

A BACKGROUND STUDY OF SOIL SURVEY AND THE CHARACTERIZATION
OF SOME OKLAHOMA SOILS BY THEIR MORPHOLOGIES
AND THEIR PRODUCTION OF COTTON

By

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Bachelor of Arts

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Plainview, Texas

1955

Submitted to the faculty of the Graduate School of
the Oklahoma Agricultural and Mechanical College
in partial fulfillment of the requirements
for the degree of
MASTER OF SCIENCE
May, 1957

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383172

ACKNOWLEDGEMENTS

The author wishes to express gratitude to Dr. Fenton Gray, major adviser, for inviting me to work on this problem, which has proved to be so interesting, and for giving supervision along the way; to Mr. Harry Galloway, my "professor in the field," whose intimate knowledge of the soils of Oklahoma has been indispensable in the preparation of this paper; to Ruel Bain, fellow member of the team gathering data on key soil types of Oklahoma, whose aid and encouragement have been most valuable; to Dr. John Green and Dr. Lester Reed for the use of cotton yield data in their care; to other members of the Agronomy staff and to fellow graduate students for additional advice, criticisms, and information; and to the Agronomy Department for financial aid and for making this study possible. A special note of thanks is also given to Miss Carole Hoover, typist.

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CHAPTER I

INTRODUCTION

Soil survey involves the technique and practice of soil classification; it is the act of describing, identifying, and mapping the different soil areas. The recording of other research, chemical, and physical data is a part of the program, as also is the interpretation and use of the completed maps and reports.

There exists a dual need of making more profitable use of agronomic research and proper utilization of each acre of Oklahoma's soils. Both are concerned with efficient production of needed crops and the future productivity of the soil. Each phase can be aided by the judicious use of the detailed soil survey maps and reports.

The objective of this study is to promote a wider understanding of soil survey and a greater use of its findings by bringing together in one paper (A) a background history of soil survey, a broad view of what has been done and the criteria of mapping which have been evolved, (B) the fact that soils do not just happen, the five factors concerned with making any soil what it is, and (C) a characterization of some Oklahoma soils, what they are and how they react.

This is a preliminary study and is presented as a part of a greater project of compiling morphological, chemical, and physical data on key soils in Oklahoma to aid in the classification of these soils. These data will be used to supply information leading to the most efficient use of each soil type, issuance of recommended management practices for

each soil type, issuance of average and potential yields for each soil type, and recognition of conservation needs of each soil type.

CHAPTER II

METHODS AND PROCEDURES

Original papers, United States Department of Agriculture and agricultural experiment station publications, private correspondence, in-service literature for soil survey, and county soil survey reports were used to establish the history of soil survey as a practice and of agencies responsible for conducting this work. These sources were used as cross-references to correct errors common to historical documents.

Text books, original papers, and USDA publications were reviewed to obtain a comprehensive view of soil formation and reasons for variation in soils.

Maps, original papers, county soil survey reports, unpublished material from the Oklahoma Experiment Station, conversation with widely experienced personnel, and observation in the field were used to describe the soil areas of Oklahoma and to characterize the soils given.

Morphological features were taken from published and unpublished data of the Oklahoma Experiment Station where the profile was previously described. Other profiles were described in the field using standard soil survey methods; this work was done by a team of which the author was a member. The team was responsible for collecting morphological data on out-state plots where Agronomy Department personnel have or have had experimental plots. The soil features observed were recorded on soil data forms and filed according to soil type.

Cotton yield data were obtained from experiment station reports,

both published and unpublished, cotton variety study reports, and from raw data from experiments on experiment station plots and on out-state plots.

CHAPTER III

BACKGROUND STUDY

History of Survey

Man has always recognized local soil differences. Especially since he began to till the soil he has seen the variation in color and in productivity and he observed that some areas are more easily tilled than others.

As men began to travel they saw recurring likenesses and differences in soils and began to study these patterns. The oldest record of such study is a classification of soils based on color and structure by Yu, a Chinese engineer, some 4,000 years ago (4). Most of the early systems of classification were based on single features such as texture or color and had only local significance. Later systems have been based on geology, geography, vegetation, or chemistry.

It was reported by Coffey (14) in 1913 that American soil surveys began in 1820 with a geological survey at Albany County, New York. This work was undertaken for the Agricultural Society of Albany County and a classification of soils was included. Similar, geologically inclined soils maps of other regions followed. The early geologists agreed that the bulk of the soil is composed of broken fragments of disintegrated rock, so it was natural to infer that the soil of any region could be known by the rock from which it was formed. The important soil maps of this country began with Emmons and his Natural History

Survey of New York, Part V, Agriculture, 1846. This work contains a lengthy discussion of the characteristics and properties of the soils of New York and also an agricultural map of that state. In 1854, Owen and Peters pioneered the systematic study of the soils of the country by means of chemical analysis. Hilgard's geological map of Mississippi, 1860, and E. A. Smith's geological report for Alabama, 1882, gave valuable information concerning the physical properties of the soils of each state. Chamberlain's soil map of Wisconsin, 1882, was the first published in this country based on the physical properties of the soil itself.

Soil mapping in the United States received its greatest impetus with the entry of the government into this field. After a few years under another department, the Division of Soils was organized in the United States Department of Agriculture in 1899, with the responsibility of conducting the National Soil Survey. Milton Whitney was the pioneer head of this project, and the foundation which he laid has come to be the most comprehensive system of soil classification and mapping in the world (28). Curtis F. Marbut, who served under and succeeded Dr. Whitney, established basic criteria for soil identification and thus developed a consistent and logical system of soil classification. He advanced soil survey from an empirical procedure to a scientific discipline (28). Under Charles E. Kellogg, the basic understanding of soils has increased and soil maps have been improved, but Dr. Kellogg's greatest contribution has been in the area of interpretation and use of soil maps. The National Soil Survey has been under various agencies and is now a part of the Soil Conservation Service of the USDA.

The first detailed soil survey in Oklahoma was conducted in 1905

when Oklahoma County and a small area near Tishomingo was surveyed. There was no further mapping until 1914 when Bryan, Muskogee, Canadian, Roger Mills, Kay, and Payne were mapped during the four-year period extending to 1918. These surveys are now out-of-date. Intensive surveying was resumed in 1930 and has been conducted sporadically since. At the present, standard county soil survey reports with detailed maps are available for 25 counties:

Alfalfa	Kiowa	Pittsburg
Carter	Le Flore	Pontotoc
Choctaw	Major	Texas
Cleveland	Mayes	Tillman
Craig	McIntosh	Tulsa
Garfield	Murray	Washita
Grant	Noble	Woods
Greer	Okfuskee	Woodward
Harmon		

A report of slightly different nature with a soil association map is available for Wagoner County. Work is now progressing toward the publication of maps and reports for Logan, Creek, Pawnee, Harper, Jackson, Cimarron, Beaver, and Commanche counties. Unpublished detailed soil conservation surveys and standard soil surveys are locally available for a large portion of Oklahoma.

Present Criteria of Classification and Mapping

The taxonomic units by which soils are progressively divided are: Order, Sub-order, Great Soil Group, Family, Series, Type, and Phase. The first three are collectively called higher categories and the latter four are the lower categories. This concept is under critical review by soil scientists at the present time and a new system based on more nearly on the factors in the soil itself is being proposed (20).

The Order refers to the normality of the soil profile. Soils are

classified according to the relationships of their profile characteristics to the characteristics of the soil normal to that zone. It is well established that definite relationships exist between soils and the biotic and climatic environments under which they have developed (35).

If the nature and arrangement of the various horizons of a soil reflect the mature stage of development under its particular environment it is placed in the Zonal Order. The Intrazonal Order includes those soils with strongly developed horizons, but with some abnormality which hinders plant growth; this may be the presence of salt, alkali, or calcium carbonate; it may be an excessively high water table, or it may be a cemented horizon. The Azonal Order includes youthful soils which do not yet reflect the full effect of the soil forming factors of the region in which they are found.

The Soil Sub-orders are broad categories which include soils with similar characteristics and genesis. They are given descriptive names in terms of general characteristics, for example, Light-colored soils of the timbered regions; there are genetic and regional inferences in these names (35).

The Great Soil Group is the most useful of the higher categories, because it is possible to indicate many specific facts about each of the soils included. The names such as Tundra soils, Reddish Prairie soils, or Brown Podzolic soils carry definite connotations. This category is sometimes used in small scale mapping to indicate the general character of zonal soils by regions of a nation or continent.

The Family is, at present, a poorly defined category grouping soils with similar horizons and developed from parent materials of similar nature. It is intermediate in generalization between the Great

Soil Group and the Series; therefore, the number of specific, fundamental soil profile features used will be intermediate.

The most important taxonomic unit is the Soil Series, defined as a group of soils having horizons similar in their distinguishing characteristics and developed from a particular type of parent material (29). Except for texture of the A horizon, the morphological features of the soil profile, as determined in the physical characteristics, thicknesses, and arrangement of the soil horizons, do not vary significantly within a series. These characteristics include especially structure, color, and texture (except the texture of the A horizon), but not these alone. The content of carbonates and other salts, the acidity or alkalinity, and the humus content are included with the characteristics which determine the series. The series name suggests a mental picture of a soil profile to a person familiar with that series. While the soil series is not used alone as a mapping unit, it is the foundation unit from which more specific units are divided.

The texture of the A horizon or plow layer is the basis for differentiating series into types. The soil series name is combined with the textural class to give the soil type. While it is possible for a soil series to have a complete range of types, there are generally not more than two or three; many series are monotypes. Because the surface texture of a soil is so important to its use, the permissible types within a series is becoming more restricted.

The phase is a subdivision of the soil type. Its properties must therefore be within the defined range of the soil type and series. Phases are separations within a soil type on the basis of characteristics, which, although significant to the use of the soil by man, have

little or no significance in the genesis of the soil. Although there has been too little consistency in the past in deciding whether to recognize a phase or establish a new series, such features as variations in slope, degree of erosion, stoniness, and thickness of alluvial deposits have customarily been used to separate phases within a soil type (29).

The soil mapping unit as placed on published maps depends on the intended use and the scale of that particular map. While it is possible to use the soil phase as the cartographic unit on a large scale map, referred to as a detailed soil map, it is more common that compromises must be made. Such compromises are the inclusion of alien soil types within the mapping unit. No separation is made if it is too small or lacking in sharply distinguishing characteristics to be utilized separately by the farmer.

A common mapping unit for small scale maps is the soil association. This is a flexible unit collecting broad areas of closely associated soils which have been developed in similar kinds of parent material and which strongly reflect the combined influences of climate and vegetation in their development. Individual members of an association may vary widely due mostly to land slope and length of time they have developed. On very small scale maps the association may include soils developed from different kinds of parent material but which lie in association with one another.

The criteria by which different soils are distinguished follow closely the pedological soil characteristics as listed by Marbut in 1920 (15):

1. Number of horizons.
2. Color of the various horizons, with special

emphasis on the surface one or two; or where color denotes reduction or change in parent material.

3. Texture of the horizons.
4. Structure of the horizons.
5. Relative arrangement of the horizons.
6. Chemical composition of each horizon.
7. Thickness of each horizon.
8. Geology of the parent material where significant.
9. Mineralogical content of the soil material.
10. Relative landscape position.

These characteristics are determined in the field by trained experts; laboratory analyses are used as supporting evidence when necessary.

Factors of Soil Formation

Soils are individuals by reason of the complexity of their formation. Any given soil is a three-dimensional, natural living body which has characteristics of its own. It is the result of climate and living organisms modifying the parent material on a particular slope over a period of time or, as stated by Kellogg (21), since the soil is a synthetic product of climate, living matter, parent rock, and relief, acting in time, each different combination of these will produce a different soil.

Parent material is any mass of material which contains the products which can be converted by the other soil forming factors into a soil body. It is geologic material weathered in place or eroded and deposited in a new position. It is not soil, rather it is the material from which soil is made. The parent material may not exert a large influence on a mature soil, due to the influence of the other soil forming factors. In general, though, we may say that the texture of the soil is largely determined by that of the material from which it developed. Soil color, pH, mineral content, and nutrient availability are

often functions of parent material.

Topography as a factor of soil formation is an arbitrary designation; actually, it is a condition influencing in many important ways the other factors of soil formation. Through the transportation agents of water and gravity it aids in the accumulation of soil parent material, or it prevents the formation of deep A horizons on steep slopes. It also affects the amount of moisture available for soil development; a slight difference in kind of slope or its gradient may alter the depth and color of the solum, the sharpness of the horizon distinctions, and the presence of various concretions. The direction of the slope is of considerable consequence; southern exposures are warmer and drier and are subjected to greater fluctuations in temperature and moisture (19).

In relation to soil formation, time is one of the more important factors in all processes. This is more than to say that it takes time for climate and living organisms to transform a mass of rock debris into a soil. Useful statements regarding the rate of soil development cannot be made in terms of years because some soils have formed very rapidly and others exceedingly slow (10). Evidence can occasionally be seen within a profile that it is passing from one equilibrium to another. Each soil goes through a process of evolution; the soil goes through stages of youth, maturity, and old age.

Climate and life are the two in one factors of active soil formation which utilize the passive factors in the continual process of soil genesis (20). Each phase of both factors is a complexity within itself.

Moisture, as one of the primary elements of climate, is largely responsible for the features of a soil body. It does its work through

solution and hydration of mineral matter, translocating substances in solution and in colloidal state from one point in the soil body to another, and through mechanical transportation of larger particles of soil both vertically and horizontally. The amount of percolation also affects the level of ground water and in turn has an effect on the movement of salt into and out of the profile. With increasing moisture and vegetative growth there is increasing humus in the soil (18). In evaluating the effect of precipitation on soil formation, consideration must be given to seasonal distribution and intensity of rainfall, atmospheric humidity, land slope, and texture of the parent material.

The obvious effect of temperature is that of modifying moisture levels and the activity of living organisms. Through its direct influence on decomposition rates, temperature controls, to a large extent, the humus content of the soil (18). Temperature also has a mechanical action; frost heaving may keep the horizons stirred, and alternate freezing and thawing is thought to be a factor in the formation of granular structure.

As a factor of soil formation, winds are of direct importance in connection with the moisture component in their influence on the evaporation rate. The importance of their mechanical action is an inverse function of moisture; the cutting action of wind-borne particles and the transportation of soil parent material is great in arid regions. Since wind impoverishes one region of material transported to another, it is usually thought of as a soil destroyer rather than a soil former.

The larger plants act directly and indirectly in soil formation. Their roots penetrate into the lithosphere where they act mechanically on the rock and mineral material. Acid secretions from the roots aid

in the chemical break-down of rocks and minerals. Old root channels serve as drainage and for accumulation of suspended material. By their metabolic functions plants transfer mineral substances from the soil profile or parent material to the surface. The organic complexes resulting from life become an intimate part of the soil. Typically, soils formed under grassland vegetation tend to have deep profiles high in organic matter and base content, while temperate zone forest soils have more distinct horizons, are acid in reaction, and have accumulation of iron and aluminum in their subsoils.

Earthworms not only mechanically stir the soil and transport particles, but they also ingest large amounts of soil material and plant debris which they leave behind as castings. Their channels also serve as routes for percolation of water and for aeration. In local areas ants and termites are of considerable importance in their tunneling and building of underground storage bins. The work of rodents, moles, gophers, prairie dogs, badgers, etc. is similar to that of worms and ants in mixing soil horizons and in leaving passages open for deep formation.

Soil microorganisms are active in decomposition of organic debris, synthesis of new organic substances, aiding in formation of granular structure, and making plant nutrients available. The chemical activity within the soil, both organic and inorganic, is largely the function of soil microbes (36).

Geological Areas of Oklahoma

The area of Oklahoma has had a varied geological history. Great periods in which it was lifted have been altered with those in which it

stood near or below sea level, and when it was dropped well below sea level (32). Those periods are reflected by the type of deposits and their relation to one another. Generally, the dip of the rock is to the west, or once-level deposits lie further above sea level in their eastern extensions. On the other hand, the surface elevation varies from above 4,000 feet in the panhandle area down to less than 500 feet in the southeastern corner of the state.

The land surface in the Ozark region of northeast Oklahoma is a broad, strongly dissected cherty plateau dominantly of Mississippian deposits. The rough Ouachita mountains and valley area south of the Ozarks is underlain by bedded Pennsylvanian rocks; the valleys were formed in shale members, the mountains in sandstones. A detached mountain area, the Arbuckles, resulted from an igneous uplift; exposing Mississippian limestones and shales. To the west this same uplift produced the Wichita mountains of granite which broke through the surface of the plains.

South of the Arbuckles and Ouachitas is a wooded sandy plain through which run long narrow limestone and calcareous clay deposits supporting tall grasses. These are Cretaceous coastal plain sediments which extend westward to about the center of the state.

West of the Ozarks and Ouachitas is the eastern prairie plain or Cherokee Prairie which is mostly on Pennsylvanian shales with local limestones and is broken in many places by low wooded sandstone ridges. This extends west to a more rugged area of sandstones usually called Cross Timbers.

The Cross Timbers, a much discussed area well recognized by the early travellers because of the difficult terrain and scrubby timbers,

is underlain by both Pennsylvanian and Permian sandstones. The characteristic small open prairies are formed on more clayey deposits of the same ages. The area extends west to Caddo County in the central part of Oklahoma.

A second broad plain, the Reddish Prairie, extends west from the sandstone belt and is formed on Permian age clay beds and fine grained sandstones locally overlain by loess. This grades westward to a more rugged country termed Rolling Red Plains, which extends into the breaks of the High Plains.

The extreme northwest part of the state and the panhandle is called the High Plains and is a broad, smooth area covered by loose loamy Tertiary deposits of high lime content and characterized by calcareous breaks and broad, almost level interstream divides. Locally there are thick smooth loess deposits of wind-blown sands in low dune tracts.

Among all of Oklahoma's major rivers are belts of loose Pleistocene materials. Sandy loams and sands occupy north sides; loams and silt loams, the south sides. These belts widen noticeably from the center of the state westward. In places they are found without apparent relation to present streams.

Soil Resource Areas of Oklahoma

Soils of the Ozark Highlands are light-colored, deep, cherty silt loams with reddish, cherty, clay loam subsoils, many of which have excessive drainage. The chert makes these soils droughty except where land slopes are gentle and deep subsoils are found.

In the Ouachita Highlands the soils of mountain slopes are usually light-brown, stony, sandy loams, and many are quite shallow. The valleys

are of deeper foot slope and alluvial soils of light-brown sandy loam, the subsoils are reddish to yellowish clay loam or sandy clay. The soils in the southern portion of this area are sometimes used for the production of cotton and will be discussed in greater detail later.

The Grand Prairies around the Arbuckles are areas of shallow and deep, dark clay loams fairly high in organic matter with dark clay subsoils over medium-hard limestones and limy shales. There are considerable bodies of shallow, stony land similar to the central mountain itself. Some cotton is grown on the smooth bodies of soil in this region.

The Wichita mountains form a disjointed chain from Lawton to Granite on which there is almost no soil except in narrow valleys between the ridges. Some alluvial outwash has occurred to the south but this is limited, and its effect on soils is not great. A few soil areas occurring on these materials are of coarse, brown loams over gravelly clay subsoils.

The forested portions of the Coastal Plains have light-colored acid, sandy soils with yellowish and reddish sandy clay subsoils. The grassed limestone and shale areas are locally called Grand Prairie and consist of two major kinds of soil. One is a nearly-black, strong granular, calcareous clay of high organic matter content over marls and shales; this is sometimes referred to as Black-waxy soil. The other kind is acid silt loam with clayey subsoils developed on neutral to alkaline clay beds and shales. Many areas on favorable slopes are used for cotton production.

The Cherokee Prairies have weakly acid, brown, granular soils with clayey subsoils. On indigenous sandstone ridges are soils similar to

those in the Cross Timbers. On limestones and calcareous shales are dark, granular, weakly-acid clay loams with olive-brown mottled subsoils; limestone escarpments are common. Many of the soils are used for cotton in the portion south of the Arkansas River.

The soils of the Cross Timbers are mostly shallow, light-colored, and sandy. The smooth ridges and footslopes have deep soils with light-brown, sandy loam surfaces and reddish to yellowish clay loam or sandy clay subsoils. These are not as strongly leached as the forested soils to the east and south. The soils of the prairie openings occurring on the finer textured rocks are like those of the prairies near which they occur; those on the east side like Cherokee Prairie soils, and those to the west like the soils of the Reddish Prairie. Cotton was once widely grown throughout this entire belt but its production is now largely limited to the southern portion.

The Reddish Prairie soil resource area has brown to reddish brown, slightly acid loamy soils with nearly neutral to alkaline clay or clay loam subsoils. Through it are many bodies of shallow soils. This too was once an important cotton producing area but most cotton is now grown on the smoothest uplands south of the Canadian River.

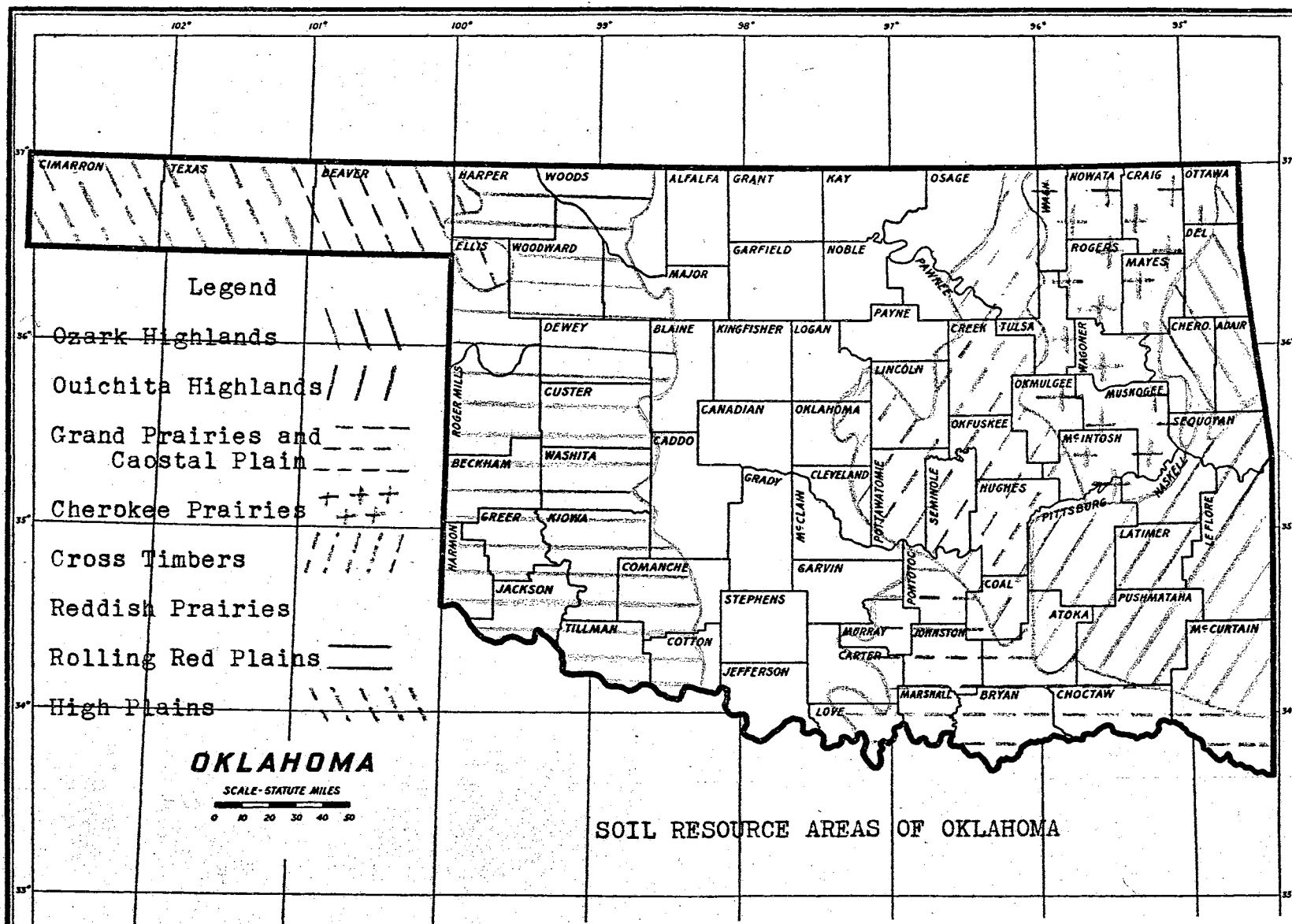
The transition to the rougher area of the Rolling Red Plains is very gradual, the main difference in soils being that they are less leached, have neutral reactions and lime carbonate accumulations in the subsoils. The southern two tiers of counties is underlain mostly by clayey deposits and has the smoothest terrain; this is probably the most important cotton area in the state. North of this, the land is rolling, soils are developed in sandy shales and sandstones, and the cotton is in smaller blocks. There is a greater amount of shallow soil

and a tendency toward ranching and wheat farming. Cotton is almost completely restricted to land south of the South Canadian.

Soils of the High Plains are mostly dark-brown, neutral loams and clay loams with alkaline to calcareous clay loam and clay subsoils. Caliche layers are common except on the most sandy soils which have loamy sand and sandy loam surfaces and loam or clay loam subsoils usually leached of free lime and about neutral in reaction. Cotton production is not attempted except under irrigation and the crop is seldom grown in the Oklahoma portion of the High Plains.

Soil areas on the unconsolidated mantles of sandy loams and loams bordering the rivers are very important croplands. They usually occupy terrace-like areas or are undulating to gently rolling. Loamy textured soils are brown and granular and have clay loam subsoils. Those in the east are leached and moderately acid while the western members are only slightly leached, are neutral to alkaline, and have weak profile development. Sandy soils are light-brown, granular to loose loamy sands and sandy loams with reddish to brownish clay loam and sandy clay subsoils. Leaching is more intense on these and weak acid soils extend westward past the middle of the state. Important areas in the extreme west part appear unrelated to the present stream pattern and seem to be on outwash from the receding front of the Tertiary cap. These soils are the most leached of the western part of the state and have lower phosphate and base saturation than soils around them.

Youthful soils built on alluviums and unconsolidated mantles high in weatherable minerals are very important to agriculture throughout Oklahoma. Cotton is grown on them even where it is not common on the surrounding uplands. The nature of alluvial soils is extremely variable

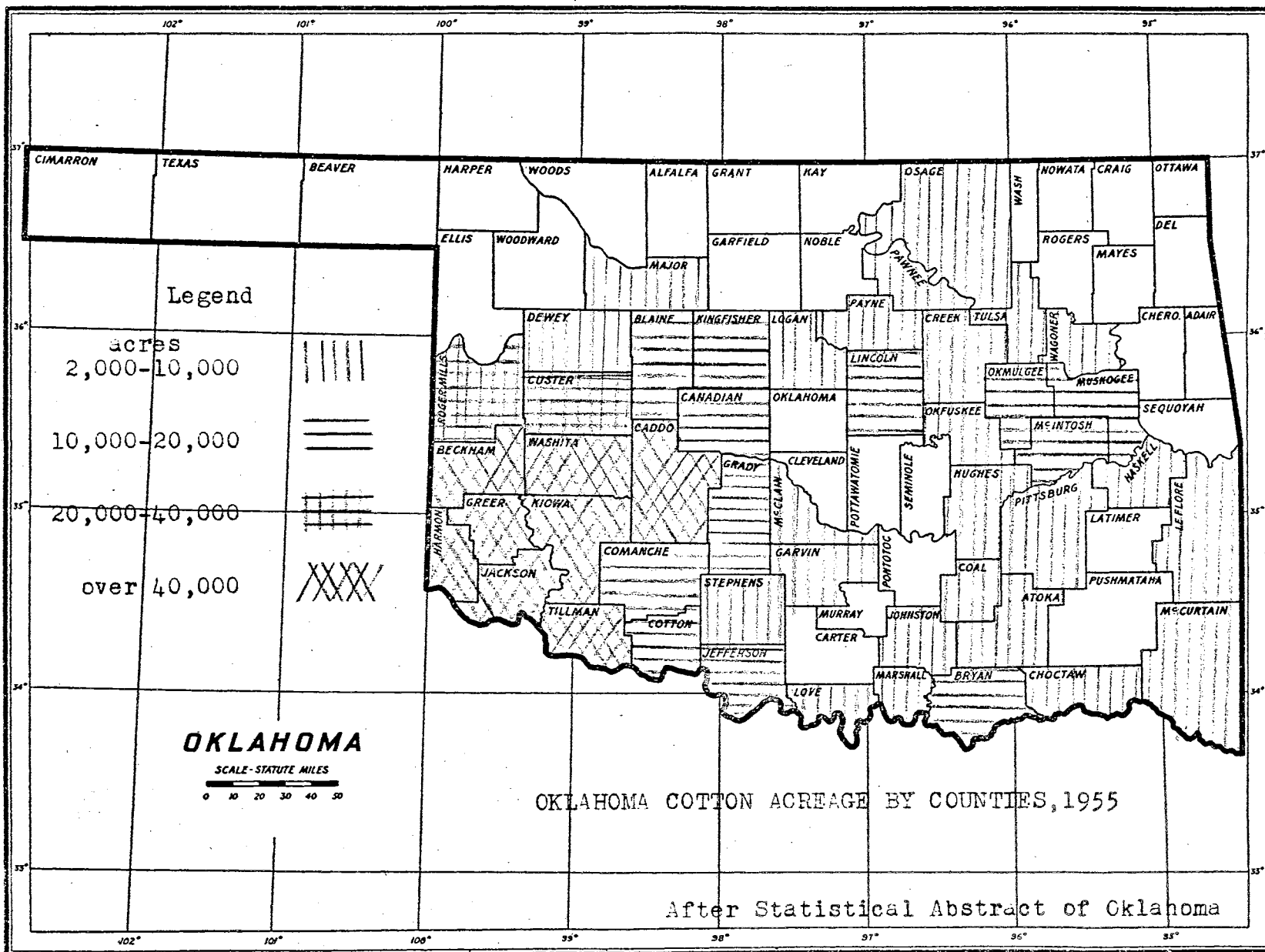


from place to place and within any given profile; the texture of a deposit depends on its source and the relative speed of depositing waters.

Where Cotton Is Produced

Present Oklahoma cotton acreage, as shown by Plate 2, is now confined largely to the southwestern portion of the state. Reasons for this distribution, other than original soil differences, are many and varied. Among these are the longer growing season in the south and the larger, more economic size of fields in the southwest. As economic conditions and farming habits change, the cotton acreage pattern may be still further altered.

Hector, Cleburne, and Conway are the major upland soils of the Ouachita Highlands used for cotton production. As southeastern Oklahoma cotton production decreases, upland acreage of the crop is practically limited to Kirvin and Bowie in the Forested Coastal Plains and Durant, San Saba, and Denton in the Grand Prairies. Most of the upland cotton grown in the Cherokee Prairies is on Dennis, Bates, Parsons, Okemah, and Taloka. Cross Timbers upland soils used for cotton production are Stephenville and Dougherty. Important soils of the Reddish Prairies for cotton production are Renfrow, Kirkland, Bethany, Zaneis, Cobb, Vanoss, Mineo, Norge, Canadian, Chickasha, Brewer, and Teller. Soils of the Rolling Red Plains on which cotton has been grown in considerable amounts are Tillman, Foard, Carey, Woodward, St. Paul, Dill, Enterprise, Tipton, Abilene, Brownfield, Hollister, and Miles. Considerable cotton is produced throughout the state on alluvial and mantle soils such as Miller, Yahola, Verdigris, and Pope of the east and Dale, McLain, Reinach, Canadian, Yahola, and Port in the central and southwest.



CHAPTER IV

RESULTS

The soils discussed here are limited to those investigated in a general study of Oklahoma soils upon which field research trials are being or have been conducted. They are limited to those soils on which precise cotton data are available. The location, use, morphology, and production of cotton will be given along with a brief discussion of each soil.

San Saba Soils

San Saba soils are located in the Grand Prairie region of Oklahoma as well as larger areas in Texas. They are part of broad open prairies and are on broad gentle slopes with gradients usually less than two percent. The original vegetation was tall and mid grasses; the land is now used for general farming with summer row crops predominating.

San Saba clay is often referred to as a Black-waxy soil, having a shiny dark-gray to black surface horizon. This is often 16 inches thick and is characteristically granular, friable, calcareous, and high in organic matter. Lying under this is a horizon of dark-gray clay which is weak coarse granular, calcareous, stiff and sticky, but relatively permeable; this horizon is extremely variable in depth, its lower edge being wavy due to the pressures from deep cracking on drying and subsequent swelling from deep within the profile on wetting. The

parent material is Cretaceous age marl, soft limestone, or calcareous shales.

Cotton variety tests were conducted two miles east of Caddo for five years, 1951-1955, J. H. Joines cooperating. A spot location profile of this San Saba clay with one to two percent slope is given on page 1 of the Appendix. As no fertility treatment was made, this is considered a medium level management for this soil type. The average for recommended varieties for the five years was 339 pounds of lint per acre.

San Saba soils are high in native fertility and their "self swallowing" nature should aid in keeping them relatively fertile for long periods to come. The high exchange capacity of these soils makes it quite unlikely that they would respond to light applications of fertilizer. While these soils are easily managed, mismanagement has led to considerable erosion.

Okemah Soils

Okemah soils are found principally in the Cherokee Prairies and the eastern portion of the Reddish Prairie. They are developed from Pennsylvanian shales and clays on gently rolling erosional upland. The surface is weakly convex to plane and the gradient is dominantly one to two percent. The vegetation was once tall grass; the present use is for general farming.

The A horizons of Okemah soils are about 14 inches of dark-gray silt loam which is weakly granular, friable, slightly acid, and grades through a broad transition which becomes browner and heavier with depth and may be divided into two transition horizons. The B horizon is

mottled olive-yellow and light-gray clay which is blocky to about three feet and massive below, hard when dry and sticky when wet, very slowly permeable, mildly alkaline, and grades to the C horizon at about four feet. The parent material is mottled light-gray and brownish-yellow clay with interbedded siltstone and sandstone.

Cotton fertility tests were located on the Earl Franklin farm one-half mile east of Council Hill in 1954, 1955, and 1956. They were dominantly on Okemah heavy silty clay loam with a 16 inch A horizon and one percent gradient. Some of the area was transitional to Parsons and some to Dennis. Fertility response tests were of two different types but seemed to indicate favorable response to potassium and also to nitrogen and phosphorus when there was sufficient moisture. Under a high level of management, cotton following cowpeas and receiving various rates of fertilizer, cotton produced an average of 348 pounds of lint per acre.

Okemah soils take up water readily for a while but water moves through the profile quite slowly. There is difficulty due to excessive water only in extremely wet periods. Okemah soils are relatively droughty. It is not a responsive soil to light applications of fertilizer.

Kirkland Soils

Kirkland soils occur in the Reddish Prairie soil resource area but are somewhat darker and more strongly developed than more modal members of the region. They are upland soils found on broad, smoothly rolling plains with weakly convex slopes and gradients of one to two percent. The vegetation was once dominantly tall grass; heavily used pastures are

now short and mid grasses. Smooth fields are now used for general farming of small grains and row crops.

The surface horizon is usually 10 to 12 inches of dark-brown or grayish-brown silt loam which is moderate medium granular, friable, slightly acid, and which rests abruptly on the B horizon. The B horizon is usually about two feet of dark-brown to dark-grayish-brown clay. It is blocky, very firm and becomes alkaline with depth; it often becomes less dense at about 30 inches. The B horizon grades slowly through a zone increasing in red color and lessening in structural development to a parent material of weathered red bed clay. There may be calcium carbonate concretions scattered through the subsoils.

From a 40-year cotton fertility study, 1917-1956, on plots 4100 to 8100 of the Agronomy Farm west of Stillwater come these results on Kirkland silt loam with eight inch A horizons and zero to one percent slopes:*

	Pounds lint per acre
Low level management	
Continuous cotton, no treatment237
Medium level management	
Continuous cotton, all residue returned plus 150 pounds 0-20-0 annually since 1931.249
Rotation cotton, annual legume, and wheat, No treatment.252
High level management	
Rotation cotton, annual legume, and wheat, average of all plots receiving phosphate.296
Proved potential	
Rotation cotton, annual legume, and wheat, 150 pounds gypsum, 5 tons manure, and 500 pounds rock phosphate applied once in rotation, 1933701
Cotton on plot 2100 produced 303 pounds lint per acre when fertilized with three tons of cotton burrs every third year.	

*For complete profile see Appendix, p. 52.

When in good tilth, the surface will absorb water fairly readily but movement of water through the clay subsoil is very slow, therefore the surface intake of moisture is limited. Under optimum conditions the clayey B horizon may take up and store water but it retains its moisture tenaciously; its resistance to plant root growth also tends to make Kirkland droughty to summer crops. Phosphorus is often the limiting nutrient. Kirkland is not highly responsive to fertilization. The use of winter cover and green manure crops has depressed average yields of continuous cotton (30).

Norge Soils

Soils of the Norge series are found principally within the Reddish Prairie zone on mantles of old alkaline alluvium or loess. The topography is nearly level to gently sloping upland; Norge soils are usually developed on convex surfaces with gradients of one to four percent. These soils were once covered with tall and mid grasses; they are now used for general farming and are especially suited to the production of summer row crops.

Norge soils have surface horizons of about 12 inches of brown to reddish-brown loams which are weakly granular, friable, and neutral to weakly acid. They grade through a broad transition to horizons of red to reddish-brown sandy clay which is weak blocky and sometimes prismatic, firm, slowly permeable and extends down to about 40-44 inches. The transition to the parent material is broad and the parent material itself is stratified yellowish-red or red sandy clay or sandy loam and neutral to calcareous.

Data from nine years, 1947-1955, of the cotton fertility study on

series 1000 and 1100 of the Perkins Farm nine miles south of Stillwater gave the following results on Norge loam with 12 to 16 inch A horizons on one to two percent slopes:*

	Pounds lint per acre
Low level management	
Continuous cotton, no fertilizers	308
Medium level management	
Continuous cotton, 200 pounds 4-12-4 per acre	370
Rotation 4 years alfalfa and 4 years oats, barley, cotton, and darso, limed	360
High level management	
Rotation 4 years alfalfa and 4 years of oats, barley, cotton, and darso, limed, residual from 40 pounds P_2O_5 applied to alfalfa.	452
Proved potential	
Rotation 4 years alfalfa and 4 years of oats, barley, cotton, and darso, limed, residual from manure (80 pounds N) and 40 pounds P_2O_5 , 19531190

Vanoss Soils

Vanoss is a series of somewhat youthful soils found on mantles in the Reddish Prairie region. They are developed on aeolian or alluvial sediments well above, and often removed from, present flood plains. The topography is nearly level to very gently rolling; Vanoss is developed on plane to weakly convex surfaces with gradient usually less than one percent. The original vegetation was tall grasses; the present use is general farm crops, especially summer row crops.

Vanoss soils are less red than the often associated Norge and Teller soils. The surface horizon of about 15 inches of brown or gray-brown loam, which is granular, friable, and slightly acid, grades slowly into the B horizon of brown clay loams. This horizon is coarse granular and blocky, friable to firm, and very permeable for its fine

*For complete profile see Appendix, p. 53.

texture; this general horizon may be subdivided as it becomes coarser in texture and more nearly neutral in reaction. At about four feet it passes slowly into the parent material which may be stratified. This is often yellowish to reddish fine sands, loams, or clays, friable and slightly acid to alkaline.

A cotton variety test was conducted on Vanoss loam on zero to one percent slopes located on series 3800-4100* of the Perkins Farm, nine miles south of Stillwater, for the 13 years of 1944-1956. Under a low level of management, continuous cotton and no fertility treatments, the recommended varieties averaged 286 pounds of lint per acre.

Vanoss soils are well aerated, have good internal drainage, and have adequate moisture storage. They are relatively high in weatherable minerals, yet they should be responsive to proper fertilization. The use of winter cover crops in favorable moisture years should lead to improved yields and help maintain good soil structure.

Teller Soils

Soils of the Teller series are rather youthful soils found on old alluvial mantles or stream terraces in the Reddish Prairie region and elsewhere in east and central Oklahoma. The topography is gently rolling, the surface being plane to convex with slopes usually less than five percent. The original vegetation was deciduous forest; primarily, it is now used for summer grown row crops.

Teller soil profiles are characterized by having about 10 inches of brown, very fine sandy loam which is weakly granular and very friable and which grades slowly into two feet of reddish-brown sandy clay

*For complete profile see Appendix, p. 54.

loam which is also granular and friable. This grades to the parent material which exhibits various degrees of stratification and is usually neutral to alkaline while the solum is slightly acid. The parent material shows considerable weathering to about six feet.

Cotton variety tests were conducted on the Austin Livesay farm, three miles west of Broken Arrow, for five years, 1951-1955. Rye and vetch were plowed down in the spring and 100 pounds of 5-10-5 was applied at planting time. The soil was Teller fine sandy loam on about two percent gradients. The average yield for recommended varieties was 633 pounds of lint per acre.

Being youthful, Teller soils contain moderate amounts of weatherable minerals, and so are relatively high in native fertility. Their low buffering capacity and favorable moisture relationships, however, make them quite responsive to fertility amendments. These soils give positive yield response to the use of winter cover crops. Care must be taken to avoid excessive water erosion.

Reinach Soils

Reinach is an alluvial series found in the Reddish Prairie soil resource area and westward. These soils are usually found on low terraces above the flood plain of streams that carry sediments from the subhumid plains to the west. Reinach soils occupy extensive areas of these nearly level terraces and are associated with other soils such as McLain. The vegetation was once tall and mid grasses with scattered trees; it is well suited to general farming, especially the production of summer row crops.

The profiles are deep and change little with depth except for

accumulation of organic matter in the upper 16 to 18 inches. The surface horizons are usually reddish-brown loams, granular, friable, permeable, and neutral. The parent material is redder and more alkaline; it may become calcareous at about three feet and contains occasional streaks of lime below that.

In a nine-year cotton variety study, 1948-1956, on the Chickasha cotton experiment station, with continuous cotton and no fertilizers, a low level of management, Reinach silt loam with zero to one percent slopes* produced an average of 378 pounds lint per acre.

Reinach is freely but not excessively drained. It is not droughty but probably would respond to carefully timed irrigation. It is inherently fertile due to the relatively unweathered deposits from which it developed. Reinach should be responsive to proper fertilization under irrigation.

Port Soils

The Port series composes youthful soils that are found on bottomlands throughout much of the Reddish Prairies and Rolling Red Plains. They are developed on local alluvium in flood plains of streams draining subhumid plains underlain by red bed clays and sandstones. The topography is broadly level but undulating. The vegetation was once mixed deciduous forests or tall and mid grasses. The Port soils are now used for general farming with heavy emphasis on alfalfa production.

Being developed from alluvium, Port soils exhibit stratification in most profiles. Usually the A horizon of about 12 inches is brown to reddish-brown heavy silt loam, granular, friable, neutral, and

*For complete profile see Appendix, p. 55.

passes shortly into the parent material deposits. These deposits will average reddish-brown in color and loam in texture; there is seldom an impervious layer of any thickness to interfere with drainage. The parent material is granular, firm to crumbly, alkaline clay loam or loam.

During the five years, 1952-1956, cotton variety tests were conducted one and one-half miles south of Webbers Falls on Port silt loam, with A horizons 10 to 16 inches thick on zero to one percent slopes, E. L. Cude cooperating. One year the tests were possibly on Reinach silt loam and two years they were located on a phase of Port silt loam with a substrata that is more clayey than usual. A relatively high level of management was followed by rotation of crops and the use of 300 pounds of 3-9-18 per acre. The average production of recommended varieties was 466 pounds lint per acre.

The moisture relations are excellent. The inherent fertility is moderate, but Port soils respond well to moderate applications of fertilizer. They should respond favorably to the use of winter cover and green manure crops.

Zaneis Soils

Soils of the Zaneis series are some of the medium textured members of modal Reddish Prairie soils. They are found on erosional upland with slopes usually between one and four percent gradient. The land once supported tall and mid grasses; on areas not cultivated, the shorter grasses now predominate. Most Zaneis soils are cultivated, however, and lend themselves to general farming.

A horizons of Zaneis soils consist of about eight inches of brown to reddish-brown loam or fine sandy loam which is granular, friable,

permeable, and slightly acid. This grades through about six inches of light clay loam to the B horizon which is typically reddish-brown clay loam, granular and weak prismatic, firm to friable, slowly permeable, and neutral to about two feet where it becomes redder, the peds are larger, and it is slightly more permeable. After passing through another broad transition, the parent material is found at about 40 inches. This is characteristically red, shaly, sandy clay or interbedded clay shale and fine grained sandstone and is neutral to alkaline in reaction.

Records for 25 years, 1930-1954, from the Red Plains Conservation Experiment Station at Guthrie show relative soil and water loss with and without legumes in rotation when cotton rows are run down a steep slope. The soil is Zaneis loam of variable depth with a surface gradient of about eight percent; the upper end of the plot is quite shallow and the lower end is overlain with erosional debris. No fertilizer was used the initial 10 years and 250 pounds of 0-20-0 per acre was applied every third year after 1940. Under very low level management, involving continuous cotton on excessive slopes, cotton has averaged 143 pounds lint per acre. Under low to medium level management, a rotation of wheat, sweet clover, and cotton, the cotton has averaged 210 pounds lint per acre.

With proper surface management, Zaneis soils take in and store water reasonably well and plants are able to utilize this moisture to a large extent. Zaneis soils are not inherently fertile but respond well to proper fertilization and to use of winter cover and green manure crops. There is greater erosion under continuous cotton than when rotations are used.

Brownfield Soils

The Brownfield series is comprised of loose sandy soils found to occur in the Rolling Red Plains. They are developed on sandy aeolian material deposited on undulating, erosional upland. The vegetation was scrubby shinnery oaks and bunch grasses; these soils are now used for general farming, especially summer row crops. Their surfaces are slightly undulating with gradients of one to five percent.

In its natural condition Brownfield has an A horizon of six inches of brown loamy fine sand which is single grain, very friable and neutral to slightly acid. This lies over a 12 inch leached horizon of light reddish-brown loamy fine sand; this rests abruptly on a B horizon of red sandy clay loam which is blocky, firm, and neutral. At about four feet the B horizon grades slowly into the parent material of yellowish-red loam which is neutral to calcareous.

A four-year test, 1952-1955, on Brownfield loamy fine sand, with a slope gradient of one percent and located on the Sandy Land Experiment Station at Mangum, has given the following results with continuous cotton:

	Pounds lint per acre
Low level management	
Shallow tillage, no treatment	109
Medium level management	
Deep plowed,* no treatment.	223
Moderately high level management	
Deep plowed,* 100 pounds 12-24-12 placed to side and below seed.	279
Moderately high level management	
Deep plowed,* 100 pounds 12-24-12 placed 12 inches below seed, 4 replications, 1955.	517

*Plowed deep enough to bring sandy clay material to surface.

Brownfield soils are drought resistant but are low in native fertility and are subject to wind erosion which creates a problem in establishing and keeping a stand of any seeded crop. Where the clay horizon is shallow enough to plow to the surface, this material will aid in the formation of a more favorable soil structure which will offer resistance to wind erosion and will increase the cation exchange capacity of the surface horizon. Brownfield soils are responsive to fertilization. Applications of gin trash, cotton burrs, and barn manure have resulted in higher yields, as has the use of rye as a winter cover and green manure crop.

Dill Soils

Dill soils occur most frequently in the southern portion of the Rolling Red Plains. They are developed on gently sloping erosional uplands from Permian age packsands. Most of these soils occur on gentle convex slopes of about two percent gradient. The original vegetation was tall and mid grasses. These soils are now used for general farming, with emphasis on summer row crops.

The A horizon of a typical profile is about 12 inches of reddish-brown to red fine sandy loam, granular, friable, very permeable, and neutral. This grades shortly to the B horizon which is two or more feet of red sandy clay loam, weak blocky to nearly massive, firm, permeable, and about neutral. The B horizon grades slowly to the parent material which is red packsand stratified with thin bands of sandy loams and clay loams and is neutral to alkaline.

Cotton variety tests were conducted on Dill fine sandy loam,* with

*For complete profile see Appendix, p. 57.

15 inch A horizons and two percent slopes, one mile east of Elk City during the five years of 1952 to 1956. The cooperator, Dale McLain, supplemented these tests and found good response to 11 inch plowing, use of rye for winter cover and green manure crop, use of sweet clover for residue after pasturing, and rotations with small grains. He found no response to 300 pounds 5-10-5 per acre in 1955. Under this relatively high level of management the recommended varieties produced average of 237 pounds of lint per acre.

Dill soils are well drained yet have reasonably high moisture storage capacity. They are not high in native fertility but are not known to respond to fertilization; it is reasonable to expect favorable response to proper fertilization in years with high rainfall.

Enterprise Soils

The Enterprise series is composed of youthful soils found in the southern part of the Rolling Red Plains. They are developed on extensive aeolian mantles deposited on erosional uplands near streams draining the plains of western Oklahoma and Texas. The general topography is smooth to gently rolling, most surfaces are plane to convex and gradients are usually one to two percent. The surface was once covered by mid and tall grasses. The present use is general farming, much of the area being in row crops and alfalfa.

Enterprise profiles do not change greatly with depth in color or texture. The A horizons of brown very fine sandy loams are granular, friable, permeable, and slightly alkaline. They develop to about 15 inches and grade shortly to the parent material which is slightly weathered, reddish-brown aeolian deposits of Pleistocene or Recent age.

The parent material has less aggregation and is more alkaline than the A horizon and may have thin seams of lime concretions.

Cotton variety tests were conducted on Enterprise very fine sandy loam with an 18 inch A horizon on zero to one percent slopes, 11 miles southeast of Davidson on the Galen Briggs farm. Under a low level management for the five years, 1952-1956, the recommended varieties produced an average of 296 pounds per acre.

Enterprise has a very good physical condition allowing it to produce some crop under adverse moisture conditions. Its youthful nature contributes to the presence of weatherable minerals. There is little to indicate that applications of any fertilizer would be profitable, yet one would expect Enterprise to be very responsive to high levels of management if moisture were not the limiting factor.

Tipton Soils

These are youthful soils of the Rolling Red Plains developed from calcareous alluvial or aeolian deposits along major streams draining semiarid to subhumid regions. They occur on nearly level topography and often occupy the depressional areas of broad very gently undulating terraces and mantle deposits. They once supported short and tall grasses; they are now used for general farming.

The A horizon is of about 18 inches of brown loam which is moderately granular, friable, permeable, and neutral to alkaline. This grades shortly into a very similar horizon except that it is redder and often has fine specks of lime concretions. These later two layers may constitute a weakly developed B horizon or may be the result of stratification; each may have occasional black concretions. The parent

material is reddish-brown or brown silty clay loam interlayered with fine sand which appears to be alluvial deposits. There are numerous streaks of accumulated lime.

Tipton silt loam with 18 inch horizons on one half percent slopes, located on the Oklahoma Cotton Substation at Tipton,* has been used for cotton variety tests and other experimental work. It was established that irrigation results in economic yield increase and that fertilizers are beneficial only under irrigation. The cotton variety tests were with continuous cotton, no irrigation, and no fertilizers. Under this low level management for the 13 years of 1944 to 1956 the recommended varieties averaged 276 pounds lint per acre.

Foard Soils

Foard is a series of well developed soils found on nearly level upland in the Rolling Red Plains. They are developed from Permian age red bed clays. The native vegetation was of short and mid grasses; the present use is for general farming, especially small grains.

Foard soils are characterized by brown clay loam A horizons five to eight inches thick which are weak granular, friable but hard when dry, and neutral to alkaline. This A horizon rests abruptly on the B horizon of brown clay which is blocky, firm, and alkaline and which becomes massive and calcareous with depth; while this horizon is compact and high in clay content, it is not a true clay pan. The B horizon grades slowly into the parent material at about four feet; this is clayey red bed deposits which has accumulations of soft lime and may show distinct banding.

*For complete profile see Appendix, p. 59.

Records are available for the four years of 1952, 1954, 1955, and 1956 from cotton variety tests conducted on the Irrigation Research Station at Altus. The soil tested was Foard silty clay loam with six inch A horizons on one percent slope.* Irrigation was applied to all plots. 100 pounds of 16-20-0 per acre was used in 1952, 500 pounds of 8-10-0 in 1955, and 267 pounds of 15-15-0 in 1956. The recommended varieties grown under this high level management produced an average of 864 pounds lint per acre.

Foard soils are moderately high in inherent fertility and are not responsive to fertilization under dryland conditions. They have a high water requirement to produce good yields. Considerable care is needed to maintain favorable tilth; the surface soil slakes badly on wetting and develops two to three inch crusts on drying. Excessive tillage should be avoided. Cover crops, where their use is made feasible by irrigation, should be worked into the surface. Great care must be exercised to avoid excessive applications of high sodium content water.

Lawton Soils

The Lawton soils have been developed in old gravelly alluvium from igneous rocks and associated soils in the vicinity of the Wichita mountains in the southeastern part of the Rolling Red Plains. They are found on upland in old alluvial fans. The surfaces are largely convex and the gradient is one to three percent. The native vegetation was mixed grasses; the major present land use is general farming with some areas still in short and mid grasses.

The A horizon is usually about 12 inches of brown silt loam which

*For complete profile see Appendix, p. 60.

is strong fine granular, friable, and slightly acid. This grades through two transition horizons to the major B horizon of reddish-brown clay which is compound coarse granular and prismatic, firm, and slowly permeable. This grades shortly into stratified layers of igneous pebbles mixed with red clay and sandy clay. Some igneous pebbles occur near the surface without seriously altering the soil characteristics. There are numerous films and concretions of black material below 30 inches.

Lawton silt loam, with 12 inch A horizons on one percent slopes,* was used for general experimental work on the old Dryland Experiment Station at Lawton. Cotton production records for the 17 years, 1933-1949, give the following results:

	Pounds lint per acre
Very low level management	
Continuous cotton, spring listing	135
Low level management	
Continuous cotton, fall plowing	221
Rotation cotton, cowpeas, spring plowing.	207
Medium level management	
Rotation cotton, oats, Kafir (manured), cowpeas, fall plowing.	250
Proved potential	
Rotation sweet clover, sweet clover, cotton, and Kafir, fall plowing, 1942	659

Lawton soils are not particularly droughty but moisture is usually the first limiting factor. They are moderately high in native fertility and were not shown to be responsive to fertilization.

*For complete profile see Appendix, p. 61.

Table 1. Cotton Production by Soil Types and Management Levels

Soil Type	Slope	Years in Test	Low Level* Management	Med. Level* Management	High Level* Management	Proven* Potential
San Saba clay	1.5%	5		339		
Okemah silt loam	1.0%	3			348	
Kirkland silt loam	1.0%	40	237	252	296	701
Norge loam	1.2%	9	308	360	452	1190
Vanoss loam	1.0%	13	286			
Teller fine s. loam	2.0%	5			633	
Reinach silt loam	0.5%	9	378			
Port silt loam	0.5%	5			466	
Zaneis loam	7.7%	25	210			
Brownfield l. f. sand	1.0%	4	109	223	279	517
Dill f. sandy loam	2.0%	5			237	
Enterprise v. f. s. loam	0.5%	5	296			
Tipton silt loam	0.5%	5	276			
Foard silty clay loam	1.0%	4			864*	
Lawton silt loam	1.0%	17	221	250		659

*Irrigated

Note: This list is for convenience only and not for direct comparison of one soil against another.

Low level management includes those plots on which reasonable management practices were employed but nothing more was done to improve yields. Usually fall plowed, continuous cotton.

Medium level management includes those plots where some additional practice was employed to increase production. Usually fall plowed and rotations or commercial fertilizers.

High level management includes those plots where several yield boosting practices were used. Often fall plowed, rotations, and commercial fertilizers.

Proved potentials are given only where there has been variation of treatments to cause a wide spread in yields and where individual plot yields are available. No editing was done to select treatments which could be recommended. No statement is made as to probability of duplicating these yields.

CHAPTER V

DISCUSSION

Mapping of soils did not start in this country until late in the nineteenth century. Earlier attempts at mapping soils were really expressions of surface geology and revealed very little concerning the soil body itself. Even the early soil maps are unsatisfactory by today's standards and criteria. Yet this generation of soil scientists will have failed if today's maps are acceptable when another 60 years elapse. There is some indication that the hard part of developing correct criteria and procedure is over; but knowledge is built on knowledge and advances are being made in our understanding of soils. The classification scheme is constantly and agonizingly being revised. The changes come slowly.

Soils are individuals. Each is the unique result of interaction of the soil-forming factors. Soils are three-dimensional bodies usually surrounded by other soils. Even where the earth is continuously covered with soil, the individual soils may change with variation in slope, surface soil texture, permeability, depth of soil, or other factors which affect the growth of plants. Soils are individuals just as each animal in a herd of cattle is an individual. By the same analogy, soils are grouped by soil series just as cattle are grouped by breeds. Members of a series are found wherever similar conditions of soil forming factors occur.

The study of crop yields and results of management practices

according to the soil type is an empirical study. It does not contribute directly to our store of fundamental facts of biological, chemical, or physical reactions which result in crop production. It does, however, shed light on areas where we need additional basic research and it puts to work the knowledge we do have. Reactions observed on one plot can be expected to be duplicated wherever similar soil and climatic conditions exist. Thus, the detailed soil survey is a vehicle for carrying experimental results to the farm. When similar features are found in soil types other than the one with experimental evidence, logical inferences can be made.

Cotton is grown on soil types which differ widely in soil characteristics. Climatic conditions have more influence on any one yield than do soil characteristics, yet the soil type has more influence on the average yield than does the average rainfall.

The use of winter cover and green manure crops was shown to decrease continuous cotton yields on Kirkland silt loam. This is due to the loss of moisture used in growing and in decomposing these crops. This practice could be expected to decrease cotton yields on Lawton, Foard, Okemah, and San Saba soils except under most favorable moisture conditions. The use of green manure crops increases the average continuous cotton yield on deep plowed Brownfield loamy fine sand and on Dill fine sandy loam. Continued use of green manure crops should be beneficial on Vanoss, Zaneis, Port, Reinach, Enterprise, and possibly Tipton soils.

Commercial fertilizers have been shown to increase cotton yields materially on Teller fine sandy loam, Norge loam, Port silt loam, and Brownfield loamy fine sand. Fertility tests on Lawton silt loam,

Kirkland silt loam, and Tipton silt loam have shown little or no response of cotton to added nutrients. Reinach, Vanoss, Zaneis, Dill, and Enterprise soils should respond to proper fertilization while no response could be expected on San Saba or Foard soils except with high moisture levels.

There seems to be an interaction between cotton variety and soil types; the reason for the relation is not readily apparent. For the five year period of 1944-1948 Hi-Bred produced higher yields at Chickasha and Perkins than did Lankart 57 or Mebane 6801-2-1; its yield was well below both at Lawton; its yield was below that of Mebane 6801-2-1 and above Lankart 57 at Tipton. For the period 1950 to 1954 Lankart 57 competed best on tight upland soils of central and western Oklahoma (16).

In no case do we know the limits of response of cotton to increasing increments of one nutrient on a given Oklahoma soil. The over-all effect of any tillage operation on the moisture of any given soil is known by inference only; the inference varies with soils. We have little recorded information on the effect of tillage on structure or tilth as influenced by other soil characteristics. The reasons for beneficial influence of organic debris such as cotton burrs is not adequately understood.

In order to learn more concerning Oklahoma soils, minimum tests should be placed on key soils in each of the major soil associations. These tests should be designed to study response to rates and combinations of fertilizers, fertilizer placement, tillage methods, and cropping practices. Valuable information can also be gathered if management practices and yields are recorded from fields selected on the basis of uniformity of soils and management practices.

CHAPTER VI

SUMMARY AND CONCLUSIONS

The history of soil survey activity was reviewed. The literature was examined to determine the earliest attempt at classification and mapping to follow the early work in the United States. The contribution of key men was ascertained and the criteria by which soils are classified were briefly recorded.

The factors of soil formation and, therefore, variation in soils was listed and discussed. The variation in Oklahoma's geological deposits was presented as a means of explaining some of the variability of the state's soils. A discussion of the Soil Resource Areas of Oklahoma was given as a background for the individual soils presented later.

Fifteen soils were characterized by their location, geologic position, topography, use, morphology, and cotton production in relation to management practices. A general discussion, based on these data and preceding material, was given to show that the soil type is the logical basis for utilizing experimental results.

The major conclusions drawn are given as follows:

1. The real beginning of soil survey in this country was the establishment of the Division of Soils within USDA in 1899.
2. Mapping was begun in Oklahoma in 1905. Standard soil survey reports are available for 25 counties. Unpublished detailed surveys are locally available for a large portion of Oklahoma.
3. Good, practical classification criteria and sound mapping techniques are in use.

4. Soils are individuals and should be treated as such. Cultural practices which may be very beneficial on one soil type may decrease crop yields on another. The characteristics of a soil type are largely responsible for the average crop production over an extended period.
5. There is need for further research to determine response to management practices on key cotton soils of Oklahoma.

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APPENDIX

SAN SABA CLAY

Spot location near the center of Sec. 6, T 5 S, R 10 E, two miles east of Caddo on a weakly convex surface with a gradient of about $1\frac{1}{2}$ percent.

Profile:

- A 0-16" Very dark-gray (2.5Y 3/0) heavy clay loam; strong medium granular, coarse below plow layer of 6 inches; firm but extremely crumbly; pH 8.0, calcareous; many roots; grades to next horizon.
- AC 16-46 Dark-gray (2.5Y 4/0) clay; massive to weak coarse granular; plastic when wet and firm when dry; pH 8.0; few fine concretions of CaCO_3 ; grades slowly to horizon below.
- C 46-54 Olive-brown (2.5Y 4/4) clay; massive; plastic; pH 8.0; numerous CaCO_3 concretions. This may be calcareous marl of Cretaceous age.

KIRKLAND SILT LOAM

Spot location in plot 6100 of the Agronomy Farm, SE 1/4, Sec. 16, T 19 N, R 2 E, immediately west of Stillwater. Plane slope with gradient of slightly less than 1 percent.

Profile:

- A₁ 0-8" Grayish-brown (10YR 4.5/2; 3.5/2 moist) heavy silt loam; weak medium granular; friable; pH 6.5; a few fine pores; rests abruptly on horizon below.
- B₂₁ 8-22 Dark-grayish-brown (9YR 4.5/2; 3/2 moist) clay; moderate fine blocky; very firm; sticky and plastic when wet; very slowly permeable; pH 7.0; strong clay films on sides of peds; occasional fine black concretions; grades slowly to:
- B₂₂ 22-32 Dark-grayish-brown (10YR 4/2; 3/2 moist) clay; weak angular blocky; very firm and compact; very slowly permeable; pH 7.5; occasional fine black pellets; a few strong-brown specks about the tiny root holes; many fine CaCO₃ concretions below 26"; weak clay skins; grades slowly to horizon below.
- B₃ 32-42 Brown (7.5YR 5/4; 4/3 moist) light clay; weak medium blocky; firm to very firm, very hard when dry; pH 7.5; occasional black pellets and CaCO₃ concretions; sides of peds have weak coatings of dark-brown material; grades to layer below.
- C₁ 42-52 Reddish-brown (5YR 5/4; 4/4 moist) heavy silty clay loam or light silty clay much like the layer above; pH 7.5; occasional coarse CaCO₃ concretions and black ferruginous films; grades to layer below.
- C₂ 52-64 Reddish-brown (3.4YR 5/4; 4/4 moist) silty clay loam with occasional splotches of red and fewer light-gray streaks; weak irregular blocky; firm; slowly permeable; pH 7.5; occasional fine black pellets and fine concretions of CaCO₃; grades to layer below.
- C₃ 64-84 Red (2.5YR 4/6; 3/6 moist) silty clay with occasional light-gray streaks and splotches; weak medium blocky; firm but not compact; pH 7.5; many fine pores; changes little with depth.

NORGE LOAM

Location in Series 1000 of Perkins Farm, nine miles south of Stillwater, Sec. 36, T 18 N, R 2 E. The surface is broadly convex and the gradient is slightly over 1 percent.

Profile:

- A₁ 0-14" Brown (7.5YR 5/3; 4/2 moist) loam with visible very fine sand; compound angular breakage and moderate medium granular; friable; porous and permeable; pH 6.0; contains many worm holes and casts and fine root holes; crushes slightly more red; structure weaker in plow zone; grades to layer below.
- B₁ 14-22 Brown (7.5YR 5/3; 4/3 moist) clay loam thinly and faintly streaked with light-brown; moderate medium subangular blocky; firm; hard when dry; permeable; pH 6.0; contains many pores and pin holes and occasional black concretions; becomes more streaked as it grades to:
- B₂₁ 22-32 Reddish-brown (5YR 5/5; 4/5 moist) light sandy clay with a few fine light-brown streaks; compound weak coarse prismatic and moderate medium subangular blocky; firm; slowly permeable; pH 6.5; occasional medium black concretions; grades to layer below.
- B₂₂ 32-44 Light-brown (7.5YR 6/4; 5/4 moist) light sandy clay with common coarse distinct brownish-yellow and yellowish-red mottles; weak coarse prismatic and weak medium subangular blocky; firm; slowly permeable; pH 6.5; occasional medium and coarse black concretions and ferruginous films; grades slowly to horizon below.
- B₃ 44-54 Reddish-yellow (7.5YR 6/6; 5/6 moist) heavy sandy clay loam containing much coarse sand; fragmental breakage and weak medium subangular blocky; firm; permeable; pH 7.0; occasional fine black concretions and streaks of brownish-yellow and brown; grades to layer below through a broad transition zone.
- C 54-84 Streaks of light-reddish-brown, strong-brown, and reddish-yellow fine sandy loam with lenses of light sandy clay loam; friable and permeable; pH 7.0. This appears to be stratified old alluvium of Pleistocene age.

VANOSS LOAM

Perkins Farm, plots 3800-4100, near southwest corner of Sec. 36,
T 18 N, R 2 E, in continuous cotton plots, surface is plane to weak
convex and the gradient is about $\frac{1}{2}$ percent.

Profile:

- A₁ 0-16" Brown (7.5YR 5/3; 3.5/2 moist) loam; moderate medium granular; crumbly and friable; porous and permeable; pH 6.0; many pores and pin holes; shear glazed face at plow depth of 8 inches with less granulation above and tendency to weak coarse platiness below; grades to layer below.
- A₃ 16-22 Brown (7.5YR 5/3; 3/2 moist) heavy loam; moderate medium granular; permeable; pH 6.0; many pin holes; grades to horizon below.
- B₂₁ 22-32 Brown (7.5YR 5/3; 4/3 moist) clay loam; compound moderate medium granular and weak fine subangular blocky; firm, hard when dry; porous and permeable; pH 6.0; grades to horizon below.
- B₂₂ 32-40 Brown (7.5YR 5/4; 4/4 moist) sandy clay loam; same structure and consistence as above; pH 6.5; becomes increasingly coarse with depth and grades into layer below.
- B₃ 40-50 Strong brown (7.5YR 5.5/6; 5/6 moist) sandy clay loam; weak medium subangular blocky; friable to firm; porous and permeable; pH 6.5; grades to layer below.
- C₁ 50-60 Same as above but contains a few, medium, distinct yellowish-red mottles; pH 6.5; grades to layer below.
- C₂ 60-110 Visibly stratified old alluvium with reddish-yellow (7.5YR 6/6; 5/6 moist) fine sandy loam and sandy clay loam, red (2.5YR 5/6; 4/6 moist) sandy clay loam, and a few seams of pink (7.5YR 7/4) fine sandy loam. This alluvium is possibly of Pleistocene age.

REINACH SILT LOAM

Spot location near southeast corner of Sec. 27, T 7 N, R 7 W, on Oklahoma Cotton Research Station one mile east of Chickasha, above flood plain of Washita River. The surface is weakly convex and has a gradient of about $\frac{1}{2}$ percent.

Profile:

- A 0-18" Reddish-brown (5YR 5/4; 3/4 moist) silt loam; weak medium granular; friable; porous and permeable; pH 7.0; many worm holes and casts and pin holes. The color becomes redder and texture heavier with depth and there is weak prismatic breakage below plow depth.
- C₁ 18-38 Red (2.5YR 5/7; 4/7 moist) silt loam; weak prismatic and moderate medium granular; friable and permeable; pH 8.0; a few calcareous, light reddish-brown mottles or spots in lower portion; grades to horizon below.
- C₂ 36-84 Red (2.5YR 5.7; 4.7 moist) strongly calcareous silt loam with occasional streaks and a few concretions of CaCO_3 , becomes light-red with depth. This is probably Recent age alluvium but is not noticeably stratified.

BROWNFIELD LOAMY FINE SAND

No spot location is available of the test area before deep plowing. The beneficially affected areas were similar to this idealized profile description. The surface of Brownfield is plane to gently undulating with the gradient seldom exceeding 3 percent.

Profile:

- A₁ 0-6" Brown (7.5YR 5/3; 4/3 moist) loamy fine sand; single grain; friable; pH 6.8; grades to horizon below.
- A₂ 6-18 Light reddish-brown (5YR 6/4; 6/4 moist) loamy fine sand; single grain, friable; pH 6.8; rests abruptly on horizon below.
- B₂ 18-44 Red (2.5YR 4/6; 3/6 moist) heavy sandy clay loam; weak coarse-blocky; friable to firm; pH 7.0; grades slowly to horizon below.
- C 44-54 Yellowish-red sticky loam becoming more sandy with depth; pH 7.0; in places the material is slightly calcareous in lower portion. This may be Quarternary outwash which was deposited over the Permian red bed materials below.

DILL FINE SANDY LOAM

Spot location near north quarter-corner of Sec. 26, T 11 N,
R 21 W, east of Elk City on gently sloping upland with a long 2
percent gradient, weakly convex.

Profile:

- A₁ 0-15" Red (2.5YR 4/5; 3/4 moist) fine sandy loam; weak fine granular; porous and permeable; pH 7.0; shear plow face at 10 inches with weaker structure above and with worm holes and fine pores below; grades to horizon below.
- B₂₁ 15-26 Red (2.5YR 5/5; 3/4 moist) light sandy clay loam; weak medium subangular blocky; friable; slightly hard dry; few fine pores and root holes; pH 7.5; grades to horizon below.
- B₂₂ 26-36 Weak-red (10 R 5/4; 4/4 moist) sandy clay loam; frag- mental breakage, weak medium subangular blocky; friable to firm, slightly hard when dry; permeable; pH 7.5; grades to horizon below.
- C₁ 36-44 Weak-red soft sands with seams of reddish-yellow fine sandy loam of partly weathered sandy beds; pH 7.5.
- C₂ 44-54 Red (2.5YR 5/6) slightly weathered packsand of the Quarter-master formation and thin bands of reddish- yellow sandy loams and shale-like silty clay loams; pH 7.5.

ENTERPRISE VERY FINE SANDY LOAM

Spot location near north quarter-corner of Sec. 13, T 4 S, R 17 W, on a smooth, nearly level field, very gently undulating surface. There are long, low dunes in the vicinity of the farm buildings to the south and nearer the Red River.

Profile:

- A 0-18" Brown (6.5YR 4/4 moist) very fine sandy loam; weak medium granular; friable; porous and permeable; many fine pores below average plow depth; pH 7.5; grades through a 3 inch transition to:
- C₁ 18-36 Light-reddish-brown (5YR 6/5; 4/5 moist) very fine sandy loam; friable and permeable but only a few stable granular aggregates; occasional small white spots and threads of CaCO₃; pH 8.0; grades to horizon below.
- C₂ 36-54 Pink (6.5YR 7/5; 5.5/5 moist) very fine sandy loam; porous and permeable; CaCO₃ not in evidence. This appears to be an aeolian deposit of Pleistocene and Recent geologic age.

TIPTON SILT LOAM

Spot location in the N $\frac{1}{2}$ of the SE $\frac{1}{4}$ Sec. 25, T 1 S, R 19 W, on the Cotton Substation, Tipton. Surface is nearly level to plane with $\frac{1}{2}$ percent gradient.

Profile:

- A 0-18" Brown (7.5 YR 5/3; 4/3 moist) silt loam; weak medium granular; friable; permeable; pH 7.2; many pores and fine root holes; plow planes evident; grades to horizon below.
- B₂₁ 18-32 Brown (7.5YR 5/3; 4/3 moist) heavy silt loam; weak medium granular; friable, permeable; pH 7.5; occasional very fine black concretions; grades to horizon below.
- B₂₂ 32-48 Light-reddish-brown (5YR 6/3; 4/3 moist) light clay loam; weak medium granular; friable; hard when dry; a few very fine pink specks of CaCO₃ in the lower portion; pH 7.5; many pin holes and worm holes; occasional round black concretions; grades to horizon below.
- C_{ca} 48-64 As above but with numerous threads and streaks of nearly white CaCO₃; grades to horizon below.
- C₂ 64-84 Light-brown (7.5YR 6/4; 4/3 moist) calcareous heavy silt loam with a few streaks of CaCO₃. It appears to be loess which has an appreciable amount of very fine sand.

FOARD SILTY CLAY LOAM

Spot location near center of Sec. 6, T 1 N, R 20 W. Gently sloping to the north with plane slope of 1 percent. Irrigation Research Station, Altus.

Profile:

- A₁ 0-6" Dark-brown (7.5YR 4/2; 3/2 moist) silty clay loam; weak fine subangular blocky; firm, hard when dry; pH 7.5; surface is cloddy and tilth is poor; grades shortly to layer below.
- B₂₁ 6-18 Dark-brown (7.5YR 4/2; 3/2 moist) clay; compound fine prismatic and moderate medium subangular blocky; firm, very hard when dry; slowly permeable; pH 8.0 but non-calcareous; occasional fine black concretions, pin holes and fine root channels; ped surfaces slightly shiny.
- B₂₂ 18-30 Reddish-brown (5YR 5/3; 4/3 moist) silty clay much like horizon above but with numerous fine concretions and threads of CaCO₃; weakly calcareous; grades to layer below.
- B_{ca} 30-44 Reddish-brown (5YR 4/3; 3/3 moist) calcareous silty clay; weak medium subangular blocky; firm to hard dry, slightly crumbly moist; slowly permeable; many coarse CaCO₃ concretions; occasional fine black concretions and fine pores; grades to horizon below.
- C₁ 44-66 Reddish-brown (5YR 4/4; 3/4 moist) silty clay like layer above but slightly more red; weak calcareous in mass to strong calcareous in specks and seams; occasional fine pores and roots; grades slowly to:
- C₂ 66-84 Red (2.5YR 4/6; 3/6 moist) calcareous clayey red beds material which is streaked with pink, loamy soft CaCO₃. This appears to be weathered soft red clay of the Hennessay formation.

LAWTON SILT LOAM

Spot location near south quarter-corner of Sec. 19, T 2 N,
R 11 W, on farm adjoining the old Dryland Experiment Station. Sur-
face weakly convex with gradient of about 1 percent.

Profile:

- A₁ 0-12" Brown (7.5YR 4/3; 3/3 moist) silt loam; strong medium granular; friable; noncalcareous; grades to horizon below.
- B₁ 12-19 Reddish-brown (5YR 4/4; 3/4 moist) silty clay; strong medium granular; friable; noncalcareous; grades below.
- B₂ 19-30 Reddish-brown (4YR 3.5/4; 3/4 moist) clay; compound moderate medium granular and medium prismatic; firm; permeable; color is verigated; grades shortly to horizon below.
- B₃ 30-54 Red (3YR 3/5; 3/6 moist) clay and sandy clay; strong prismatic; noncalcareous; ped surfaces coated with dark-brown films; strong stratification of these materials and weathered igneous pebbles; grades to horizon below.
- C 54-61 Partly weathered igneous gravel in a matrix of noncalcareous clayey fine earth. This material is alluvial deposits composed of Precambrian granite and gabbro and local clay deposits.

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