless it is checked. Recovery is rapid, however, if brush is controlled and grazing is deferred.

In the southwestern part of the county, the potential yield per acre of air-dry herbage on this site ranges from 600 pounds in unfavorable years to 850 pounds in favor-

able years. In the northeastern part, the yield ranges from 650 pounds in unfavorable years to 950 pounds in favorable years.

SANDY PLAINS SITE

The soils of this site are nearly level and occur throughout the county, mainly in slight depressions within much larger areas of Brownfield soils. In a few places, however, these soils occupy broad expanses of gently sloping, undulating plains. The soils in this site are—

Gomez loamy fine sand.

Springer loamy fine sand (climatic zone 2).

These soils are deep and coarse textured. Permeability is moderately rapid, and roots penetrate fairly easily. The capacity for holding water and plant nutrients, however, is limited. These soils are highly susceptible to wind erosion if they are not protected by a cover of plants. If properly managed, they produce a good stand of mid grasses. About 65 percent of the climax vegetation on this site consists of decreaseers, mainly sideoats grama, cane bluestem, plains bristlegrass, Arizona cottontop, and blue grama. The major increaseers are black grama, hooded windmillgrass, sand dropseed, and perennial three-awn. Common invaders are mesquite, yucca, catclaw, and annuals.

If this site is maintained in good or excellent condition, it is capable of high production. Recovery from deterioration is rapid if the soils are well managed and brush is controlled, because a source of seed is usually present.

In the southwestern part of the county, the potential yield per acre of air-dry herbage on this site ranges from 700 pounds in unfavorable years to 950 pounds in favorable years. In the northeastern part, the yield ranges from 800 pounds in unfavorable years to 1,050 pounds in favorable years.

SHALLOW LAND SITE

The soils that make up this site occur throughout the county. They are—

Berthoud-Potter complex (Potter soils only).

Kimbrough soils.

Tivoli-Potter complex (Potter soils only).

These soils are shallow, and their capacity for holding water and plant nutrients is limited. They are highly susceptible to water erosion if they are not protected by a cover of plants.

In the northeastern part of the county, about 50 percent of the climax vegetation on this site consists of decreaseers, but in the southwestern part, about 70 percent consists of decreaseers. The main reason for this difference is that black grama is a decreaseer in the southwestern part of the county, but it is an increaseer in the northeastern part. Other major decreaseers are sideoats grama, cane bluestem, black grama, and plains bristlegrass. The major increaseers are hairy grama, slim tridens, sand dropseed, and perennial three-awn. Common invaders on this site are mesquite, broom snakeweed, and annuals.

Any deterioration in this site results in the rapid increase of mesquite and broom snakeweed. Recovery is slow.

In the southwestern part of the county, the potential yield per acre of air-dry herbage ranges from 400 pounds in unfavorable years to 650 pounds in favorable years. In

the northeastern part, the yield ranges from 500 pounds in unfavorable years to 750 pounds in favorable years.

Practices for rangeland

The basic purpose of good range management is to increase the number of desirable native forage plants and to encourage their growth. The main practices needed to achieve this purpose are described in the following pages.

Control of grazing.—Unless grazing is controlled, all other practices are ineffective. In their green leaves, grasses manufacture the food they need to grow, flower, and reproduce. The plant is weakened and stunted if too much of the foliage is removed by grazing.

Livestock constantly seek out and graze the plants that are most palatable and nutritious; consequently, the less palatable plants and those that are low-growing and matted tend to survive. For this reason, it is necessary to control grazing so that the desirable grasses survive and are vigorous enough to compete successfully for water and plant nutrients. Generally, the desirable plants will thrive if not more than half of their yearly top growth is removed by grazing. The top growth that is left does these things:

1. It serves as mulch that encourages the intake and storage of water. The more water stored in the ground, the better the growth of grasses for grazing.
2. It permits deeper penetration of roots and more efficient use of moisture throughout the soil profile. Development of roots is retarded if the range is overgrazed.
3. It protects the soil from wind and water erosion. Grass is the best cover for controlling erosion.
4. It permits the desirable grasses to crowd out weeds. When this happens, the range improves.
5. It provides a reserve of feed that can be used during dry spells, and thus avoids the forced sale of livestock.

When the rancher stocks his range, he needs to know the kinds of range that make up his holdings and to know the condition of each range site. He should be able to identify the cover of plants and to judge how much of the top growth will be removed by wind or other weathering processes and by rodents or other causes. He should keep in mind that at least half of the year's top growth should be left, and he must decide when to lower the stocking rate so that depleted pasture will be restored.

The key grasses are the most productive and palatable perennial grasses currently growing on a site, and the rancher needs to know how these plants are affected by grazing. If they are grazed properly, the site will remain productive and deteriorated areas will improve. If the key grasses are sand bluestem and little bluestem, care should be taken that they are not cropped too closely by livestock. If the key forage plant for the site is fall witchgrass, the rancher can judge how much of this plant is being grazed off if he compares ungrazed areas with those that have been grazed. If less than half of the dry weight of the key grasses is left, all or part of the livestock should be removed.

Adjusting the stocking rate for a pasture so that the highest returns will be obtained without lowering the production of native grasses requires skill and experience.

The descriptions of the individual range sites in the preceding pages list the plants suitable for each site and give the potential yields of forage. The experience of other ranchers on similar rangeland may be helpful. Also, the rancher can get assistance from a representative of the local soil conservation district or from other agencies.

Deferred grazing.—Most of the rangeland in this county is in fair or poor condition and should be rested periodically to increase the vigor of the stand of forage plants. If grazing is deferred, desirable plants grow freely, produce seed, and spread. In this area the best time to defer grazing of most grasses is usually late in summer and early in fall so that seed can develop without interference. During this period all livestock should be kept off the range that is being rested because they eat the seed stalks and flowers of the key grasses first. Consequently, the poorer grasses increase.

On most farms and ranches, it is not practical to defer grazing on all of the range in the same year, but some areas can be rested while other parts are grazed. If part of the range is overgrazed, however, while other parts are rested, the benefits are decreased. Over a period of years, all of the rangeland will benefit from rest periods during the growing season. As the more palatable plants increase in number, their vigor and condition improve and the amount of available forage increases.

Control of brush.—On most of the rangeland in this county, brush has increased to such an extent that the growth of grass is suppressed, and only about 25 percent of the potential production of forage is realized. Little or no protection from erosion is provided by the cover of grass, and measures to control brush are needed before the condition of most of the range can be improved.

Mesquite and shin oak are the most troublesome kinds of brush in this county and should be controlled if the brush exceeds 10 percent of the total cover of vegetation under an open canopy. Brush can be controlled by either chemical or mechanical methods (fig. 11).

Range seeding.—Normally, a good source of seed of the native grasses is present on the sandy soils of this county, and under good management, these grasses will increase if brush is controlled. Some of the shallow soils need to be reseeded, however, in areas where the stand of desirable grasses is so nearly depleted that those grasses cannot reseed and spread naturally. Many areas that are cultivated should be reseeded to grass, which is the best way of controlling erosion.

Fencing.—Most of the rangeland in the county is adequately fenced to control livestock and to regulate grazing. Additional cross-fences, however, could be built within some of the fenced areas to permit deferred or seasonal grazing.

Water for livestock.—Good range management requires that livestock have an adequate supply of good-quality water properly distributed over the range. An adequate number of watering places also makes the distribution of grazing more even. Wells are the only source of water for livestock. In most areas these wells provide an adequate amount of water.

Care of livestock.—Fitting the right kind and number of livestock to the range results in the highest production and in the best use of the range resources. Cattle do best on range that is mostly grass. Sheep make better use of

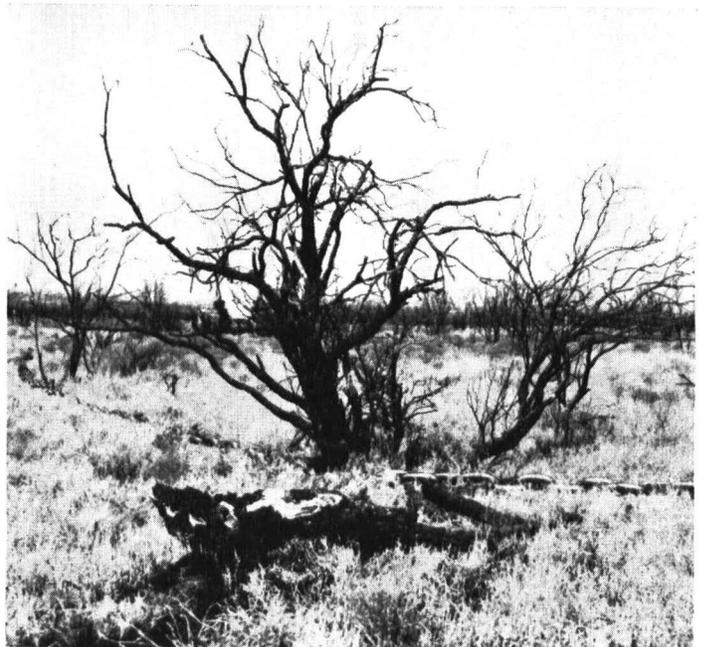


Figure 11.—Two methods of controlling brush. The upper picture shows the spraying of mesquite by using an airplane for applying a chemical, and the lower picture shows mesquite being uprooted by pulling a chain in a loop between two tractors.

range if the forage consists of an abundance of weeds. Good long-term management requires improvement of the range so that the better stands of grass will be supported. To keep livestock in a productive condition throughout the year, it is necessary to plan a feed and forage program that makes use of the available forage, feed concentrates, hay, and cropland used for temporary pasture.

It is desirable also to keep some of the livestock as a "floater" herd of readily salable stock, such as stocker

steers. This permits ranchers to balance the number of livestock on hand with the available forage without sacrificing breeding animals.

Animals that are best suited to the range should be selected for breeding, and nonproductive animals should be culled. Also, the breeding program should be timed so that the young calves can take advantage of forage when it is most nutritious, and the animals in the herd will continually improve.

Use of the Soils for Engineering³

Information in this report can be used to—

1. Make soil and land use studies that will aid in selecting sites for industrial, business, residential, and recreational development.
2. Make preliminary estimates of the engineering properties of soils in planning for the construction of farm ponds and irrigation systems and in planning soil and water conservation measures.
3. Make preliminary evaluations of soil and ground conditions that will aid in selecting locations for highways, airports, and storage areas and in planning detailed investigations of selected locations.
4. Locate probable sources of sand, gravel, topsoil, and other construction material.
5. Correlate performance of engineering structures with soil mapping units and thus develop information useful in designing and maintaining structures.
6. Determine the suitability of soil units for cross-country movement of vehicles and construction equipment.
7. Supplement information obtained from other published maps, reports, and aerial photographs to make maps and reports that can be used readily by engineers.
8. Develop other preliminary estimates for construction in a particular area.

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

Some of the terms used by the soil scientist may not be familiar to the engineer, and some words, for example, soil, clay, silt, and sand, have special meanings in soil science. These terms are defined in the Glossary. As used in this report, the term "poorly graded" refers to soil material consisting mainly of particles of nearly the same size. Because there is little difference in size of the particles in poorly graded soil material, density can be increased only slightly by compaction.

Engineering classification systems

Agricultural scientists of the U.S. Department of Agriculture (USDA) classify soils according to texture.

³By LEE H. WILLIAMSON, area engineer, Soil Conservation Service, Big Spring, Tex.

In some ways this system of naming textural classes is comparable to the two systems used by engineers for classifying soils, that is, the Unified system and the system of the American Association of State Highway Officials (AASHO).

The Unified classification system was developed by the Corps of Engineers, U.S. Army. In this system soil material is grouped in 15 classes that are designated by pairs of letters. These classes range from GW, which consists of well-graded gravel, gravel and sand mixtures, and a little fine material, to Pt, which consists of peat and other highly organic soils.

Many highway engineers classify soil material according to the system approved by AASHO. In this system soil material is classified in seven principal groups. The groups range from A-1, consisting of soils that have high bearing capacity, to A-7, consisting of clayey soils that have low strength when wet.

Engineering interpretations of the soils

This section contains two tables. Table 3 gives a brief description of the soils in Gaines County and estimates of their physical properties that are important in engineering. Table 4 gives the results of evaluating the soils from an engineering standpoint. Mechanical analysis was not made of soil samples from Gaines County. The data given in tables 3 and 4 are estimated on the basis of tests made by the Texas State Highway Department on samples from Terry County, on tests made by the Bureau of Public Roads on samples from Lynn County, and on information obtained from soil scientists, State highway engineers, and personnel in construction companies.

In table 3 the soil material in the horizons of a typical profile for each soil type was classified in all three systems—USDA, Unified, and AASHO. The classification by grain size (percentage passing a No. 4, No. 10, and No. 200 sieve) was determined from data compiled by the Bureau of Public Roads and by the Texas State Highway Department. If test data giving grain size were not available, the range of grain sizes was determined for a typical soil from the USDA textural classification chart for 2-micron clay.

The values for permeability and for available water capacity were compiled from data in the technical guide used by the SCS work unit serving Gaines County. Permeability is the rate, in inches per hour, that water moves through a soil horizon.

The available water capacity, given in inches per inch of depth, is a measure of the water-holding capacity of a soil. For example, a layer of Amarillo fine sandy loam 1 inch thick will hold 0.12 inch of water that has soaked down from the surface. If another 0.12 inch of water is added, another inch of soil will be moistened. In contrast, a layer of Tivoli fine sand 1 inch thick will hold only half as much, or 0.06 inch of water after the excess water has drained away.

The shrink-swell potential is an estimate of how much a soil will expand when wet or contract when dry. A knowledge of this potential is important in planning the use of a soil for building roads and other engineering structures. In this county the shrink-swell potential was estimated by technicians familiar with the soils of the area.

Depth to a seasonally high water table is not given in table 3, because all of the soils in the county, except the

TABLE 3.—*Brief description of the soils*

Map symbol	Soil	Description	Depth from surface	Classification
				Texture USDA
			<i>Inches</i>	
AfA	Amarillo fine sandy loam, 0 to 1 percent slopes.	8 to 14 inches of fine sandy loam over 24 to 48 inches of moderately permeable, well-drained sandy clay loam; developed in unconsolidated, moderately sandy alluvial and windblown sediments.	0-14	Fine sandy loam.....
AfB	Amarillo fine sandy loam, 1 to 3 percent slopes.		14-48	Sandy clay loam.....
			48-68	Sandy clay loam.....
AmB	Amarillo loamy fine sand, 0 to 3 percent slopes.	10 to 16 inches of loamy fine sand over 24 to 48 inches of moderately permeable, well-drained sandy clay loam; developed in unconsolidated, moderately sandy alluvial and windblown sediments; soft caliche is 36 inches or more below the surface.	0-16	Loamy fine sand.....
			16-60	Sandy clay loam.....
			60-96	Sandy clay loam.....
Ar	Arch soils.	4 to 10 inches of well-drained, strongly calcareous loam or fine sandy loam over chalky material consisting of old alluvium or Plains outwash; apparently modified by calcium carbonate deposited by ground water; in broad valleys and on benches around intermittent lakes.	0-9	Loam.....
			9-60	Clay loam.....
AvA	Arvana fine sandy loam, 0 to 1 percent slopes.	6 to 10 inches of fine sandy loam over 8 to 20 inches of moderately permeable, well-drained sandy clay loam; developed in a thin, sandy mantle of wind-blown deposits over indurated caliche.	0-8	Fine sandy loam.....
AvB	Arvana fine sandy loam, 1 to 3 percent slopes.		8-30	Sandy clay loam.....
			30+	Hard caliche.....
AwB	Arvana fine sandy loam, shallow, 0 to 3 percent slopes.	Like the Arvana fine sandy loams just described, except that caliche is nearer the surface.	0-6	Fine sandy loam.....
			6-17	Sandy clay loam.....
			17+	Hard caliche.....
Be	Berthoud soils of the Berthoud-Potter complex.	8 to 12 inches of calcareous fine sandy loam over 20 to 36 inches of well-drained, calcareous loam in which permeability is moderately rapid; below is strongly calcareous loam over a thick layer of whitish, soft caliche.	0-10	Fine sandy loam.....
			10-38	Loam.....
			38-72	Loam.....
Br	Brownfield fine sand, thick surface.	18 to 40 inches of fine sand; if this soil is not eroded, the fine sand overlies 20 to 50 inches of well-drained, moderately permeable sandy clay loam; developed in sandy material that appears to be eolian; in some places hard caliche is at a depth of 3 to 7 feet.	0-24	Fine sand.....
			24-68	Sandy clay loam.....
			68-96	Fine sandy loam.....
Bs	Brownfield fine sand, thin surface.	0 to 18 inches of fine sand over 20 to 50 inches of well-drained, moderately permeable sandy clay loam; developed in sandy material that appears to be eolian; in some places hard caliche is at a depth of 3 to 7 feet.	0-18	Fine sand.....
			18-80	Sandy clay loam.....
			80-96	Fine sandy loam.....
Bt3	Brownfield soils, severely eroded.	Surface layer is extremely variable in thickness because the soils have been "plowed out" and dunes are common. The original surface layer, where present, is fine sand. Other layers are similar to those in Brownfield fine sand, thick surface.	-----	-----
DrB	Drake soils, 1 to 3 percent slopes.	6 to 12 inches of strongly calcareous, well-drained clay loam or fine sandy loam over white, chalky, limy material; developed in eolian deposits from playas in the southern High Plains.	0-8	Clay loam or fine sandy loam.
DrC	Drake soils, 3 to 5 percent slopes.		8-40	Clay loam.....
DrD	Drake soils, 5 to 30 percent slopes.		40-74	Clay loam.....
Gf	Gomez fine sand.	12 to 18 inches of loamy fine sand to fine sand over 10 to 24 inches of well-drained, slightly more clayey material; underlain by strongly calcareous sandy material that is saturated with water at times during periods of heavy rainfall.	0-14	Loamy fine sand.....
Gl	Gomez loamy fine sand.		14-26	Fine sandy loam.....
			26-60+	Sandy clay loam (caliche).
Km	Kimbrough soils.	2 to 14 inches of loam over hard, platy caliche.	0-5	Loam.....
			5-60+	Hard caliche.....

See footnote at end of table.

and their estimated physical properties

Classification—Continued		Percentage passing sieve—			Permeability	Available water capacity	Reaction	Shrink-swell potential	
Unified ¹	AASHO ²	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 200 (0.074 mm.)					
SM.....	A-2 or A-4.....	³ 100	³ 100	³ 25-45	1.0-2.0	Inches per inch of depth pH	7.5-7.8	Low.	
SC or CL.....	A-4 or A-6.....	³ 100	³ 100	³ 35-55	0.5-1.0		0.12	7.5-8.0	Low to moderate.
GC or CL.....	A-2, A-4, or A-6.....	⁴ 95-100	⁴ 95-100	⁴ 20-70	0.5-1.0		0.16	8.0-8.4	Low to moderate.
SM.....	A-2.....	³ 100	³ 100	³ 15-20	1.5-5.0	0.08	7.2-7.7	Low.	
SM or SC.....	A-2 or A-6.....	³ 100	³ 100	³ 30-40	0.5-1.5	0.16	7.5-8.0	Low to moderate.	
SC.....	A-2 or A-6.....	³ 100	³ 100	³ 30-40	0.5-1.5	0.08	8.0-8.5	Low to moderate.	
CL ⁵	A-6.....	⁶ 100	⁶ 55-80	⁶ 55-80	0.2-0.8	0.18	8.0+	Moderate.	
CL ⁵	A-6.....	⁶ 100	⁶ 55-80	⁶ 55-80	0.2-0.8	0.18	8.0+	Moderate.	
SM or ML ⁵	A-2 or A-4.....	⁶ 100	⁶ 45-85	⁶ 30-60	1.0-2.0	0.12	7.5-7.8	Low.	
SC or SM ⁶	A-2, A-4, or A-6 ⁵	⁶ 100	⁶ 45-80	⁶ 20-55	0.5-1.5	0.16	7.5-7.8	Low to moderate.	
						0.04	8.0+	Low.	
SM or ML.....	A-2 or A-4.....	100	45-85	30-60	1.0-2.0	0.12	7.5-7.8	Low.	
SC or SM.....	A-2, A-4, or A-6.....	100	45-80	20-55	0.5-1.5	0.16	7.5-7.8	Low to moderate.	
						0.04	8.0+	Low.	
SC.....	A-4.....	100	100	35-40	1.0-2.0	0.12	7.2-8.3	Low to moderate.	
CL.....	A-6.....	96-100	94-100	56-59	0.5-1.0	2.0	8.0-8.5	Moderate.	
CL.....	A-6.....	96-100	94-100	56-59	0.5-1.0	2.0	8.0-8.5	Moderate.	
SM.....	A-2.....	100	100	12-20	1.5-3.0	1.0 -1.4	6.5-7.0	Low to moderate.	
SC.....	A-2.....	³ 100	³ 100	³ 25-35	0.5-1.5	0.16	7.2-7.8	Low to moderate.	
SM.....	A-2 or A-4.....	³ 100	³ 100	³ 25-40	1.0-2.0	0.12	7.2-8.0	Low to moderate.	
SM.....	A-2.....	100	100	12-20	1.5-3.0	1.0 -1.4	6.5-7.0	Low to moderate.	
SC.....	A-6.....	⁴ 100	⁴ 100	⁴ 35-40	0.5-1.5	0.16	7.2-7.9	Low to moderate.	
SC.....	A-6.....	⁴ 100	⁴ 100	⁴ 35-40	1.0-2.0	0.12	7.2-8.3	Low to moderate.	
CL ⁵	A-6.....	⁶ 100	⁶ 55-80	⁶ 55-80	0.2-0.8	0.18	8.0+	Moderate.	
CL ⁵	A-6 ⁵	⁶ 100	⁶ 55-80	⁶ 55-80	0.2-0.8	0.18	8.0+	Moderate.	
CL ⁵	A-6 ⁵	⁶ 100	⁶ 20-45	⁶ 55-80	0.2-0.8	0.18	8.0+	Moderate.	
SM ⁵	A-2.....	⁶ 100	⁶ 70-90	⁶ 10-30	1.5-5.0	0.08	7.2-7.8	Low.	
SM or ML ⁵	A-2 or A-4.....	⁶ 100	⁶ 45-85	⁶ 15-55	1.0-2.0	0.12	7.5-8.0+	Low.	
SM or ML.....	A-2 or A-4.....	⁶ 100	⁶ 45-80	⁶ 20-55	0.5-1.5	0.04	8.0+	Low to moderate.	
CL.....	A-4.....	96	94-100	56-59	0.5-1.0	2.0	8.0-8.5	Moderate. Low.	

See footnote at end of table.

TABLE 3.—*Brief description of the soils and*

Map symbol	Soil	Description	Depth from surface	Classification
				Texture USDA
Lr	Lubbock soils of Lubbock and Randall soils.	0 to 12 inches of noncalcareous clay loam over non-calcareous clay loam to light clay.	0-12 12-48	Clay loam..... Clay loam or light clay.....
PfA	Portales fine sandy loam, 0 to 1 percent slopes.	8 to 16 inches of well-drained, calcareous fine sandy loam over 6 to 18 inches of sandy clay loam; developed in strongly calcareous, medium- to fine-textured sediments of outwash material from the High Plains; the underlying material is very strongly calcareous caliche; these soils occur in most parts of the county.	0-12	Fine sandy loam.....
PfB	Portales fine sandy loam, 1 to 3 percent slopes.		12-34 34-60+	Sandy clay loam..... Sandy clay loam.....
PmA	Portales loam, 0 to 1 percent slopes.	6 to 12 inches of calcareous, well-drained, moderately permeable loam to clay loam; developed in limy Plains sediments; underlain by a thick layer of whitish, soft caliche.	0-12 12-36 36-60	Loam..... Clay loam ⁵ Clay loam ⁵
Be, Tx	Potter soils of Berthoud-Potter complex and Tivoli-Potter complex.	2 to 10 inches of strongly calcareous, well-drained loam or fine sandy loam; developed in deep beds of soft or weakly cemented caliche.	0-6 6+	Loam or fine sandy loam..... Caliche.....
Lr	Randall clay of Lubbock and Randall soils.	4 to 5 feet of poorly drained, dense clay on the floors of enclosed depressions or intermittent lakes; the underlying material is calcareous clay.	0-20 20-58	Clay..... Clay.....
Sa	Simona fine sandy loam.	6 to 12 inches of fine sandy loam over 4 to 12 inches of moderately coarse textured sediments; underlain by strongly cemented caliche at a depth of 12 to 20 inches.	0-8 8-20 20-36+	Fine sandy loam..... Fine sandy loam..... Strongly cemented caliche.....
Sm	Springer and Brownfield soils, moderately deep.	For description of the Springer soils of this mapping unit, see Springer loamy fine sand (Sp); for description of the Brownfield soils, see Brownfield fine sand, thin surface (Bs).		
Sp	Springer loamy fine sand.	18 to 30 inches of loamy fine sand over fine sandy loam; underlying material is soft caliche.	0-23 23-36 36-44	Loamy fine sand..... Fine sandy loam..... Fine sandy loam.....
Sb	Springer soils of Springer and Brownfield soils, shallow.	10 to 12 inches of well-drained loamy fine sand over 6 to 8 inches of moderately permeable sandy clay loam to fine sandy loam; underlain by a thick bed of soft to indurated caliche at a depth of 16 to 20 inches.	0-10 10-18 18+	Loamy fine sand..... Fine sandy loam..... Hard caliche.....
Ps	Spur fine sandy loam of Portales and Spur soils.	8 to 24 inches of fine sandy loam over 20 to 50 inches of calcareous fine sandy loam or clay loam; underlain by caliche.	0-24 24-48 48-78+	Fine sandy loam..... Fine sandy loam..... Clay loam.....
StA	Stegall loam, 0 to 1 percent slopes.	4 to 12 inches of well-drained, noncalcareous loam over slowly permeable, noncalcareous heavy clay loam; developed over indurated caliche.	0-8 8-38 38-60	Loam..... Heavy clay loam..... Hard caliche.....
Tv	Tivoli fine sand.	3½ to 7 feet of well-drained fine sand; developed in windblown material deposited in the Quaternary period.	0-8 8-96	Fine sand..... Fine sand.....
Tx	Tivoli soils of the Tivoli-Potter complex.	2 to 4 feet of fine sand over caliche; the engineering properties of the fine sand are similar to those of Tivoli fine sand; the underlying caliche is similar to that underlying the Potter soils.	0-8 8-96	Fine sand..... Fine sand.....
ZfA	Zita fine sandy loam, 0 to 1 percent slopes.	8 to 16 inches of fine sandy loam over 14 to 20 inches of well-drained sandy clay loam; developed in highly calcareous, windblown or alluvial material of the High Plains.	0-10 10-36 36-44+	Fine sandy loam..... Clay loam ⁵ Clay loam ⁵

¹ For an explanation of the Unified system, see "The Unified Soil Classification System," Tech. Memo. No. 3-357, v. 1, Waterways Expt. Sta., Corps of Engineers, March 1953, rev. 1957.

² For an explanation of the AASHTO system, see AASHTO Designation: M 145-49, "The Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes" in "Standard Specifications for Highway Materials and Methods of Sampling and Testing," pt. 1, Ed. 8 (1961), published by AASHTO.

their estimated physical properties—Continued

Classification—Continued		Percentage passing sieve—			Permeability	Available water capacity	Reaction	Shrink-swell potential
Unified ¹	AASHO ²	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 200 (0.074 mm.)				
CL or CH	A-6	100	100	56-65	0.5-1.0	0.15	7.5-8.0	Moderate.
CL or CH	A-7	100	100	70-80	0.2-0.7	0.2	7.2-7.8	High.
SM or CL	A-2 or A-4	³ 100	³ 95-100	³ 20-55	1.0-2.0	0.12	7.8-8.0	Low to moderate.
SC or CL	A-2 or A-6	³ 100	³ 100	³ 35-55	0.5-1.5	0.04-0.12	8.0-8.1	Low to moderate.
SC or CL	A-4 or A-6	³ 100	³ 80-95	³ 40-55	0.5-1.5	0.04	8.0+	Low to moderate.
CL ⁵	A-4 ⁵	⁶ 100	⁶ 55-80	⁶ 55-80	0.2-0.8	0.18	7.8-8.0	Moderate.
CL ⁵	A-6 ⁵	⁶ 100	⁶ 55-80	⁶ 55-80	0.2-0.8	0.18	8.0+	Moderate.
CL ⁵	A-6 ⁵	⁶ 100	⁶ 85-100	⁶ 55-80	0.2-0.8	0.04	8.0+	Moderate.
SM or ML	A-2 or A-4	⁶ 100	⁶ 45-85	⁶ 15-55	1.0-2.0	0.12	8.0+	Low to moderate.
						0.04	8.0+	Low.
CH	A-7	⁴ 100	⁴ 100	⁴ 88-85	0.0-0.2	0.21	7.4-8.0+	High.
CL or CH	A-7	⁴ 100	⁴ 100	⁴ 80-85	0.0-0.2	0.21	7.4-8.0+	High to moderate.
SM or ML ⁵	A-2 or A-4 ⁵	⁶ 100	⁶ 45-85	⁶ 15-55	1.0-2.0	0.12	7.5-8.0	Low.
SM or ML	A-2 or A-6	100	45-85	15-55	1.0-2.0	0.12	7.5-8.0	Low.
								Low.
SM	A-2	100	100	10-20	2.5-5.0	0.1	6.8-7.5	Low.
SM or SC	A-2 or A-4	100	100	30-40		0.1	6.8-7.5	Low.
SM or SC	A-2 or A-4	100	100	20-40		0.06	6.8-7.5	Low.
SM	A-6	93-100	97-100	15-40	2.5-5.0	1.0	7.0-7.2	Low.
SM	A-2, A-4	100	45-85	15-55	1.0-2.0	1.5	7.0-7.2	Low.
						0.5	8.0+	
SM or ML	A-2 or A-4	100	45-85	15-55	1.0-2.0	0.12	8.0+	Low.
SM or ML	A-2 or A-4	100	45-85	15-55	1.0-2.0	0.14	8.0	Low.
CL	A-4 or A-6	100	55-80	55-80	0.2-0.8	0.18	8.0+	Moderate.
CL	A-6	100	100	50-60	0.5-2.0	1.8	7.0	Low.
CL	A-6	100	100	70-80	0.6-1.0	2.0	7.0-7.5	High.
SM or SP ⁵	A-2 or A-3 ⁵	⁶ 100	⁶ 85-100	⁶ 0-15	5.0-8.0	0.06	7.0-7.5	Low.
SM or SP ⁵	A-2 or A-3 ⁵	⁶ 100	⁶ 85-100	⁶ 0-15	5.0-8.0	0.06	7.0-7.5	Low.
SM or SP ⁵	A-2 or A-3 ⁵	⁶ 100	⁶ 85-100	⁶ 0-15	5.0-8.0	0.06	7.0-7.5	Low.
SM or SP ⁵	A-2 or A-3 ⁵	⁶ 100	⁶ 85-100	⁶ 0-15	5.0-8.0	0.06	7.0-7.5	Low.
SM or ML ⁵	A-2 or A-4 ⁵	⁶ 100	⁶ 45-85	⁶ 15-55	1.0-2.0	0.12	7.4-7.8	Low.
SC or CL ⁵	A-4 or A-6 ⁵	⁶ 100	⁶ 45-85	⁶ 35-55	0.5-1.5	0.16	7.6-8.0	Low to moderate.
SC or CL ⁵	A-6 ⁵	⁶ 100	⁶ 45-80	⁶ 35-65	0.5-1.5	0.14	8.0+	Low to moderate.

³ Data from tests by Texas State Highway Department on samples from Terry County, Tex.

⁴ Data from tests by Bureau of Public Roads (BPR) on samples from Lynn County, Tex.

⁵ Classification estimated for modal soil in survey area using test data for soils of similar classification.

⁶ Data estimated for modal soil using USDA, Soil Conservation Service, textural chart for 2-micron clay.

TABLE 4.—*Engineering*

Soil type and map symbol	Suitability for—		Highway location
	Topsoil	Road fill	
Amarillo fine sandy loam (AfA, AfB)-----	Surface layer satisfactory---	Satisfactory-----	Satisfactory-----
Amarillo loamy fine sand (AmB)-----	Surface layer satisfactory---	Satisfactory-----	Satisfactory-----
Arch soils (Ar)-----	Surface layer satisfactory---	Satisfactory-----	Satisfactory-----
Arvana fine sandy loam (AvA, AvB)-----	} Surface layer satisfactory---	Satisfactory-----	Satisfactory-----
Arvana fine sandy loam, shallow (AwB)-----			
Berthoud soils of the Berthoud-Potter complex (Be)-----	Fair-----	Poor to fair-----	Satisfactory-----
Brownfield fine sand, thick surface (Br)-----	} Surface layer satisfactory---	Satisfactory-----	Satisfactory-----
Brownfield soils, severely eroded (Bt3)-----			
Brownfield fine sand, thin surface (Bs)-----	Surface layer satisfactory---	Satisfactory-----	Satisfactory-----
Drake soils (DrB, DrC, DrD)-----	Surface layer satisfactory---	Satisfactory-----	Satisfactory-----
Gomez fine sand (Gf)-----	Surface layer satisfactory---	Satisfactory-----	Satisfactory-----
Gomez loamy fine sand (Gl)-----	Surface layer satisfactory---	Satisfactory-----	Satisfactory-----
Kimbrough soils (Km)-----	Surface layer satisfactory---	Satisfactory-----	Satisfactory-----
Lubbock clay loam of Lubbock and Randall soils (Lr)-----	Poor to fair-----	Fair-----	Satisfactory-----
Portales fine sandy loam (PfA, PfB)-----	Surface layer satisfactory---	Satisfactory-----	Satisfactory-----
Portales loam (PmA)-----	Surface layer satisfactory---	Satisfactory-----	Satisfactory-----
Potter soils of Berthoud-Potter complex and Tivoli-Potter complex (Be, Tx).	Surface layer satisfactory---	Satisfactory-----	Satisfactory-----
Randall clay of Lubbock and Randall soils (Lr)-----	Poor-----	Satisfactory to unsatisfactory.	Poor-----
Simona fine sandy loam (Sa)-----	Surface layer satisfactory---	Satisfactory-----	Satisfactory-----
Springer loamy fine sand (Sp)-----	Surface layer satisfactory---	Fair to poor-----	Satisfactory-----
Springer soils of Springer and Brownfield soils (Sb, Sm)-----	Poor-----	Fair-----	Satisfactory-----
Spur fine sandy loam of Portales and Spur soils (Ps)-----	Surface layer satisfactory---	Satisfactory-----	Occasional high water table; subject to overflow.
Stegall loam (StA)-----	Poor to fair-----	Fair-----	Satisfactory-----
Tivoli fine sand and the Tivoli soil of the Tivoli-Potter complex (Tv, Tx).	Surface layer satisfactory---	Satisfactory-----	Satisfactory-----
Zita fine sandy loam (ZfA)-----	Surface layer satisfactory---	Satisfactory-----	Satisfactory-----

Spur, have a low water table. The Spur soils have a high water table at times.

Table 4 rates the soils of the county according to their suitability for topsoil. The surface layer of almost all of the soils can be used as a source of topsoil. This layer is thin in some soils, however, and does not contain much material suitable for topsoil.

Practically all of the soils in the county are suitable for road fill if the material is properly placed and compacted. To make the best fill material, the sandy material from the surface layer of some of the soils must be graded with finer textured material from horizons lower in the profile. Sandy soils that do not contain enough fine material to permit binding are the most difficult to place and compact. The finer textured soils are more easily compacted, but they are susceptible to overcompac-

tion, which can make the fill unstable and the surface corrugated or uneven.

Table 4 does not rate the soils as a source of sand and gravel, for there is little sand and gravel in the county. Some sand and gravel suitable for subbase, surfacing, or other uses can be quarried in small overwash areas, but few such areas are large enough for sand and gravel to be obtained on a commercial basis. The hard caliche underlying many of the soils can be used for subgrade and subbase material. It is also suitable for use in a mixture for asphalt surfacing if the caliche is properly crushed and graded.

All of the soils in the county, except the Randall, are suitable as locations for highways. All of them can be graded in winter, for long periods of subfreezing weather are unlikely to occur. Even the Spur soils, which are subject to overflow, are not likely to be hard to grade.

interpretations of the soils

Soil features adversely affecting—		
Irrigation	Terraces and diversion terraces	Waterways
None..... High susceptibility to wind erosion; low water-holding capacity. Low water-holding capacity.....	None..... High susceptibility to wind erosion; poorly graded surface layer. Hazard of wind erosion.....	Highly calcareous subsoil. High susceptibility to wind erosion. Subject to wind erosion; low water-holding capacity.
Moderate water-holding capacity..... Steep slopes.....	Substratum is hard caliche..... Hazard of erosion.....	Hard caliche in substratum. Hazard of erosion; calcareous substratum.
High susceptibility to wind erosion; low water-holding capacity. High susceptibility to wind erosion; low water-holding capacity. Moderately rapid permeability; high susceptibility to wind erosion; low water-holding capacity. Moderately rapid permeability; high susceptibility to wind erosion; low water-holding capacity. Moderately rapid permeability; high susceptibility to wind erosion; low water-holding capacity. Moderately rapid permeability; very shallow. Low intake rate.....	High susceptibility to wind erosion; poorly graded surface layer. High susceptibility to wind erosion; poorly graded surface layer. Poor stability; high susceptibility to wind erosion. Poor stability..... Poor stability; high susceptibility to wind erosion; highly calcareous subsoil. Very shallow surface layer; less than 10 inches deep. Low intake rate.....	High susceptibility to wind erosion. High susceptibility to wind erosion; highly calcareous subsoil. High susceptibility to wind erosion; highly calcareous subsoil. High susceptibility to wind erosion; highly calcareous subsoil. Very shallow surface layer; stony throughout profile. Subject to erosion.
Moderately rapid permeability; moderate water-holding capacity. None..... Moderate to rapid permeability; very shallow. Very slow permeability; hazard of flooding. Shallow; low water-holding capacity..... Low water-holding capacity.....	Poor stability; highly calcareous subsoil..... Hazard of erosion..... Very shallow; soft caliche near the surface..... Very slow permeability; hazard of flooding; subject to cracking. Shallow; soft caliche near the surface.....	Highly calcareous subsoil. Hazard of erosion; calcareous substratum. Very shallow; caliche near the surface. Subject to cracking; hazard of flooding. Shallow; caliche near the surface; fair stability. Highly susceptible to wind erosion.
Low water-holding capacity..... Possible high water table; subject to overflow Low intake rate..... Moderately rapid permeability; high susceptibility to wind erosion; low water-holding capacity. None.....	Very high susceptibility to wind erosion..... Subject to overflow..... None..... Low stability; hazard of wind erosion..... None.....	Very high susceptibility to wind erosion. Highly calcareous subsoil; subject to overflow. None. Hazard of wind erosion; poor stability. Highly calcareous substratum.

Many of the soils of this county are poorly suited to irrigation because they have low water-holding capacity. Where the soils are irrigated, however, the irrigation water can be applied by using a sprinkler system or by flooding. A sprinkler system can be used to irrigate any of the soils. The level-border system and the level- or graded-furrow systems are suited to the fine-textured soils.

Terraces and diversions can be constructed in most places, but they are hard to maintain on the coarser textured soils. It is difficult to keep the terrace ridges and channels in good condition. Soil material accumulates in the channels, and some is blown out of the ridges by wind.

Wind erosion is a serious hazard to waterways constructed in this county. Windblown material accumulates in the waterways and hinders the flow of water. In places the vegetation is smothered by windblown material.

Table 4 does not name soil features that adversely affect use of the soils for ponds, because the soils in Gaines County ordinarily are not suitable for ponds. The surface layer of many of the soils is suitable for construction of pond fills, but the underlying layers will not hold water.

In engineering construction in Gaines County, bedrock is not likely to be reached.

Genesis, Classification, and Morphology of Soils

This section describes the major morphologic characteristics of the soils of Gaines County and relates them to the factors of soil formation. Physical and chemical data on the soils are limited, however, and the discussion

of soil genesis and morphology are correspondingly incomplete. The first part of the section deals with the environment of the soils; the second, with their classification; and the third, with their morphology.

Factors of Soil Formation

Soil is a function of climate, plant and animal life, parent material, topography or relief, and time. The nature of the soil at any point on the earth depends upon the combination of the five major soil-forming factors at that point. All five of these factors come into play in the genesis of every soil. The relative importance of each differs from place to place. In some places one factor is important, and in other places some other factor is important. In extreme cases one factor may dominate in the formation of the soil and fix most of its properties, as is common when the parent material consists of pure quartz sand. Little can happen to quartz sand, and the soils derived from it usually have faint horizons. Even in quartz sand, however, distinct profiles can be formed under certain types of vegetation where the topography is low and flat and a high water table is present. Thus, for every soil the past combination of the five major factors is of the first importance to its present character.

The interrelationships among the factors of soil formation are complex, and the effects of any one factor cannot be isolated and identified with certainty. It is convenient, however, to discuss the factors of soil formation separately and to indicate some of their probable effects. The reader should remember that the factors interact continually in the processes of soil formation and that the interactions are important to the nature of every soil.

Climate.—Precipitation, temperature, humidity, and wind have been important in the development of the soils of Gaines County. The wet climate of past geologic ages influenced the disposition of parent material. Later, rainfall was limited and seldom moistened the soil below the area penetrated by roots. As a result, most of the zonal and intrazonal soils have a horizon of calcium carbonate. Many of the younger soils have free lime throughout the profile because not enough rainwater has passed through them to leach out the lime.

Wind is a major factor in the development of soils in this area. It has affected soil development from the time it deposited sands over preexisting alluvial material in the Illinoian stage of the Pleistocene epoch to its present shifting of coarse sands on the surface.

Plant and animal life.—Vegetation, micro-organisms, earthworms, and other forms of life that live on and in the soil contribute to its development. The type and amount of vegetation are important. They are determined partly by the climate and partly by the kind of parent material. The climate limited the vegetation of this county mainly to grasses. The parent material determined whether the grasses would be tall, as on the sands, or short, as on the clays.

The mixed prairie type of native vegetation contributed a large amount of organic matter to the soil. Decaying leaves and stems of grass distributed this organic matter on the surface. Decomposition of the fine roots distributed it throughout the solum. The network of tubes and pores left by these decaying roots hastened the passage of air and

water through the soil and provided abundant food for bacteria, actinomycetes, and fungi.

Earthworms are the most noticeable form of animal life in the soil. Despite the low rainfall in this area and periods when the entire solum is dry, the importance of earthworm activity in the development of soils is easily seen. In some places worm casts make up about 40 percent of the B2 horizon of the Amarillo soils. These worm casts add greatly to the free movement of air, water, and plant roots in a soil.

Rodents that dwell in the soils have had a part in the development of some soils. Farmers who have occupied the land since it was in native grasses know where there were formerly large towns of prairie dogs. The burrowing of these animals did much to offset the leaching of free lime from the soils. It greatly altered the structure of soils that were already formed. As an example, some areas of Portales soils, which occur within large areas of Amarillo soils, have been formed by the work of prairie dogs. In contrast to the surrounding Amarillo soils, the Portales soils are calcareous to the surface, have weaker structure in the subsoil, and in many places have weaker calcium carbonate horizons.

The influence of man on the formation of soils should not be ignored. At first, man fenced the range, brought livestock in, and permitted the range to be overgrazed. He then plowed the land and planted crops. By harvesting the crops and allowing runoff and wind erosion to go uncontrolled, he reduced the amount of organic matter and the particles of silt and clay in the plow layer. Through the use of heavy machines and poorly timed tillage, man has compacted the soil to the extent that aeration and infiltration of water have been retarded in some areas. Man has also drastically changed the moisture regime in some areas by irrigation.

These practices have had a marked effect on the soils of the county in the past 50 years. The way that future generations manage the soils will affect further development of the soil profiles.

Parent material.—Most of the soils in this county developed in windblown material deposited in the Quaternary and late Tertiary periods. The very shallow soils, however, developed partly in material weathered from exposed beds of caliche. The source of the windblown material is thought to be soils of the Pecos Valley to the southwest. Wind has reworked most of the sediments since the alluvium was originally deposited. The parent material is largely alkaline or calcareous, unconsolidated sandy and silty material. In some areas the content of lime has been increased by a high water table. Some shallow, enclosed basins have received lime and alluvial sediments from surrounding slopes.

The texture of the parent material greatly influences soil development. Soils that have developed in fine-textured material generally have developed more rapidly and to a greater degree than soils that have developed in coarse-textured material.

Relief.—Relief influences development of soils through its effect on drainage and runoff. The degree of development of the profile depends mainly on the average amount of moisture in the soil, provided other factors of soil formation are equal. The soils on steep slopes absorb less moisture, and normally, their profiles consist of less distinctly developed layers or horizons than are in soils

on flats and in depressions. Also, the soil-forming processes on steep slopes are retarded by continuous erosion.

Time.—Many characteristics of a soil are determined by the length of time that the soil-forming factors have been acting. Some material that has been in place for only a short time has not been influenced enough by climate and plant and animal life for the development of well-defined and genetically related horizons. The material in the eolian dunes bordering playas is an example.

The soils on steep slopes are immature, because geologic erosion has displaced the soil material and has weakened the effects of soil formation. The soils that have been in place for a long time and have approached equilibrium with their environment are mature or old soils. These soils show marked horizon differentiation. They are well drained and occupy nearly level to gently sloping areas.

Classification of Soils by Higher Categories

Soils are placed in narrow classes for the organization and application of knowledge about their behavior within farms, ranches, or counties. They are placed in broad classes for study and comparison of large areas, such as continents. In the comprehensive system of soil classification⁴ followed in the United States, the soils are placed in six categories, one above the other. Beginning at the top, the six categories are order, suborder, great soil group, family, series, and type.

In the highest category, the soils of the whole country are grouped into three orders, whereas thousands of soil types are recognized in the lowest category. The suborder and family categories have never been fully developed and thus have been little used. Attention has been given largely to the classification of soils into soil types and series within counties or comparable areas and to the subsequent grouping of series into great soil groups and orders. The subdivision of soil types into phases provides finer distinctions significant to use and management; however, phases are not a category of classification. Soil series, type, and phase are defined in the section "How This Soil Survey Was Made."

Classes in the highest category of the classification scheme are the zonal, intrazonal, and azonal orders.⁵ Because of the way in which the soil orders are defined, all three orders can usually be found within a single county, as is true in Gaines County. Two of the orders, and sometimes all three of them, may occur in a single field.

The great soil group is the next lower category beneath the order. Classes in that category have been widely used because they indicate a number of relationships in soil genesis and also indicate something of the fertility status of soils, their suitability for crops or trees, and the like.

Each great soil group consists of a large number of soil series that have many internal features in common. Thus, all members of a single great soil group, if in either the zonal or intrazonal order, have the same number and kind

of definitive horizons in their profiles. These definitive horizons need not be expressed to the same degree, nor do they need to be of the same thickness in all soils within one great soil group. Specific horizons must be recognizable, however, in every profile of a soil in a series that represents a given great soil group.

In the following list, the soil series are classified by orders and great soil groups. Following the list is a discussion of the morphology of each series and a description of a typical profile for each.

Order and great soil group

Zonal—

	<i>Series</i>
Reddish Chestnut----	Amarillo, Arvana.
Chestnut-----	Lubbock, Stegall, Zita.
Reddish Brown-----	Brownfield, Springer.
Intrazonal—	
Calcisol-----	Arch, Gomez, Portales, Simona.
Grumusol-----	Randall.
Azonal—	
Alluvial-----	Spur.
Lithosol-----	Kimbrough, Potter.
Regosol-----	Berthoud, Drake, Tivoli.

Zonal order

The zonal order consists of soils that have evident, genetically related horizons that reflect the dominant influence of climate and plant and animal life in their formation. These soils are nearly in equilibrium with their environment. Zonal soils that occur in Gaines County are in the Reddish Chestnut, Chestnut, and Reddish Brown great soil groups.

The Reddish Chestnut soils have a dark-brown, pinkish or reddish surface layer, as much as 2 feet thick, overlying a finer textured reddish-brown subsoil. The subsoil is underlain by an accumulation of grayish or pinkish lime. These soils formed in a semiarid, warm-temperate climate under mixed grass vegetation that included some shrubs. In this county this great soil group is represented by soils of the Amarillo and Arvana series.

The Chestnut soils have a dark-brown surface layer that grades to lighter colored material, which in turn grades to a horizon of lime accumulation. These soils formed under mixed tall and short grasses in a subhumid to semiarid, temperate to cool-temperate climate. In this county this great soil group is represented by soils of the Lubbock, Stegall, and Zita series.

The Reddish Brown soils have a light-brown surface layer of a slightly reddish cast that grades to dull reddish-brown or red material that is finer textured than that in the surface layer. This finer textured material grades to a horizon of whitish or pinkish lime accumulation. These soils formed under shrubs and short grasses in a semiarid, warm-temperate or tropical climate. In this county this great soil group is represented by soils of the Brownfield and Springer series.

Intrazonal order

The intrazonal order consists of soils that have evident, genetically related horizons that reflect the dominant influence of a local factor of topography or parent mate-

⁴ BALDWIN, MARK, KELLOGG, CHARLES E., AND THORP, JAMES. SOIL CLASSIFICATION. U.S. Dept. Agr. Ybk.: 979-1001. 1938.

⁵ THORP, JAMES, AND SMITH, GUY D. HIGHER CATEGORIES OF SOIL CLASSIFICATION: ORDER, SUBORDER, AND GREAT SOIL GROUPS. Soil Sci. 67: 117-126, illus. 1949.

rial over the effects of climate and plant and animal life. The relief and the length of time these soils have been developing have much to do with determining the kind of soils that develop. Generally, soils of this county that are in the intrazonal order do not have a textural B horizon, but in a few places a weakly developed B horizon is present. In most places the horizon sequence is A, AC, Cca, C, and IIC. Intrazonal soils that occur in Gaines County are in the Calcisol and Grumusol great soil groups.

The Calcisols have an A horizon that is variable in thickness and color, a prominent deeper horizon of lime accumulation, and parent material that has a high to very high content of carbonates. In this county this great soil group is represented by soils of the Arch, Gomez, Portales, and Simona series.

Normally, the Simona soils developed on very gently sloping ridges where less water percolates through the profile than through the profile of the adjacent, lower lying, nearly level Portales soils. The Gomez soils developed in more sandy material than the Arch, Portales, and Simona soils.

The Gomez, Portales, and Simona soils are medial Calcisols, that is, the characteristics of Calcisols are expressed to a moderate degree in their profile. The Arch soils, on the other hand, are minimal Calcisols, for the characteristics of Calcisols are expressed to only a slight degree in their profile. In other soils, called maximal Calcisols, the characteristics of Calcisols are expressed to the maximum degree.

The Grumusols have relatively uniform texture and a high content of montmorillonite clay. Swelling and shrinking continually churn these soils. During shrinking, the soil "swallows itself," as dry soil falls into the cracks and is mixed with lower lying material. The native cover is mid and short grasses. The Randall soils are the only Grumusols in the county.

Azonal order

The azonal order consists of soils that lack distinct, genetically related horizons, commonly because of their youth or because of resistant parent material. In Gaines County this order is represented by the Alluvial soils, Lithosols, and Regosols.

Alluvial soils are soils that are developing in transported and relatively recently deposited material (alluvium) that shows little or no modification by soil-forming processes. The Spur soils are the only Alluvial soils in this county. They developed in recent alluvium, and except in the A1 horizon show little horizon differentiation.

Lithosols are soils that have a thin solum overlying consolidated bedrock. In this county this great soil group is represented by soils of the Kinbrough and Potter series.

Regosols are soils that do not have distinct horizons and developed in deep, unconsolidated or soft, rocky deposits. In this county this great soil group is represented by soils of the Berthoud, Drake, and Tivoli series. The Drake soils are young and formed in material that was blown fairly recently from nearby playas and deposited in crescent-shaped dunes. The Tivoli soils developed in siliceous material that contains only a small proportion of minerals that can be weathered. The Ber-

thoud soils have a calcareous, loamy subsoil and lack distinct genetic horizons, except for a weak A1 horizon.

Morphology of Soils

This section has been prepared for soil scientists and others who need more detailed descriptions of the soils in the county than are given elsewhere in this report. In the following pages each soil series is described. A typical profile of a soil type in each series is described in detail, and the range in important characteristics of the soils within the series is stated.

AMARILLO SERIES

This series consists of moderately sandy Reddish Chestnut soils developed in unconsolidated alluvial sediments and in windblown sediments that are calcareous and moderately sandy. The sediments appear to contain a component derived from eroded red beds. The underlying material consists of pinkish-white caliche that contains some concretions at a depth of 36 to 70 inches.

The Amarillo soils occupy areas 40 to 80 acres in size. They occur on gently undulating uplands throughout the county but are mostly in the northern half. The slopes are convex and range from 0 to 3 percent, but in most places they are about 2 percent. These soils are moderately permeable and are well drained. The principal vegetation is sand dropseed and perennial three-awn. Some hairy grama and mesquite grow on the fine sandy loams; shin oak and sand sage grow on the loamy fine sands.

The Amarillo soils are less sandy and are darker than the Brownfield soils. They also have a Cca horizon that is lacking in the Brownfield soils. They are redder than the associated Portales soils that occupy the more nearly level, slightly lower areas. Their subsoil is more clayey than that of the Springer soils.

The following describes a typical profile of Amarillo loamy fine sand in an area where the slope is about 1 percent (0.3 mile north and 100 feet west of the southeast corner of section 207, block G, 8 miles southwest of Seagraves):

- Ap—0 to 15 inches, reddish-brown (5YR 4/4) loamy fine sand, dark reddish brown (5YR 3/4) when moist; structureless; loose when dry, nearly loose when moist, and nonsticky when wet; common fine roots; 20 percent small clods of sandy clay loam plowed up from the B21t horizon; noncalcareous; pH 7.0; abrupt boundary (plow slice).
- B21t—15 to 26 inches, reddish-brown (5YR 4/4) sandy clay loam, dark reddish brown (5YR 3/4) when moist; moderate, very coarse, prismatic and weak, subangular blocky structure; very hard when dry, friable when moist, and sticky when wet; few fine roots; few insect casts and burrows; noncalcareous; pH 7.0; clear boundary.
- B22t—26 to 45 inches, red (2.5YR 5/6) sandy clay loam, red (2.5YR 4/6) when moist; very coarse, prismatic structure; very hard when dry, friable when moist, and sticky when wet; few fine roots; noncalcareous; pH 7.0; clear boundary.
- B3t—45 to 58 inches, red (2.5YR 5/6) sandy clay loam, red (2.5YR 4/6) when moist; hard when dry, friable when moist, and sticky when wet; few films, threads, and very fine fragments of calcium carbonate; strongly calcareous; pH 8.0; clear boundary.
- Cca—58 to 80 inches, pink (5YR 8/4) sandy clay loam, pink (5YR 7/4) when moist; hard when dry, friable when moist, and sticky when wet; common, medium, soft

concretions of calcium carbonate; very strongly calcareous; pH 8.0; gradual boundary.

C—80 to 84 inches +, reddish-yellow (5YR 7/6) sandy clay loam, reddish yellow (5YR 6/6) when moist; strongly calcareous; pH 8.0.

The A horizon ranges from 8 to 16 inches in thickness and from fine sandy loam to loamy fine sand in texture. The color of the A horizon ranges from reddish brown to reddish yellow. The hues range from 5YR to 7.5YR, with values from 4 to 6 and chromas from 2 to 6 when dry.

The B21t horizon ranges from 8 to 20 inches in thickness. Its color ranges from reddish brown to reddish yellow; the hues range from 5YR to 7.5YR, the values from 4 to 5, and the chromas from 3 to 6. The B22t horizon ranges from 10 to 20 inches in thickness and from reddish brown to yellowish red in color; hues range from 2.5YR to 5YR, with values ranging from 4 to 5 and chromas ranging from 4 to 6. In places the color of the B3t horizon is one unit higher in value than that of the B22t horizon. The B3t horizon is weakly to strongly calcareous and ranges from 6 to 15 inches in thickness.

Depth to the Cca horizon ranges from 48 to 80 inches, and the thickness of that horizon ranges from 8 to 24 inches. The color of the Cca horizon ranges from reddish yellow to pinkish white, the hue ranging from 5YR to 7.5YR, the value from 6 to 8, and the chroma from 2 to 4.

Depth to the C horizon ranges from 56 to 96 inches. The C horizon has the same range in color as the Cca horizon, except that the color is one unit lower in value than that of the Cca horizon. The C horizon is less calcareous than the Cca. Depth to indurated caliche is 60 to 96 inches.

ARCH SERIES

This series consists of shallow, smooth, strongly calcareous Calcisols. The soils are medium textured to moderately coarse textured. The underlying material is old alluvium that has been modified by calcium carbonate deposited by ground water.

The Arch soils occupy areas 20 to 80 acres in size and occur throughout the county. The slopes are single and convex and range from 0 to 2 percent. Runoff is slow, and permeability is moderately rapid. The principal vegetation is sideoats grama, black grama, and sand muhly. Four-winged saltbush and annual weeds are the principal invaders.

The Arch soils occur with the Drake soils but are at a lower elevation than those soils. They are lighter colored and shallower than the Simona and Portales soils, and they contain more lime.

The following describes a typical profile of Arch loam in an area where the slope is about 1 percent (0.25 mile south and 0.05 mile west of the northeast corner of section 23, block C-44, 6 miles east and 1 mile south of Seminole on Farm Road 1429):

A1—0 to 9 inches, grayish-brown (10YR 5/2) loam, dark grayish brown (10YR 4/2) when moist; compound moderate, coarse, prismatic and weak, subangular blocky structure; slightly hard when dry, friable when moist, and sticky when wet; many very fine, many fine, and few medium roots, tubes, and pores; many insect casts and burrows; strongly calcareous; pH 8.0; clear boundary.

Cca—9 to 18 inches, white (10YR 8/2) light clay loam, light gray (10YR 7/2) when moist; hard when dry, friable when moist, and sticky when wet; common very fine to fine roots; many segregated pockets of soft calcium

carbonate; very strongly calcareous; pH 8.0; gradual boundary.

C—18 to 37 inches +, light-gray (2.5Y 7/2) light clay loam, grayish brown (2.5Y 5/2) when moist; hard when dry, firm when moist, and sticky when wet; very strongly calcareous; pH 8.0.

The A horizon ranges from 4 to 10 inches in thickness and from loam to fine sandy loam in texture. The color of the A horizon ranges from grayish brown to very pale brown. The hue ranges from 10YR to 2.5Y, with values of 5 to 7 and chromas of 2 to 4.

The Cca horizon ranges from 4 to 20 inches in thickness. Its color ranges from grayish brown to white; the values range from 6 to 8, and the chromas from 1 to 3.

The color of the C horizon ranges from white to light gray; the hues range from 10YR to 2.5Y, the values from 7 to 8, and the chromas from 1 to 2. In most places the C horizon is soft and chalky and does not contain as much pure, soft, segregated calcium carbonate as the Cca horizon. Also, in most places concretions of calcium carbonate are lacking.

ARVANA SERIES

This series consists of shallow to moderately deep Reddish Chestnut soils that are moderately sandy. The soils are reddish, noncalcareous, and loamy. They developed in a thin mantle of sandy, windblown material deposited over caliche. This material is indurated and platy in the upper part.

These soils are nearly level to gently sloping and occur in the uplands where the slopes are single and convex. Drainage is good, and the soils are moderately permeable. The principal grasses are sideoats grama, blue and black grama, sand dropseed, and perennial three-awn. The principal invaders are mesquite and catclaw.

The Arvana soils occupy small ridges within larger areas of Amarillo soils. They also occur with the Kimbrough soils; in many places they surround small areas of Kimbrough soils on gradual slopes below ridgetops. Arvana soils are shallower than the Amarillo soils, and they are underlain by hard, platy caliche instead of by unconsolidated material. Also, their solum is only 10 to 36 inches thick. The Arvana soils are deeper than the Kimbrough soils.

The following describes a typical profile of Arvana fine sandy loam in an area where the slope is about 1 percent (0.4 mile south and 50 feet east of the northwest corner of section 10, block AX, 15 miles west and southwest of Seminole):

A1—0 to 8 inches, dark-brown (7.5YR 4/2) fine sandy loam, dark brown (7.5YR 3/2) when moist; weak, subangular blocky structure; soft when dry, very friable when moist, and slightly sticky when wet; many fine and few medium roots; common insect casts and burrows; noncalcareous; pH 7.0; clear boundary.

B21t—8 to 19 inches, reddish-brown (5YR 4/4) sandy clay loam, dark reddish brown (5YR 3/4) when moist; moderate, coarse, prismatic structure; very hard when dry, friable when moist, and sticky when wet; many fine to very fine roots, tubes, and pores; common insect casts; noncalcareous; pH 7.0; clear boundary.

B22t—19 to 32 inches, reddish-brown (5YR 5/4) sandy clay loam, reddish brown (5YR 4/4) when moist; weak, subangular blocky structure; very hard when dry, friable when moist, and sticky when wet; common fine roots, tubes, and pores; few insect casts and burrows; noncalcareous; pH 7.0; abrupt boundary.

IIRca—32 inches +, indurated caliche; uppermost 4 to 10 inches consists of plates, 1 to 2 inches thick and as much as 8 inches in diameter; indurated caliche is laminar, especially in the upper layers of plates; caliche is softer as depth increases; pH 8.0.

The A horizon ranges from 6 to 10 inches in thickness. The color of the A horizon ranges from reddish brown to dark brown. The hues range from 5YR to 7.5YR, with values of 3 to 5 and chromas of 2 to 4.

The B21t horizon ranges from 8 to 30 inches in thickness. Its color ranges from dark reddish brown to yellowish red; the hues range from 2.5YR to 7.5YR, the dominant hue being 5YR. The values range from 3 to 6, and the chromas from 3 to 6.

The depth to hard, platy caliche ranges from 14 to 36 inches. Within the areas the depth varies as much as 10 to 12 inches within a distance of 500 feet.

BERTHOUD SERIES

This series consists of brown to dark grayish-brown moderately deep, well-drained, calcareous Regosols. These soils are on long, narrow foot slopes and developed in alluvium washed from higher lying soils. The slopes are concave and range from 5 to 20 percent. They follow the contour of the higher slopes that border the draws. Vertically, they are irregular because they are cut by secondary small drainageways that lead into the main draws. Permeability is moderately rapid. The principal vegetation is black grama, hooded windmillgrass, sand dropseed, perennial three-awn, sand sage, and broom snake-weed.

The Berthoud soils lie just above the Spur soils, which are on the bottom of the draws, and they occur with Potter soils. They are shallower, lighter colored, and more sloping than the Spur soils and are deeper than the Potter soils. The Berthoud soils in this county are mapped only in a complex with the Potter soils.

The following describes a typical profile of Berthoud fine sandy loam in an area where the slope is about 5 percent (0.3 mile east and 0.15 mile north of the southwest corner of section 224, block G, 8 miles southwest of Seminole on Farm Road 181) :

- A1—0 to 10 inches, dark grayish-brown (10YR 4/2) fine sandy loam, very dark grayish brown (10YR 3/2) when moist; weak, prismatic structure; soft when dry, very friable when moist, and slightly sticky when wet; many fine and common medium roots; common insect casts and burrows; noncalcareous; gradual boundary.
- AC—10 to 38 inches, brown (10YR 5/3) loam, brown (10YR 4/3) when moist; strongly calcareous; gradual boundary.
- Cca—38 to 72 inches +, light yellowish-brown (10YR 6/4) loam, yellowish brown (10YR 5/4) when moist; common fine fragments of calcium carbonate; very strongly calcareous.

The texture of the A horizon ranges from loam to fine sandy loam, and the thickness of that horizon ranges from 8 to 12 inches. The color ranges from brown to dark grayish brown with a hue of 10YR, a range in value from 4 to 5, and range in chroma from 2 to 4.

The texture of the AC horizon ranges from sandy clay loam to loam, and the thickness of that horizon ranges from 20 to 36 inches. The color ranges from light yellowish brown to brown with a hue of 10YR, a range in value from 5 to 6, and a range in chroma from 3 to 4.

Depth to the Cca horizon ranges from 36 to 60 inches. The texture of that horizon ranges from sandy clay loam to loam. The color ranges from brown to very pale brown with a hue of 10YR, a range in value from 5 to 7, and a range in chroma from 3 to 4.

BROWNFIELD SERIES

This series consists of loose, sandy Reddish Brown soils that developed in reddish, windblown fine sandy loam and sandy clay loam. In some places a relict layer of soft or cemented caliche is 3 to 10 feet below the surface. In those areas the entire mantle of windblown material has been subject to soil-forming processes that have left no identifiable parent material.

The Brownfield soils occupy areas 10 to 40 acres in size. They occur throughout the county and make up about 68 percent of the acreage. The areas are undulating. The slopes are concave and convex and range from 0 to 3 percent. These soils are moderately permeable and well drained. They are used mainly for range, but large areas are cultivated. The principal vegetation is sand dropseed, little bluestem, perennial three-awn, shin oak, mesquite, and some sand sage. Grain sorghum and cotton are grown in both dryfarmed and irrigated areas.

The Brownfield soils occur with the Amarillo, Tivoli, and Springer soils. They have a thicker and more sandy surface layer and a more sandy subsoil than the Amarillo soils. They are also more undulating than the Amarillo soils and lack a horizon of calcium carbonate accumulation. Unlike the Tivoli soils, which are sandy throughout the profile, the Brownfield soils have a subsoil of sandy clay loam. Their subsoil is less sandy than that of the Springer soils.

The following describes a typical profile of Brownfield fine sand in an area where the slope is about 1 percent (0.5 mile east and 100 feet north of the southwest corner of section 6, block C-31, 6.5 miles east of Loop, north of State Highway 83) :

- A1—0 to 7 inches, reddish-brown (5YR 5/4) fine sand, reddish brown (5YR 4/4) when moist; structureless; loose when dry, nearly loose when moist, and nonsticky when wet; many very fine and common fine and medium roots; noncalcareous; pH 7.0; clear boundary.
- A2—7 to 16 inches, yellowish-red (5YR 5/6) fine sand, yellowish red (5YR 4/6) when moist; structureless; loose when dry, nearly loose when moist, and nonsticky when wet; many very fine and few fine to medium roots; noncalcareous; pH 7.0; clear boundary.
- B21t—16 to 34 inches, red (2.5YR 4/6) sandy clay loam, dark red (2.5YR 3/6) when moist; moderate, very coarse, prismatic and weak, subangular blocky structure; very hard when dry, firm when moist, and sticky when wet; many very fine and common fine roots, tubes, and pores; few insect casts and burrows; noncalcareous; pH 7.0; gradual boundary.
- B22t—34 to 47 inches, red (2.5YR 5/6) sandy clay loam, red (2.5YR 4/6) when moist; very coarse, prismatic structure; very hard when dry, friable when moist, and sticky when wet; few very fine to fine roots, tubes, and pores; noncalcareous; pH 7.0; clear boundary.
- C—47 to 60 inches +, red (2.5YR 5/8) fine sandy loam, red (2.5YR 4/8) when moist; slightly sticky when wet; few very fine roots; noncalcareous; pH 7.0.

The A horizons range from 10 to 40 inches in thickness. The color of the A horizons ranges from reddish yellow to reddish brown. The hues range from 5YR to 7.5YR, with values from 5 to 6 and chromas from 4 to 6.

The B21t horizon ranges from 10 to 30 inches in thickness. Its color ranges from red to yellowish red; the hues range from 2.5YR to 5YR, the values from 4 to 5, and the chromas from 4 to 8. The B22t horizon ranges from 10 to 20 inches in thickness and from red to yellowish red in color; the hues range from 2.5YR to 5YR, with values ranging from 4 to 5 and chromas ranging from 6 to 8. A hue of 2.5YR is most common.

Depth to the C horizon ranges from 30 to 90 inches. The texture of the C horizon ranges from light sandy clay loam to loamy fine sand. The color ranges from red to yellowish red; the hue ranges from 2.5YR to 5YR, with values ranging from 4 to 6 and chromas ranging from 6 to 8. Depth to cemented or indurated caliche ranges from 3 to 11 feet.

In some areas where the elevation is 1 to 2 feet lower than that of the surrounding Brownfield soils, the color of the C horizon is neutral light brownish gray to very pale brown; with a hue of 10YR, values ranging from 6 to 7, and chromas ranging from 2 to 3. In those areas the texture of the C horizon ranges from sandy clay loam to fine sandy loam.

DRAKE SERIES

This series consists of strongly calcareous Regosols that developed in deposits of calcareous fine sandy loam to clay blown from playas or from areas of Arch soils. The sediments date from the Pleistocene epoch. At the time these soils were forming, the prevailing winds were from the west and southwest. Therefore, the soils consist of stabilized dunes on the leeward, or east and northeast sides of playas.

The Drake soils occur in patterns of various sizes in areas where the slopes are long and narrow and are convex and crescent or oblong shaped. The slopes range from 1 to 30 percent. The soils are well drained and have moderately rapid permeability. The principal vegetation is sideoats grama, blue and black grama, and four-winged saltbush. Small areas that occur within larger areas of soils more suitable for cropping are used for cultivated crops.

The Drake soils occur with the lower lying Arch and Portales soils. They are steeper than the Arch soils and are lighter colored and more calcareous than the Portales soils.

The following describes a typical profile of Drake fine sandy loam in an area on the east side of McKenzie Lake where the slope is about 3 percent (League 293, 19 miles east of Seminole, 100 feet north of U.S. Highway No. 180) :

- A1—0 to 8 inches, light brownish-gray (10YR 6/2) fine sandy loam, grayish brown (10YR 5/2) when moist; weak, prismatic structure; soft when dry, very friable when moist, and slightly sticky when wet; many fine roots, tubes, and pores; strongly calcareous; pH 8.0; diffuse boundary.
- AC—8 to 30 inches, white (10YR 8/2) clay loam, light gray (10YR 7/2) when moist; structureless; soft when dry, friable when moist, and sticky when wet; very strongly calcareous; pH 8.0; diffuse boundary.
- C—30 to 50 inches, white (10YR 8/2) clay loam, light gray (10YR 7/2) when moist; soft and chalky; very strongly calcareous; pH 8.0.

The A horizon ranges from 6 to 12 inches in thickness and from light clay loam to heavy fine sandy loam in texture. The color of the A horizon ranges from light gray to very pale brown, with a hue of 10YR, values ranging

from 5 to 7, and chromas from 1 to 4. The AC horizon ranges from 10 to 24 inches in thickness and from white to light brownish gray in color. The hue is 10YR; values range from 6 to 8, and chromas from 1 to 2.

Depth to the C horizon ranges from 20 to 40 inches. The color of the C horizon ranges from white to light gray, with hues ranging from 10YR to 2.5Y, values from 7 to 8, and chromas from 1 to 2.

GOMEZ SERIES

This series consists of moderately deep, light-colored, sandy Calcisols that developed in strongly calcareous, unconsolidated, sandy, eolian-lacustrine sediments. These soils occupying nearly level, low-lying, shallow depressions within larger areas of Brownfield soils. The slopes are less than 2 percent, very gently undulating, and slightly concave. The soils are well drained and have moderately rapid permeability. The principal vegetation consists of sideoats grama, black grama, hooded windmillgrass, and a moderate stand of shin oak.

The Gomez soils are more sandy throughout the profile than the Portales soils, and their surface layer is lighter colored. They are less reddish and less clayey than the Brownfield soils, but they are more calcareous and more permeable than those soils. They are less reddish than the Springer soils and are calcareous below the surface layer, rather than noncalcareous.

The following describes a typical profile of Gomez loamy fine sand (0.1 mile east and 0.25 mile north of the southwest corner of section 14, block A-27, 30 miles southwest of Seminole) :

- A1—0 to 14 inches, brown (10YR 5/3) loamy fine sand, dark brown (10YR 4/3) when moist; structureless; loose when dry, nearly loose when moist, and nonsticky when wet; common fine and few medium roots; noncalcareous; pH 6.5; clear boundary.
- AC—14 to 26 inches, light brownish-gray (10YR 6/2) fine sandy loam, grayish brown (10YR 5/2) when moist; weak, subangular blocky structure; soft when dry, very friable when moist, and slightly sticky when wet; common fine to medium insect casts and burrows; strongly calcareous; pH 7.5; gradual boundary.
- Cca—26 to 34 inches, light-gray (10YR 7/2) fine sandy loam, light brownish gray (10YR 6/2) when moist; common medium fragments of calcium carbonate; very strongly calcareous; pH 8.0; gradual boundary.
- C—34 to 60 inches ±, white (10YR 8/2) light sandy clay loam, light gray (10YR 7/2) when moist; pH 8.0; very strongly calcareous.

The A horizon ranges from 10 to 24 inches in thickness and from loamy fine sand to fine sand in texture. The color of the A horizon ranges from dark brown or brown to dark grayish brown, with hues ranging from 7.5YR to 10YR, values ranging from 4 to 5, and chromas ranging from 2 to 3. The thickness of the AC horizon ranges from 6 to 24 inches. The color of the AC horizon ranges from light brownish gray or grayish brown to pale brown, with a hue of 10YR. The values range from 4 to 6, and the chromas from 2 to 3.

Depth to the Cca horizon ranges from 20 to 36 inches. The color of the Cca horizon ranges from light gray to white, with a hue of 10YR, a range in value from 6 to 8, and a range in chroma from 1 to 2. Depth to the C horizon ranges from 24 to 48 inches. The color of the C horizon ranges from white to light brownish gray, with hues ranging from 10YR to 2.5Y, values from 5 to

8, and chromas from 1 to 2. In places cemented caliche is at a depth ranging from 30 to 84 inches.

KIMBROUGH SERIES

This series consists of dark, noncalcareous or weakly calcareous Lithosols that are very shallow over caliche and that developed in material weathered from thick beds of indurated, stonelike caliche. The thickness of the solum varies within short distances.

In places the Kimbrough soils occupy areas as large as 200 to 300 acres. They are on smooth plains where the slopes are convex and less than 3 percent. Drainage is good and permeability is moderate.

The soils have few to many small fragments of indurated caliche on the surface. In small areas the topmost 2 to 3 inches of soil material has been shifted about or removed by wind erosion and concretions and flat rock are exposed. In places water erosion has caused small rills and gullies on the steeper slopes and has caused the vegetation to grow in small clumps or on pedestals. The principal vegetation is sideoats grama, black grama, mesquite, and broom snakeweed.

The Kimbrough soils are at a higher elevation than the Potter soils and at a lower elevation than the Arvana soils. In some places the swales between areas of Kimbrough soils are occupied by Stegall soils. The Kimbrough soils are darker and have a smoother surface layer than the Potter soils. Also, most of the lime has been leached out of the surface layer, and the rest of the profile is not strongly calcareous like that of the Potter soils. More vegetation grows on the Kimbrough than on the Potter soils.

The following describes a typical area of Kimbrough loam in an area where the slope is about 1 percent (0.4 mile south and 100 feet west of the northeast corner of section 190, block C, south of Seminole):

A—0 to 5 inches, dark grayish-brown (10YR 4/2) loam, very dark grayish brown (10YR 3/2) when moist; moderate, fine, subangular blocky structure; soft when dry, friable when moist, and slightly sticky when wet; many fine and common medium roots and tubes; noncalcareous; pH 6.5; abrupt boundary.

Rca—5 inches +, hard, platy caliche that has a hardness of 3 or more on the Mohs scale.

In general the texture of the surface layer ranges from loam to gravelly loam, but in some places it is fine sandy loam or light clay loam. Depth to caliche ranges from 2 to 14 inches. The color ranges from dark grayish brown to dark brown; the hue is commonly 10YR, but in some areas where these soils occur with the Arvana soils, the hue is 7.5YR. The values range from 3 to 5, and the chromas from 2 to 3.

LUBBOCK SERIES

This series consists of smooth, nearly level Chestnut soils that developed in moderately fine textured, windblown or alluvial sediments that date from the Pleistocene epoch. The underlying material is whitish, strongly calcareous clay loam or light clay.

The Lubbock soils occur with the Randall soils in small depressions 2 to 10 acres in size. They receive runoff from the surrounding higher lying soils, but they are well drained. Permeability is slow. The principal vegetation is buffalograss, sedges, and devilsclaw vines.

The Lubbock soils developed in material similar to that in which the Amarillo soils developed; the main difference is that the Lubbock material is more highly calcified and more compact. Lubbock soils are less reddish and more clayey than the Amarillo soils and less clayey than the Randall soils.

The following describes a typical profile of Lubbock clay loam (0.3 mile east and 0.55 mile north of the southwest corner of section 161, block G, 1 mile south and 0.3 mile east of Seminole):

A1—0 to 12 inches, dark-brown (10YR 4/3) clay loam, dark brown (10YR 3/3) when moist; compound moderate, coarse, prismatic and moderate, medium, subangular blocky structure; hard when dry, friable when moist, and very sticky when wet; many very fine roots; noncalcareous; pH 7.0; clear boundary.

B1—12 to 18 inches, very dark grayish-brown (10YR 3/2) clay loam, very dark brown (10YR 2/2) when moist; moderate, coarse, prismatic and moderate, medium, subangular blocky structure; hard when dry, friable when moist, and very sticky when wet; few to common fine to medium roots, pores, and worm casts; noncalcareous; pH 7.5; gradual boundary.

B21—18 to 24 inches, dark grayish-brown (10YR 4/2) heavy clay loam, very dark grayish brown (10YR 3/2) when moist; very hard when dry, firm when moist, and very sticky when wet; few fine roots on the surfaces of peds; noncalcareous; pH 7.5; gradual boundary.

B22—24 to 34 inches, dark-gray (10YR 4/1) light clay, very dark gray (10YR 3/1) when moist; strong, fine to medium, blocky structure that breaks down to fine, angular blocky; extremely hard when dry, very firm when moist, and very sticky and plastic when wet; few fine and very fine roots that follow the surfaces of peds; noncalcareous; pH 7.5; gradual boundary.

Cca—34 to 48 inches +, gray (10YR 6/1) heavy clay loam, gray (10YR 5/1) when moist; moderate, fine, subangular blocky and granular structure; hard when dry, friable when moist, and very sticky when wet; 20 percent, by volume, is concretions of calcium carbonate; very strongly calcareous.

The A horizon ranges from 8 to 12 inches in thickness and from heavy clay loam to sandy clay loam in texture. Its color ranges from dark brown to grayish brown; the hues range from 7.5YR to 10YR, the values from 3 to 4, and the chromas from 2 to 4.

The B horizons range from 22 to 36 inches in thickness and from heavy clay loam to light clay in texture. The color ranges from very dark gray to dark grayish brown, with a hue of 10YR, values from 3 to 6, and chromas from 1 to 2.

Depth to the Cca horizon ranges from 30 to 50 inches. The color of the Cca horizon ranges from pink to white or gray; the hues range from 7.5YR to 10YR, the values from 6 to 8, and the chromas from 1 to 4.

PORTALES SERIES

In this series are calcareous, grayish-brown, loamy Calcisols that developed in strongly calcareous old alluvium from lakebed deposits. The soils are in broad, shallow valleys throughout the northern half of the county, generally in areas 20 to 40 acres in size. The slopes are smooth and range from 0 to 3 percent, but in most places they are about 2 percent. Drainage is good, and permeability is moderately rapid. The principal grasses are sideoats grama and blue and black grama. Mesquite is the major invader.

These soils occur with the Zita and Arch soils and are surrounded by slightly higher lying Amarillo and Brown-

field soils. They are lighter colored than the Zita soils and are calcareous to the surface, rather than noncalcareous to a depth of 10 to 20 inches. They are deeper and darker colored than the Arch soils and have less lime in the surface layer. Normally, the Portales soils are shallower and less reddish than the Amarillo soils.

The following describes a typical profile of Portales fine sandy loam in an area where the slope is 1 percent (0.5 mile west and 100 feet north of the southeast corner of section 13, 20 miles southwest of Seminole):

- Ap—0 to 12 inches, dark-brown (10YR 4/3) fine sandy loam, dark brown (10YR 3/3) when moist; weak, prismatic, and weak, subangular blocky structure; soft when dry, very friable when moist, and nonsticky when wet; common fine and few medium root cavities; strongly calcareous; pH 8.0; clear boundary.
- AC—12 to 34 inches, brown (10YR 5/3) sandy clay loam, dark brown (10YR 4/3) when moist; weak, prismatic structure; slightly hard when dry, friable when moist, and slightly sticky when wet; many fine roots and worm casts; strongly calcareous; pH 8.0; gradual boundary.
- Cca—34 to 44 inches, white (10YR 8/2) sandy clay loam, light gray (10YR 7/2) when moist; hard when dry, friable when moist, and sticky when wet; many, fine, soft concretions of calcium carbonate; very strongly calcareous; gradual boundary.
- C—44 to 60 inches +, very pale brown (10YR 7/3) clay loam, pale brown (10YR 6/3) when moist; hard when dry, friable when moist, and sticky when wet; very strongly calcareous.

The A horizon ranges from 6 to 18 inches in thickness and from loam to fine sandy loam in texture. The color of the A horizon ranges from dark grayish brown to brown. The hue is 10YR, with values ranging from 4 to 5, and chromas from 2 to 3.

The AC horizon ranges from 12 to 24 inches in thickness. Its color ranges from grayish brown to brown or pale brown; the hue is 10YR, the values range from 5 to 7, and the chromas from 2 to 3.

Depth to the Cca horizon ranges from 22 to 36 inches. Its color ranges from pink to white; the hue ranges from 7.5YR to 10YR, the value from 7 to 8, and the chromas from 2 to 4.

Depth to the C horizon ranges from 30 to 48 inches. The color of the C horizon ranges from reddish yellow or very pale brown to white; the hue ranges from 7.5YR to 10YR, the value from 6 to 7, and the chroma from 2 to 6.

POTTER SERIES

The soils of this series are calcareous, pale-brown to dark grayish-brown Lithosols. They are very shallow over weakly cemented caliche or a mixture of soil material and caliche that is more than half calcium carbonate.

These soils occur as narrow bands on steep convex slopes of ancient drains. The slopes are irregular and range from 8 to 20 percent. Small secondary drainageways lead into the main draws. The soils are well drained and moderately permeable. The principal grasses are black grama, sand dropseed, and broom snakeweed.

In most places the Potter soils occur with the Arvana and Amarillo soils, but they are at a lower elevation than those soils. They are more calcareous and lighter colored than the Kimbrough soils, and they are underlain by softer caliche.

The following describes a typical profile of Potter loam in an area where the slope is about 12 percent (0.3 mile east

and 0.1 mile north of the southwest corner of section 224, block G, 6 miles southwest of Seminole on Farm Road 181):

- A1—0 to 6 inches, grayish-brown (10YR 5/2) loam, dark grayish brown (10YR 4/2) when moist; weak, subangular blocky structure; soft when dry, very friable when moist, and slightly sticky when wet; few medium and common fine roots; few medium fragments of calcium carbonate; strongly calcareous; pH 7.5; abrupt boundary.
- R—6 inches +, subrounded or irregularly shaped fragments of caliche, roughly 1 to 3 inches in diameter, with fine-textured material between the fragments.

The A horizon ranges from 2 to 10 inches in thickness and from heavy loam to fine sandy loam in texture. The color ranges from pale brown to dark grayish brown. The hue is 10YR, the value ranges from 4 to 6, and the chroma from 1 to 3. The fragments of caliche in the R horizon are weakly to strongly cemented.

RANDALL SERIES

This series consists of gray to dark-gray, clayey Grumusols that occupy the floors of enclosed depressions or intermittent lakes. These lakes were probably formed by water that dissolved the underlying bedrock. The AC horizon is dark-gray or gray, tough, plastic clay that is slowly permeable. The underlying material contains alluvial silt and clay washed from surrounding higher lying soils.

In this county the Randall soils generally occur in a circular or oval pattern in depressions or playas. The areas are about 4 to 10 acres in size. In most places the Randall soils are smooth and nearly level, but in some areas they have a gilgai relief with wallows 2 to 3 feet across and 6 to 8 inches deep. Drainage is poor to fair, but in most places it is better than is typical for the Randall soils. Permeability is slow, and at times the soils are under water for a short period after heavy rains. The principal vegetation is buffalograss, some of the sedges, and annual weeds.

The following describes a typical profile of Randall clay (0.25 mile east and 0.05 mile north of the southwest corner of section 161-G, 1 mile southeast of Seminole):

- A1—0 to 20 inches, dark-gray (10YR 4/1) clay, very dark gray (10YR 3/1) when moist; moderate, fine to medium, irregular blocky structure; hard when dry, firm when moist, and very sticky when wet; common very fine and fine roots and tubes; common insect casts; weakly calcareous; gradual boundary.
- AC—20 to 58 inches, gray (10YR 5/1) clay, dark gray (10YR 4/1) when moist; moderate, medium, subangular blocky structure; extremely hard when dry, firm and sticky when moist, and sticky and plastic when wet; few very fine roots; strongly calcareous; clear boundary.
- C—58 to 70 inches +, light-gray (10YR 6/1) heavy clay loam, gray (10YR 5/1) when moist; moderate, medium, subangular blocky structure; very hard when dry, firm when moist, and very sticky and plastic when wet; common very fine fragments of calcium carbonate; strongly calcareous.

The A horizon ranges from 10 to 30 inches in thickness. The color ranges from very dark gray to grayish brown. The hue is 10YR; values range from 3 to 5, and chromas from 1 to 2. This horizon is neutral to mildly alkaline.

The AC horizon ranges from 20 to 40 inches in thickness and from very dark gray to light brownish gray or gray in color. The hue is 10YR; values range from 3 to 6, and

chromas from 1 to 2. The reaction ranges from mildly alkaline to moderate alkaline.

In some areas there is a Cca horizon. In areas where it is present, that horizon ranges from 20 to 40 inches in thickness. Its color ranges from dark grayish brown to light brownish gray, with hues of 10YR to 2.5Y, values of 4 to 6, and a chroma of 2.

SIMONA SERIES

This series consists of moderately coarse textured, grayish-brown Calcisols. The soils developed in moderately coarse textured sediments, probably eolian, overlying caliche. They are shallow over weakly to strongly cemented calcareous plates or fragments. These fragments are 1 to 2 inches thick and 2 to 8 inches in diameter. They are white and are interspersed with pinkish-white spots of caliche that contain cemented sand grains. The plates are rough and wavy on top and are slightly nodular and concretionary on the bottom. They can be loosened or broken and dug out with a tile spade. Some soil material is mixed with the caliche.

The Simona soils are nearly level to gently sloping and occupy areas 40 to 200 acres in size, mostly in the western half of the county. Drainage is good, and permeability is moderately rapid. The principal vegetation is sideoats grama, blue and black grama, and broom snakeweed.

The more sandy subsoil and the indurated or pronounced cementation of the underlying caliche distinguish the Simona soils from the Portales. Simona soils are less shallow than the associated Kimbrough and Potter soils and are not reddish like the associated Arvana soils. Unlike the Arvana soils, they are calcareous.

The following describes a typical profile of Simona fine sandy loam in an area where the slope is about 1 percent (0.25 mile south and 0.1 mile west of the northeast corner of section 251, block G, 2½ miles northwest of Seminole on Highway 214, then 1 mile west and 1 mile north on a dirt road):

A1—0 to 8 inches, grayish-brown (10YR 5/2) fine sandy loam, dark grayish brown (10YR 4/2) when moist; weak, subangular blocky and weak, prismatic structure; soft when dry, very friable when moist, and slightly sticky when wet; few medium and common fine roots; few fine fragments of calcium carbonate; strongly calcareous; pH 8.0; clear boundary.

AC—8 to 20 inches, pale-brown (10YR 6/3) fine sandy loam, brown (10YR 5/3) when moist; weak, prismatic and weak, subangular blocky structure; soft when dry, very friable when moist, and slightly sticky when wet; common fine roots; common fine to medium worm casts; few medium fragments and concretions of calcium carbonate; very strongly calcareous; pH 8.0; abrupt boundary.

IIRca—20 inches +, fragments of strongly cemented whitish caliche.

The A horizon ranges from 6 to 12 inches in thickness and from dark grayish brown to pale brown in color. The hue is 10YR, with values ranging from 4 to 6 and chromas from 2 to 3. The AC horizon ranges from 4 to 12 inches in thickness. Its color ranges from brown to pale brown; the hue is 10YR, the value ranges from 4 to 6, and the chroma ranges from 2 to 3. Depth to cemented caliche ranges from 12 to 20 inches.

SPRINGER SERIES

This series consists of loose, sandy Reddish Brown soils overlying indurated caliche. In most places the C

horizon is calcareous, pinkish loam or fine sandy loam.

The Springer soils occur throughout the county in nearly level areas where the slopes are less than 3 percent and are undulating and convex. They occupy areas of various size. Drainage is good, and permeability is moderately rapid. The principal vegetation is sideoats grama, black grama, hooded windmillgrass, sand dropseed, sand sage, and shin oak.

The Springer soils occur mostly with the Brownfield soils, but they also occur with Tivoli and Gomez soils. They are somewhat similar to the Brownfield soils, but their subsoil is loam to fine sandy loam instead of sandy clay loam. The Springer soils are less sandy than the Tivoli soils, and they have a textural B horizon that is lacking in those soils. They are more reddish and have a less calcareous subsoil than the Gomez soils.

The following describes a typical profile of Springer loamy fine sand in an area where the slope is about 1 percent (0.5 mile east and 50 feet south of the northwest corner of section 250-G, 4 miles northwest of Seminole on the Denver City Highway, then 1 mile west on a dirt road):

A11—0 to 8 inches, reddish-brown (5YR 4/4) loamy fine sand, dark reddish brown (5YR 3/4) when moist; structureless; loose when dry, nearly loose when moist, and nonsticky when wet; many fine and few medium roots; noncalcareous; pH 6.5; gradual boundary.

A12—8 to 23 inches, reddish-brown (5YR 5/4) loamy fine sand, reddish brown (5YR 4/4) when moist; structureless; loose when dry, nearly loose when moist, and nonsticky when wet; few fine roots; weakly calcareous; pH 7.5; gradual boundary.

B2—23 to 36 inches, light reddish-brown (5YR 6/3) fine sandy loam, reddish brown (5YR 5/3) when moist; weak, prismatic structure; soft when dry, very friable when moist, and slightly sticky when wet; few fine roots; weakly calcareous; pH 7.5; gradual boundary.

Cca—36 to 44 inches, pink (5YR 7/4) fine sandy loam, light reddish brown (5YR 6/4) when moist; structureless; soft when dry, very friable when moist, and slightly sticky when wet; very strongly calcareous; abrupt boundary.

IIRca—44 inches +, indurated caliche.

The A horizons range from 10 to 30 inches in thickness. The color of the A horizons range from reddish brown to reddish yellow. The hue ranges from 5YR to 7.5YR, with values from 4 to 6 and chromas from 3 to 6. The B horizon ranges from 6 to 40 inches in thickness and from loam to fine sandy loam in texture. It is noncalcareous to strongly calcareous. Its color ranges from light reddish brown to reddish yellow; the hues range from 5YR to 7.5YR, with values from 5 to 7 and chromas from 3 to 6.

Depth to the Cca horizon ranges from 16 to 60 inches, and this horizon ranges from 6 to 24 inches in thickness. The color of the Cca horizon ranges from pink to reddish yellow; the hues range from 5YR to 7.5YR, with values from 6 to 8 and chromas from 3 to 6. The texture of this horizon ranges from loam to fine sandy loam.

SPUR SERIES

This series consists of pale-brown to dark grayish-brown, calcareous Alluvial soils. The soils are smooth and nearly level; the slopes are concave and are less than 1 percent. These soils occur only on the floors of ancient drainage channels that cross the county from the northwest to the southeast. They are moderately well drained

and moderately permeable. The principal vegetation is blue grama, vine-mesquite, and small mesquite trees.

The Spur soils occur with Potter soils, which occupy the steep slopes on the edge of draws, and they also occur with Berthoud soils. They are at a lower elevation than these associated soils and are darker than the Berthoud soils.

The following describes a typical profile of Spur fine sandy loam (0.05 mile east of the southwest corner of section 292-G, 4 miles southwest of Seminole on Farm Road 181, then 4 miles west on a paved county road) :

- A1—0 to 10 inches, grayish-brown (10YR 5/2) fine sandy loam, very dark grayish brown (10YR 3/2) when moist; weak, subangular blocky structure; slightly hard when dry, very friable when moist, and slightly sticky when wet; many fine and common medium roots, tubes, and pores; common insect casts and burrows; common very fine fragments of calcium carbonate; strongly calcareous; pH 8.0; clear boundary.
- AC—10 to 36 inches, pale-brown (10YR 6/3) heavy fine sandy loam, dark brown (10YR 4/3) when moist; moderate, coarse, prismatic and weak, subangular blocky structure; slightly hard when dry, friable when moist, and sticky when wet; common fine and few medium roots, tubes, and pores; common insect casts and burrows; common very fine fragments of calcium carbonate; strongly calcareous; pH 8.0; clear boundary.
- Cca—36 to 45 inches, white (10YR 8/2) clay loam, light gray (10YR 7/2) when moist; slightly hard when dry, friable when moist, and sticky when wet; very strongly calcareous; gradual boundary.
- C—45 to 72 inches +, very pale brown (10YR 8/3) clay loam or loam, very pale brown (10YR 7/3) when moist; soft when dry, very friable when moist, and slightly sticky when wet; very strongly calcareous.

The A horizon ranges from 8 to 24 inches in thickness and from clay loam to fine sandy loam in texture. This horizon is less sandy in the northwestern part of the county than in other areas; the content of sand increases toward the southeastern corner of the county. The color of the A horizon ranges from pale brown to dark grayish brown; the hue is 10YR, and values range from 4 to 6 and chromas from 2 to 3. This horizon ranges from noncalcareous to strongly calcareous.

The AC horizon ranges from 24 to 48 inches in thickness and from clay loam to fine sandy loam in texture. The color of the AC horizon ranges from very pale brown to dark grayish brown. The hue is 10YR; the values range from 4 to 7 and the chromas from 2 to 3.

Depth to the Cca horizon ranges from 30 to 60 inches. The color of that horizon ranges from light gray to white; the hue is 10YR, the value 7 to 8, and the chroma 2 to 3.

The texture of the C horizon ranges from clay loam to light fine sandy loam. The color of the C horizon ranges from grayish brown to very pale brown. The hue is 10YR, the value 5 to 8, and the chroma 2 to 3.

STEGALL SERIES

This series consists of very dark grayish-brown, noncalcareous, moderately deep Chestnut soils that developed in moderately fine textured, unconsolidated, calcareous plains sediments on nearly level uplands. The underlying material is indurated caliche.

These soils are smooth and nearly level. Runoff from the surface is slow, and permeability is slow in the subsoil. The principal vegetation is buffalograss and annual weeds.

The Stegall soils occur with the Kimbrough soils, but they are not shallow like those soils. They are less reddish, less sandy, and less permeable than the Amarillo and Arvana soils. Unlike the Amarillo and Portales soils, they are underlain by indurated caliche. They are less grayish and less permeable than the Portales soils and are not calcareous to the surface.

The following describes a typical profile of Stegall loam in an area where the slope is about 1 percent (0.15 mile east and 75 feet north of the southwest corner of section 161, block G, 1 mile southeast of Seminole) :

- A1—0 to 8 inches, dark grayish-brown (10YR 4/2) loam, very dark grayish brown (10YR 3/2) when moist; moderate, fine to medium, subangular blocky structure; very hard when dry, firm when moist, and very sticky when wet, common very fine, many fine, and common medium roots, tubes, and pores; many insect casts and burrows; few medium and coarse fragments; noncalcareous; pH 6.5; gradual boundary.
- B21t—8 to 23 inches, dark grayish-brown (10YR 4/2) heavy clay loam, very dark grayish brown (10YR 3/2) when moist; weak to moderate, medium, subangular blocky structure; extremely hard when dry, firm and sticky when moist, and very sticky and plastic when wet; many very fine and fine and few medium roots, tubes, and pores; common insect casts and burrows; noncalcareous; pH 6.5; gradual boundary.
- B22t—23 to 38 inches, dark-brown (10YR 4/3) light clay, dark brown (10YR 3/3) when moist; moderate, medium, blocky structure; extremely hard when dry, firm and sticky when moist, and very sticky and plastic when wet; common very fine to fine roots and tubes; few insect casts; few fragments of calcium carbonate in lower 8 inches; noncalcareous; pH 6.5; abrupt boundary.
- IIRca—38 inches +, indurated caliche.

The A horizon ranges from 4 to 12 inches in thickness. The color of the A horizon ranges from very dark grayish brown to brown; the hue is 10YR, with values ranging from 3 to 5 and chromas from 2 to 3.

The color of the B21t horizon ranges from very dark grayish brown to brown; the hue is 10YR, with values ranging from 3 to 5 and chromas from 2 to 3. Depth to indurated caliche ranges from 24 to 40 inches.

TIVOLI SERIES

This series consists of deep, light-colored, loose sands in the Regosol great soil group. Most of the fine sediments have been sorted out by wind and blown away so that the soils now consist of deep fine sand. The siliceous, sandy material resists breakdown into finer material, and as a result, these soils have practically no profile development. Because the content of organic matter supplied by decaying plants is small, the uppermost 8 to 10 inches is only slightly darkened by organic matter.

The Tivoli soils are billowy and rolling and occur as choppy dunes as high as 10 to 15 feet, with slopes as steep as 20 percent. They occupy two areas in this county, one in the northeastern part along the Dawson County line, and the other in the southwestern corner. The soils are well drained and have rapid permeability. The principal vegetation is sand bluestem, giant dropseed, sand dropseed, perennial three-awn, shin oak, and sand sage.

The Tivoli soils occur with the Brownfield and Springer soils. They are more sandy than those soils.

The following describes a typical profile of Tivoli fine sand (0.75 mile south and 0.2 mile west of the northeast

corner of section 16, block 28, 35 miles southwest of Seminole):

- A—0 to 8 inches, pale-brown (10YR 6/3) fine sand, brown (10YR 5/3) when moist; single grain (structureless); loose when dry, nearly loose when moist, and nonsticky when wet; few fine and common medium roots; noncalcareous; pH 6.5; diffuse boundary.
- C—8 to 60 inches +, very pale brown (10YR 7/4) fine sand, light yellowish brown (10YR 6/4) when moist; single grain (structureless); loose when dry, nearly loose when moist, and nonsticky when wet; noncalcareous; pH 6.5.

The A horizon ranges from 2 to 10 inches in thickness. The color ranges from brown to very pale brown, with a hue of 10YR, values ranging from 5 to 7, and chromas ranging from 3 to 4.

The color of the C horizon ranges from pale brown to very pale brown, with a hue of 10YR, values ranging from 6 to 7, and chromas ranging from 3 to 4.

ZITA SERIES

The Zita series consists of moderately deep Chestnut soils in the uplands. The soils occupy areas 20 to 40 acres in size. They occur mostly in the northeastern part of the county and near the town of Seminole. They are smooth and nearly level to very gently sloping; the slopes are less than 1 percent. Drainage is good and permeability is moderate. These soils are cultivated along with the surrounding Amarillo and Portales soils. In addition to cultivated crops, the vegetation is mainly sideoats grama, blue grama, black grama, mesquite, and catclaw.

The Zita soils occur with the Portales soils, but unlike those soils, they have a noncalcareous surface layer. They are less reddish and have a shallower Cca horizon than the Amarillo soils, and they are calcareous below the surface layer, rather than noncalcareous.

The following describes a typical profile of Zita fine sandy loam in an area where the slope is about 1 percent (0.45 mile south and 100 feet west of the northeast corner of section 24, block C-44, 6 miles east of Seminole on U.S. Highway 180, then south on Farm Road 1429):

- A11—0 to 10 inches, brown (10YR 4/3) fine sandy loam, dark brown (10YR 3/3) when moist; weak, subangular blocky structure; slightly hard when dry, very friable when moist, and slightly sticky when wet; many very fine, many fine, and few medium roots, tubes, and pores; many insect casts and burrows; noncalcareous; pH 7.2; clear boundary.
- A12—10 to 16 inches, brown (10YR 5/3) sandy clay loam, dark brown (10YR 3/3) when moist; moderate, coarse, prismatic and weak, subangular blocky structure; hard when dry, firm when moist, and very sticky when wet; many fine and few medium roots; many insect casts and burrows; noncalcareous; pH 7.2; clear boundary.
- AC—16 to 26 inches, pale-brown (10YR 6/3) clay loam, brown (10YR 5/3) when moist; weak, subangular blocky structure; slightly hard when dry, friable when moist, and sticky when wet; common very fine to fine roots, common insect casts and burrows; few very fine fragments and few films of calcium carbonate; strongly calcareous; clear boundary.
- Cca—26 to 31 inches, pink (7.5YR 8/4) light clay loam, pink (7.5YR 7/4) when moist; slightly hard when dry, friable when moist, and sticky when wet; few fine fragments of calcium carbonate; very strongly calcareous; gradual boundary.
- C—31 to 48 inches +, reddish-yellow (5YR 7/6) clay loam, reddish yellow (5YR 6/6) when moist; hard when dry, firm when moist, and sticky when wet; very strongly calcareous.

The A horizon ranges from 8 to 18 inches in thickness and from loam to fine sandy loam in texture. The color of the A horizon ranges from brown to very dark brown; the hue is 10YR, with values ranging from 2 to 5 and chromas from 2 to 3. The AC horizon ranges from 6 to 12 inches in thickness and from clay loam to sandy clay loam in texture. The color of the AC horizon ranges from pale brown to dark grayish brown; the hue is 10YR, with values ranging from 4 to 6 and chromas from 2 to 3.

The texture of the Cca and C horizons ranges from clay loam to light clay loam. The color of those horizons ranges from reddish yellow through pink to very pale brown. The hues range from 5YR to 10YR, the values from 7 to 8, and the chromas from 4 to 6. Depth to indurated caliche ranges from 40 to 60 inches.

General Nature of the County

In this section important features about the geology, climate, and natural resources of the county are described. Also discussed are the social and industrial development, significant facts about agriculture, and the wildlife. The agricultural statistics are mainly from reports of the U.S. Bureau of the Census.

Geology

The outstanding event in the geologic history of Gaines County was the deposition of the Ogallala formation. This formation is the main source of irrigation water in the county. It consists of material deposited more than a million years ago, during the early part of the Pliocene epoch. To understand how this underground formation developed, it is necessary to review the geologic history of the area.

About 180 million years ago (shortly before the uplift of the Appalachian Mountains), a shallow sea covered the area that is now western Texas. Marine sediments that were deposited during this period formed the Permian red beds. While the Appalachian Mountains were being formed, the High Plains rose above the level of the sea. Streams that flowed over the exposed Permian rocks eroded fine-textured material and redeposited it along the flood plains. This material formed the Triassic red beds, the impervious stratum that underlies the Ogallala formation.

During the Cretaceous period, a shallow arm of the sea again partly covered the High Plains. Sand, clay, and limestone were deposited over most of the area.

The formation of the Rocky Mountains was the next significant development. Swift streams from the mountains cut valleys and canyons through the rock formed from the deposits of the Cretaceous period and then cut into the underlying Triassic red beds. Most of the material of the Cretaceous period that had been deposited on the High Plains was washed away, but part of the Cretaceous formation that remains crops out in a small area northwest of Cedar Lake.⁶

⁶ BRAND, JOHN P. CRETACEOUS OF LLANO ESTACADO OF TEXAS. Univ. Tex. Bur. of Econ. Geol. Rept. of Invest. No. 20. Austin, Tex. 59 pp., illus. 1953.

When the Rocky Mountains reached their maximum height, they began to erode. Coarse, gravelly material was carried great distances by the swift streams. As the mountains eroded, the streams became less swift and began to deposit gravel, sand, and silt near their sources. These deposits formed alluvial fans of gravelly, coarse material along the foot slopes of the mountains. The finer material was transported and spread farther to the east.

The Ogallala formation developed in these deposits more than a million years ago. The outwash was deposited just before the beginning of the ice age. The glaciers did not move as far south as Texas, but a much moister climate than the present one prevailed in that area; when the glaciers receded, the climate became more arid. Because precipitation increased during the ice age, streams formed and flowed across the Ogallala formation and the area probably consisted of humid prairies and of wooded tracts along streams. The draws that now cross the county are probably the remains of those streams.

The source of the underground water in Gaines County is the saturated beds of sand and gravel in the lower part of the Ogallala formation, and not an underground river or lake. The Triassic red beds below the Ogallala formation are nearly impervious so it is not likely that water could be obtained from any of the lower strata. During a period of nearly a million years, while the Ogallala formation was developing, water from the Rocky Mountains was stored in a water-bearing stratum. The Pecos River on the west and the Canadian River on the north cut off the Ogallala formation from the mountains and blocked its source of water. At present, rain or snow that falls on the High Plains is probably the only source of water to replenish the underground supply.

The Ogallala formation of water-bearing sand is between 100 and 300 feet thick. Saturated sand is generally thin in this county. The average depth to water is 200 feet.

The water table slopes gently to the southeast, and the water moves very slowly. The natural rate of flow is probably not more than 1 or 2 feet a day. Before wells were drilled for irrigation, the water was discharged mainly by springs along the caprock to the east at about the same rate it was replenished. At present, water is being pumped for irrigation faster than it is being restored.

In places the amount of water available varies considerably because of variations in the thickness of the water-producing stratum and the depth to the red beds. Apparently, the red beds are undulating, and in places they rise nearly to the static water table, or above it. For this reason, probably, certain areas of the county have only a small amount of water available for irrigation.

The material from which the soils developed was deposited during the Pliocene epoch and was then reworked in the Pleistocene epoch. The wind did most of this reworking during the Illinoian age. This age was fairly dry, and the wind shifted and sorted the surface material. During that age, Gaines County was probably a prairie and had a scant supply of water. It was during this period that the soils and vegetation developed as they are now.

Climate ⁷

Gaines County has the warm-temperate, continental climate that is characteristic of the Southern High Plains. Rapid changes and wide variations in the temperature and rainfall are common. Agriculture is risky because of the low annual precipitation, the high velocity of the wind, the high temperature in summer, and the low humidity. Table 5 gives data for temperature and precipitation that are representative for this county.

TABLE 5.—*Temperature and precipitation at Seminole, Tex.*

[Elevation, 3,315 feet]

Month	Temperature ¹			Precipitation ²			
	Average daily maximum	Maximum recorded	Minimum recorded	Average total	Total in driest year (1934)	Total in wettest year (1941)	Average amount of snowfall
	°F.	°F.	°F.	Inches	Inches	Inches	Inches
January.....	42.1	82	-1	0.47	0.10	0.60	1.7
February.....	46.5	86	-23	.64	(³)	.65	1.9
March.....	52.3	91	8	.63	1.28	3.65	1.6
April.....	61.4	99	21	1.04	.52	2.51	.5
May.....	69.1	105	31	2.21	.24	10.58	(³)
June.....	77.6	109	38	2.00	.05	5.61	0
July.....	79.6	112	50	1.93	.31	2.43	(³)
August.....	78.7	109	52	2.06	2.86	1.13	0
September.....	72.6	106	34	2.08	.52	3.41	0
October.....	62.6	98	25	1.91	.58	5.88	(³)
November.....	50.6	89	7	.64	.10	.74	.1
December.....	43.5	85	0	.76	.01	.44	1.5
Year.....	61.4	112	-23	16.37	6.57	37.63	7.6

¹ Average temperature based on a 31-year record, through 1955; highest and lowest temperatures based on a 23-year record, through 1952.

² Average precipitation based on a 32-year record, through 1955; wettest and driest years based on records for the period 1923-1955; snowfall based on a 23-year record, through 1952.

³ Trace.

The average annual rainfall, based on a 32-year record through 1955, is 16.37 inches. This value is misleading, however, because large differences of as much as 200 to 300 percent occur from 1 year to the next. In 1934, the driest year on record, the annual rainfall at Seminole totaled only 6.57 inches, and 44 percent of this amount fell in the month of August. In 1941, the wettest year on record, a total of 37.63 inches was recorded for the same area. Extremely heavy downpours, with rapid runoff, have occurred in most of the several years when excessive precipitation has been received. When such downpours occur, little benefit is derived from the extra rainfall. In the average year, 75 percent of the rainfall occurs during the period from May through October. Most of it is in the form of thunderstorms, and this adds to variability of the climate, as one part of the county may receive excessive rainfall while another section receives none.

⁷ By ROBERT B. ORTON, State climatologist, U.S. Weather Bureau, Austin, Tex.

Snow falls occasionally during the winter months, but it is generally light and remains on the ground only a short time. Infrequently, deep, low-pressure centers that produce heavy snows develop over the Southern Plains late in January or February, but excessive snowfall is rare.

Temperature, like rainfall, varies widely in this county. Many cold spells occur in winter, but they are followed by rapid warming. Consequently, changes in temperature are frequent and pronounced. Summers are hot and usually dry, except for brief thunderstorms, but the low humidity and good circulation of wind lessens the discomfort of the heat. Because of the high elevation (3,315 feet at Seminole) and dry air, summer nights are cool; low temperatures are in the 60's.

The prevailing winds are from the southeast during the warmer months and from the southwest during the colder months. The winds are strongest during severe thunderstorms late in spring and early in summer, but they are gusty and of short duration. The strongest continuous winds occur during February, March, and April; they result from intense low-pressure centers that originate in the High Plains region just east of the Rocky Mountains. In drought years these winds often cause severe duststorms. The soils in the county are highly susceptible to wind erosion, but the extensive cover of grass and shin oak helps to minimize this hazard.

The humidity is relatively low. It is highest early in the morning, usually between 65 and 75 percent, and lowest in the afternoon, generally between 30 and 40 percent.

Hail may accompany thunderstorms at any time, but the most frequent and damaging hailstorms occur during severe thunderstorms late in spring and early in summer.

The growing season is short⁸ compared to that in the central and southern parts of Texas, but it is long enough for cotton, which has increased in importance in recent years. The average monthly rainfall for May is 2.21 inches, as shown in table 5, and this amount is favorable for planting cotton. The best stands of cotton are obtained if the crop is planted after the soil temperature has reached 60° F. at sunrise for 10 consecutive days. This 10-day period usually begins between May 5 and May 10.

The average date of the last occurrence of a temperature of 32° or lower in spring is April 8, and the average date of the first occurrence of a temperature of 32° or lower in fall is November 4. Thus, the average freeze-free season is approximately 210 days. There is a 20-percent chance of the occurrence of freezing temperatures later than April 21 in spring and earlier than October 28 in fall. There is a 5-percent chance of the occurrence of freezing temperatures later than May 4 in spring and earlier than October 21 in fall. The average number of days between the last occurrence of a temperature of 28° or lower in spring and the first occurrence of a temperature of 28° or lower in fall is 224 days.

Sunshine is abundant; the infrequent cloudy weather occurs mostly in the winter and early in spring. The region is semiarid, and evaporation is high. The average evaporation from Weather Bureau evaporation pans is between 105 and 107 inches, and about 66 percent of that amount evaporates during the period May through Octo-

ber. The average annual evaporation from lakes is somewhat less, or about 72 inches per year.

A good supply of underground water is making the agricultural economy less dependent on natural rainfall, but most of the county is still used for range. Thus, a large part of the agricultural economy is still seriously affected by the extreme variability of precipitation.

Natural Resources

The soils are the greatest natural resource in Gaines County, but the supplies of underground water and oil are other important natural resources. Enough underground water for home use and for the use of livestock is available in most parts of the county. There is little or no recharge of the supply, however, and care must be taken to conserve water until other sources are found or until an effective system of recharge is devised. Facts about the ground water in the county are given in the section "Geology," and facts about irrigation and the management of irrigated soils are given in the section "Use and Management of the Soils."

The first producing oil well was drilled in this county in 1935. Wells drilled in that year are still productive, and the drilling of new wells has continued. At the time this survey was made, 17 oilfields were in the county and 4,400 wells were active.

Social and Industrial Development

Before 1874 the Comanche Indians lived in the area now known as Gaines County. Cedar Lake is reputedly the birthplace of Quannah Parker, the last chief of the Comanches, and near that lake are the remains of an Indian burial ground. The Indians hunted buffalo that ranged by the thousands over the vast, treeless plains, and they caught quail and antelope, which were plentiful in the area.

The abundance of native grasses suitable for grazing livestock first attracted settlers to the area. The settlers established ranches near sources of water, and stock farming and ranching were soon the main occupations. Before wells were dug and windmills were built, the use of the range was controlled by people who held water rights to the few natural springs. Seminole Wells, southwest of the present town of Seminole, was a well-known watering place.

Later, farmers were attracted by the fertile soils. Good yields of cotton, grain sorghum, and other crops encouraged farming in years when rainfall was favorable. By 1876 enough settlers had come into the area so that Gaines County was created from Bexar Territory. Gaines County was attached to several other counties for judicial purposes, however, and was not organized until 1905.

The first attempts at irrigation were made in 1912, and efforts to irrigate the soils were renewed in the 1940's. After that time, the rapid increase in the number of irrigation wells brought an increase in the production of crops.

As more land was used for crops, the need arose for better farm-to-market roads. Now, approximately 250 miles of hard-surfaced roads serve the county, and all communities are connected by paved roads. Most farms are within 4 miles of at least one paved road. The unpaved

⁸BLOOD, RICHARD D., AND HILDRETH, R. J. LATE SPRING AND EARLY FALL LOW TEMPERATURES IN TEXAS. *Tex. Agr. Expt. Sta. and Tex. Agr. Ext. Serv. MP 298*, 12 pp., illus. Aug. 1958.

roads are passable, except during the rare periods of severe weather.

U.S. Highway 180 crosses the county in an east-west direction and passes through the town of Seminole; U.S. Highway 385 runs in a north-south direction and passes through Seagraves and Seminole. Texas State Highway 214 connects Seminole with Denver City in Yoakum County and with points north of Denver City. Bus and truck lines operate on the main highways and connect points in this county with other parts of Texas and with New Mexico. One railroad extends into the county as far as Seagraves.

Agriculture

The economy of Gaines County depends primarily on agriculture. Farming consists mainly of growing cotton and grain sorghum for market and of growing grass so that livestock can be pastured. In 1959 there were 467 farms in the county, and a total of 624,629 acres was in farms. Cropland harvested amounted to nearly 218,000 acres. About 63,450 acres of the cropland was irrigated, and most of this, or 54,079 acres, was irrigated by sprinklers. Land in pasture, of which 3,700 acres was improved pasture, totaled 377,597 acres. Cotton was grown on 62,003 acres in 1959, and sorghum was grown on 144,302 acres.

Beef cattle are the most important kind of livestock, and cattle ranches are located throughout the county. Because the production of crops is risky, most farmers raise a few cattle for market so that they will have additional income in years when the harvest is poor. Within the past few years, a large acreage of shallow and steep soils has been reseeded to grass.

A few ranchers have purebred herds, but most ranchers use purebred bulls and have high-grade cows. The quality of the herd is gradually improved by culling annually and selling the old and inferior animals. Some of the cattle are sold at auction in nearby towns, but cattle from the larger ranches are generally shipped to distant markets, such as those at Fort Worth and Lubbock. Most of the cattle are kept on the range throughout the year. In winter cottonseed cake and bundle feed are used to supplement the range forage. In summer sudangrass and bermudagrass are used for temporary grazing. This allows the native grasses to rest during part of the growing season, and the grasses can make some growth and produce seed.

In addition to beef cattle, most farmers and ranchers keep a few milk cows, mostly to provide milk for home use, but only 250 milk cows were in the county in 1959. The number of horses and mules has declined rapidly since the use of tractors has become common. At present, horses are used only for ranching and for recreation. Few of the farmers raise hogs. In this county the number of hogs has never been high; in 1959 there were 4,850 hogs and pigs in the county, and most of these were marketed locally. Chickens 4 months old or older numbered about 114,000 in 1959. Sheep are of minor importance.

Wildlife

Bobwhite, blue quail, and mourning dove are the principal game birds in the county. Crows, sandhill cranes,

and curlews also inhabit the county, and there are many different kinds of migratory birds.

The county has large numbers of cottontail rabbits and jackrabbits. At times practices to control these animals are needed so that small grains will not be excessively damaged. The ground squirrel is increasing in numbers and may eventually become a pest. There are many field mice and a few porcupines. Skunks are also numerous.

The hardy little prairie dog has survived attempts of farmers and ranchers at eradication. A few small towns of prairie dogs remain in remote areas of Amarillo fine sandy loam and Portales fine sandy loam. The burrows are hazardous to livestock.

Antelope are almost extinct and are protected by a closed season. There is no open season on the few prairie chickens.

Although great quantities of feed crops are raised in this county, little remains on the land in winter; all species of wildlife suffer from lack of food and cover during periods of severe weather in winter and early in spring. The early preparation of cultivated soils not only increases the hazard of wind erosion, but it also destroys essential food and cover for wildlife. Thus, game is threatened by starvation in severe weather. A large acreage of land that was formerly tilled, however, has been planted permanently to tall forage, and these areas provide food and cover for wildlife. The population of both quail and doves has increased in recent years, mainly because rainfall has been favorable.

Glossary

Alluvium. Soil material, such as sand, silt, or clay, that has been deposited on land by streams.

Calcareous soil. A soil containing enough calcium carbonate (often with magnesium carbonate) to effervesce (fizz) visibly when treated with cold, dilute hydrochloric acid.

Caliche. A more or less cemented deposit of calcium carbonate in many soils of warm-temperate areas, as in the Southwestern States. The material may consist of soft, thin layers in the soil or of hard, thick beds just beneath the solum, or it may be exposed at the surface by erosion.

Chlorosis. A yellowing of the leaves resulting from the failure of chlorophyll (the green coloring matter) to develop, usually because of deficiency of an essential nutrient. Leaves of chlorotic plants range from light green through yellow to almost white.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt. See also Texture, soil.

Concretions. Grains, pellets, or nodules of various sizes, shapes, and colors consisting of concentrations of compounds, or of soil grains cemented together. The composition of some concretions is unlike that of the surrounding soil. Calcium carbonate and iron oxide are examples of material commonly found in concretions.

Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are—

Loose.—Noncoherent; will not hold together in a mass.

Friable.—When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

Firm.—When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Plastic.—When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger.

Sticky.—When wet, adheres to other material, and tends to stretch somewhat and pull apart, rather than to pull free from other material.

Hard.—When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Soft.—When dry, breaks to powder or individual grains under very slight pressure.

Cemented.—Hard and brittle; little affected by moistening.

Eolian deposits. Wind-deposited material moved fairly short distances.

Indurated (soil). A soil horizon cemented into a hard mass that will not soften or lose its firmness when wet.

Playas. Flat, generally dry, undrained basins that contain water for periods of time following rains.

Reaction, soil. The degree of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is precisely neutral in reaction because it is neither acid nor alkaline. An acid, or "sour," soil is one that gives an acid reaction; an alkaline soil is one that is alkaline in reaction. In words, the degrees of acidity or alkalinity are expressed thus:

	<i>pH</i>		<i>pH</i>
Extremely acid	Below 4.5	Mildly alkaline	7.4 to 7.8
Very strongly acid	4.5 to 5.0	Moderately alkaline	7.9 to 8.4
Strongly acid	5.1 to 5.5	Strongly alkaline	8.5 to 9.0
Medium acid	5.6 to 6.0	Very strongly alkaline	9.1 and higher
Slightly acid	6.1 to 6.5		
Neutral	6.6 to 7.3		

Sand. Individual rock or mineral fragments in soils having diameters ranging from 0.05 to 2.0 millimeters. Most sand grains consist of quartz, but they may be of any mineral composition. The textural class name of any soil that contains 85 percent or more sand and not more than 10 percent clay. See also Texture, soil.

Silt. Individual mineral particles in a soil that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). Soil of the silt textural class is 80 percent or more silt and less than 12 percent clay. See also Texture, soil.

Soil. A natural, three-dimensional body on the earth's surface that supports plants and that has properties resulting from the integrated effect of climate and living matter acting upon parent material, as conditioned by relief over periods of time.

Solum. The upper part of a soil profile, above the parent material, in which the processes of soil formation are active. The solum in a mature soil includes the A and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the underlying material. The living roots and other plant and animal life characteristic of the soil are largely confined to the solum.

Structure, soil. The arrangement of primary soil particles into compound particles or clusters that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil particles. The principal forms of soil structure are—*platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular*. *Structureless* soils are (1) *single grain* (each grain by itself, as in dune sand) or (2) *massive* (the particles adhering together without any regular cleavage, as in many claypans and hardpans).

Subsoil. Technically, the B horizon; roughly, the part of the profile below plow depth.

Surface layer. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, about 5 to 8 inches in thickness. The plowed layer.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay, and clay. The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine." See also Clay; Sand; Silt.

Underlying material (parent material). The horizon of weathered rock or partly weathered soil material from which soil has formed; horizon C in the soil profile.

GUIDE TO MAPPING UNITS, CAPABILITY UNITS, AND RANGE SITES

[See table 1, p. 7, for the approximate acreage and proportionate extent of the soils, and table 2, p. 27, for predicted average yields per acre; for information significant to engineering, see the section beginning on p. 33]

Map symbol	Mapping unit	Page	Dryland capability unit			Irrigated capability unit		Range site	
			Climatic zone 1	Climatic zone 2	Page	Symbol	Page	Name	Page
AfA	Amarillo fine sandy loam, 0 to 1 percent slopes.	7	IIIe-1	IVe-4	20	IIe-3	24	Mixed Land	30
AfB	Amarillo fine sandy loam, 1 to 3 percent slopes.	8	IIIe-1	IVe-4	20	IIIe-1	25	Mixed Land	30
AmB	Amarillo loamy fine sand, 0 to 3 percent slopes.	6	IVe-1	VIe-5	21	IIIe-3	25	Sandy Land	30
Ar	Arch soils.....	8	IVes-1	VIes-1	22	IIIes-1	26	High Lime	29
AvA	Arvana fine sandy loam, 0 to 1 percent slopes.	8	IIIe-1	IVe-4	20	IIe-3	24	Mixed Land	30
AvB	Arvana fine sandy loam, 1 to 3 percent slopes.	8	IIIe-1	IVe-4	20	IIIe-1	25	Mixed Land	30
AwB	Arvana fine sandy loam, shallow, 0 to 3 percent slopes.	8	IVe-3	VIe-7	21	IIIe-5	26	Mixed Land	30
Be	Berthoud-Potter complex.....	9	VIe-4	VIe-4	22	(¹)		Mixed Plains and Shallow Land	30 31
Br	Brownfield fine sand, thick surface.....	9	VIe-2	VIe-2	22	IVe-2	27	Deep Sand	29
Bs	Brownfield fine sand, thin surface.....	9	IVe-2	VIe-6	21	IIIe-4	26	Sandy Land	30
Bt3	Brownfield soils, severely eroded.....	10	VIe-2	VIe-2	22	(¹)		Sandy Land	30
DrB	Drake soils, 1 to 3 percent slopes.....	10	IVes-1	VIes-1	22	IIIes-1	26	High Lime	29
DrC	Drake soils, 3 to 5 percent slopes.....	10	VIe-3	VIe-3	22	(¹)		High Lime	29
DrD	Drake soils, 5 to 30 percent slopes.....	10	VIe-3	VIe-3	22	(¹)		High Lime	29
Gf	Gomez fine sand.....	11	VIe-1	VIe-1	22	IVe-2	27	Sandy Land	30
Gl	Gomez loamy fine sand.....	11	IVe-1	VIe-5	21	IIIe-3	25	Sandy Plains	31
Km	Kimbrough soils.....	11	VIIIs-1	VIIIs-1	23	(¹)		Shallow Land	31
Lr	Lubbock and Randall soils.....	11	VIw-1	VIw-1	22	(¹)		(²)	
PfA	Portales fine sandy loam, 0 to 1 percent slopes.	11	IIIe-2	IVe-5	20	IIe-4	25	Mixed Plains	30
PfB	Portales fine sandy loam, 1 to 3 percent slopes.	12	IIIe-2	IVe-5	20	IIIe-2	25	Mixed Plains	30
PmA	Portales loam, 0 to 1 percent slopes.....	12	IIIce-2	IVce-2	20	IIe-2	24	Mixed Plains	30
Ps	Portales and Spur soils.....	12	IIIe-1	IVe-4	20	IIe-4	25	Bottom Land	29
Sa	Simona fine sandy loam.....	12	IVe-3	VIe-7	21	IIIe-5	26	Mixed Plains	30
Sb	Springer and Brownfield soils, shallow.....	13	VIe-1	VIe-1	22	IVe-1	26	Sandy Land	30
Sm	Springer and Brownfield soils, moderately deep.	13	IVe-2	VIe-6	21	IIIe-4	26	Sandy Land	30
Sp	Springer loamy fine sand.....	13	VIe-1	VIe-1	22	IVe-2	27	Sandy Land (climatic zone 1) Sandy Plains (climatic zone 2)	30 31
StA	Stegall loam, 0 to 1 percent slopes.....	13	IIIce-1	IVce-1	20	IIe-1	24	(²)	
Tv	Tivoli fine sand.....	14	VIIe-1	VIIe-1	23	(¹)		Deep Sand	29
Tx	Tivoli-Potter complex.....	14	VIIe-1	VIIe-1	23	(¹)		Deep Sand and Shallow Land	29 31
ZfA	Zita fine sandy loam, 0 to 1 percent slopes.	14	IIIe-1	IVe-4	20	IIe-3	24	Mixed Land	30

¹ Not suitable for irrigation.

² Not assigned to a range site; included in site designated for surrounding soils.



Accessibility Statement

The Natural Resources Conservation Service (NRCS) is committed to making its information accessible to all of its customers and employees. If you are experiencing accessibility issues and need assistance, please contact our Helpdesk by phone at (800) 457-3642 or by e-mail at ServiceDesk-FTC@ftc.usda.gov. For assistance with publications that include maps, graphs, or similar forms of information, you may also wish to contact our State or local office. You can locate the correct office and phone number at <http://offices.sc.egov.usda.gov/locator/app>.

The USDA Target Center can convert USDA information and documents into alternative formats, including Braille, large print, video description, diskette, and audiotape. For more information, visit the TARGET Center's Web site (<http://www.targetcenter.dm.usda.gov/>) or call (202) 720-2600 (Voice/TTY).

Nondiscrimination Policy

The U.S. Department of Agriculture (USDA) prohibits discrimination against its customers, employees, and applicants for employment on the basis of race, color, national origin, age, disability, sex, gender identity, religion, reprisal, and where applicable, political beliefs, marital status, familial or parental status, sexual orientation, whether all or part of an individual's income is derived from any public assistance program, or protected genetic information. The Department prohibits discrimination in employment or in any program or activity conducted or funded by the Department. (Not all prohibited bases apply to all programs and/or employment activities.)

To File an Employment Complaint

If you wish to file an employment complaint, you must contact your agency's EEO Counselor (<http://directives.sc.egov.usda.gov/33081.wba>) within 45 days of the date of the alleged discriminatory act, event, or personnel action. Additional information can be found online at http://www.ascr.usda.gov/complaint_filing_file.html.

To File a Program Complaint

If you wish to file a Civil Rights program complaint of discrimination, complete the USDA Program Discrimination Complaint Form, found online at http://www.ascr.usda.gov/complaint_filing_cust.html or at any USDA office, or call (866) 632-9992 to request the form. You may also write a letter containing all of the information requested in the form. Send your completed complaint form or letter by mail to U.S. Department of Agriculture; Director, Office of Adjudication; 1400 Independence Avenue, S.W.; Washington, D.C. 20250-9419; by fax to (202) 690-7442; or by email to program.intake@usda.gov.

Persons with Disabilities

If you are deaf, are hard of hearing, or have speech disabilities and you wish to file either an EEO or program complaint, please contact USDA through the Federal Relay Service at (800) 877-8339 or (800) 845-6136 (in Spanish).

If you have other disabilities and wish to file a program complaint, please see the contact information above. If you require alternative means of communication for program information (e.g., Braille, large print, audiotape, etc.), please contact USDA's TARGET Center at (202) 720-2600 (voice and TDD).