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TEXAS AGRICULTURAL EXPERIMENT STATION

A. B. CONNER, DIRECTOR
COLLEGE STATION, BRAZOS COUNTY, TEXAS

BULLETIN NO. 431 JULY, 1931

DIVISION OF SOIL SURVEY

IN COOPERATION WITH THE DIVISION OF SOIL SURVEY, BUREAU OF CHEMISTRY AND SOILS, UNITED STATES DEPARTMENT OF AGRICULTURE

THE SOILS OF TEXAS

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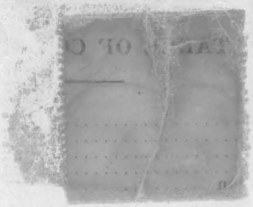
†As of September 1, 1931.



Nearly 80 per cent of Texas has been reached by some form of soil urvey work (Fig. 1). This work is done cooperatively by Texas Agri-ultural Experiment Station and Bureau of Chemistry and Soils of the U. S.)epartment of Agriculture.

Of the 168,000,000 acres comprising the land area of Texas some 35,000,000 cres—nearly 21 per cent—have been covered in detailed soil surveys of ome 70 areas, consisting of counties or parts of counties, scattered through-ut all parts of the State. On about 98,000,000 acres, 58 per cent of the ind, mostly located in Western and Southern Texas, the soils have been ess intensively surveyed by reconnaissance methods in 138 counties included n eight separate areas. In these surveys more than 100 soil series have een recognized and of these over 500 soil types have been studied and apped. The information collected in these surveys has been issued in bout 80 publications, which consist of a soil map and a report. The soil ap shows the location and extent of each soil in the area surveyed while he report gives the characteristics and features of the soils and their uses nd suitability to crops with various other related information.

The present knowledge of the soils of the State thus obtained together vith many soil studies made in unsurveyed areas has provided sufficient nformation to enable the preparation of the very general soil map of Texas iere shown, together with brief descriptions of the soil regions and of the rincipal soils, with their general agricultural importance and relationships.

Nearly 100 of the most important series of soils that occur in the State re described briefly in this paper, and these with the map, give in gen-ralized form an outline of the present information relating to soil classifica-ion and soil values in this great area. The large number of soil types vithin the State forbids the attempt to describe them in detail in this paper, ut the general character of many of the more important of these minor oil divisions has been brought out in the series descriptions.

The soils of Texas, many of them found in no other part of the United States, are of widely differing characteristics and features and extend hrough a wide range of productiveness and suitability for crops. On the haracteristics of the soils are based the uses for which they are best uited. The success of agriculture in Texas depends upon the appropriate se of the soils, which constitute the most valuable resource of the State. Vhile the present population and wealth of Texas are largely due to the roductive soils there are large amounts of marginal soils being used for urposes for which they are not well suited and are not returning a profit or the effort and expense expended to obtain the uncertain production. ome soils, many naturally very productive, are being injured by erosion nd by exhaustive cropping. Other soils of high inherent productiveness re not being utilized because of insufficient drainage or on account of nsufficient moisture. Many soils are farmed that are so low in productive alue that those devoting their time to their cultivation cannot hope to gain nore than a bare existence.

It is only in using the soils of Texas for the crops for which they are best uited, be these either timber, natural range plants, or cultivated crops, nd by protecting the soils and improving them, that a prosperous agricul-ure can be maintained. In this work it is hoped that a general knowledge f the characteristics and capabilities of the soils of Texas may be provided hat will afford a basis for a more careful appreciation of the soil resources f the State.

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THE SOILS OF TEXAS

W. T. CARTER

GENERAL DESCRIPTION

Texas is situated in south-central United States, bordering on the Gulf of Mexico and the Republic of Mexico. It embraces nearly one-eleventh of the total land area of Continental United States, having an area of 262,117 square miles, or 167,754,880 acres. It is the largest state of the Union, and includes 254 counties, the smallest of which is about 150 square miles in extent and the largest nearly 6,000 square miles. It is included between the meridians 94° and 107° west longitude and between 26° and 37° north latitude.

Three great physiographic regions extend through the State. The chief of these is the Great Plains region occupying a very large portion of the western part of the State, and the Coastal Plain, which forms a large portion of the eastern and southern parts of the State. In the extreme western part lying just west of the Great Plains, the region of Mountains and Basins occupies a considerable area. The Coastal Plain region is timbered over large sections, though large areas of prairie lands also occur in the western and southern parts of this division. The Great Plains area, occupying nearly one-third of the State, is composed of rolling grass-land plains with some flat plateau plains and large areas of greatly dissected limestone plains. This great division merges on the east with rolling grass-land prairies and on the south is terminated by rapidly descending stony escarpments leading down to undulating brushy plains. The region of Mountains and Basins comprises mountain ranges and isolated rough highlands with a sparse growth of grasses, trees, and shrubs, and intervening flat basins and plains of arid character on which grow many desert shrubs.

Subdivisions of these great physiographic areas occur which are distinguished by local characteristic features of land relief, soils, native vegetation, and climatic conditions.

The surface of Texas is a dissected plain, tilted toward the southwest. It rises from sea-level to more than 4,000 feet above sea-level in the extreme northwestern part. The surface is dissected by many rivers flowing in a general southeasterly direction through broad flat-bottomed trenches. Local relief varies largely according to the extent of dissection by the tributaries of these major waterways. Some large areas are nearly flat; others are undulating to rolling; and still others are hilly or rugged with many deep valleys. In the extreme western part a number of mountains rise from 5,000 to 9,000 feet above sea-level, with some peaks standing more than 5,000 feet above the general level of the sur-

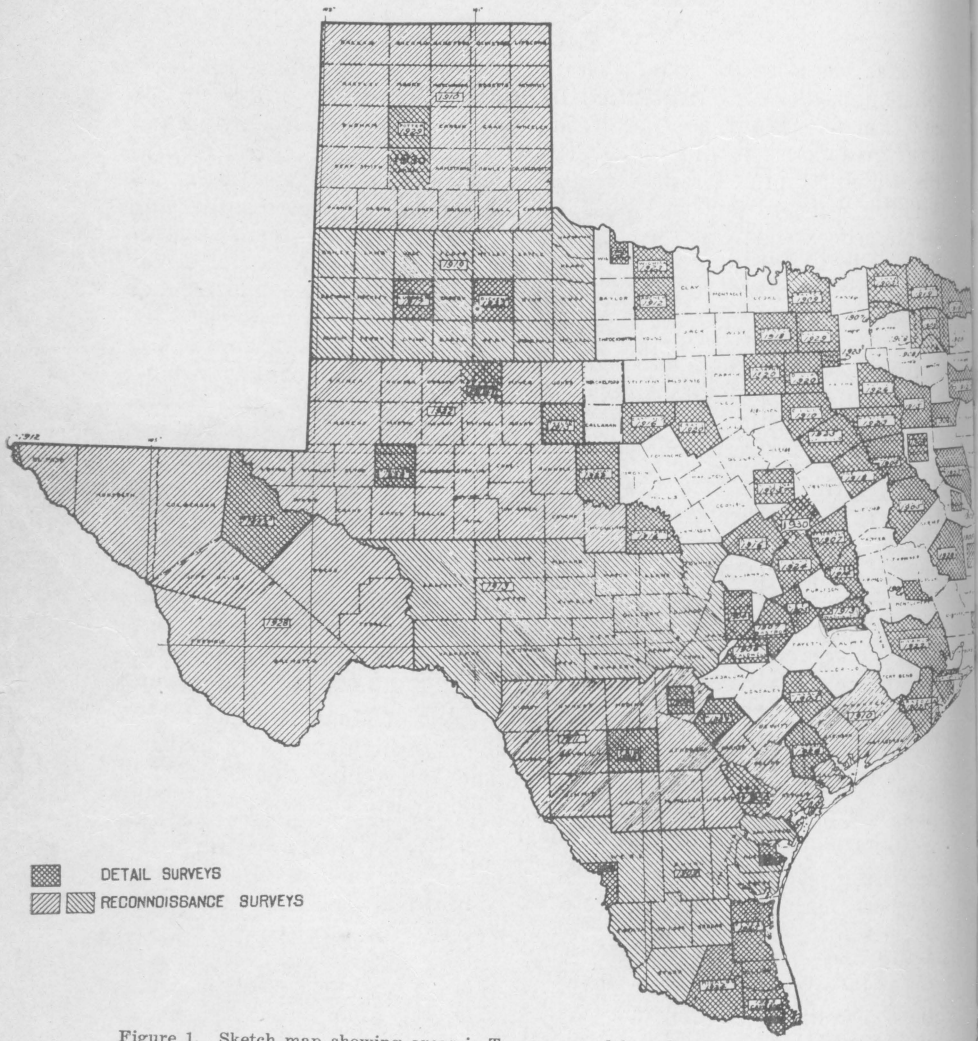

Figure 1. Sketch map showing areas is Texas covered by soil surveys from 1901 to 1930.

rounding country, which is from 3,000 to 4,000 feet above sea-level. These mountains are a part of, or are associated with, the central Cordilleran system. The general elevations and regional slope are indicated in Figure 2.

NATIVE VEGETATION

Texas has a varied flora. The natural vegetation differs greatly in different parts of the State, and its character is closely related to soil and climate. Plant associations and communities of distinctive plants cover great areas in different sections of the State. The great Coastal Plain Belt of pine forests reaching south from New Jersey along the Atlantic seaboard and westward through the states bordering the Gulf of Mexico extends into eastern Texas, covering a large section of the State. In places this forest consists almost entirely of pine, but a considerable quantity of hardwood timber, mainly oak, is scattered through the pine. In the northern part this timber land extends more than 100 miles into Texas and in the southern part extends as a narrower belt southwestward for a distance of more than 200 miles, where the timber land gradually gives way to brushy plains which extend far into Mexico. The pine timber extends in the northern part only about 50 miles, and in the southern part about 125 miles west of the eastern boundary of Texas, giving way to a forest of oak timber, which occupies a broad fringe as the western extensions of this great timber belt. Smaller areas of oak timber occupy some portions of north Texas, and a small scrubby growth of oaks occurs in limited areas throughout various portions of the western part of the State. Where uncultivated, the prairies of the humid region are covered with a heavy growth of coarse bunch grasses and in places with a considerable growth of short grasses, which increase in proportion as the humid areas merge with the subhumid plains. Along the coast are narrow marginal areas of coarse plants and grasses peculiar to marshy or semi-marshy conditions.

The plains are in places covered with a heavy growth of short grasses consisting largely of buffalo grass (*Bulbilis dactyloides*) and mesquite grass (*Hilaria sp.*), though in other places bunch grasses (largely *Andropogon sp.)* predominate. Large portions of the plains support a scattering growth of shrubs consisting largely of mesquite. In the southern plains the characteristic bush growth is very thick, consisting of mesquite and other small trees and shrubs, largely thorny, and usually associated with prickly pear.

In the extreme western part of the State, where arid climatic conditions prevail, large areas support little growth other than such desert plants as Covillea and Flourensia species and other small shrubs which characterize areas of light rainfall.

The extreme northwestern part of the State, consisting of very high plains, is largely devoid of trees and shrubs, but supports a dense cover of short grasses on heavy soils and coarse grasses on the sandy soils. In places a considerable growth of shin-oak trees a few feet high occur

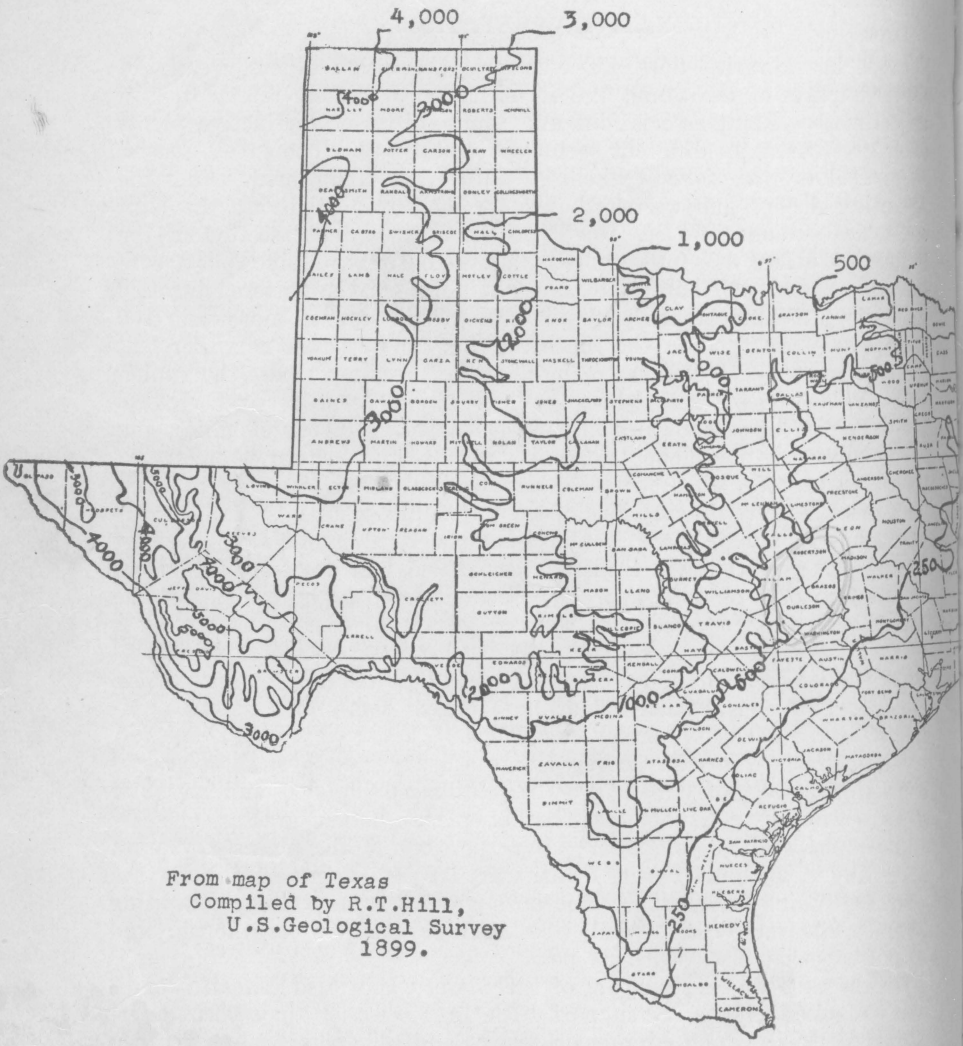

Figure 2. Map of Texas showing approximately the lines of equal elevation at 250, 500, 1000, 2000, 3000, 4000 and 5000 feet above sea level.

on the very light sandy soils of the western regions. The general distribution of the vegetation is shown in Figure 3.

CLIMATE

Texas lies within the latitude of the temperate zone and, therefore, the climate is one of moderate temperatures and precipitation. In the extreme southern part, subtropical conditions prevail and freezing temperatures are uncommon. In the extreme northwestern part, winter temperatures are occasionally as low as zero and a little below, though these do not occur every winter or extend over a long period of time. The winters are relatively short, and warm weather prevails a considerable part of the time in the southern part of the State, whereas in the northern part much of the winter season is cool. During the winter, cold winds sweep down periodically from the north, accompanied by freezing temperatures in the northern sections, but the cold diminishes greatly in severity in the southern part. These cold winds, or "northers," last several days, but many do not reach as far south as the coast. The summers are warm, with midsummer temperatures during the day reaching to more than 90° F. and at times as high as 100° F. The summers have a large number of days of sunshine. The high temperatures of summer are tempered by gentle southerly winds which blow from the Gulf, and where elevations are more than 2,000 feet above sea-level, in the subhumid region, the low humidity, and bracing atmosphere offset the summer heat to a large extent. In the extreme southern part of the State, the average annual temperature is about 74° F. and in the extreme northern part it is about 56° F. Figures 4 and 5 show zones of Texas based on average dates of last killing frost in spring and first in fall.

The precipitation is practically all derived from rainfall, as snows occur rarely even in the northern portions of the State. In the extreme eastern part the rainfall averages about 45 inches a year, with a small portion of the eastern part receiving slightly more. Rainfall decreases gradually toward the west, and in the extreme western part, as well as in some of the arid basin sections of the Trans-Pecos region, the average yearly precipitation is 10 inches or less. Slightly greater rainfall occurs in the higher mountain areas throughout the Trans-Pecos region than occurs in the basin and larger valleys of that region. The eastern part of Texas, comprising an area of approximately two-fifths of the State, lies within the humid region east of a general line indicated by changes in characteristics of soils and vegetation. Where the dividing line touches the Gulf Coast, the average annual rainfall is about 35 inches but the area from Central Texas northward lies within a zone where the average annual rainfall is between 25 and 30 inches. West of this line the subhumid plains extend in a broad belt across the State from north to south. Changes in soil characteristics, indicating a change from subhumid to semiarid conditions, occur about where the average annual

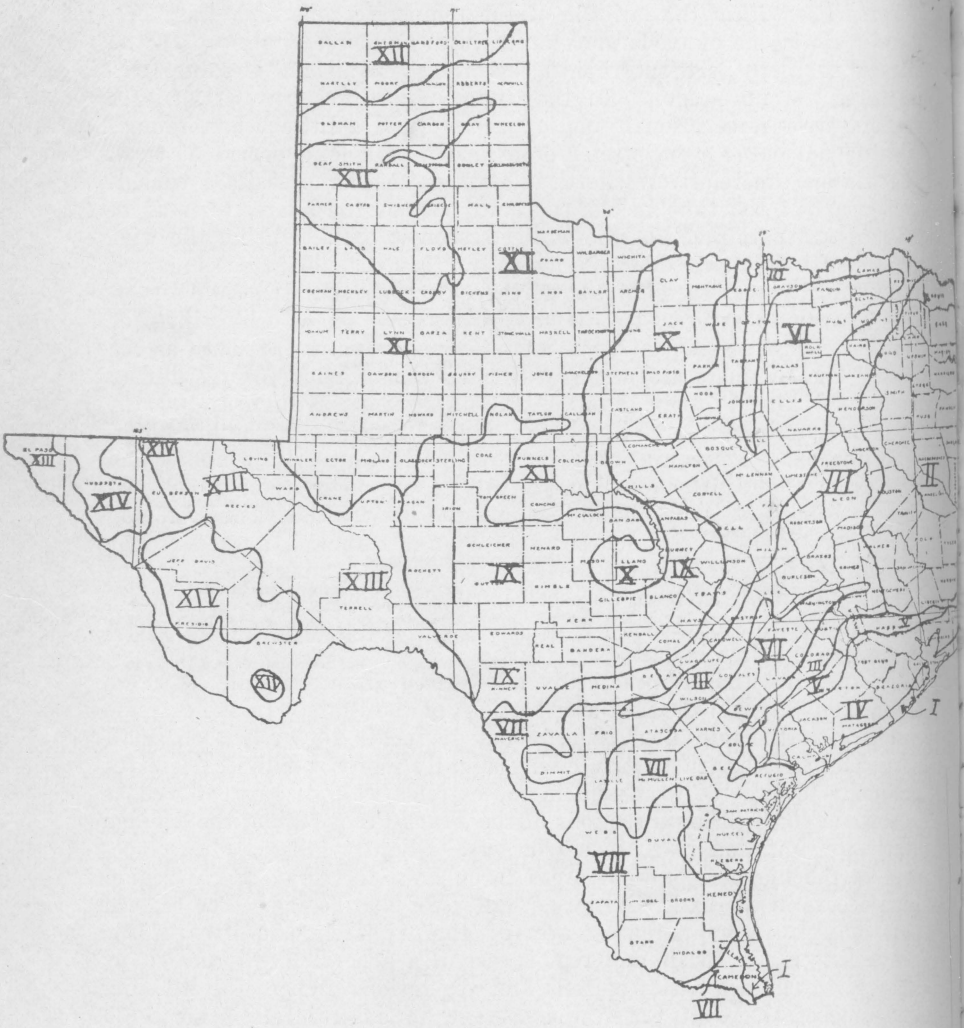

Figure 3. Map showing general distribution of native vegetation in Texas.

General character of native vegetation in various parts of Texas.

I. Marsh and salt grasses.

II. Timbered areas. Shortleaf pine with some hardwoods, mostly oaks, in northern part. Shortleaf, longleaf, and loblolly pine in southern part with small amount of hardwoods.

III. Timbered areas. Mainly post-oak with small amount of other oaks and hickory. No pine except on small area in Bastrop County reaching into northwestern Fayette County. Many small prairies included in this division.

IV. Prairie. Coarse grasses, largely Andropogons and many others, some grama grasses in western part.

V. Prairie. Coarse bunch grasses, largely certain species of Andropogon, Paspalum, Panicum, and others.

VI. Prairie. Bunch grasses, largely Andropogons; grama; some short grasses (buffalo grass) in places. Small clumps of live-oaks in northwestern part, with few other oaks in scattered growth in places; mesquite trees and shrubs in scattered growth in southern part.

VII. Brush plains. Largely short grasses, buffalo and curly mesquite. Many shrubs and mesquite trees in scattered growth; these shrubs and trees with prickly pear very thick in places.

VIII. Brush plains. Largely coarse bunch grasses; some grama grasses; scattered growth of mesquite trees and shrubs. Small post-oak trees in certain areas, while some live-oak trees occur in a thick growth in other places.

IX. Thin cover of short grasses, largely buffalo and mesquite grasses and various others; scattered growth of small trees in many places. These are chiefly live-oak and shin-oak with in eastern sections also some western red-oak, and juniper, and small amounts of post-oak. Many shrubs.

X. Timbered mainly, but with included prairies. Many post-oak, some black-jack oak. On prairies coarse grasses mainly with some grama and other grasses. Mesquite trees in southern part.

XI. Bunch-grass and short-grass plains with scattered mesquite trees and shrubs. Some areas with very coarse bunch grasses and shin-oak shrubs; some places coarse bunch grass, grama, needle, and other grasses; some areas of short grasses (mainly buffalo) with grama.

XII. Short-grass plains. Mainly buffalo grass with some grama.

XIII. Arid-land vegetation. Very thin growth of grass. On rough highlands mainly sotol, lechuguilla, yucca, catclaw, cenizo, Nolina, and various other coarse plants, with, in places, chino, yeso, and tobosa grasses. On lowland mostly creosote bush and tar-bush, with some tussock, burro, and salt grasses.

XIV. Moderate grass cover; largely grama, Nolina, tobosa, and others; many small shrubs. On some mountains, oaks, pine, juniper trees in places.

rainfall is 15 or 20 inches. The semiarid belt changes within a short distance into arid basins and plains, lying mostly west of Pecos River, and these are readily recognized by the presence of a very abundant growth of desert shrubs. The arid portions have an average yearly rainfall of less than 15 inches.

Rainfall occurs regularly in the humid regions, as a rule, but in the other climatic regions in the western part of the State the rainfall varies considerably from year to year; in some seasons it is very low, and in others it is considerably above that of normal years. As a rule, the largest amount of rainfall occurs during the spring and summer months in all of the regions. Much of the rainfall of the western part of the State is from local thunder storms, accompanied by sudden dashing rains, during which a large amount of water often falls in a very short time, and unless the surface is very smooth or nearly flat, large amounts of water run off into the streams. Summer droughts of short duration occur frequently in the humid region causing some crops to suffer, but in the subhumid region periods of extremely low rainfall occasionally

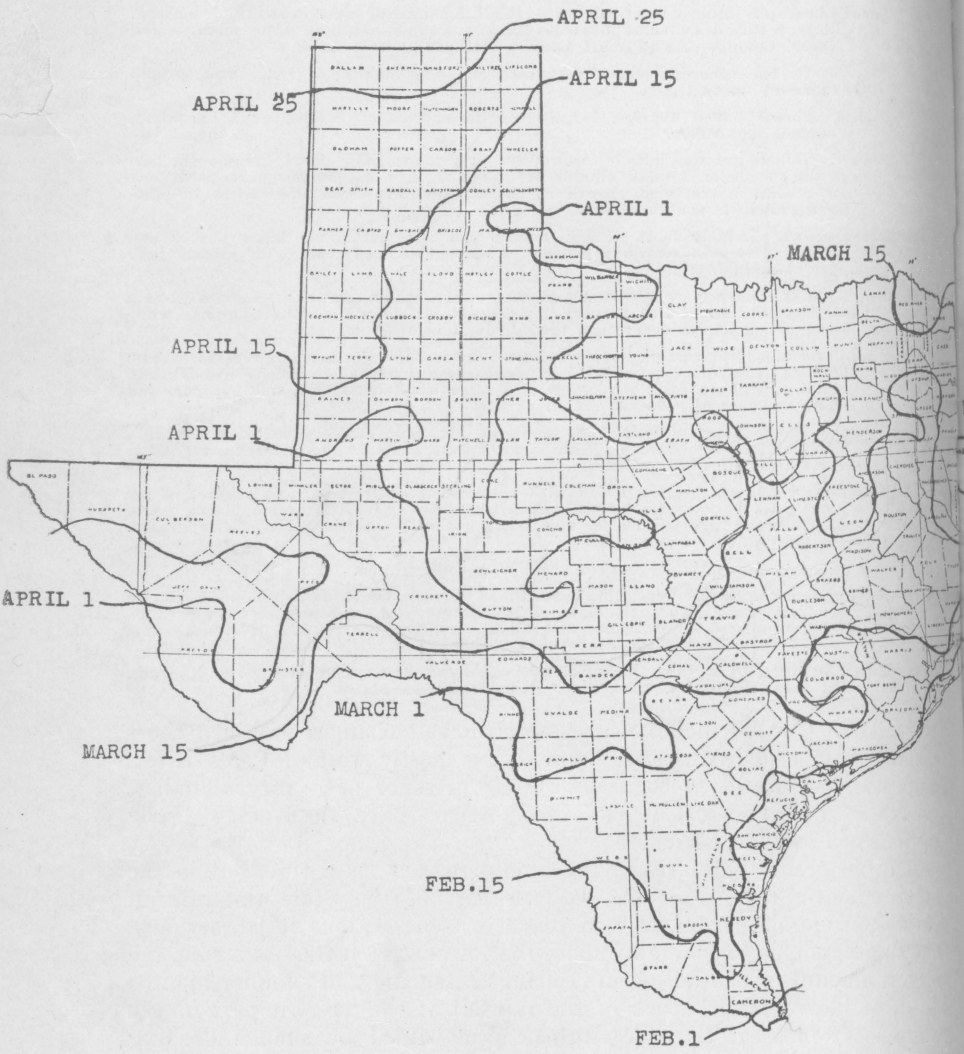

Figure 4. Zones of Texas based on average date of last killing frost in Spring. Data from United States Weather Bureau records to 1920.

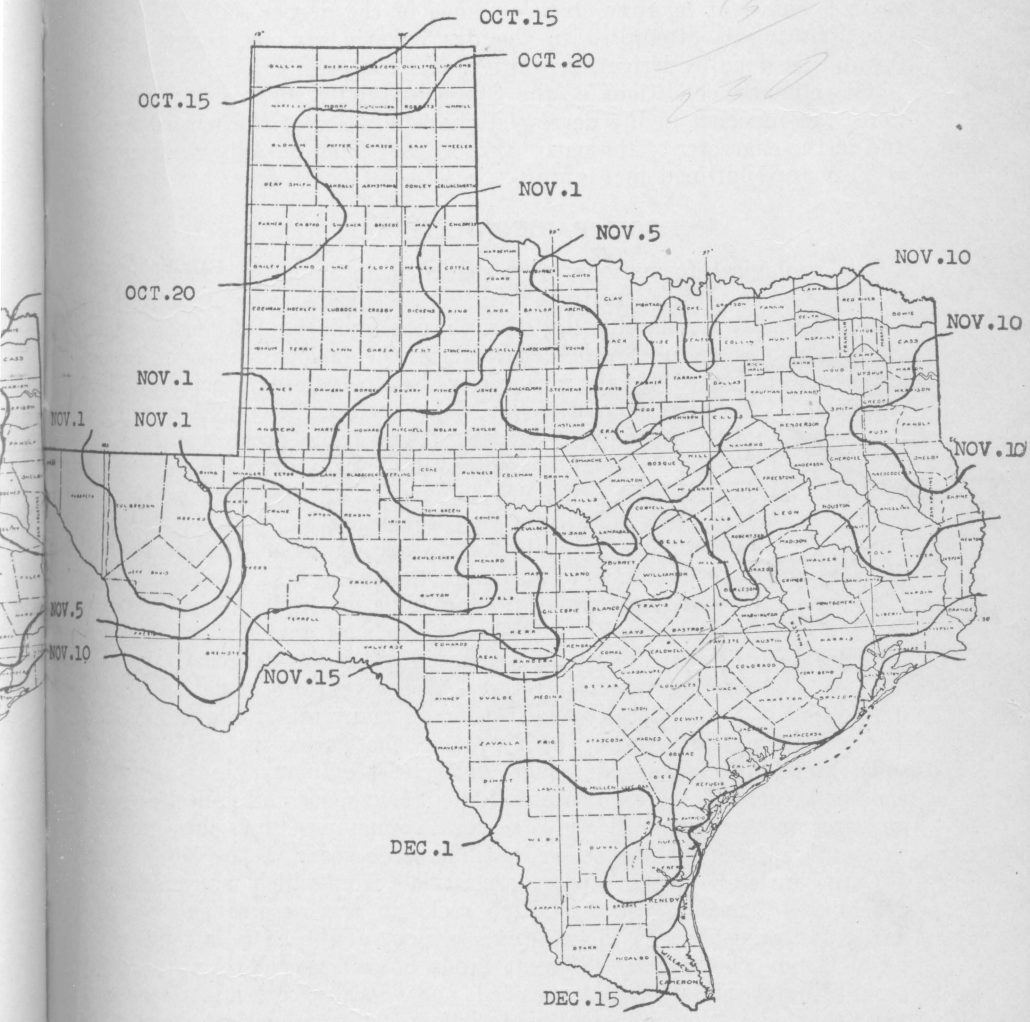

Figure 5. Zones of Texas based on first killing frost in Fall. Data from United States Weather Bureau records to 1920.

extend over periods of one or more years, being followed, as a rule, by several years in which rainfall is ample for the production of good crop yields. Rainfall of semiarid areas is usually insufficient for the successful practice of dry-land farming, though the rainfall during some years is sufficient to grow crops on some of the deeper soils. No dry-land farming is attempted in the dry or arid regions, though some farming is done by irrigating where water can be secured.

The climatic conditions of the State, especially the moisture conditions, are reflected in the developed characteristics of the normal soils, and in the character of the native vegetation. The four climatic regions of Texas are outlined in Figure 6.

SOIL PARENT-MATERIALS

The geological formations of Texas have an important relationship to the soils, as these formations furnish the raw parent-materials from which the soils are developed. The physiographic land forms and the features of surface relief which characterize the various regions of Texas have been produced by the agencies of earth-building, including the elevation of the earth's crust, followed by surface dissection caused by the erosive action of water. The character of the present surface of rough lands, rolling areas, and smooth flat plains and prairies has been produced largely by the resistance to erosion of the various exposed geological formations. The soils vary somewhat in character according to the character of the geological formation from which they are derived, and the smoothness and slope of the surface. The soil-developing agencies of a region tend to produce soils of similar characteristics from geological formations of different kinds of materials, but these agencies act differently, or with less rapidity on the various geological materials, depending largely on the degree of surface slope, and have developed many soils locally which differ in many minor characteristics. The geological formations which provide the parent-materials of the soils extend through a wide range and consist of many kinds of materials both consolidated and unconsolidated, calcareous and noncalcareous, and are made up of a variety of mineral compounds of various proportions which resist disintegration in different degrees.

Large areas of limestone provide materials from which many soils are developed. Igneous and crystalline rocks in the western and central parts, and sandstones in the northern sections of the State, all give materials from which many different kinds of soils are developed. Vast areas of unconsolidated calcareous beds and noncalcareous materials comprise the foundation of parent materials from which a great many different soils are developed. Recent deposits of alluvium consisting of soil materials brought from different upland sources occur throughout all parts of the State in the flood plains of many streams. On this alluvial material the imprint of the processes of soil development has not

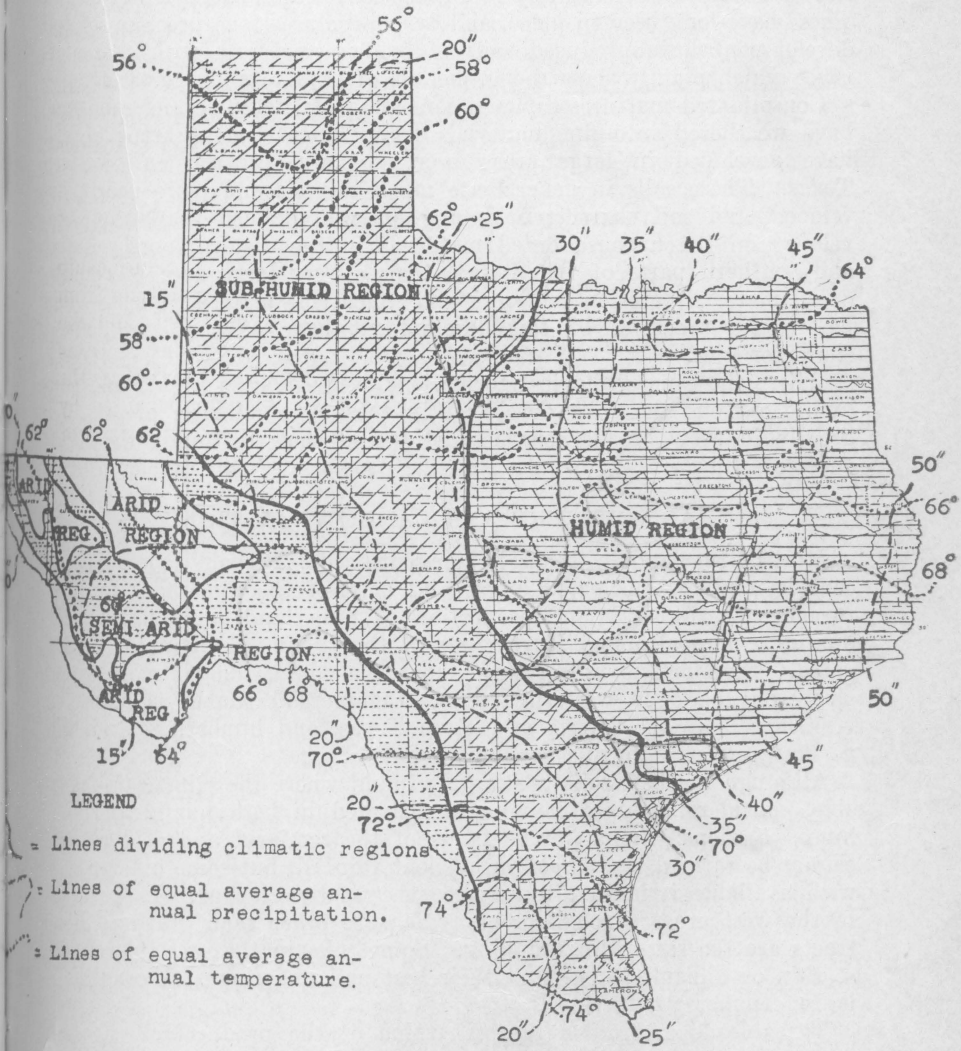

Figure 6. Climatic regions of Texas as based on characteristics of soils and natural vegetation. Lines of equal annual precipitation and of equal annual temperature also shown as given by United States Weather Bureau.

yet been established except on some of the higher-lying areas which are no longer overflowed by the streams.

Throughtout a vast portion of the western plains the soil parent-materials consist of calcareous unconsolidated sediments of fresh-water origin. These have long been in place, and over large areas the processes of soil development have produced soils of evident maturity with characteristics which plainly show the influences of climate and vegetation.

Consolidated marine sediments consisting of limestone and sandstone have weathered into fine materials from which various kinds of soil have developed in large areas over northern, central, and western Texas. These soils in general are much thinner and more poorly developed, and soil characteristics are less well defined than where developed on the unconsolidated materials in the eastern, northwestern, and southern parts of the State. Over a very large area of consolidated materials erosion is severe and much soil material washes away before the processes of soil development have effected well-defined characteristics.

Where the same geological formations occur in both humid and subhumid regions the soils developed in these two climatic areas differ greatly in their broader characteristics and show distinctly the influences of climate and vegetation on the processes of soil development.

AGRICULTURE AND LAND UTILIZATION

Most of the land in Texas is being utilized. Probably about 20 per cent is used for cultivated crops, and most of the remainder for pasturage and timber. The proportion of crop land is largest in the humid region, although large parts of the subhumid plains are cultivated. Livestock is raised throughout the State, though most extensively on the open western ranges. Commercial timber is restricted very largely to the forests of eastern Texas, and lumbering is an important industry in this section.

Although the best soils are largely found where the climate is favorable, considerable areas remain uncultivated in both humid and subhumid sections. Some fertile lands of the semiarid and arid regions cannot be farmed because of insufficient rainfall, but some other bodies with available irrigation water are successfully cropped. Large areas in the west are too rough or stony for use other than grazing; other tracts are too sandy for cropping. Some soils in the eastern part are so thin or difficult to till that their best use, under present conditions, is for timber production.

Texas leads all States in total value of the products of the soil. These values for the year 1924 were: Farm crops, $756,000,000; livestock, $284,000,000; and forest products, $60,000,000.

The crops grown consist mainly of cotton, corn, grain sorghums, forage crops, and small grain crops. Other miscellaneous crops are grown in certain sections where climatic conditions and soils are

especially suited, in addition to many of the other important crops. In southeastern Texas considerable rice is grown, on the soils of the Gulf Coast prairie considerable amounts of truck crops and figs are produced commercially, and in the extreme southern part citrus fruits are a very important crop. In the western regions grain sorghums are grown extensively as also are wheat and oats in certain sections. Cotton is the chief industrial crop produced by the farmers of the State. Practically one-half of all land in cultivation is devoted to cotton and the State produces about one-third of all the cotton produced in the United States. It is grown on very many different kinds of soils located throughout a great range of climatic conditions. Fruits and vegetables are grown on all kinds of soils for home use, though in some sections especially favored with suitable soils and climate together with convenient marketing facilities, fruits and vegetable and other special crops are grown commercially.

Successful crop production in Texas is largely dependent on soil and climate. There are considerable areas of unused fertile land which could be cultivated; but for profitable use, some modification of the natural conditions would generally be necessary, such as drainage, irrigation, protection from erosion, and conservation of the rainfall. Some lands are being farmed with little or no profit, and some others are being used for crops not particularly adapted to them. As an illustration of the special suitability of soils, the use of the Houston and Wilson soils of the Blackland prairies may be cited as a conspicuous example. This group of soils constitutes only about 6 per cent of the total land area of the State, but it produces nearly one-third of the cotton crop.

The soils of Texas constitute the principal resource of the State and provide a basis for the industry in which the largest proportion of the 6,000,000 inhabitants are engaged. Agriculture is the chief industry of the State and probably will remain indefinitely the chief source of revenue for the majority of the population, so that proper utilization and conservation of the soil resources is of paramount importance.

THE SOILS

The soils of the State differ in characteristics according to the character of the parent-materials, climate, and other environmental factors. Soil-developing processes differ in the various regions; accordingly, great regional soil differences exist, as well as local differences.

Reconnaissance soil surveys have been made of more than one-half the land of the State, and cover a number of areas which together make up all of the western and considerable of the southern parts of the State. Detailed soil surveys have been made of some 70 counties or parts of counties scattered through the State, but these lie largely in the eastern half, aggregating a total area equal to nearly one-fifth of all the land in Texas.

About 130 series of soils, including more than 500 soil types, have been shown on the soil maps in these surveys. These have been identified, classified, and studied, and the data published in the soil reports.

The soils of Texas range through every textural class and are of many colors and combinations of colors, and the structural characteristics are numerous and varied. The productive capacities and crop adaptations of the soils differ greatly.

For purposes of classification the soils of Texas are divided into two great groups, the soils of the one differing from those of the other in certain characteristics which have been produced largely by the influence of climatic factors. The soils developed under the humid conditions prevailing over approximately two-fifths of the State differ in their natural characteristics from those of the western dry and relatively dry regions comprising about three-fifths of the State. These two great soil groups occupy, in general, the eastern and western halves of the United States and are separated by a line (Fig. 7) which according to Marbut (1) follows a narrow transitional belt which crosses the country from north to south from Canada through western Minnesota, northwestern Iowa, southeastern Nebraska, a little east of the center of

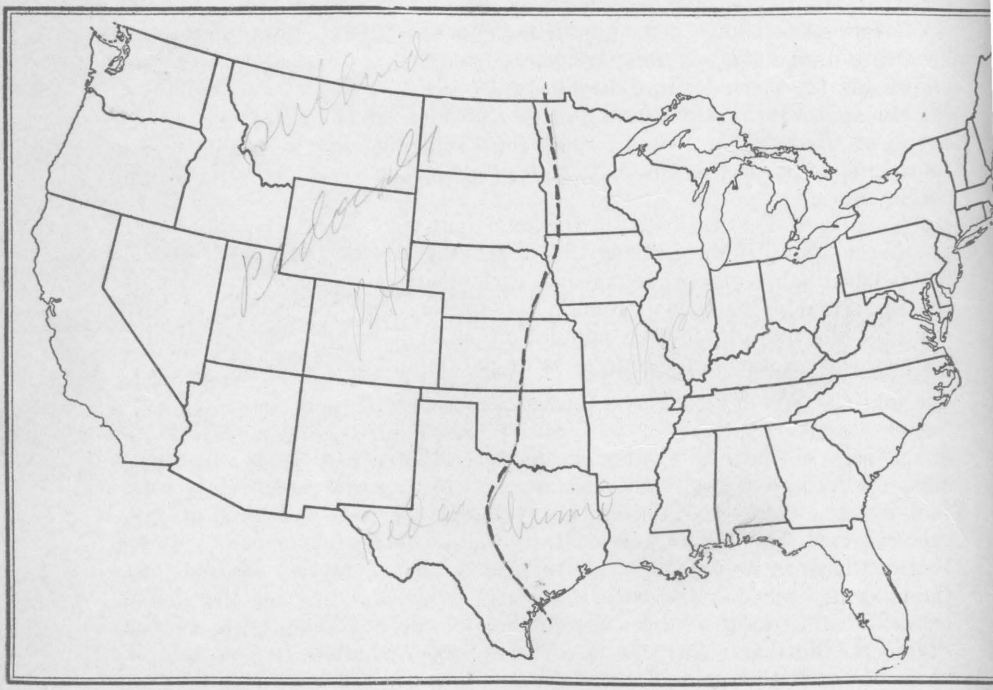

Figure 7. Approximate location of line separating the two great soil regions of the United States.

(1) C. F. Marbut, a Scheme for Soil Classification, Proceedings and Papers of the First International Congress of Soil Science, Vol. IV, June, 1927.

Kansas, central Oklahoma, and divides Texas into almost equal parts. In Texas this line extends in a general north south direction passing near Wichita Falls, Abilene, and Fredericksburg, and, veering eastward near the latter place, passing near San Antonio in a general southeasterly direction and reaching the Gulf of Mexico near San Antonio Bay. The line in Texas runs through a belt wherein the average annual rainfall is 25 or 30 inches, the easterly inclination increasing as the relatively higher temperatures of the more southerly latitudes are reached. The belt of transition is fairly well defined by differences in the broader or basic soil characteristics and is but a few miles wide, though in the general transition area isolated areas of each soil group may lie out of place several miles on each side of the line.

The soil group of the eastern or humid region includes soils in whose maturely developed profiles no larger amounts of carbonates of lime occur than in the parent-material beneath them. In these soils a shifting or accumulation of sesquioxides has also taken place.

The soil group of the western or subhumid region and other low rainfall areas includes soils wherein some horizon of the fully developed soil profile contains a greater amount of carbonate of lime than is present in the parent geological material beneath.

These groups have been established by Marbut (1), and to them he gives tentatively the names Pedalfers for the humid region group, and Pedocals for the subhumid region group.

Owing to the great differences in the characteristics of the normal soils of these major soil divisions the grasslands of the humid region are here referred to as prairies, while the treeless areas of the subhumid soils are called plains.

NATURAL GEOGRAPHIC DIVISIONS OF TEXAS

Though Texas lies entirely within four natural physiographic regions of continental scope, the Coastal Plain, Prairies, Great Plains, and Mountain-Basin, these are naturally subdivided into sections or subregions on the basis of distinctive features of relief, soils, and native vegetation. The close relationship of soils to these sub-regions is marked, as each division is occupied by a group of soils which for the most part are found in no other section. These soil groups are made up of a number of soil series more or less related in some broad characteristics and these differ, as a rule, markedly from the general characteristics of the soils of all the other sub-regions. The names of the regions have in many cases long been in local use and are usually taken from some outstanding geographic feature. These regions are as follows: Gulf Coast Prairie, East Texas Timber Country, East Cross Timbers, Blackland Prairies, Grand Prairie, West Cross Timbers, Central Basin, Rio Grande Plain, Edwards Plateau, Rolling Plains, High

(1) C. F. Marbut, a Scheme for Soil Classification, Proceedings and Papers of the First International Congress of Soil Science, Vol. IV, June, 1927.

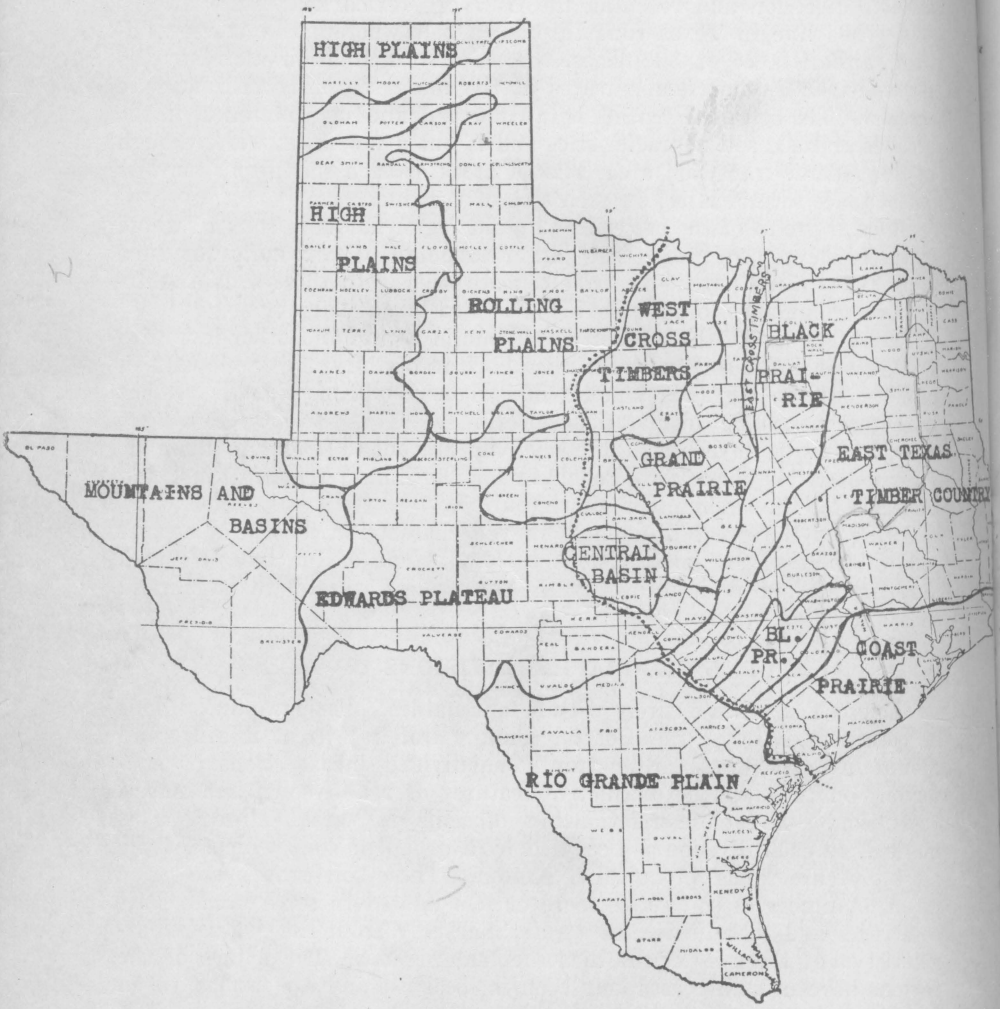

Figure 8. Natural geographic divisions of Texas. Dotted line separates the two major soil groups of the State.

Plains, and Mountain-Basin. These divisions are indicated in Figure 8.

The accompanying soil map made on a scale of one inch to 24 miles shows the location of the principal soil groups in Texas. Some 32 areas are thus outlined, though the alluvial soil group is further separated into seven divisions. Due to the small size of the map, and to the limited information about some soils in unsurveyed sections, it is not possible to show, consistently, a more detailed separation of the soil areas of the State.

In the areas shown the largest amount of the soils are related in their characteristics. However, soils of widely differing characteristics occur in some areas and in such cases the map grouping is made on the basis of soil association, as separation was not possible on a map of this size.

The soil map and report have been compiled from data secured in soil surveys, and by less detailed studies in unsurveyed areas. Doubtless many new soil series and soil types will be identified as soil surveys are extended over the unsurveyed sections.

As each geographic division is occupied, for the most part, by soils found only in that area the soil groups are arranged under the regional headings. The boundaries of the geographic regions are shown in solid lines, and those of the soil division within the region in broken lines. The different soil-group areas are sharply separated in places, while in other places they merge together through a wide zone of transition.

Following are descriptions of the regions of Texas with reference to their location and extent, surface features, climate, native vegetation, agriculture, and outstanding relationships, with descriptions of the more important soils.

GULF COAST PRAIRIE

A nearly flat strip of country 20 to 80 miles wide borders the Gulf Coast. This strip occupies two general sections, which are separated about the vicinity of the San Antonio River; the eastern section, constituting the Coast Prairie, consists of a nearly flat prairie, and the western section, differing but little in surface relief, constitutes the coastal brush lands of the Rio Grande Plain.

The Gulf Coastal Prairie covers about 8,000,000 acres of land lying within, or partly within, 19 counties. The surface is covered with a heavy growth of coarse grasses, and a narrow fringe of marshy land occurs along the coast line.

Along the coast the surface is but a few feet above sea-level. It rises northward very gradually and uniformly to elevations of more than 100 feet above sea-level in the more northerly sections. The surface is very smooth and generally flat, though near the interior border it is undulating. Many areas are so flat, or even slightly depressed, as to allow water to stand for a long time. This is due in part to the heavy dense clay subsoils and substratum, which cause very slow underdrainage. Several

important rivers flow across the prairie through shallow trenched timbered bottomland areas. In place trees grow on bordering slopes and strips of the adjacent upland.

The average annual temperature is between 68° and 70° F., and the average annual rainfall is about 50 inches in the eastern section and 35 inches in the western section. The winters are short and temperatures as low as freezing are rare. The summers are long and hot, though the heat of summer is moderated by breezes from the Gulf.

Agriculture

The soils of the Coast Prairie are suited to a great variety of crops, many of them inherently capable of producing high yields. The long frost-free growing season, ranging approximately from 240 to 280 days a year, according to location, together with the mild winters, making it possible to grow some crops during the colder seasons, provides climatic conditions favoring several types of agricultural industry.

However, due to inadequate drainage together with a large rainfall, much of the land remains wet too long for successful use in growing crops and is used only for the grazing of range cattle.

Therefore, due largely to poor drainage conditions agricultural development is not extensive over parts of the eastern section. It is, however, more general in the western and central sections where rainfall is lower and considerable areas have moderately free natural drainage. In the drier sections cotton is generally the important crop grown with some corn and other feed crops, and in some of these counties rice is grown extensively. In the eastern section rice is the chief crop, though some corn and other crops are grown, but very little cotton is produced.

In places favorably situated throughout the Coast Prairie special commercial crops are grown. These are chiefly figs, put up in local preserving plants; truck crops, shipped to large markets over the country; pecans, grown in the better drained river-bottom areas; and many vegetables, fruits, and berries grown for the local markets. In places alfalfa and certain varieties of clover are grown successfully. The raising of beef cattle on the range, and dairy farming near the larger centers of population comprise important industries.

According to the census of 1925 the counties least developed agriculturally lie mostly in the eastern section. In some of these only about 4 to 8 per cent of the land was in cultivated crops, while crop land in the western section ranged from 14 to more than 30 per cent of the total land area in most of the counties. Some of the most extensively developed counties through which large rivers pass contain a large amount of alluvial soils, of which a considerable proportion is farmed.

Most of the land is so smooth that it is suited to the use of power farm machinery.

While some areas of the soils have sufficient natural drainage for successful crop production there is a large amount of land that would be

greatly improved for farming by the installation of adequate drainage. In some localities artificial drainage has been provided by ditching and has proved valuable.

Soils

On the basis of the main soil characteristics, the soils of the Coast Prairie are divided into (1) Dark-colored prairie soils; (2) Light-colored prairie soils; (3) Marshy and Semi-marshy soils; and (4) Alluvial soils. The Dark-colored soils are chiefly of the Lake Charles series, which occupy the main body of the smooth flat prairie. Closely associated with the Lake Charles are many areas of Edna soils of the light-colored division and though not related in characteristics these soils are shown as one group on the soil map. The soils of the Coast Prairie have been developed largely from marl under a heavy grass cover. The normally developed soils are generally of acid reaction in the upper layers and only in the layers grading into parent marl does calcium carbonate appear.

The table on page 24 gives the principal soils, their characteristics, and chief uses.

Dark-Colored Prairie Soils

Occurring over the larger areas of the Coast Prairie are the dark-colored soils. These are the most extensive and most productive soils of the prairie. They have deep surface soils which grade below into dark-gray subsoils, and at a depth of several feet these grade into calcareous clay, the parent material. The topsoils are acid in reaction and contain moderate amounts of organic matter. The soils are developed on smooth surfaces under conditions of heavy grass cover, slow drainage, and high-moisture content. They are mostly of the Lake Charles series. The dark-colored soils probably total 3,750,000 acres.

Lake Charles Soils: The Lake Charles soils are black to dark-gray in color, with dark-gray heavy clay subsoils in many places resting on marl or slightly calcareous clay at a depth of several feet. In some shallow phases, the marl lies within 2 or 3 feet of the surface or even at less depth. The soils are deep and in most places are acid in reaction. The topsoils grade below into the subsoils with no sharp change. Though very hard when dry, the soil material breaks to grains readily when handled in a slightly moist condition. These soils occupy large smooth nearly flat areas of great uniformity in surface relief and soil character. The principal soil is the clay (Fig. 9), though some clay loam and fine sandy loam soils also occur. The clay soil, which is black, deep, and very heavy, is pitted by numerous small depressions know as "hogwallows," though these disappear when the land is put under cultivation. In many places brown or yellowish-brown calcareous clay lies but a few inches beneath the surface of the elevation of the hogwallows, and a few feet away in the depressions the black clay is several feet deep and is acid in reaction. In many places the surface

Principal soils of the Coast Prairie

Soil groups (Series)	Topsoil	Subsoil	Substratum (parent material)	Chief crops grown
Nearly flat, dark-colored prairie soils.				
Lake Charles	Black, dark-gray or brown, not calcareous, fairly tight on drying. Large areas of heavy soils.	Heavy, black or gray, not calcareous. Slowly penetrable to water.	Light-colored calcareous clay or chalky marl.	Cotton, rice, feed crops, corn, truck crops, figs.
Flat to undulating light-colored prairie soils.				
Edna	Light-brown to gray, largely sandy. Become tight on drying; acid.	Dense gray clay, almost impervious to water; acid.	Dense gray clay, calcareous in places at a great depth.	Native grasses, cotton, rice, feed crops, truck crops.
Hockley	Light-brown to gray, mostly sandy; acid.	Dense mottled gray and yellow clay; acid.	Heavy clay, non-calcareous.	Native grasses, cotton, feed chops, truck chops.
Katy	Light-brown to gray, mostly sandy; acid.	Dense mottled gray, red, and yellow clay; acid.	Heavy clay, non-calcareous.	Native grasses, rice, feed crops, truck crops, some cotton.
Galveston	Gray, loose and incoherent; acid.	Yellow or gray; acid.	Loose sand.	Truck crops, berries, grapes.
Flat; timbered.				
Acadia	Light-brown, gray or slightly mottled; hard and tight when dry; acid.	Gray or slightly mottled dense clay; acid.	Heavy clay, calcereous at a great depth.	Slightly used for cultivated crops, rice, feed crops, truck crops, timber
Flat marshy or semi-marshy prairies.				
Harris	Gray to brown, salt content high.	Gray or brown dense clay; high water table.	Clay.	Native plants, grazing
Flat stream bottoms. (Subject to overflow.)				
Trinity	Black or dark gray, calcareous.	Black or dark gray, calcareous.	Clay, calcareous.	Cotton, corn, feed crops.
Miller	Reddish, friable, calcareous.	Red, crumbly, heavier than surface soils.	Interbedded clay and other textures.	Cotton, sugar cane, corn, various feed crops, alfalfa, pecans.
Yahola	Reddish, friable, calcareous.	Light-red, sandy. lighter texture than surface soils.	Same.	Same.
Pledger	Brown or black friable, calcareous.	Red, friable, calcareous.	Same.	Same.
Ochlockonee	Brown or light-brown; acid.	Brown, yellow or gray or mottled: acid.	Same.	Same.

of the lighter-textured soils is dotted with small low circular sand mounds, many of which are surrounded at the base by narrow spots of bare soil containing considerable salt. The surface of the Lake Charles soils, especially the clay, is so nearly flat that drainage is very slow and during rainy seasons water stands for a long time. In the eastern part of the Coast Prairie, where rainfall is highest, drainage conditions are such that under natural conditions rice seems to be the crop best suited to large areas of the clay. The native vegetation consists chiefly of a thick cover of rank-growing coarse prairie grasses. Though some of the soils are cultivated and farmed, large areas of the virgin soils remain,

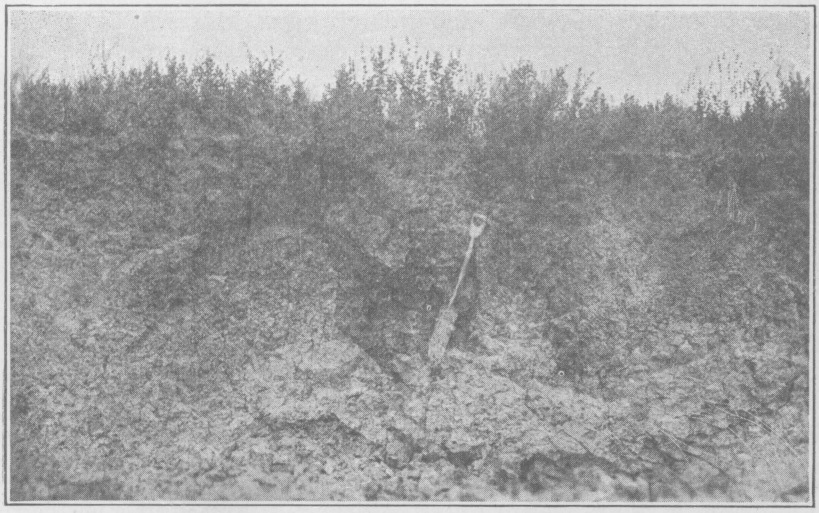

Figure 9. Soil profile of Victoria clay near Lake Placedo, Victoria County. This soil is very dark and is underlain by marl.

which are used only for livestock grazing. Land utilization for crops is hindered by lack of adequate drainage, but in some sections artificial drainage by ditching has been established with success. The soils are very productive and the chief crops grown are rice (in the eastern and central parts mostly), cotton (principally in the western part), figs, various feed crops, and, in places, considerable truck crops are grown on the lighter-textured soils. The clay is highly esteemed for rice and figs.

Light-Colored Prairie Soils

The light-colored soils of the Coast Prairie are confined chiefly to a narrow belt in the interior margin adjacent to the timbered areas of the East Texas Timber Country. However, small bodies occur scattered throughout all portions of the region and some occupy narrow coastal fringes and islands. The topsoils are for the most part of sandy texture and rest sharply upon heavy dense subsoils which merge below with light-

colored clay parent materials of acid reaction, though in places some calcareous material lies very deep. These soils are acid in reaction from the surface down, and the top layer contains only a small amount of organic matter. They are not highly productive. In general the surface drainage is slightly more free than on the dark-colored soils, but underdrainage is slower on account of the more impervious character of the underlying clays.

The chief soils are of the Edna, Hockley, Katy, Galveston, and Acadia series. The first three are quite similar in many characteristics, being underlain by dense clays, but the Galveston has friable permeable subsoils, and the Acadia is of very light color due to its development under timber vegetation, the others having developed under a heavy cover of grass. The light-colored soils probably cover a total area of nearly 2,750,000 acres.

Edna Soils: The Edna series of soils consists of gray, dark-gray, or brownish-gray soils underlain abruptly (with almost no gradational change) by heavy, dense tough gray or bluish-gray clay subsoils which, in many places, have slight spots and streaks of yellow or brown colors in the upper part. In a few spots, especially adjoining the Lake Charles soils, calcareous clay occurs at a depth of several feet beneath the surface. The soils and subsoils are acid in reaction. On drying thoroughly, the soils become very hard. The topsoils contain only a small amount of organic matter, which for the most part gives a slightly darker color to the upper few inches of surface soil. A few fine dark concretions occur in the subsoils. The fine and very fine sandy loam types predominate in the Edna series, though small areas of heavier soils occur. These soils occur in relatively small bodies associated in many places with the Lake Charles soils, though considerable areas also occur associated with the main light-colored Katy-Hockley soils belt in the northern part of the prairie. The surface is nearly flat to slightly depressed, and with the almost impermeable character of the subsoils, drainage is very slow. In places rainwater covers the surface most of the winter. Crawfish holes are abundant in many places. Many small, low circular sand mounds occur over the surface. Coarse grasses grow on these soils, though in some low areas water stands in pond-like depressions, where only coffee beans or other coarse plants grow. In places a growth of small oak trees has spread onto some of the Edna soils. These soils are not cultivated to a great extent though they comprise all or parts of some farms. Insufficient drainage prevents good crop yields in many locations; but with adequate drainage the soils are not highly productive. The chief crops grown are cotton, corn, and other feed crops, and some vegetables.

Hockley Soils: The Hockley soils have light-brown to grayish-brown topsoils resting abruptly on heavy, dense clay subsoils of mottled yellow and gray color (Fig. 10). The virgin soils are low in organic matter.

The heavy subsoils are so dense that water passes through the materials very slowly. The soils and subsoils are acid in reaction. The principal soils are sandy types. The fine sandy loam predominates and occupies large bodies of coarse-grass prairie in the northern sandy belt with the Katy and Edna soils. Small circular sand mounds dot the surface in places. The surface is nearly flat to undulating and drainage is slow on account of the dense heavy subsoils and substratum which allow but slight underdrainage. The Hockley soils are not highly productive, though with adequate drainage and by good systems of management fair yields may be secured. A small proportion of the soils is

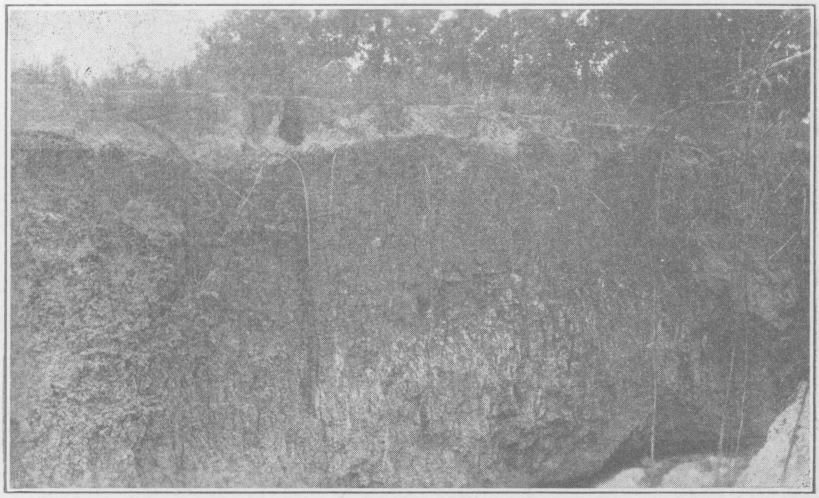

Figure 10. The surface sandy soil of the Hockley fine sandy loam rests sharply defined on the dense clay subsoil.

in cultivation, and they are used mostly for livestock grazing. The chief crops are cotton, feed crops, and, in places, vegetables.

Katy Soils: The Katy soils are light-brown, drying to a grayish cast. The upper layers rest abruptly on heavy mottled clay subsoils in which yellow, red, and gray colors predominate (Fig. 11). The subsoils become so hard as to form dense claypan layers. In places small dark concretions are present in considerable amounts in the subsoils. The soils are low in organic matter and all layers are of acid reaction. The surface is generally nearly flat to undulating and surface drainage is very imperfect, this condition being accentuated by the dense impervious character of the clay subsoils. The fine sandy loam is the principal soil of the series and it occurs in association with the Hockley and Edna soils largely in the sandy coarse-grass belt in the northern part of the Coast Prairie. Owing to insufficient drainage, a small proportion of Katy

soils is in cultivation. Rice is grown to some extent and yields are good for the first few years. Some cotton, corn, peanuts, and truck crops are grown with fair success. With adequate drainage and the practice of soil-improving methods, crop yields would doubless be increased.

Acadia Soils: The Acadia soils comprise gray or brownish-gray topsoils resting on heavy, ashy-gray subsoils which are, in places, mottled with yellow or red colors. In places, black concretions occur in the subsoils. Calcareous clay, or clay containing lime concretions occurs beneath some areas at a depth of several feet. Surface soils and subsoils

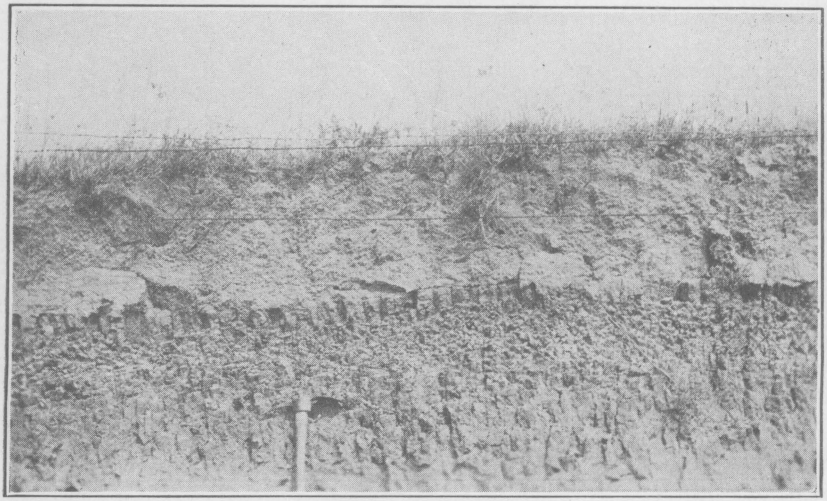

Figure 11. Soil profile of Katy fine sandy loam. The topsoil rests on dense mottled red, gray and yellow clay.

are acid in reaction and contain little organic matter. These soils occur in flat or nearly flat positions on the upland near streams, and water stands in places for a long time after rains. They have a timber growth of pine, oaks, gum, and other trees. The areas are mostly located adjacent to areas of the Lake Charles soils. The series comprises both heavy and sandy soils, the latter having some small circular sand mounds scattered over the surface. Very little of the land has been cleared and placed in cultivation. Where drainage conditions are suitable, the soils are fairly productive and produce moderate yields of the general farm and truck crops.

Galveston Soils: These comprise light-colored grayish soils of which a deep gray loose fine sand with a gray or yellow fine sand subsoil is practically the only representative of the series on the Coast Prairie. This occupies portions of islands and strips of land bordering the

waters of the Gulf and is of very slight extent. The soil is very loose, contains very little organic matter and is of only moderate agricultural value, though in places melons and other vine crops, grapes, berries, and some vegetables produce fair yields. Where unprotected, the soil blows and drifts in the wind.

Marshy and Semi-marshy Soils

These soils occupy strips of lowland adjacent to the waters of the Gulf. The topsoils are gray or brown with subsoils of similar color and of generally the same characteristics. The surface is very flat and lies but slightly above sea-level and in places some is at times covered with salt water blown from the Gulf during storms. The water table lies near the surface and the soil remains wet for months at a time. Soil development has not continued for a sufficient time to produce well-developed soil characteristics. The soils contain considerable salt in places and the wet and salty conditions are reflected in the natural vegetation consisting chiefly of salt and water-tolerant plants. These soils do not cover a very great proportion of the Coast Prairie though in places, especially in the eastern part, there are large areas. The soils are mainly of the Harris series and the wettest areas are locally called marsh lands. Probably three-quarter million acres of these soils occur.

Harris Soils: The Harris soils consist of gray or brown topsoil layers which pass gradually below into brown, gray, or mottled subsoils, and these grade below into the underlying clays which constitute the parent materials. The soils contain relatively large amounts of salt as indicated by the dominating salt grass vegetation. They occur in very flat low areas and are saturated with water most of the time (Fig. 12). They merge with the tidal and salt marshes in places, with very

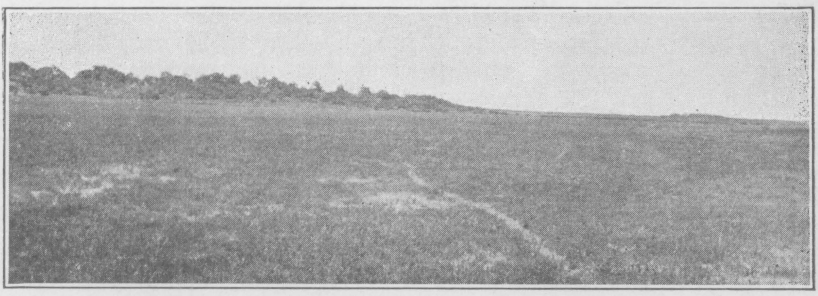

Figure 12. The Harris clay is a flat semi-marshy soil. It lies but sightly higher than the waters of the coastal bays.

little change in surface conditions, but the true marsh areas have a larger proportion of salt grass and are inundated by wind-blown salt water more frequently. The soils are mostly of heavy texture and due to the wet conditions and salt content they are not suitable for crops, but are used for the scant livestock grazing afforded by the natural

vegetation. If reclaimed by diking, and adequate drainage is maintained, the soils will doubtless produce good crops after the salt has been washed out.

Alluvial Soils

Few streams originate within the Coast Prairie, as the surface is so nearly flat in most sections that a natural local drainage system has not been developed. A number of large streams pass through the region and along these there are some large areas of alluvial soils. These are mainly of the Trinity, Miller, Yahola, Pledger, Guadalupe, and Ochlockonee series, and comprises soil materials washed from other soil regions. These soils are treated in more detail in discussions of the soil region in which the alluvial soil materials originate, as in those localities the more typical soils occur. The Trinity soils are of dark and calcareous soil materials from the prairies; the Miller and Yahola consist of red calcareous soil materials washed from red soils and formations of the Rolling Plains; the Pledger are dark calcareous soils with red subsoil layers of materials from both these regions; and the Ochlockonee soils are of brown non-calcareous soil materials washed mainly from soils of the East Texas Timber Country. There are doubtless other unmapped alluvial soils along the large streams passing through the Coast Prairie. The alluvial soils of the region that have been classified and correlated are fairly typical, though some Trinity soils appear less calcareous, and the Miller and Yahola soils slightly darker, than in locations nearer the source of the original soil materials. The Pledger soils appear to be typically represented here, and locally may be more extensive than elsewhere. The Ochlockonee soils along some streams appear somewhat darker than found in locations near the source of the soil materials. The Guadalupe are brown calcareous soils with sandy subsoils.

The alluvial soils are farmed to a considerable extent in some sections where drainage conditions permit, though sometimes crops are lost by overflows. They are well suited to cotton, corn, sugar cane, feed crops, alfalfa, pecans, and some truck crops. A very large proportion of these soils remain forested. Nearly 750,000 acres of these soils lie in this region.

Soil Utilization

The proportion of soils in cultivation differs greatly throughout different parts of the Coast Prairie depending largely on the character of the soils. As a rule, the largest percentage of land in cultivation is of the more highly productive Lake Charles soils, but there are large areas of these that are as yet used only for livestock grazing. Large areas of the productive soils would probably be more largely farmed if the land were better drained, and in the case of the alluvial soils protected from overflow.

The soils most extensively cultivated other than those of the Lake Charles series are the fine sandy loams of the Edna, Hockley, and Katy

series, with a considerable amount of Miller, Yahola, Trinity, and Ochlockonee soils in some of the river bottoms. The Lake Charles clay is probably the most extensive soil type in the region. It occurs in large smooth areas and owing to its high productiveness it is used largely for cotton, rice, corn, figs, and other crops, but it is not so well suited for vegetables and truck farming and is not used much for such crops (Figs. 13 and 14). The clay loam, and fine sandy loam of the Lake Charles series are highly productive and are used for all the general

Figure 13. Lake Charles clay is almost flat, and where dainage is adequate it produces good yields of many crops. This shows cotton and corn near McFaddin.

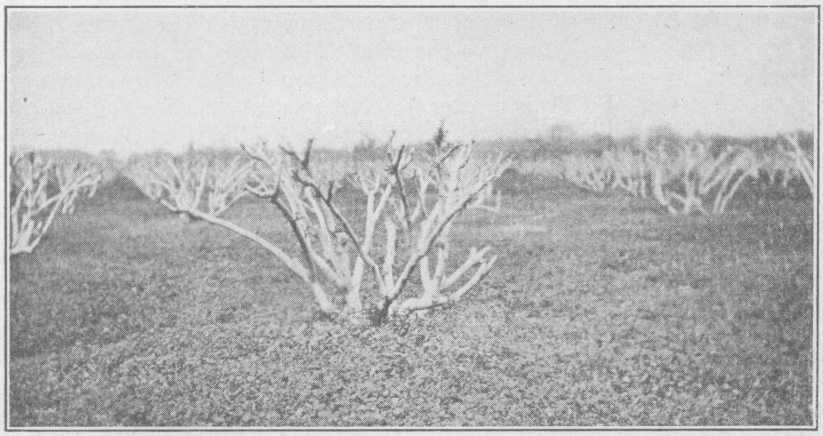

Figure 14. Fig orchard on Lake Charles clay in Galveston County. During the winter some orchardists grow Bur clover to improve the soil.

farm crops and, in places, for truck farming and market gardening. The fine sandy loams of the Edna, Hockley, and Katy series are not highly productive, but with attention given to soil improvement, fair yields of the general farm crops and vegetables are produced. These soils are used on small farms for cotton, corn, and other feed crops. The sandy soils generally respond well to applications of organic matter and to applications of fertilizers where moisture conditions are favorable. All of the soils respond well to improvements in drainage

conditions. The sandy soils are well suited to vegetables, berries, and small fruits. The Acadia soils are not used to any considerable amount, as soils free of timber growth are more readily placed in cultivation. The Galveston soils are used to some extent in places for producing vegetables, berries, grapes, and various other truck crops such as watermelons and cantaloupes. The Harris soils are not cultivated, as they have deficient drainage and, in places, contain salt.

EAST TEXAS TIMBER COUNTRY

That great coastal belt of timbered sandy land extending from New Jersey along the Atlantic and Gulf seaboard reaches into eastern Texas and there comprises that region known as the East Texas Timber Country. This great body of land consists of many kinds of soils, but they have many common features and characteristics which indicate their general relationship. These soils are mostly of light texture, light-colored, and low in organic matter. On account of soils relationships the East Cross Timbers area is included on the soil map with this region. This is a narrow strip of timbered sandy soils lying 50 to 75 miles west of the East Texas Timber Country in northeastern Texas. It extends about 150 miles southward from Red River. The East Texas Timber Country and East Cross Timbers have a total area of some 26,000,000 acres covering all or parts of about 74 counties. On the north this region extends to the Ozark Mountains in Oklahoma; on the south it joins the Coast Prairie; and on the west it terminates sharply at the Black Prairie, except for a narrow fringe on the north of that prairie which practically connects with the East Cross Timbers. On the south a broad belt extends southwestward from the main region and merges in southern Texas with the brush plains of the Rio Grande Plain.

The timber growth consists mainly of mixed pine and hardwood, though in the southeastern section pine trees predominate and constitute the source of a great lumbering industry. On the western side the pine gives way to a fringe of oak timber 20 to 50 miles wide which borders the prairie. Though much of the pine timber has been cut, considerable areas are being reforested (Fig. 15).

The surface relief of the region is uneven with a general slope from north to south. Elevations in the southern parts range from 100 to 200 feet and increase northward to 300 to 600 feet above sea-level in some sections. The land is generally undulating to rolling and hilly. It is deeply carved by stream dissection, many rivers originating or passing through in broad valley trenches from which extend numerous smaller tributaries reaching back into all sections. Near the larger streams some rough hilly lands with steep slopes occur while in places some stony hills occupy divides. Erosion is active in many places and surface soil layers are thin on many of the steeper slopes. The larger nearly flat areas are located mostly in the southeastern part.

The average annual temperature of the general region is about 68° F. in the southern part, becoming gradually lower to around 64° in the northern sections. The average annual rainfall is between 45 and 50 inches in the eastern part, decreasing westward to about 35 inches in the southwest extension of the region. The summers are long with rainfall usually occurring at intervals sufficiently regular to provide ample moisture for crops. The winters are short and although moderate weather prevails, there are occasional periods of moderately cold weather lasting several days, during which temperatures often fall below the freezing point.

Figure 15. This shows cutover pine forest land in Jasper County that is being reforested. The light-colored soils of the East Texas Timber Country are valuable for producing timber.

On the basis of natural features the East Texas Timber Country is divided into five sections. These local sections, characterized by the predominance of certain soils, features of surface relief, and native vegetation are distinctive although in most places they merge together without sharp lines of separation. These sections, shown on the soil map in terms of the dominant soil groups consist of:

(1) The northern oak-belt section consisting of wide strips of rolling oak timberland bordering the prairie, is occupied largely by soils of the Kirvin-Norfolk group; area about 6,500,000 acres;

(2) The typical section, a very rolling shortleaf pine country having the general characteristic features prevailing in the Coastal Plain throughout the Southern States, the dominant soils of this section being mostly of the Kirvin-Bowie group (Fig. 16); area about 6,000,000 acres;

(3) The dense subsoil section, a rolling to gently rolling area containing soils chiefly of the Lufkin-Susquehanna group with included small prairies of dark-colored soils, and covered in the western part mainly by

post-oak timber and in the eastern part by pine forests; area about 9,500,000 acres;

(4) The flatwoods section, a relatively small area of about 2,000,000 acres in the southeastern part which is largely flat to undulating (Fig. 17) and is occupied mainly by soils of the Segno-Caddo group supporting a forest of pine; and

(5) The redlands section, a rolling to hilly pine-hardwood area conspicuously featured, in places, by the presence of some very red soils comprising the famous "East Texas Redlands." Here the chief soils are of the Nacogdoches-Norfolk group. This section covers about 2,000,000 acres.

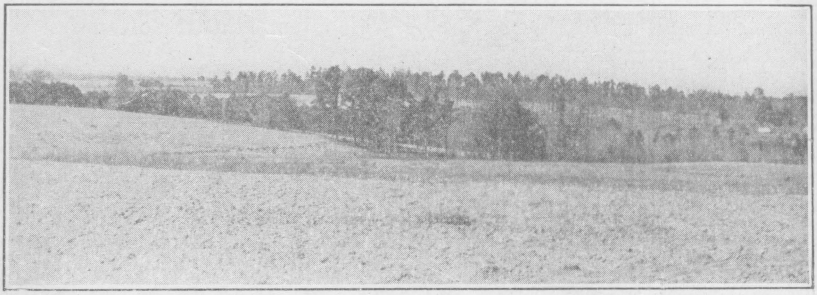

Figure 16. This view of rolling farmland in Rusk County shows the characteristic surface relief of the light-colored sandy soils throughout the East Texas Timber Country.

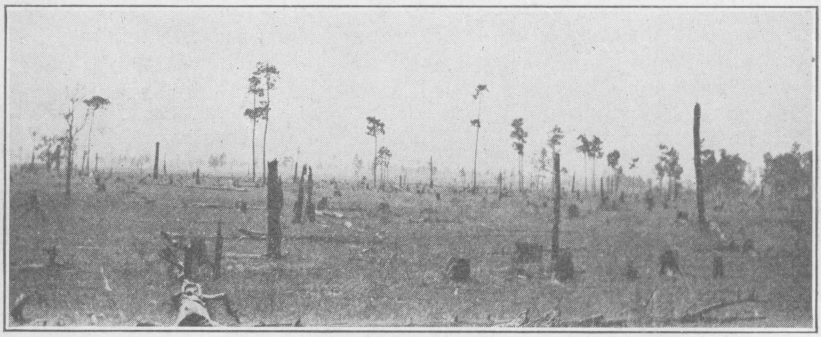

Figure 17. In the flatwoods section the surface is mostly smooth. This also shows the effects of fire injury to young trees in an area that is being reforested.

Agriculture

While agricultural development is quite general throughout the East Texas Timber Country a rather small proportion of the land is devoted to farm crops. The greatest development is on the most productive upland soils near the larger centers of population, while, on account of lumbering and insufficient drainage accentuated by heavy rainfall, the soils in some southeastern sections have been used very little for farm crops. In some of the southeastern sections the crop land in

some counties amounts to less than 3 per cent of the total land area, while in others it is only as high as 10 per cent. In the more thickly settled sections the proportion in some counties is about 16 per cent; in others it is as high as 40 per cent, according to the census of 1925.

Value of crop production in 1924 ranged from less than $1,000,000 in some southeastern counties to more than $4,000,000 in others located in more highly-developed sections.

The farms are mostly small, and the chief crop grown is cotton. Corn, sorgo, and various other feed crops, vegetables, fruits, and berries are also important products. The leading truck crops are watermelons, sweet potatoes, and tomatoes, although various others are grown and in places plant nurseries are successfully operated, while dairying is an important and growing industry fostered by large plants that manufacture milk products. Cattle and hogs are raised on many farms, and in places are ranged throughout the forests.

While the soils of the region are generally of only moderate productiveness they are susceptible to improvement, including fertilization. They are suited to many crops and their use for crops is facilitated by the long frost-free growing season averaging about 230 days in the northern, and 265 days in the southern parts. The soils are not generally suited to small grains, but are especially suited to truck crops, fruits, many farm crops, and to some grasses and pasture crops.

The agricultural values of the soils can be made greater in many places by terracing to prevent erosion and in other places by providing adequate drainage conditions.

Soils

The soils of the East Texas Timber Country consist mainly of fine sands and fine sandy loams. The surface soils, mostly light in color (though some are red), as a rule, are underlain by subsoils that are heavier than the surface layers. The surface soils are in most places of two distinct layers, the upper, containing only a small amount of organic matter, grading below into a subsurface layer of similar texture. In virgin areas the organic layer is but two or three inches thick, but with cultivation this is increased to a thickness of six inches or more. The color of the organic layer (where not red) is brown or gray, while the subsurface, corresponding largely to the color of the subsoil beneath, is mostly red, brown, yellow, or gray, or shades of these colors. The subsoils, mostly of clay or sandy clay, differ greatly in color and structure and on their characteristics is based the differentiation of the soils into series groups. As a rule, all of the soil and subsoil layers are of acid reaction. The surface and subsoil layers merge together beneath many of the soils, but in others there is a sharp line of separation between the surface soil and subsoil layers.

The soils have been developed mostly from beds of noncalcareous clay, sandy clay, clay shale, or sand. They reflect, in their developed characteristics, the influences of a warm, moist, climate and the vege-

tative cover of trees which contribute but little organic matter. The results of leaching and erosion, due to high rainfall, are indicated in the developed deep beds of fine sand on the nearly flat high areas, and in the variable thickness of soil and subsoil layers on slopes of different gradients where, in places, erosion has removed all or part of the soil layers before they have become thoroughly developed. Where free underdrainage occurs, red and yellow colors become established in the subsoils, but where drainage is very slow gray color predominates. Little or no true soil development has taken place in the soil materials comprising the alluvial soils of the stream-bottom lands. These consist of soil materials washed chiefly from the local upland soils and are periodically receiving fresh deposits from the same source. On some relatively small flat areas comprising old stream terraces the ancient alluvium has been developed into soils which have characteristics very similar to those of the higher upland soils developed from older parent materials.

The upland soils are the most extensive, probably covering 85 per cent of the region. On the basis of pronounced characteristics of the subsoils the soils are of two divisions: (1) the soils having friable, crumbly, permeable subsoils, and (2) soils with dense, very heavy subsoils. While soils of each division occur extensively in different sections, neither occupies large areas exclusively, and in many sections they are to be found in many small and large bodies in close association. The soils with the friable subsoils usually have better drainage, respond more favorably to methods of soil improvement and fertilization, and, therefore, are on the whole more satisfactory for the production of farm crops.

The table on page 37 gives the characteristics and chief crops grown on the principal soils of the region.

Upland Soils with Friable Subsoils

This division includes a number of soils of which the topsoils are mostly light-colored, though some are red. The topsoils grade downward into the subsoils without a sharp line of division between the different layers. These soils are mainly of the Kirvin, Bowie, Ruston, Caddo, Norfolk, Segno, and Kalmia series, the two latter being located on smooth benches adjacent to the stream bottoms. Most of these soils occur in both large and small areas scattered throughout all sections of the region, but, on the whole, are probably more extensive in the northern and southeastern sections. Figure 18 illustrates a soil profile of the Kirvin fine sandy loam, a representative of the friable subsoil division.

Kirvin Soils: The Kirvin soils are brown or reddish-brown in color, some having light-brown or gray shades when dry. These grade below into rather heavy red clay subsoils which in places have slight mottlings or streaks of limonite-yellow color. In the lower or parent-material part, at a depth of about 2 to 4 feet beneath the surface, there is

Principal soils of the East Texas Timber country

Soil groups (Series)	Topsoil	Subsoil	Substratum (parent material)	Chief crops grown
Timbered Uplands.				
Friable subsoils:				
Undulating to rolling.				
Kirvin	Light-brown to grayish or slightly reddish.	Red, some gray mottlings in lower part, slowly permeable.	Clay or sandy clay.	Cotton, corn, feed crops, truck crops, fruits.
Undulating to gently rolling.				
Bowie	Gray to light-brown; yellow sub-surface.	Yellow mottled with gray and red; permeable.	Clay or sandy clay.	Cotton, feed crops, truck crops, fruit.
Gently rolling.				
Ruston	Light brown to grayish with brown, yellowish, or reddish subsurface.	Reddish-yellow, reddish-brown, or light red; very permeable.	Clay or sandy clay.	Cotton, feed crops, truck crops, fruits.
Flat to undulating.				
Caddo	Gray with yellow subsurface.	Yellow mottled with gray in lower part; slowly permeable.	Clay or sandy clay.	Cotton, feed crops.
Nearly flat to rolling.				
Norfolk	Gray with yellow subsurface.	Yellow; very permeable and sandy.	Sandy clay.	Cotton, feed crops, truck crops, fruits.
Flat to undulating.				
Segno	Light-brown or gray with yellow subsurface; ironstone pebbles.	Yellow with red spots; permeable, ironstone pebbles.	Sandy clay.	Cotton, feed crops, truck crops, timbers.
Undulating to very rolling.				
Nacogdoches	Red; ironstone fragments in many places.	Red; slowly permeable.	Clay or sandy clay; marl in places.	Cotton, feed crops, truck crops, fruits.
Flat to undulating old stream benches (above overflow).				
Cahaba	Light-brown with reddish or yellowish subsurface.	Light-red; very permeable.	Sandy clay, on beds of gravel.	Cotton, feed crops, truck crops, fruits.
Kalmia	Light-brown or gray with yellow subsurface.	Yellow; very permeable.	Sandy clay, on beds of gravel.	Cotton, feed crops, truck crops, fruits.

Principal soils of the East Texas Timber country—Continued

Soil groups (Series)	Topsoil	Subsoil	Substratum (parent material)	Chief crops grown
Timbered Uplands—Continued.				
Dense Subsoils:				
Nearly flat to undulating.				
Lufkin	Gray; becomes tight on drying.	Gray; dense, very slowly permeable.	Clay or shaly clay.	Cotton, feed crops, timber.
Undulating to rolling.				
Susquehanna	Light-brown to gray with yellow subsurface.	Red and gray mottled; dense, very slowly permeable.	Clay or shaly clay.	Cotton, feed crops, truck crops, timber.
Nearly flat to undulating.				
Tabor	Light-brown to gray with yellow subsurface.	Yellow with gray mottlingsinlower part; rather dense; moderately permeable.	Clay.	Cotton, feed crops, truck crops.
Flat to undulating old stream benches (above overflow).				
Leaf	Light-brown; reddish or yellowish subsurface.	Dense; mottled red and gray; very slowly permeable.	Clay on beds of gravel.	Cotton, feed crops, truck crops, fruits.
Myatt	Gray; becomes tight on drying.	Gray; dense; very slowly permeable.	Clay on beds of gravel.	Cotton, feed crops, timber.
Flat Stream Bottoms. (Subject to overflow.)				
Ochlockonee	Light-brown or grayish.	Brown or yellow or mottled with gray.	Beds of alluvial deposits—sandy to clayey.	Cotton, feed crops, sugar cane.
Bibb	Gray or slightly mottled.	Gray, with slight mottlings.	Beds of alluvial deposits—sandy to clayey.	Mostly timber, some cotton, feed crops.
Hannahatchie	Red or brown.	Red.	Beds of alluvial deposits—sandy to clayey.	Cotton, feed crops, truck crops.

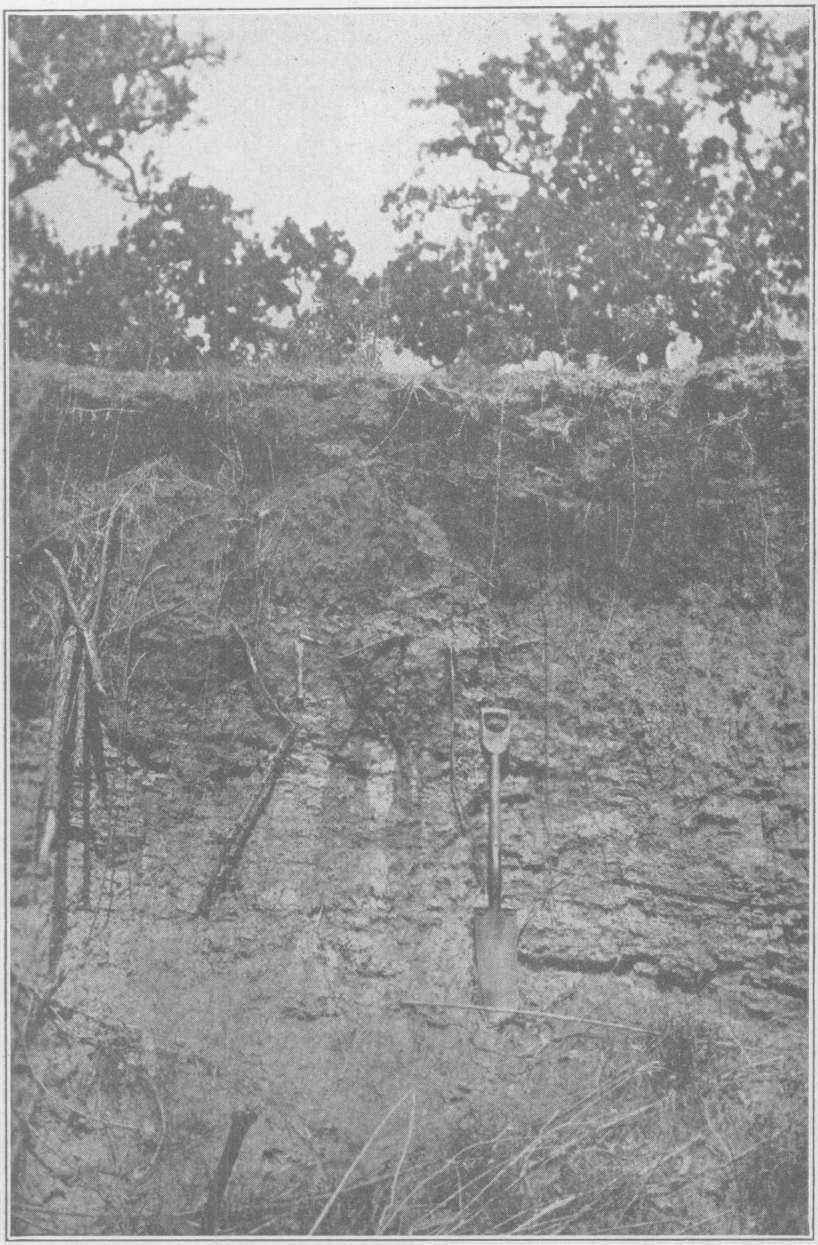

Figure 18. The soil profile of Kirvin fine sandy loam. At a depth of about four feet the crumbly clay subsoil grades into parent material consisting of clay interbedded with sand.

found mottled red and gray clay much like the subsoil of the Susquehanna soils. In most areas small fragments of ironstone or iron-cemented sandstone occur throughout the layers of topsoil and subsoil. The surface relief ranges frrom undulating to rolling. The surface drainage is rapid and underdrainage is good. Erosion is severe on unprotected slopes. The fine sandy loam is the predominant soil type of the series. The Kirvin soils are widely scattered over many parts of the East Texas Timber Country, but appear to be most extensive in the typical, the redlands, and the northern oak-belt sections, where they occur in many large and small areas in close association with Susquehanna, Norfolk, Ruston, Bowie, and other soils. The soils are moderately productive and are utilized for all the regional crops to some extent. Some areas of the soil are relatively low in productive capacity on account of erosion and exhaustive cropping, but where protected and managed properly, they respond well to cultivation. The soils are well suited to the general farm crops, fruits, and vegetables, and comprise an important proportion of the soils of the region. The natural vegetation is a timber growth of pine and oak in some sections, and in others it is chiefly post-oak, red-oak, some other species of oak, and hickory.

Norfolk Soils: The Norfolk soils are gray on the surface with a yellow subsurface color. The topsoil layers are friable or loose and merge below either with yellow friable sandy clay or loose very sandy material. The soils and subsoils are readily penetrated by water and both surface and underdrainage are good. The surface is mostly rolling or undulating and slopes are generally moderate. The fine sandy loam and fine sand are the principal soils of the series. The fine sand occurs in many large and small areas in many sections of the region, where it constitutes an easily recognizable feature (Fig. 19). In places it occupies high smooth plateau-like areas. The soils are used to some extent for farming though they are thin and not highly productive unless good methods of soil improvement are employed. The natural vegetative growth in the eastern areas is pine or mixed pine and oak; in the more westerly sections post-oak, blackjack oak, and sandjack oak are the principal trees. The soils are well suited to a number of the general crops, the lighter soils seeming to be best suited to melons, sweet potatoes, and other vine crops, and to vegetables, berries, and small fruits.

Bowie Soils: The Bowie topsoils are gray or brownish-gray on the surface but at a depth of several inches the subsurface is yellow. The surface layers pass below into yellow, friable sandy clay subsoils which at a depth of about 2 or 3 feet are mottled or splotched with gray, yellow, and red. The subsoil colors are somewhat similar to those of the Susquehanna soils but the friable permeable structure differs greatly from the heavy dense clay beneath the Susquehanna soils. The Bowie soils are moderately rolling to undulating and have fairly rapid surface drainage, and free underdrainage.

Figure 19. Soil profile of Norfolk fine sand. This is a loose gray fine sand about four inches deep underlain by pale yellow fine sand twelve feet deep.

The fine and very fine sandy loams seem to be the most extensive soils of the series. These are located mostly in the northeastern part of the East Texas Timber Country. The principal natural vegetation is shortleaf pine, with various species of oaks, such as post-oak and red-oak, and a few other kinds of trees. Some of these soils lie within the oak belts, where no pine grows. The soils occur in some large and many small bodies associated with areas of many other soils. The Bowie soils are farmed to some extent and are naturally of moderate productiveness. The general farm crops, vegetables, and fruits are grown and the soils seem well suited to many crops and yield returns in proportion to efficiency of management.

Nacogdoches Soils: The Nacogdoches soils are red, blood-red, or reddish-brown. They merge below with red, rather heavy, crumbly, permeable clay subsoils, which in some places at least are underlain by beds of greensand and limy material at a depth of several feet. The soils and subsoils characteristically contain fragments and layers of ironstone. The surface is generally rolling and in places hilly and some slopes are rather steep. Where rapidly drained, the unprotected surface is subjected to severe erosion, though possibly this is not so severe as on some soils of either denser, or more sandy friable subsoils. Some smooth, nearly flat or undulating divides are occupied by some of these soils. The fine sandy loam seems to be the most extensive soil of the series though other soils also occur, some of which contain a large amount of ironstone fragments. The Nacogdoches soils occur almost entirely within the "redlands" section of the region and constitute the famous red soils of eastern Texas. They are associated with many of the various light-colored soils, but in the aggregate comprise as much as 16 per cent or more of some counties. The native vegetation consists mainly of a mixed growth of shortleaf pine, red-oak, and some other species of oak with a few other trees. A large proportion of these soils is under cultivation as they are suited to most farm and truck crops and fruits and produce good yields. They respond profitably to good methods of soil improvement and fertilization and appear to be lasting in their productive capacity. Even the soils which have a large amount of the ironstone are productive. Some of the soils are especially suited to the production of fine quality cigar tobacco.

Segno Soils: The Segno soils are gray in color to a depth of a few inches, the subsurface material being yellow. The topsoils grade below into yellow friable subsoils, which below a depth of about 3 or 4 feet show spots or streaks of yellow and red colors. Small dark concretions and ironstone pebbles occur in many places in the soils and subsoils. The subsoils are friable and crumbly and allow ready passage of water and air. The surface of these soils ranges from smooth undulating divides to rolling areas with moderate slopes. Surface drainage as well as

underdrainage is sufficiently rapid for the removal of excess water except in some very flat positions where underlain by dense clay parent-material. In places erosion is severe on unprotected slopes. The fine sandy loam seems to be the most extensive soil of the series. These soils occur mainly in the southeastern flatwoods section though possibly they may be found in some other sections. The soils occur in some good-sized and many small areas in association with Caddo and various other soils. The natural vegetation is largely shortleaf pine and loblolly pine with only small amounts of oaks and other trees. The soils are moderately productive and are suitable for being used for many crops with the practice of proper methods of soil conservation. Only small areas of these soils are in cultivation as they lie largely within a region where lumbering has not as yet given way to extensive crop production.

Caddo Soils: The Caddo topsoils are gray to a depth of several inches and pass below into gray or yellow subsurface soil material. The soils grade below into friable, moderately heavy sandy subsoils of yellow and gray mottled colors. In places a few dark round concretions occur throughout the subsoil material. These soils occupy rather smooth, nearly flat or even slightly depressed areas. The structure of surface soils and subsoils enable ready penetrability of water, but in many places the surface allows little or no runoff and, therefore, the soil becomes saturated and remains wet for a long time in cool or rainy seasons. In places the parent-material several feet beneath the surface is a heavy clay so slowly penetrable as to hinder underdrainge. In many places there are small domelike mounds of fine sand which dot the surface at irregular intervals. The timber is the dominant natural growth, and pine, several species of oak, and sweet gum, and some other trees occur. Shortleaf and loblolly pine are the principal species, though in places a small amount of longleaf pine also occurs. The fine sandy loam is the principal soil of the series. The soils occur probably more extensively and in larger areas in the flatwoods and typical shortleaf pine belt than elsewhere, though some small-sized bodies are in some of the other sections. Owing to slow drainage and generally slow agricultural development, only a small acreage of these soils is used for crops though there are many farms on, or partly on, some of these soils. The soils are moderately productive and seem fairly well suited to the commonly grown crops of the region.

Ruston Soils: The Ruston soils have a grayish-brown or light-brown color to a depth of several inches and below they grade into a subsurface layer of brown, yellow, or slightly red color. The surface soils merge below with friable, crumbly subsoils of yellowish-red or reddish-yellow color. The soils and subsoils are very friable and readily penetrable to water and air. The surface of the soils is mostly undulating to rolling and slopes are sufficiently steep to allow serious erosion

where the soil is unprotected. Surface drainage is moderately rapid and underdrainage is effective. The fine sandy loam and fine sand are the principal soils of the series. These soils occur in small scattered areas in many parts of the region, though the larger proportion occurs in the northern sections and in the redlands section. The principal natural growth is shortleaf pine with some hardwoods such as red-oak, post-oak, and hickory. The soils are moderately productive, respond well to good methods of improvement and are well suited to the general farm crops, truck crops, and fruits.

Cahaba Soils: The Cahaba surface soils are light-brown to gray in color and merge below with reddish-yellow or light-red friable subsoils. The fine sandy loam is the chief soil of the series. The Cahaba soils are not extensive. They occupy narrow, smooth, undulating to nearly flat benches adjacent to, but higher than the stream bottoms, and are developed from old water-laid soil materials washed from the sandy soils of the uplands. These soils are similar to the Ruston soils, but occupy second-bottom positions and have a higher water table. The soils rest on beds of gravel and sand in places. The native pine or oak or mixed pine and oak growth of the local uplands occurs on these soils. They are very productive and are not subjected to such severe erosion as soils of more rolling surface. These soils are farmed successfully in many places, and are well suited to the farm and truck crops, fruits, and berries.

Kalmia Soils: The Kalmia soils are gray or light-brown surface soils several inches deep, underlain by yellow subsurface soil material which grades below into yellow friable subsoils. The fine sand and fine sandy loam are the principal soils in the series. The surface is smooth, as these soils occur on undulating to nearly flat high narrow terrace benches adjacent to stream bottom. These soils are similar to the Norfolk soils but occupy smoother positions and have a higher water table. In many places they are underlain by beds of gravel and sand. The native growth is mostly pine and oak, though in the western sections no pine is present. These soils have developed from sediments washed from the upland light-colored sandy soils. They are moderately productive and suited to most of the crops of the region, being more especially suited to vegetables, vine crops and small fruits.

Upland Soils with Dense Subsoils

This division consists of soils in which the surface soils rest upon dense heavy subsoils which allow only very slow penetration of water. The soil layers are separated from subsoil layers by a distinct line of separation. These soils are chiefly of the Susquehanna, Lufkin, Tabor, Leaf, and Myatt series. They occur in areas scattered throughout all parts of the region, and predominate in some of the southern and southwestern sections. These soils occupy more generally smooth and less sloping surfaces than most soils of the friable subsoil division.

Susquehanna Soils: The Susquehanna soils are light-brown or grayish-brown to a depth of several inches, but grade below into yellow or gray subsurface material which rests upon dense, plastic clay, mottled red and gray. The gray color increases and the red decreases with increasing depth (Fig. 20). The soil and subsoil layers are rather thin in many places and the parent-material consisting of gray clay, in many places of shaly structure, lies near the surface. The surface is undulating to rolling, and on some slopes erosion is severe. The soils have fairly rapid surface drainage, but due to the dense nature of the subsoils underdrainage is very slow. The flat areas remain wet for long periods in cool or wet seasons. The fine sandy loam is the principal type of the series. These soils occur in many parts of the East Texas Timber Country in association with many other soils. The timber

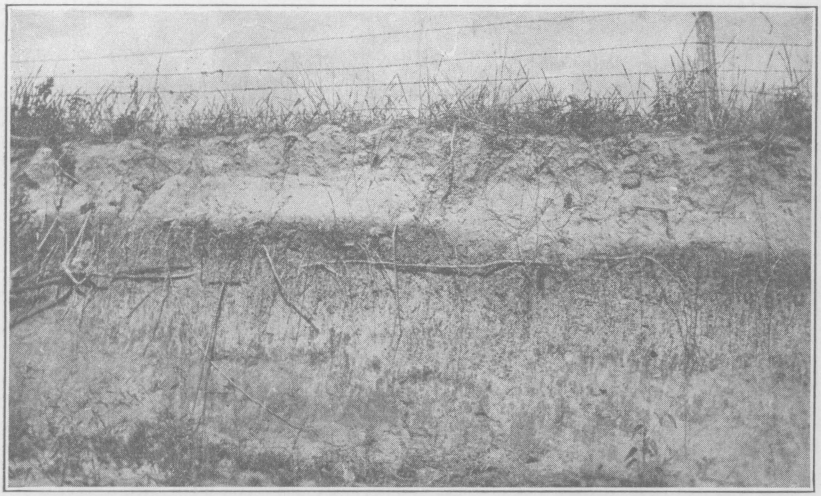

Figure 20. Soil profile of Susquehanna fine sandy loam in Milam County. This soil consists of a light-colored sandy layer fifteen inches thick resting on dense mottled red and gray clay which at a depth of four feet grades into the parent material of heavy gray clay.

growth consists largely of pine, including some longleaf, over considerable areas; elsewhere it is mainly of post-oak. The soils are of moderate productiveness, the fine sandy loam where the soil and subsoil layers are of moderate thickness being farmed with fair success when good methods of soil improvement are employed. Some areas appear to be so well suited to timber that it seems possible that in places this would be more profitable than farm crops. In the southwestern part of the region some large areas occur that consist of very gravelly soils.

Lufkin Soils: The Lufkin soils are gray in color and rest upon dense plastic clay subsoils which in many places have slight yellow

mottlings. In places the subsoil has a wave-like form (Fig. 21). These soils have very slow underdrainage, and on smooth, flat areas the soils remain very wet for long periods. The Lufkin fine sandy loam is the principal soil type of the series, though other textural classes also occur. The natural growth is pine, including some longleaf pine in places in the eastern sections, but more largely post-oak in the western sections. These soils occur most extensively in some of the southern parts of the region, but small bodies are located in all sections. They remain wet and cold during the winters, warm up slowly in spring, and when dry are worked with difficulty, especially the heavier soils, as the soils dry out to a hard crusty mass. With careful treatment, moderate yields of the general farm crops are secured. Considerable land is used for the general farm crops.

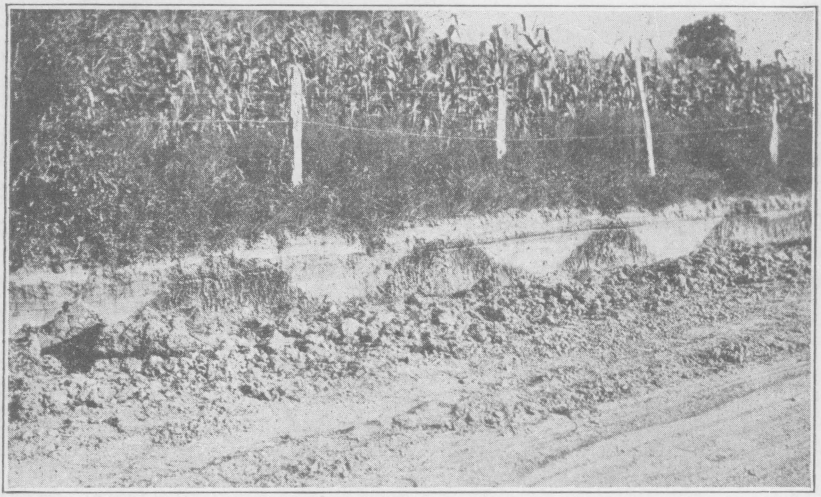

Figure 21. The Lufkin fine sandy loam is underlain by a dense tough gray clay subsoil that in places has a wave-like form. This feature of the soil and subsoil is common in Brazos County on nearly flat areas.

Leaf Soils: The topsoils of this series are gray or light-brown and at a depth of several inches are underlain by a yellow subsurface layer. The upper layers rest on heavy clay subsoils of mottled red and gray colors. These soils occur on old stream terraces high above overflow. They are developed from soil materials washed from the light-colored upland soils of the region when streams lay at a higher level. The fine sandy loam is the principal soils of the series. These soils have a timber growth mainly of pine or oak very similar to the local higher upland forests. The surface is smoothly undulating to nearly flat. Drainage is slow owing to the dense character of the subsoils. The soils are moderately productive and in places are used for a number of the general farm crops, truck crops, and fruits. The soils are quite similar

to the deeper phases of the Susquehanna soils but are less rolling and have a higher water table and in many places rest on beds of gravel. They are not extensive, though many widely scattered small bodies are in many of the valleys throughout all parts of the region.

Myatt Soils: The Myatt soils have a gray surface layer, which rests on heavy dense gray clay subsoils. These soils occupy flat benches lying high above the adjacent stream bottoms. The fine sandy loam and clay loam soils are the chief soil types of the series. On drying, the soils become very hard and tight. They have very slow natural drainage owing to the flat position and dense, almost impenetrable subsoils. The natural growth is largely post-oak, willow-oak, water-oak, and some other trees, though in some eastern sections pine also grows. The soils are not extensive, but they occur in widely scattered small areas throughout many sections of the East Texas Timber Country. The soil characteristics are somewhat similar to those of the Lufkin soils. Owing to slow drainage, much of these soils has not been placed in cultivation. Where cultivated the better drained areas produce moderate yields of the general farm crops.

Alluvial Soils

Probably not less than 15 per cent of the land area of the East Texas Timber Country is occupied by alluvial soils. These soils consist of soil materials transported by water from eroded upland surfaces and deposited in the stream valleys. They consist of deep beds of materials which have not been in place long enough to have developed soil characteristics similar to the upland soils. The alluvial soils are widespread in occurrence along the numerous streams which originate within or which pass through the region. The local stream bottoms are from a few hundred feet to a mile or more wide, while the larger streams originating outside the region occupy flood plains ranging up to 2 or 3 miles wide.

The soils are of two general kinds: first, those typical of the region, which are composed of soil material washed from the local light-colored upland soils; and, second, those made up mostly of materials transported from other soil regions.

The soils composed of local soil materials are mostly of the Ochlockonee, Bibb, and Hannahatchie series. They are light-colored for the most part and range in textural classes from the light sandy to the heavy clay soils, the sandy soils predominating in the smaller stream valleys. They are deep, relatively rich in organic matter, acid in reaction, and are friable and quite permeable though the heavier soils are but slowly penetrated by water and cannot be subjected to tillage when very wet or very dry.

The alluvial soils of materials transported by streams from outside the regions are red, brown, or black, mostly calcareous, and the heavy textures predominate. These are mainly of the Miller, Yahola, Pledger, Trinity, Catalpa, and Johnston series, and occur mostly in

the valleys which are traversed by the Red, Sulphur, Sabine, Trinity, Brazos and Colorado rivers. These soils are typically exemplified in the regions whence the soil materials originate and are described in the treatment of those regions. As the areas of these soils reach into the East Texas Timber Country the soils generally become less calcareous, the red soils somewhat darker, and the black soils, in many places, less dark than in the regions where the soil materials originate. These changes are brought about, at least partly, by the admixture of some local soil materials, and by longer periods of saturation by water through more frequent overflows and greater rainfall than prevails in the parent regions of their typical occurrence.

The hardwoods dominate the natural vegetative growth of the soils from outside sources, but pine trees are prominent on the soils of local soil materials.

Ochlockonee Soils: The Ochlockonee series comprises brown to dark-gray soils which grade below into mottled yellow and gray subsoils. The surface is low and nearly flat so that surface drainage is slow. Although the subsoils are rapidly penetrated by water, the water table is high and underdrainage is not rapid. During the warm months of the year, however, the soils are fairly dry the most of the time. Although overflows occur occasionally and heavy rainfall covers the surface with water at times, the natural drainage is sufficient in many places to enable crop production. The series includes several types of soil ranging from very light sandy soils to clay soils, the latter having the slowest drainage. The soils occur throughout all parts of the region, but are less extensive in the eastern than in the western parts. The natural growth is mainly water-oak, willow-oak, ash, elm, hackberry, and pine in some eastern sections, and various other trees. Some pecan trees grow in some of the better drained locations. The soils are naturally highly productive and are suited to all of the general farm crops. They produce an excellent yield and quality of sugar cane sirup.

Bibb Soils: The Bibb soils are gray or light-brown in color and typically show slight mottlings of yellow, or red, or rust-brown. The subsoils are of much the same character as the surface soils, though somewhat lighter in color. These soils occupy very low flat bottom lands and remain wet for long periods. They are frequently overflowed. These soils, like the Ochlockonee, consist of local soil materials deposited by overflow water of streams, but they lie in positions of much slower natural drainage. The soils range from sandy to heavy clay soil types, and they occur in many sections of the region, but more extensively in the eastern part. The timber growth is largely water-oak, willow-oak, pine, gum, and various other trees. Very little of these soils is in cultivation, though doubtless they are inherently very productive and with adequate drainage would produce good yields of many crops.

Hannahatchie Soils: The Hannahatchie soils are red or reddish-brown in color and have reddish-brown subsoils. These occur in narrow stream bottoms mainly within the redlands section. They consist of soil materials washed mostly from local areas of the Nacogdoches soils. The surface is flat and overflows occur at times, but the soils are mostly rather light in texture and water passes downward readily giving sufficient underdrainage for successful cultivation. Timber growth consists of some species of oak, sweet gum, elm, pine, and other trees.

Soil Utilization

The soils of the East Texas Timber Country are mostly of only moderate productiveness, though they may be greatly improved for crop production by protecting them from erosion, by drainage, by cultural methods of soil improvement, and by fertilization. The most productive soils of the region are the alluvial soils although only some areas, more largely of the Miller, Yahola, Trinity, Ochlockonee, and Hannahatchie series, have sufficient natural drainage for growing farm crops. With well established drainage these soils, as well as the Bibb soils, would afford considerable additions of valuable soils to many farms. The soils of the upland differ in productiveness largely in proportion to the thickness of the soil layers, many of the soils on steep slopes having been so thinned by erosion that the productive capacity is very low.

The Nacogdoches soils, of which the fine sandy loam seems the most extensive, are the most productive, naturally, of the upland soils. They are very largely farmed and are well suited to all the general farm crops, truck crops, and fruit (Fig. 22). As a rule, the upland soils having friable, permeable, though moderately heavy, clay subsoils are more productive and more satisfactorily farmed than the soils with the dense heavy subsoils. The most suitable soils of great extent of this

Figure 22. Truck farm on Nacogdoches fine sandy loam in Cherokee County.

division, other than the Nacogdoches soils, are the fine sandy loams of the Kirvin, Ruston, Bowie, Segno, Norfolk, and Cahaba series. These are farmed largely; cotton is the chief crop, but corn, sorgo, vegetables, and fruits and other crops are also grown, and grasses and pasture crops do well (Fig. 23). The deep sands, mostly Norfolk fine sand, are less suited to the farm crops than for vegetables and various vine crops, berries, and small fruits. The most extensive soils of the dense subsoil group are the fine sandy loams of the Susquehanna and Lufkin series. These are farmed quite extensively in places and with careful management produce moderate yields of the general farm crops. In places it seems that on such soils trees are more profitable than cultivated crops.

Most of the soils of the region being of sandy texture are naturally suited to vegetables, vine crops, berries, and fruits, but are not suited to the small grains.

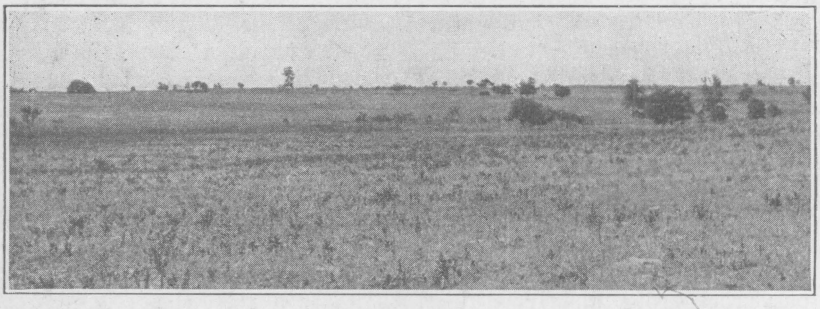

Figure 23. Excellent Bermuda grass pasture on light sandy soils of the East Texas Timber Country. This shows that good pasturage can be provided on the light sandy soils.

The soils respond well to the growing of legumes and to organic matter, organic manures, and mineral fertilizers. Commercial fertilizers are used quite generally, usually with good results, for cotton and special truck crops. As a rule, the best return from fertilizers is secured from soils with moderately deep surface soils underlain by heavy, but permeable subsoils. Results of experiments on cotton at the agricultural experiment substations at Nacogdoches and Troup show that fertilizers of formulas 4-8-4 or 4-12-4 applied at the rate of 200 to 400 pounds per acre have generally been profitable on the Kirvin and Ruston fine sandy loams (2). Other experiments indicate that similar soils having friable subsoils respond more favorably to fertilizers than do the soils with the very dense subsoils. However, it has been found to be a safe practice on the more freely underdrained soils to apply light side dressings of fertilizers during the growing season in order to prevent the possible leaching out of the plant nutrients. In gen-

(2) Records of the Division of Agronomy of Texas Agricultural Experiment Station.

eral the soils of the region seem more deficient in nitrogen and phosphoric acid than in other plant nutrients.

Erosion has caused great damage to many of the soils of the region, and this destruction continues where the surface is not protected by some crop or by terraces. The land is washed so badly in many places that great gullies are formed (Fig. 24) while in other places bare hillsides and slopes are denuded of all or most of the surface soil. In many places the smooth surfaces sustain a great loss of the valuable soil constituents that are dissolved and carried away by runoff water

Figure 24. When erosion starts, gullies may even work back into the soils protected by timber growth.

with no observable physical injury to the land. Many farmers in the region are now constructing terraces to protect their soils from the ravages of erosion.

BLACKLAND PRAIRIES

The Blackland Prairies comprise treeless areas of eastern Texas where certain dark heavy soils predominate. The main area, the well known "Black Prairie" or "Black Waxy" prairie belt extends in a southwesterly direction, as a broad wedge-shaped area from near Red River in northeastern Texas to the vicinity of San Antonio, where it merges with the brushy plains of the Rio Grande Plain. It is over 300 miles long and narrows from a width of about 75 miles in the northern part to 20 miles in the southwestern extension. On the east, the Black Prairie adjoins the East Texas Timber Country and on the west it merges with the Grand Prairie and Edwards Plateau except in the northern part, where it is separated from the Grand Prairie by the East Cross Timbers.

Smaller prairies of the same character as the main prairie lie separated from it in southern Texas. These, in places, are 10 to 20 miles across, and may be referred to as the minor interior prairies, though such names as Yegua Prairies, Fayette Prairie, and Washington Prairie have been applied to some of these local prairies. These smaller prairies constitute important land divisions within the southwestern reaches of broad belts of oak timberland extending from the main body of the East Texas Timber Country. The Blackland Prairies occupy all or parts of some 45 counties with a total area of approximately 11,000,000 acres. The Black Prairie, the main body, with an area of about 9,000,000 acres, comprises all or portions of some 30 counties, and the minor interior prairies of approximately 2,000,000 acres occupy portions of 15 counties. The area shown on the map as minor prairies is not composed wholly of Blackland Prairie, as many small local bodies of timberland are included.

The native vegetation consists both of bunch grasses, of which Andropogons and grama grasses are important, and some short grass, largely buffalo grass. In the southern sections, there is considerable scattered growth of small mesquite trees and shrubs which are said to have become abundant only in recent years.

The surface of the Blackland Prairies is generally rolling with some smoothly undulating and flat surfaces (Fig. 25). Elevations above

Figure 25. The undulating to rolling surface of the Blackland Prairie allows cultivation of practically all of the land.

sea-level range from 400 to 800 feet on the main belt, and from 300 to 500 feet on the minor prairies. Stream dissection has been thorough, and some rivers, originating farther west, cross the prairies in broad shallow valleys which extend in a general southeasterly direction, and from these radiate smaller tributary streams which reach into and drain all parts of the prairies. As a rule, surface drainage is rapid from most parts of the prairies, and on many of the slopes soils have been seriously injured both by gullying and sheet-water forms of erosion.

The mean annual temperature ranges from around 68° F. in the minor prairies and southern main prairie to about 64° F. in the

northern part of the main belt. The rainfall is 35 to 40 inches a year over most of the prairies. The southwestern limit of the Blackland Prairies is reached where the annual rainfall is about 30 inches. Here the prairies merge with the brush plains of the subhumid region, where the soils resemble superficially the dark soils of the Blackland Prairies. As a rule, rainfall is regular and ample for crops, though in the southwestern areas the rainfall during some seasons is irregular and at times is insufficient for the best service to crops. The winters are short and moderate with occasional cold periods with freezing temperatures.

There is a consistent uniformity of the natural features throughout

Figure 26. Chalk formation exposed by erosion on the Blackland Prairies. On the Houston black clay here shown even the gentle slopes erode rapidly in cultivated fields and the valuable soil is washed into the lower areas.

all parts of the Blackland Prairies, but there are local differences in soils, soil parent-materials, surface relief, and native vegetation which give rise to sections which differ from the main typical areas.

In the southern sections the native vegetation consists more largely of short grasses and a scattered growth of mesquite trees, but in the northern areas the bunch grasses predominate, with, in places, small amounts of elm or hackberry trees. However, owing to the thick settlement and cultivation, very little of the original natural vegetation remains.

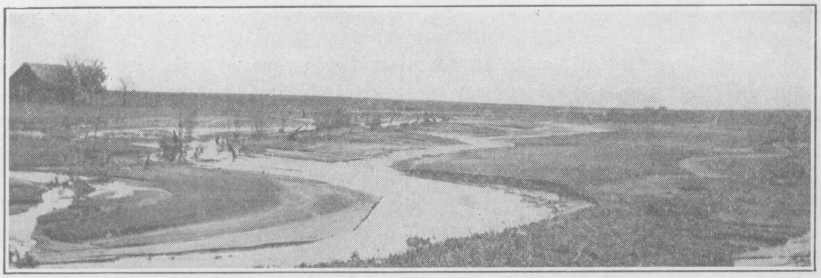

Figure 27. Layer of soil in shallow valley of same field as above carried by a recent rain from the higher slopes.

In the western part of the main prairie there is a strip of land several miles wide underlain by chalk. Erosion has cut deeply into this chalk formation and produced a very rolling surface. In many places the soils over the chalk are very shallow and numerous spots occur where the soil has all been washed away and the chalk exposed (Figs. 26 and 27). The west-facing slope of the chalk belt includes conspicuous outcrops of chalk and is known as the White Rock Escarpment. South of Temple the chalk belt is very narrow but in Collin, Dallas, Ellis, Hill, and McLennan counties there is a considerable acreage of shallow soils resting on this chalk. In Dallas County alone 75,000 acres, over 13 per cent of the county, consist of shallow and chalky soils of this belt.

On the east side of the main prairie a strip several miles wide is smoothly undulating to nearly flat. Here the soils, on drying, become very tight and hard. This area is outlined in a very general way on the map as the Wilson-Crockett group of soils. The parent-materials beneath this group are less calcareous than elsewhere on the prairies. The tight-soil areas have only slight development on the main prairie south of Milam County, though they are rather extensive on the minor prairies.

Agriculture

The Blackland Prairies are thickly settled and more intensively developed agriculturally than any other region of the State. All of the land is in farms, mostly 50 to 200 acres in size. A very large proportion of the farm land is devoted to crops. Due to the productive soils, with smooth surfaces enabling the use of improved farm machinery, the Blackland Prairie region has long been a successful farming area. It is the greatest cotton-producing part of the State. Of the four counties lying entirely within the Blackland Prairie about 70 per cent of the total land area is used for crops (census of 1925) and doubtless this proportion prevails in all of the region. These four counties, having an aggregate area of about 1,800,000 acres, approximately 16 per cent of the region, produced crops valued at more than $43,000,000 in 1924, according to the census. In one county alone, Ellis, the crop value was over $16,000,000.

Cotton, the chief crop, is grown on about 70 per cent of the crop land. In the four counties mentioned the average yield in 1924 was about 173 pounds of lint cotton per acre. Corn, the next crop in importance, is grown on most farms with some sorgo and various other feed crops. Oats and wheat are grown to some extent. Vegetables and fruits are grown in a small way for home use. Only a small amount of livestock is raised on the farms, although of recent years considerable dairying is done and the feeding of beef cattle on farms promises to become an important form of diversification.

With the placing of all the land in farms most of the natural cover of prairie grasses has been removed, leaving the soils free of protection

from erosion. The cultivated crops, which for the most require thorough tillage, afford but a slight hindrance to soil washing. Soil injury by erosion and the exhaustive cropping of the soil by the methods of intensive cotton farming have lowered crop yields on many farms of the region. This depletion of the great soil resources afforded by this magnificent body of land is causing more attention to be paid to soil protection by the building of terraces (Figs. 28 and 29) and

Figure 28. Terraced farm on Houston clay.

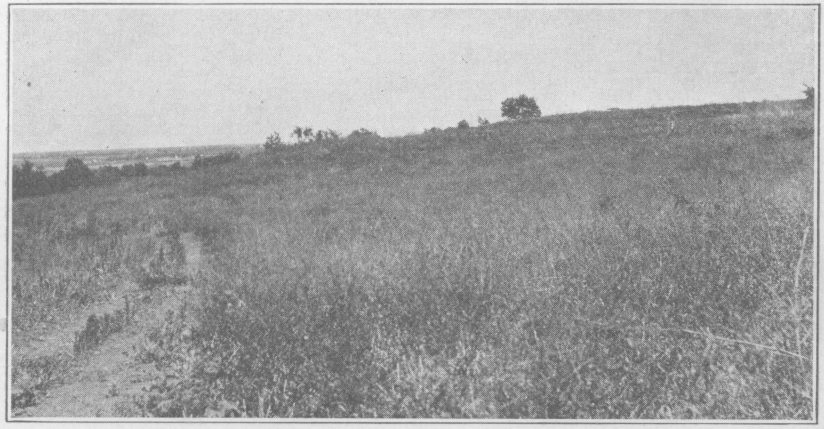

Figure 29. Sweet clover sowed on steep slopes of Houston clay minimizes soil erosion and is a valuable soil-improving crop.

to the question of soil improvement and crop rotation. Changes in the cropping system are also being rendered more necessary by the ravages of the cotton root-rot, a fungus disease which causes considerable losses of the cotton crop on the Blackland Prairies.

Soils

The predominating soils of the Blackland Prairie region are very dark and of heavy clay texture. On account of the dark color and waxy,

sticky consistency of these soils when wet they are commonly included in the term "Blackland" or "Black waxy" land. The normal soils developed on areas that are smooth and without much slope, are made up of thick, deep soil layers which merge together and grade below into the parent-material without a sharp line of change. The soils are moderately well supplied with organic matter, and are of two general kinds as regards structure. The greater part of the area is occupied by soils that are calcareous and granular, while other soils, developed chiefly on flat surfaces are not calcareous and on drying become very tight and hard. Small areas of soils occur that while not calcareous are moderately friable.

The upland prairie soils have been developed from soft calcareous parent-materials comprising deep beds of chalk, marl, or slightly limy clay. The dark color of the soils is doubtless the result of the accumulation of organic matter contributed by the heavy growth of prairie grasses, beneath which soil development has occurred. The clay, the first product of the weathered parent-materials, although permeable, does not absorb water quickly and, therefore, much of the rainfall runs rapidly down the slopes and washes away much of the soil before normal soil development is effected. Therefore, the largest proportion of the area is occupied by immature soils which still retain a large amount of the calcium carbonate that was in the original parent-material. In the soils on the limited areas having flat surfaces, the leaching effect of the water takes place, and the low content of calcium carbonate, dark-gray color, and dense, tight structure of the soils are characteristics which indicate the result of normal soil development where undisturbed by erosion.

On the basis of the soil characteristics, the prairie soils are included in three divisions as follows: (1) calcareous prairie soils of granular structure; (2) noncalcareous prairie soils, which on drying become dense and tight; and (3) noncalcareous prairie soils of only moderate friability. Narrow strips of old alluvium lying high above overflow of present time occupy flat terrace benches adjacent to the flood plains in the larger valleys. These areas comprise soils having the characteristics of the older higher-lying upland soils. In many places these so closely resemble the soils developed from older formations that it is difficult to effect consistent differentiations.

The alluvial soils are mostly of soil materials washed from the upland soils of the Blackland Prairies and from other soils developed from calcareous materials. They have no characteristics that have been developed in place, but in many features resemble the soils from which the materials were washed.

The following table gives the characteristics and crops grown on the principal soils of the region:

Principal soils of the Blackland Prairies.

Soil groups (Series)	Topsoil	Subsoil	Substratum (parent material)	Chief crops grown
Rolling Upland Prairies				
Calcareous: (granular)				
Undulating to rolling.				
Houston	Black, dark-gray or ashy-black to brown; friable.	Dark-gray, brown or yellowish; highly calcareous; moderately friable or crumbly.	Chalk or marl.	Cotton, corn, small grains, sorghums, various feed crops.
Rolling, steep slopes.				
Sumter	Brown or yellowish-brown; friable.	Yellow to greenish-yellow; crumbly.	Marl.	Cotton, small grains, sorgo and other feed crops.
Flat to undulating old stream benches (above overflow).				
Bell	Black to dark-brown; friable.	Dark-gray to brown; crumbly.	Calcareous clay over beds of gravel in places.	Cotton, corn, various feed crops, small grains.
Lewisville	Brown; friable.	Brown or yellow; crumbly.	Calcareous clay over beds of gravel.	Cotton, corn, feed crops, small grains.
Non-calcareous: (not granular).				
Flat to gently rolling.				
Wilson	Black to dark gray; very tight when dry.	Brown or dark gray; dense, tough.	Marl or very slightly calcareous clay.	Cotton, feed crops, small grains.
Flat to undulating old stream benches (above overflow).				
Irving	Dark ashy-gray to black; very tight when dry.	Dark gray or brown; dense, tough.	Clay or sandy clay on beds of gravel.	Cotton, feed crops, small grains.
Noncalcareous: (cloddy to moderately granular).				
Rolling.				
Ellis	Brown, moderately friable.	Greenish-yellow; dense, calcareous in places.	Shale and clay, calcareous in places.	Cotton, small grains, sorgo and other feed crops.
Gently rolling.				
Crockett	Black to brown or spotted; moderately friable.	Reddish or yellowish or mottled with gray.	Slightly calcareous, clay.	Cotton, feed crops.
Flat Stream Bottoms (Subject to overflow.)				
Calcareous:				
Trinity	Black to dark brown; friable, permeable	Black or dark gray; heavy, but permeable and crumbly.	Calcareous clay.	Cotton, corn, alfalfa and various other feed crops, pecans.
Catalpa	Brown; friable; permeable.	Brown or grayish, friable, and permeable.	Calcareous clay.	Cotton, corn, alfalfa, other feed crops, pecans.
Noncalcareous:				
Johnston	Black or very dark-brown, moderately friable.	Brown, black or dark-gray; moderately crumbly and permeable.	Clay.	Cotton, corn, feed crops, pecans.

Calcareous Prairie Soils, Granular

The soils of this division occupy most of the main Blackland Prairie, and much of the minor prairies. The heavy clay soils predominate. Although the soils are very sticky when wet, they naturally break to grains on drying, due in large part to the abundant content of calcium carbonate. In smooth locations where drainage is slow the soils are deep, but on many slopes erosion is severe and the soil layers are thin. The soils are black or brown in color, but in spots where the soil layers are greatly eroded, and only slightly developed, lighter brown and gray colors are prominent. Erosion has been especially rapid since the prairie sod has given way to cultivated crops. The soils are mostly of the Houston, Sumter, Bell, and Lewisville series, which occupy approximately 7,500,000 acres of land.

Houston Soils: The Houston soils are black, dark-gray, ashy-black, or dark-brown calcareous soils grading below into dark-gray, brown, or yellowish-brown calcareous subsoils, which in turn pass beneath into marl or chalk (Fig. 30). The soils and subsoils are granular in structure when dry. Under proper moisture conditions, they are easily maintained in a friable condition. On drying, the heavier soils crack deeply, though cultivation largely reduces this cracking. The soils range from very deep on nearly flat areas to very shallow on slopes where erosion has long been active. In the western part of the main belt of the Black Prairie underlain by chalk, erosion is more generally pronounced than elsewhere. Numerous small areas have but a shallow soil covering, and the white chalk is exposed in places. The surface of the Houston soils is generally rolling and slopes are moderate to steep, though in some places some nearly flat areas occur. Drainage is rapid and though the soils and subsoils are rather penetrable, they absorb water so slowly during heavy rains that the runoff is rapid. The Houston soils probably occupy not less than 80 per cent of the uplands of the main Black Prairie area. They are less extensive in the minor prairies. The Houston black clay and clay are the chief types, the former being considerably more extensive. This black heavy soil is extremely sticky when wet and for this reason the soil is generaly referred to as "black waxy land." In the virgin condition the surface of the black clay is pitted with numerous small depressions called hogwallows. These surface inequalities disappear with cultivation.

The Houston soils are highly productive, and when properly managed give good yields for a long time. However, erosion and long continued exhaustive cropping have reduced the producing capacity in many places. The soils are well suited to cotton, corn, sorghums, small grains, alfalfa, and grasses, and a very large proportion is used for these crops.

Sumter Soils: The Sumter soils are brown or yellow calcareous soils underlain by yellow or olive-colored calcareous clay. These soils are

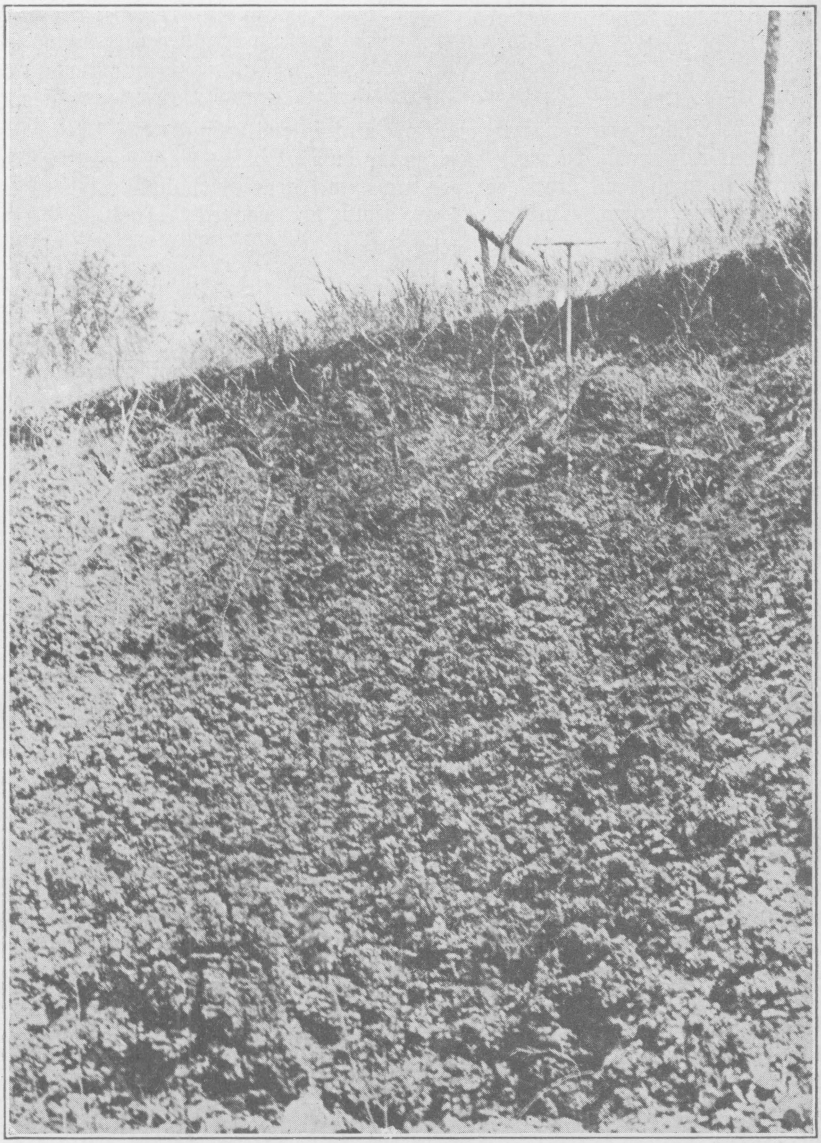

Figure 30. Soil profile of Houston black clay. Note how the soil layers grade together, with little change in color or texture, and on drying the material crumbles to grains.

friable and crumble when dry. Only the heavier types, the clay and clay loam, have been mapped in Texas thus far. These occupy steeply sloping areas where erosion is severe and much of the Sumter really constitute partly weathered marl. They represent very immature soils, which, if not disturbed by erosion, eventually would produce Houston soils. The Sumter soils are not extensive, and none too highly productive. They are generally shallow and in many spots the topsoil has been entirely washed away, leaving the subsoil bare. The soils are best suited to such feed crops as sorghums and grasses though some cotton and oats are grown. Only moderate yields are secured. Much of the soil is not cultivated.

Bell Soils: The Bell soils comprise black to dark-brown calcareous soils which grade below into dark-gray or brown calcareous clay. In places the parent clay rests on beds of rounded gravel. The soils are granular in structure. They resemble the Houston soils, but are located on smoother surfaces, beneath which free water is more permanently stored than beneath the Houston soils. The clay is the chief member of the series. It is nearly flat to faintly undulating, and is generally subjected to severe sheet erosion. In very flat areas drainage is slow. The clay has a "hogwallow" surface in most of the virgin areas. Though originally a grass-covered prairie there is in places a native growth of elm and hackberry, with some oaks, and a few other trees. The soils are very productive, well suited to the general farm crops and are very largely cultivated. Though relatively of slight extent they occur in widely distributed areas throughout the Blackland Prairie region, mostly near or within the broader valleys.

Lewisville Soils: The Lewisville series include brown calcareous surface soils underlain by light-brown or yellowish-brown calcareous clay subsoils, which, in places, rest on beds of gravel. These soils are found in close association with the Bell soils on terrace benches in various parts of the region, but occupy more rolling and sloping positions and have more rapid surface drainage. Erosion is severe in places. The clay is the principal type of the series. Though grasses are locally abundant, much of the virgin soil supports a growth of some elm, hackberry, and oak. The soils are granular and are easily cultivated when moisture conditions are favorable. These are productive soils, valuable for the various general farm crops. They are largely in cultivation.

Noncalcareous Prairie Soils, Tight

The soils of this division occur chiefly in the northern parts of the main prairie, and in the minor prairies, the largest areas lying in a belt several miles wide at the northeast edge of the Black Prairie. On drying, the soils become very hard and tight, and the subsoils are so dense and tough that water passes through them very slowly. The upper soil layers of the normal soils, though dark, have a gray cast,

especially when dry, and seem to be free, or nearly free, of calcium carbonate. The surface is generally smooth and much of the land is nearly flat. Therefore, erosion occurs less than on the more rolling calcareous granular soils. The generally lighter color and tight structure set these soils well apart in character from the granular soils. There are several textural classes represented, some of sandy and some of clay texture, but the clay loams seem to be the most extensive. The soils of this division are included chiefly within the Wilson and Irving series. In places the parent-materials underlying these soils are only slightly calcareous.

Wilson Soils: The topsoils of the Wilson soils are nearly black to dark-gray, the lighter-textured sandy soils having the lightest color. The topsoils grade below into dark-gray clay, which, below a depth of about 3 to 5 feet, merge with marl or slightly calcareous clay parent-material. The normal Wilson soils are not calcareous in the upper layers, but below a depth of 2 or 3 feet the subsoils contain a small amount of calcium carbonate. The soils dry out to a hard condition, and are broken with difficulty with implements of cultivation into large resistant clods. The subsoils are very tough and dense. This structural characteristic constitutes one of the chief differences between the Wilson soil and the Houston soil. The Wilson soils are locally referred to as "tight land"

Figure 31. Wilson clay loam occupies large flat areas and is highly prized as a cotton soil.

or "rawhide land." The clay loam, clay, and fine sandy loam soils occur, but the clay loam is probably the most extensive. These soils occur largely on the marginal prairie areas adjacent to the timbered sandy lands. The surface is characteristically undulating or nearly flat, with occasional gently rolling areas. The soils are generally much less eroded than those of the Houston series. They are very productive, though requiring careful treatment to overcome their adverse physical character. They are very well suited to the general farm

crops (Fig. 31), and are largely in cultivation. The Wilson soils probably constitute the most extensive land of the minor prairies.

Irving Soils: The Irving series includes dark-gray to black soils which grade below into dense heavy gray clay subsoils. These merge below with clay or sandy clay resting, in many places, on beds of rounded gravel. On drying the soils become hard and tight and in this characteristic are like the Wilson soils. The subsoils are so heavy and tough that water penetrates very slowly. Neither soil nor subsoil is calcareous but in places the underlying beds contain much limy material. These soils occupy nearly flat terrace benches in valleys and have slow drainage. A scattered growth of elm, post-oak, and other trees grow in places.

These soils are cultivated extensively though they do not constitute a considerable proportion of the land of the region. Aside from the difficulty in cultural operations, due to the tight structure, these soils seem to be quite good agricultural soils, and are suited to the general farm crops, many of which are grown successfully. The soils are underlain deeply in many places by a good store of free water.

Noncalcerous Prairie Soils, Moderately Granular

These are dark soils that are developed from parent-materials which, in places, are low in calcium carbonate content. They are dark soils and the upper layers of the normal soils contain little or no free carbonate of lime. The soils are of moderate friability and though less tight than the Wilson soils are not so granular or open in structure as the soils of the Houston group. These soils occur chiefly in the northern part of the main prairie and in the minor prairies. They are not extensive. The surface is generally undulating, and the slopes are mostly gentle to moderate. The chief soils of this division are of the Ellis and Crockett series, the former being located just west of the White Rock Escarpment, and the latter occurring largely in association with the Wilson soils.

Ellis Soils: The Ellis soils are brown in color and grade below into yellow or greenish-yellow subsoils. Normally the soils are not calcareous though in places a small amount of calcium carbonate is present. The Ellis clay is the only soil type of the series that has been mapped and it is not extensive. It occurs in narrow strips just west of the chalky soils of the Houston series, where it is developed from clays and shales of the Eagle Ford formation. When wet, the soil is extremely sticky, and on drying it breaks to small clods and coarse grains. It is of moderate friability when cultivated in the proper moisture conditions. The surface is moderately rolling, though in places some slopes are fairly steep and eroded. The soil is used to some extent for cotton and small grains and seems best suited to oats and grass.

Crockett Soils: The topsoils of the soils of the Crockett series are nearly black or brown. They grade below into subsoils that are brown, yellow, or mottled red and gray. There is a lack of uniformity in the color characteristics of the subsoils. The surface of Crockett clay is in places dotted with numerous very small intermingled spots of black and brown surface soils. Neither soils nor subsoils are calcareous, though, in places, the parent-material is limy. The subsoils are, in places, quite similar to subsoils of adjoining light-colored timbered soils. The Crockett soils are developed largely from parent-materials of transitional character lying between formations of the East Texas Timber Country, and slightly calcarous clays underlying the Blackland Prairies. In places, they occupy the more sloping surfaces of nearly flat areas occupied chiefly by Wilson soils and here the development of the Crockett soils seems to be largely due to more complete drainage.

The topsoils range in texture from sandy and loamy to clay. They are moderately friable, though somewhat cloddy, but do not have the granular structure such as is found in the calcareous soils (Fig. 32).

The surface is moderately rolling or undulating and natural surface drainage is sufficiently rapid in places to cause erosion. The soils occur in widely scattered areas, mostly at or near the margins of prairies adjoining light-colored sandy soils, and in many small bodies throughout certain sections of the forests of eastern Texas. These isolated areas seem to be prairie soils which in places have been encroached upon by a growth of trees from adjacent timberlands.

These soils are quite productive and suited to cotton, small grains, corn, sorghums, and grass. They are largely cultivated.

Alluvial Soils

The alluvial soils of the Blackland Prairies comprises an important and valuable part of the land area. They constitute probably 10 or 15 per cent of the region, although in some counties crossed by rivers the proportion is nearly 20 per cent. The areas occupy strips in valleys a hundred feet wide up to several miles across.

The alluvial soils are mostly dark, and consist of deep beds of soil materials that have been transported by water from the surface of the dark prairie soils from both Blackland Prairies and from the prairies farther west. The soils are mainly of heavy textures, calcareous, and of friable structure. Owing to periodic additions of fresh soil materials during overflows the materials have not acquired the soil characteristics produced by the regional processes of development.

A heavy growth of hardwood timber, mostly oak, elm, hackberry, ash, pecan, and other trees, occurs on the uncleared areas.

The surface is generally flat and so low that overflows occur. However, natural drainage is sufficient in many areas to allow successful utilization of these very productive soils for various important farm crops.

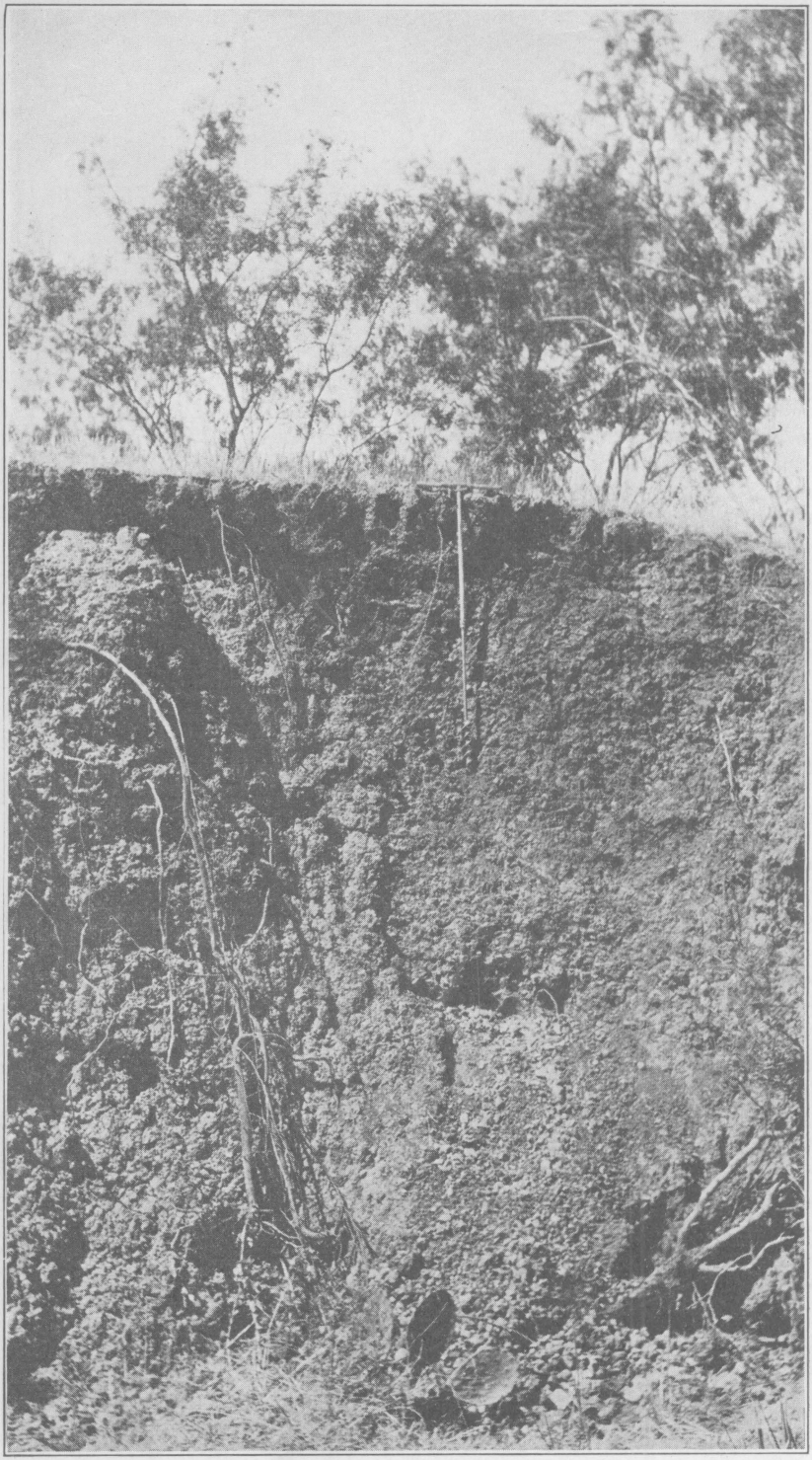

Figure 32. Soil profile of Crockett fine sandy loam. The topsoil is about eight inches deep and is underlain by dark crumbly clay.

The alluvial soils are chiefly of the Trinity, Catalpa, and Johnston series.

Trinity Soils: The Trinity soils are black or very dark-brown calcareous soils underlain by subsoils very similar to the surface soils but somewhat light in color. The clay is the principal type. It occupies large areas in the larger stream valleys and in many narrow strips along the small streams in all sections of the region. The soils are granular in structure, though the clay when wet is very sticky and plastic. The surface is nearly flat and drainage is slow, though much of the surface is sufficiently well drained, normally, to permit satisfactory growth of crops. Overflows occur occasionally, but several seasons may pass without flood injury to crops. These soils are highly productive and well suited to cotton, corn, alfalfa, and various other crops, and are cultivated extensively. Pecan trees grow well in the freely drained locations.

Catalpa Soils: The Catalpa series comprises brown calcareous soils with subsoils of a similar character, but somewhat lighter in color. These soils are much like the Trinity soils except in color. They are less extensive, however. The Catalpa soils are smooth and nearly flat and have rather slow drainage, but have, as a rule, slightly more rapid drainage than those of the Trinity series. They are strong and productive and well suited to cotton, alfalfa (Fig. 33), and corn. These

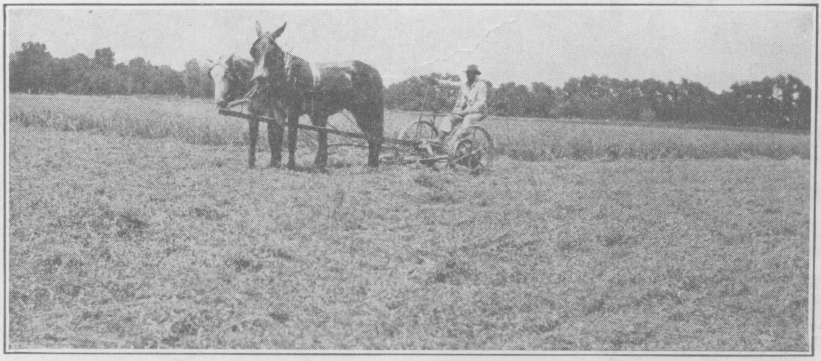

Figure 33. Alfalfa on Catalpa clay near Cameron. Excellent alfalfa can be grown on many of the other alluvial soils throughout the State. This is an important soil along Little River.

crops are grown extensively, though occasionally injured or stunted by overflows. Pecan trees grow well where the soils have free drainage.

Johnston Soils: The Johnston series includes dark alluvial soils with dark subsoils occurring in stream bottoms. They closely resemble the Trinity soils, but differ in that they are not calcareous. They are of slight extent, and are probably made up largely of materials washed

from noncalcareous soils of the Blackland Prairies and adjacent regions. They are suited to the general crops, are quite productive, and are largely farmed to cotton and corn.

In some of the larger stream valleys of the Blackland Prairies, there are, in places, narrow strips of soils, mostly sandy, which are more extensively developed in other regions. These soils are mostly of the Leaf, Cahaba, Kalmia, and Milam series, soils that are generally more prominent in timbered sandy soil regions. The soils are developed from soil materials transported by water chiefly from the sandy upland soils of the East and West Cross Timber areas. These materials were placed before the streams had cut deeply to their present levels, and having been free of overflows for a long time, the soils have developed characteristics of maturity quite similar to those of the upland sandy soils from which the material originated. The Leaf, Cahaba, and Kalmia soils have been described as found in the East Texas Timber Country.

Milam Soils: The Milam soils consist of a brown or reddish-brown surface layer grading below into a brown, yellow, or red subsurface layer which merges through a thin transition zone with a rather heavy red clay. In places the subsoil has a very irregular form (Fig. 34). The

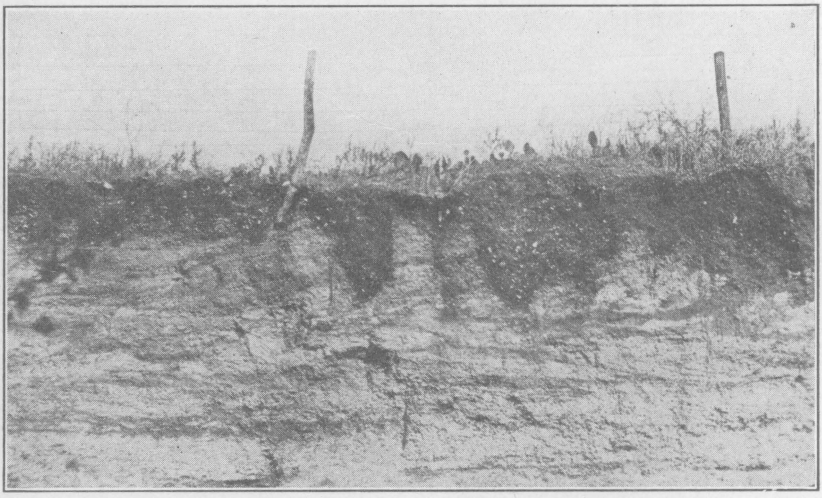

Figure 34. Soil profile of Milam fine sandy loam on high terrace adjacent to the Little River Flood Plain. This soil has been developed from ancient alluvium long free of overflows. It consists of a brown fine sandy loam over red clay, which rests on beds of gravel containing considerable calcareous material.

fine sandy loam is the chief soil of the series, and in some areas it contains a large amount of rounded gravel. The soils and subsoils are not calcareous, but at a depth of several feet the subsoils rest on beds

of sand and gravel which, in places, contain a considerable amount of calcium carbonate.

The Milam soils appear to be developed from soil materials transported from the West Cross Timbers. The soils occur in association with Leaf soils, in places, and as they have more rapid drainage than those soils it seems that the solid color and less dense structure of subsoil has been produced by more complete drainage.

The Milam soils occupy important areas in Milam and Bell and possibly other counties. They have a timber growth consisting mainly of oaks. They are moderately productive and are suited more especially to vegetables and fruits, and moderately well to the general farm crops.

Soil Utilization

The soils of the Blackland Prairies are mostly very strong and productive. They are of long-lasting quality when proper methods of soil protection and improvement are employed in their use. Being mainly of heavy texture they are best suited to the general farm crops, and cotton, corn, sorghums, small grain, alfalfa, and various other crops are grown. Although the heavy soils require relatively heavy equipment and strong power for their cultivation, the predominating soils are naturally granular, and under proper moisture conditions are easily worked into a friable loamy condition. The normal soils are moderately drought-resistant. Crops grow more rapidly on the soils that have the granular open structure, such as the Houston soils, than on the tight soils of the Wilson group, though the latter do not crack so much in very dry weather. All of the soils are well suited to cotton, the universal crop of the region. The staple of the better varieties is of good length and quality. Corn grows well, but as a rule the best yields are made on the Trinity and Catalpa soils on account of the more favorable moisture conditions of these soils during the hot dry periods of summer when the crop often suffers on the upland soils. This is also true of alfalfa, and this crop is grown mostly on these alluvial soils. However, alfalfa is not extensively grown. The upland soils are well suited to the small grains, and wheat and oats are grown extensively in some sections, though probably more largely in the northern areas.

The principal soils of the region are Houston black clay, Houston clay, Wilson clay loam, and Crockett clay loam. The Houston black clay probably occupies a larger area than all other soils.

Soil erosion is especially injurious on the Houston black clay and Houston clay. Terracing of these and other sloping soils, and placing levees to protect the Trinity and Catalpa soils from overflows, are means that are being taken throughout the region to conserve and utilize the soils. Some farmers sow feed crops on the more sloping areas to reduce erosion, and on the soils injured by erosion some grow such soil-improving crops as sweet clover to restore productiveness. In

places the productiveness of the soils has been reduced by exhaustive cropping continued over a long period. The soils respond well to incorporated organic matter and organic manures, to legumes, and to systematic crop rotation. Due to variable results with commercial fertilizers their use has not become generally established.

GRAND PRAIRIE

The Grand Prairie Region lies just west of the main Black Prairie and extends south from Red River to the vicinity of the Colorado River, where it merges with the Edwards Plateau. The region occupies a north-south belt about 250 miles long and 20 to 75 miles wide. The western boundary is very crooked and irregular because of the intermingling arm-like extensions of the prairie and West Cross Timbers areas. Included within the general area of the region are narrow strips consisting of isolated portions of the West Cross Timbers. The Grand Prairie area comprises approximately 7,000,000 acres of land in 21 counties, some of which are wholly and some partly within the area.

The region occupies a high rolling and hilly, deeply dissected limestone area crossed by a number of deep valleys through which rivers flow in narrow strips of bottomland in a general southeasterly direction (Fig. 35). Numerous smaller tributary streams extend through

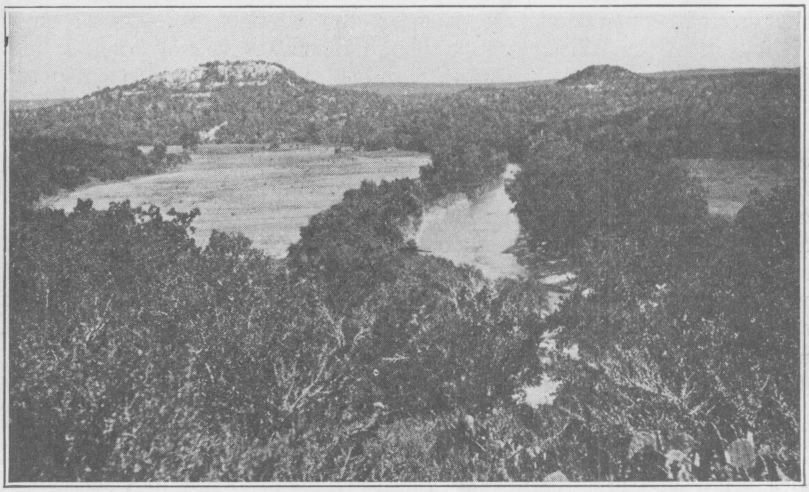

Figure 35. Roughlands and valleys occur in Grand Prairie Region along the larger streams. This is Lampasas River.

all sections of the region in valleys which range from shallow and narrow near the divides to deep and wide in their lower reaches. Drainage is rapid in most sections, and erosion has cut through the thick

beds of limestone in places leaving rough stony ridges and high plateau-like remnants of land, and many valley walls and slopes are bare and rocky or have very little soil covering. In the section north of Brazos River, generally known as the Fort Worth Prairie, large areas of smooth to rolling lands occur. The southern part, known as the Lampasas Cut Plain (Fig. 36) is more hilly and rolling, as the higher general surface has been largely cut away by erosion, leaving good-sized stony hills and areas of plateau form with steep, stony slopes descending to valleys and broad rolling prairies (Fig. 37). Elevations

Figure 36. General character of the surface of Grand Prairie in Lampasas County.

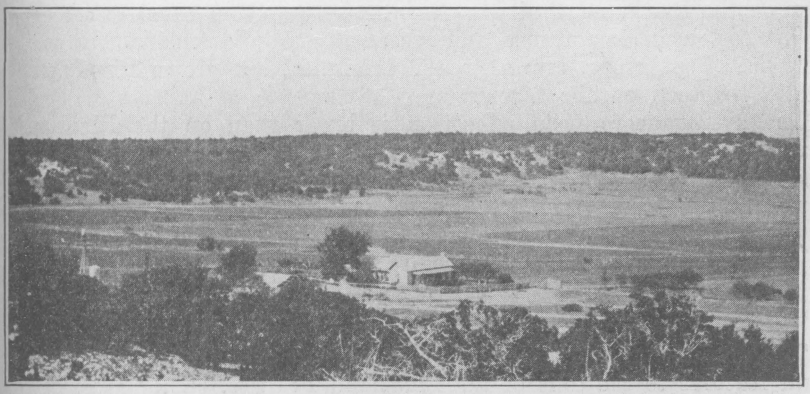

Figure 37. Farm on San Saba clay in narrow areas almost surrounded by Rough stony land in Grand Prairie Region of western Bell County.

above sea-level range from 800 to 1,200 feet. Many of the larger streams have water the year round, while freely flowing springs are to be found in many places. Good water is secured in wells.

The native vegetation on the deeper soils consists of a growth of short grasses and some bunch grasses. On the rough lands and very shallow soils the grass growth is thin, but in many places there is a

considerable growth of small oaks, some juniper and mesquite trees. In some places this tree growth is very thick, though the trees are mostly small. Buffalo grass and grama grasses are the most widespread valuable native grasses.

The average annual temperatures are about 64° F. in the northern and 66° F. in the southern sections, and the mean annual rainfall is about 35 inches a year in the eastern and about 30 inches in the western parts. Rainfall is sufficient for crop growth in normal seasons, but much of it comes at irregular intervals, and during some seasons it is so slight that moisture is insufficient for the best growth of crops.

Agriculture

All of the Grand Prairie region is in farms and ranches. Although farming is done in all sections, the considerable areas of roughlands and thin soils of the southern part cause a larger development of the stock raising and stock farming industries than in the northern sections where the land of this character is less extensive. In the few counties lying entirely within the region, census data shows that 30 or 35 per cent of the land is devoted to farm crops, but in some southern counties the proportion is less, and in some northern counties it is greater.

The crops grown consist mostly of cotton, corn, oats, wheat, and sorghums with various other feed crops. Cotton, the leading crop, is grown on about 50 per cent of the crop land, a smaller proportion than on the Blackland Prairies. Corn and oats, about equal in acreage, follow cotton in importance and wheat is grown extensively in some sections. Feed crops, especially the sorghums, are grown largely and fed to livestock on the farms.

The average acre yield of cotton is lower than on the Blackland Prairies, judging from the census data for 1924, which shows the average for the four counties lying wholly within the region was but 115 pounds of lint cotton per acre.

Cattle, sheep, and goats are raised on many of the farms and ranged on small ranches throughout all the section.

Soils

The normal soils of the Grand Prairie are similar in color and textural features to the soils of the Blackland Prairies. They are mostly dark, ranging from black to brown, though some shallow soils are lighter in color. On smooth surfaces the soils are black and the layers are thick, but much of the surface is rolling and the soils shallow. The soils of normal development on the flat areas are not calcareous in the upper layers, but the shallow soils contain considerable calcium carbonate in all layers. A moderate amount of organic matter is in the topsoils. Erosion has cut deeply, and in places bare rock is exposed, and large areas of stony soils occur.

The soils have been devoloped under a grass cover from hard limestone, in places consisting of limestone interbedded with chalk or marl. Over large areas erosion removes much of the soil material almost as fast as it is formed by disintegration of the limestone.

Small nearly flat areas of soil occur on the smooth terraces in or near the larger valleys. These soils are developed from old soil materials transported by water and consist of thick soil layers on beds of gravel. These soils, in most places, are related in character to the more maturely developed soils of the limestone uplands.

The alluvial soils comprise probably 10 or 15 per cent of the land area. These are mostly dark and calcareous and have not acquired the characteristics of the normally developed soils of the uplands.

The table on page 72 lists the principal soils of Grand Prairie with their outstanding characteristics and uses.

Upland Soils

Soils of this division occupy the main part of the Grand Prairie. Most of the soils are developed from limestone formations, but local differences in surface conditions and in character of parent-materials give rise to minor differences in the soil characteristics. On the basis of characteristics the principal soils of the region are included in six soil series, the San Saba, Denton, Crawford, Brackett, Bell, and Lewisville, the two last named being developed from very old beds of water-transported material washed mainly from areas of the first four. Of the soils developed in places on the limestone, the normal San Saba soils, which are black in color, are the most maturely developed, and, as a rule, have the thickest soil layers. The Denton and Crawford soils are generally considerably shallower, and the Brackett soils are of very thin, slightly developed layers. Many of the soils are quite stony and areas that are very rough and stony have little or no developed soil layers and are included under the general term Rough Stony land.

San Saba Soils: The San Saba series comprises soils that have black or very dark-brown topsoils underlain by dark-brown or yellowish-brown, or in places, very dark-gray clay subsoils. The subsoils rest on limestone or merge with a layer of marl or chalky material which is interbedded with limestone. The calcareous parent-material lies at a depth of one to several feet beneath the surface, the deeper soils being located on nearly flat smooth areas, as a rule, though not all such flat areas have deep soils. Where the soils are deep the soil and upper subsoil material is not generally calcareous, but the shallow soils are mostly calcareous from the surface down through all the soil layers. The surface is smoothly undulating to rolling and drainage is slow to rapid, depending on the degree of slope. The soils are granular and the subsoils show fairly rapid penetration of water, though in some areas the hard parent-material lies sufficiently near the surface to cause very slow underdrainage. The natural vegetation consists largely of

Principal soils of Grand Prairie

Soil groups (Series)	Topsoil	Subsoil	Substratum (parent material)	Chief crops grown
Rolling Upland Prairie.				
Undulating to gently rolling.				
San Saba	Black or very dark brown; friable.	Dark-gray, yellow, or brown; crumbly.	Limestone and chalk interbedded.	Cotton, corn, small grains, sorghums.
Gently rolling to very rolling.				
Denton	Brown; friable.	Brown or yellow; calcareous; crumbly.	Limestone and chalk interbedded.	Cotton, corn, small grains, sorghums, grass.
Undulating to rolling.				
Crawford	Brown, red, or reddish-brown; friable.	Red or brownish; lower part calcareous, crumbly.	Limestone and chalk interbedded.	Cotton, small grains, corn, sorghums, grass, browse.
Rolling to hilly, steeply sloping.				
Brackett	Brown or light-brown to grayish; friable; calcareous, shallow. Much stony land.	Yellow or whitish; chalky; calcareous; friable; thin.	Limestone and chalk interbedded.	Grass and browse.
Very stony and broken.				
Rough stony land	Very stony, steeply sloping; light-colored soil material.	Limestone	Limestone	Browse, grass.
Nearly flat to undulating stream benches (above overflow).				
Bell	Black or very dark-brown; calcareous; friable.	Dark-gray to brown; crumbly; calcareous.	Clay on beds of rounded gravel.	Cotton, corn, small grains, sorghums.
Lewisville	Brown; calcareous; friable.	Brown or yellow, calcareous: crumbly.	Clay on beds of rounded gravel.	Cotton, corn, small grains, sorghums.
Flat Stream Bottoms. (Subject to overflow)				
Trinity	Black to dark-brown; friable, permeable; calcareous.	Black or dark gray; heavy but permeable; crumbly; calcareous.	Calcareous clay.	Cotton, corn, sorghums, pecans.
Catalpa	Brown; calcareous; friable.	Brown or grayish; calcareous; crumbly; permeable.	Calcareous clay.	Cotton, corn, sorghums, pecans.

short grasess and some coarse grasses, though in many places a scattering growth of mesquite trees, live oaks, and other trees occur. On the shallow and stony soils a rather heavy small-tree and shrub growth occurs in places, consisting of live-oak, shin-oak, western red-oak, mesquite, juniper, and various shrubs and grasses. The principal soils of the series are a clay and a stony clay. These occur in all parts of the region, though the stony soils are more extensive in the Lampasas Cut Plain section. The clay soils are moderately strong and productive and are suited to cotton, corn, sorghums, and small grains, but the stony soils are better suited to livestock grazing, and browsing than to farming.

Denton Soils: The Denton soils include brown soils underlain by brown or yellowish-brown subsoils. Calcareous clay subsoils predominate and at a depth of a few inches to two or three feet they rest on limestone or grade into the thin chalky layers that occur interbedded with limestone strata. The normally developed deep soils are not calcareous, but in many places the thin soil layers over shallow-lying limy parent-materials contain considerable calcium carbonate. The soils are granular and the subsoils though heavy are crumbly and readily penetrated by water. The land is generally rolling to strongly rolling and hilly in places. Natural surface drainage is rapid and erosion is severe in many places. The clay and stony clay types are the most extensive of the series. These soils cover considerable areas of land. The larger areas of stony soils occur in the Lampasas Cut Plain section. The natural growth comprises various grasses, of which the short grasses, mostly buffalo grass, are abundant, together with grama and some coarse grasses. On the stony and very thin soils as well as on some areas of deeper soils there is a scattered growth of oaks, mostly live-oak, some shin-oak, and western red oak, junipers, mesquite, and various other small trees. This brush and small-tree growth is very thick in places. The Denton soils where the surface layers are deep are moderately strong and productive. These soils are not strongly resistant to drought, especially on the shallow and more steeply sloping areas, as there is a considerable loss of rainwater by runoff, while the thin subsoil layers afford no large storage of moisture. The stony soils as a rule are better suited to grazing and browsing than to crops and are used largely for livestock range. The principal non-stony soil, Denton clay, is used to a considerable extent for cotton, corn, small grains, sorghums, and a few other crops, to all of which it is well suited, and good yields are secured when moisture conditions are favorable.

Crawford Soils: The Crawford soils are red, reddish-brown, or brown in color and merge below with red or reddish-brown clay subsoils which commonly rest on limestone or chalky material on limestone at a depth of 1 to 3 feet below the surface. In places the subsoil layer ex-

tends to a greater depth. The soils and subsoils where developed deeply on smooth locations are not calcareous, but in many places, especially where the surface soil is shallow, the soil layers are calcareous throughout. The surface is generally undulating to gently rolling and has fairly rapid drainage. Some of the soils occupy flat-topped table-lands of plateau-like ridges in the Lampasas Cut Plain section. The principal soils of the series are a clay and a stony clay. The stony limestone material includes many chert fragments giving rise to the local name of "flint land," not only for the very stony soils but for the soils containing but a small amount of the chert fragments. These soils are confined principally to the southern parts of the Grand Prairie region. The natural growth of short grasses, consisting largely of buffalo grass, occurs in association with a small tree growth of live-oak, shin-oak, western red-oak, elm, some mesquite, juniper, and various other trees. The tree growth is more abundant on the stony and shallow soils. Some Crawford clay is cultivated and produces good yields of cotton, corn, sorghums, various other feed crops, and small grains, to all of which it seems well suited. The stony clay is utilized more largely for livestock grazing and is generally better for this purpose than for producing crops. The shallow soils are droughty and crops suffer in dry seasons.

Brackett Soils: The Brackett soils are light-brown or grayish-brown calcareous soils. In most places they are very shallow and overlie yellow or brown calcareous subsoils. The subsoils as well as the surface soils are very thin. They merge below with chalky material or marl, or rest on limestone which lies near the surface, or, in places, outcrops to form stony areas. The clay and clay loam soils predominate and the larger areas of these contain much stony and small stony (gravelly) material. The Brackett soils are widely scattered throughout the region, being most extensive in the southern or Lampasas Cut Plain section. The surface is rolling and the slopes are rather steep in many places permitting severe erosion. The principal natural vegetation consists of a very thin growth of coarse and short grasses and a small-tree and shrub growth consisting chiefly of mesquite, live oak, shin-oak, western red oak, and juniper. These soils are too thin and shallow in most places for profitable crop production. They are used mainly for the grazing and browse afforded by some of the grasses, shrubs, and trees. Some of the deeper soils produce small yields of sorgo but on the whole even these are marginal soils of doubtful value for farm crops.

Rough Stony Land: The soils described occupy the greater portion of the uplands of the region. However, in places there occur considerable areas of rough stony land which consists of steeply sloping hills and valley walls with outcropping limestone and numerous large boulders of limestone scattered over the surface. The rough stony land

occurs more largely in the Lampasas Cut Plain section, mostly where erosion has cut steep slopes. Various species of oak, largely live-oak, juniper, and other trees grow thickly on the land. The juniper grows abundantly in places producing the well known "cedar brakes," which afford valuable wood for posts and other uses. The trees and shrubs supply browse for goats and other livestock, and though grass is not abundant on the very stony areas it grows thickly in the small valleys reaching into these areas, and affords much valuable pasturage.

Associated with the upland soils of the Grand Prairie are the small areas of Bell, Lewisville, Milam, Cahaba, and Leaf soils which occur on the high smooth old stream terraces in some of the larger valleys. These soils have been developed deeply due to generally undisturbed surface conditions and the Bell and Lewisville soils, which are calcareous and mostly of heavy texture, have been developed from soil materials transporated by water from the upland limestone soils and formations. The Milam, Leaf, and Cahaba soils, mostly of sandy texture, and not calcareous, are from materials brought from the West Cross Timbers region, where sandy noncalcareous soils prevail. The terrace soils mentioned have been described in parts of this discussion relating to other regions in which they are of greater extent. Here, however, these are important and valuable soils, used largely for the general farm crops grown throughout the region.

Alluvial Soils

The alluvial soils of the Grand Prairie region probably comprise 10 per cent of the land area. They occur in narrow areas as the flood plains of streams, and consist of water-laid soil materials washed from the upland soils. The principal soils, dark and calcareous, are of the Trinity and Catalpa series. These are chiefly of heavy textures and are about the same in character as found in the valleys of the Blackland Prairies, although a larger proportion is of lighter texture and lighter in color owing to a larger amount of the coarser fine-earth particles brought from the local limestone uplands. The alluvial soils of the valleys of Red, Brazos, and Colorado Rivers, which cross this region, are mostly red and calcareous and of the Miller and Yahola series.

Soil Utilization

There are large areas of soils throughout the Grand Prairie that are productive and well suited to many crops. However, there is also much land occupied by soils that are so thin that they constitute marginal soils; that is, for profitable production they require especially favorable climatic conditions and careful cultural treatment. These are the soils that naturally are not highly productive and which, due to erosion, have topsoil layers and subsoils that are not sufficiently thick to afford a large storage of moisture. Such soils are the stony types and shallow phases of the San Saba, Denton, Crawford, and Brackett series. The deeper

soils, chief of which are the clay soils of the San Saba, Denton, and Crawford series, all of which have been developed on the rolling uplands; the soils of the Bell, Lewisville, and other series of the smoother benchlands; and the Trinity and Catalpa soils with others occupying the stream bottoms, are all highly productive and produce good yields when the soil moisture is adequate. Although the rainfall, when normally distributed, is usually sufficient for most crops, it is often of irregular occurrence and soil moisture is sometimes deficient during the crop-growing season. On the Trinity, Catalpa, and other alluvial soils the moisture conditions are usually more favorable and crops are more certain of yielding well than on the upland soils, especially on those that are so sloping that a large amount of rain water is lost by runoff. Therefore the alluvial soils, as a rule, are the best for alfalfa and corn, the latter crop with cotton, the important commercial crop, and some feed crops, comprising the chief crops grown on these very extensively utilized soils. The small grains, however, are inclined to grow too rank on the alluvial soils and wheat, oats, and similar crops are confined largely to the Denton, San Saba, and Crawford clay soil types. These soils as well as those of the Bell, Lewisville, and others of the terrace benches and the Trinity and Catalpa soils occupy the principal areas of good farmland and are also well suited to cotton, corn, grain sorghums, sorgo, and various other crops, all of which are largely grown. Pecan trees grow well on the alluvial soils and are often allowed to remain when the other timber is cleared away. In places pecans afford a considerable revenue.

The rough stony land, and stony soil types, together with areas of very thin soils are best suited to livestock grazing and as a rule practically all such land is used for that purpose. Considerable areas of deep productive soils are also used for livestock as economic demands have not as yet required their complete utilization for farm crops. The soils, well suited for producing feed crops, are used largely for stock farming as well as for ranching. Cattle are raised and grazed in all sections, but goats and sheep are largely confined to the rougher and stony lands of the southern section.

As the surface of the prairie is generally sloping, water runs off rapidly after rains and the soils, especially where cultivated, are subject to injurious erosion. Terracing is being done on many farms to prevent this erosion and at the same time hold the valuable rainwater until absorbed by the soils and subsoils, where it may be stored for the use of growing crops.

WEST CROSS TIMBERS

The West Cross Timbers area, a timbered region in central-northern Texas, reaches southward from Red River well into central Texas. This timber belt, interspersed with many large and small areas of prairie land, is about 200 miles long, and in places, more than 50 miles wide.

It occupies, or extends partly into, 21 counties and has an area of about 7,000,000 acres. On the north it extends into Oklahoma. On the east it abuts the west-facing scarp of Grand Prairie, and on the south merges with westerly extensions of Grand Prairie and roughlands of Edwards Plateau; its western border is formed by the Rolling Plains.

The surface ranges from gently rolling to very rolling, with smoothly undulating broad divides, and considerable areas of hilly and rough stony lands in some sections. Streams are numerous, the largest being Red, Brazos, and Colorado rivers, which pursuing a southeasterly course have cut deep narrow valleys across the region. Into these flow many local tributaries, which provide rapid surface drainage in all sections. Large bodies of land long subjected to severe erosion have been denuded of much of the soil material, leaving stony and shallow soils on ridges and steep slopes. Many areas of smooth soils in cultivation have been injured by erosion, and the soil layers have been thinned or removed entirely with an accompanying formation of deeply cut gullies. The general altitudes of the region range from 1,000 to 1,200 feet above sea-level.

The native vegetation is mainly oak trees, mostly post-oak and blackjack oak with small amounts of other hardwoods, all of rather small size. The included prairies are covered with a growth of native grass, mostly bunch grasses, and some short grasses, with scattered mesquite trees.

Climatically, the West Cross Timbers area lies at the western edge of the humid region. The average annual rainfall of about 30 inches in the eastern and 26 inches in the western parts is somewhat less than that of the Grand Prairie, though the temperature does not differ greatly. Owing to the more westward location, however, the variations in precipitation are more marked and extend throughout a greater range than on Grand Prairie. Some seasons occur with rainfall so light that there is not sufficient moisture to produce high crop yields.

Agriculture

Not a very large proportion of the land in the West Cross Timbers area is devoted to farm crops, although farming, stock farming, and ranching are carried on in all sections. The farms are mostly small, and the timbered sandy soils are used for the general farm crops with cotton as the principal crop, though corn, sorghums, peanuts, truck crops, and fruits are also grown. The small grains, oats and wheat, are important crops on many farms on the heavier soils of the included prairies, though on these cotton is also grown. Ranching is confined mostly to the large areas of rough lands, but this industry is not so generally important as in some other regions.

According to the census of 1925, the proportion of land used for crops in five representative counties ranged from about 9 per cent in

one county to 29.4 per cent in another, and for all five the average was 17.5 per cent. As a rule, farm crops are grown on the smoother and more favorably situated lands. Cotton, the principal crop, takes up about 35 per cent of the crop land of the region, though in some counties the proportion is as low as 20 per cent, and in others amounts to 40 or 50 per cent. The average yield in five counties in 1924 (as given by the census) was 131 pounds of lint cotton per acre. In one county it was only 112 pounds, and in another (the highest) was 160 pounds.

Corn, though universally grown, is exceeded in acreage by cotton, and in a few counties by oats. Wheat as well as oats is an important crop on many prairie-land farms of the region. In many sections peanuts are an important crop. Sorghums are grown on most farms, sometimes, for grain, but chiefly for forage.

Crop yields are fairly good on the deeper soils, especially where the soils are protected from erosion and the fertility is maintained by well recognized methods of soil improvement. However, production is low on the thin, shallow, and very sloping soils, especially in the very dry seasons.

Soils

The predominating soils of the West Cross Timbers are largely of sandy texture, and under natural conditions support a forest growth of oak trees. In places open spaces of considerable extent are free of trees or have relatively small patches of oak timber or widely scattered small mesquite trees. On these prairies the soils in places are mainly sandy types similar to the timbered areas, but in many places good-sized bodies of dark-colored soils of heavy texture occur that are of Denton, Brackett, or San Saba series, or other soils belonging to that general group. Narrow strips of bench lands high above overflow occur in the larger valleys, and alluvial soils of the narrow flood plains of the streams, though widely distributed in most sections, occupy but a small proportion of the total land area.

In one representative county, Eastland, soil surveys show that the timbered upland soils amount to about 61 per cent of the total land area, prairie soils 26.3 per cent, smooth terrace-bench soils 6.4 per cent, and alluvial bottom land soils 6.2 per cent. Of these, the timbered upland stony soils amount to 12.4 per cent of the county, and shallow stony prairie soils 14 per cent. This probably represents fairly well the proportions of the soils throughout the region.

The parent-materials of most of the timbered and prairie sandy soils consists largely of noncalcareous formations, mainly sandstone, while the heavy prairie soils are developed from limestone or other limy materials. The soils of the high valley benches are developed from materials of mixed origin, both from heavy prairie and light sandy soils of the higher uplands. The alluvial soils of the flood plains consist of

recently deposited soil materials washed from sandy and heavy soil uplands.

The table on page 80 gives the main characteristics of the principal soils and the chief crops grown.

Upland Soils

The uplands comprise both timbered and prairie soils. The soils of the timbered areas and of some of the prairies are sandy, being developed from sandstone or non-calcareous sandy formations. These soils are noncalcareous and are developed deeply in places, but large areas occur where the soil and subsoil layers are thin. In many places the soil has been largely washed off by erosion, and in some areas stony material comprises much of the soil and subsoil layers. The topsoils contain but little organic matter and are mostly much lighter in texture than the subsoils. The soils of this group are mainly of the Windthorst and Nimrod series.

Windthorst Soils: The Windthorst soils comprise brown, light-brown, or reddish-brown surface soils which rest upon red heavy sandy clay subsoils. The subsoils are not very deep, and in many places pass below at a depth of 2 or 3 feet into partly weathered sandstone. The surface is generally rolling, though the stony soils occupy ridges and rather steep slopes of valleys. Erosion has been severe, as evidenced by the presence of shallow, stony soils, rough stony lands, and dissection of the surface by numerous small streams. The Windthorst fine sandy loam is the most extensive soil type of the region (Fig. 38). It is fairly

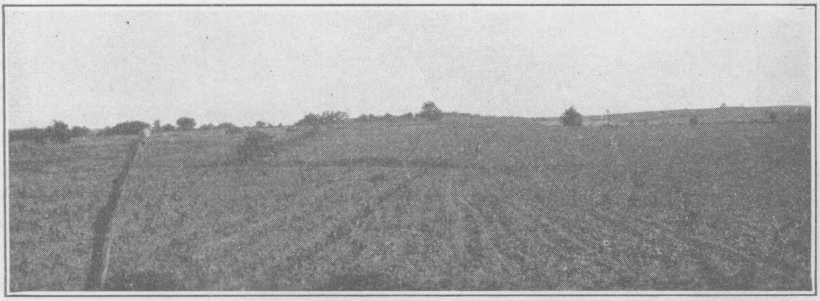

Figure 38. Windthorst fine sandy loam in Parker County, near Weatherford. This is an excellent soil for truck crops.

productive and accordingly is the most important soil on many farms in this region. It is well suited to cotton, peanuts, sorghums, vegetables and fruits, which are the principal crops grown. Truck crops are grown extensively in some sections. These soils are fairly resistant to drought. They resemble somewhat the Kirvin soils of the East Texas Timber Country.

Principal soils of West Cross Timbers

Soil groups (Series)	Topsoil	Subsoil	Substratum (or parent material)	Chief crops grown
Rolling Upland.				
Timbered:				
Undulating to rolling.				
Windthorst	Brown, reddish-brown, or red; friable.	Red, heavy but crumbly.	Sandstone and sandy beds.	Cotton, corn, sorghums, peanuts, vegetables, fruits.
Flat to undulating.				
Nimrod	Light-brown or gray; yellowish subsurface, friable.	Yellow; friable; sandy.	Sandstone and sandy beds.	Cotton, peanuts, corn, sorghums, vegetables, fruits.
Rough, hilly, steep.				
Rough stony land.	Very large fragments of limestone or sandstone; little soil material.	Bed rock of sandstone or limestone.		Grazing and browse for livestock.
Nearly flat to undulating stream benches (above overflow)				
Milam	Brown or reddish-brown; friable.	Red, heavy, crumbly; permeable.	Sandy and clay beds on beds of rounded gravel.	Cotton, corn, peanuts, vegetables.
Bell	Black or very dark-brown; calcareous, friable.	Dark gray to brown; crumbly; calcareous.	Clay on beds of rounded gravel.	Cotton, corn, sorghums, oats.
Lewisville	Brown; calcareous; friable.	Brown or yellow; calcareous; friable.	Clay on beds of rounded gravel.	Cotton, corn, sorghums, oats.
Prairie:				
Undulating to rolling.				
Denton	Brown; friable.	Brown or yellow; calcareous, crumbly.	Limestone or chalk, or calcareous limey clay.	Oats, cotton, wheat, corn, sorghums.
Rolling to hilly.				
Brackett	Brown or light-brown, or grayish; friable; calcareous; shallow.	Yellow or whitish; calcareous; thin.	Limestone or calcareous clay.	Grass and browse.
Flat Stream Bottoms.				
(Subject to overflow)				
Ochlockonee	Brown or light-brown, friable.	Gray, yellow or mottled.	Alluvial beds of clay or sandy material.	Cotton, corn, sorghums, pecans.
Catalpa	Brown; calcareous; friable.	Brown or grayish; calcareous; crumbly.	Alluvial beds of clay or sandy material.	Cotton, corn, sorghums, pecans.
Frio	Grayish-brown; calcareous; friable.	Grayish-brown; calcareous; crumbly.	Alluvial beds of clay or sandy material.	Cotton, corn, feed crops, pecans.

Nimrod Soils: The Nimrod soils consist of gray surface soils which pass below into yellow subsoils. Rather heavy stiff clay subsoils occur deeply beneath the soils in places. Only one type, the fine sand, has been mapped. This soil occurs on smooth, flat areas. The parent sandstone lies deeply beneath the surface. This soil is locally known as "blowsand," in some sections, as it is easily drifted over unprotected areas by hard winds. The type is not generally extensive although in one county it comprises nearly 18 per cent of the land area. It is only moderately productive and is used for cotton, peanuts, sorghums, vegetables, and fruits.

Rough Stony Land: Large areas of Rough stony land occur throughout the region on hills and on rough steep slopes covered with large rock fragments and outcroppings of sandstone. In some areas the stony material is limestone. The natural growth on the sandstone land is largely small oak trees, while on the limestone small brushy trees and bushes are more abundant (Fig. 39). Grass is not everywhere abund-

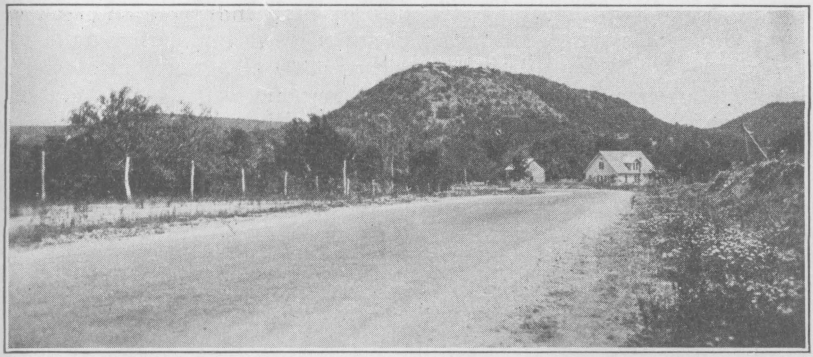

Figure 39. Rough stony land in western Palo Pinto County. Some areas of this rough land occurs throughout West Cross Timbers.

ant on this type of land. However, the grass and browse afforded by other vegetation, comprise a fair range for livestock, and the land is mostly used for pasturage.

The soils of the Milam, Bell, and Lewisville series occupy portions of the high benches of the valleys. These have been described with other regions. Probably other soils of this character occur on these benches but these have not yet been classified.

Alluvial Soils

The alluvial soils do not make up a large proportion of the land area though they are widespread in occurrence in the numerous narrow shallow valleys. Some of these are of the Ochlockonee, Catalpa, and Frio series which are described in other regions where they are more extensive. There are doubtless other alluvial soils which have not been classified. Along some of the rivers which cross the

region there are narrow belts of the soils of the Miller, Yahola, Trinity, and other series.

Soil Utilization

From the standpoint of agricultural uses the soils of the West Cross Timbers area lie within two broad divisions: first, the soils that are moderately deep and smooth and suitable for the production of farm crops; and, second, the very stony, rough, and shallow soils suitable only for the pasturage of livestock.

The more extensive soils that are valuable for farm crops are the Windthorst fine sandy loam, Nimrod fine sand; Denton clay, and other prairie soils; Lewisville, Leaf, Milam, and similar smooth benchland soils; and Ochlockonee, Catalpa, and other alluvial soils. Of these the most inherently productive are the heavier alluvial soils. The principal soils of the uplands also produce well where good methods of soil protection and improvement are employed. The soils are well suited to many crops but those of sandy texture, chiefly the Windthorst and Nimrod soils, are not well suited to the production of the small grains. Oats and wheat are important crops grown on Denton clay and similar prairie soils. The sandy soils are well suited to cotton, corn, sorghums, peanuts, vegetables, and fruits and these are all grown extensively. These soils are low in organic matter and respond well to incorporation of this material. The sandy soils are naturally resistant to drought where the soil layers have not been too greatly thinned by erosion. The Denton clay and the other prairie soils are well suited to cotton and the small grains, corn, sorghums, and other feed crops. The alluvial soils are best for cotton, corn, sorghums, alfalfa, and pecans.

The Rough stony land and the shallow soils are used advantageously as pasturage for range livestock.

Soil erosion is destructive on many of the soils where the surface is sloping, and is especially damaging in many fields where cultivated crops afford but a slight protective cover. Terracing has been found to be an effective means for keeping the soils from eroding and for holding the rain water until it is absorbed by the soil and subsoil.

CENTRAL BASIN

The Central Basin, also known as Llano Basin, is a relatively small region in central Texas at the northeastern edge of Edwards Plateau. As this area lies somewhat lower than the surrounding regions, it is called a basin. This surface condition is the result of removal of surface rocks by long-continued erosion of the Colorado River and its tributaries. The region is surrounded by the limestone beds of the higher-lying Edwards Plateau, an area which at one time doubtless covered all of the basin region. Considerable areas of limestone still occupy parts of the basin giving rough and stony lands, some of which comprise high hills and ridges. Portions of eight counties are occupied by the general basin area, which comprises approximately 2,000,000 acres.

The surface of Central Basin is rolling to hilly. There are relatively smooth valleys and broad gently rolling lowlands interspersed with stony hills and rough lands (Fig. 40). The general area is surrounded by a rim of high hills into which reach valleys extending from the lower-lying Basin lands. The elevation of the Basin ranges from about 800 feet on the Colorado River to over 1,300 feet above sea-level in the western part. The higher-lying encircling areas of Edwards Plateau lie at an elevation of about 2,000 feet above ssa-level. Isolated remnants of the plateau lying within or partly within the Basin consist of mountain-like hills with steep stony slopes which rise 400 to 600 feet above the lowland. The Colorado River passes through the eastern part of the Basin and Pedernales, Llano, and San Saba rivers cross it from west to east. The main streams have flowing water the year round. These streams have numerous small tributaries reaching into all parts of the Basin. Only very narrow strips of smooth alluvial land occur along the streams.

The native vegetation of the Basin is mainly small oak trees and in

Figure 40. Looking down across the Central Basin area from the encircling rim of limestone fifteen miles north of Mason.

places considerable mesquite and juniper trees, the latter growing more extensively on the rough lands. On the valley lands there are many fine pecan trees. Various shrubs and grasses occur in the smaller timber growth, which in many places is open and scattered.

The climate of the basin region is temperate with a yearly average in temperature of 67.4° F. and of rainfall about 25 inches. As the basin lies in the extreme western part of the humid climatic region, the yearly and seasonal rainfall is variable, in some growing seasons being plentiful, and in others insufficient for the best production of crops. As a rule, the moisture conditions are adequate for crop production on the deepest soils, wherein a good supply of rain-water may be stored and held in reserve for crops.

Agriculture

Not a large proportion of the Central Basin is farmed. This is mainly a ranching country because much of the land is stony and rough and large areas of the smoother lands are occupied by shallow soils. In the three counties which lie chiefly within this area, one had less than 5 per cent, another less than 7 per cent, and the other about 13

per cent of the land in farm crops, according to the 1925 census. The principal crop grown is cotton, for which approximately one-half of the crop land is used. Corn, the crop of next importance in acreage, is grown on about one-fourth as much land as cotton. The other chief crops include sorghums for grain and forage and some oats and wheat. Stock farming is carried on by some farmers in conjunction with the production of crops. Cattle, sheep, and goats are raised on both farms and ranches.

Crop yields are quite good on the deeper smooth soils though occasional very dry seasons prevent a highly successful production. The average yield of cotton for the three main counties of the Basin area was only about 107 pounds of lint cotton per acre in 1924, acccording to the census.

Soils

The soils of the Central Basin are of several series. The sandy soils predominate and some are very shallow and stony, and considerable areas of Rough stony land occur.

The various soils have been developed from parent-materials consisting of limestone, sandstone, and old crystalline rocks such as granites and schists. The soils are mostly noncalcareous, and red is the prevailing color. Because of erosion, soil development has not produced very deep soil layers and the parent rocks mostly lie near the surface. The topsoils are of coarser texture and more crumbly structure than the subsoils, which are mostly of heavy texture. There is a well defined line of change between soil and subsoil.

The soils are chiefly of the Tishomingo, Lancaster, Pototoc, Katemcy, and Pedernales series.

The table on page 85 gives the characteristics of these soils and the chief crops.

The soils of the Central Basin occur in many intricately associated small areas and doubtless a detailed soil survey would locate many more of these than were shown in the reconnaissance survey made in 1913. From the different kinds of rocks in the region there have been developed a number of soils of similar color features, but these differ essentially in other characteristics. Only very slight strips of alluvial soils occur.

Tishomingo Soils: The Tishomingo soils consist of brown, reddish-brown, or red surface soils resting on red or reddish-brown clay or sandy clay subsoils which in places have a slight admixture or mottling of some other colors. The soils and subsoils are mostly thin and rest on the parent rock at a depth of one to three feet, though in places the rock is covered by soil layers 5 or 6 feet think. The parent rocks consist chiefly of granites, schists, and gneisses. Some seven soil types have been identified in the Tishomingo series. These are mostly shallow and of a stony or gravelly nature. They are, as a rule, best suited to grazing and browsing. The surface is smoothly rolling to hilly,

Principal soils of Central Basin

Soil groups (Series)	Topsoil	Subsoil	Substratum (or parent material)	Chief crops grown
Rolling Upland				
Nearly flat to rolling and hilly. Tishomingo	Brown to reddish-brown; friable. Considerable shallow and stony soils.	Red or mottled; thin layers, dense.	Granite, schist, gneiss.	Cotton, corn, sorghums, oats, natural range.
Gently rolling to hilly. Lancaster	Brown to slight reddish-dish-brown. Considerable shallow and stony.	Yellow or mottled; thin layers, crumbly.	Sandstone.	Cotton, corn, sorghums, natural range.
Nearly flat to hilly. Pontotoc	Bright red, friable; much stony land.	Dark red; crumbly; thin layers.	Red sandstone.	Cotton, corn, sorghums, oats, natural range.
Nearly flat to hilly and rough. Pedernales	Red or reddish-brown; friable; much stony land.	Red; crumbly; thin layers.	Limestone and sandstoue.	Cotton, corn, sorghums, oats, natural range.
Smooth, nearly flat valleys. Katemcy	Dark-brown or black; friable.	Pale red; crumbly.	Granite and imposed limestone material.	Cotton, corn, sorghums, oats.
Very rough, hilly, and stony. Rough stony land	Various areas have either limestone, sandstone, or crystalline rocks as large bowlders and outcrops.	Bed rock.	Bed rock.	Natural range forage.

though some areas are nearly flat. Various grasses are found, though the chief growth consists of live-oak, post-oak, mesquite, and other trees. The sandy loam and fine sandy loam are moderately productive, but crops often suffer for lack of moisture in dry seasons because the surface soils and subsoils are not sufficiently deep to hold a large reserve of water. These soils are fairly well suited to cotton, corn, sorghums, vegetables, melons, and sweet potatoes, and these are generally grown successfully on the deeper soils.

Lancaster Soils: The Lancaster soils are somewhat similar to those of the Tishomingo series, being, however, less red in color. The soils are gray, brown, or reddish-brown and the subsoils are yellow or mottled yellow and gray. These soils are developed rather deeply on the smoother surfaces. In hilly areas the parent rock or ferruginous sandstone lies near the surface or outcrops, giving a stony condition. There are two principal types: a fine sandy loam of smooth surface, which is fairly good for cotton, corn, sorghums, and other crops; and a stony fine sandy loam of hilly to broken surface, chiefly non-arable. The principal natural growth is characterized by the usual oak and mesquite growth of the region, with a few other trees and a small amount of native grasses.

Pontotoc Soils: The Pontotoc soils have bright-red surface soils which rest on red subsoils. The subsoils, in turn, rest on red ferruginous sandstone, the soil parent-material, at a depth of a few inches to two or three feet. Two soils of sandy texture occur in the series, one a stony sandy loam occupying slopes and ridges and having little or no value for farm crops, the other being a sandy loam undulating to gently rolling, and largely used on farms for cotton, sorghums, corn, and other crops, producing fairly good yields when moisture conditions are favorable. These soils are of very slight extent.

Katemcy Soils: The soils of the Katemcy series have dark-brown to black surface soils resting on pale-red subsoils. They appear to be developed mostly from granitic rocks, with some admixture of material from limestone. These soils are not very extensive and occur in smooth valleys. Several textures are represented in many small areas. The soils are generally quite productive and are used for the general farm crops of the region.

Pedernales Soils: The Pedernales soils have reddish-brown surface soils and red subsoils. Several soil types occur, ranging in texture from sandy loam to clay. These types are not deeply weathered and beds of limestone or sandstone lie at a depth of three feet or less. The soils are developed from clays, sandstones, and limestone. Some soil development has occurred from the rocks in places, though some of the soil material has been transported by water and placed within the residual material. The soils occupy nearly flat to gently rolling valley locations,

though some of the stony soils are hilly to moderately rough. The natural growth is largely of an oak-mesquite association with some grasses. The non-stony soils are moderately productive and good yields of the general farm crops are produced on many farms. The stony soils are used only for the pasturage and browse afforded livestock by the natural vegetation.

Rough Stony Land: Large areas of Rough stony land occur, some of which are of limestone, while others are of sandstone, and in places, of crystalline rock materials. These lands are very rough and stony with a small-tree growth of oak, mesquite, juniper, and others. The land is used for grazing and browse of livestock.

Soil Utilization

The Central Basin constitutes an area of distinctive soils to be found in no other part of the state. It is a ranching country in which some of the more suitable soils are locally cultivated. The greater part of the land is used for cattle, sheep, and goats. Though there is a considerable growth of small trees and shrubs occupying the range pasture lands, many of these afford browse for the stock and on the more stony and rougher land sheep and goats do well. Considerable native grasess and herbaceous plants on the smoother lands provide grazing for livestock.

The chief soils used for farm crops are the sandy loams, which comprise over half a million acres. The stony soil types are somewhat more extensive and occupy about three-quarters of a million acres while Rough stony land, which has no soil classification, probably has an aggregate of another three-quarter-millon acres. The sandy loams of the Pedernales and Tishomingo series are the most extensive soil types of the region.

The sandy loams are well suited to many crops and are moderately productive. Though not specially suited to the small grains, some oats and wheat are grown on some of the soil types fairly successfully. The soils produce good yields of the sorghums, Sudan grass, and other feed crops, and are well suited to stock farming.

RIO GRANDE PLAIN

The Rio Grande Plain comprises a wedge-shaped area in the extreme southern and southwestern parts of Texas, terminating in the most southernly projection of the State at the mouth of the Rio Grande. This plain is bordered on the north by the higher rough country of the Balcones Escarpment portion of the Edwards Plateau. On the east its border is marked by an irregular transition zone where the plain on the east merges with the East Texas Timber Country, Blackland Prairies, and Coast Prairie. This zone is unmarked by a physiographic change. The changes of natural vegetation from the brushlands of the

Rio Grande Plain to the timberlands on the east is marked by gradual transition. This border zone, however, is characterized by a change in the broader soil characteristics, due to the effect of difference in climate, a change from humid to subhumid conditions. The southern extension of the region follows the Gulf Coast some 170 miles, while on the west it extends into Mexico, the Texas portion being separated from that country by Rio Grande, the International boundary.

The Rio Grande Plain has an area of approximately 22,000,000 acres included in 34 counties, some of which are wholly and others partly within the plain.

The region consists of a broad undulating to rolling plain with a general regional slope to the southeast. It is crossed by several small rivers confined to relatively shallow flat-bottomed narrow valleys. Smaller tributary streams reach into the various areas between rivers and provide drainage ways for carrying runoff water. Water flows continuously only in the larger streams which rise outside the region. In the extreme southern part there are very few streams, and over large sections of the area only a few shallow gullies provide drainage for the runoff water after rains. Most of the region lies at elevations between 200 and 700 feet above sea-level, though the extreme elevations range from sea-level at the coast line to nearly 1,000 feet at the north border. Although the general character of the natural features mark this as a distinctive geographic region, there are variations of soil and vegetation in different sections which characterize fairly large and well defined subdivisions. These are, briefly, the flat coastal belt, the dune sand and marshy areas bordering the Gulf, the sandy plains with coarse grass and scattered brush growth, and the blackland belts with dense growth of shrubs and short grasses. These various subdivisions are thus marked by contrasting features of landscape, soils, and vegetation.

The native vegetation is varied, though characterized by the predominance of species of plants common to climatic conditions of rather high temperatures and low rainfall. A growth of small mesquite trees occurs over most of the region, widely scattered in places but, in some sections, very thick. Small oak trees grow on some of the soils, in places, with a very thick scrubby low growth (Fig. 41). Various thorny shrubs of many species grow abundantly in all sections, and are commonly included in the general term "chaparral" (Fig. 42). In places, prickly pear is very abundant. Bunch grasses of various species including Andropogons, needle grass, grama grass, and many other grow on the lighter soils, while buffalo, mesquite, some species of grama and others abound on the heavy soils. The stream bottoms have a rather heavy growth of mesquite, oak, hackberry, elm, and other trees, with, in places, some pecan trees.

The climate of the Rio Grande Plain is mild, that of the southern part being sub-tropical. The average annual temperature in the northern part is about 68° F. and in the extreme southern part around 74° F. The winters are, as a rule, very mild though cold waves occasion-

ally reach to the southern part accompanied by short periods of freezing temperatures. The average annual rainfall is about 30 inches in the eastern part and gradually decreases westward until it is only approximately 20 inches in the extreme western sections, where semiarid climatic conditions prevail. Dry-land farming is carried on success-

Figure 41. Small live oak trees make a dense growth on some of the deep sandy soils. Nueces fine sand in Nueces County.

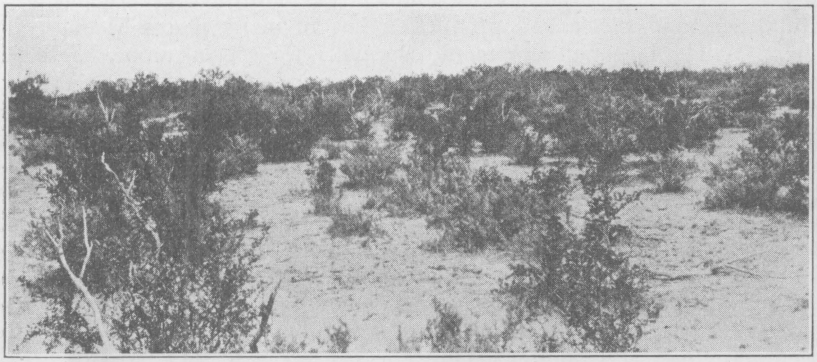

Figure 42. Thorny shrubs (chaparral) and small mesquite trees and associated short grasses characterize the heavy dark-colored soils of the Rio Grande Plains, La Salle County.

fully in the eastern part of the plain on the deep and productive soils. In the western parts only small amounts of land are cultivated without irrigation and moisture is often insufficient for successful production even on the most favorable soils. Considerable land in the northern, southern, and western sections is farmed under irrigation. A very large proportion of the region is still occupied by cattle ranches.

Agriculture

Agriculturally, the Rio Grande Plain is a large region undergoing a gradual change from cattle ranching to farming. However, in the eastern parts, where the average annual rainfall is around 25 inches or more, the counties are fairly thickly settled and much of the land has long been cultivated in small and fairly large farms. Here farming is done without irrigation, but going westward dry-land farming becomes gradually less important. In some sections dry-land farming has been extended so far west that even on the more productive and drought-resistant soils there is rarely sufficient moisture for good crop production. In many parts of the region irrigation from streams and wells has proven highly satisfactory in supplementing soil moisture. In places along the Rio Grande and some other streams irrigation was long successfully practiced in a small way by Mexicans and others by employing simple methods of applying water. With the recognition of the value of many of the soils for producing many kinds of crops together with the mild climate allowing long free-frost periods of growth many sections have been settled by farmers. Various sections have been exploited and the lands made available have been reached by irrigation systems while new sources of underground water have been located and developed. Thus much of the best land has been placed in cultivation and where the water supply is adequate, agriculture has become well established, and specialized production has in many places become important. The larger development, especially for special crops, has been in the Lower Rio Grande Valley in Cameron, Hidalgo, and Willacy counties, where citrus-fruit growing, truck farming, and production of the general farm crops such as cotton and corn take up large areas of land. The Laredo section, specializing in onions, has also an important truck-farming area, while in other parts of the Winter Garden district, which includes several of the counties in the northern part of the region, the general farm crops and truck crops are raised extensively. In most places this development is by the use of irrigation water from streams and wells in such amounts as are required to supplement the soil moisture when rainfall is light. Important truck-crop production occurs around Carrizo Springs, Crystal City, Uvalde, Natalia, Pearsall, Del Rio, and other places. Many kinds of truck crops are produced though onions, spinach, cabbage, peppers, watermelons, cantaloupes, beans and tomatoes are the most important. Systematic dry-land farming in all parts of the region is confined more largely to cotton, corn, and sorghums though some truck crops are also grown in the eastern sections without recourse to irrigation.

Some counties of the more eastern sections, on account of large areas of smooth moisture-conserving and highly productive soils, have attained front rank in cotton production under dry-land farming. However, there are various sections relatively small, which because of thin and

eroded soils, or very gravelly or stony conditions, or lack of sufficient water for irrigation, will probably always be used for livestock.

Owing to the variations in soils and climate, the proportion of land used for crops differs greatly in the counties throughout the region. In some of the more eastern counties the proportion of land in crops probably amounts to 30 to 50 per cent, while in some of the western counties where irrigation has not become important less than 5 per cent is farmed. Practically all of the land not farmed is used for the pasturage of livestock, chiefly range cattle.

Soils

The soils of the Rio Grande Plain have been developed under a climate of relatively high temperature and light rainfall, and though there are short periods at irregular intervals in which the soils and soil materials become thoroughly saturated with water by heavy rains, these often remain very dry for many months at a time. The soil parent-materials consist mainly of two general kinds: one, of calcareous clays, marl, or other limy material; and the other of beds of noncalcareous clay and sandy materials. In places small amounts of thin limestone or sandstone strata occur. Geologically, the parent-materials are southwesterly extensions of formations from which the soils of the Blackland Prairies, East Texas Timber Country, and Coast Prairie regions are developed.

The prevailing warmer and drier climate of Rio Grande Plain, with a different character of vegetative growth give rise to soil-developing processes which differ from those of the humid region, and the resulting soils differ in some of their chief characteristics. Here the normal soils of mature or partly advanced development are underlain by layers in which calcium carbonate has been cencentrated at some part of the soil profile, and this layer contains more of this constituent than is in the parent-material (Fig. 43). This feature is prominent and the chalky layers appear in many eroded spots and cut banks, where, when in a nearly pure form, it dries to a hard rock-like material known as caliche. The soils most advanced in age are generally not calcareous in the upper layers.

Westward the dark-colored soils become gradually lighter in color as drier climatic conditions prevail. Here also the underlying layer of accumulated calcium carbonate generally lies nearer the surface.

On the basis of soil characteristics, the soils of the Rio Grande Plain are included in six divisions. The chief areas of these are shown on the soil map, though many small areas could not be shown on a map of this scale. These groups are as follows: (1) dark-colored soils (Victoria-Goliad-Orelia group); (2) light-brown soils (Maverick-Zapata group); (3) light-colored soils (Brennan-Nueces group); (4) red soils (Duval-Webb group); (5) semi-marshy soils (Lomalta-Point Isabel

group); and (6) alluvial soils comprising the Frio-Leona, Rio Grande-Laredo, and Harlingen-Gila sub-groups.

The various soil-group areas are characterized by readily recognizable features of soils, surface relief, and vegetation, and each division is well differentiated by economic values.

The table on page 93 gives the principal soils of the region with their outstanding characteristics and chief crops grown.

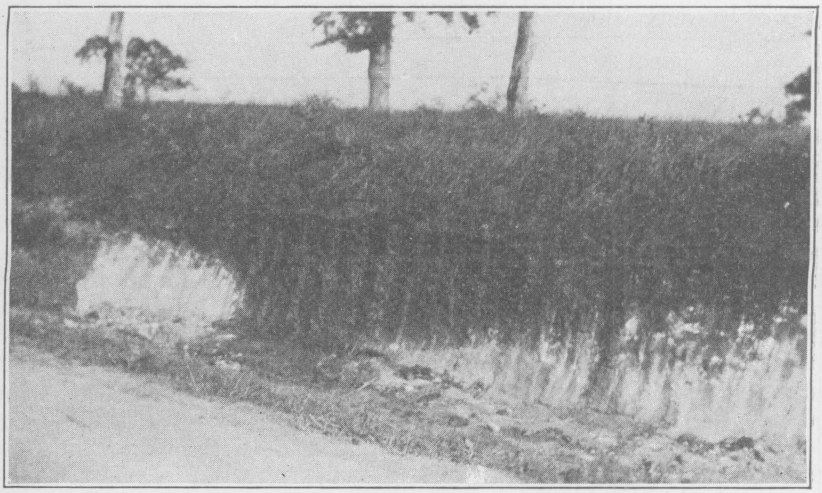

Figure 43. Soil profile in eastern Goliad County, showing irregular accumulation of calcium carbonate in soils developed in the transition zone between the humid and subhumid regions.

Dark-Colored Soils

The dark-colored soils of the plain have black or dark-brown surface soils which are underlain by gray, brown, or red clay subsoils. The soils are developed deeply, as a rule, from soil materials more or less calcareous, mostly clays, marl, or other unconsolidated materials. The surface soils grade below into the subsoils and mostly there is no sharp change from one layer into the other. The most mature soils of the group are not calcareous in the upper layers, but some of less maturity are calcareous from the surface down through the entire soil profile. The soils are developed mostly on smooth, nearly flat to undulating, or gently rolling surfaces. In surface features these soils resemble their humid-region correlatives, the Houston, Wilson, Lake Charles, and others. However, the layer of accumulated calcium carbonate at some part of the profile denotes a subhumid-region characteristic not to be found in the soils of the humid region. These soils have been developed under a heavy growth of short grass which has added a relatively large amount of organic matter to the soils. The clay and clay loam soils are the most extensive textural classes of the group. Detailed surveys have not

Principal soils of Rio Grande Plain

Soil groups (Series)	Topsoil	Subsoil	Substratum (or parent material)	Chief crops grown
Upland Plains.				
Dark colored soils:				
Flat to undulating.				
Victoria	Black to very dark-brown or dark-grayish-brown; calcareous; friable.	Dark-gray, brown or yellowish; calcareous; crumbly.	Calcareous clay or chalky marl.	Cotton, corn, feed crops. truck crops, citrus fruits,
Hidalgo	Brown; calcareous; friable.	Brown, or yellowish; calcareous; crumbly.	Marl.	Same.
Willacy	Brown; not calcareous; friable.	Brown or yellowish; calcareous in lower part; crumbly.	Marl.	Same.
Orelia	Dark-brown or black; tight and crusty when dry; not calcareous.	Dark-brown or dark-gray; dense, heavy: not calcareous.	Marl.	Cotton, corn, sorghum, truck crops.
San Antonio	Dark-brown; not calcareous; tight when dry.	Brown or reddish-brown, dense, heavy; not calcareous.	Marl.	Cotton, corn, sorghum, truck crops.
Miguel	Brown, not calcareous; tight when dry.	Red, not calcareous; tough, dense when dry.	Slightly calcareous clays.	Cotton, corn, sorghum, truck crops.
Undulating to rolling.				
Goliad	Dark-brown or black; not calcareous; friable.	Red or reddish-brown; calcareous in lower part.	Marl.	Cotton, corn, truck crops, feed chops.
Light-brown soils:				
Flat to gently rolling.				
Maverick	Light-brown; calcareous; thin; friable.	Brown or yellow; thin; crumbly; calcareous.	Caliche over calcareous clay or limestone; some sandstone.	Range forage.
Rolling to hilly.				
Zapata	Light-brown or grayish; thin; calcareous; friable.	Gray; calcareous; thin; crumbly.	Caliche over limestone or sandstone.	Range forage.
Flat to undulating stream benches (above overflow).				
Uvalde	Light brown or grayish; calcareous; friable.	Light brown, grayish or yellowish; calcareous; crumbly.	Beds of rounded gravel.	Truck crops, cotton, sorghums.
Light-colored soils:				
Nearly flat to gently rolling.				
Brennan	Very light grayish-brown or gray; not calcareous; friable.	Yellow; not calcareous; crumbly.	Caliche over sandy clay that in places is slightly calcareous.	Cotton, truck crops, vine crops, feed crops (sorghums), citrus fruits in places.

Principal soils of Rio Grande Plain—Continued

Soil groups (Series)	Topsoil	Subsoil	Substratum (or) parent material)	Chief crops grown
Upland Plains—Continued.				
Nueces	Gray; not calcareous; friable.	Gray or yellowish; not calcareous; friable.	Sandy clay (caliche on clay in places).	Truck crops, vine crops feed crops, grapes, berries.
Red soils:				
Undulating to rolling.				
Duval	Red or reddish-brown; not calcareous; friable.	Red; not calcareous except where thin; crumbly.	Caliche over sandy clays.	Cotton, truck crops, corn, grain sorghum, fruits, berries, citrus fruits in places.
Webb	Red or reddish-brown; not calcareous; heavier soils crust on drying.	Red or brownish-red; rather heavy and dense; not calcereous.	Caliche over sandy clays.	Same.
Semi-marshy and associated soils:				
Flat coast border.				
Lomalta	Brown, calcareous, wet salty land; friable.	Brown or gray; calcareous; salty; high water table.	Clay.	Slight amount of natural range forage.
Flat to dune-like ridges.				
Point Isabel	Gray to ashy-brown; calcareous; salty; friable.	Yellow; calcareous; salty.	Clay.	Same.
Flat Stream Bottoms. (Subject to overflow.)				
Frio	Light-brown to grayish; calcareous; friable.	Light-brown or gray; calcareous; crumbly	Clay, sandy material, gravel.	Cotton, corn, feed crops, truck crops, pecans.
Blanco	Gray or light-gray; calcareous; friable.	Light-gray or yellowish; calcareous. ;crumbly.	Beds of sand or clay or gravel.	Cotton, corn, truck crops, pecans, feed crops.
Leona	Black or very dark brown; calcareous; friable.	Gray or brown; calcareous; crumbly.	Beds of alluvial material; some gravel.	Cotton, corn, feed crops, truck crops, pecans.
Rio Grande	Light-brown to gray; calcareous; friable.	Gray to light-brown or yellowish; calcareous; crumbly.	Sandy clay and sand layers.	Truck crops, cotton, corn, feed crops.
Laredo	Brown; calcareous; friable.	Brown or yellow; calcareous; crumbly.	Sandy clay and gravel.	Cotton, corn, truck crops, feed crops, citrus fruits.
Harlingen	Dark-gray to dark-brown; calcareous; heavy.	Dark-gray or brown; calcareous; dense.	Clay.	Cotton, corn, feed crops, truck crops.
Cameron	Black or very dark-brown; calcareous; heavy.	Dark-gray or black; calcareous; heavy.	Clay.	Cotton, corn, feed crops.

covered this region sufficiently to allow a classification of some of the soils, but some series and a number of soil types have been studied. The principal soils are those of the Victoria, Hidalgo, Willacy, San Antonio, Miguel, Orelia, and Goliad series. These and similar dark-colored soils probably occupy around 8,500,000 acres of land in this region.

Victoria Soils: The Victoria soils have black, brown, or very dark blackish-gray calcareous surface soils grading below into dark-gray or brown calcareous subsoils. The soils and subsoils are granular and cultivate to a friable loam-like condition (Fig. 44). At a depth of 3 to 6 feet the subsoils grade below into buff, yellow or cream-colored, soft calcareous clay or clay loam containing a large amount of soft lumps or streaks of calcium carbonate and in places also hard concretions of the same material. This is the layer of accumulated calcium carbonate. It varies from one or two feet to several feet in thickness, and merges below with light-colored chalky clay or marl, the parent-material.

The principal soil types of the series are the fine sandy loam, clay loam, and clay. These soils occur in scattered areas, some small and some large, in various parts of the region, mostly in association with other dark soils. The most extensive areas occur in the coastal section. A considerable number of these are located on the smooth plain centering about Corpus Christi and in the Lower Rio Grande Valley. The surface is generally very smooth and almost flat to gently undulating. Large bodies of the soils are so uniform and smooth that they are well suited to power farming. Natural surface drainage is slow over most areas, though some is sufficiently sloping to cause moderately rapid runoff. The soils and subsoils are quite penetrable to water, though in the heavier textures underdrainage is slow. The natural vegetation is largely buffalo grass (also locally known as mesquite grass), and curly mesquite grass, especially on the heavy soils, though on the sandy soils bunch grasses are more abundant. The principal vegetation comprises mesquite trees, ebony, various thorny shrubs, and small trees of many species generally included in the general term "chaparral," with prickly pear and various other plants. In places this small-tree and shrub growth is so thick that it is practically impenetrable. In places the soils of sandy texture have the heaviest tree-shrub growth, while on the clay soil there are some open grasslands with only a small amount of the woody plants. The Victoria soils are very strong productive soils well suited to many kinds of crops. Cotton does well and is grown very extensively. Large areas of the Victoria clay in Nueces, San Patricio, and Refugio counties are devoted to this crop. Corn, sorghums, citrus fruits, and vegetables of all kinds do well, and many truck crops are raised successfully. The fine sandy loam seems best suited to citrus and truck crops, and on this, as well as on some other soils of the series, are located some of the best citrus-fruit orchards of the Lower Rio Grande Valley (Fig. 45). Rainfall is sometimes insuffi-

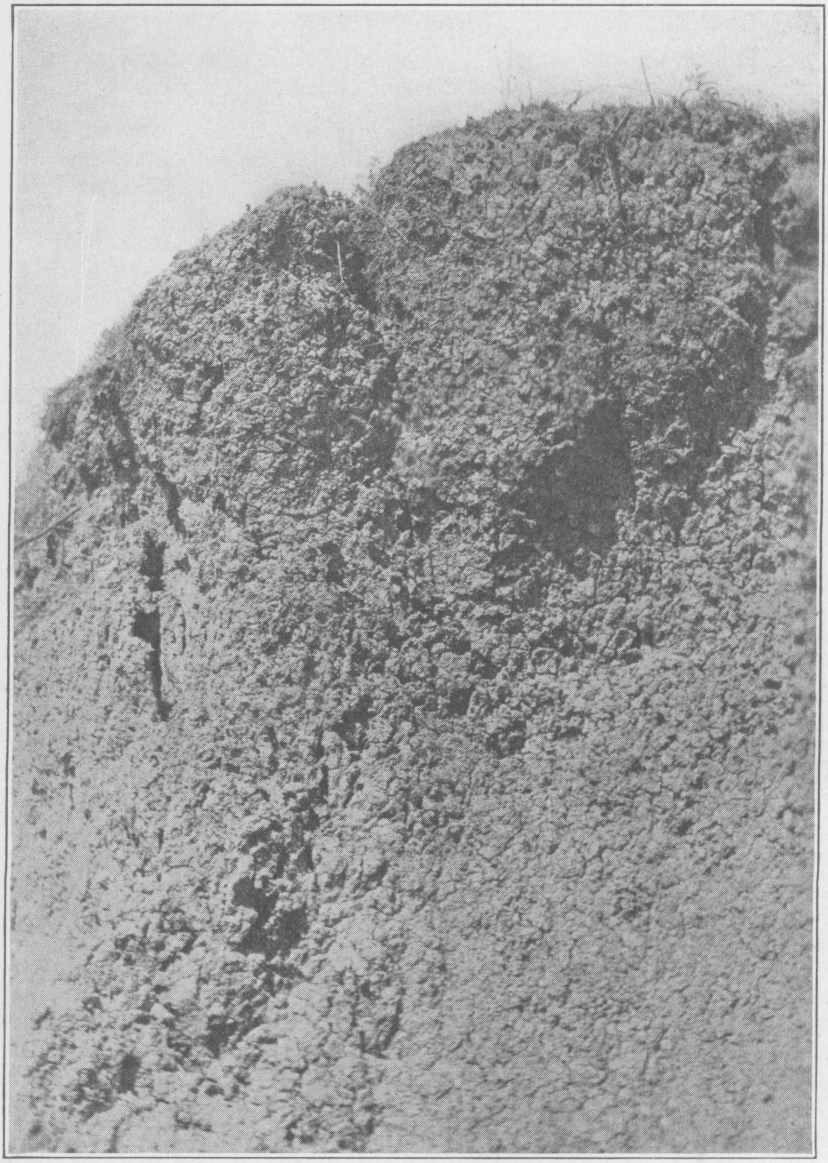

Figure 44. Exposed section of Lake Charles clay near Corpus Christi. Note the natural breakage of the soil to small particles.

cient for the moisture requirements of crops, and in the Rio Grande Valley these soils are largely irrigated.

Hidalgo Soils: The Hidalgo soils constitute a certain group wherein the surface soils are light-brown, brown, or rather dark-brown in color. These become grayish or light-brown in color when thoroughly dried. The surface soils grade below into light-brown or grayish-brown subsoils, mostly of clay or clay loam textures. Soils and subsoils are calcareous and granular in structure, and break down naturally into a friable condition. The Hidalgo soils are very similar to the Victoria but are somewhat lighter in color and the virgin soil, as a rule, seems to contain less organic matter. The subsoils merge below with pale yellow, cream-colored, yellowish-gray, or pale-buff calcareous clay or clay loam, containing a large amount of soft, chalky calcium carbonate

Figure 45. Orchard of grapefruit in Hidalgo County, on Victoria fine sandy loam. This and similar soils are especially suited to citrus fruits.

and concretions of the same material. This layer, in which calcium carbonate is concentrated by accumulation, is several feet thick and merges below with the parent marl.

Several types of the Hidalgo series have been identified, these ranging in texture from a fine sandy loam, probably the most extensive of the series, to clay loam. It seems that most of these soils are located in the Lower Rio Grande Valley, where, in Hidalgo county, they comprise nearly 16 per cent of all the land, though some may occur in other sections. The surface of these soils is quite smooth, ranging generally from almost flat to undulating. Though surface drainage is slow in many places, underdrainage is moderately free beneath the fine sandy loam but is slow beneath some areas of the clay loam. The natural vegetation is much the same as on the Victoria soils. The Hidalgo are strong productive soils suited to a wide range of crops, including most general farm and truck crops, and these are grown extensively. The

fine sandy loam is used largely for citrus fruits, to which it is well suited.

Willacy Soils: The Willacy soils include brown or grayish-brown topsoils which grade below into brown, moderately heavy, subsoils of sandy clay loam or clay. These soils resemble the Victoria and Hidalgo soils in some features. As a rule, the surface soil and upper subsoil layers are not calcareous, though the lower subsoils and parent-material contain considerable calcium carbonate. The parent-material is a yellow, brown, or cream-colored calcareous clay loam or clay. No very well defined layer of calcium carbonate is accumulated in the soil profile. These soils, of which the fine sandy loam seems the most prominent, have been mapped only in Willacy county in the Lower Rio Grande Valley but may occur elsewhere in the region. The surface is nearly flat to undulating, and natural drainage is fairly free except in a few places where it is very flat and has a very heavy subsoil. The natural vegetation, quite similar to that of the Victoria soils, is very dense in places. Where drainage is free, the soils are suited to many of the general farm and truck crops and to citrus fruits. It is used for many of these crops and, where irrigated, much of the land produces good yields.

Orelia Soils: The Orelia series comprises soils with dark-brown, black, or very dark grayish-black topsoils underlain by dark-brown, dark-gray, or black subsoils. The surface and upper subsoil layers are not calcareous, but below a depth of one or two feet the subsoils are calcareous and contain lumps or concretions of calcium carbonate. The Orelia soils resemble the Victoria in surface appearance but differ in that they are not calcareous in the upper layers, and are more dense and less granular in structure than the corresponding soils of the Victoria series. Below a depth of two or three feet the soils are underlain by a grayish calcareous clay containing a large amount of soft and hard lumps of calcium carbonate. At a depth of several feet this merges below with the parent-material, which is yellowish-gray marl. The surface is mostly nearly flat and drainage is slow. The natural vegetation consists of short grasses and shrubs with small trees, including mesquite, lote bush, granjeno, huisache, guayacan, and others, with much prickly pear.

San Antonio Soils: The San Antonio soils are brown or dark-brown in color and are underlain by very heavy, dense, dark, reddish-brown clay subsoils, slightly mottled locally. The soils and subsoils are not calcareous. The material of both soil and subsoil is quite dense, and when dry is hard and intractable. The subsoils grade at a depth of two or three feet into yellowish calcareous clay containing limy concretions. The surface relief is nearly flat and natural drainage is slow. The heavy, dense subsoil is not rapidly penetrated by water. The natural vegetation consists mainly of grasses, including some of the short grasses,

such as buffalo grass and mesquite grass. Some grama grasses and various other coarser bunch grasses are abundant. Small mesquite trees, huisache, chaparral, and various other shrubs also occur. Soils of heavy texture appear to be the most extensive in the series. The extent of the San Antonio soils is not yet known but it seems that they do not cover such large areas as some of the other soils of the region. They are fairly productive, strong soils well suited to cotton, corn, sorghums, and some truck crops, and are used for these crops to a considerable extent. They are probably developed more extensively in the northeastern part of the region than elsewhere.

Miguel Soils: The topsoils of the types of the Miguel series are brown in color and rest on heavy, dense subsoils of mottled brown, yellow, and gray. The subsoils grade below into yellowish, rather friable, calcareous clay material (Fig. 46) The surface and upper subsoil layers are

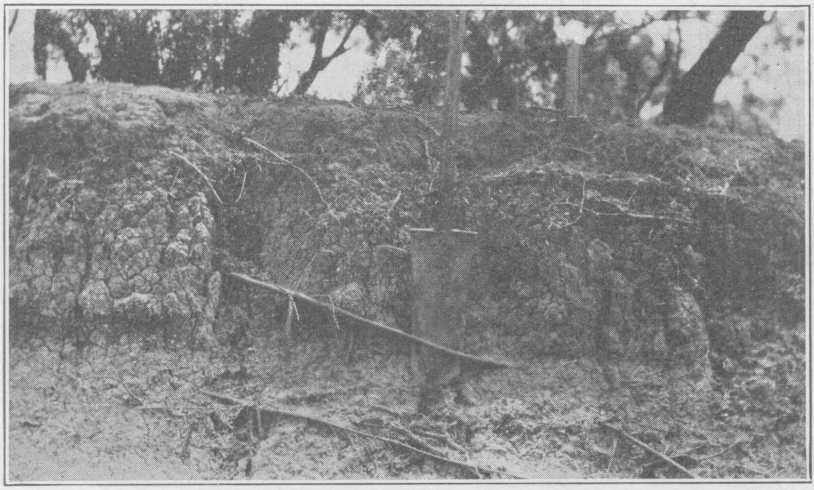

Figure 46. Soil profile of Miguel fine sandy loam in Frio County. Note the dense cloddy structure of the subsoil.

not calcareous. Below a depth of 2 or 3 feet the subsoil merges below with a brown or yellow fine sandy clay which contains a few concretions of calcium carbonate and some fine black concretions. This lower layer constitutes the parent-material which, in most places, seems to be noncalcareous. The surface is quite smooth, in places lying below the level of the surrounding soils. On account of the flat surface and slow penetrability of water through the heavy subsoils, the natural drainage is slow. The Miguel soils occur in small areas in the northern sections, and possibly elsewhere. They seem well suited to the general farm crops and are used mainly for cotton and feed crops.

Goliad Soils: The Goliad soils are characterized by brown or black surface soils passing below into brown or red subsoils. These, at a depth of 1 to 3 feet, are underlain by a highly calcareous material which, in places, consists of almost pure, soft, white calcium carbonate (Fig. 47). This is several feet thick and merges below with soft calcareous clay or marl. The normal soil and upper subsoil layers are not calcareous as a rule. The soils are moderately granular. The several types range in texture from sandy to clay loam and clay. These occur mostly in the extreme eastern part of the Rio Grande Plain. Passing eastward into the Humid Region, the Goliad soils merge with the soils of Houston and Wilson series. The surface is generally fairly rolling and in places erosion has produced rather shallow soil layers, and in such

Figure 47. Soil profile of Goliad fine sandy loam in northwestern Victoria County. Note the accumulated layer of white chalky calcium carbonate that characterizes the normal soils of the Subhumid Region.

spots the whitish layer of calcium carbonate lies near the surface. Natural surface drainage is rapid and the subsoils allow free underdrainage. The soils, though locally covered by a heavy growth of short and some bunch grasses, support a fairly dense to scattered growth of small trees and shrubs represented mainly by leguminous species. Of these, mesquite, brazil, huisache, lignum-vitae, agrito, catclaw, and others are prominent, while some live-oak also occurs in places, and prickly pear

is abundant. The normal soils on smooth locations are very productive and retain much of the rain water. On some sloping areas the soils lose much of the rain water as runoff, which causes erosion and loss of valuable topsoil material. Terracing tends to hold the water until absorbed into the soil and reduces the loss of soil material. The deeper soils are very productive and are used largely for general farming with cotton as the dominant crop.

Light-Brown Soils

In the northwestern part of the Rio Grande Plain there are considerable areas of light-brown soils. These, like the dark soils of the plain, are developed from calcareous parent-materials, chiefly limestone, marl, or alluvial deposits of calcareous soil materials. They are developed under very dry climatic conditions wherein moisture is insufficient to maintain a heavy growth of grass, or to leach out the calcium carbonate from the soil layers. The most extensive areas comprise soils on slopes subject to erosion, and thick soil layers have not been developed. The layer of accumulated calcium carbonate occurs in thick beds, in many places near the surface or outcropping. A small amount of the short grasses and scattered shrubs comprise the native vegetative growth. The principal soils are of the Maverick, Zapata, Ector, and Uvalde series. The areas occupied by these soils here aggregate approximately 3,000,000 acres.

Maverick Soils: The Maverick soils have brown or grayish-brown surface soils underlain by light-brown or yellowish-brown subsoils. The soils and subsoils are calcareous and granular in structure. These have been developed from calcareous clay materials, overlain in the present stage by a bed of calcium carbonate. The soils are undulating to rolling and have rapid natural drainage. The native vegetation consists chiefly of a sparse growth of various grasses including some of the short grasses, together with scattered mesquite trees, thorny shrubs, prickly pear, and some other plants. The deep soils of the smoother areas are moderately productive with adequate moisture. They give good yields of cotton, corn, sorghums, and vegetables. Rainfall is generally insufficient for the best crop growth. Some of the land is irrigated and farmed successfully.

Zapata Soils: The Zapata soils have gray or grayish-brown surface soils with gray or yellow subsoils. Both soil and subsoil are calcareous. The underlying rocks are limestone or sandstone, these occurring at a depth of 3 or 4 feet beneath the surface. On slopes the rock locally outcrops. The surface ranges trom rolling to hilly with some areas steeply sloping and moderately broken. The native vegetation consists of a thin cover of grasses, along with scattered small trees and shrubs, such as mesquite, chaparral, and prickly pear. These soils are mostly sandy or loamy with some stony and gravelly areas, but are not very extensive. The larger areas are those in the central western section, though some are

in the northwestern part. These soils are best suited to the grazing and browse afforded livestock by the natural vegetation. The many areas of shallow soils are unsuited for farming and the deeper soils lie where rainfall is usually insufficient for growing crops.

Ector Soils: In the extreme northwestern part of the region there is a considerable body of light-brown to grayish-brown shallow soil underlain by chalk or soft limesotne. On the surface and throughout the soil there are fragments of limestone. This soil has been developed from chalk and limestone materials. The surface is undulating to rolling and in places somewhat hilly, though some large bodies are almost flat. The native vegetation consists of a scattering growth of grasses with some huisache, chaparral, catclaw, and other shrubs. The soil is shallow and unsuited to farm crops generally, though it affords some grazing and browse for livestock.

Uvalde Soils: The Uvalde soils consist of light-brown to gray calcareous soils underlain by brown or yellow calcareous subsoils grading below into chalky material resting in many places on beds of rounded gravel. The silty clay loam and loam are the principal soils of the series, though gravelly soils also occur in considerable amount. The soils occupy flat or almost flat terrace-benches high above overflow and have moderately rapid underdrainage. These soils are developed from old deposits of sediments carried by water flowing from Edwards Plateau and spread over the plain. The natural vegetation comprises some mesquite and buffalo grasses with some bunch grasses and a growth of mesquite trees, chaparral, and various other shrubs and prickly pear. Naturally, the soils are very productive though the very gravelly soils are unsuited for farm crops. Situated in a region of low rainfall, moisture is often insufficient for crops and irrigation is necessary for successful farming. The farm crops grown include cotton, corn, and sorghums, and various truck crops are produced very successfully in some sections by irrigation. The gravelly soils provide good natural grazing and browse for cattle, sheep, and goats.

Light-Colored Soils

The light-colored soils of the Rio Grande Plain are included in several series of soils. These soils are developed deeply from clays and sands that contain but little calcium carbonate. They are chiefly light, sandy soils with clay or sandy subsoils and are underlain in many places by a layer or bed of accumulated, almost pure, calcium carbonate. The soils are low in organic matter, having been developed beneath a coarse grass cover, and neither surface soils nor subsoils are calcareous where the soils are normally developed. These soils are largely of the Brennan and Nueces series, though possibly some others may later be identified. The soils of this group occupy about 5,200,000 acres.

Brennan Soils: The Brennan soils have gray or grayish-brown surface soils grading below into yellow or yellowish-brown sandy clay or sand subsoils which become very compact and hard on drying where the clay content is large. The soils and subsoils are not calcareous except on some slopes where erosion has prevented the deep development of soil layers. The soils contain only a very small amount of organic matter. Beds of accumulated calcium carbonate (caliche), in places hard and containing almost no fine earth, occur at a depth of several feet beneath these soils. These have a layer of calcareous clay over them in places but, as a rule, the soil layers rest sharply on hard caliche and contain little or no calcareous fine earth. The hard caliche does not occur in all sections but is rather abundant in the southern part of the region. The surface of these soils is generally undulating to gently rolling and drainage, both from the surface and below, is moderately rapid. Small rolling areas have slopes that are eroded to some extent. The principal soils are a fine sandy loam and fine sand. The natural vegetative growth consists of coarse grasses, mesquite and other small trees, and a scattered growth of shrubs, such as granjeno, brazil, ebony, retama, catclaw, and various other plants, as well as considerable prickly pear. On the more open grasslands the shrub and tree growth is mostly small and there are many coarse grasses and weeds. These soils are not farmed to a great extent on account of the light rainfall, though they are said to be fairly drought-resistant. The fine sandy loam is cultivated and various crops grown by dry-land farming and, in places, some areas are irrigated successfully. The soils are well suited to vegetables, some fruits, berries, grapes, cotton, sorghums, and many other crops. Some citrus trees are grown successfully in the southern part of the region. The soils, however, are still largely used for cattle grazing.

Nueces Soils: The Nueces soils consist of light-gray or brownish-gray surface soils underlain by yellow subsoils. Neither surface soils nor subsoils are calcareous. The surface soils contain only very small amounts of organic matter. A layer of calcium carbonate accumulation occurs in the more western areas beneath these soils, mostly at a depth of 6 feet or more, and some is in almost pure caliche form. Only one soil type of this series has been identified and mapped. This is the fine sand which occurs in narrow belts adjacent to water of the Gulf and in a westerly extension of a broad area through several counties in the southern part of the region. Small areas occur also in the northeastern part of the region. This is a loose, fine sand which, where unprotected, blows and drifts rapidly in heavy winds and, in places, if not checked, produces areas of dune sand. The surface is undulating to nearly flat and drainage is accomplished readily by the downward passage of water through the loose soil. In places the surface is dune-like in form where the drifted sand has been held by encroaching vegetation. Large areas of the soils are covered with a growth of coarse

grasses and weeds, though there is also some small mesquite tree growth in places while in some sections there is a very thick growth of small live-oak trees. This soil is well suited to many vegetables, grapes, melons, berries, and small fruits, and in some localities considerable truck farming is done. However, much of it remains as grazing land on large cattle ranches. The soil is quite drought-resistant where the clay substratum lies within a few feet of the surface. In the northern part of the region some areas are occupied by a growth of relatively large live-oak, blackjack-oak, and other trees.

Dunesand: Dunesand consists of light-colored fine sand that has been blown into ridges and dunes 10 to 25 feet high. These dunes are mostly bare of vegetation. The material is slowly driven forward by wind, covering new areas and smothering the vegetation. Locally, the dunes have become stationary sufficiently long to enable a permanent or temporary establishment of vegetation in sufficient density to fix the sand. Small areas of sand dunes occur throughout the large bodies of Nueces fine sand and the islands bordering the coast are largely composed of the shifting dunes. The Dunesand has no value for crops. It is not extensive.

Red Soils

A group of distinctive red soils covers large areas of the Rio Grande Plain, the largest bodies occurring in the northern part. These soils have been developed from noncalcareous or only slightly calcareous parent-materials consisting largely of sandy clay and sandstone. They have a good depth on the smooth areas but are shallow on some of the slopes, on account of erosion. The normal soils are not calcareous. They contain a relatively small amount of organic matter and are generally of light texture with a high content of fine sand. The subsoils contain considerably more of the finer material than the surface soils, though fine sand is usually present also. The caliche layer (accumulated calcium carbonate) rests on the substratum or beds of parent-materials. Practically all of these soils belong in two series: one group, the Duval soils, wherein the surface soils grade below into friable subsoils; and another, the Webb soils, made up of soil types of which the surface soils rest upon or grade through a very short zone of change into rather heavy subsoils. Duval and Webb soils occur closely associated in many places but, as a rule, the Webb soils occur more extensively in the western and the Duval in the eastern and southern sections. This soil group occupies approximately 5,000,000 acres.

Duval Soils: The Duval soils have red or reddish-brown surface soils grading below into red, friable subsoils. The subsoils merge below with buff, yellowish or reddish-yellow calcareous fine sandy loam or fine sandy clay containing soft concretions, lumps, and layers of calcium carbonate. The upper part of this layer of accumulated calcium carbonate lies 2 or 3 feet beneath the surface of the shallow soils

but is 6 or 7 feet below the surface of the deeper soils. Locally, the upper part of this layer consists of almost pure calcium carbonate. This layer is 1 to 5 feet thick and rests on sandy material consisting of compact sand, or sandy clay, with, in some places, some interbedded thin strata of sandstone. The principal type, fine sandy loam, covers large areas in some counties. Other soils of the series, most of which are of sandy texture, also occur. The surface of these soils is gently rolling, as a rule, though very smoothly undulating areas occur and some quite rolling bodies of land with fairly steep slopes are located nearer the deeper valleys. Erosion has thinned the soil layers considerably on some slopes. Natural surface drainage is quite rapid while underdrainage is readily accomplished through the friable subsoils. The natural vegetation is mainly grasses, the bunch grasses, including some grama species, comprising the principal growth. With this is a widely scattered growth of mesquite trees, catclaw, huisache, lote bush, prickly pear, and various other shrubs. The normal soils are quite productive and are well suited to the general farm crops and truck crops. Vegetables and small fruits, vine crops, and berries do especially well (Fig. 48). These soils are, for the most part, quite drought-resistant, especially where smooth and deep. Though these soils are farmed to some extent in the more eastern locations, rainfall is often

Figure 48. Commercial production of cabbage plants on Duval fine sandy loam near Pearsall. This is a splendid trucking soil where irrigation can be practiced.

so light that irrigation, largely from wells, is practiced with success by some farmers. In places some small orchards of citrus-fruit trees are being grown under irrigation on the fine sandy loam.

Webb Soils: The Webb soils consist of brown or reddish-brown surface soils resting on heavy red or reddish-brown clay subsoils which are slightly yellowish in the lower part. The soils and subsoils are not

calcareous, and the heavier soils and the subsoils dry to a rather hard mass and have not the friable, open structure that characterizes the Duval soils. The normal soils developed on smooth positions are underlain at a depth of 2 or 3 feet by a calcareous layer consisting of yellow clay containing concretions and soft particles of calcium carbonate. This layer is one or two feet thick and rests on noncalcareous sandy clay with, in places, some thin layers of interbedded sandstone. There are several soils in this series, the fine sandy loam, the most extensive, occupying large flat to gently rolling areas. The stony fine sandy loam occurs on sandstone ridges, has relatively thin soil layers, and only a slightly developed underlying layer of calcium carbonate. The gravelly fine sandy loam, a rather extensive soil on smooth ridges and high positions, is in many places underlain by a thin layer of accumulated calcium carbonate which becomes very hard on drying. The clay loam appears to be an extremely shallow phase of the fine sandy loam, due to the removal of most of the sandy surface layer by erosion.

The Webb soils are undulating to rolling. Underdrainage of the soils is slow except beneath the stony and gravelly soils. These soils are grasslands on which the coarse grasses, with some grama and other grasses, grow abundantly on the deep soils, but only slightly on the gravelly, stony, and shallow soils. The smoother, deep soils have a scattered to fairly thick growth of small mesquite and huisache trees, chaparral, various other thorny shrubs, and prickly pear. The shrub growth is generally very thick on the gravelly and stony soils. The fine sandy loam is well suited to the various crops of the region and is used largely for cotton, sorghums, truck crops, and various other crops. It produces good yields when moisture conditions are favorable and some of the land is irrigated from wells. The soils are not considered quite so desirable, especially under irrigation, as the Duval soils. Small plantings of citrus fruits grow fairly well under irrigation. The stony and gravelly soils are used mainly for grazing of livestock, some of the shrubs, especially huajillo, affording valuable browse for goats.

Semi-marshy Soils

Adjacent to the waters of the Gulf there are low, flat areas of soils which remain wet for a long time after rain. These soils are characterized by a distinctive vegetative growth indicative of excessive water and salt. These soils are not very extensive as compared to the total area of the region. Water-deposited material, not subjected sufficiently long to processes of soil development to have acquired any of the normal regional soil characteristics, constitutes the bulk of the material. These soils, which belong for the most part to the Lomalta series, are not extensive. Local dune-like elevations, mainly of clay, occupy positions in areas of the Lomalta soils. These have been formed by the wind-blown fragments of the Lomalta soils carried out of the flats and piled in ridges. Probably about 300,000 acres of soils of this group occur.

Lomalta Soils: The Lomalta soils have brown or gray surface soils which grade below into brown or yellow subsoils, these, in places, also having mottled colors of brown, yellow, or gray. The soils and subsoils are mostly calcareous from the surface down but no well developed layer of segregated calcium carbonate occurs in the soil profile. The surface is practically flat and water stands for a long time during rainy seasons and throughout the winter. Some areas lie slightly higher and have more rapid drainage than the main body of the soils. The soils generally contain a rather high percentage of salt and support a characteristic salt-land vegetation, chief of which is a rank, coarse, grass-like plant locally known as salt grass or sacahuiste. The clay and clay loam are the most extensive soils of the series. The largest of these areas occurs as a fluviatile delta bordering the coast in the lower Rio Grande Valley. Some sandy soils of the series appear to be composed largely of wind-blown sand spread over the surface of the heavier soils. They are too often wet and contain too high percentage of salt in most places to be of value for crops. If these soils were properly drained and the salt washed out, they would probably produce good yields of some crops but at present they are used for the slight grazing offered livestock by the natural vegetation.

Point Isabel Soils: The Point Isabel soils have ashy-brown or gray surface soils underlain by subsoils of similar but rather lighter color. The soils are calcareous and in places contain considerable salt. They are not extensive, the clay being the chief type of the series. The areas occur mostly in association with the Lomalta soils but occupy generally higher positions which have more rapid drainage. The surface of the clay soil is largely of a low ridge or dune-like character caused by the wind-drifting of the clay aggregates. The natural vegetation comprises a sparse growth of coarse shrubs and plants and, in places, some grasses. The soils are generally not suited to farm crops, though some of the favorably situated areas of the fine sandy loam have been used successfully for the production of cotton, corn, and sorghums.

Alluvial Soils

There are some important areas of alluvial soils along the few large streams of the Rio Grande Plain, but these are limited in extent, constituting probably not more than 8 per cent of the total land area of the region. These soils occur mainly along streams which originate outside the region and flow through in rather shallow, narrow valleys. No streams with wide, bottom lands originate within the region. The soils are mostly dark to gray in color, calcareous, granular, and open in structure and contain relatively large amounts of organic matter. Overflows are infrequent, as the bottom lands lie rather high, while rainfall is not often so heavy that the water cannot be confined to the stream channels. These stream-bottom soils are all naturally timbered

with various trees, species of oak, ash, elm, hackberry, mesquite, and, in places, pecan being abundant.

The principal alluvial soils of the region are included in three groups. based on soil features and source of parent-materials. The Frio, Blanco, and Leona soils are composed mainly of soil materials transported from the calcareous soils and formations of Edwards Plateau. The other soils, made up largely of materials from semi-arid and arid regions, are of the Rio Grande-Laredo group, which mostly are moderately well drained and normally do not contain appreciable amounts of salts, and of the Harlingen group, which consists of soils which, in places, have such slow drainage that small amounts of salts accumulate.

Frio Soils: The Frio soils are light-brown, calcareous soils which dry out to a pronounced grayish cast. These are deep soils and the subsoils, though mostly heavier, are crumbly and have the same granular, open structure as the surface soils but are lighter-colored or yellow. These soils contain much limy material washed with the soil material from Edwards Plateau. On account of the flat surface, natural drainage is slow although the lighter-textured soils generally lying near the streams, and in places underlain by beds of gravel, are slightly higher and have fairly rapid surface drainage and free underdrainage. Tree growth consists of mesquite, oak, and other trees, and some pecan trees grow in the well drained positions. The Frio soils are highly productive and suited to many farm and truck crops and to some fruits. They are extensively farmed and in some sections crops are grown under irrigation. Small plantings of the date palm have been successful (Fig. 49). Buffalo grass is abundant on the more open areas. These soils are very productive and the subsoils afford a good reservoir for soil moisture, which gives them a good drought resistance. They are highly productive and suited to many crops. They are farmed to a considerable extent, cotton, sorghums, and various other feed crops comprising the chief crops grown.

Blanco Soils: The Blanco soils are light-gray in color, drying out to almost white in places. They contain a large amount of calcium carbonate. The subsoils are yellowish or yellowish-gray, also high in limy material. In places the subsoils have layers of fine sandy loam interbedded with soil materials of heavier texture. These soils are granular and when dry are easily worked to a loamy friable condition. Natural drainage is accomplished readily through the permeable subsoils, though surface runoff of water is slow. The soils occupy high flat bottom lands, and are occasionally overflowed. The natural growth comprises many trees, pecan trees growing on the more freely drained positions and mesquite trees more abundantly on the more slowly drained areas. These soils consist largely of soil materials washed from Edwards Plateau including a large amount of fine calcareous chalky material from the bare limestone formations of that region. The soils are quite productive and suited to the various general farm crops.

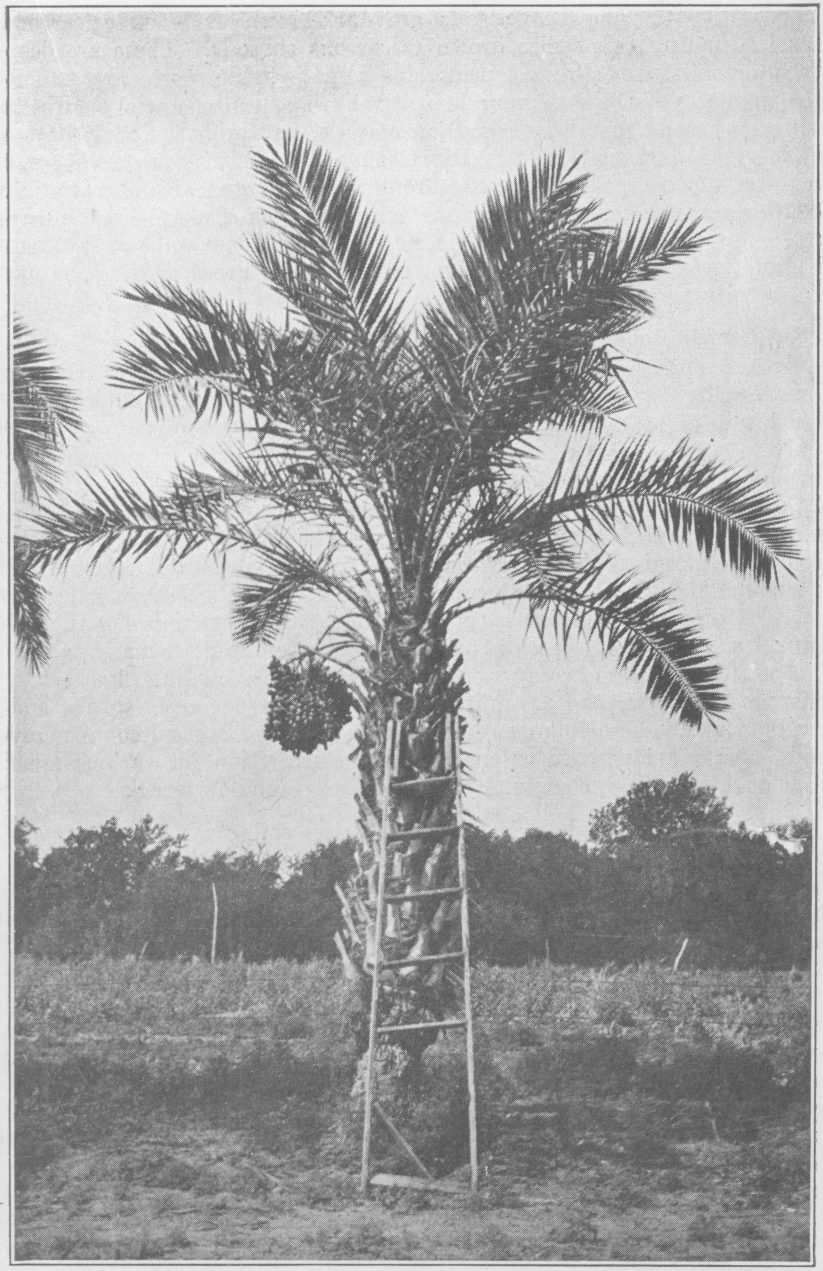

Figure 49. Date palm on Frio clay near Cotulla. Small plantings of these trees are grown successfully on the Frio soils in this section.

Leona Soils: The Leona soils are dark-brown or black calcareous topsoils grading below into brown calcareous subsoils. These are deep granular soils, containing considerable organic matter and are underlain in places by beds of rounded gravel. The soil material has been in part washed from Edwards Plateau soils, but probably considerable is from the dark soils of the Rio Grande Plain. The surface is flat and drainage is readily effected through the soil and subsoil material. Overflows are infrequent. Various trees grow on the soils and pecan trees grow where underdrainage is most rapid. These soils are productive and suited to the general farm crops. Some areas of the soils are successfully farmed.

Rio Grande Soils: The Rio Grande soils are light-brown or grayish calcareous surface soils with subsoils very similar in character, though somewhat lighter in color, and in places are of irregular interbedded thin layers of sandy and heavy soil materials. These soils range from sandy to clay soil textures. They are not very extensive, though important areas occur in several counties. These soils occur in the flood plain of the Rio Grande and comprise soil materials transported mostly from semiarid and arid regions of the west. The soils occupy relatively high bottomland positions adjacent to the stream channel, and along esteros or lakes formed by abandoned stream channels. The surface of much of these soils is not overflowed except by very high floods, and natural surface drainage and underdrainage are rapid in many places. The timber growth comprises various trees, including hackberry, huisache, ash, elm, and mesquite and also many species of shrubs and small plants. These soils are quite productive and are suited to many crops. They are utilized extensively under irrigation for various farm crops such as cotton, corn, and other feed crops and for truck crops.

Laredo Soils: The Laredo series comprises soils with brown surface soils which grade below into yellowish-brown or brown subsoils. These soils are calcareous. They occupy rather flat, high bottomland areas and have moderately rapid natural drainage. The soils are of textures ranging from fine sandy loam to clay. The soils have relatively rapid natural drainage, and though subject to occasional overflow in some areas, only unusually high flood waters reach and cover the surface. In places where the soils occupy slight ridges there are very gentle slopes. The natural vegetation is largely of small trees and shrubs, chief of which are mesquite, ebony, guayucan, granjeno, catclaw, prickly pear, and others. The Laredo soils occur in the flood plains of the Rio Grande and are considered very desirable soils for the production of all the general farm and truck crops. They are utilized extensively under irrigation and produce good yields.

Harlingen Soils: The Harlingen soils have ashy-gray, dark ashy-gray, or grayish-brown surface soils. The subsoils are quite similar to the surface soils, though slightly lighter in color. Soils and subsoils are

calcareous, and in places contain a comparatively high percentage of soluble salts. The chief soil of the series is a clay. It occurs in the lower Rio Grande Valley in some good-sized areas. The soil is heavy and difficult to work, and the subsoil is rather dense and very slowly penetrated by water. The surface is nearly flat and some areas lie slightly lower than the other alluvial soils of the flood plain. It is subject to occasional overflow. Owing to the nearly flat position and very heavy soils and subsoil, underdrainage is slow and surface water may stand for a time in places. This lack of proper drainage is largely the cause for the accumulation of the soluble salts in the soil. Where uncleared the soil is occupied by a rather heavy growth of small trees and shrubs consisting largely of mesquite, chaparral, huisache, retama, prickly pear, and other plants. The soil is inherently quite productive and where drainage is adequate, is well suited to the general farm crops and to some truck crops. Not a great proportion of the soil is used for crops, though some is cultivated and cotton, corn, sorghums, and various truck crops are grown. Much of the soil requires better drainage.

Cameron Soils: The Cameron soils are nearly black calcareous soils underlain by brown or yellow dense heavy calcareous subsoils. Only one type has thus far been correlated with this series. This, the clay, occurs in the Lower Rio Grande Valley. The surface is very nearly flat and both surface and underdrainage are very deficient. This condition causes accumulation of soluble salts in the soil and in places the amount of these is rather large. The type supports a natural growth of small trees and shrubs, mainly mesquite, huisache, retama, chaparral, and others. Under conditions of insufficient drainage, this soil is not suitable for crops, although it is inherently quite productive. Small amounts of the soil have been used with moderate success for some of the general farm crops such as cotton and corn.

Soil Utilization

The question of moisture determines largely the extent to which the soils of the Rio Grande Plain are used for crops. The region has large areas of soils well suited to many crops and where farmed the yields are largely in proportion to the amount of moisture secured. Where irrigation is practiced large yields are constantly made. The alluvial soils, the most resistant to drought, are highly productive and are largely utilized, both in dry-land farming and with irrigation. The Frio, Blanco, and Leona soils are highly desirable, and in the eastern sections are farmed largely without irrigation, but in the western areas many farms are equipped to supply water for irrigation. The general farm crops are grown on these soils, consisting chiefly of cotton, corn, sorghums, and other feed crops, though some truck crops are also grown in places. Pecan trees do well in many places on these soils in situations where underdrainage is free. In some eastern sections these afford a valuable

income from nuts. The Rio Grande and Laredo soils, limited to the flood plain of the Rio Grande, are valuable soils and are extensively used for producing truck crops under irrigation, though cotton, corn, and various other farm crops are also grown. The Harlingen and Cameron soils are naturally strong and productive soils well suited to farm crops and some truck crops, but for their most successful use better drainage conditions should be provided. Though the alluvial soils are limited in extent they are mostly highly valuable, and in places comprise important farming areas.

The dark-colored soils are for the most part the strongest and most productive upland soils of the region. The deep heavy clay subsoils afford a good reservoir for holding a large amount of moisture to be drawn on by crops during the growing season, while the generally smooth surface enables the retention of a large part of rain water until it has been absorbed by the soil and subsoil. These soils are suited to many crops but the clays and clay loams appear best suited, and are more largely used for cotton, corn, sorghums, and other farm crops. The sandy-soil types, though also used greatly for these crops with excellent results, are especially well suited to truck crops and fruits and these special crops are grown quite largely in some sections where irrigation can be practiced. The Victoria clay occurs in large areas in the eastern section along the coast and is especially valued as a cotton-producing soil. The lighter-textured soils of the Victoria series, and soils of similar texture of Hidalgo and Willacy series, are developed largely in the Lower Rio Grande Valley section and in addition to producing large amounts of farm and truck crops are especially valued for growing citrus fruits. In the northern and eastern parts of the region the dark-colored soils are largely used for the general farm crops with some truck crops also grown under irrigation. A considerable amount of the dark-colored soils remain uncleared and are used only for grazing.

The light-brown soils lie in the semiarid section, where rainfall is insufficient to enable satisfactory dry-land farming. Much of the Maverick and Zapata soils are thin and not highly productive and under the prevailing climatic conditions are best suited for grazing, except in such places where the surface is sufficiently smooth to practice irrigation. The Uvalde soils are quite productive, though the very gravelly soils are not suited to farming. The clay-loam and loam of the series are deep productive soils that produce high yields when moisture conditions are suitable. Some areas of these are highly-prized soils and under irrigation they are largely utilized for general farm and truck crops.

The light-colored soils are of moderate productiveness, but are quite drought-resistant, as the soils are mostly sandy and porous and collect and retain most of the rain water. The Brennan soils, of which the fine sandy loam is quite extensive, is a valuable soil especially suited to truck crops, some fruits, and to cotton, sorghums, and many other crops. The Nueces soils, of which the fine sand is the principal type,

are rather light and loose, but in many places, especially on the shallow phase, the fine sand is quite drought-resistant. They are well suited to vine crops such as watermelons, cantaloupes, grapes, vegetables, berries, and some fruit. Cotton and the general farm crops grow well but yields are generally lower than on the dark soils. The Nueces and Brennan soils respond well to improvement and to irrigation. Large areas of these soils remain uncleared and are used only for pasturage of ranch cattle.

The red soils are highly-valued agricultural soils. The principal soils are the Duval fine sandy loam and Webb fine sandy loam and these cover large areas. The soils are quite drought-resistant, as the smooth surface and porous topsoils enable the collection and absorption of a large proportion of the rain water, and the deep moderately heavy subsoils store and hold a large amount of moisture in reserve for growing crops. These soils are suited to the general farm crops and to truck crops and some fruits. They are productive and respond well to soil improvement and irrigation. Though considerable amounts of these soils are farmed in some sections, in places under irrigation from wells, there remain large areas used only for livestock grazing.

The Lomalta and Point Isabel soils are not generally considered good soils for farming though the soils would probably produce some of the farm and truck crops if adequate drainage was provided and the wet and salty conditions remedied.

EDWARDS PLATEAU

The Edwards Plateau is a greatly dissected high limestone plain in central-western Texas. All or portions of some 43 counties are included within this great area covering approximately 22,500,000 acres of land. The general regional slope is to the east, some of the western portions lying 4,000 feet above sea-level, while most of it is well over 2,000 feet. This plateau comprises the southeasterly limits of the Great Plains. On the northwest it merges with slightly higher areas of the High Plains, and on the northeast reaches down rocky escarpments onto lower lying areas of the Rolling Plains. On the east it merges with little physiographic change with the Lampasas Cut Plain, a division of the Grand Prairie, the Colorado River here arbitrarily marking the eastern boundary. On the southeast and south the plateau terminates in steep rocky slopes of the Balcones Escarpment descending to the lower level of the Black Prairie and Rio Grande Plain. The western part of the plateau extends across the Rio Grande into Mexico. On the west the plateau is bounded by the Mountain-Basin Region, the southern part here abutting western mountain ranges, and the northern reaching down steep escarpments to flat basins and plains. On the north there are a number of small outlying marginal plateau-remnants that have been separated from the main body by erosion. The largest of these occupies a part of Nolan and Taylor

Counties. That portion of the plateau lying west of Pecos River is also known as Stockton Plateau.

The original flat table-land surface of the plateau has been largely removed by erosion. The numerous streams crossing or originating within the region have carved deep steep-walled valleys which, as a rule, have very narrow strips of flat bottom land. Deep dissection along the larger streams and their numerous tributaries has given a relief of hilly broken lands which are almost mountainous in proportion in some sections. Deep rocky steep-walled canyons and gorges occur in places along the Rio Grande, Pecos (Fig. 50), and Devil's rivers, and smaller streams. High rolling divides occur in the central areas. Flat smooth table-land remnants of the original plateau remain

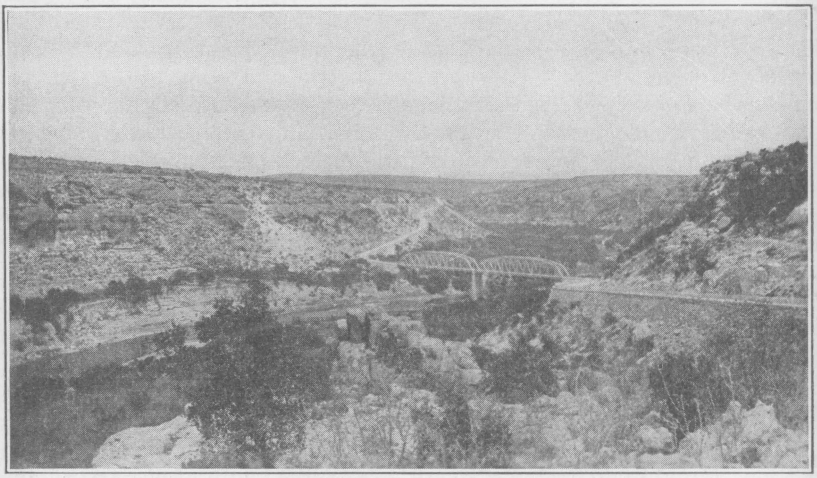

Figure 50. Gorge of Pecos River in Val Verde County.

in places, and in some sections smoothly rolling bodies of land prevail with but slight dissection by small headwater drainage valleys. The principal streams extending through the area are the Rio Grande, the Pecos, and the Colorado, while rivers originating within it are the Nueces, Concho, Pedernales, Frio, Sabinal, Guadalupe, Blanco, Llano, Devil's, and San Saba. As a rule, these streams are fed by springs and have water in them the year round, though many of the local tributaries have running water only for a short time after rains.

The slopes of the region range from gentle to very steep and all allow rapid runoff of rain water. Consequently most areas of the soils are eroded and very shallow and stony, and in many places massive hard limestone lies near the surface or is exposed. Numerous fragments of limestone occur in most of the soils and cover the surface in many places.

The Edwards Plateau, an elevated plain marked by distinctive fea-

tures of stream dissection and relief, is imposed on the limestone strata of the Lower Cretaceous formations. This great stony highland lies within a region of low rainfall, the eastern part exetnding into the edge of the humid region, while 250 to 300 miles west it borders the arid basins and plains. The region is characterized by soils and natural vegetation which have a direct relationship to the climate, especially to the moisture conditions. With the gradual decrease of climatic moisture from east to west, accompanying changes occur in the characteristics of the soils and native plant growth. Although the changes of climate, soils, and vegetation take place gradually across this broad area, there are three well defined belts within each of which the climate, soils, and vegetation are distinctive and differ from those features in the other belts. These belts on the Edwards Plateau comprise cross sections of north-south soil-climate divisions of continental scope. The eastern belt lies within the humid region, the central in the subhumid, and the western in the semi-arid region. These belts merge together gradually with no very sharp line of separation.

A varied vegetative growth occurs throughout the Edwards Plateau. A thick growth of small oak trees, largely live-oak, shin-oak, post-oak, and some other oaks grow in many parts of the eastern section as well as small amounts of mesquite. Going westward, the oaks on the central section are largely small live-oaks and shin-oak trees with generally a larger proportion of mesquite trees than in the eastern section. In the western section, the tree growth is very small and scattering, there being only small amounts of dwarfed oaks and mesquites, except in some of the valleys, where they are larger and more abundant. In the rougher lands of the eastern and central sections, there are in places a thick growth of small juniper, locally known as "cedar breaks." Many kinds of small shrubs and thorny bushes occur over the pleateau, especially in the central section, but these grow more thinly scattered in the western section. These comprise catclaw shrubs, sumac of several species, buckthorn, agrito, and many others. In the Stockton Plateau part of the western section, the more abundant plants are sotol, lechuguilla, yucca, cenizo, catclaw, prickly pear, and cacti. Grasses grow thickly on the deep or moderately deep soils of the eastern and central sections, but as a rule do not constitute much vegetative cover in the western section, except on the deep soils of narrow valleys. In places, in the western section some of the desert shrubs of Covillea and Flourensia species occur in a few small flat areas. The predominating grasses on the deeper soils are buffalo and curly mesquite, with some species of grama and needle grasses. Various weeds and other herbaceous plants abound. In the valleys of the plateau there is a considerable timber growth consisting in the eastern and central sections of oaks, elm, hackberry, ash, and in places along streams some cypress and fine native pecan trees. Going westward, these trees in valleys give way to a growth consisting mainly of mesquite trees, with small oaks and various shrubs. The relations of vegetation to the soils and cli-

matic conditions peculiar to the various belts are quite striking, showing the influence of moisture on the character and amounts of the natural plant growth.

The average annual temperatures for the Edwards Plateau range from about 65° F. in the northern parts to around 68° F. in the southern sections. The rather high elevation and relatively low humidity, with the southerly breezes occurring a considerable portion of the year, provide an invigorating climatic environment. In winter, freezing temperatures occur for short periods, and in summer occasional temperatures of more than 100° F. have been recorded. Average wind velocity is rather high, and this doubtless aids in causing a relatively high rate of evaporation. From the standpoint of precipitation the average is rather low over the main part of the plateau. The eastern section lies within the humid climatic region and here the average rainfall is about 30 inches. There is a considerable variation from year to year in the same localities of this section, and though rainfall is usually adequate for crop production on the deeper smooth soils, there are many seasons in which crops do not have sufficient moisture for their best growth. The central section lies within the subhumid climatic region and the average annual rainfall of the eastern parts of 25 or 30 inches decreases to about 20 inches in the western part. Rainfall in this section is very irregular, but is sufficient some seasons to produce fair yields of crops on the deeper soils. In the western part of the central section, crop production by dry-land farming is extremely precarious. The semiarid section, with an average rainfall of about 20 inches in the eastern part and about 15 inches in the western, is too dry for successful dry-land farming.

Agriculture

The Edwards Plateau is an important livestock-producing area. It is a region largely unsuited to the production of farm crops because of the predominance of thin, shallow, and stony soils, and insufficient rainfall except in the eastern parts. This has long been a stock-raising country and doubtless most of it will always be used for this purpose. The nutritious grasses and browse plants, with a good supply of water from streams and wells, the storm protection afforded by the valleys and brush, and the generally healthful environment makes this a region well suited to livestock. The natural herbage constitutes a valuable range forage. It is of a varied character, comprising plants which adapt themselves to seasonal changes and vagaries of climate, and afford some feed in all seasons of the year.

Cattle, sheep, and goats are raised in all sections and the different kinds of forage allow all three types of livestock to range together on the same land. Cattle, being heavy grass-feeders, are confined largely to the less rough well-grassed areas of the eastern and central sections, while sheep and goats thriving on forage consisting largely of shrubs,

herbaceous plants, and small trees, comprise a larger proportion of the livestock in the western section and on the rougher lands generally. The region produces and ships many animals for beef, mutton, and chevon, while large amounts of wool and mohair are marketed.

Probably not more than 10 per cent of the land is farmed in the eastern section while in more favorably situated counties of the central section probably not over 5 per cent of the land is used for farm crops. In the western part of the central section and in the western section the amount of crop land is very slight.

The chief crops grown when farming is done, are cotton, corn, sorghums, and various other feed crops and in places small amounts of oats and wheat.

Soils

The soils of the Edwards Plateau are developed from limestone or from limestone with interbedded chalky layers. Deeply developed soils are of slight extent, as the rolling and sloping surfaces permit free erosion and the soil material is washed away before being sufficiently acted on by the agencies of soil development to acquire characteristics of maturity. Therefore, the greater part of the surface is occupied by thin shallow soil layers resting on limestone. In most places the soil contains a large amount of broken stony material, and on the steeper slopes the massive limestone beds are exposed. Rough stony land occurring in large areas throughout all sections is the designation applied to the very rough and stony areas where the soil material is so slight that it affords little basis for soil classification.

The normal soils developed in each section differ in their characteristics according to differences in the local soil-developing agencies, which are largely due to climatic differences. However, these differences, though exemplified distinctly in the deep mature soils, are not so apparent to casual observation over most of the region, on account of the very thin imperfectly developed soil layers which almost everywhere are intermixed with fragments of the limestone, the common parent-material. The soil differences are least apparent in the areas of rough stony land.

The soils of the eastern section, developed under humid climatic conditions, are of the San Saba-Denton group; those of the central section of subhumid-climate development are of the Valera group; and in the western section where semiarid climatic conditions prevail the Ector group predominates. The soils of the region are mostly of clay or clay loam textures.

Soils of the alluvial groups are very limited, as the flood plains are of slight extent.

The following table gives the principal soils and their characteristics and the chief crops grown:

Principal soils of Edwards Plateau

Soil groups (Series)	Topsoil	Subsoil	Substratum (or parent material)	Chief crops grown
Uplands.				
Eastern (Humid) Section:				
Undulating to rolling.				
San Saba	Black or very dark-brown, friable.	Dark-gray, yellow, or brown; crumbly.	Limestone.	Cotton, corn sorghum, small grains.
Gently rolling to strongly rolling and hilly.				
Denton	Brown, friable.	Brown or yellowish; calcareous; crumbly.	Limestone.	Same.
Undulating to hilly.				
Crawford	Brown, red, or reddish-brown; friable.	Red or brownish-red; lower part calcareous; crumbly.	Limestone.	Same.
Rolling to hilly.				
Brackett	Brown or light-brown; calcareous; friable; much stony material in many places.	Yellow or whitish; calcareous; thin.	Limestone.	Natural range forage.
Central (Subhumid) Section:				
Undulating to hilly.				
Valera	Brown to black; calcareous; friable; thin; much stony material in places.	Brown or yellow; calcareous; thin.	Limestone or caliche on limestone.	Natural range forage, cotton, sorghums, small grains.
Western (Semiarid) Section:				
Undulating to rolling and hilly.				
Ector	Light-brown; calcareous; thin; mostly very stony.	Light-brown or yellow; calcareous; thin.	Limestone or caliche on limestone.	Natural range forage.
Flat to undulating.				
Reagan	Light-brown; calcareous; friable.	Light-brown or yellowish; calcareous; friable.	Caliche on beds of broken limestone or gravel.	Natural range forage.
All Sections.				
Very rough, hilly and steep.				
Rough stony land	Very little soil material, large stone fragments.	Stone fragments and bed rock.	Limestone bed rock.	Natural range forage.
Flat Stream Bottoms. (Subject to overflow.)				
All Sections:				
Frio	Gray or dark gray; calcareous; friable.	Gray or light gray; calcareous; crumbly.	Clay on beds of gravel.	Natural range forage, cotton, feed crops, pecans.

Eastern Section

The soils of this section are mostly of the Denton, San Saba, Crawford, and Brackett series. These have already been described as located on the Grand Prairie. From the standpoint of soils this section may be considered as a southern extension of the Grand Prairie, but as the greatly dissected surface is occupied by so much Rough stony land and shallow stony soils it comprises, topographically, an uninterrupted eastern extension of Edwards Plateau. The eastern section comprising about 2,000,000 acres of land occupies parts of nine counties and almost surrounds the Central Basin area. The great areas of rough lands and stony soils of this section have been produced by erosion of the Colorado and Guadalupe Rivers and tributaries of those streams. These have cut deep narrow valleys with steep rough slopes, from which beds of limestone are exposed.

Central Section

This section of 12,000,000 acres extends over all or portions of twenty-eight counties. The surface is generally rough, but rather narrow moderately smooth to undulating areas occur on some drainage divides. The soils are mostly of the Valera series and the main areas are shallow and stony. Only very small areas occur where normal soil development has been undisturbed by erosion. Soil development under subhumid climatic conditions is here characterized by a layer of accumulated calcium carbonate (caliche) in the soil profile; by a dark color due to a grass vegetation; and by a granular structure. Because of erosion only thin soil layers are developed in most places and these are generally calcareous. In the few small areas of deep soils the upper layers contain much less calcium carbonate than where the layers are thin and shallow. The principal soils are of the Valera series, though some small areas of Abilene soils occur and large areas of Rough stony land are prominent.

Valera Soils: The Valera series is characterized by brown or dark-brown surface soils, locally nearly black. The subsoils are brown or yellow. The surface soil rests either directly on (1) hard calcium carbonate of a caliche nature which overlies limestone (Fig. 51) or a chalky layer resting on limestone; or on (2) limestone. The Valera soils are mostly shallow and calcareous. The principal type is the stony clay. Some areas of clay and clay-loam also occur on the smoother locations. The surface is moderately rolling to very rolling and some slopes are steep. The steep slopes of the large areas are in many places so eroded and stony that they are included with the type of land called Rough stony land. The native vegetation is largely short grasses, mesquite and buffalo, and various bunch grasses. However, in places, especially on the stony clay, there are many small trees consisting largely of small cedar (juniper), shin-oak, live-oak, and western red oak, redbud, and many shrubs including catclaw, lote bush, agrito, sumac, and others (Fig. 52). A Nolina species locally called sacahuiste is abundant. Very

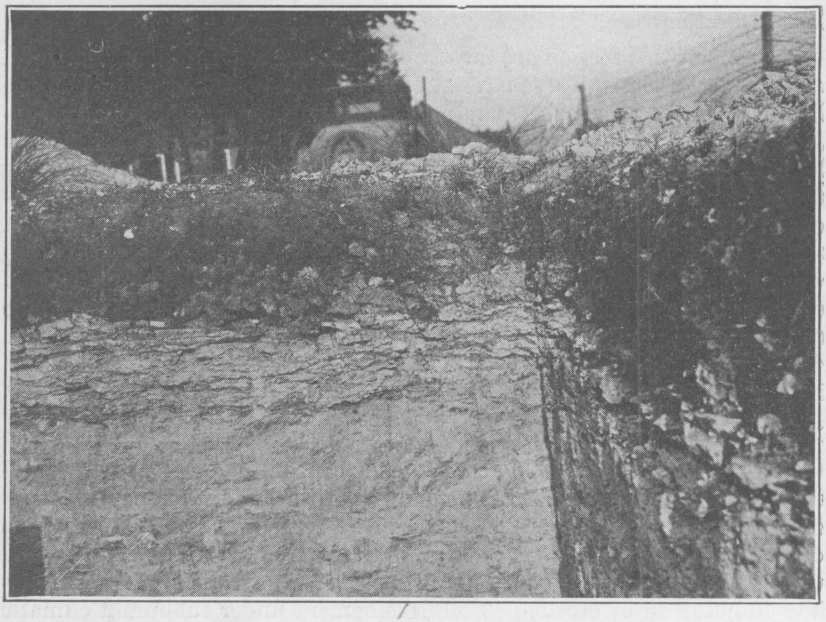

Figure 51. Soil profile of Valera stony clay. This is a shallow stony soil resting on caliche imposed upon limestone.

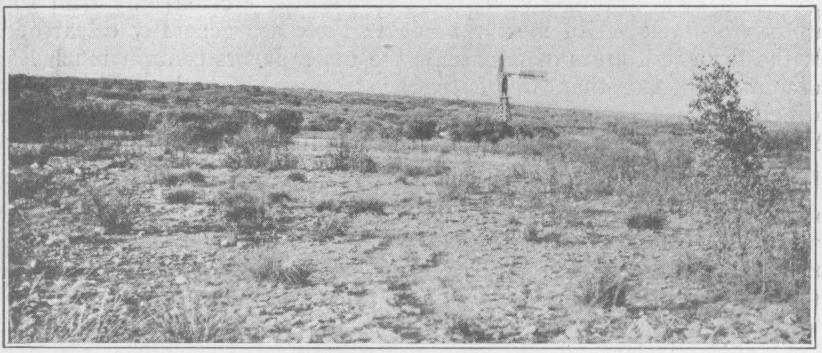

Figure 52. On the smoother divides Valera stony clay supports a varied growth of native vegetation. Near Sonora.

large areas of the stony clay occur. The deeper soils, clay and clay-loam, are fairly productive when moisture conditions are favorable, and they are well suited to the general farm crops. A small amount of the deeper soils are farmed and produce cotton, corn, small grains, sorghums, and some other crops. Most of these soils are in ranches on which cattle, sheep, and goats graze and browse on the native vegetation (Figs. 53 and 54).

Small amounts of Abilene clay and clay loam occur in this section on the smooth, nearly flat places on some divides and in some valleys. A very small amount of alluvial soils occur, these being chiefly of the Frio series.

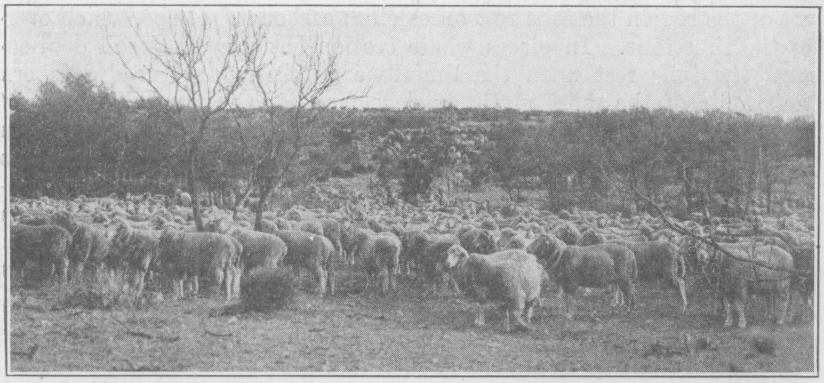

Figure 53. Sheep constitute one of the chief types of livestock ranged on Valera stony clay and other soils of the central and other sections of the Edwards Plateau.

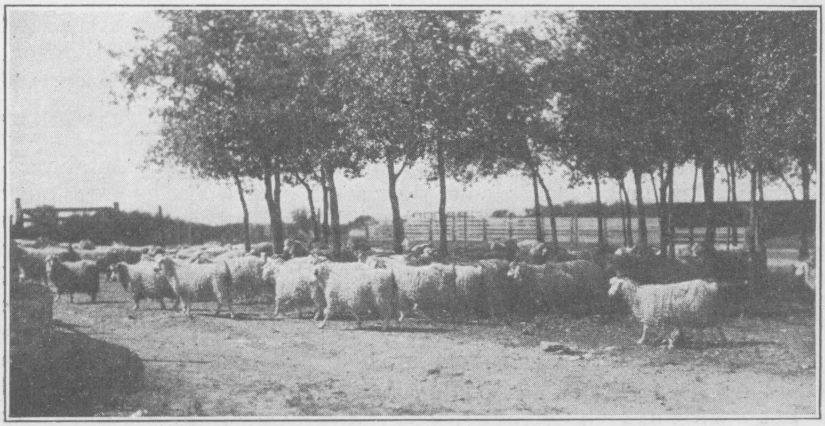

Figure 54. Angora goats raised in large numbers on Edwards Plateau give Texas the lead in the production of mohair.

Western Section

The western section extends into twelve counties, of which some are wholly and others partly included in the total area of about 8,500,000 acres. Though largely rolling and hilly, with much rough and stony land and some mountain-like areas in the extreme western extension, there are some fairly smooth divides in various places and in the northern part, in Reagan and Upton Counties, some large bodies of very smoothly

undulating land. The clay and silty clay loam soil textures predominate, though the greater proportion of the land areas comprise stony soils and Rough stony land. The soils are mainly brown or light-brown and on drying assume a distinct grayish cast. They are underlain by yellow or brown subsoils where these layers have been developed, but in the larger part of the region the soils rest on calcium carbonate caliche, which overlies the limestone. In places where erosion has prevented soil development, the soils rest upon the limestone or chalky interbedded layers. The profile of the more maturely developed soils is much like that of the normal soils of the central section except that they are lighter in color, apparently contain less organic matter, and are calcareous from the surface down through all the layers. The dry climate and soil conditions of this section are clearly indicated by the generally thinner vegetation, both of shrubs and grasses, than occurs in the central section, and in places by some of the arid region shrubs. The soils of this section are chiefly of the Ector and Reagan series.

Ector Soils: The Ector soils are composed of light-brown calcareous surface soils underlain by calcareous yellowish-brown subsoils resting on caliche of calcium carbonate or directly on hard limestone or chalky limestone material. The stony and gravelly soils are the most extensive of the series, there being little difference in these two soils except in the size of the stony fragments. On drying the soils have almost a whitish appearance in places where chalky material or fine limestone particles make up a large proportion of the soil. The clay loam and clay textures predominate. The surface is rolling to rather hilly, but the steeper rougher stony slopes and sharp ridges of the areas have been so eroded as to form Rough stony land. The natural vegetation is thin and consists chiefly of some grama, needle, and other bunch grasses, buckthorn, catclaw, huajillo, and other shrubs. Where moisture conditions are more favorable some buffalo and mesquite grasses grow. In the extreme western portions lying mostly west of the Pecos River, sotol, lechuguilla, yucca, cenizo, and various other herbaceous plants of an arid-land character abound, with but little grass (Fig. 55). The Ector soils are too shallow and thin for use in producing cultivated crops, and also lie within a region where rainfall is not sufficient for crop production. The soils are used entirely for the grazing and browse afforded livestock by the natural vegetation. Owing to the thin growth of grasses, the browse of shrubs, trees, and other plants makes up a large part of the range stock fed and for this reason the section lying west of the Pecos River is used more generally for sheep and goats than for cattle.

Reagan Soils: The Reagan soils have light-brown or fawn-colored surface soils merging below with brown or yellow subsoils which, in turn, grade beneath into (1) almost pure soft calcium carbonate of caliche nature, or into (2) yellow clay or clay-loam containing a large

amount of this caliche material. This layer rests on calcareous clay, limestone, or, in places, on beds of gravel. The soils contain only a small amount of organic matter and are calcareous from the surface down through the subsoils. The soils are very granular and have an open penetrable structure throughout.

The silty clay loam is the most important member of the series. The surface is mostly smooth and flat to undulating. Not a large proportion of the plateau is occupied by the Reagan soils, though some good-sized areas occur in the northern part of the western section and probably some in places on the smoother divides. The largest areas occur in Reagan and Upton Counties in a smooth nearly flat plain slightly lower than the adjacent plateau areas to the south and the High

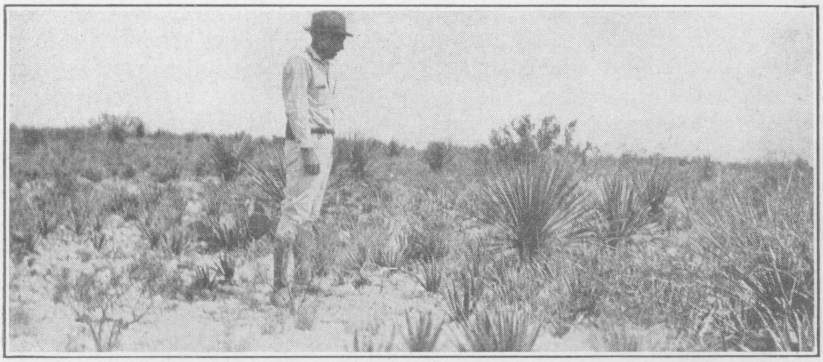

Figure 55. The natural vegetation of the Ector soils on the Edwards Plateau west of the Pecos River includes considerable lechuguilla and sotol, woody plants which can be used as range forage for livestock. Near Sanderson.

Plains bordering areas on the north. There are some areas of sandy and stony soils. The natural growth consists of grasses and shrubs. The grasses, moderately abundant on the deeper soils where moisture conditions are relatively most favorable, consist of buffalo, mesquite, needle, tobosa, and others, while the shrubs are mainly small mesquite trees, buckthorn, yucca, and others. A desert shrub, Flourensia cernua, locally known as black brush, is a characteristic plant in places.

Rough Stony Land: The areas of land of Edward Plateau that are very rough and stony are included under the general term Rough stony land. So little soil material is present that no attempt is made to separate the areas on the basis of soil characteristics.

Rough stony land consists of rolling to hilly land covered with massive fragments of limestone resting on bed rock of the same material. The slopes are mostly very steep and occupied largely by outcrops of massive rock ledges. Included small areas of stony soils of the Denton and Brackett series occur in the eastern sections, Valera in the central, and Ector in the western section. However, in the various sec-

tions there is little difference in the character of the scant soil material lodged between the rocks. In the eastern section, it is largely black. Going westward, it becomes gradually lighter in color and is mostly light grayish-brown in the western section. There is little difference in the Rough stony land throughout all sections, though in the extreme western part the rough hilly areas are in places of mountainous proportions. The large areas as well as the roughest occur at the margins of the region where the larger streams have cut deep valleys and gorges.

The natural vegetation of Rough stony land comprises chiefly a thin growth of trees and shrubs, with only very small amounts of grasses. The growth decreases in abundance and in character from east to west. In the eastern section the grasses comprise some buffalo, curly mesquite, grama, and others, with small trees of shin-oak, live-oak, western red oak, juniper, and mesquite. In the central section the same growth occurs, but the oaks are less abundant in the western part, where various shrubs become more prominent. In the western section very few oak trees occur but there is a considerable amount of woody plants and shrubs such as lechuguilla, sotol, canutilla, lote bush, catclaw, ocatillo, and mesquite.

Alluvial Soils

As the streams of Edwards Plateau are confined to narrow valleys there are no large areas of alluvial soils, though very narrow strips occur in places. Probably the alluvial soils amount to not more than 5 per cent of the total land area. These soils are chiefly brown or grayish-brown soils which belong in the Frio series. Small amounts of Blanco and other soils occur in places. In the eastern and central sections, small areas are farmed and good yields of cotton, corn, sorghums, and various other crops are secured. In these sections some tree growth occurs consisting of some oaks, hackberry, and other trees including many fine pecan trees. In the western section mesquite trees predominate. Buffalo, mesquite, and grama grasses grow abundantly on the alluvial soils.

Soil Utilization

Only a very small proportion of the Edwards Plateau is occupied by soils suitable for the production of farm crops. The chief of these are Denton and San Saba clays in the eastern section, Valera and Abilene clays in the central, Reagan silty clay loam in the western, and Frio soils in all sections. These soils are of slight extent as compared to the total area of the region, and only in the eastern section is rainfall sufficient for growing crops. Soil moisture becomes more deficient to the west, and even on the deeper more drought-resistant soils can dryland farming be carried on in the central section. The soils are generally well suited to cotton, corn, sorghums, and various other feed crops; and these are grown chiefly, though on some of the Denton, San Saba and Valera clays small amounts of oats and wheat are also

grown successfully in places. The Frio and other alluvial soils, though of slight extent, are valuable and productive soils. They produce good pecan trees in the eastern and central sections.

The stony and shallow soils of the Denton, San Saba, Brackett, Valera, and Ector and Rough stony land are not suited to farming, but the natural growth provides excellent range forage for cattle, sheep, and goats. The land is all included in small ranches and livestock is successfully raised on all of these soils. The heavier growth of grasses on Denton, San Saba, Valera, and Frio soils provide excellent range for cattle but the soils of the Ector group with less grass and more of the shrubs and woody plants are utilized more profitably for sheep and goats than for cattle.

Owing to the generally sloping surfaces prevailing throughout Edwards Plateau much of the rain water runs off the land and is carried away by streams. Much of this could be held on the less rough lands by the construction of low banks and dams. This would also allow diversion of the runoff water onto smooth valley land, where it could be held by earthen barriers until absorbed by the soils. By this means a considerable amount of the much needed soil moisture could be augmented and conserved to increase the growth of the natural range forage plants, and on the smoother deep soils would allow the growth of considerable amounts of sorghums, Sudan grass, Johnson grass, and other feed crops.

ROLLING PLAINS

In northwestern Texas reaching from Edwards Plateau northward into western Oklahoma, there is an eastern division of the Great Plains to which the name Rolling Plains is here applied. The region is bounded on the east by the West Cross Timbers and on the west by the High Plains (Llano Estacado). Within this great area is included the Red Beds and associated red lands, which cause large portions of the Rolling Plains to be referred to as "Red Plains," or "Red lands of northwest Texas." The region occupies either parts or entire areas of fifty-eight counties and has a total area of about 24,500,000 acres. The main body of the area in Texas lies south of Red River and is approximately 200 miles long by 125 to 175 miles wide.

The Rolling Plains area has a rolling surface with a general regional slope from west to east. Elevations above sea-level ranging above 2,500 feet in the western part descend to around 1,500 feet in the eastern, with some deep-cut valleys in the east edge of these plains having elevations of less than 1,000 feet. In some parts of Canadian Valley, which is included within this region, there are elevations of more than 3,000 feet above sea-level. The surface of the region is greatly dissected by numerous streams and in many places it is severely eroded. The larger streams comprise rivers rising in areas to the west. The chief of these are the Canadian, Red, Pease, Wichita, Brazos, Colorado, and Concho. These have cut moderately deep valleys in which there are

only very narrow strips of flat alluvial bottom lands. Some streams occupy broad flats of shifting quicksand which slight rises quickly cover with water. Many small tributaries of these streams reach into all parts of the region and provide rapid drainage. Large areas of rough lands occur in many sections, especially near some of the larger streams, while considerable bodies of land on divides are nearly flat. Much of the surface of the divides is gently rolling, and some is steeply sloping. The geological formations underlying the surface are unconsolidated and for the most part free of stony strata, though in places beds of gypsum and limestone occur. The soils and underlying materials are readily cut and washed by runoff water. Erosion is especially severe in the Red Bed sections, where great areas are cut by numerous deep steep-walled valleys from which radiate numerous gullies reaching to the crests of the major divides. The streams of the region are for the most part dry except after rains, though several of the rivers have a small amount of running water all the time. A few springs occur in places. Shallow well water of good quality is secured in most sections in low places and valleys. In places this water contains considerable gypsum and other salts, though this does not prevent its use for livestock.

The natural vegetation of the Rolling Plains consists of a varied growth differing from place to place according to the character of the soils and surface conditions. Over much of the area, especially on the heavier soils, there is a considerable growth of mesquite, buffalo, and grama grasses. On the sandy soils the Andropogons, grama, and needle grasses are abundant. Shin-oaks, and, in places, sand sage (Artemesia) grow on the very loose sandy soils. Small mesquite trees are thinly distributed over the greater part of the area except on the very deep loose sands. Mesquite, elm, hackberry, oak, and other small trees grow in many of the valleys. In the eastern sections there are fine pecan trees along some of the streams. The native vegetation is largely typical of subhumid climatic conditions and no desert plant communities occur.

The climate of the Rolling Plains is much like that of the Central Belt of Edwards Plateau, especially as regards rainfall. The average annual temperature in the northern part is around 58° F. and in the southern, 64° F. The summers are long and temperatures are high during the day. Almost constant breezes temper the summer heat. The winters are moderate, with some freezing temperatures, but most of the time cool dry weather prevails with temperatures much above freezing. Rainfall is irregular and much of it comes in sudden dashing rainstorms in the spring and summer. The average annual rainfall is 25 to 27 inches in various parts of the eastern sections and decreases to the westward, where, in the extreme western parts, it is about 22 inches. During some years, the rainfall is very light and in others much higher than the average. As the rain falls rapidly, much of it runs off the surface, especially on very sloping areas. The region lies entirely

within the subhumid region, though its eastern boundary is considered about the dividing line between the subhumid and humid regions.

Agriculture

The Rolling Plains Region constitutes an important agricultural area. Since earliest settlement it has been used largely for cattle ranching. The abundance of nutritious grasses, healthful climate, readily available water supply, and the protection afforded livestock by the inequalities of surface relief, comprise features which make possible very successful cattle raising. A very large proportion of the region is still used for cattle raising on ranches which occupy the rough and broken lands, and in places considerable portions of the smoother areas.

With increased settlement of the region farming has become an important industry in many sections and now a very large proportion of the smooth lands are used for the production of cotton, corn, sorgo, grain sorghums, small grains, and some less important crops. Vegetables and fruits do well but are grown commercially only in a limited way for local markets.

Owing to the light and irregular rainfall of the region, some seasons occur with insufficient moisture for the best growth of crops. The successful production of farm crops is, therefore, sometimes limited, owing to the deficiency of moisture within the soils, though, during many years rainfall is adequate. This uncertainty of climate is largely counterbalanced by several advantages provided by natural conditions and by the practice of systems of farming which tend to overcome the occasional adverse moisture conditions. The advantages consist of large areas of smooth, deep, and productive soils which retain and absorb a large amount of rain water and hold it in reserve for growing crops, the comparative freedom from insect pests and plant diseases, the use of crops of drought-resistant character, and the smooth surfaces well suited to cultivation with labor-saving farm machinery.

No large areas are farmed by the aid of irrigation except in Wichita County, where a large irrigation project is successfully operated.

Agricultural development on the Rolling Plains is confined largely to the areas of deep productive soils and, therefore, some sections comprising in places several counties are thickly settled and occupied by many moderate-sized to large farms. In other places where much of the land is broken or the soils thin little farming is done, though a great deal of land suitable for farming is as yet also unused for any other purpose than cattle raising.

In some of the counties with large areas of smooth deep soils approximately half or more of the total land area is devoted to crops, while in many others the range in proportion of crop land is 25 to 40 per cent. In some counties where large ranches remain, less than 5 or 10 per cent is used for farm crops.

The principal crops grown are cotton, grain sorghums, wheat, oats,

and corn. Cotton in most counties is the leading crop and occupies about one-third to as much as two-thirds or more of the crop land. In all sections grain sorghums and sorgo are important crops, and in some counties exceed cotton in acreage. In other counties the small grains, wheat, oats, and some barley, are important crops. Corn is not grown so extensively as most of the other crops, as the grain sorghums take the place of corn and withstand more readily irregular and light-moisture conditions. The successful production of grain sorghums and other feed crops makes the region well suited to stock farming.

Soils

The soils of the Rolling Plains differ greatly from place to place in characteristics of color, texture, depth and thickness of soil layers. These differences are due in part to differences in the character of the parent-materials and to sloping surfaces where erosion prevents complete soil development. Large areas occur where the surface has been so greatly eroded that little or no soil remains, while in other places relatively small areas of smooth surface allow undisturbed action of the soil-developing processes. The normal soils of the region have the characteristics of soils developed in a subhumid climate, the most pronounced feature being the layer of accumulated calcium carbonate in the soil profile. This layer (caliche) exposed in cut banks and on eroded slopes hardens on exposure to air. The more mature soils are characterized by noncalcareous surface layers grading below into noncalcareous subsoil layers heavier than the layers above. These become calcareous with increase in depth as they merge with the layer of accumulated limy material at a depth of 3 to 5 feet beneath the surface.

The soils are developed mostly from unconsolidated beds of clay or sandy clay which is more or less calcareous. Thin layers of limestone or sandstone rocks occur in places while in the Red Beds strata of gypsum are abundant. The soils are developed under a vegetative cover of grasses; in some places bunch grasses prevail, while in other places short grasses predominate. The heavy soils are moderately well supplied with organic matter.

The more mature soils are developed on the nearly flat surfaces. They are dark and have thickly developed soil layers. The sloping and eroded surfaces are occupied mainly by red or brown calcareous soils of immature development with the thin soil layers in some places barely covering the caliche or parent-materials.

The upland soils of the Rolling Plains may be divided into three general groups according to differences in their characteristics. These are (1) dark-colored soils (Abilene-Roscoe-Foard group); (2) red soils (Vernon group); and (3) brownish-red soils (Miles group). On the soil map the larger areas of the groups are shown in a very general way, but many small areas could not be shown separately on a map of this scale. On the map the chief areas of Vernon soils and Rough

broken land are shown in one division on account of the close association of large areas of each, and the Miles group as shown includes many small areas of Vernon and other soils.

The alluvial soils comprise soil materials transported mainly from the upland soils of the Rolling Plains and High Plains. These are not extensive but comprise important local areas. They are red or brown in color and calcareous. These soils are chiefly of the Miller, Yahola, Frio, and Spur series.

The table on page 130 gives the principal soils of the region with their main characteristics and chief crops grown.

Dark-Colored Soils

The dark-colored soils occur most extensively on the smooth nearly flat areas of the southeastern part of the Rolling Plains area, though many small spots are located in all parts of the region. Even where they predominate there are in places associated areas of red or reddish-brown soils on the more sloping areas. Probably 25 per cent of the region (about 6,000,000 acres) is occupied by areas of dark-colored soils. The dark-colored soils are developed on smooth nearly flat areas from calcareous clays which rest on unconsolidated clay beds, and in places on deep beds of gravel. The soils have been relatively less disturbed by erosion than the other soils and have thickly developed layers which in most cases merge together without a sharp change. The principal soils are of the Abilene, Roscoe, and Foard series, and in the southeastern sections there are also some areas of Valera soils developed over limestone.

Abilene Soils: The topsoils of the Abilene soils are brown or dark chocolate-brown in color grading below into brown or chocolate-brown subsoils which in places have red or yellow shades in the deeper layers. As a rule, the soils and upper subsoils are not calcareous except in locations where the soil layers are not thickly developed, such as on slopes where erosion is active. The subsoils merge below with the calcium carbonate layer at a depth of 3 to 5 feet. This consists of a pink or yellow calcareous clay containing a large amount of soft chalky calcium carbonate. In places the material is almost pure soft calcium carbonate. The soils are granular and the subsoils, though quite heavy, are of fairly open and permeable character. The soils contain a moderately large amount of organic matter. Although the clay loam is the most extensive soil of the series there are some other textural classes represented, the lighter-textured soils being of lighter color. For the most part, the soils are deep. The surface is undulating to nearly flat (Fig. 56), though on some slopes the soils have been thinned by erosion. The natural vegetation is mainly short grasses,—buffalo grass (locally called mesquite grass), with some other grasses, such as grama, needle, and on the sandy soils some coarse bunch grasses. A scattering growth of small mesquite trees occurs with some lote bush and a few other shrubs. The Abilene soils are largely developed from ma-

Principal soils of Rolling Plains

Soil groups (Series)	Topsoil	Subsoil	Substratum (or parent material)	Chief crops grown
Uplands.				
Dark-Colored Soils:				
Flat to undulating.				
Abilene	Brown or dark-brown; not calcareous; friable.	Brown or yellowish; calcareous in lower part; crumbly.	Calcareous clay.	Cotton, sorghums, and various feed crops, small grains.
Roscoe	Very dark-brown or black; not calcareous; friable.	Dark-brown to dark gray; heavy but crumbly; not calcareous.	Calcareous clay.	Cotton, sorghum, other feed crops, small grains.
Foard	Brown to very dark-brown; tight when dry; not calcareous.	Brown or dark-gray; not calcareous; dense and tough.	Calcareous clay.	Cotton, sorghums, other feed crops, small grains.
Red Soils:				
Undulating to rolling.				
Vernon	Red or reddish-brown; calcareous; friable.	Red; calcareous; crumbly.	Sandy or clay beds (Red Beds).	Cotton, sorghums, other feed crops, small grains.
Fowlkes	Red or reddish-brown; calcareous; tight when dry.	Red; calcareous; tight and dense.	Clay beds (Red Beds).	Same.
Brownish-Red Soils:				
Undulating to rolling.				
Miles	Reddish-brown or brownish-red; not calcareous; friable.	Red or brownish-red; not calcareous; crumbly.	Clay or sandy clay.	Cotton, sorghums, other feed crops, small grains.
Enterprise	Brown or dull-reddish; not calcareous; friable.	Brown, red or yellowish; not calcareous; crumbly.	Sandy and clay beds.	Same.
Flat to undulating old stream benches (above overflow)				
Wichita	Red or brown; not calcareous; friable.	Red; not calcareous; crumbly.	Beds of sand and gravelly material.	Cotton, sorghums, truck crops.
Flat Stream Bottoms.				
(Subject to overflow.)				
Miller	Red; calcareous; friable.	Red; calcareous, crumbly.	Sandy and clay beds.	Cotton, corn, sorghums, feed crops, alfalfa, truck crops, pecans.
Yahola	Red; calcareous; friable.	Red; calcareous; subsoils lighter in texture than surface soils.	Sandy beds with clay layers.	Same.
Spur	Brown or chocolate-brown; calcareous; friable.	Chocolate-brown; calcareous; crumbly.	Sandy or clay beds.	Same.

terials forming an outwash plain, but in places seem to be also from older formations. The soils are the most extensive of the dark-colored soils, and occupy large bodies of land in several counties. The soils and subsoils readily absorb water and the deep heavy clay subsoils and substrata act as a reservoir to hold a large amount of water for growing crops. These soils are among the most highly esteemed soils of the region for farming and are extensively utilized for the general farm crops. These consist of cotton, corn, sorghums, small grains, and other crops, to all of which the soils are well suited.

Roscoe Soils: The Roscoe soils have black or very dark-brown surface soils with dark-gray or brown subsoils. The soils and upper subsoils are not calcareous. The subsoils merge below with whitish calcium carbonate or highly calcareous chalky clay constituting the accumulated layer, and this merges below with the parent material of less calcareous clay. The chief soils of the series are of clay and clay loam textures. The soils are moderately granular, but the subsoils are rather heavy and

Figure 56. Smoothly undulating Abilene soils in southern Dickens County.

slowly penetrated by water. The soils occupy very flat and some slightly depressed areas having very slow natural drainage. The natural vegetation is chiefly short grasses with scattered mesquite trees. The soils are limited in extent and are usually associated with the Abilene soils. They are well suited to cotton, corn, grain sorghums, and other general farm crops and as the soils are nearly flat they collect and retain a very large proportion of the rain water and are fairly drought-resistant, provided, a supply of moisture is beneath the soil before dry seasons begin. The soils are also well suited to small grains.

Foard Soils: The Foard soils have light-brown to dark-brown surface soils resting on brown, tough, heavy clay subsoils. The surface soils and upper subsoils are not calcareous, but the lower subsoils contain considerable calcium carbonate and are more crumbly and friable than the layers above. The subsoils merge below at a depth of 3 to 5 feet with very calcareous clay, which is the layer of accumulation. Below

this is the soil parent-material, which consist of clay or sandy clay with in places some thin interbedded sandstone strata. The Foard soils are not extensive. They are developed mainly from Red Beds materials and represent the most mature soil development on these formations. A characteristic feature is the presence in many places of small bare spots with a light-colored smooth surface practically devoid of vegetation. These are locally called "alkali spots" and the soil material contains a considerable percentage of sodium chloride and less amounts of other salts. The tendency of the soils to dry out to a very hard mass, and the extremely tough dense subsoils slowly penetrable by water constitute distinctive characteristics. The Foard soils do not contain a large amount of organic matter. The surface is generally quite flat, and though there is a relatively light runoff of rain water, soils are often too tight to allow easy penetration. Therefore, the soils are not highly drought-resistant. A considerable amount of the land is in cultivation and fairly good yields are secured when moisture conditions are favorable. The principal crops grown are cotton, sorghums, and small grains to all of which the soils seem well suited. The principal types are a very fine sandy loam (Fig. 57), clay cloam, and clay. Where

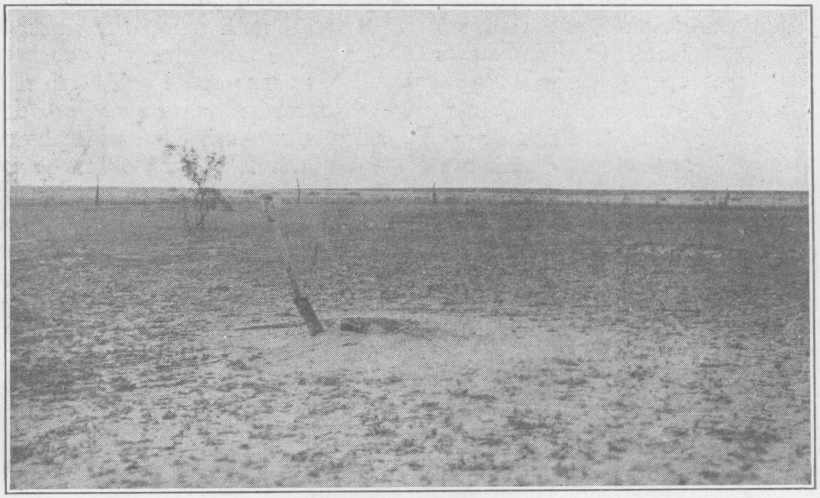

Figure 57. Foard very fine sandy loam has a very flat surface. Wichita County.

uncultivated, they support a heavy growth of short grasses, which provide valuable forage for the grazing of range cattle. Small mesquite trees also grow rather abundantly.

Associated with the Foard soils, which occur mainly in the northeastern part of the region, are very similar soils developed on flat high terrace benches from old alluvium which is no longer overflowed. These are the Calumet soils, of which the topsoils are brown in color, and rest

on chocolate-brown or yellow stiff dense clay subsoils. The soils and subsoils are not calcareous, but merge below with calcareous clay layers, which constitute the accumulated calcium carbonate. These soils are underlain by a relatively high water table, from which good water is secured in wells 20 or 30 feet deep. These soils, therefore, differ in this respect from the Foard soils, beneath which the water table is much deeper. The Calumet soils have the same hard tight structure as the Foard and are suited to about the same crops.

Red Soils

The Red soils are developed from deep beds of calcareous clays on heavy sandy materials, of the Red Beds formation (Fig. 58). This material is subject to rapid erosion and the surface is generally cut into

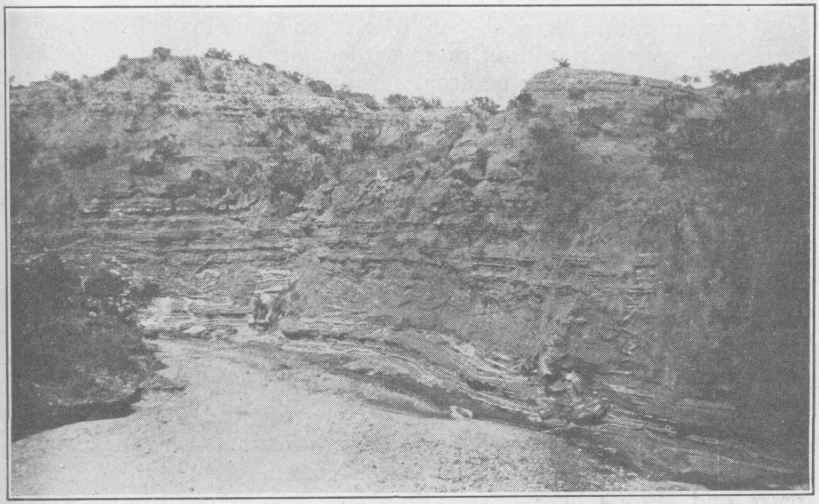

Figure 58. The Red Beds of the Rolling Plains are deeply cut and eroded by water, which carries much of the material downstream, to be deposited in valleys to form the red alluvial soils. The beds contain numerous layers of gypsum.

deeply by streams and is mostly quite rolling with some very rough eroded areas. Even on the smoother surfaces erosion is sufficiently active to remove the soil material before mature development occurs. Therefore, the soils have not the well defined accumulated layer of calcium carbonate, and the soil layers are calcareous throughout. These soils are chiefly of the Vernon series though some Fowlkes soils also occur. These soils occupy large areas, and in places many are associated with large bodies of Rough broken land. They also occur in many small areas throughout other parts of the region.

Vernon Soils: The Vernon soils have red, reddish-brown or brownish-red calcareous surface soils that grade below into chocolate-red or pur-

plish-red calcareous subsoils. The soils and subsoils are mostly of open granular structure and of ready penetrability. Owing to the imperfect development of the Vernon soils due to excessive erosion, the soil layers are thin in many places and the parent formations of calcareous clay or sandy clay lie near the surface and in places are exposed. No well defined segregation of calcium carbonate occurs within any layer of the soil profile. The beds of parent materials, Red Beds, have in places some strata of gypsum, limestone, and sandstone, and on some greatly eroded surfaces these materials are exposed. In the rough lands such areas are known as "gyp hills." The surface of these soils ranges from smoothly undulating to very rolling, with fairly steep slopes. The soils and parent-materials are very susceptible to erosion and in many places, even under natural conditions where a heavy grass cover occurs, the surface is so cut and denuded of soil or dissected by so many gullies that the land has little or no value for cultivated crops. In some large gently rolling areas with moderate slopes, the grassland is occupied by a network of deep, steep-walled gullies reaching up the slopes to the drainage divides, with numerous smaller lateral gullies branching in all directions. The soils range in texture from fine sandy loam to clay. Probably the very fine sandy loam is the most extensive. The natural vegetation is mainly grasses. These grow thickly on the deeper soils, accompanied by a scattering of mesquite trees and various shrubs. The short grasses with some grama and others are abundant on the heavy soils, but coarse bunch grasses, grama grasses, and others, predominate on the sandy soils. The Vernon soils are quite extensive, and occupy exclusively some large areas. The more deeply developed soils are quite productive and are suited to many kinds of crops, but in many places the thin eroded soils are not highly productive and many slopes are so steep that a great deal of the rain water runs off and is lost for use of vegetative growth. The smoother soils are used to a considerable extent for cotton, corn, grain sorghums, sorgo, and on the heavier soils for some small grains. The natural vegetation of these soils provides good range forage for livestock and large bodies of the virgin soils occur on many of the cattle ranches of the region.

Fowlkes Soils: The Fowlkes soils are very similar to the Vernon soils, with which they are closely associated. However, the Fowlkes soils have heavy tough subsoils in contrast to the more open penetrable structure of the Vernon soils. The Fowlkes soils have red or reddish-brown calcareous surface soils underlain by heavy tough clay subsoils. Soil development is imperfect owing to erosion, and the soil layers are thin, while the parent clay lies near the surface in many places. No distinct layer of calcium carbonate accumulation has been developed in the soil profile. The surface is rolling and erosion is very active. The native vegetation is about the same as on the Vernon soils. The Fowlkes soils occupy only a small proportion of the region.

Brownish-Red Soils

The soils of this group are brown to brownish-red with red or dull-red subsoils. In places the red color of the surface soils is almost as prominent as that of some soils of the Red soil group. However, there are greater differences in some of the other soil characteristics of the two groups. The normal soils of this group have a well developed layer of accumulated calcium carbonate in the soil profile. The normal surface soil and upper subsoil layers are not calcareous. The surface is generally smoothly rolling, though some slopes are quite steep. The natural vegetation is quite similar to that of the Red soils, chiefly short grasses on the soils of heavy texture, and bunch grasses on the sandy soils. The principal soils of the group are of the Miles, Wichita, and Enterprise series.

Miles Soils: The topsoils of the Miles soils are reddish-brown, brownish-red or brown, and grade below into red or reddish-brown subsoils. The subsoils merge below with a calcareous layer (Fig. 59) at a depth of 3 to 6 feet. This layer of accumulated calcium carbonate consists either of red or yellow calcareous clay containing a large amount of the soft chalky material or the calcium carbonate is almost pure and free of fine earth. Where normally developed the topsoil and upper subsoil layers are not calcareous, but in eroded places where the soil layers are thin and imperfectly developed they are highly calcareous and the limy layer lies near the surface. The Miles topsoils are granular in natural breakage of the fine earth materials while the subsoils are of open structure and are readily penetrated by air and water. These soils are developed on smooth to fairly rolling surfaces with some rather steep slopes. The soils are naturally rapidly drained both from the surface and underneath. Much of the surface is sufficiently sloping to allow rapid runoff of rain water, which is lost to crops, while erosion injures the soils by removing valuable soil materials and plant food constituents. Where smooth or of sandy texture, the soils absorb much of the rain water which is retained in the subsoils. In very dry seasons crops suffer least on the sandy soils which are underlaid by clay subsoils. The fine sandy loams and other sandy soils are the most extensive of the series. The natural vegetation on the sandy soils is mainly bunch grasses with some shin-oaks growing thickly in places. On the heavy soils, the short grasses, grama grasses, and others grow. A scattered growth of small mesquite trees and various shrubs occurs on the heavier soils. The Miles soils occupy many large areas, but in places are intimately associated with small areas of the Vernon soils. They mostly cover the smoother divides, and the associated Vernon soils the more sloping and rolling areas. The fine sandy loams are considered quite desirable for all of the general crops on account of their drought-resistant qualities. They are suited to cotton, grain sorghums, fruits, and vegetables. The heavier soils, where sloping, do not collect much rain water and, therefore, do not strongly resist droughty conditions. The deeper heavy soils are quite productive, being suited

Figure 59. Soil profile of Miles find sandy loam (near Snyder) in the Rolling Plains Region. Note the layer of calcium carbonate which lies four feet beneath the surface.

to cotton, grain sorghums, and small grains. The soils are farmed quite extensively. Considerable areas of the virgin soils comprise valuable ranch lands.

Wichita Soils: The Wichita soils have reddish-brown or brownish-red surface soils with subsoils which become lighter in color with increase in depth. The subsoils in many places rest on beds of rounded gravel. The soils and subsoils are not calcareous, but a calcareous clay layer is present in many places just beneath the subsoils. In numerous places the gravel is cemented to a hard concrete form by calcium carbonate. These soils have an open friable structure. The Wichita soils are developed on smooth high terrace benches that are undulating to gently rolling. They are somewhat similar to the Miles soils, but are underlain by more open substrata and have less development of a calcium carbonate layer. They are developed from old alluvial materials which are no longer overflowed. These soils, of which the fine sandy loam seems the most extensive, are occupied by a heavy growth of coarse bunch grasses and a scattering of small mesquite trees. They are suited to many crops, especially to cotton, vegetables, melons, and fruits, and are farmed extensively in places. Some truck and fruit crops are raised successfully. The Wichita soils are of slight extent.

Enterprise Soils: The Enterprise soils have chocolate-brown or reddish-brown topsoils with red or reddish-brown subsoils many feet deep. The soils grade below into the subsoils with little change in color or texture, though the subsoils are less dark as a rule. The soils and subsoils in some areas are calcareous. They have been developed from deep beds of wind-blown soil materials. Some important bodies of the land border the Red River Valley from which the soil materials have been blown. The surface is undulating to gently rolling and the soils, largely of sandy texture, are sufficiently open to absorb much of the rain water as it falls, and hold it stored in the deep subsoils. Therefore, erosion is not excessive. Where the surface material is sandy, coarse grasses prevail. These soils are well suited to the general farm crops, vegetables, fruits, and berries. Owing to their resistance to drought they are largely in cultivation. The very loose deep sands are too light for crops. A large amount of the soils are used for cotton, grain sorghums, and other crops. In places large areas of the very sandy soils lie on low undulating ridges and seepage of water from these soils through underground layers causes a high water table to form under the lower-lying adjacent soils. This supply of water causes subirrigation, and crops do not suffer for moisture in the very dry seasons. However, in places this has caused the water table to rise so near the surface that salt accumulation in the soil has become so excessive in spots that crops will not grow. It seems that on some farms drainage will be required to remedy this condition before these spots of valuable soils can again be highly productive.

Alluvial Soils

The Alluvial soils of the region probably do not occupy more than 8 per cent of the total land area. Few large streams cross the region and these as well as the smaller local streams have only very narrow strips of bottom land. The widest areas of alluvial soils are along the Red, Wichita, Colorado, Concho, and Pease Rivers, and North, Salt, and Clear Forks of the Brazos. Most of these areas are less than one mile wide. The principal alluvial soils are of the Miller, Yahola, Frio, and Spur series. These have timber in places consisting mainly of elm, hackberry, ash, haw, and in the eastern sections some pecan trees. Mesquite trees are also common. These soils are calcareous, deep, and contain considerable organic matter. Overflows occur periodically.

Miller Soils: The Miller soils have chocolate-red calcareous surface soil merging below with chocolate-red calcareous subsoils. The surface soils are a little darker in color and lighter in texture than the subsoils, but otherwise there is little difference. The soils are granular and work readily into a friable condition, while the subsoils, though fairly heavy, are permeable and of moderately open structure. In some locations where the soils lie so high that overflows are very infrequent, the surface soils are less calcareous, and are inclined to crust over on drying, while here the rather heavy subsoils are not readily penetrated by water. The Miller soils are made up of soil materials washed from the Red Beds and red soils of the region. They range from sandy to clay in texture. They occupy low flat valley positions in the flood plains and are overflowed occasionally. As a rule, they have sufficient natural drainage to permit the growth of crops. They are for the most part highly productive, have good moisture-holding qualities, and are suited to all the general farm crops, and to alfalfa, pecans, and vegetables. They are very largely utilized for cotton, corn, grain sorghums, and various other crops. The Miller soils occur along the Red, Brazos, and Colorado rivers in all the different soil regions through which these streams pass, as the soil materials are deposited down stream all the way from the Red Beds to the Gulf.

Yahola Soils: The Yahola soils have chocolate-red, red, or brownish-red calcareous surface soils underlain by calcarous red subsoils. The Yahola subsoils, characteristically lighter in texture than the topsoils, consist of fine sandy materials, either in solid beds or in thin layers interbedded with heavier material. The subsoils are markedly lighter in texture than the subsoils of the corresponding types of the Miller series. The Yahola soils are associated with the Miller soils in the stream bottoms and are made up of soil materials from the same source as the Miller, but are laid down more irregularly from overflow waters (Fig. 60). Where found together, the Yahola soils lie nearest the stream as a rule, and the Miller farther back. The Yahola soils include several textural classes ranging from fine sands to clay. They

have rapid natural drainge and except for the very light soils are utilized to a considerable extent for crop production. They are suited to the same crops as the Miller soils, but are less productive as a rule, and their loose porous subsoils do not have the favorable moisture-holding quality of the Miller soils.

Spur Soils: The Spur soils are light-brown to dark chocolate-brown in color, the subsoils being much the same as the surface soils except that they are slightly lighter in color. They are calcareous and composed of materials washed largely from the brown upland soils of the plains together with some of the calcareous materials beneath those soils. Several types, ranging in texture from sandy to clay loam, oc-

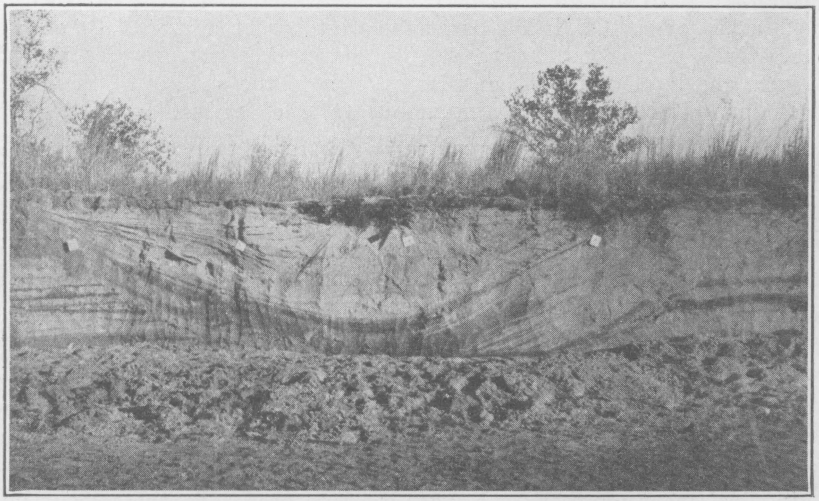

Figure 60. Yahola fine sand in Red River Valley. Note the irregular layers that characterize this soil composed of soil materials deposited by water.

cur in this series. The soils occupy bottom land and are overflowed occasionally. They are deep, well drained soils, friable, and permeable, and are quite productive, though the very light sandy types are not highly so. These soils hold large amounts of water and have very favorable moisture conditions for crop growth. They are suited to many crops and a large part is farmed. The principal crops are cotton, corn, sorghums, alfalfa, and various other crops.

Frio Soils: The Frio soils occur in the southeastern part of the Rolling Plains area, chiefly along Concho River. They are composed of soil materials washed from the limestone soils of Edwards Plateau. These soils have been described as occurring in Rio Grande Plain and Edwards Plateau. They are brown calcareous soils, highly productive and suited to many kinds of crops. These soils are farmed and irri-

gated considerably along the Concho River and some other streams. Practically all the general farm crops and truck crops do well and the soils are especially suited to alfalfa and pecans.

Rough Broken Land: Throughout some sections of the Rolling Plains there are considerable areas of eroded, broken, and hilly land from which the surface soil material has been mostly or entirely washed away leaving only exposed clay or sandy clay or gravel and sand debris. Only a small proportion of this is stony but the surface relief is quite similar to that of Rough stony land. The surface of Rough broken land is cut by numerous deep and shallow valleys and gullies and the slopes are mostly steep and bare of soil and vegetation. One long irregular strip of this land constitutes the eastern escarpment or "breaks" of the High Plains at the west border of the Rolling Plains Region. This comprises a steeply descending narrow area reaching from the level of the High Plains down to the surface of the Rolling Plains. It is cut into by numerous valleys and gullies which extend back into the High Plains in canyons and steep-walled valleys, the largest presenting a rugged and picturesque type of landscape. Within the main body of the Rolling Plains are also some considerable areas of Rough broken land, these as a rule occurring as strips several miles wide adjacent to the larger valleys. Some areas of the Red Beds have been cut into so deeply by such a complete invasion of valleys and gullies that a "bad land" type is well exemplified. The largest of these areas lies in the central part of the region. Rough broken land supports a varied growth of grasses which in many very narrow strips of valley bottoms and on ridge crests is quite abundant. Various short grasses and grama grass species abound. The land is not suited to farming, but is a highly prized grazing land included within many cattle ranches. Its rough character affords shelter for livestock during inclement weather, and the nutritious grasses in the many narrow valleys afford valuable range forage.

Soil Utilization

The development of a successful agricultural industry on the Rolling Plains has been made possible by the large areas of productive soils having characteristics which enable many crops to be grown profitably under conditions of limited rainfall. There are many kinds of soils ranging through nearly all textural classes, and they differ in inherent productiveness. They also differ considerably in moisture-holding and drought-resistant qualities. The crops grown and methods employed are based largely on two general classes of soils, the sandy soils, of which the Miles fine sandy loam is the chief representative, and the heavy soils, represented by the Abilene clay loam. Other extensive soils of the Miles fine sandy loam division largely used for farming are the fine sandy loams of the Vernon, Foard, Enterprise, and Wichita series with some similar soils not as yet mapped. Of the heavy soils

of the Abilene clay loam division the Roscoe clay, Foard clay loam, and Miles clay loam cover large areas and are extensively farmed. The fine sandy loams throughout the region are used for cotton (Fig. 61), sorghums, and other feed crops, and the heavy soils, though also used for these crops, are in some sections employed largely for small grains, mostly oats (Fig. 62), wheat, and barley. The heavy soils where the layers are deeply developed and the surface smooth are more productive as a rule than the sandy soils. Where the surface is very nearly

Figure 61. Cotton is an important crop on many soils on the Rolling Plains.

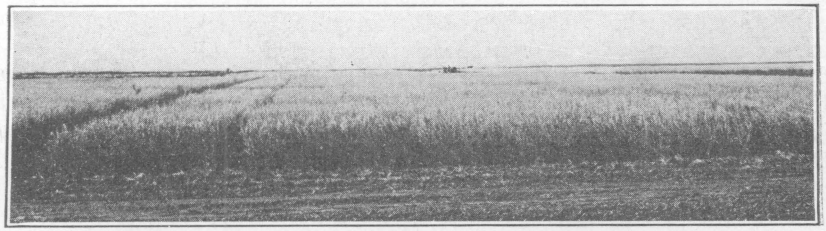

Figure 62. The Abilene soils of the Rolling Plains are well suited to oats, and in places considerable of this crop is grown on the smooth areas of these and other soils of heavy texture.

flat making possible the retention of a large amount of the rain water the heavy soils are quite drought-resistant, though if no large reserve of moisture has been stored in the subsoils prior to a long rainless period, crops suffer, and on the more sloping shallow soils crop production may fail. The fine sandy loams are sufficiently porous and open to absorb a large proportion of the rain water, even on sloping surfaces, and the deep heavy subsoils nearly always carry a considerable reserve of soil moisture. Therefore, the fine sandy loams are remarkably drought-resistant. The deep fine sands of which some areas

of the Enterprise and Miles series occur, are used mostly for livestock grazing.

The alluvial soils are quite productive and mostly have excellent moisture-holding qualities, though some very light sandy soils, chiefly of the Yahola series, are not very good, either in productive capacity or in drought-resistance. The alluvial soils are generally better suited to corn than are the upland soils. They are used chiefly for cotton, corn, sorghums, and various feed crops with some alfalfa in places. They are well suited to pecans and some commercial production of nuts is made from native trees.

The Rough broken land is used only for the grazing of livestock on the native grasses.

Though some of the soils of the region retain a considerable proportion of rain water, it has been demonstrated by experiments at the Texas Agricultural Experiment Station at Spur that even on very gently sloping soils a very large proportion of the water that falls is lost by runoff. This loss is facilitated by the rapid dashing type of rainfall, which is not readily absorbed by the soils, especially when they have become hard and packed in long periods of dry weather. Experiments have shown that much of this water can be held by earthen barriers or terraces until absorbed by the soil and subsoil, and that crop yields are thereby materially increased. It was also discovered that much of the valuable topsoil is being lost by erosion on the Rolling Plains and that terracing is also valuable in minimizing this loss. Considerable areas of farmland are now being terraced.

Terracing has been found valuable even on the soils with nearly flat surfaces where the effects of sheet erosion are especially insidious because the characteristic granular structure of the soils permits gently flowing water to remove much soil material without the formation of the defacing scars wrought by the gullying type of erosion, and the injury may not be noticed until the diminishing crop yields indicate that much valuable topsoil has been lost.

HIGH PLAINS

The High Plains, also known as the Staked Plains or Llano Estacado, occupy a vast outstanding plateau area of northwest Texas reaching north into Oklahoma and on the west into New Mexico. On the east this plateau-plain is sharply outlined in most places by steeply descending rough escarpment slopes (Fig. 63), reaching down to bordering areas of the Rolling Plains, which lie several hundred feet lower. In the northern part, however, some smoothly sloping areas mark a gradual descent to the lower-lying Rolling Plains areas. On the south the High Plains merge with slightly lower flats of the Edwards Plateau through gently descending slopes and undulating areas which in but a few places assume a well defined escarpment form. The High

Plains include all or parts of forty-six counties and comprise a total area of about 21,000,000 acres.

Although the smooth surface of the High Plains appears almost perfectly flat it has a very uniform general slope from northwest to southeast, which averages 10 to 15 feet to the mile. Elevations above sea-level range from about 3,000 feet in the southeastern part to around 4,500 feet in the extreme northwestern part. The very nearly flat surface is pitted by many small playa lake basins about 10 to 20 feet deep which occupy areas of 5 to 40 acres. They are dry except during and after rainy seasons. Stream dissection is mostly very slight except at the eastern border, where eastward-flowing head-water drainage of several rivers and their tributaries have carved deep valleys and canyons. Short distances back from the eastern margin the stream-ways occupy shallow smooth-sloped drainage trenches which in a few cases extend across the region to the New Mexico line. An exception to this is the deeply cut valley of the Canadian River, which, with its bordering rolling areas and rough lands, reaches across the entire Panhandle sec-

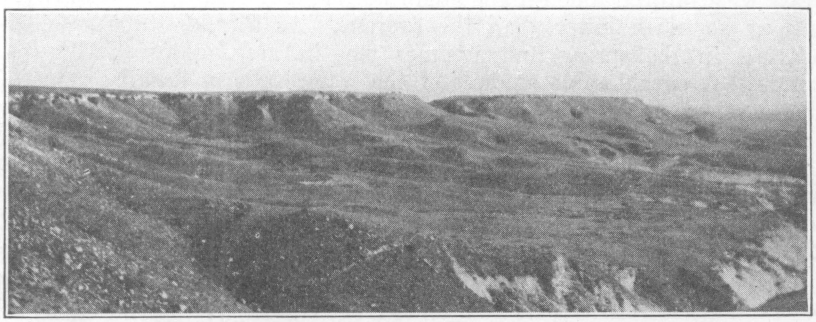

Figure 63. Rough broken land escarpment leading down from the flat areas of the High Plains to the lower-lying Rolling Plains.

tion and divides the flat surface of the High Plains into two parts. Extreme headwaters of the Red, Pease, Brazos, and Colorado rivers reach across or nearly across the High Plains in the shallow winding swales which originate near the Texas-New Mexico line, but these leave the region through narrow gorges in the eastern part. These streamways crossing the High Plains have but few local tributaries and contain water only after rains. They drain only an extremely small proportion of the High Plains, as most of the rain water sinks into the smooth deep soils. The small amount of runoff water goes mostly into the playa lake basins. The High Plains lie in two main bodies separated by the Canadian Valley. These are similar in physiographic character, and in features of soils and natural vegetation. In the southwestern part, some areas are undulating, due largely to shifting of the loose sandy soils by the wind. A plentiful supply of good water is secured from wells in most parts of the region.

The surface of the High Plains is occupied by two types of vegetative growth. The northern portions occupied by heavy soils is a typical short-grass country covered with a very thick growth of buffalo grass including some grama grass. The southern part, mainly of sandy loam soils, has a plant community composed largely of grama and needle grasses with a scattered growth of catclaw shrubs, while some areas of light sands sustain a bunch-grass association comprising Andropogons (blue stem or sedge grass) and other coarse grasses with some needle grass and others. Associated with the bunch grasses in places, there is a thick growth of very small shin-oaks and some patches of sand sage (Artemesia Sp.).

The climate of the High Plains is of subhumid type. The average annual rainfall, but little more than 20 inches a year in the eastern part, decreases gradually westward to about 16 or 17 inches along the State line, with only about 15 inches in the southwestern part. Practically all of the precipitation is rainfall, as there is but little snow. The rainfall is often irregular, there being periods of one or several years with rainfall much higher than normal while during other periods it may be much lower than the average. As a rule, the rainfall is heaviest in the spring and summer months and lightest during the winter. A considerable amount of the water falls as dashing rains of thunderstorms. The average annual temperature is 62° F. in the southern part and 56° F. in the northern. The winters are longer than in most regions of the state and cold periods with temperatures below freezing may continue for several days. Summer temperatures sometimes reach to 100° F., though the heat is tempered by the dry atmosphere and cool breezes. The northern sections with highest altitude have longer and colder winters than the lower lying southern sections. In the northern part the growing season is often too short to permit maturing of cotton. High winds prevail during the spring months, though destructive storms rarely occur. Local hailstorms sometimes occur during the summer months. Owing to the high elevations of the region, together with rather warm summers, low humidity, and abundance of bright sunshine, water evaporates rapidly. Dryland farming is carried on in practically all parts of the region.

Agriculture

The High Plains area in Texas comprises a large and important agricultural region. For many years the only industry was cattle ranching, as the heavy growth of nutritious grasses provided an excellent forage for range livestock. During the early period of settlement the soils and climatic conditions were thought to be entirely unsuited to the production of farm crops. Sporadic attempts by early settlers at growing feed crops, notably sorgo, prove fairly successful and with the extension of railroads in the region bringing a larger population more land was placed in cultivation. The introduction of grain sorghums

provided a drought-resistant crop insuring a fairly certain source of grain for feed. These sorghums have been gradually improved and have become one of the most important crops in all sections. Small grains, especially wheat, have been found to be highly successful crops and a large amount of land is used for wheat, oats, and barley. These crops are confined largely to the northern sections, where the heavy soils predominate. Successful farming in the region has been made possible largely by the use of drought-resistant crops and by the practice of methods of dry-land farming designed to overcome deficiencies of soil moisture.

Cotton is not grown generally in the northern section of the region on account of the short growing season. Damage to the crop by early frost makes successful cotton-growing quite uncertain in the region where the elevation is over 3,500 feet above sea-level. The crop is grown extensively in the southern and central parts and in many counties is the chief commercial crop. Cotton, small grains, and sorghums comprise the chief crops grown in the region. Although rainfall is light and irregular throughout all sections, the soils collect and retain much of the rain water and are generally quite drought-resistant. The natural soil conditions favoring moisture conservation, the comparative freedom of crops from parasites and insect pests, and the smooth bodies of friable productive soils which allow the cultivation of large areas with improved machinery, are factors which go far to make up for the disadvantages of the light rainfall. Many other crops are grown in a small way on various farms. These are mostly Sudan grass, sorgo, broom corn, fruits, and vegetables. Corn is grown extensively in some sections of the southern part of the region. Alfalfa grows well when soil moisture is abundant.

Dairy farming and stock farming are successfully carried on in places and apparently the possibilities are good for increasing these industries. Fruits and vegetables are grown on the farms for home use and in places some of these products are marketed in the local towns. Agricultural development differs in various parts of the High Plains according to the character of the soils and climate, while the presence of transportation facilities influences largely the local development in farming. In some counties where cotton or small grains are important crops the proportion of land devoted to crops ranges from 25 to 40 per cent or more of the total land area. In some of the counties occupied more largely by loose sandy soils the amount of crop land is less than 10 per cent of the whole.

In some sections, some farm land is irrigated from wells but in most parts of the region the water lies so deep as to make pumping rather expensive. Cattle ranching continues to be an important industry on land not yet used for farming. While a large amount of land is farmed there remains much good farm land that is as yet used only for grazing.

Soils

On the High Plains normal soil development under a subhumid climate and heavy grass cover is well exemplified. Erosion has not disturbed vast reaches of the smooth nearly flat lands. Because of this favorable condition for soil development great areas of soils here have attained characteristics of maturely developed soils.

The soils have been developed mainly from deep beds of friable calcareous clays and sandy clays made up of ancient water-transported soil materials brought probably from higher-lying western areas.

The soils are mostly brown or red, though small spots occur with topsoils that are black. The very flat surfaces have the darkest soils; the very slightly undulating or nearly flat areas show the largest development of brown; and red or reddish-brown colors of either surface or subsoil layers are more evident where the surface is sloping, or where the soil material is sandy and porous. Texturally the soils of the region are divided into two great divisions, the heavy soils, mostly clay loams, located mainly in the northern section, and the light soils, sands, and fine sandy loams, confined chiefly to southern and western parts.

The normal soils are characterized by thick deeply developed topsoil and subsoil layers which merge without a sharp line of contact. The surface and upper subsoil layers are not calcareous in the normally developed soils. The heavy soils developed under a dense short grass cover contain a fairly large amount of organic matter, while the sandy soils developed under coarser grasses have only moderate amounts of this material. The layer of accumulated calcium carbonate, a characteristic feature of normal soils developed in a subhumid climate, is located at a depth of 4 or 5 feet under the deeper soils. This layer consists of pinkish or buff calcareous clay of open crumbly structure containing a large amount of soft white lumps or masses of calcium carbonate. In places the bed is composed of the practically pure carbonate. This rests upon the parent-material, or grades into it, but contains a larger proportion of calcium carbonate than the underlying parent clays. The thickness of the layer of accumulation varies from one or two feet to as much as twenty feet or more. Though this layer is well defined it merges upward with the subsoils and below with the parent clays. However, in places the subsoils of very sandy soil types rest upon, rather than merge with, the carbonate layer, which under such conditions is often found to be indurated in the upper portion.

The soils are generally open and friable, the heavy soils breaking down naturally to aggregates of small grains. The subsoils, though mostly heavy, are readily penetrated by water. In some areas where erosion is sufficient to prevent normal soil development the soil and subsoil layers are thin and calcareous, and the underlying layer of accumulated calcium carbonate, in places not well defined, lies near the surface.

The alluvial soils are confined to a few very narrow strips along some of the shallow draws occupied by the few drainage ways which occur in the region.

On the basis of the soil characteristics, the soils of the High Plains are divided into four groups, each of which comprises one or more series. These are: (1) dark-colored soils, including mostly the soils of the Pullman, Potter, and Richfield series; (2) red soils, mainly soil types of the Amarillo series; (3) light-colored soils, comprising here the light sands of the Enterprise series; and (4) alluvial soils, consisting of small bodies of the Spur and Randall series.

On the soil map the soils of the Dark-Colored Soils division are indicated as the Potter-Richfield grip; the Red Soils as the Amarillo sandy loam group, and Amarillo sands group; and the Light-Colored Soils as the Enterprise sands group. The small scale of the map does not allow the slight areas of alluvial soils to be shown.

The table on page 148 gives the characteristics of the principal soils and the chief crops grown.

Dark-Colored Soils

The dark-colored soils group includes mostly the soils of the Pullman, Richfield, and Potter series. These soils range from brown to black in color and for the most part are represented by clay loam soils with nearly flat to undulating surfaces. They are confined chiefly to the northern and eastern part of the region. The Pullman and Richfield soils are largely of normal development with thick soil layers, but the Potter, imperfectly developed on sloping surfaces, has only thinly developed soil layers. The soils of this group occupy about ten million acres.

Pullman Soils: The Pullman soils have brown or dark-chocolate-brown surface soils which grade below into subsoils of dark-brown or dark chocolate-brown color, the latter changing beneath gradually into slightly lighter-colored material, usually slightly reddish. The subsoils grade below, at a depth of 4 to 6 feet, into yellowish or buff calcareous clay containing a large amount of soft almost pure calcium carbonate. This is the layer of accumulated calcium carbonate. In places the upper subsoil layer is slightly reddish, especially in the shallower soil phases. Neither soils nor upper subsoils are calcareous, but the lower subsoils contain some calcium carbonate. The soils are of granular structure and the subsoils, though heavy, are penetrable and not tough. The Pullman soils cover very large areas in the northern part of the High Plains. The clay loam texture predominates and with smaller amounts of Richfield and Randall soils occupies the main part of nearly all of the northern High Plains. These important soils have heavy clay subsoils. The surface is nearly flat, though there is a gentle but almost imperceptible slope in most places. Natural drainage is slow, but in a region of such light rainfall, this is an advantage. Much of the surface is so nearly level that rain water runs off very slowly and,

Principal soils of High Plains

Soil groups (Series)	Topsoil	Subsoil	Substratum (or parent material)	Chief crops grown
Plains Upland				
Dark-Colored Soils:				
Flat to slightly depressed.				
Richfield	Dark-brown to black; not calcareous; friable.	Dark-brown to dark-gray; not calcareous; crumbly.	Accumulated layer of calcium carbonate on calcareous clay.	Wheat, oats, grain sorghums, other feed crops.
Nearly flat to undulating.				
Pullman	Brown or dark-brown; not calcareous; friable.	Dark-brown or chocolate-brown, slightly reddish in places; not calcareous in upper part; crumbly.	Same.	Same. (Cotton in places.)
Undulating to rolling.				
Potter	Brown or light-brown; calcareous; thin layers; calcareous; friable.	Light-brown or yellowish; calcareous; thin layers: crumbly.	Same.	Small grains, grain sorghums, sorgo.
Red Soils:				
Undulating to gently rolling.				
Amarillo	Red, brown, or reddish-brown; not calcareous; friable.	Red, not calcareous in upper part; crumbly.	Same.	Cotton, grain sorghums, sorgo and other feed crops, in places corn, some small grains.
Light-Colored Soils:				
Undulating.				
Enterprise	Light-brown or gray, not calcareous; loose.	Pale yellow, not calcareous, loose.	Deep sand.	Natural range forage.
Undulating to billowy.				
Dunesand	Gray, loose, windblown, shifting sand.	Pale yellow or gray, loose, incoherent.	Deep sand.	Natural range forage.
Flat Stream Bottoms. (Subject to overflow.)				
Spur	Brown or chocolate-brown; calcareous; friable.	Brown or chocolate-brown; calcareous; crumbly.	Clay and sand.	Alfalfa, sorghums, and other feed crops.
Lake Beds				
Randall	Nearly black or dark-gray; not calcareous.	Dark-gray; not calcareous.	Clay.	Natural range forage.

therefore, a large proportion is absorbed into the soil and subsoil. The deep clays hold a large amount of moisture in reserve to be used by crops in dry seasons, and the soils, therefore, are quite resistant to droughty conditions. The surface of the clay loam is covered with a dense growth consisting largely of buffalo grass (Bulbilis dactyloides) and some grama grasses. Coarse grasses with some grama grass occur on the sandy soils of the series. The Pullman soils of heavy texture, chiefly clay loams, are especially valued for small grains, and a very large amount of wheat is grown. Grain sorghums and various other crops are also produced successfully. A very large amount of these soils lie so high above sea-level that the growing seasons are often too short to allow cotton or corn to mature before frost. In the southern and central parts these crops are grown successfully, with only occasional losses incurred by early frosts or freezes. Other crops grown to which the soils are suited are sorgo, alfalfa, various other feed crops, and many vegetables and fruits. Wheat and sorghums are the chief crops grown. Much of the land is farmed in large tracts with highly improved power machinery. These soils occupy large areas, and much is not as yet in cultivation.

Richfield Soils: The Richfield soils comprise black topsoils grading below into dark-gray or brown subsoils, which at a depth of several feet are underlain by a layer in which is concentrated a large amount of soft white calcium carbonate. The soils are granular in structure. The surface soils and upper portion of the subsoils are not calcareous. These soils, of which the clay loam is the chief soil type, occupy very flat to slightly depressed surfaces and have slow drainage. The crops which seem to do best are the small grains, grains sorghums, sorgo and various other feed crops. These are grown to a considerable extent. The natural vegetation is similar to that of the Pullman soils. The soils are highly productive and fairly resistant to drought. The clay loam, the principal soil of the series, is underlain by a heavy clay subsoil.

Potter Soils: The Potter soils are shallow calcareous soils (Fig. 64). The topsoils are light-brown or grayish-brown in color and are underlain by yellow or yellowish-brown subsoils. The subsoils are highly calcareous and extend down and merge with the parent material without much change except that at a depth of one or two feet segregated soft and hard lumps of calcium carbonate occur in a layer one or two feet thick and indicate the rather poorly developed zone of calcium carbonate accumulation. The Potter soils occur on gently rolling and sloping surfaces, mostly near the sloping edge of the flat areas of the High Plains. These soils are subjected to erosion and the soil material does not remain in place sufficiently long to acquire the characteristics common to the maturely developed soils of the region. This is indicated by the light-colored shallow soils, calcareous from the sur-

face downward and by the imperfectly defined layer of accumulated calcium carbonate. The natural vegetation is largely bluestem grasses (Andropogons), grama, needle, and on the heavier soils some buffalo grass. On the eroded areas some small shrubs also occur. The Potter soils are not highly productive and as the surface slopes of the heavy soils allow the rain water to run off rapidly, crops on these do not generally withstand droughty conditions very well. These soils do not occupy a very large proportion of the region.

Red Soils

The red soils are represented chiefly by soils of the Amarillo series. These soils are mostly of sandy textures, and they cover large areas in the southern part of the region.

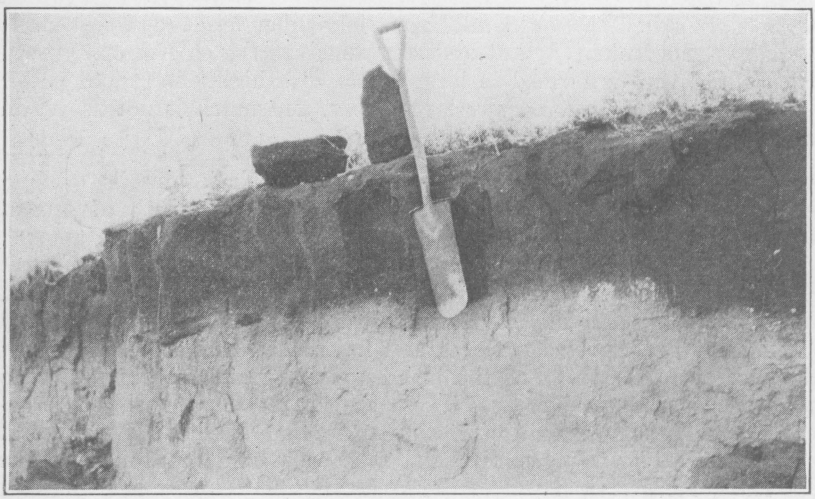

Figure 64. Soil profile of Potter fine clay loam. Note the soil columns which form in the dry soil. This soil is not maturely developed.

Amarillo Soils: The topsoils of the Amarillo soils are red, reddish-brown or brown in color and grade below into red subsoils. The surface and upper subsoil layers are not calcareous, but the lower subsoil layers contain some calcium carbonate, and grade below at a depth of 5 to 10 feet into reddish-brown, reddish-yellow, or buff-colored calcareous clay containing soft segregated calcium carbonate. This is many feet thick in places. In many places the calcium carbonate material lies nearer the surface and hardens into rock-like caliche. The Amarillo soils are of friable structure and the subsoils, while heavy, are easily penetrated by water. The surface is smoothly undulating to nearly flat and generally the amount of water lost by runoff is not excessive. Probably the most extensive soil of the series is the Amarillo fine sandy loam. This soil occupies large areas in the southern part of the High

Plains. Probably 6,500,000 acres is a fair estimate of its extent. The surface soil is red or reddish-brown and grades at a depth of 12 or 18 inches into red fine sandy clay, which is underlain at a depth of 3 to 10 feet by the thick beds of almost pure calcium carbonate in both hard and soft masses. The fine sandy loam is undulating to gently rolling. It catches and holds a large proportion of the rain water and is quite drought-resistant. It supports a heavy growth of grama, needle, and other grasses, and in places considerable catclaw (Fig. 65). This soil occurs in great bodies with some associated small areas of other soils. A large amount of the soil is farmed and good yields of cotton, grain sorghums, and various other crops are produced. It is a highly esteemed soil, especially suited to cotton and grain sorghums. It is suited to many other crops including vegetables and fruits. The Amarillo sands occupy a considerable area in the southwestern part of the High Plains. A large

Figure 65. Amarillo fine sandy loam with typical growth of catclaw.

part of the soils included in this division consists of Amarillo loamy fine sand while the largest proportion belongs to the soil that has been called Amarillo fine sandy loam, light phase. These soils occupy about 3,500,000 acres. The Amarillo loamy fine sand is a brownish-red fine sand grading below into a subsoil of red loamy fine sand, which at a depth of several feet rests on soft calcium carbonate beds. The surface soil and subsoil are not calcareous. The surface is gently undulating and the soil absorbs practically all of the rain water. It, therefore, supports a rather abundant growth of coarse grasses with some grama grass, and is considered good grazing land for cattle. The soil is suited to the production of moderate yields of farm crops, vegetables, and fruits. The Amarillo fine sandy loam, light phase, occupies a large portion of the area shown on the map as Amarillo sands. It is included within this division because it consists of a shallow fine sand. The surface soil is a light-pink, light-brown, or reddish-brown, fine sand grading below at a depth of several inches into fine sand having

a deeper red color than occurs in the surface layer. This merges below at a depth ranging from about 12 to 24 inches with red fine sandy clay. With increase in depth this passes into soft calcareous pinkish clay containing a large amount of soft calcium carbonate. This material in places consists almost entirely of a solid bed of chalky material containing very little fine earth. The surface soil is very loose and where not covered with vegetation, blows and drifts about in heavy winds. The subsoil, though apparently quite penetrable, is sufficiently dense to allow water to stand in depressions for a considerable period of time after rains. The surface is nearly flat to gently undulating, and nearly all the rain water is taken up readily by the soil. Small shin-oak trees are abundant in places, and the coarse grasses such as bluestem grow thickly. The soil is highly resistant to drought and even in very dry seasons some crops are produced. The soil is suited to grain sorghums, sorgo, cotton, and other feed crops. In some sections, considerable acreage is devoted to corn and fairly good yields are secured. Not a very great proportion of the soil is in cultivation, though in places many farms are operated. The chief hindrance to its use as farm land is the blowing and drifting of the soil in the strong spring winds. Often young plants are thus killed and replanting becomes necessary. The soil is well suited to vegetables, melons, and other vine crops, fruits, berries, and grapes.

The virgin soil is still largely used for cattle ranching. It is covered with a heavy growth of bluestem, needle, and various other grasses which afford good pasturage for cattle, and in many places small shin-oak trees are very abundant.

Light-Colored Soils

The light-colored soils of the region consist chiefly of deep sands of the Enterprise fine sand, dune phase (formerly correlated as Derby fine sand, dune phase) and of Dunesand. These soils do not occupy a large proportion of the region, but in the western part they occupy strips several miles wide. The soils are shown on the map as the Enterprise sands group. The soils of this group are mainly of fine sands many feet deep and in places have an accumulated layer of calcium carbonate at a depth of several feet. They probably cover nearly one million acres.

Enterprise Fine Sand, Dune Phase: This soil is a light-brown or gray loose fine sand grading below into pale-yellow fine sand many feet deep. The soil contains very little organic matter. The surface has a dune-like configuration due to having been drifted by winds before becoming covered with vegetation. Neither soil nor subsoil is calcareous, though at a depth of several feet some calcium carbonate occurs. The natural vegetation is composed largely of coarse grasses, including bluestems, with a small amount of grama, needle, and other grasses. Weeds are abundant and in places small shin-oak trees, yucca, artemisia,

and other woody plants occur. This soil is best suited to the grazing of livestock and is used for that purpose.

Dunesand: This consists of loose fine sand almost devoid of organic matter which has been blown into low dunes that shift with the recurrent heavy winds. The soil is gray or nearly white, changing below into pale yellow fine sand many feet deep. Calcium carbonate layers lie several feet beneath the surface in many places. The Dunesand is almost bare of vegetation, though the intervening depressions between the dunes have a growth of coarse grasses, weeds, and in places small shin-oak trees (Fig. 66). Vegetation encroaches onto some of the dunes and hold the shifting sand in place for a time. The dunesand is similar to the Enterprise fine sand, dune phase, but is of somewhat lighter color and having little vegetation is shifted about more by the winds. Dunesand is used for the grazing of livestock.

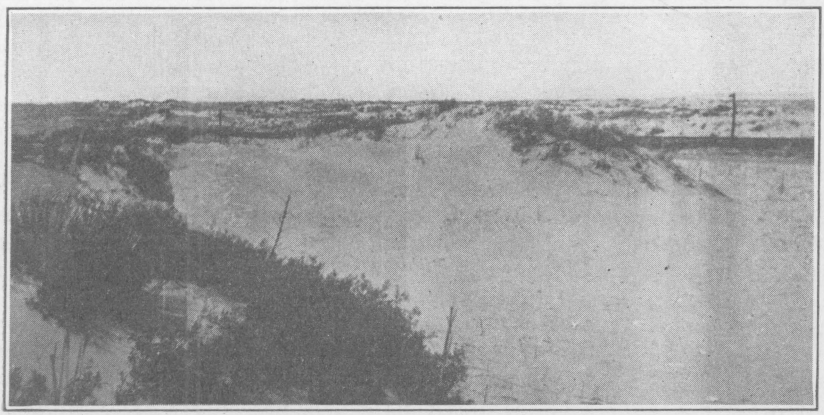

Figure 66. Although a loose drifting sand, Dunesand provides livestock considerable range forage even in the driest seasons. "Monahan sands" in Ward County.

Alluvial Soils

No stream bottoms occur on the High Plains except in very narrow strips along a few shallow draws, which mostly comprise head-water drainage ways of the Brazos, Red, and Colorado rivers. The soils of these bottoms are made up of soil materials washed from local areas and are chiefly of the Spur series. They are of very slight extent. Numerous small playa lakes dot the surface of the plains and as they are dry most of the time the soils of the lake beds have been included in the Randall series.

Spur Soils: These are brown or chocolate-brown calcareous soils passing below into subsoils, which, though of very similar character, are generally lighter in color and contain little organic matter. The surface is nearly flat and natural drainage is slow except where the sub-

soils are sandy and allow free underdrainage. The soils are naturally friable and easy to cultivate. The principal crops grown are feed crops, mostly alfalfa and sorghums. The soils are quite productive and are farmed to some extent.

Randall Soils: The Randall soils occupy the beds of the small lakes, which are dry the most of the time. These lakes occur surrounded chiefly by the Richfield and Pullman soils, and range in size from a few acres up to 40 acres. The surface soils are very dark-gray, very dark-brown or black in color, and are underlain by dark-gray or bluish-gray clay many feet deep. The soils and subsoils are not calcareous and no developed layer of calcium carbonate occurs in the soil profile. The soils are made up of very fine soil materials washed from the adjacent slopes of the higher-lying soils. The surface is flat and as the soils and subsoils are dense, water stands for a long time after extended rains. The only soil type that occurs is a dense heavy clay. This soil is mostly bare of vegetation and is not used for crops on account of the absence of drainage and because of the dense heavy structure, which renders cultivation very difficult. Occasionaly crops have been grown on the soil, and the yields obtained showed it to be fairly productive.

Soil Utilization

Successful agriculture on the High Plains is due to the presence of large areas of soils well suited to crop production under limited rainfall. The characteristics and features of the dominant soils compensate largely for the moisture deficiencies imposed by the climate.

The principal soils are inherently productive and suited to a number of important crops. The characteristics of soil structure are such that cultivation is readily accomplished. The soils and subsoils, even of the heaviest texture, are quite penetrable to water, air, and plant roots. The structural features thus enable not only the ready absorption of water and allow it to be held in large quantities in the thick heavy layers of subsoil and parent-material, but facilitate the withdrawal of soil moisture by the plant roots, which gain access to all parts of the fine earth mass of soil and subsoil. The normal soils, therefore, have high qualities of drought-resistance. The smooth nearly flat surface of the soils prevents a large proportion of rain water to be lost by runoff, thereby inducing a high degree of moisture conservation. This topographic feature also enables the farming of large areas per unit of man and mechanical power with highly improved farm machinery, thus reducing operative costs.

The various soils of the region differ in textural features and as texture influences largely the suitability of soils to kinds of crops, the type of agricultural usage is here based to a considerable extent with reference to soil texture, in so far as climatic conditions permit.

The heavy soils are suited to many crops. These consist mainly of Pullman and Richfield clay loams, which occupy the greater part of the

northern High Plains, though small amounts of Potter and Amarillo clay loams are also associated with them. However, the more northern areas lie at such a high elevation that the growing season is generally too short for regular production of cotton and corn. On these heavy soils located in the southern and central sections, cotton is produced extensively. Corn is not grown largely, as the grain sorghums, naturally more resistant to irregular moisture supply, are grown very successfully and supply the requirements of grain feed for livestock. The heavy soils are excellent for the production of small grains, and wheat, oats, and barley are important crops. Wheat is grown extensively with the use of power machinery and the Pullman and Richfield soils provide one of the important wheat-producing areas of the country (Fig. 67). The heavy soils also produce various other crops such

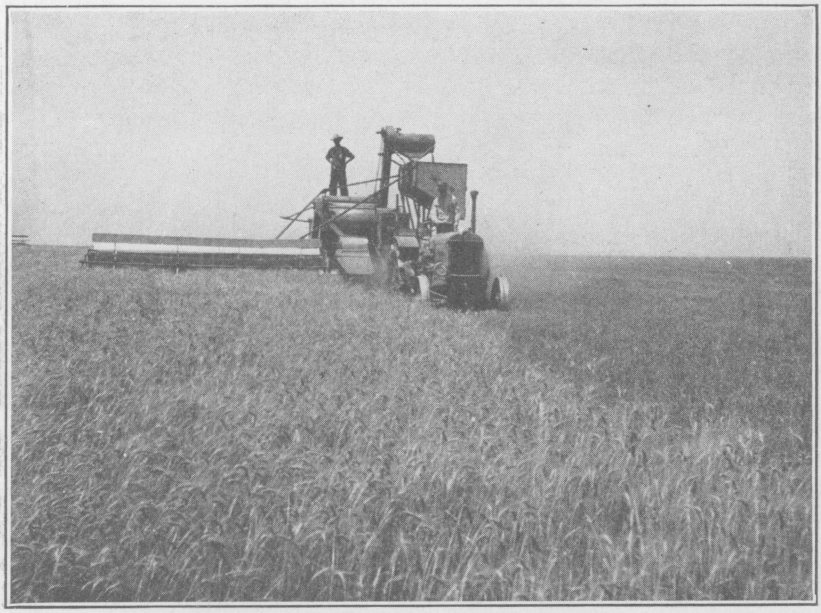

Figure 67. Harvesting wheat on the High Plains. On the smooth heavy soils great fields of wheat are grown with the most highly improved types of farm machinery.

as Sudan grass, sorgo, broom corn, vegetables, and fruits. These crops are mostly grown only in such quantities as are required for home and local use. Alfalfa does well when moisture conditions are favorable. In Hale, Lamb, and some other counties the soils have responded well to irrigation from shallow wells.

The sandy soils of the region are not so well suited to the production of small grains. The chief soil of this textural group is Amarillo fine sandy loam, which occupies very large areas in the southern part

of the region of High Plains, though smaller bodies lie also in the northwestern part. This soil is quite productive and drought-resistant. It is well suited to cotton, grain sorghums (Fig. 68), sorgo, various other feed crops, vegetables and fruits, and these are the chief crops grown. It is on this soil that the greatest extension of cotton-growing in the west has occurred during recent years.

The light sandy soils, the Amarillo sands group, consist largely of Amarillo fine sandy loam, light phase, which occupies most of a fairly large area in the southwestern part of the High Plains. This soil is drought-resisting, as all of the rain that falls is absorbed by the soil

Figure 68. Amarillo fine sandy loam occupies great areas of the south High Plains. It produces good yields of grain sorghums, as well as many other crops.

and is held stored in the deep underlying heavy clay. Owing to the loose structure, the soil drifts during heavy winds and injures the young crops. This soil is well suited to all the crops grown on the typical Amarillo fine sandy loam, but as yet not a large proportion is farmed, as it is subjected more to the hazard of wind-blown sand and probably not quite so productive. In some sections a considerable amount of this soil is successfully used for growing corn. The soil is especially suited to grain sorghums, sorgo, cotton, various feed crops, grapes, berries, vegetables, and fruits. Of these the general farm crops are chiefly grown.

The very light sandy soils are mainly of the Enterprise series and Dunesand. These soils are too light for successful production of most crops and are not farmed. On some of the smoother areas probably

grapes, berries, plums, and some vegetables would produce fair yields if it were possible to prevent drifting of the sand by the wind.

The Spur soils, used for alfalfa and feed crops, are valuable soils but are very limited in extent.

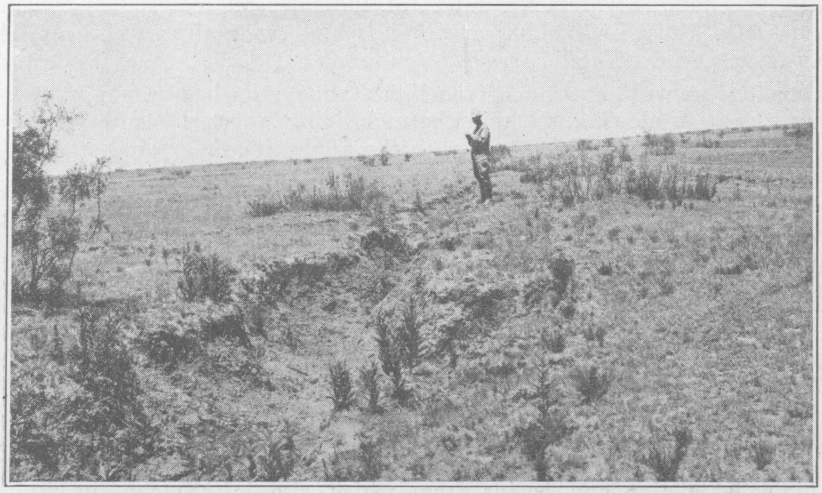

Figure 69. Erosion rapidly carves gullies in wagon trails on the nearly flat heavily grassed plains soils. When the road is abandoned, the native grasses attempt to reclaim the worn spots.

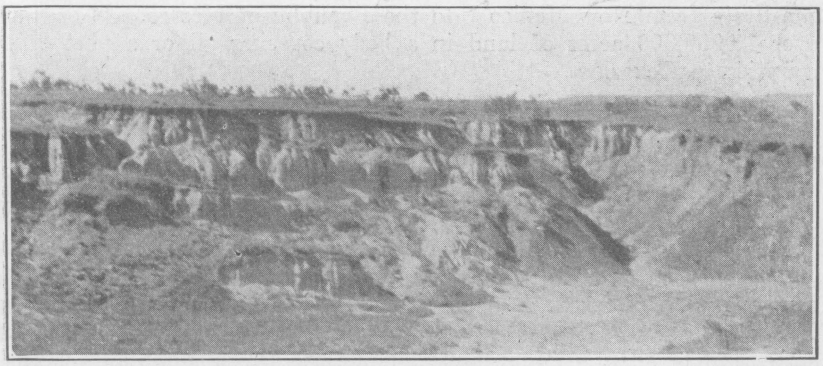

Figure 70. Type of gully erosion that forms on the smooth plains soils if erosion is not checked.

The soils most largely cultivated on account of their great extent and value are the Pullman clay loam and Amarillo fine sandy loam, though large amounts of these soils are still used only for livestock grazing.

Terracing has been found advantageous on smooth areas with only very slight slope, as this prevents loss of water carried by runoff onto lower-lying soil areas, and also prevents sheet erosion, which is most active on some of the clay loam soils. Injuries by sheet erosion are not apparent for a long time so far as surface conditions are concerned, but this gradually removes much of the fine soil material and plant nutrients, thus diminishing crop yields and eventually causing gullies to form (Figs. 69 and 70).

In places wind erosion of the light sandy soils has been minimized by very deep plowing, wherein the underlying clay has been brought to the surface and become mixed with the sand. The clay binds the loose sand and prevents it from drifting. It is reported that the results have been satisfactory.

MOUNTAINS AND BASINS

(Mainly the Trans-Pecos Region)

The region of Mountains and Basins occupies the extreme western part of Texas. It lies mostly west of the Pecos River and with that part of the Edwards Plateau also lying west of that stream comprises what is generally known as Trans-Pecos Texas. This great area is markedly different from any other part of the State. It consists of high flat plains and basins from which rise lofty mountain ranges and isolated mountain bodies, reaching thousands of feet above sea-level. This great basin-highlands area, through which extend outlying mountains of the Rocky Mountain system, crosses the western part of the State from New Mexico into the Republic of Mexico. It occupies over 17,000,000 acres of land in a body covering all or a part of 10 counties in Texas.

The surface of the almost flat basins and plains sections has elevations ranging from 2,500 to 4,000 feet above sea-level, and the adjacent mountains and roughlands rise 1,000 to 5,000 feet higher.

El Capitan Peak rising to about 9,020 feet above sea-level in the Guadalupe Mountains in the northern part of the region is believed to be the highest point in Texas (Fig. 71).

There are three principal mountain areas crossing the region from northwest to southeast. These on the eastern side, known as the Front Range, consist of Sierra del Carmen, Santiago, Davis, Apache, Delaware, and Guadalupe Mountains, all but the Davis Mountains consisting of thick strata of hard limestone. They have a regular directional trend, which indicates their relation to the area of Cordilleran uplift. The Davis Mountains occupy an irregular area occupied by high rugged masses of igneous rocks. The Central Range extends across the western part of the area in a direction parallel to the Front Range, from

which it is separated by a vast trough occupied by several basins. From this trough near the Rio Grande rises the Chisos Mountains to an elevation of over 8,000 feet above sea-level (Fig. 72). The Central Range comprises a series of short ranges and isolated areas consisting mainly of the Hueco, Finlay, Quitman, Sierra Diablo, Van Horn, Eagle,

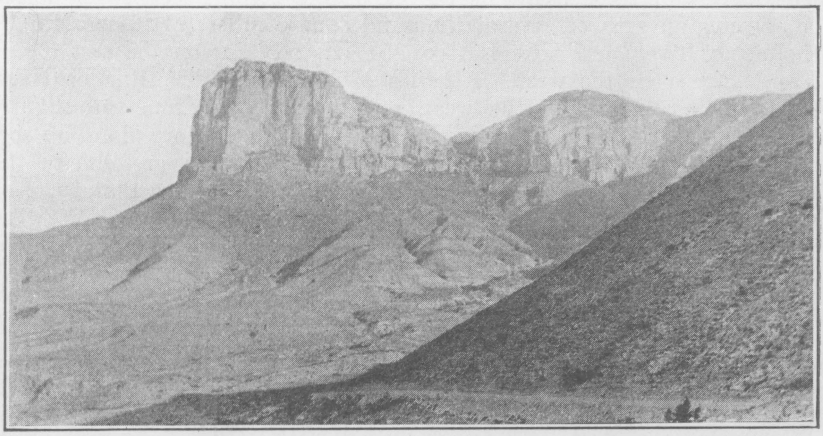

Figure 71. Guadalupe and El Capitan Peaks mark the southern extension of the rugged limestone roughlands of the Guadalupe Mountains. The base of the Guadalupes here rests upon the crest of the Delaware Mountains.

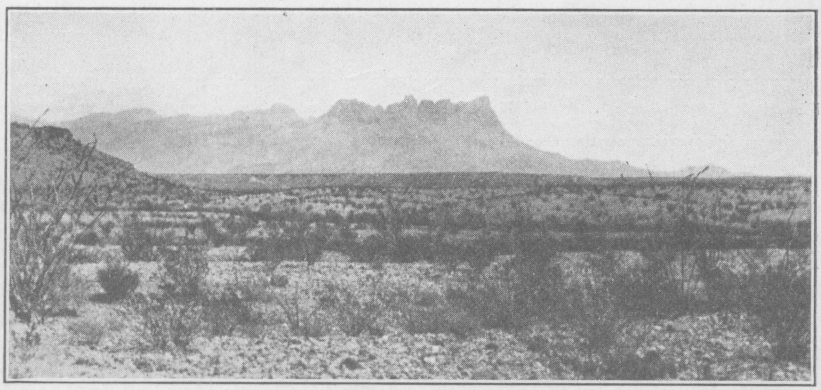

Figure 72. The Chisos Mountains comprise vast protrusions of igneous rocks rising from the arid gravel plain of the Big Bend to elevations of more than 8,000 feet above sea-level.

Tierra Vieja, Chinati, and Bofecillas Mountains, and Mesa de Anguila. These mountains are made up largely of limestone rocks, though Bofecillas, Chinati, Tierra Vieja, Eagle, and portions of Quitman are of igneous rocks. The most westerly of the local ranges consists of the Franklin Mountains at the extreme west edge of the area.

These consist of various kinds of rocks, but limestones probably predominate. The mountains and very rough hilly lands occupy about one-fourth of the region.

Lying between these mountain ranges are the flat plains locally known as basins, many of them completely surrounded by mountains. The largest of these basins is the Pecos Basin, or Pecos Plain, which constitutes an area of several thousand square miles. It is crossed by the Pecos River, and extends from the High Plains on the east to the Front Range on the west. A series of limestone hills, Rustler Hills, bounds Pecos Basin on the west, and separates it from the slightly higher areas of the Culberson Plateau, a high rolling plain of soft gypsum. Lying between Front and Central Ranges are chiefly the Salt Basin (Fig. 73) and Valentine Basin, Presidio Plateau, and

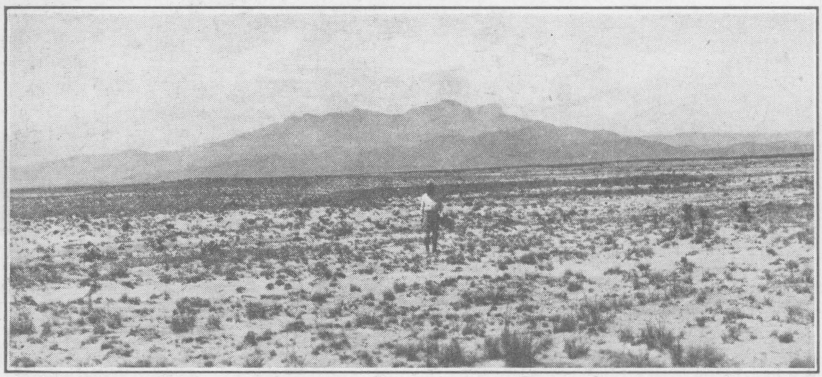

Figure 73. Salt Basin, occupied largely by deep beds of soft gypsum, lies at an elevation of nearly 4,000 feet above sea-level, but is more than 4,000 feet lower than the crests of the Guadalupe Mountains shown in the background, fifteen miles distant.

Marfa Plateau. The Salt Basin is a depressed area which has no drainage outlet, and great salt lake beds surrounded by slightly higher-lying beds of soft gypsum occupy much of the land. Salt Basin is characterized by the presence of alkaline salts, which are readily recognized as white incrustations on the surface, and the characteristic plants here are only those tolerant to alkali. South of the Texas Pacific Railroad the basin area is free of salt or alkali and constitutes the Valentine Basin. This basin reaches almost to the Davis Mountains, but on the southeast it becomes a slightly higher dissected plain of fairly well defined plateau relief, to which the name Marfa Plateau is given. The more broken areas of adjacent high-lying very gravelly hills comprise the Presidio Plateau. This great area of depression between the ranges extends on into the Big Bend of the Rio Grande, where it is characterized by diverse forms of relief, consisting of minor eroded basins dissected by interior-reaching tributaries of the Rio Grande;

by eroded areas of "bad land" character; by beds of volcanic ash and eroded lava plains (Fig. 74); and by a number of isolated mountains, chief of which are the Chisos Mountains, the highest peak of which, Mount Emory, ascends more than one mile higher than the Rio Grande lying in its narrowly grooved valley only a few miles away. The western basin area, lying between the Central Range and Western Range, consists chiefly of Hueco Bolson, a large flat sand plain.

Several narrow valleys have been cut by streams through the region of Mountains and Basins. The chief of these are constricted to gorges where the Rio Grande (Fig. 75), Pecos River, and other streams have cut through rough highlands and moutains. Several short streams of

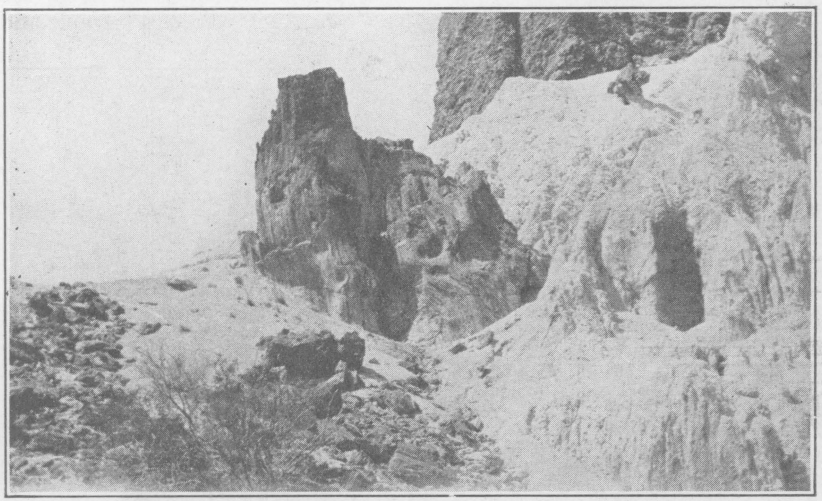

Figure 74. Huge rock cinders protrude through beds of volcanic ash and resemble fragments of enormous trees. Near Castolon in the Big Bend.

intermittent flow originate within the mountain sections, and carry drainage water to these rivers.

The native vegetation of the region is of two general types, one of species of grasses which occur in the subhumid region to the east under conditions of higher rainfall, and the other of various plants which grow only in very dry regions. In the larger areas of basins and flat lands, the chief growth consists largely of creosote bush (Covillea sp.), or blackbrush (Flourensia sp.), the first largely on soils that are very thin and dry, and the latter on deeper soils which have slightly better moisture-holding capacity. Associated with these plants are very slight amounts of grasses, which consist largely of burro, tussock, and tobosa grasses. A few scattered shrubs occur, consisting of mesquite, catclaw, buckthorn, allthorn, ocotillo, yucca, and others. In places on these flats where runoff water from mountain slopes flows far

Figure 75. Grand Canyon of Santa Helena in the Big Bend. Here the Rio Grande flows through a narrow gorge of solid limestone, the walls rising to a height of 1,600 feet above the stream.

out on the dry lands of the basins, there are large areas covered with tobosa grass giving rise to the term "tobosa flats." On the very sandy basin lands, the vegetation is more largely coarse grasses, weeds, and mesquite shrubs. In the flood plains of valleys mesquite and tornillo trees attain fair size and coarse grasses also grow. In some very small spots of some flood plain areas as well as in some basin areas, a high salt content of the soil is indicated by salt grass and other salt-tolerant plants. In many of the small basins and narrow valleys within the mountains there is a fairly abundant growth of grama and other grasses (Fig. 76) with very few or none of the desert shrubs.

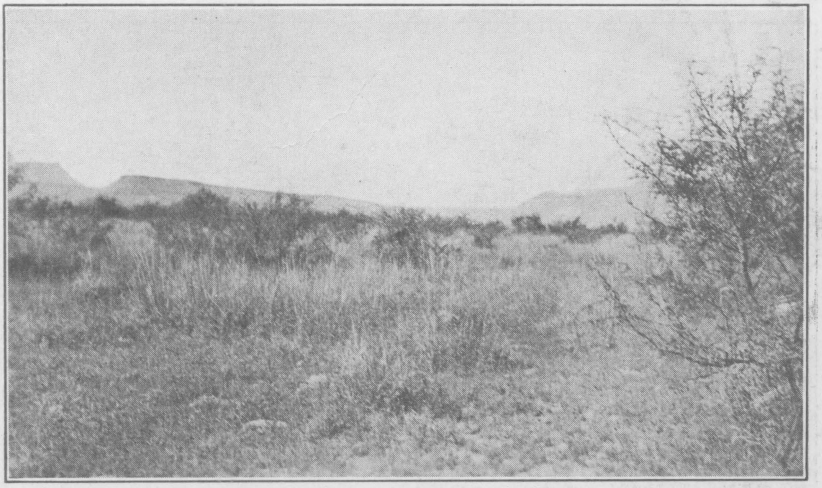

Figure 76. Some basin lands support a good growth of grasses and shrubs. Grama, tussock, and other grasses in Green Valley on Reeves silty clay loam, deep phase.

On the igneous-rock mountains and rough lands, more especially in the Davis Mountains, there is a fairly heavy growth of several species of grama grass, of which black grama and blue grama are the most abundant. Associated with them in these places are various other coarser grasses (Fig. 77). In places on these mountains and in the narrow mountain valleys are several species of oak, pine (Fig. 78), and juniper trees. These trees also grow on some parts of the limestone mountains. Dry-land plants such as lechuguilla, sotol, mesquite, catclaw, yucca, buckthorn, sacahuiste, and other woody plants grow more or less abundantly on the limestone mountains and roughlands and to some extent in places on the igneous-rock roughlands, and in very gravelly basins. A very thinly scattered growth of grama, needle, and some other grasses is found on the limestone mountains, but large areas of these are almost devoid of grass.

The climate of the region of Mountains and Basins is of arid and semiarid types. In the eastern part of the area the average annual

rainfall is 14 or 15 inches a year, but in the central part in the Davis Mountains sections it is about 17 inches a year. Apparently the higher mountains generally receive slightly larger amounts of rainfall than the main lowland areas, as is evidenced by the heavier grass growth in and around the Davis and other mountains. The average annual temperature is about 64° F. in the eastern part, but less than 62° F. in the western part, with an average of about 60° F. in the Davis Mountains section. The winters are relatively long as compared with most regions of the State. They are marked by periods of long continued cool weather during which the temperatures are at times below the freezing point. Snowfall is light. The summers are marked by much

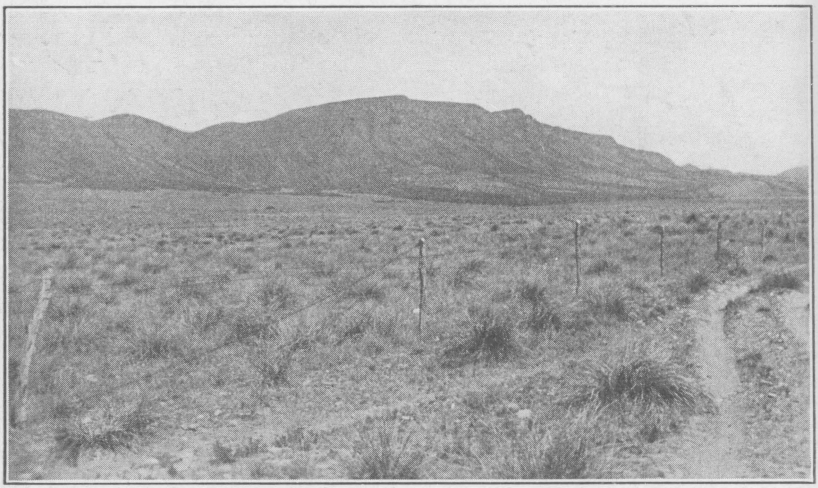

Figure 77. In many mountain valleys there is a fairly heavy growth of grasses. "Sacahuiste" (Nolina) and grama grasses on Reagan gravelly loam near Marathon in valley of Glass Mountains.

sunshine, and frequently rather high temperatures prevail during the day. However, cool breezes with low humidity and a bracing atmosphere due to high altitude tempers the heat. Winter weather is not so severe as to require artificial shelter for range livestock. Late freezes sometimes destroy the fruit crop. The rainfall is entirely too low to furnish sufficient moisture for the production of crops, and where farming is done it is necessary to irrigate the land.

Agriculture

Stock raising constitutes the major industry of the region of Mountains and Basins. This will probably always remain the principal occupation as the large areas of rough stony lands are not suited for any other agricultural purpose.

Practically all of the land has long been subdivided into large ranch

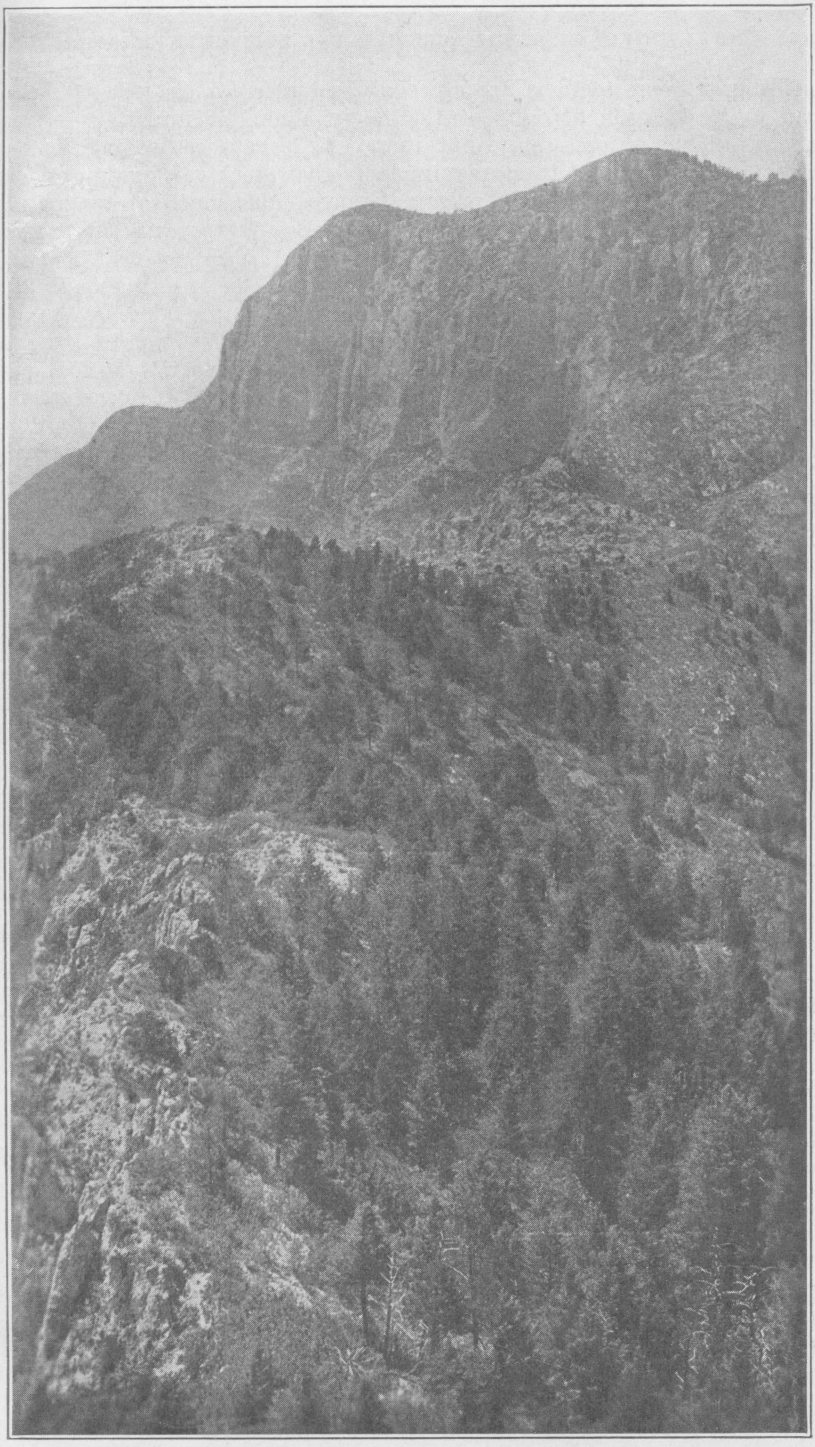

Figure 78. Pine timber on crest of Guadalupe Mountains.

holdings. Some sections are especially valuable for the production of range livestock on account of the fairly abundant nutritious grasses and available water supply, but there are large areas so deficient in either one or both of these requirements that stock raising is attended with uncertainty. On these marginal ranch lands some seasons may be attended with sufficient rainfall to produce a fair growth of grazing forage, while in other periods moisture may be so deficient and the range so bare that it may be necessary to move or feed livestock. On many ranches a good supply of water has been provided by sinking wells, and by constructing reservoirs to hold storm water. On the whole, the most abundant and best grasses are on the igneous-rock mountains and roughlands, and the associated smooth plateaus, basins, and valleys. The most favorable grazing conditions are generally to be found in the Davis Mountains and surrounding areas including the Marfa and Presidio plateaus. In these sections careful attention to breeding high-grade cattle has produced a splendid type of beef animal that is much sought after by stock feeders in other states. Beef cattle constitute the principal livestock of the region, though many sheep and some goats are also raised in places. In the Big Bend section and in the mountainous roughlands along the Rio Grande, a considerable amount of the land is not utilized to much extent for any livestock except goats, which are largely the native Mexican unimproved native stock, though some improved Angora goats here, and in other parts of the region, are successfully raised for mohair. Sheep range well on the less rough mountains and other lands in the Davis Mountains and adjacent sections. They are of highly improved breeds and considerable wool is produced.

The farming in the region is confined to areas where water is available for irrigation. Probably not more than 150,000 acres of land, less than one per cent of the total, is used for producing farm crops. While considerable areas of the smooth lands are productive and suited to various crops these remain unused except as livestock range on account of the absence of available water for irrigation or because there is at present no economic necessity for bringing this land under cultivation.

The largest areas devoted to farming are in the Rio Grande and Pecos River valleys with irrigation from those streams; in the Madera valley near Balmorhea and on Pecos Plain near Fort Stockton with water from springs and reservoirs; in the valleys in and around the Davis Mountains from springs; and on the Pecos Plain from wells. Many Mexican families living throughout the mountains and valley sections produce no small proportion of their food requirements by growing corn, beans, and other vegetables, and even wheat on small patches of land irrigated and farmed under the ancient temporal system. This comprises the cultivation of small patches of smooth land so situated that by means of ditches and constructed embankments runoff

rain water is diverted from higher slopes and made to flow onto the farm land, where, held by earth banks, it is taken up by the soil.

The crops grown under irrigation are of many kinds, but the largest acreage is devoted to cotton and alfalfa. Corn, sorghums, small grains, and other farm crops are produced in the various sections. Fruits, and truck crops, are also grow extensively in the El Paso Valley along the Rio Grande, and some truck crops near Pecos are produced successfully. Apples are produced commercially in a number of large orchards near Fort Davis in the Davis Mountains, with small amounts of other fruits and vegetables.

The ranching industry in the region represents an admirable adaptation of the valuable resources of native vegetation to the uses of livestock, for which they are best suited. Besides the valuable grasses available, which are grazed largely by cattle, many of the other native plants such as the various shrubs and woody plants afford valuable browse for sheep and goats. In the vicinity of Balmorhea and Marathon large amounts of honey are produced from the native plants, largely from such plants as mesquite, catclaw, white brush, and many others.

Soils

The normal soils of the region are those that have been developed on the smooth surfaces of the basins and plains, but on the mountains and rough lands erosion has rapidly removed most of the soils and there little or no soil development has occurred.

The soils of the smooth lands reflect the processes of soil development under a very dry climate with a wide range of temperatures between seasons and with little or no vegetative cover. The normal soils of the smooth lands are characterized by light color due largely to the small amount of organic matter, and the layers, calcareous by reason of insufficient rain to leach them, do not differ greatly but merge together with no marked change in characteristics. The soils and subsoils are of pronounced open granular structure. They are underlain by the well developed layer of calcium carbonate, in places accompanied by soft gypsum, which characterizes the normal soils in regions of light rainfall. A distinctive characteristic of the soils indicative of development in an arid climate is the presence of a thin surface crust one-sixteenth to one-eighth inch thick on the surface of the air-dry virgin soil. This crust is slick on the upper and rough on the lower side. It rests on a thin layer of granules one-fourth to one inch thick, and this on the hard soil beneath. These soils have been developed from ancient fine sediments deposited by wash from mountain areas and spread in varying degrees of thickness over deep beds of mountain debris consisting mainly of rounded gravel. The very light rainfall supporting only slight amounts of grasses has been responsible largely for the low organic-matter content.

The soils of the mountains and rough lands have not developed deep

layers, as the soil material is washed away before soil development occurs. These soils are largely composed of fine earth in thin layers on rocks and lodged in rock debris on slopes and ridges. Soil material from the igneous rocks is red or brown and generally is deeper and darker than are the soils from limestone. The igneous-rock soil materials find a deep lodgment in the irregular broken rock material and support a heavier growth of grasses than the less abundant fine-earth soil materials of the limestone soils. This is probably due to the differences of the breaking and disintegration of igneous rocks, which form a thick layer of broken rock providing space for holding more soil than is held on the hard horizontal limestone strata.

The alluvial soils are of very slight extent and are confined to the narrow flood plains in the larger valleys occupied by the main streams. These soils are made up largely of soil materials transported by flood water from the areas of local mountains and rough lands, and from the deeper soils of the arid basins.

The table on page 169 gives the principal soils with their characteristics and chief crops grown.

Basins and Plains Soils

This division of soils occupies 12,500,000 acres, a much larger proportion of the region than the mountains and rough lands. These soils are largely of the Reeves series, with smaller amounts of the Reagan and Verhalen soils. The Reeves soils are very light-colored, very calcareous, and contain little organic matter. The Reagan soils are slightly darker and have a heavier growth of grasses. The Verhalen are red or brown to reddish-brown and contain moderate amounts of organic matter. The Anthony soils are of slight extent and occupy narrow, high terrace benches in the Rio Grande Valley.

Reeves Soils: The Reeves soils have light-brown to ashy-gray calcareous surface soils which grade below into calcareous subsoils of light shades of yellow or buff color. In places the topsoil and subsoil layers of the very sandy soils are slightly red in color. The subsoils merge below with the layer of accumulated soft, nearly pure, calcium carbonate, with which, in places, is associated a considerable amount of soft calcium sulphate. In the shallow and gravelly soils the upper part of this limy layer becomes hard on drying and, in places, the broken rock-like caliche fragments occur on the surface and throughout the soil layers.

The soils and subsoils are of open structure and allow rapid penetration of air and water. The air-dried soils have a well developed, thin, fragile surface crust. The Reeves soils are very extensive and are developed under the driest climatic conditions that prevail in the region. They are very low in organic matter. The soils of the series range in texture from sandy to silty clay loam with some large areas of gravelly soils. The silty clay loam is extensive and occupies very

Principal soils of Mountains and Basins

Soil Groups (Series)	Topsoil	Subsoil	Substratum (or parent material)	Chief crops grown
Basins and Plains.				
Smooth, nearly flat:				
Reeves	Light-brown to gray; calcareous; friable.	Light-brown or yellowish; calcareous; friable; some gypsum.	Calcareous clay on deep beds of gravel.	Natural range forage; cotton, truck crops, small grains, alfalfa.
Reagan	Brown or light-brown; calcareous; friable.	Light-brown or yellowish; calcareous; crumbly.	Calcareous clay on beds of gravel or limestone.	Same.
Verhalen	Calcareous; brown or reddish-brown; friable.	Calcareous; red or reddish-brown; crumbly.	Calcareous clay on deep beds of gravel.	Same.
Flat old stream benches (above overflow).				
Anthony	Light-brown; very calcareous; friable.	Yellow; calcareous; crumbly.	Beds of gravel.	
Mountains and Roughlands.				
Igneous rocks;				
Brewster	Red or brown; not calcareous; friable; mostly very stony.	Red or brown; not calcareous; crumbly; stony.	Bed rock.	Natural range forage.
Limestone:				
Ector	Light-brown or brown; calcareous; friable; mostly stony.	Light-brown or yellowish; calcareous; stony.	Bed rock.	Same.
Very rough stony lands:				
Rough Stony land	Either igneous or limestone rocks, some sandstone; granite, and various others.	Broken stone or bed rock.	Bed rock.	Same.
Flat Stream Bottoms. (Subject to overflow.)				
Gila	Light-brown or grayish; calcareous; friable; (some salt).	Light-brown or grayish; calcareous; friable; (some salt).	Layers of sand and clay.	Cotton, corn, alfalfa, sorghums, truck crops, fruits.
Rio Grande	Light-brown or brown; calcareous; friable.	Light-brown, calcareous; friable.	Same.	Same.
Toyah	Brown or dark-brown; calcareous; friable.	Brown or light-brown; calcareous; friable.	Beds of gravel.	Cotton, alfalfa, feed crops.

Principal soils of Mountains and Basins—Continued

Soil groups (Series)	Topsoil	Subsoil	Substratum (or parent material)	Chief crops grown
Flat Stream Bottoms—Cont.				
Balmorhea	Black or very dark-brown; calcareous; friable.	Brown; calcareous; crumbly.	Same.	Same.
Pecos	Brown or gray; calcareous; friable; (some salt).	Dark-gray or chocolate-red, contains gypsum; calcareous; (some salt).	Layers of sand and clay.	Cotton, feed crops.
Patrole	Gray; calcareous; friable; (some salt).	Chocolate-red; dense, heavy; calcareous; (some salt).	Same.	Natural range forage.
Arno	Chocolate-red or dark-red; calcareous; friable.; (some salt).	Chocolate-red; calcareous; (some salt).	Same.	Same.

nearly flat surfaces throughout the basins and plains areas. The underlying, accumulated, white beds of calcium salts lie near the surface of the typical soil but a deep phase of the silty clay loam is composed of soil layers two to five feet deep over this material. In some places, as in Salt Basin, or in other depressions with slow drainage, the soil contains a considerable amount of sodium chloride, but areas of soil thus affected are comparatively small. The vegetation of this soil is largely creosote bush, with the surface almost bare of grass. On the deep phase, however, this bush is of slight extent and there is a larger proportion of blackbrush and grass, especially in shallow depressions. The grasses are mainly burro and tussock, with a few others. The Reeves fine sandy loam and fine sand occupy fairly good-sized bodies of land in various sections. These occur on smooth, nearly flat to undulating, surfaces and have fairly deep soil layers. The vegetation is chiefly small shrubs of mesquite, canutilla, yucca, and others, with a small amount of weeds and coarse grasses. In places, dune-like areas of the sand consist of grains of gypsum which look exactly like particles of siliceous sand. The Reeves gravelly soils occupy areas wherein the surface soil is composed largely of either rounded gravel (mainly of igneous rocks) or material consisting of broken fragments of hard, rock-like caliche. The gravelly soils cover large areas. The Rio Grande Valley gravel plain, consisting of very high benches of old valley-filled debris, is made up almost entirely of very deep beds of rounded gravel with very little soil material. The gravelly soils support a very thin growth consisting mainly of creosote bush with a few scattered shrubs and, in places, some lechuguilla, sotol, and other plants. Reeves chalk comprises deep beds of soft gypsum exposed to the surface or with only a slight soil layer. It occurs notably on Culberson Plateau and in Salt Basin. Vegetation is very scant, though a thin scattering of many shrubs occur with some Yeso grass and tussock grass in places where there is a thin layer of soil. Numerous depressions occur with deeper soils on which various other grasses also make a fairly good growth. The Reeves silty clay loam, deep phase, and the fine sandy loam are suited to a number of crops, and where irrigation water can be secured, fair yields of cotton, corn, many vegetables, alfalfa, sorghums, and various other crops are grown successfully. Some irrigation water, containing a considerable amount of soluble salts, has been used and found to cause an accumulation of soluble salts within the heavier soils where underdrainage is slow, and in some cases this has caused adverse conditions for plant growth. The greater proportion of the Reeves soils lies in large cattle ranches and is used only for the scant grazing afforded by the native vegetation.

Reagan Soils: The Reagan soils, already described as occurring in the Edwards Plateau, are also found in the Mountains and Basins region on the smooth, nearly flat, surfaces of the basins. Developed from old sediment, largely over gravel beds, they occur in the eastern and moun-

tain sections, where rainfall is slightly higher, and runoff water from the adjacent highlands provides more moisture than in the larger basin areas. Here the soils comprise light-brown calcareous surface soils grading below into light-brown or yellow calcareous subsoils which lie upon a bed of accumulated calcium carbonate. These soils are associated with the Reeves soils in places. They contain a larger amount of organic matter than the Reeves and are slightly darker. The desert shrubs are of only slight occurrence and several species of grama grass make a fairly thick growth. The silty clay loam (Fig. 79) and some gravelly soils occur, with some shallow phases. The soils are moderately productive and have free drainage. The deeper and less gravelly types produce good crops of various kinds under irrigation. Only a very small proportion of the soil is farmed. Practically all the land is used for grazing livestock, for which the moderately heavy growth of nutritious native grasses makes the soils well suited.

Verhalen Soils: The Verhalen soils consist of chocolate-brown or reddish-brown surface soils which grade below into red subsoils, and these, at a depth of about 3 to 5 feet, rest either on nearly pure, white calcium carbonate—hard in places—or on pinkish calcareous clay containing a large amount of the soft limy material. In places the soils and subsoils are calcareous. Verhalen clay and clay loam are the chief soils of the series and these occur in the basins, mostly near mountains or other highlands of igneous rocks. The surface is nearly flat and a typical thick growth of tobosa grass gives rise to the local term of "tobosa flats" for these areas. In many places the soils are so nearly flat that water stands for a long time after rains. Small amounts of these soils have been farmed by irrigating from wells and fairly good yields of a number of crops were secured. The heavy soils appear to be well suited to cotton, grain sorghums, alfalfa, small grains, and various other crops. Some gravelly and sandy soils of the series occur in small areas and these support a thin growth of shrubs and grasses.

Anthony Soils: The Anthony soils are light-brown in color. They grade beneath into yellow, crumbly subsoils, which in turn pass below into beds of rounded gravel at a depth of several feet. These soils occur on narrow terrace-benches in the Rio Grande Valley. These lie high above the bordering flood plains and do not cover extensive areas. The silty clay loam and some sandy and gravelly types occur. Practically none of the soils are cultivated, but with irrigation some of the heavier types would probably produce fair yields of various crops.

Mountain and Roughland Soils

The soils of the roughland areas are of slight extent, as erosion carries away the soil material before soil development occurs, leaving only thin layers and pockets of soil material on the rocks. The areas with slight soil development and not occupied by rough, stony land are included in two series,—the Brewster soils, developed from igneous rocks, and Ector

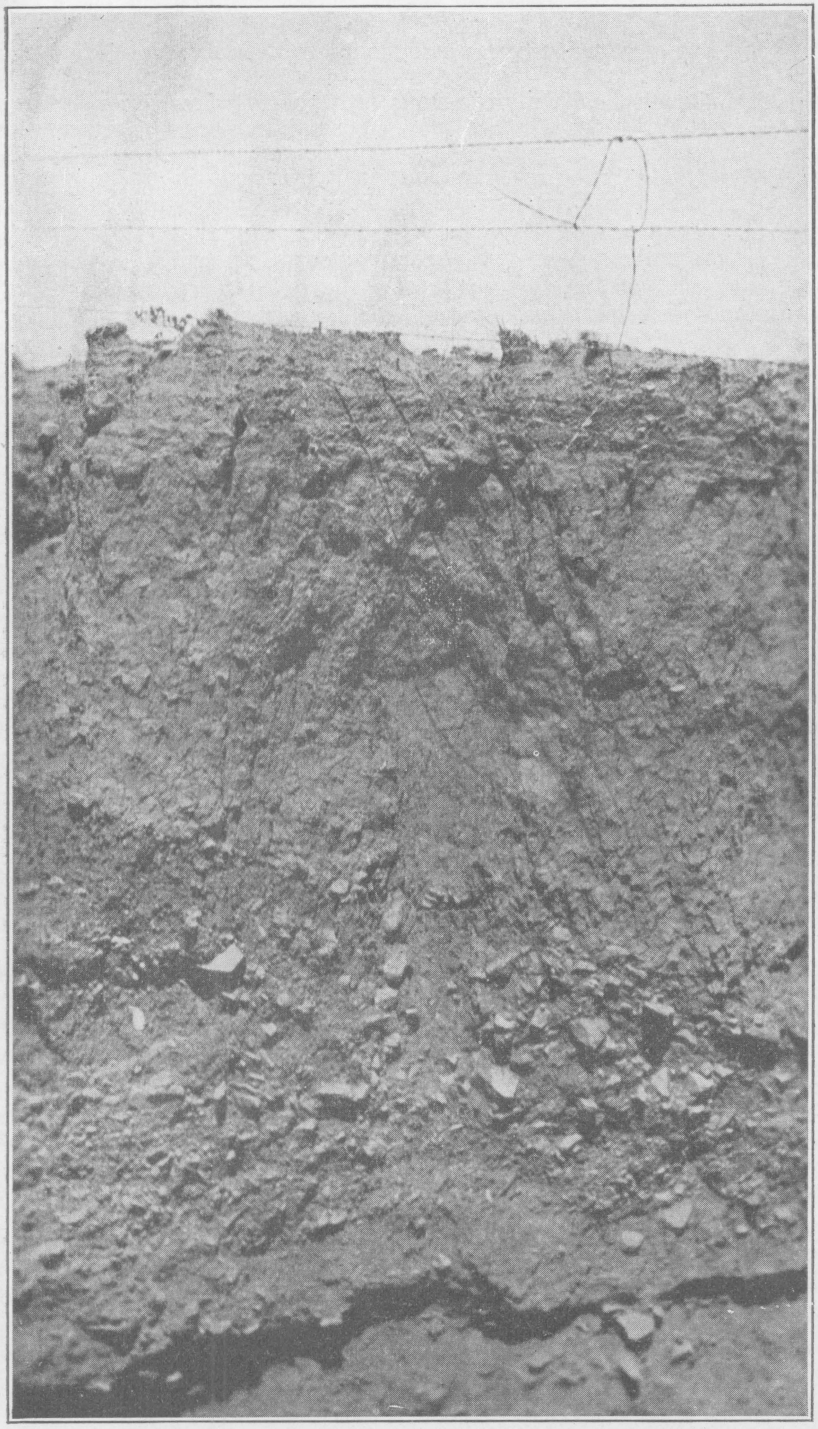

Figure 79. Soil profile of Reagan silty clay loam.

soils from limestone. Only the stony soil types of these series occur in this region.

Brewster Soils: The Brewster soils are red or reddish-brown in color. As only the very thin, stony soils of the series occur in this region the subsoils are not well developed and the shallow topsoil rests upon either bedrock or masses of broken rock fragments. In a few small areas occupying flat positions on mountains the soil is deeper than on the slopes and rests on thin layers of calcium carbonate caliche imposed on bedrock (Fig. 80). In fact, this accumulated carbonate occurs in places beneath the very shallow, stony soils as thin layers on the rock and as seams extending along cracks down in the bedrock. The prin-

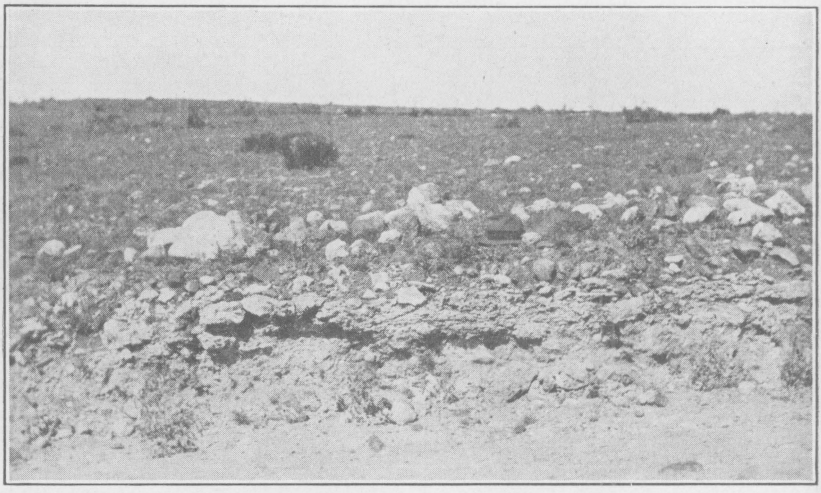

Figure 80. Soil profile of Brewster stony loam, showing layer of accumulated calcium carbonate resting on the igneous rocks. This is on smooth crest of Davis Mountains.

cipal type of the series is the stony loam. This occurs on the foothills and less rough areas of the igneous-rock mountains (Fig. 81). The soil is not calcareous. It is moderately rough and steeply sloping or very rolling. Surface drainage is very rapid and much of the rain water runs off. The slopes are denuded of soil material about as fast as the rocks are disintegrated by weathering. The broken rocks occupy the most of the surface and facilitate penetration of water into the small amount of fine earth that is held by the rocks. The soil, supporting a moderately heavy growth of grasses, of which some of the grama species are abundant, with some scattered small shrubs, is all in ranches and is considered a valuable grazing land.

Ector Soils: The Ector soils, already described as they occur in Edwards Plateau, are also found in large areas throughout the sections

of the region of Mountains and Basins. Here these soils occupy the less rugged limestone mountains and roughlands. However, only a very thin layer of the light-brown soil material remains on or in the rocks and this contains a large amount of small and fine-rock fragments. The Ector stony loam and stony clay loam are the chief soils of the series in the region. The principal natural vegetation comprises shrubs and woody plants consisting largely of sotol, lechuguilla, cacti, yucca, candelilla, cenizo, catclaw, buckthorn, and others. Guayule, the plant from which rubber is extracted, is found growing almost exclusively on these soils. Candelilla, a valuable wax producing plant, grows abundantly on the Ector soils in places. Although this land affords but a scant supply of range forage, it is all in large ranches. However, many small valleys and draws occur in which a

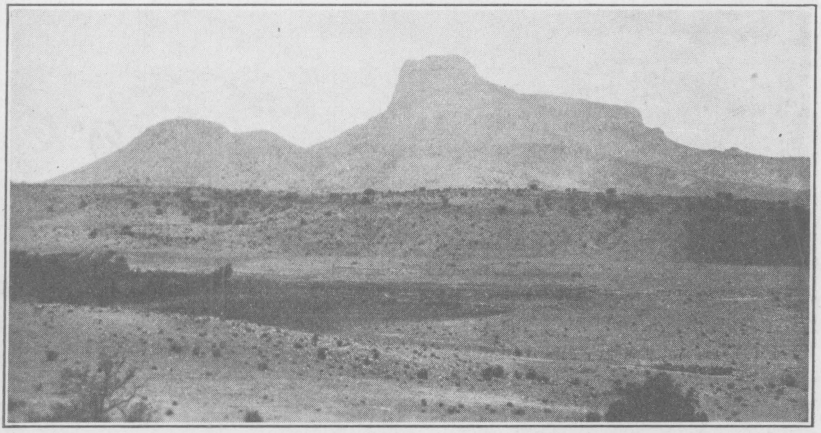

Figure 81. Brewster stony loam occupies the less rough areas of the igneous rock roughlands. Davis Mountains near Alpine.

deep accumulation of soil supports a fairly heavy growth of grasses and shrubs and these constitute a valuable addition to the pasturage.

Rough Stony Land: Under this designation is placed the very rough and stony mountain and hilly land on which occurs very little soil. The mountains, rising several thousand feet above the basins in many places, have steep slopes, some precipitous bluffs, narrow canyons and valleys, peaks and small areas of rolling table-lands surmounting the slopes of some of the highlands. Rock outcrops and cliffs of bare rock are prominent and the surface generally is occupied by large and small bowlders and rock fragments. Here there are two general kinds of Rough stony land, one made up of igneous rocks (Fig. 82), and the other of limestone (Figs. 83 and 84), each occupying large areas. On the igneous-rock formations there is considerable grama and other grasses, but on the limestone rocks grass is less abundant. Various

shrubs occur in all sections and in places oak, pine, and juniper trees grow. Nearly all the Rough stony land is used for livestock grazing, chiefly for cattle, but also for some sheep and goats. The igneous-rock land is considered more valuable for grazing than the limestone land on account of the more abundant growth of grasses.

Some mountain areas, too high, rough, and steep for cattle, are ranged over by goats.

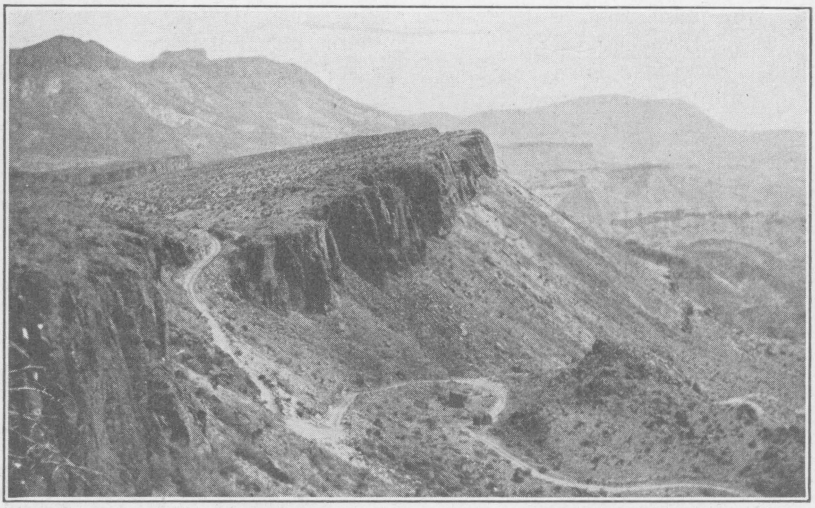

Figure 82. Rough stony land of igneous rocks. Chinati Mountains in Presidio County.

Rough Broken Land: This type of land consists of rough, eroded, and deeply gullied slopes and hills where most of the surface soil has been washed away leaving formations of bare clay, shale, or general debris of unconsolidated materials with little or no stony material. Such areas occur in some of the basins, the largest areas being located in the Big Bend section. This is a typical "bad land" condition, wherein very little vegetation occurs. The areas of this type of land are relatively small.

Alluvial Soils

The alluvial soils of the Mountains and Basins region, though not extensive, are valuable. The largest areas occur along the Rio Grande, the Pecos River, and in the local stream valleys. The alluvial soils lie in narrow valleys, and in the aggregate, constitute but a very small proportion of the total land area of the region. The soil materials making up the soils in the Rio Grande and Pecos Valleys have been transported from arid regions and some contain a relatively large amount of soluble salts, though where free drainage exists and irrigation water does not

contain a large amount of salts, excessive amounts are not accumulated. The soils are calcareous, deep, and contain moderate amounts of organic matter. Overflows are infrequent, as the waters are held largely under control in reservoirs on the upper reaches of the larger streams. Some of the soils have very slow drainage from either the surface or beneath.

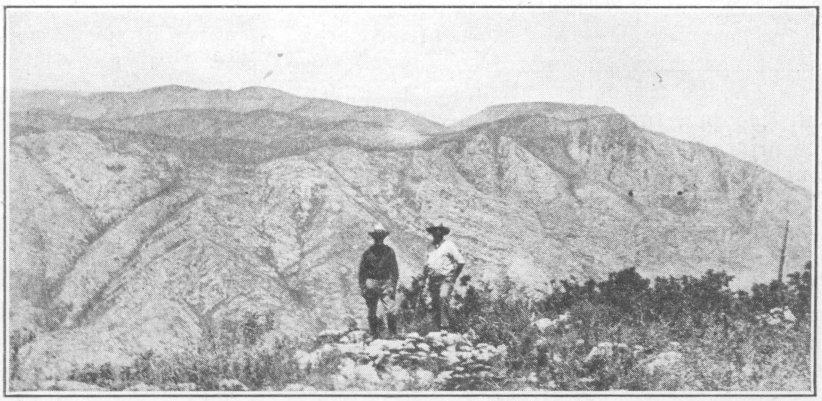

Figure 83. Rough stony land of limestone. Crest of Guadalupe Mountains from El Capitan Peak, the highest point in Texas.

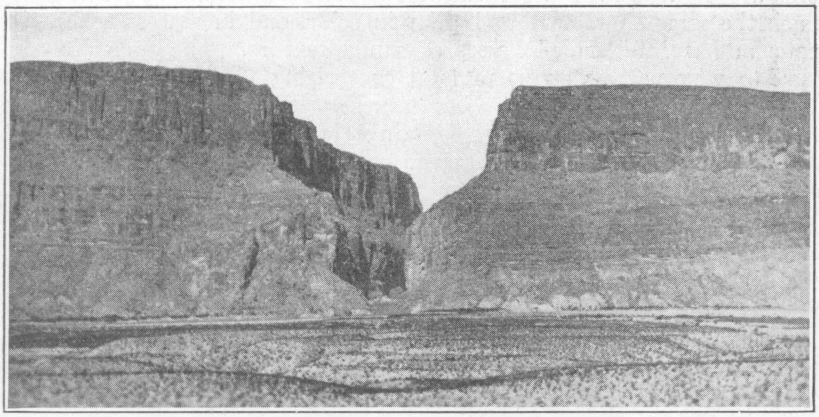

Figure 84. Rough stony land of Mesa de Anguila, a limestone ridge through which the Rio Grande has cut a narrow gorge 1,600 feet deep.

The soils of the Rio Grande Valley are prevailingly brown in color and belong in two series, the Gila and Rio Grande. Along the Pecos River they are light-colored or reddish and are of Pecos, Patrole, and Arno series. The local, narrow mountain valleys are occupied by dark soils of Toyah and Balmorhea series.

Gila Soils: The Gila soils comprise grayish-brown, light-brown, or brown surface soils grading below into subsoils of much the same color, though of slightly lighter shades. The soils are of friable structure, calcareous, and contain only moderate amounts of organic matter. Several soils are included in the series, these ranging from fine sand to clay. The fine sand and silt loams are probably the most extensive. The surface is smooth and drainage is moderately free except in some of the heavier soils in slightly depressed areas. Some of the soils contain an excessive amount of soluble salts in slowly drained positions or where the use of irrigation water has been excessive. By draining and flooding, the salts are sometimes removed and the land freed of the injurious accumulations. The Gila soils lie in strips of land one-fourth to two or three miles wide in the Rio Grande Valley in El Paso, Hudspeth, and Presidio counties. The soils are already utilized for farm crops by irrigation from the Rio Grande; the upper valley receives water from the Elephant Butte reservoir, while in the areas farther down stream it is secured from the river direct. The soils are quite productive and are suited to many crops. Cotton, corn, alfalfa, small grains, fruits, and vegetables are all grown successfully.

Rio Grande Soils: The soils of the Rio Grande series in this region are very similar to those located in the Lower Rio Grande Valley in the Rio Grande Plain, which have already been described. Here the soils are light-brown, deep, calcareous soils underlain by subsoils of much the same character but lighter in color, and in places the heavier material has interbedded layers of sandy texture. The soils are confined to very narrow strips of land comprising the flood plain of the river below the entrance of Los Conchos River from Mexico. The water of that stream does not contain a large amount of soluble salts and probably the sediments it transports are also fairly free of this material. This may account for the freedom from salts in the well drained soils along the Rio Grande below the confluence of the streams. Rio Grande soils are quite similar to Gila soils, but under natural conditions, contain much less of the soluble salts. The Rio Grande soils are quite productive and are utilized by irrigation from the river. The sandy and silty textures predominate. Many crops are successfully grown. The soils occupy only a few very small strips of land in the region.

Pecos Soils: The Pecos series includes dark-gray or grayish-brown soils with somewhat light-colored subsoils which, in places, are mottled with yellow and rusty-brown colors. The lower subsoils are of heavy, stiff, red clay which, in many places, contain crystals of gypsum. These soils occur in the narrow flood plains of the Pecos River and are not extensive. The surface is nearly flat and underdrainage is generally slow, especially beneath the clay type. The water rises within a few feet of the surface in the lowest areas. In places soluble

salts are abundant and artificial drainage is required to free them of these harmful constituents. The better drained soils with the lowest amounts of salts are farmed to some extent under irrigation from Pecos River. Cotton, alfalfa, grain sorghums, and other crops produce good yields under the most favorable conditions.

Patrole Soils: The Patrole series comprises ashy-gray soils underlain by lighter-colored subsoils which, in the lower part, rest on stiff, chocolate-red clay containing gypsum crystals. The surface is nearly flat and underdrainage is very slow. The soils and subsoils contain a high percentage of salts in places. The Patrole soils are located in the Pecos River Valley and are not extensive. They are used mainly for pasturage.

Arno Soils: The Arno series consists of soils that are light to dark chocolate-red in color that are underlain by chocolate-red, heavy clay subsoils, which, in places, contain layers of fine sand. These soils are nearly flat and have slow underdrainage. They are the most extensive soils of the Pecos flood plain but are not used much for farming. The soils require better drainage to free them of salts and thus render them more suitable for crops.

Toyah Soils: The Toyah soils have brown or light-brown surface soils underlain by brownish subsoils, which, at a depth of several feet, rest on beds of gravel. The fine sandy loam and silty clay loam are the chief soils of the series. The soils have free underdrainage and are highly productive. They are well suited to many crops and comprise the chief soils in the highly developed irrigation district at Balmorhea, where water from springs and from a reservoir containing impounded mountain storm water is used for irrigation. Cotton, corn, alfalfa, sorghums, and other crops are successfully grown. The valleys of Davis Mountains are occupied by Toyah soils. Small areas of Toyah soils in the narrow valleys of the Davis Mountains are used under irrigation from springs and wells to produce vegetables and fruits, and apples are produced commercially in a number of fine orchards (Fig. 85).

Balmorhea Soils: The Balmorhea soils have black topsoils with yellow or brown subsoils underlain by chalky calcareous clay. The Balmorhea clay is the chief soil. It contains a rather large amount of organic matter, and in some places, this is so abundant as to resemble a muck soil. It has a flat surface, but owing to gravel beds beneath, it has moderately free drainage. It is of slight extent and occurs in association with the Toyah soils and with them is used under irrigation for about the same crops. It produces good yields of various crops and is highly prized as an alfalfa soil.

Soil Utilization

Large areas of the soils of the region of Mountains and Basins are unsuited to growing farm crops on account of the very stony or gravelly condition. In the smooth-basin areas the soils that are well suited to crops are mostly unused because of insufficient rainfall or lack of water for irrigation.

The principal soils farmed under irrigation are the Gila and Rio Grande soils in the Rio Grande Valley; the Toyah and Balmorhea soils in the Madera Valleys and in the Davis Mountain valleys; the Pecos, Patrole, and Arno soils in the Pecos River Valley; and some Reeves soils in the Pecos Plain near Fort Stockton, Buena Vista, Imperial, Grandfalls, Barstow, and Pecos.

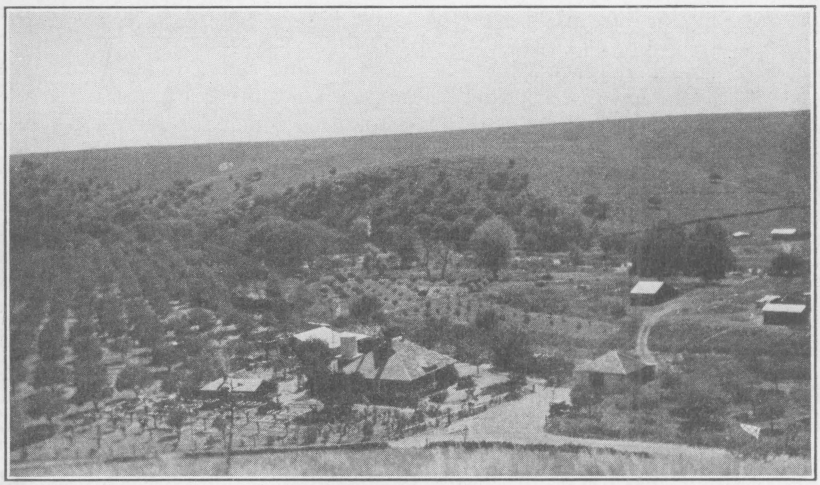

Figure 85. Apple orchard on Toyah soils in Limpia Valley near Fort Davis.

These soils range in texture from fine sands to clay and, therefore, are suited to many kinds of crops, but those of the heavier textures are somewhat stronger and better suited to small grains.

The principal crops grown on most of the soils are cotton and alfalfa. Many other crops are also grown, including vegetables, fruits, and wheat, on the Gila soils in the El Paso Valley, fruits and vegetables on the Toyah soils in the Davis Mountains, oats on Reeves soils near Fort Stockton and Barstow, and cantaloupes and other truck crops on Reeves soils near Pecos. Corn and many other crops do well on these soils under irrigation; cotton leads in acreage.

Where underdrainage is very slow, salts accumulate in some of the soils to the point where crops are injured, especially where the irrigation water contains a rather high percentage of the salts. Soils that have had a high accumulation of these salts in places are the heavier

soils of the Gila series and soils of the Pecos, Arno, Patrole, and Reeves series. The injurious salts have been washed out of some of the soils —mainly some of the Gila soils—by flooding the land and allowing large amounts of water to stand on the surface and pass through the soil until the salts are dissolved and leached out. Also, by artificial drainage in places the soils have been rendered less susceptible to salt accumulation. The Toyah, Balmorhea, and Rio Grande soils have not accumulated much of the salts, as they have good underdrainage, and also are mostly irrigated by water that has a low percentage of the salts. The Reeves silty clay loam, deep phase, is farmed and irrigated from springs near Fort Stockton and there has been no injury from salts, but this soil and Reeves fine sandy loam, and also Pecos, Patrole, and Arno soils, irrigated from Pecos River when the water in the stream is low, are all sometimes adversely affected by accumulation of salts.

The Reeves silty clay loam and gravelly loam are shallow and not generally suited to producing high yields of crops, even with irrigation, and are practically unused for farming. The Verhalen clay loam and clay, Reagan clay loam and Reeves silty clay loam, deep phase, are productive soils on which various crops could be grown more largely if water for irrigation could be secured. Probably some areas of these and other soils could be irrigated from wells or from reservoirs built to impound storm water.

All of the mountains and roughlands, as well as most of the basins and plains soils, are utilized for stock raising. The soils and Rough stony land of igneous rocks, with the associated valleys, are the best suited for livestock because of the heavier growth of nutritious grasses. Cattle are grazed in practically all sections but the soils of Brewster and Reagan series and associated roughlands of igneous rocks support a large number per unit of land (Fig. 86). Sheep also do best on

Figure 86. Hereford cattle grazing on Reagan silty clay loam, near Alpine.

these soils but they adapt themselves to rougher lands not so well suited to cattle. Many sheep are raised and ranged in various sections but the largest development of this industry is at present in the Davis Mountain region and vicinity. Goats do well in the roughland areas and valleys owing to their ability to browse over the roughest lands and adapt themselves to deficiencies in water supply, and are raised in some of the more inaccessible areas. Ranching on the soils and Rough

stony land areas that support a good growth of grasses is highly successful, and the ranch lands are well fenced, watered, and equipped with good buildings (Figs. 87 and 88).

In a region of light rainfall, it is surprising to observe the large

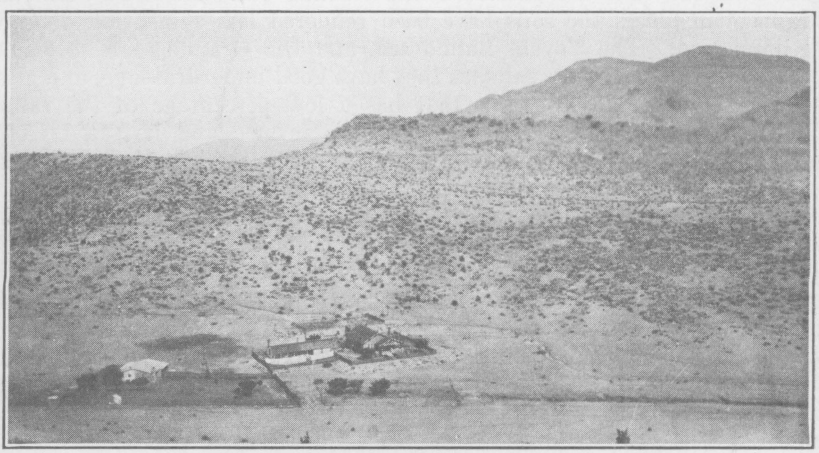

Figure 87. Typical ranch home at the east edge of Chinati Mountains.

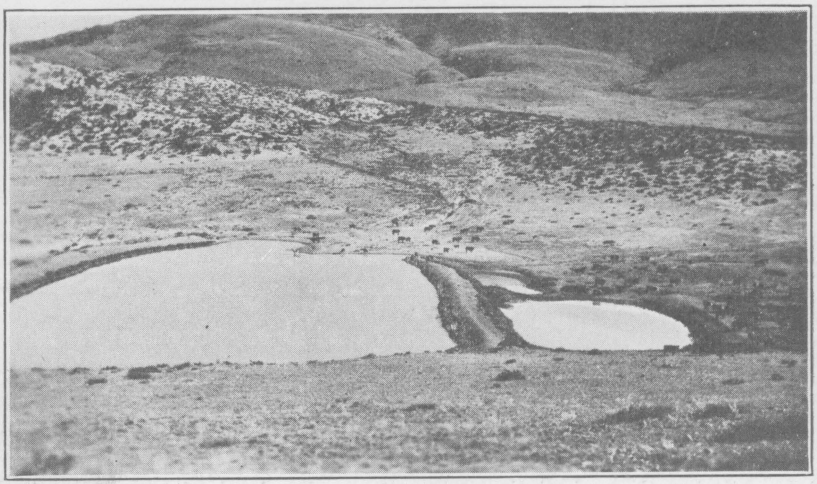

Figure 88. Storm water is collected in earthen reservoirs for the use of livestock on the ranches in Davis Mountains.

amount of rain water that is lost by runoff, with the consequent severe soil injury caused by erosion. Much of the rain falls in sudden, dashing thunderstorms at seasons when the soils are dry and hard. The hard soils, even on gentle slopes, do not quickly absorb the short de-

luges of water and the moderate vegetative cover does not greatly check the flow. Therefore, a large proportion of the natural supply of water is lost, and in passing off the land it rushes down old stock trails, roads (Fig. 89), and other worn places and gouges deep gullies, which become larger during every rain. In this way considerable areas

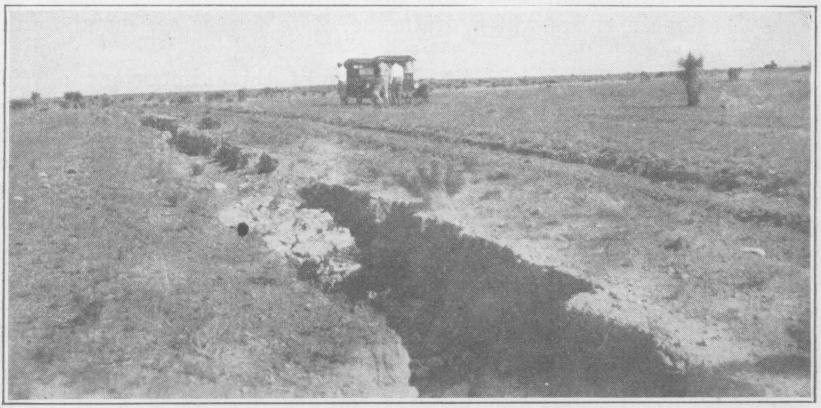

Figure 89. Through erosion, gullies quickly form in roadways on the nearly flat soils, and if these are not checked much valuable grazing land is destroyed.

formerly comprising good grassland have been denuded of a large amount of soil and rendered almost useless for grazing or for any other purpose.

A few ranchers have demonstrated the value of conserving the water by an adaptation of the old temporal system of irrigation where by the construction of earthen banks the runoff water has been diverted to smooth grasslands. This has been found an effective means of increasing the growth of range grasses (Fig. 90) and also reduces the damage caused by erosion.

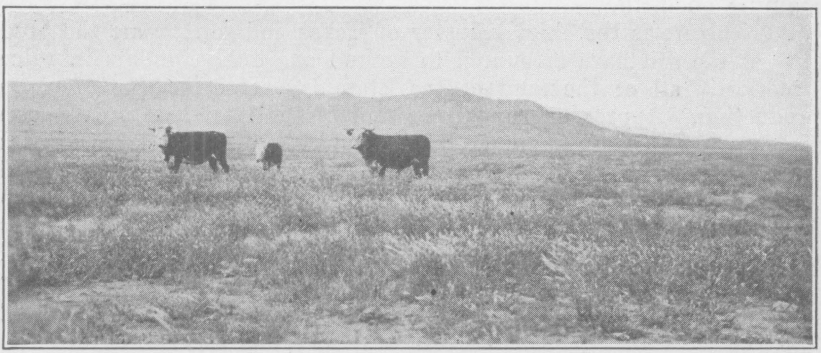

Figure 90. This heavy growth of valuable range grasses has been produced by watering the land with runoff rainwater deflected from gullies by constructed earthen banks.

SUMMARY

Texas has a land area of about 168,000,000 acres. The surface is mostly smoothly rolling, though in various sections nearly every form of land relief occurs, ranging from nearly flat to hilly and mountainous. From sea-level at the coast the surface rises gradually northwestward to more than 4,000 feet above on the plains 600 miles distant. The main rivers which drain the State pursue a general southeasterly course.

Texas is occupied mainly by divisions of three important physiographic provinces of continental scope: the Coastal Plain in eastern and southern Texas; the Mountains and Basins region of the extreme western part; and the Great Plains constituting a vast area between these. These provinces in Texas are naturally divided into 11 smaller regions, each characterized by distinctive features of surface relief, soils, and natural vegetation.

The natural vegetation of Texas consists of timber, mainly confined to large eastern areas, bunch-grass communities on the humid prairies and sandy plains, and short grasses on the heavy soils of the plains. Desert shrubs characterize the arid basin lands of the west.

The climate of Texas, subtropical in the Coast sections, becomes gradually cooler passing northward, and 600 miles distant the High Plains areas, with an average yearly temperature of around 56° F., have a frost-free growing period averaging only about 175 days a year. Precipitation in the extreme eastern part, averaging around 50 inches a year, decreases gradually westward to about 10 inches in a distance of little more than 500 miles. The State is naturally divided into four north-south moisture belts determined by the supply of available soil moisture, which is reflected by the developed characteristics of soils and by the types of natural vegetation. The eastern belt, the humid region, occupies approximately two-fifths of the State; the subhumid, immediately west, covers an area of about equal size; while the semiarid and arid regions in the extreme west include the remaining one-fifth.

Agriculture is the chief industry of Texas and some years the products of the soil have amounted to around one billion dollars in value. Practically all of the land of the State is useful for some form of production. Approximately 20 per cent of the total land area is used for farm crops, the remainder being used chiefly for stock raising and timber products. Cotton is the chief crop and is grown in nearly all farming sections. Corn is grown largely, though grain sorghums are grown instead over large western areas. Small grains, chiefly wheat, oats, and barley, are important crops in the central and northwestern sections, and rice is grown in the southeastern section. Truck crops, including many vegetables and fruits, are grown universally and by specialized effort in some sections. Citrus fruits are produced in the extreme southern sections. Range cattle are raised over great areas

of the west and to some extent in eastern sections. Goats and sheep are raised in large numbers, especially in Edwards Plateau and other western roughlands.

The soils of the State are of many kinds. They include all textural classes from sand to clay, though fine sandy loams, clay loams, and clay textures predominate. The humid region of Texas is occupied by Pedalferic soils, while those of the other regions are of the Pedocalic group. The Pedalfers, developed under conditions of relatively abundant moisture, are leached and the normal soils are free of calcium carbonate except on eroded calcareous parent-materials where the imperfectly developed soil layers still retain a portion of the limy material. The soils known as Pedocals are developed in regions of limited moisture and the normal soils are characterized by the presence of a layer of calcium carbonate within the soil profile. These two major divisions of soils are made up of soil series which consist of a number of soil types differing chiefly in the texture of the topsoils. Soil surveys in various parts of the State have established more than 100 series of soils, which include over 500 soil types that have been classified and mapped. The many soils have a wide range in degrees of productiveness and in suitability to crops.

Each of the 11 regions in Texas is occupied by related groups of soils having characteristics and features that have been determined by the regional and local factors of soil development, which are chiefly, the character of surface relief, climate, natural vegetation, and parent-materials.

The Coast Prairie, a nearly flat coastal belt of some 8,000,000 acres, includes large areas of smooth, productive soils, largely unused in the eastern part because of high rainfall and slow drainage. The chief soils are of Lake Charles, Edna, Katy, Hockley, Harris, and Galveston series. The Lake Charles soils are dark-gray to black and mainly represented by the clay soil. The Edna, Katy, and Hockley soils are light-colored soils, mostly fine sandy loams with dense clay subsoils. The Harris soils are low, wet, marshy or semi-marshy soils of the coast fringe, while the Galveston soils, mainly light, fine sands, are confined to coastal borders and islands. The Lake Charles soils are highly productive and on them is grown much rice, cotton, corn, truck crops, and figs. The Hockley, Katy, and Edna soils are less productive but are cultivated to some extent. The Harris and Galveston soils are not well suited to most crops. The most productive soils of this region require more drainage for their best use.

East Texas Timber Country comprises (with East Cross Timbers) an area of about 26,000,000 acres in eastern Texas. The upland surface is undulating to rolling and is occupied by two general divisions of soils: (1) light-colored, fine sandy loams and fine sands with friable or crumbly clay subsoils, mainly of the Kirvin, Bowie, Norfolk, Ruston, Caddo, and other series, with some red soils of the Nacogdoches series; and (2) light-colored soils with dense, heavy clay sub-

soils, chiefly of the Susquehanna and Lufkin series. All of these soils are of moderate productiveness, the dense subsoil group being generally somewhat less suited to most crops. The soils are susceptible to improvement and fertilization. Many of the soils are subject to severe erosion. The chief crops grown on the many farms are cotton, corn, truck crops, and fruits. The better soils are well suited to vegetables and fruits and moderately well to cotton and corn.

The Blackland Prairies comprise some 11,000,000 acres of dark soils in eastern Texas. These consist largely of soils of the Houston series, which are black calcareous granular soils naturally of high productiveness. Smaller areas of Wilson soils also occur, and these, though productive, are not calcareous and on drying become hard and crusted, thereby being more difficult to cultivate. The clay textures predominate and Houston black clay occupies the main part of the main prairie while the Wilson and Crockett soils are more abundant on the minor prairies. The soils of the Blackland Prairies are very extensively used for the production of cotton with smaller amounts of corn and small grains, to all of which these soils are well suited.

Erosion has injured much of the soils of this region, and the inherent productiveness has been greatly reduced in many places by this agency of soil destruction.

A very large proportion of the soils is used for cotton, making this the most important cotton-producing region of the State.

The Grand Prairie reaching from central to northern Texas comprises an area of about 7,000,000 acres. The soils, chiefly of dark color, are developed over hard limestone strata and in many places are shallow or stony, while associated areas of rough limestone hills and slopes also occur. The San Saba (black) and Denton (brown) soils are the most extensive, while the Crawford (red) and Brackett (brown or light-colored) are less abundant. The clay soil types prevail. The soils, where deep, are quite productive and are used chiefly for wheat, oats, cotton, and various feed crops. Stock farming and ranching occupy the less productive and stony lands, cattle and sheep comprising the principal livestock.

West Cross Timbers is a region of about 7,000,000 acres in extent in northern Texas. It is covered with oak timber with some prairies on the western margin and some isolated prairies within the timbered areas. The timbered soils are chiefly sandy soil types of Windthorst and Nimrod series, the former having red and the latter yellow subsoils. The prairie soils are mainly heavy soils of Denton, Brackett, and other similar series.

The Windthorst and Nimrod soils are largely cultivated and produce moderate yields of cotton, corn, grain sorghums, peanuts, truck crops, and fruits. The heavy prairie soils produce cotton and the small grains mostly. The stony rough land areas are used for range livestock.

The Central Basin occupies a relatively low area of about 2,000,000

acres in central Texas, wherein the soils, largely of shallow and stony character, have been developed chiefly from crystalline rocks, and in places from limestone or sandstone. These soils are generally of red color, and where deeply developed, are quite productive, but the shallow and stony soils are of low productiveness and are used mostly for range livestock. On the better soils the land is used mainly for the production of cotton, sorghums, and other feed crops, and for some oats and wheat. The better agricultural soils are chiefly the fine sandy loams of the Tishomingo, Pedernales, Katemcy, and Lancaster series.

Rio Grande Plain comprises the wedge-shaped area extending from the south-central to the most southern point of the State. It consists of a smooth undulating to rolling plain of about 22,000,000 acres. The soils, of many kinds, are characteristic of subhumid conditions and are of five general groups. The dark soils, largely of Victoria, Goliad, Orelia, and other series occupy important areas, are highly productive and the texturally varied soils are suited to many different crops.

The red soils consist mostly of sandy soil types of Duval and Webb series. These are productive soils suited to cotton, sorghums, truck crops, and fruits. The light-brown soils of Uvalde, Maverick, and Zapata series are largely thin and shallow, and best suited to grazing, but where deeply developed they are very productive. The light-colored soils comprise sandy soils mainly of the Brennan and Nueces series and are of moderate productiveness and suited to cotton, feed crops, vegetables, and fruits. The semi-marshy coast lands are of the Lomalta and Point Isabel series and are generally not well suited to crops.

The Rio Grande Plain lies in a region of light rainfall and in the western part irrigation is necessary to insure successful farming. Cotton, the chief farm crop, is grown extensively on the dark soils and red soils, and grain sorghums, sorgo, and other feed crops do well. Truck crops and fruits are important crops on many of the soils, especially where irrigated. Citrus fruits are grown successfully, largely in the Lower Rio Grande Valley, where the fine sandy loams of the Victoria, Hidalgo, Willacy, Duval, Brennan, and some other less important series seem to be the best suited. Large areas of almost all of the soils, especially in the western part, are used only for raising range cattle on large ranches.

The Edwards Plateau, a high greatly dissected limestone plain of central-west Texas, comprises about 22,500,000 acres of rolling to hilly land occupied mostly by dark shallow stony soils and Rough stony land. In the eastern section the plateau reaches well into the humid region and the soils are mainly of Denton, San Saba, and Brackett series. The central section lying within the subhumid climatic belt has dark soils mostly of the Valera series. The western section is characterized by brown and light-brown soils chiefly of Ector and Rea-

gan series. Rough stony land and shallow stony soils are extensive in all sections. The clay and clay loam soil textures are prevalent. Only in the eastern part, mainly the eastern section and the eastern part of the central section, is rainfall sufficient to permit farming. The deeper soils, though not of great extent, are used in places for the production of cotton, wheat, oats, and sorghums, and various other feed crops, to all of which the soils are well suited, and good yields are secured where soil moisture is adequate. The soils of the region support a growth of valuable grasses and browse plants and the land is all in ranches, on which are raised cattle, sheep and goats. This region is especially well suited to sheep and goats, and large amounts of wool and mohair are produced.

The Rolling Plains, an important agricultural area of about 24,500,000 acres, is in northwest Texas. The surface is undulating to rolling and some is quite hilly and broken. Large areas are occupied by red or reddish-brown soils, of which the fine sandy loams predominate. Of these the Vernon, imperfectly developed from Red Beds, comprise red calcareous soils that have been severely cut by erosion in many areas. The Miles soils, also developed over Red Beds and from unconsolidated clay and sandy beds, are more deeply developed and are generally noncalcareous in the upper layers. A smaller proportion of the region is occupied by a group of dark soils, of which the Abilene, Roscoe, and Foard are the main series, with clay loam and clay soils predominating. The deeper soils are largely used for cotton, sorghums, and various feed crops with considerable wheat, oats, and barley also produced on the soils of clay loam and clay textures. Successful agriculture has been made possible by the productive drought-resistant soils. A very great proportion of the region is in large cattle ranches, and all of the less suitable farm land as well as large amounts of deep productive soils provide range for livestock. The soils, especially of the Vernon series, are subject to very injurious erosion.

The High Plains comprise a high plateau-like, very smooth area of 21,000,000 acres in northwest Texas. The principal soils are of the Pullman, Richfield, and Amarillo series. Of these, the clay loams occupy the most of the northern half of the region and the sandy soils, chiefly of the Amarillo series, the southern. The soils are highly drought-resistant and the clay loams are largely used for small grains (mainly wheat), grain sorghums, and some cotton, while the heavier sandy soils consisting largely of Amarillo fine sandy loam are used extensively for cotton, grain sorghums, and various other feed crops.

The region of Mountains and Basins comprises the extreme western part of the State, having an area of 17,000,000 acres. The nearly flat plains and basins are of arid character while the associated mountains receive slightly more rainfall and support a better growth of grasses. The soils of the basins are light-colored and mostly of Reeves series, with some darker-brown and red soils of Reagan and Verhalen series.

The mountains and highlands are largely of Rough stony land, with the less rough areas of igneous-rock formation occuped by red soils of Brewster series, and the limestone lands of the Ector soils. Cattle ranching, with some sheep and goats, comprises the chief use of the soils and roughlands. Some of the alluvial soils and smooth basin areas are farmed where water for irrigation is available. Cotton, alfalfa, truck crops, and fruits are the chief crops.

The alluvial soils of Texas are agriculturally important. These are of soil materials which have no developed characteristics, but on the basis of their outstanding features they are divided into seven groups.

The Ochlockonee-Bibb group comprises gray and brown noncalcareous soils along the streams of eastern Texas. They consist of soil materials washed largely from light-colored noncalcareous upland soils. The Trinity-Catalpa group includes dark calcareous soils along streams draining dark prairie soils developed upon limy formations. The Miller-Yahola-Pledger group consists of red or reddish-brown calcareous soils made up of soil materials washed largely from the Red Beds of the plains. These occur chiefly in the valleys of the Rolling Plains and in the valleys of Red, Brazos, and Colorado rivers extending across other regions. The Frio-Spur-Leona group is of brown and gray soils in valleys receiving drainage from the brown soils of the plains and from Edwards Plateau. The Harlingen-Gila group consists chiefly of brown, gray, and reddish soils along the Rio Grande and Pecos Rivers composed of soil materials transported from arid regions which because of imperfect drainage have in places an accumulation of salts. The Rio Grande-Laredo group, also occurring along the Rio Grande, are brown soils of soil materials transported from arid regions, but under natural conditions they have sufficient drainage to prevent accumulation of salts. The Toyah-Balmorhea group are brown and black soils consisting of soil materials in the valleys of the west receiving deposits mainly from the igneous-rock mountains and rough lands.

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