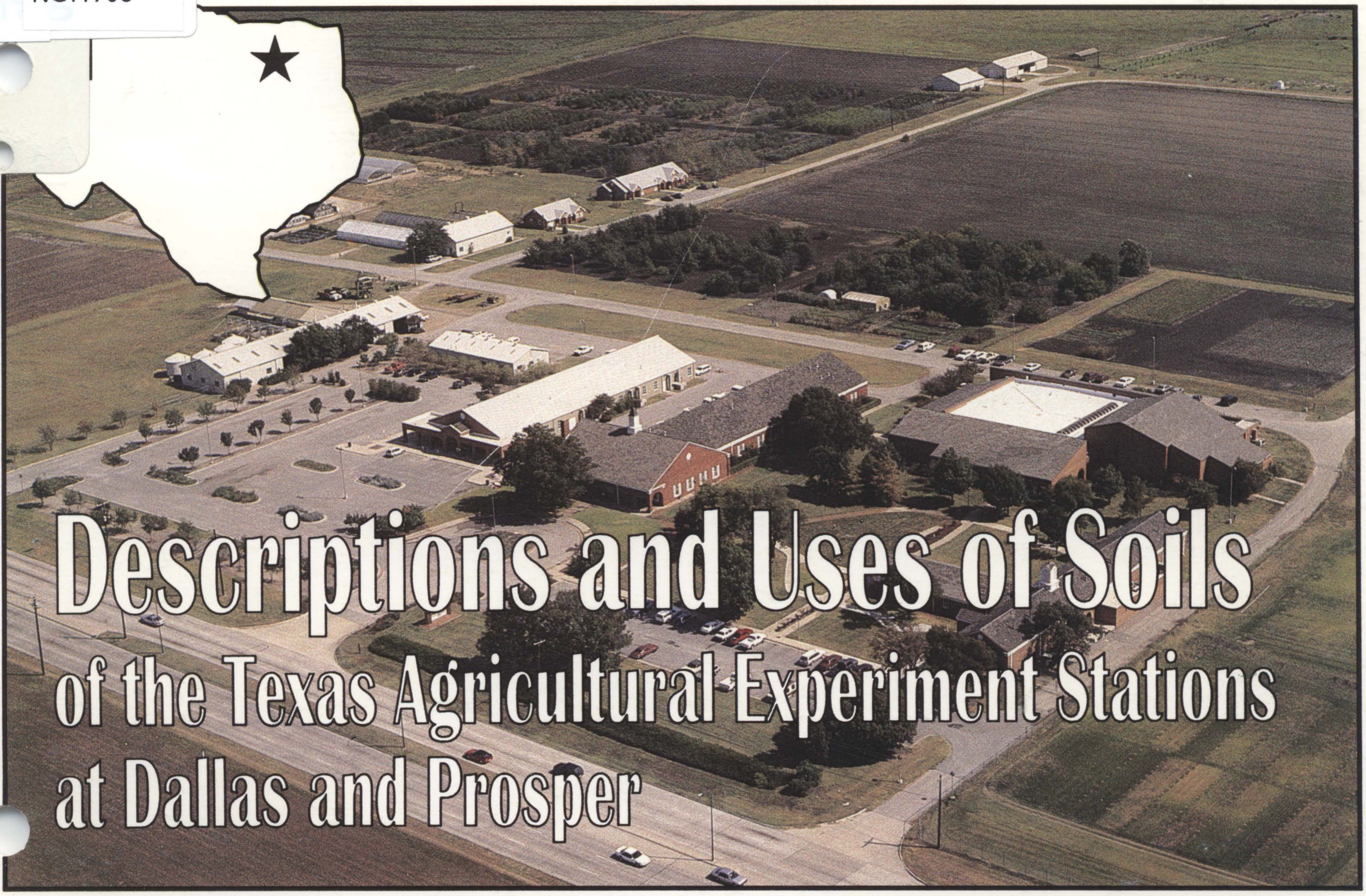
B-1705
April 1992



Descriptions and Uses of Soils of the Texas Agricultural Experiment Stations at Dallas and Prosper

Texas Agricultural Experiment Station
J. Charles Lee, Interim Director
The Texas A&M University System
College Station, Texas

[Blank Page in Original Bulletin]

Descriptions and Uses of Soils of the Texas Agricultural Experiment Stations at Dallas and Prosper

by

Billy W. Hipp, Tim C. Knowles, and Benny J. Simpson
Professor, Research Associate, and Research Scientist, respectively
Texas A&M University Research and Extension Center at Dallas
Texas Agricultural Experiment Station

in cooperation with

Billy R. Stringer
Soil Scientist
Soil Conservation Service, Terrell, TX

and

C. Tom Hallmark
Professor, Soil Genesis and Classification
Department of Soil and Crop Sciences
Texas A&M University, College Station, TX

Keywords: Morphology/ classification

Cover (clockwise from top): The Texas Agricultural Experiment Station at Dallas, research plot investigating fertilizer requirements of native ornamental shrubs, research on range and pasture fertilizer requirements.

This publication was edited by R. Marie Jones, and the cover was designed by Roxy A. Pike, Department of Agricultural Communications, Texas A&M University, College Station, TX.

Contents

Summary 1
Introduction 1
Climate 2
Soils of the Centers 2
Soil Series Descriptions 3
Laboratory Analyses of Selected Soil Profiles 9
Water Quality for Agricultural and Domestic Purposes 12
Use and Management of Soils for Agriculture 13
Use and Management of Soils for Urban Purposes 14
Use and Management of Soils for Urban Landscapes 15
Literature Cited 18
Glossary 19

Summary

Austin silty clay and Houston Black clay are the major soils on the Texas A&M University Research and Extension Center at Dallas. Fairlie clay, Stephen silty clay, and Eddy gravelly clay loam are present to a minor extent. Because of their complex patterns, the Stephen and Eddy soils are shown as one unit in this survey.

Austin and Stephen soils are classified as Mollisols in the Comprehensive Soil Classification System of the United States. Houston Black and Fairlie soils are classified as Vertisols. Eddy soils are Entisols. Mollisols are dark-colored granular soils containing more than 1 percent organic matter in the surface layer. Vertisols are referred to as self-mulching soils or cracking clays. Entisols show little or no evidence of horizon development.

The soils of the Dallas Center developed mainly from chalk and interbedded marl under tallgrass and mid-bunchgrass vegetation. The relief is nearly level to gently sloping with slopes ranging from 0 to greater than 3 percent.

Permeability of the Houston Black and Fairlie soils is very slow. The Austin, Stephen, and Eddy soils have moderately slow permeability. All soils on the Dallas Center are calcareous and have an average pH of 7.8. Montmorillonite is the major clay mineral, which accounts for shrinking and swelling of the soils when drying and wetting. Austin and Eddy soils contain more than 35 percent carbonate in the A horizon. The C horizons of both the Austin and Houston Black soils approach a carbonate content of 75 percent.

Introduction

On September 1, 1972, the Board of Trustees of the Texas Research Foundation, Renner, Texas, formally presented to Texas A&M University the 380 acres and facilities and buildings of Texas Research Foundation for the purpose of creating the Texas A&M University Research and Extension Center at Dallas. The remaining 270 acres of the Foundation were given to The University of Texas at Dallas.

The Texas Research Foundation was chartered on April 11, 1946, as an independent, non-profit research and educational institution. Business leaders in the Dallas - Fort Worth area, concerned about the decline of agricultural productivity of the Texas Blacklands, had formed the Foundation.

For 125 years, Blacklands agriculture fostered growth of cities and towns of Texas, which are inseparable from the history of the state. These towns include Paris, Sherman, Gainesville, Greenville, Denton, McKinney, Dallas, Prosper, Celina, Fort Worth, Hillsboro, Waco, Temple, Austin, San Antonio, and many others. Agricultural production from the Blacklands area passes through the ports of Galveston and Houston to worldwide markets.

From the time of the first Spaniards some 400 years ago to the coming of the railroads 100 to 120 years ago, the Blacklands of Texas were covered with tallgrasses and mid-grasses that produced wild game and supported cattle and sheep. Settlers relocating in the West and hides of the diminishing bison provided early traffic for the railroads. With the arrival of the railroads and their ability to transport principal crops such as cotton, the plows turned the fertile grassland into vast acreages of cultivated fields. Cotton became known as "king." Small crops of corn and small grains were produced, but in this early period of history they were not commercially important. During this period, the Blacklands were considered to be some of the richest soils in America. This fertility was commonly assumed to be inexhaustible.

The Texas Blacklands north of San Antonio account for only a small part of the land of the state, but Blackland land resource areas are found extensively in Arkansas, Alabama, and Mississippi. Before 1900, nearly all the plowed land of Texas was in this belt.

In the early 1920's, a sharp drop in prices for farm products focused attention on the declining fertility of the Blacklands. Many efforts were made to restore soil fertility, some of which in the early 1940's prompted the establishment of Texas Research Foundation.

The excellent facilities and location of Texas Research Foundation made it ideal for one of the Research and Extension Centers being established in Texas by Texas A&M University. Added to a continuation of research and extension activities of the Texas Research Foundation is an expanded program of research in all agricultural areas, and especially in horticulture at the Texas A&M University Research and Extension Center at Dallas. Located in the urban area of the Dallas - Fort Worth metroplex, the Dallas Center serves approximately 3.9 million people who reportedly control directly or indirectly the largest land ownership in the state.

In 1986, the Dallas Satellite Farm at Prosper was purchased from the sale of approximately 40 acres of the Dallas Research and Extension Center land west of Coit Road. The Prosper Farm consists of 161 acres that were part of a 958-acre tract deeded to D. W. Light in 1873. It is located off State Highway 289 between the towns of Prosper and Celina in Collin County. Research at Prosper is centered around the needs of the agricultural community of the north Texas Blacklands.

Future research and extension activities at Dallas and Prosper will be directed toward the agricultural and urban needs of the north-central Texas area. The soil series of these facilities represent a large segment of the total Blackland area. This bulletin details and characterizes the uniqueness of the Blackland soils, upon which the Center's research revolves.

Climate

The rolling hills of the area range from 500 to 800 ft in elevation; the Center is about 700 ft above sea level. The climate of the area is described as humid, subtropical with hot summers, and continental characterized by a wide range in annual temperature extremes (National Oceanic and Atmospheric Administration, 1977).

August, the hottest month of the year, averages a high temperature of about 95°F (Figure 1), but temperatures above 100°F are common in July and August. January, the coldest month of the year, averages a minimum temperature of 35°F (Figure 1). The average freeze-free period is 249 days. The last 32°F temperature occurs on March 16, and the first 32°F day in the fall occurs on November 21.

Average annual rainfall at the Dallas Center is 35.1 inches with distinct rainy periods in April and May (4.5 inches/month) (Figure 2a). This rainfall period is extremely important for field crop production in the area. Potential evapotranspiration (evaporation) reaches its maximum from June through July (9.5 to 10 inches/month). Actively growing plants often require supplemental irrigation between June and August. The probability of receiving more than five amounts of precipitation within 7-day periods during the year is shown in Figure 2b.

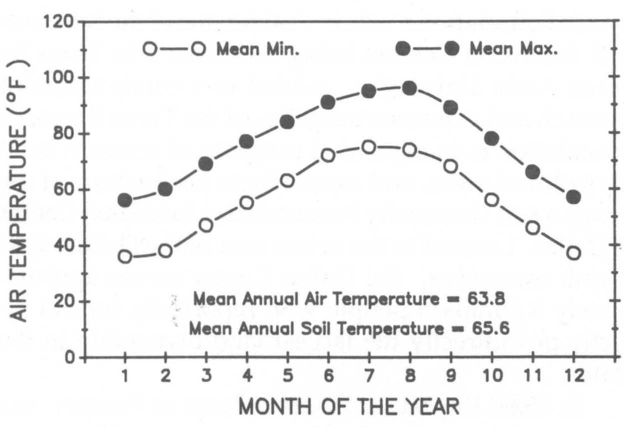


Figure 1. Average monthly minimum (min.) and maximum (max.) air temperature at the Center (recorded 1947 to 1983 at TAES-Dallas).

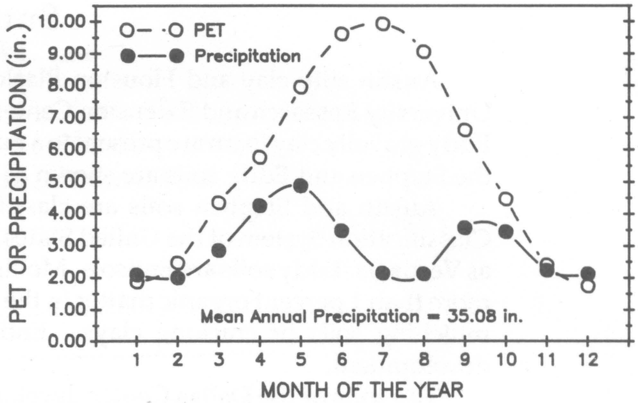


Figure 2a. Normal monthly rainfall and potential evapotranspiration (PET) at the Center (recorded 1947 to 1983 at TAES-Dallas).

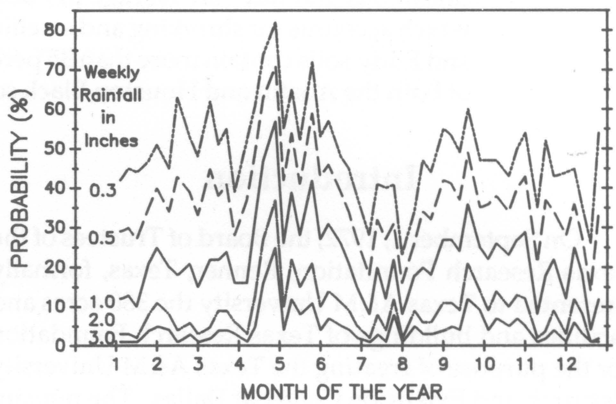


Figure 2b. Probability of receiving at least the designated amounts of precipitation in a 1-week period at TAES-Dallas.

Climate determines the classification of soil moisture and temperature regimes. Soils of the Centers are in an ustic soil moisture regime and a thermic soil temperature regime. An ustic moisture regime is typical of rainfed wheat lands. Soil moisture is limited because the soil moisture control section (about 4 to 12 inches below the soil surface) is dry for more than 90 cumulative days when evapotranspiration exceeds precipitation but is not dry 90 consecutive days in most years. A thermic temperature regime denotes a soil having a mean annual soil temperature between 59°F and 72°F at 20 inches below the soil surface.

The climate of the Dallas Center and the Prosper Research Station is nearly identical, so the climatological data presented previously also approximates that of Prosper.

Soils of the Centers

Austin silty clay and Houston Black clay are the major soils on the Texas A&M University Research and Extension Center at Dallas. Fairlie clay, Stephen silty clay, and Eddy gravelly clay loam are present to a minor extent. Because of their complex patterns, the Stephen and Eddy soils are shown as one unit in this survey.

Austin and Stephen soils are classified as Mollisols in the Comprehensive Soil Classification System of the United States. Houston Black and Fairlie are classified as Vertisols. Eddy soils are Entisols. Mollisols are dark-colored granular soils containing more than 1 percent organic matter in the surface layer and are moist more than 3 months of the year. Vertisols are referred to as self-mulching soils or cracking clays. Entisols are relatively young soils that show little or no evidence of horizon development.

The soils of the Center developed mainly from Upper Cretaceous chalk and interbedded marl under tallgrass and mid-bunchgrass vegetation (U. S. Department of Agriculture, 1969). The relief is nearly level to gently sloping with slopes ranging from 0 to 3 percent. Weathering of the marl and chalk in low, nearly level, slowly drained areas formed dark, plastic clay soils of the Houston Black and Fairlie series. On steeper, higher lying slopes, erosion exceeds soil formation, resulting in shallow, poorly developed profiles typical of the Austin, Eddy, and Stephen series. Thin, eroded profiles of Stephen and Eddy soils commonly show up as white spots in cultivated fields of the Blackland Prairies.

Permeability of the Houston Black and Fairlie soils is very slow. The Austin, Stephen, and Eddy soils have moderately slow permeability. All soils at the Center are calcareous and have an average pH of 7.8. Montmorillonite is the major clay mineral, which accounts for the shrinking and swelling of the soils when drying and wetting. Austin and Eddy soils contain more than 35 percent calcium carbonate (lime).

Soils at the Dallas Center are typical of about 6.75 million acres, or 53 percent, of the Blackland Prairie regions of Texas. The Austin series, the most extensive soil at the Dallas Center, accounts for about 70 percent of the soils at the Center. Other soils at the Dallas Center are Houston Black, Fairlie, Stephen, and Eddy series. The Prosper Farm consists entirely of the Houston Black series on 0 to 1 percent slopes. Austin, Houston Black, Stephen, and Eddy soils are found throughout the Blacklands. The Fairlie soils are extensive in other areas outside Dallas and Collin Counties. Maps of the soils and topography at the Dallas Center are shown in Figure 3. Tables 1, 2, and 3 show characteristics of the soils, their moisture relationships, topography, and capability class. Detailed descriptions of typical profiles for each of the soils are presented in the next section.

Soil Series Descriptions

This section describes the soil series and mapping units at TAES-Dallas. Five series are recognized at the Dallas Center, representing three groups within three soil orders. Only one series, the Houston Black, is recognized at TAES-Prosper. Each soil series contains both a brief nontechnical and a detailed technical description of the soil profile, or the sequence of layers beginning at the surface and continuing down to depths beyond which most plant roots do not penetrate.

Sample sites were selected after preliminary soil cores were taken from locations considered to be representative of mapping units defined after the survey was made. Soils were sampled from freshly dug pits. Morphological descriptions of each horizon were made and samples were collected for laboratory analyses (Soil Survey Staff, 1951). Soil mapping units were delineated by soil scientists of the U. S. Department of Agriculture, Soil Conservation Service. Map delineations and soil descriptions were confirmed by soil scientists on the state staff of the Soil Conservation Service. The detailed high-intensity survey was completed in November 1973, then updated in 1991.

A: Austin silty clay (fine-silty, carbonatic, thermic, Udorthentic Haplustoll)

The Austin series is a moderately deep, well-drained, moderately slowly permeable, fine-textured, calcareous soil on nearly level to gently sloping uplands. The soil formed in chalky limestone.

Type location: 800 ft east of headquarters along north end of plots, 100 ft south into cultivated field (200 ft southwest of east barn).

Typifying pedon: Austin silty clay - cropland (Figure 4, inside back cover).

Ap 0-5" Very dark grayish brown (10YR 3/2) silty clay, very dark brown (10YR 2/2) moist; moderate fine subangular blocky structure; hard, firm, sticky, and plastic; few roots; few soft $CaCO_3$ masses and fine concretions; calcareous, moderately alkaline; abrupt smooth boundary.

A 5-13" Dark grayish brown (10YR 4/2) silty clay, very dark grayish brown (10YR 3/2) moist; moderate medium subangular blocky structure; hard, firm, sticky, and plastic; few roots; few worm casts; few fine $CaCO_3$ concretions; calcareous, moderately alkaline; gradual wavy boundary.

AuA	Austin silty clay, 0 to 1 percent slopes
AuB	Austin silty clay, 1 to 3 percent slopes
FaA	Fairlie clay, 0 to 1 percent slopes
FaB	Fairlie clay, 1 to 3 percent slopes
HoA	Houston Black clay, 0 to 1 percent slopes
HoB	Houston Black clay, 1 to 3 percent slopes
SeC	Stephen-Eddy complex, 1 to 3 percent slopes, eroded

(Aerial photograph taken by Dallas Aerial Surveys, Dallas, TX, and topographic map compiled by the architectural firm of Wheeler and Stefoniak.)

Figure 3. Legend for soil maps (see following pages).

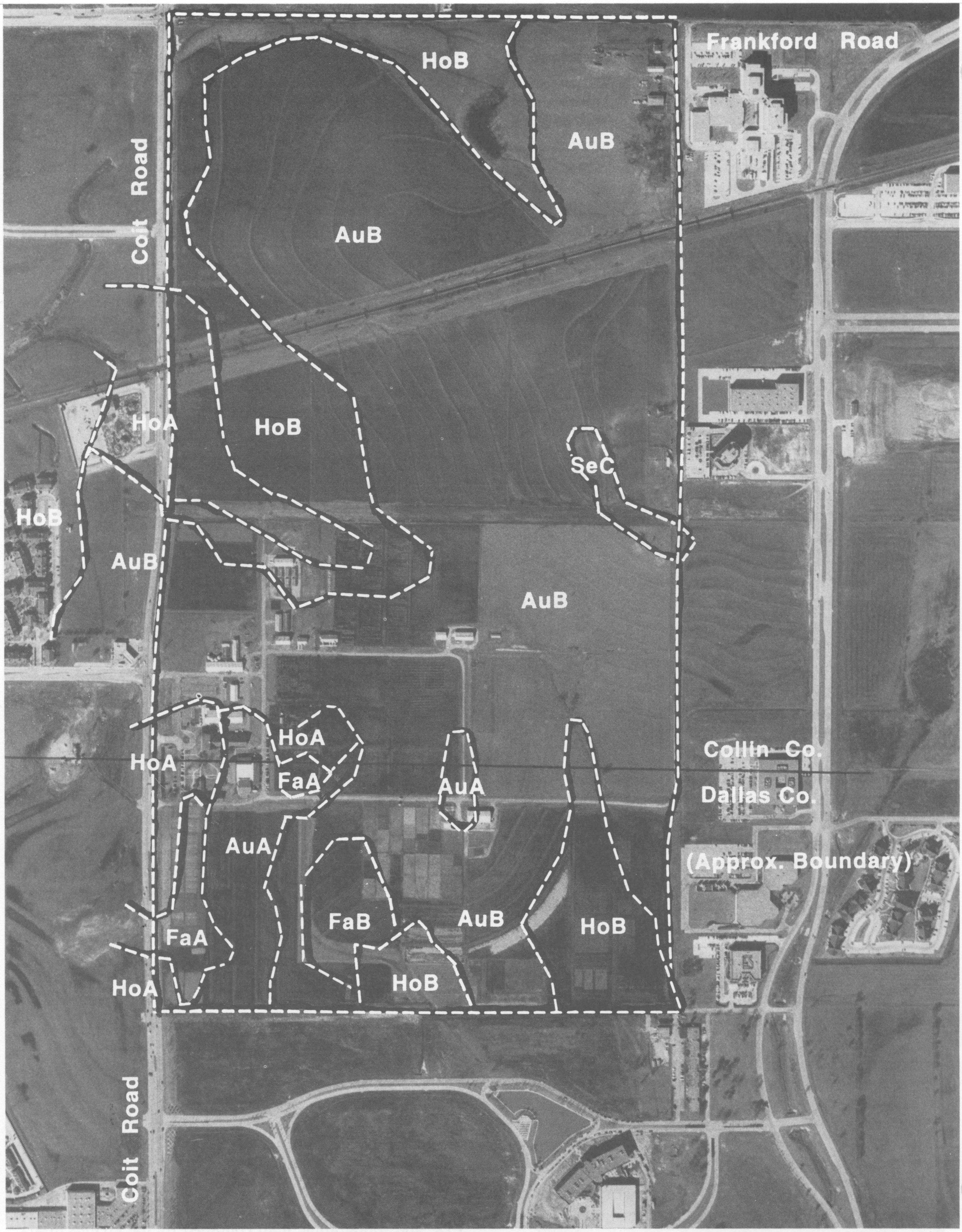


Figure 3a. Soil map of the Texas A&M University Research and Extension Center at Dallas (approximate scale: 1 inch = 720 ft).

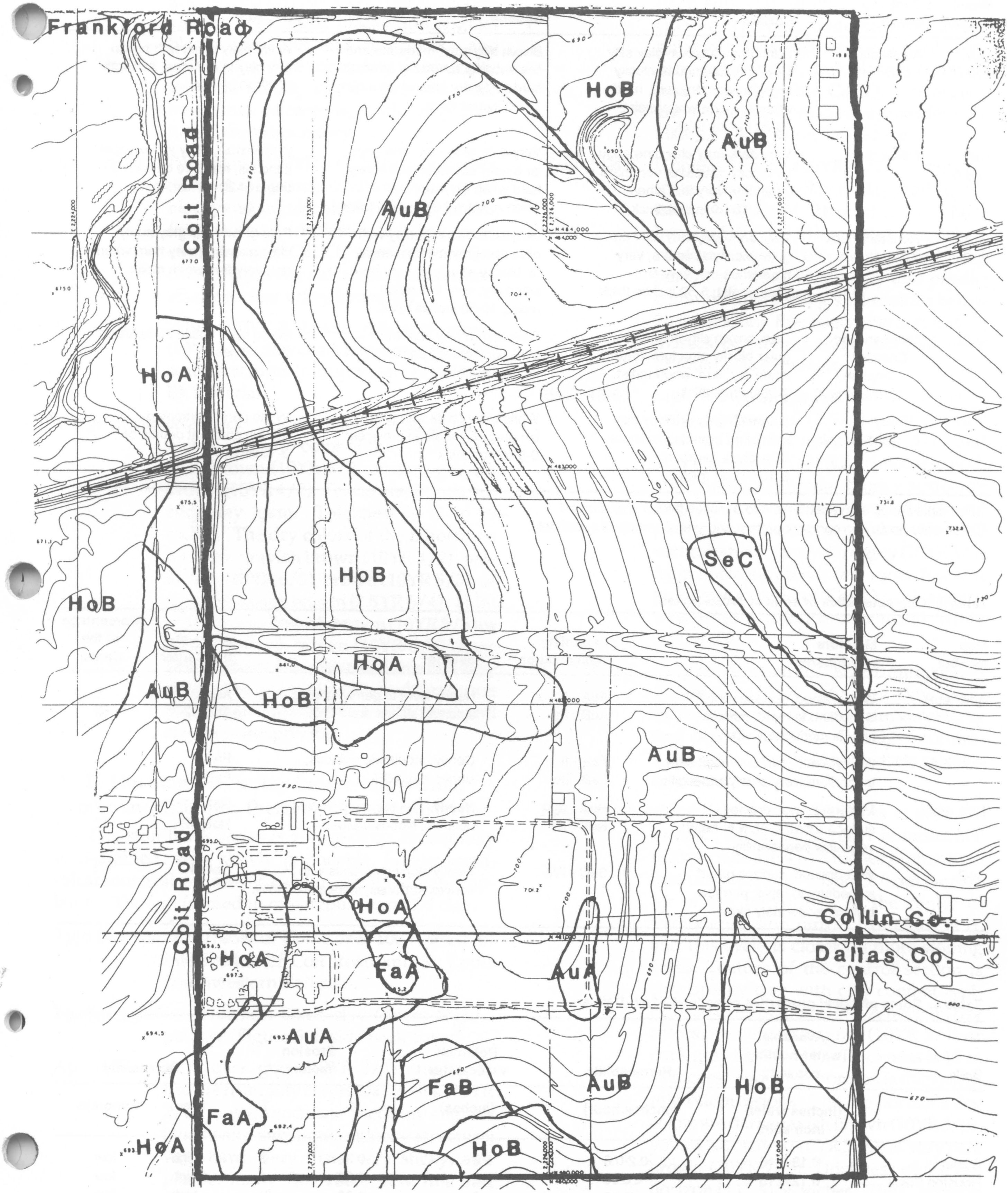


Figure 3b. Contour map of the Texas A&M University Research and Extension Center at Dallas (approximate scale: 1 inch = 400 ft with a contour interval of 2 ft).

Table 1. Characteristics of soils at TAES-Dallas.

Map symbol	Soil series	Surface	Subsoil	Substratum
AuA, AuB	Austin silty clay	Dark grayish brown clay silty clay; fine subangular blocky and granular structure, hard when dry, firm when moist, 10-20 inches thick.	Brown silty clay; moderate and fine subangular blocky structure; hard when dry, firm when moist; 10-30 inches thick.	White platy chalk with brown silty clay in crevices. At depth of 20-40 inches.
FaA, FaB	Fairlie clay[1]	Very dark-gray clay; fine angular blocky structure, very hard when dry, very firm when moist, 16-30 inches thick.	Very dark-gray clay; fine angular blocky structure, extremely hard when dry, very firm when moist, 12-34 inches thick.	White chalk, platy in the upper 6 inches, massive below. At depth of 20-40 inches.
HoA, HoB	Houston Black clay	Very dark-gray clay; fine angular blocky structure; very hard when dry, very firm when moist; 6-50 inches thick.	Grayish brown silty clay with olive and gray mottles; angular blocky structure, very hard when dry, very firm when moist; 10-50 inches thick.	Pale-brown and gray marly clay; massive; very hard when dry, very firm when moist.
SeC	Stephen-Eddy Complex[2] Stephen - (80% of unit)	Dark-brown silty clay, subangular blocky structure; hard when dry, firm when moist; 7-20 inches thick.	Dark-brown silty clay with 60% platy chalk fragments, 0-6 inches thick.	White platy chalk, at depths of 7-20 inches.
	Eddy - (20% of unit)	Brownish gray gravelly clay loam; fine granular structure; 35% chalk fragments, 3-10 inches thick.	White platy chalk with brownish gray clay loam in crevices; 0-5 inches thick	White partly cemented marine chalk, at depths of 3-15 inches.

[1]The Fairlie series at the center is 4 to 8 inches thicker than normal.
[2]These soils occur in a complex pattern and are not mapped separately.

Table 2. Characteristics of soils at TAES-Dallas.

Map symbol	Moisture relationship	Capability classification	Setting	Acres at the Center	Percentage of the Center
AuA, AuB	Well drained, surface runoff is medium to rapid; permeability is moderately slow.	AuA - I AuB - IIe	Nearly level to gently sloping uplands, slopes are 0-3%.	AuA-21 AuB-227	6 62
FaA, FaB	Well drained, surface runoff slow to medium; very slow permeability.	FaA - II FaB - IIe	Gently undulating uplands, slopes are 0-3%.	FaA-4 FaB-5	1 1
HoA, HoB	Moderately well drained, surface runoff is slow to rapid; very slow permeability	HoA - II HoB - IIe	Nearly level to gently sloping uplands, slopes are 0-3%.	HoA-27 HoB-82	7 22
SeC	Well drained, surface runoff is medium to rapid; permeability is moderately slow.	SeC - IVe	Gently sloping uplands with convex surfaces, slopes are 2-5%.	SeC-4	1

Table 3. Some physical properties of soils at TAES-Dallas.

Soils	Available water-holding capacity	Permeability	Potential vertical rise	Erosion factors		Corrosivity	
	(inches water/ inch soil)	(inches/hour)	(inches)	K	T	Steel	Concrete
Austin	0.13-0.16	0.2-0.6	> 2	0.32	2	high	low
Houston Black	0.12-0.15	< 0.06	> 2	0.32	4	high	low
Fairlie	0.12-0.15	< 0.06	> 2	0.32	3	high	low
Stephen	0.13-0.16	0.2-0.6	0.5-1.3	0.32	1	high	low
Eddy	0.17-0.19	0.2-0.6	< 0.25	0.24	1	high	low

Bw 13-26" Grayish brown (10YR 5/2) silty clay, dark grayish brown (10YR 4/2) moist; moderate fine subangular blocky and angular blocky structure; hard, firm, sticky, and plastic; few fine roots; few worm casts; few fine $CaCO_3$ soft masses and chalk fragments; calcareous, moderately alkaline; diffuse boundary.

Bk 26-33" Pale-brown (10YR 6/3) silty clay, brown (10YR 5/3) moist; medium subangular blocky and angular blocky structure; hard, firm, sticky, and plastic; few fine roots; common soft $CaCO_3$ masses, few fine chalk fragments; calcareous, moderately alkaline; clear wavy boundary.

Cr 33"+ White (10YR 8/2) and yellowish brown (10YR 5/6) platy chalk hardness of 2 Mohs' scale; fractures in upper part filled with Bk material.

Range in characteristics: Solum thickness is 26 to 37 inches. The dry color of the A horizon is dark brown (10YR 3/2) or dark grayish brown (10YR 4/2). Texture is silty clay or silty clay loam. Thickness is 11 to 19 inches. The dry colors of the B horizons are dark grayish brown (10YR 4/2), pale brown (10YR 6/3), brown (10YR 5/3), or light yellowish brown (2.5YR 6/4). Faint mottles of yellowish brown (10YR 5/6) or light yellowish brown (10YR 6/4) range from none to few. Texture is mainly silty clay but ranges to clay. The substratum is platy chalk interbedded with marl and clay in some pedons.

B: Houston Black clay (micro high) (fine, montmorillonitic, thermic, Udic Pellustert)

Houston Black series is a very deep, moderately well-drained, very slowly permeable, fine-textured, calcareous soil on nearly level to gently sloping uplands. The soil formed in calcareous marl and clay.

Type location: 200 ft east of Coit Road, 100 ft south of intersection of Coit Road and St. Louis Southwestern Railroad.

Typifying pedon: Houston Black clay (micro high) - pasture (Figure 5, inside back cover).

Ap 0-5" Very dark gray (10YR 3/1) ranging in texture from silty clay to clay, black (10YR 2/1) moist; moderate medium angular blocky and subangular blocky structure; very hard, very firm, very sticky, and plastic; many fine roots; few fine soft $CaCO_3$ masses; calcareous, moderately alkaline; abrupt smooth boundary.

A 5-14" Dark gray (10YR 4/1) ranging in texture from silty clay to clay, very dark gray (10YR 3/1) moist; moderate medium angular blocky structure; very hard, very firm, very sticky, and plastic; common fine roots; few fine $CaCO_3$ soft masses and concretions; calcareous, moderately alkaline; clear wavy boundary.

Bss1 14-46" Grayish brown (10YR 5/2) ranging in texture from silty clay to clay, dark grayish brown (10YR 4/2) moist; few fine faint brown (10YR 5/3) mottles; moderate medium angular blocky structure; very hard, very firm, very sticky and plastic; common intersecting slickensides below 20 inches; few fine roots; few soft $CaCO_3$ masses; calcareous, moderately alkaline; gradual wavy boundary.

Bss2 46-63" Light brownish gray (10YR 6/2) silty clay, grayish brown (10YR 5/2) moist; few fine faint yellowish brown (10YR 5/6) and very pale-brown (10YR 7/3) mottles; moderate medium angular blocky structure; very hard, very firm, very sticky, and plastic; few intersecting slickensides and vertical streak of very dark gray (10YR 3/1) from horizons above; few roots; few soft powdery masses of $CaCO_3$; calcareous; moderately alkaline; gradual wavy boundary.

C 63-80" Very pale-brown (10YR 7/3) and yellowish brown (10YR 5/6) silty clay loam; massive; very hard, very firm, very sticky and plastic; few fine $CaCO_3$ concentrations and soft powdery masses; calcareous, moderately alkaline.

Range in characteristics: Solum thickness is 62 to 78 inches. Gilgai microrelief is indistinct; microknolls are 4 to 8 inches higher than microdepressions. Distance from the center of the microridge to the center of microdepression ranges from 9 to 14 ft, and this cycle is closer on more sloping areas. Texture of the control section is clay or silty clay with clay content typically 50 to 60 percent. The A horizon dry colors are very dark gray (10YR 3/1) or dark gray (10YR 4/1). Thickness is 13 to 41 inches, and the A horizon is thickest in microdepressions. The Bss horizons dry colors are dark grayish brown (10YR 5/3), yellowish brown (10YR 5/6), or very pale brown (10YR 7/3). Thickness of the Bss horizon is 17 to 58 inches. The C horizon is mottled with colors of dark grayish brown (10YR 4/2), brown (10YR 5/3), very pale brown (10YR 7/3), or yellowish brown (10YR 5/6). Texture is clay or silty clay and marl.

C: Fairlie clay (fine, montmorillonitic, thermic, Udic Pellustert)

The Fairlie series is a member of the fine, montmorillonitic thermic family of Udic Pellusterts. It is a deep, moderately well-drained, very slowly permeable calcareous soil on nearly level to gently sloping uplands. These cyclic clayey soils have black A horizons and dark-gray or very dark-brown B horizons that rest on chalk about 46 inches below the surface.

Type location: 150 ft north and 50 ft east of southwest corner of the Center.

Typifying pedon: Fairlie clay, micro low - cropland.

Ap 0-5" Very dark-gray (10YR 3/1) clay, black (10YR 2/1) moist; moderate fine and medium subangular blocky structure; very hard, very firm, very sticky, and plastic; common roots; few fine $CaCO_3$ soft masses and concretions; calcareous, moderately alkaline; abrupt smooth boundary.

A 5-23" Very dark-gray (10YR 3/1) clay, black (10YR 2/1) moist; moderate medium angular blocky structure; very hard, very firm, very sticky, and plastic; common fine roots; few fine $CaCO_3$ concretions and chalk fragments; few intersecting slickensides below 20 inches; calcareous, moderately alkaline; gradual wavy boundary.

Bss 23-40" Very dark-gray (10YR 3/1) clay, black (10YR 2/1) moist; strong, medium, angular blocky structure; very hard, very firm, very sticky, and plastic; few fine roots; common intersecting slickensides and parallel-epipeds; few fine chalk fragments; calcareous, moderately alkaline; gradual wavy boundary.

Bk 40-47" Gray (10YR 5/1) clay, dark gray (10YR 4/1) moist; strong fine angular blocky structure; very hard, very firm, very sticky, and plastic; common fine soft $CaCO_3$ masses and chalk fragments; calcareous, moderately alkaline; diffuse boundary.

Cr 47-55" Very pale-brown (10YR 7/3) chalky marl, becomes platy chalk below 54 inches with hardness less than 3 on Mohs' scale.

Range in Characteristics: Solum thickness to chalk is 43 to 54 inches. Texture of the control section is clay; clay content is 40 to 50 percent. Dry color of the A horizon is black (10YR 2/1) or very dark gray (10YR 3/1). Thickness is 12 to 40 inches, and subsoil lows and highs occur each 12 to 15 ft. Dry color of the Bss horizon is very dark grey (10YR 3/1), very dark grayish brown (10YR 3/2), dark gray (10YR 4/1), dark grayish brown (10YR 4/2), or grayish brown (10YR 5/2). Some pedons have mottled Bk horizons that are very dark grayish brown (10YR 3/2) and grayish brown (10YR 5/2, 2.5YR 5/2). Mottles of brown (10YR 3/3), yellowish brown (10YR 5/4), or brown (10YR 5/3) range from none to few. The Cr horizon is platy chalk or chalky marl. The chalky marl occurs in the subsoil lows. Texture is silty clay with common chalk fragments. Colors are mottled with shades of browns and yellows.

D: Stephen silty clay (clayey, mixed, thermic, shallow, Udorthentic Haplustoll)

The Stephen series is a member of the fine, mixed, thermic, shallow family of Typic Haplustolls. It is a shallow, well-drained, moderately slowly permeable soil on nearly level to gently sloping uplands. These calcareous soils have a dark grayish brown silty clay Ap horizon, brown silty clay Bw horizon, and platy chalk at a depth of 13 inches.

Type location: Part of the Stephen-Eddy complex found 350 ft west of east property line and 1,200 ft south of St. Louis Southwestern Railroad.

Typifying pedon: Stephen silty clay - cropland.

Ap 0-7" Dark grayish brown (10YR 4/2) silty clay, very dark grayish brown (10YR 3/2) moist; moderate medium subangular blocky structure; hard, firm, sticky, and plastic; common fine roots; 5 percent chalk fragments less than 0.5 inch in diameter; calcareous, moderately alkaline; clear, smooth boundary.

Bw 7-13" Brown (7.5YR 5/4) silty clay, dark brown (7.5YR 4/4) moist; moderate fine subangular blocky and granular structure; few fine roots; common chalk fragments finer than layer above; calcareous, moderately alkaline; abrupt wavy boundary.

Cr 13-20" White (10YR 8/2) platy and massive chalky limestone with hardness of 2 on Mohs' scale, interbedded with very pale-brown (10YR 7/3) marly silty clay in upper 5 inches.

Range in characteristics: Solum thickness to chalk or marl is 9 to 18 inches. Chalk fragments in the solum range from 3 to 15 percent and in size from 0.25 to 1 inch. Texture is silty clay. Dry color of the A horizon is dark grayish brown (10YR 4/2) or brown (10YR 4/3). Dry color of the Bw horizon is dark brown (7.5YR 4/2, 4/4). Moist chroma and values are less than 3 in at least one-third of the solum depth. The C horizon is white platy chalk interbedded with very pale-brown (10YR 7/3) marly silty clay.

E: Eddy very gravelly clay loam (loamy-skeletal, carbonatic, thermic, shallow, Typic Ustorthent)

The Eddy series is a member of the loamy skeletal, carbonatic thermic family of Typic Ustorthents. It is a shallow, well-drained, moderately permeable soil. These calcareous soils have grayish brown gravelly clay loam A horizons, very pale-brown gravelly silty clay loam C horizons, and white platy chalk at depths of 11 inches.

Type location: Part of the Stephen-Eddy complex found 350 ft west of east property line and 1,200 ft south of St. Louis Southwestern Railroad.

Typifying pedon : Eddy very gravelly clay loam - cropland.

Ap 0-5" Grayish brown (10YR 5/2) very gravelly clay loam, dark grayish brown (10YR 4/2) moist; moderate fine granular structure; hard, firm; few roots; 35 to 40 percent chalk fragments 0.5 to 1 inch in diameter; calcareous, moderately alkaline; abrupt wavy boundary.

CA 5-11" Very pale-brown (10YR 7/3) very gravelly silty clay loam; structureless; hard, firm; 50 percent by volume of chalk fragments 1 to 3 inches in diameter; calcareous, moderately alkaline; abrupt wavy boundary.

Cr 11-18" White (10YR 8/2) and very pale-brown (10YR 7/3) platy and massive chalky limestone.

Range in characteristics: Solum thickness is 4 to 14 inches over chalk. The soil contains 35 to 50 percent by volume of platy chalk fragments ranging from 0.5 to 3 inches in diameter. Dry color of the A horizon is grayish brown (10YR 5/2) and brown (10YR 5/3, 7.5YR 5/2). Texture is very gravelly clay loam with 18 to 35 percent clay. The C horizon is very pale-brown (10YR 7/3) and white (10YR 8/2) platy limestone interbedded with silty clay loam in the upper 4 to 7 inches. The chalk becomes harder and plates become coarser with depth.

Stephen-Eddy complex, 2 to 5 percent slopes (SeC)

Stephen-Eddy complex soils are shallow and very shallow, gently sloping, calcareous, clayey, and loamy. The soil area is long and narrow and is slightly less than 4 acres in size (Figure 6, inside back cover). A representative area is 350 ft west of the east property line and 1,200 ft south of the St. Louis Southwestern railroad.

This soil area is 80 percent Stephen and 20 percent Eddy soils. Eddy soils occur as slightly steeper areas less than 1/4 acre in size within larger areas of Stephen soils.

Stephen soils have surface layers of very dark grayish brown silty clay about 7 inches thick. Below this to a depth of 13 inches is brown silty clay. Below 13 inches is platy white chalk interbedded with very pale-brown marly clay.

The Eddy soils have dark grayish brown clay loam surface layers about 5 inches thick that contain about 35 percent flattened chalk fragments less than 2 inches in diameter. Below this to a depth of 11 inches is a very pale-brown silty clay loam with about 70 percent flattened chalk fragments. Below 11 inches is very pale-brown and white platy chalk.

Included with these soils and shown on the map are small spots less than about 1/6 acre of soil similar to the Stephen with chalk 20 to 26 inches below the surface.

The permeability is moderately slow and surface runoff is medium to rapid. The available water capacity is low. The water erosion hazard is moderate to severe. Terracing and crop residue managed near the soil surface has reduced the erosion that normally occurs on these soils.

The capability unit is IVe-4. Pasture group is 13A.

Laboratory Analyses of Selected Soil Profiles

Soil samples representing each horizon from both the Austin and Houston Black soils were taken from freshly dug pits at TAES-Dallas in November 1989. The Texas A&M University Soil Characterization Laboratory performed soil analyses using standard procedures (Hallmark et al., 1986).

Particle-size distribution, also called soil textural analysis, measures the size distribution of mineral soil particles less than 2 mm in diameter. Soil particle fractions normally determined include sand (0.05 to 2 mm diameter), silt (0.002 to 0.05 mm diameter), and clay (<0.002 mm diameter). The pipette method of measuring suspended solids was used to estimate particle-size distribution (Tables 4 and 5).

Most of the soil horizons tested have a silty clay texture. Although the control section of the Houston Black series is silty clay, silt percentages less than 40 percent result in a clay textural class. Thus, the Houston Black soil borders between a silty clay and a clay texture. Soils that are primarily silt have intermediate nutrient-holding capacity but are easily eroded by water and have medium to rapid runoff potential. Clay soils are also sticky and heavy when wet and can be difficult to till but have a high nutrient-holding capacity.

Bulk density was determined from core samples taken horizontally within each pit with a double cylinder sampler. This reflects the density of an undisturbed volume of soil solids plus pore space. Bulk density is used primarily for converting water percentage by weight to content by volume and for estimating the weight of a volume of soil too large to weigh, such as tons per acre foot.

Soil reaction (pH), a measure of the hydrogen ion activity in soil, is a routine measurement determined on 1:1 soil-to-distilled-water suspensions. Soil pH greatly affects the availability of plant nutrients. The observed range of pH values between 7.6 to 7.9 reflects the calcareous nature of Austin and Houston Black soils (Table 6). Major effects of the slightly basic pH often are to reduce the solubility of iron (Fe) and zinc (Zn) and to reduce the availability of soil phosphorus (P).

Total carbon was determined by dry combustion. Organic carbon (Table 6) was calculated as the difference of total carbon and inorganic carbon determined in calcite ($CaCO_3$) equivalent analyses. Organic carbon was multiplied by a factor of 1.724 to obtain an estimate of soil organic matter.

Organic matter content of the surface 12 inches of Austin and Houston Black soils exceeded 2 percent (Table 7). Concentrations in these two cultivated soils ranged from 4.5 to 4.6 percent in the plow layer but were considerably lower (<0.03 percent) in subsoil. Organic matter changes are extremely slow in Blackland soils; therefore it is economically feasible to increase soil organic matter for production agriculture only by incorporating plant residues. Laws (1961) found that about 1.8 tons/acre/year of crop residue must be returned to Blackland soil to maintain organic matter levels. Smith et al. (1954) determined that Blackland soils under corn reached an equilibrium of about 2 percent organic matter.

Bases extractable in 1 M ammonium acetate (NH_4OAc, pH 7.0) and cation exchange capacity (CEC) using 1 M sodium acetate (NaOAc, pH 8.2) were also determined for the two soils (Table 6). Extractable bases measured included calcium (Ca), magnesium (Mg), sodium (Na), and potassium (K). An abundance of free lime ($CaCO_3$) in these soils resulted in high concentrations of extractable Ca. The ability of a soil to absorb cations, or plant nutrients, is quantified by its CEC. Soils containing high levels of organic matter and/or montmorillonitic clay have relatively high CEC values; but the presence of sand and silt tends to lower CEC values.

Critical levels suggested by the Texas A&M Soil Testing Laboratory are 0.9, 0.42, and 0.32 meq/100 g for extractable calcium, magnesium, and potassium, respectively, in Texas soils. Fertilizer additions are recommended when soil nutrient concentrations are below these critical levels. Thus, plants would not be expected to benefit from applications of Ca, Mg, or K fertilizers at these two sites. Sodium can affect plants by changing the physical properties of soil when extractable Na concentrations exceed 4.35 meq/100 g or when

Table 4. Particle size distribution of TAES-Dallas soils.

			Sand					Silt		Clay	
Soil series	Horizon	Depth from surface	Very coarse (2.0 - 1.0mm)	Coarse (1.0 - 0.5mm)	Medium (0.5 - 0.25mm)	Fine (0.25- 0.1mm)	Very fine (0.1- 0.05mm)	Coarse (0.1 - 0.02 mm)	Fine (0.02- 0.002 mm)	Coarse (0.002- 0.0002 mm)	Fine (<0.0002 mm)
		inches	percentage								
Austin	Ap	0-5	0.5	0.6	0.7	3.0	4.9	13.0	33.0	32.6	11.7
	A	5-13	0.2	0.4	0.2	1.2	3.2	10.0	34.1	30.7	20.0
	Bw	13-26	0.5	0.4	0.4	2.3	3.1	8.5	37.4	28.1	19.3
	Bk	26-33	0.4	0.3	0.4	2.1	3.2	8.2	42.2	27.4	15.8
	Cr	33-60	0.1	0.3	0.3	2.8	4.3	7.0	49.3	31.2	4.7
Houston Black (micro high)	Ap	0-5	0.3	0.4	0.5	1.4	2.9	16.8	28.3	44.5	4.9
	A	5-14	0.3	0.8	0.7	1.5	2.9	8.9	32.2	32.7	20.0
	Bss1	14-46	0.5	1.2	0.7	1.2	2.5	9.1	33.2	27.5	24.1
	Bss2	46-63	0.6	0.9	0.5	1.0	2.6	10.3	32.1	45.3	6.7
	C	63-72	0.3	0.6	0.8	4.2	5.4	4.9	42.2	40.9	0.7

Table 5. Texture and bulk density of TAES-Dallas soils.

Soil series	Horizon	Depth from surface	Sand (2.0-0.05mm)	Silt (0.05-0.002mm)	Clay (<0.002 mm)	Coarse fragments	Texture class	Moist bulk density
		inches	....	.... percentage	....	....		g/cm³
Austin	Ap	0-5	9.7	46.0	44.3	1	silty clay	1.00
	A	5-13	5.2	44.1	50.7	0	silty clay	0.99
	Bw	13-26	6.7	45.9	47.4	0	silty clay	1.02
	Bk	26-33	6.4	50.4	43.2	0	silty clay	1.05
	Cr	33-60	7.8	56.3	35.9	0	silty clay loam	1.09
Houston Black (micro high)	Ap	0-5	5.5	45.1	49.4	0	silty clay	1.08
	A	5-14	6.2	41.1	52.7	0	silty clay	1.07
	Bss1	14-46	6.1	42.3	51.6	0	silty clay	1.08
	Bss2	46-63	5.6	42.4	52.0	0	silty clay	1.20
	C	63-72	11.3	47.1	41.6	0	silty clay	1.39

Table 6. Soil reaction, organic carbon, and extractable bases (ammonium acetate extractable) of TAES-Dallas soils.

Soil series	Horizon	Depth from surface	pH (H_2O 1:1)	Organic carbon	Extractable bases: Calcium	Magnesium	Sodium	Potassium	Cation exchange capacity	Exchangeable sodium percentage
		inches		%	....	....	meq/100g*	....	....	%
Austin	Ap	0-5	7.6	2.59	68.0	1.3	0.1	1.3	39.5	0.2
	A	5-13	7.8	1.94	75.5	1.5	0.1	0.8	42.7	0.2
	Bw	13-26	7.8	1.23	67.8	0.7	0.2	0.3	37.3	0.5
	Bk	26-33	7.9	0.70	58.2	0.4	0.2	0.2	28.6	0.7
	Cr	33-60	7.9	0.18	50.6	0.4	0.2	0.2	11.3	1.8
Houston Black (micro high)	Ap	0-5	7.6	2.66	85.4	2.1	0.2	0.9	47.5	0.4
	A	5-14	7.8	1.20	79.7	1.1	0.4	0.4	44.3	0.9
	Bss1	14-46	7.8	0.83	83.6	0.9	0.5	0.4	45.1	1.1
	Bss2	46-63	7.8	0.44	70.8	0.9	0.4	0.4	42.0	0.9
	C	63-72	7.9	0.01	50.7	0.5	0.3	0.2	16.4	1.8

*Calcium (ppm) = calcium (meq/100 g) x 200
Magnesium (ppm) = magnesium (meq/100 g) x 120
Sodium (ppm) = sodium (meq/100 g) x 230
Potassium (ppm) = potassium (meq/100 g) x 390

Table 7. Water soluble anions (saturated paste), lime equivalent, and organic matter of TAES-Dallas soils.

Soil series	Horizon	Depth from surface	Soluble anions: Carbonate	Bi-carbonate	Chloride	Sulfate	Calcite	Dolomite	Calcite equivalent	Organic matter
		inches	....	parts per million	....	....	....	percentage	....	....
Austin	Ap	0-5	0.0	299	63.0	77	40.5	0.8	41.5	4.5
	A	5-13	0.0	159	3.5	24	35.8	0.1	35.9	3.3
	Bw	13-26	0.0	159	3.5	34	46.8	0.0	46.8	2.1
	Bk	26-33	0.0	165	3.5	34	61.4	0.7	62.2	1.2
	Cr	33-60	0.0	134	7.0	82	76.0	0.9	77.0	0.3
Houston Black (micro high)	Ap	0-5	0.0	177	28.0	58	22.7	0.4	23.2	4.6
	A	5-14	0.0	195	3.5	48	29.5	0.8	30.4	2.1
	Bss1	14-46	0.0	128	0.0	101	28.8	0.3	29.1	1.4
	Bss2	46-63	0.0	153	3.5	110	36.0	0.0	36.0	0.8
	C	63-72	0.0	128	53.0	77	72.2	0.0	72.2	0.0

exchangeable sodium percentage (ESP) exceeds 15 percent, resulting in a sodic (alkali) soil. Sodium is normally low in Blackland soils, although a few areas contain saline seeps that result in excessive total salts and/or sodium.

Many compounds that are readily soluble in NH_4OAc are only slightly soluble in water (e.g., $CaCO_3$). Therefore, concentrations of soluble salts often represent solute concentrations in the soil solution more accurately than extractable bases. Electrical conductivity (EC) and soluble cation (base) plus anion concentrations to include Ca, Mg, Na, K, carbonate (CO_3), bicarbonate (HCO_3), chloride (Cl), and sulfate (SO_4) were determined on a saturated paste extract. Final distilled water content was noted at saturation (Tables 7 and 8). Electrical conductivity was multiplied by a factor of 640 to obtain an estimate of total salt content expressed in parts per million.

The EC of a saturated soil extract is directly related to the concentration of soluble salts in the soil solution. High soluble salt concentrations lower the availability of soil water for plant uptake. Saline (salty) soils have EC's exceeding 4 mmhos/cm. When EC exceeds 2 mmhos/cm, salt damage may occur on salt sensitive plants such as beans, corn, clovers, roses, photinia, and holly. Typical ranges of EC measured at the Center were between 0.4 and 1.3 mmhos/cm (Table 8), indicating low potential for salt damage to cultivated plants.

The Texas A&M Soil Testing Laboratory suggests a critical level of 25 ppm sulfate (SO_4) in Texas soils. Plants growing on soils testing below 25 ppm soluble SO_4 could benefit from sulfur (S) fertilizer applications. Typical ranges of SO_4 measured at the Center were between 24 to 110 ppm, reflecting adequate supplies of soil sulfur.

Soils containing calcium carbonate ($CaCO_3$) are called calcareous soils. The presence of $CaCO_3$ in soil influences the soil pH, the availability of phosphorus, iron, and zinc, and the fate of applied phosphorus fertilizers. Percentages of calcite ($CaCO_3$) and dolomite ($CaCO_3 \cdot MgCO_3$) were determined by gasometric analysis using a Chittick apparatus. The calcite equivalent (total lime content) was calculated from the sum of $CaCO_3$ and $CaCO_3 \cdot MgCO_3$ percentages.

The importance of $CaCO_3$ in controlling soil pH is emphasized by the requirement of about 3 tons of sulfur (or 10 tons of sulfuric acid) per acre to neutralize every 1 percent $CaCO_3$ to a depth of 6 inches. The presence of $CaCO_3$ can be determined qualitatively by effervescence in the presence of cold, dilute hydrochloric acid (HCl). Austin and Houston Black soils contained 23 to 40 percent $CaCO_3$ in the surface 12 inches and 72 to 76 percent $CaCO_3$ in the subsoil (Table 7). Large-scale sulfur applications to decrease alkalinity are not practically or economically feasible for these soils.

Water Quality for Agricultural and Domestic Purposes

Water used at the Dallas Center is primarily surface water from Lake Lavon purchased from the city of Richardson. Two water samples were taken in February 1990 at the greenhouse facilities and the turfgrass sprinkler irrigation lines for chemical analysis at the Texas A&M University Soil Testing Laboratory. Similar laboratory results were obtained from both samples; therefore their mean chemical concentrations are presented (Table 9).

Principal uses of water at the Center include drip and sprinkler irrigation and consumption by humans and livestock. Concentrations of Ca, Mg, Na, K, CO_3, HCO_3, Cl, SO_4, and nitrate (NO_3) are well below Texas Department of Health and U. S. Environmental Protection Agency (1975) limits for drinking water (Table 9). Total soluble salt concentration was well below recommended limits of 1,000, 1,300, and 2,000 parts per million (ppm) proposed for drinking, irrigation, and livestock waters, respectively (Texas Department of Health). No danger of boron toxicity to plants or animals exists, and negligible quantities of elements

Table 8. Salinity and water soluble bases (saturated paste extract) of TAES-Dallas soils.

Soil series	Horizon	Depth from surface	Electrical conductivity	Water content	Soluble bases: Calcium	Magnesium	Sodium	Potassium	Total salts
		inches	mmhos/cm	%	parts per million				
Austin	Ap	0-5	0.8	73	140	2.4	4.6	12.0	512
	A	5-13	0.3	79	56	1.2	4.6	3.9	192
	Bw	13-26	0.4	66	72	1.2	6.9	0.0	256
	Bk	26-33	0.4	59	72	1.2	9.2	0.0	256
	Cr	33-60	0.4	58	62	0.0	16.0	0.0	256
Houston Black	Ap	0-5	1.3	81	250	25.0	14.0	3.9	832
(micro high)	A	5-14	0.4	75	70	13.0	16.0	0.0	256
	Bss1	14-46	0.4	89	70	11.0	25.0	0.0	256
	Bss2	46-63	0.4	93	68	11.0	23.0	0.0	256
	C	63-72	0.4	63	58	6.0	21.0	0.0	256

Table 9. Analytical data of TAES-Dallas water used for ornamental plant irrigation and human and animal consumption.

Analysis	Parts per million	Pounds applied per acre inch water	Recommended limit in parts per million
Calcium	25.8	5.8	75[b]
Magnesium	2.0	0.4	125[b]
Sodium	9.0	2.0	100[c]
Potassium	5.5	1.2	340[d]
Carbonate	0.0	0.0	—
Bi-carbonate	73.1	17.0	150[e]
Chloride	7.5	1.7	250[a]
Sulfate-S	6.2	1.4	250[a]
Nitrate-N	0.2	0.0	10[a]
Phosphate-P	0.0	0.0	—
Boron	0.0	0.0	1[f]
Total salts	142.0	32.0	1000[f]

Other units

Electrical conductivity (mmhos/cm)	0.30
pH	8.10
Sodium absorption ratio (SAR)	0.46
Hardness (grain/gallon)	1.66
Leaching requirement (%)	0.0
Sulfuric acid requirement (gal. of 95% H_2SO_4 per acre inch to neutralize bi-carbonate)	0.5
Gypsum requirement (lbs/ac inch)	0.0

[a] Based on upper limits for drinking water established by the EPA (1975).
[b] Proposed upper limit for drinking water for which Ca and Mg contribute to water hardness.
[c] Proposed upper limit for drinking water for persons on a low-sodium diet.
[d] Proposed upper level for drinking water for disagreeable taste.
[e] Proposed upper limit for potable water for detrimental scale formation on pipes and fixtures.
[f] Proposed upper level for irrigation of ornamental plants sensitive to salts.

essential for plant growth are applied in irrigation water. Although fluoride concentration was not determined, the low concentration of total dissolved solids could reflect low concentrations of this mineral. In fact, livestock would benefit from mineral supplements because of the low salt content of this water.

The presence of calcium and magnesium made this water slightly hard. Water hardness can be reduced with a water softener; however soft water can be corrosive and often contains excessive quantities of chloride and sodium from the softening process. Overall, no restrictions exist for irrigation, livestock, or domestic uses of this water.

Use and Management of Soils for Agriculture

Research conducted on the soils at TAES-Dallas have wide application because results and findings can often be expanded to include most soils of the Blackland Prairie. The primary crops grown in the Texas Blackland are cotton, grain sorghum, oats, wheat, corn, alfalfa, clover, and forage grasses.

The Blackland Prairie soils are subject to erosion by water and wind. These soils have inherently low permeabilities, which increase surface runoff and soil losses. Soil erosion is the major concern on about two-thirds of the cropland and pasture in Dallas and Collin Counties. If the slope exceeds 1 percent, erosion potential is high. When Austin and Stephen soils lose topsoil material to erosion, productivity is drastically reduced because chalky, limestone subsoil becomes the newly exposed surface layer. This bedrock layer restricts the rooting zone of plants and has low fertility. Additionally, soil erosion can result in sedimentation and pollution of surface waters.

Erosion control measures reduce runoff from soils and increase water infiltration. This may be accomplished by maintaining a vegetative cover on the soil through crop residue management. Terraces and diversions that reduce the length of slopes also reduce runoff and erosion. Contour farming is a common erosion control practice in Dallas and Collin Counties.

Well-maintained livestock pastures reduce erosion on sloping soils, provide nitrogen, and improve tilth for succeeding crops. Commonly grown pasture grasses include coastal bermudagrass, kleingrass, lovegrass, King Ranch bluestem, and Harding grass. Alfalfa and clovers and silage sorghum are also grown to some extent. Native rangeland vegetation suited to grazing includes big and little bluestem, silver bluestem, Indiangrass, switchgrass, sideoats grama, Texas needlegrass, Texas bluegrass, and vine mesquite.

Proper range management minimizes erosion and controls grazing so that vegetation can be about the same in kind and amount as the potential natural plant community for that site (Table 10). Overgrazing and mismanagement has depleted much of our native grassland, which is now covered with mesquite, weeds, and annual grasses. Carrying capacity should be evaluated as range conditions change and as cross fencing is installed to control free-ranging livestock. Most ranches require supplemental grazing crops such as small grains or silage sorghum. Hay and concentrates are also fed to range animals in winter months.

Houston, Fairlie, and Austin soils can be productive agricultural soils with proper management practices. The clay content results in very low water infiltration rates. Without contour farming, terracing, and proper tillage, soil erosion can be a problem. Plant residue should be managed so that water intake by the soil will be maximized and erosion will be prevented. This can be accomplished by shredding stubble with a rotary mower, incorporating the residue into the top 2 to 4 inches of soil, and leaving it in this manner as long as possible for soil and water conservation (Simpson, 1964).

Table 10. Potential native plant communities of soils at TAES-Dallas (dry weight basis).[a]

Common plant name	Austin	Houston Black	Fairlie	Stephen	Eddy
	(percentage composition)				
little bluestem	40	50	50	30	30
big bluestem	15			10	10
silver bluestem	5			5	5
Indiangrass	15	25	25	15	15
switchgrass	5	5	5		
sideoats grama	5	5	5	10	10
Texas wintergrass	5				5
Texas needlegrass				5	
hairy grama				5	5
vine mesquite		5	5		
other perennial grasses				10	10
other perennial forbs	5			5	5
other annual forbs		5	5		
other half shrubs	5	5	5		
other trees				5	5
Potential production (lbs/ac)					
favorable years	6500	7000	6000	4500	4500
normal years	5000	6000	5000	3500	3500
unfavorable years	3000	3500	3500	2000	2000

[a] Modified from Dallas County Soil Survey (1980, Range Productivity and Composition).

Field plots were in the same location and undergoing the same treatment practices each year from 1947 to 1982 at the Dallas Center. These plots, designated as the "Renner Plots," provided valuable soil chemical and physical data under equilibrium conditions with continuous, rotated, fertilized, and nonfertilized systems. Crops in the Renner Plots included cotton, corn, grain sorghum, wheat, and Hubam clover. One group of plots received a yearly application (5 tons/acre) of manure (Hipp and Simpson, 1988).

The Renner Plots have shown that under nonfertilized continuous cropping, Houston, Fairlie, and Austin Soils have the nutrient-supplying capacity to yield about 200 pounds of cotton lint, 23 bushels of wheat, 1,500 pounds of grain sorghum, or 26 bushels of corn per acre. Applications of nitrogen (N) will normally increase yields of these crops, and phosphorus (P) applications will benefit some crops if N is applied in adequate amounts. Cool-season crops such as small grains normally respond to fertilizer P applications. Split applications of fertilizer are seldom required for maximum economic yield of annual rainfed crops. When fertilized, Houston, Fairlie, and Austin soils can yield about 750 pounds of cotton lint, 60 bushels of wheat, 5,500 pounds of grain sorghum, or 100 bushels of corn per acre. These three soils will mineralize (make N available from organic N forms) about 40 to 100 pounds of N per year, depending on soil moisture, temperature, and organic N level. Crops in nonfallow rotations (such as wheat after sorghum) require higher N application rates than if a fallow period has occurred between crops (for example, sorghum after wheat). Cotton grown in rotation with sorghum or corn and wheat results in lower incidence of cotton root rot than does cotton grown continuously.

Other soils studies at TAES-Dallas involve determining fertilizer requirements of various crops grown on soils of the area, contribution of legumes to fertilizer requirements of other crops, and varietal interactions of field and forage crops with fertility and moisture needs. Continuous studies are in progress involving energy and soil conservation through soil management, fertilizer efficiency, moisture conservation, residue management, and supplemental irrigation.

Research with field crops, small grains, and forage crops involves variety selection and cultural practices for the various soil types of the Center. The variety of soils on the Dallas Center provides opportunity for interdisciplinary approaches to research on all the soil types. For example, crop and soils scientists evaluate varieties and breeding lines for adaptation to various soils through drought, disease, and insect tolerance.

Use and Management of Soils for Urban Purposes

Interest in urban-related soil problems is increasing. The location of the Texas A&M University Research and Extension Center at Dallas has brought an awareness of the needs of urban people. Much of the research done for agricultural purposes can be adapted to urban situations. Many of the management practices for agriculture are directly applicable to the management needed for urban lawns, gardens, construction sites, and landscapes.

Some urban uses of the soils, however, are not closely related to agriculture. Most of the soils on the Center are poorly suited for building foundations and other structures. Metal pipelines corrode rapidly when buried in Blackland soils. The shrinking and swelling of the clays, the fine texture of the soil, and the depth to chalk layers are all factors that should be considered in the design and construction of urban structures. These problems do not prohibit the use of the soil, but they do need special consideration before building.

Table 11 lists some selected urban and agricultural uses of the soil and soil factors that need to be considered.

Common practices used on shrink-swell soils are application of stabilization materials (commonly hydrated lime at high rates) to streets and roads during construction and irrigation of soils around houses and buildings. Maintaining moist soil around slabs and foundations partly prevents soil cracking and consequent cracks in the foundation and walls. Rapid establishment of turfgrass is important on new homesites to prevent erosion of topsoil onto streets and sidewalks.

Use of Austin, Houston, and Fairlie soils for recreational areas (parks, playgrounds, etc.) is hampered by

Table 11. Use interpretation of soils at TAES-Dallas.

Soil series	Buildings	Streets and roads	Recreation	Gardening and landscaping	Sanitary landfill	Pasture	Cropland
Austin	Poor High shrink-swell	Poor High shrink-swell	Poor Clayey texture	Fair Clayey texture	Poor Depth to rock Clayey texture	Good	Good
Fairlie	Poor High shrink-swell	Poor High shrink-swell	Poor Clayey texture Very slow permeability	Poor Clayey texture	Poor Clayey texture	Good	Fair Clayey texture
Houston Black	Poor High shrink-swell	Poor High shrink-swell	Poor Clayey texture Very slow permeability	Poor Clayey texture	Poor Clayey texture	Good	Fair Clayey texture
Stephen-Eddy	Poor Shallow to rock	Poor Shallow to rock	Poor Shallow to rock	Poor Shallow to rock	Poor Shallow to rock Sloping	Poor Shallow to rock	Poor Shallow to rock

the slow water infiltration rate, which results in standing water for long periods. The sticky nature of these soils limits use during wet weather. These problems can be partly offset by maintaining a ground cover and providing adequate drainage.

A major urban use of soils such as those found at TAES-Dallas is for gardening and landscaping. All these soils pose some particular problem, but certain management practices decrease the problems enough to permit their use. For gardening and landscapes, the primary problem with Houston Black and Fairlie soils is the high clay content and low water infiltration rates. The water infiltration rate is moderate when dry, but as soils become wet, the infiltration rate is reduced to very low (about 0.06 inches per hour). Water must be applied slowly by sprinkler or drip (trickle) irrigation systems to avoid runoff and erosion or standing water.

Associated with low permeability and high clay content is slow oxygen diffusion to plant roots. This is particularly a problem when soils remain wet for long periods and is deleterious to plant growth. Establishing a ground cover such as grass increases permeability of soils to water and air. Addition of peat moss, compost, or mulch is beneficial to home gardens because it improves tilth and physical properties. The Houston and Fairlie soils are inherently fertile, but additional nitrogen and phosphorus are normally needed for gardens and most landscape plants. Problems with permeability of Austin soils are similar to those encountered with Houston and Fairlie but to a lesser extent.

Stephen-Eddy and eroded Austin soils are common in new home developments. Establishment of vegetation is difficult because of poor water infiltration, low water-holding capacity, and poor root growth in the bedrock. Trees and shrubs normally require application of peat moss, mulch, or topsoil material at the time of transplanting. Established plants and grass roots can penetrate the subsoil to some extent, and water infiltration is greatly increased after establishment. Severely eroded areas may require a thin application of topsoil before grass can be established.

Soils such as these require slow irrigation (e.g., sprinkler or drip) and must be watered frequently because of the low water-holding capacity. Successful gardening requires the addition of peat moss or other suitable sources of organic matter and/or topsoil (mixed in the surface soil if possible). These soils require frequent but low application rates of nitrogen and phosphorus, and for some plants, iron or zinc applications may be beneficial.

Selection of adapted plants is an important consideration in establishing landscapes on soils such as those found at TAES-Dallas.

Use and Management of Soils for Urban Landscapes

The Center is on a part of the Blackland Prairie, which stretches from near the Red River in northern Texas to the Rio Grande Plains in southern Texas and from the Post Oak Savannah in the east to the East Cross Timbers in the west. It is a part of the Tallgrass Prairie of the midcontinental grasslands of North America (Collins et al., 1975). Climax vegetation is tallgrass; little bluestem is the climax dominant, and other tallgrasses are a part of any particular association depending on depth of soil, rainfall, etc. Woody plants occupied the well-watered valleys and thin hillsides where fire could not occur because of lack of fuel material on the rocky slopes and excess moisture in the valleys. Once the land became settled, the prairie broken by the plow, and fires more or less controlled, trees and shrubs established in fence lines and abandoned areas. The best place to observe what might have been part of the climax vegetation is along fenced-in railroad tracks (Simpson, in press).

Although Blackland soils present drawbacks such as high $CaCO_3$, root pruning by the shrink-swell nature of montmorillonitic clays, high incidence of cotton root rot, poor internal drainage, and a waxy, sticky nature, a rather extensive plant palette exists (Table 12), which is suitable for aesthetic landscaping (Baker, 1987; Garrett, 1975; George, 1991). Specialized lists of Texas native plants (Native Plant Society of Texas, 1990), drought-tolerant plants (Simpson and Hipp, 1984), and plants having urban erosion control potential are available (Hipp et al., 1991; Simpson and Hipp, 1986).

A well-adapted plant to this area will meet a minimum set of requirements, i.e., grow in a pH range of 7.0 to 8.3, be adapted to USDA Plant Hardiness Zones 7b to 8a (average annual minimum temperatures of 5° to 15°F), and able to withstand sustained readings of more than 100°F in the summer. These criteria are not readily controlled or easily manipulated by the homeowner or grower (Hipp and Simpson, 1986).

Other aspects of landscape gardening such as fertility requirements, pest control, water requirements, uses of mulch, organic matter enhancement, and improved internal drainage of the soil, while perhaps not simple, can usually be satisfactorily accomplished.

Correct plant selection will go a long way toward solving most garden problems. If plants are adapted to the soil type and the climatic conditions of the area, other facets of gardening become easier. Some Blackland soils are low in phosphorus and in most areas in nitrogen. Some flowering plants and many native plants require low inputs of fertilizer (Hipp et al., 1988, 1989). Potassium is normally available in adequate

Table 12. Landscape plants adapted to the soils and climate at TAES-Dallas.

	Houston Black and Fairlie	Austin	Stephen-Eddy and eroded Austin
Trees, shade	bigtooth maple*, Texas ash*, escarpment live oak*, Caddo maple*, cedar elm*, American elm*, Shumard red oak*, Texas red oak*, chinkapin oak*, bur oak*, Chinese pistache, lacebark elm, pecan*, sweetgum*, sugar hackberry*	All the trees that grow in Houston Black and Fairlie. If grown on thin Austin soil, will need supplemental irrigation.	Texas ash*, escarpment live oak*, cedar elm*, Texas red oak*, bur oak*, Chinese pistache, bigelow oak*, sugar hackberry*
Trees, flowering	desert willow*, crape myrtle, goldenrain tree, Texas redbud* (esp. the cv's Oklahoma and white Texas), Mexican redbud*, Mexican plum*, southern magnolia*, ornamental pear, Wright acacia*, mesquite*, eastern redbud*, Eve's necklace*, rusty blackhaw*	All the trees that grow in Houston Black and Fairlie. If grown on thin Austin soil, will need supplemental irrigation.	goldenrain tree, Texas redbud*, Mexican redbud*, Mexican plum*, Wright acacia*, mesquite*, Eve's necklace*
Trees, decorative	yaupon holly*, deciduous holly*, southern waxmyrtle*, prairie flameleaf sumac*, redtip photinia	All the trees that grow in Houston Black and Fairlie. If grown on thin Austin soil, will need supplemental irrigation.	deciduous holly*, prairie flameleaf sumac*
Trees, conifer	bald cypress*, Japanese black pine, deodar cedar, eastern red cedar*, ashe juniper*, Arizona cypress*, alligator juniper*	All the trees that grow in Houston Black and Fairlie. If grown on thin Austin soil, will need supplemental irrigation.	ashe juniper*, alligator juniper*, eastern red cedar*
Shrubs	barberry, crape myrtle, abelia, Japanese boxwood, dwarf and shrub junipers (many cv's), elaegnus, burford holly, Chinese holly, dwarf nandina (several cv's), compact nandina, nandina, dwarf yaupon holly, Nellie R. Stevens holly, flowering quince, spirea, smooth sumac*, fragrant sumac*, red yucca*, false indigo*, flame acanthus*, Texas barberry*, agarito*, American beautyberry*, cenizo*, white bush honeysuckle*, dwarf waxmyrtle*, mockorange*, autumn sage*, mountain sage*, Arkansas yucca*, silver dalea*	All the shrubs that grow in Houston Black and Fairlie. If grown on thin Austin soil will need supplemental irrigation during drought.	abelia, barberry, Japanese boxwood, most junipers, elaeagnus, all nandina cv's and species, smooth sumac*, fragrant sumac*, red yucca*, flame acanthus*, Texas barberry*, agarito*, cenizo*, white bush honeysuckle*, dwarf waxmyrtle*, mockorange*, autumn sage*, mountain sage*, Arkansas yucca*, silver dalea*

Table 12. (Continued)

	Houston Black and Fairlie	Austin	Stephens-Eddy and eroded Austin
Vines	Carolina jessamine*, English ivy, coral honeysuckle*, trumpet vine*, Madame Galen trumpet vine, cross vine*, climbing prairie rose*, wisteria, Boston ivy, Lady Banks rose, summer grape*, sweet mountain grape*, mustang grape*, seibel 9110 grape	All the vines that grow in Houston Black and Fairlie. During drought, will need supplemental irrigation.	coral honeysuckle*, trumpet vine*, climbing prairie rose*, sweet mountain grape*
Ground covers	creeping junipers (many cv's), Asiatic jasmine, purpleleaf honeysuckle, English ivy, greater periwinkle (*Vinca major*), common periwinkle (*V. minor*), liriope cv's, monkey grass, purpleleaf euonymus, artemesia*, Virginia creeper*, wood fern*	All the ground covers that grow in Houston Black and Fairlie. During drought, will need supplemental irrigation.	creeping junipers, purpleleaf honeysuckle, artemesia*, virginia creeper*
Flowering plants, herbaceous perennials	Mexican hat*, columbine*, butterfly weed*, chocolate daisy*, blackfoot daisy*, Barbara's buttons*, winecup*, lantana*, *Lantana* cv's, black sampson*, purple coneflower*, Engelmann daisy*, Maximillian sunflower*, Jerusalem artichoke*, Turk's cap*, pink evening primrose*, mealy blue sage*, pavonia*, dogweed*, *Aster** spp., *Penstemon** spp., Wright skullcap*, blue baptisia*, chrysanthemum, canna, daffodil, daylily, iris, thrift	All the flowering plants that grow in Houston Black and Fairlie. During drought, will need supplemental irrigation for all non-natives and for columbine* and Maximilian sunflower.*	All will grow except non-natives (*Lantana* cv's will grow) and columbine* and Maximilian sunflower.*
Flowering plants, annuals	alyssum, begonia, caladium, candletree, coleus, copperleaf, dianthus, shasta daisy, geranium, impatiens, Joseph's coat, kale, marigold, nierembergia, pansy, periwinkle, petunia, portulaca, snapdragon, tulip (act as annual), zinnia, Texas bluebonnet*, Indian blanket*, black-eyed Susan*	All the flowering plants that grow in Houston Black and Fairlie. Non-native will need supplemental irrigation.	Except for Texas bluebonnet*, all these annuals need special bed preparation (compost, peat moss, etc.) and supplemental irrigation.
Turfgrass	common Bermuda, 'tif' Bermuda, buffalo*, 'prairie' buffalo*, St. Augustine, tall fescue, *Zoysia* cv's	All the grasses that grow in Houston Black and Fairlie. Tall fescue, St. Augustine, 'tif' Bermuda, and *Zoysia* cv's will need supplemental irrigation.	common bermuda, buffalo*, 'prairie' buffalo*
Landscape grasses, cool season	Canadian wild rye*, Virginia wild rye*, Texas bluegrass*, junegrass*, western wheatgrass*, threeflower melic*, blue fescue	All the grasses that grow in Houston Black and Fairlie. During drought, will need supplemental irrigation, especially during heat of summer.	None is adapted unless planting areas are amended with organic matter.
Landscape grasses, warm season	big bluestem*, little bluestem*, season bushy bluestem*, Springfield bluestem*, splitbeard bluestem*, indiangrass*, seep muhly*, sideoats grama*, eastern gamagrass*, switchgrass*, pampasgrass	All the grasses that grow in Houston Black and Fairlie except bushy bluestem. During drought will need supplemental irrigation.	little bluestem*, Springfield bluestem*, seep muhly*, sideoats grama*

*Native Texas plants.

amounts and does not need to be added to Blackland soils for urban landscape maintenance. Organic matter is vitally important and can be obtained from composted leaves, grass, and other organic materials. These materials can be used as mulch in droughty conditions of midsummer and then incorporated into the soil at least 2 inches deep in the fall. Turfgrass should be mowed regularly, leaving all clippings on the lawn as fine organic matter (Knoop, 1988).

In most Blackland areas, plants benefit from raised flower and shrubbery beds. These need to be elevated only 6 to 12 inches but 18 inches is better. Native soil of the area should fill the bed, and composted organic matter (2 to 6 inches deep) should be added and thoroughly tilled in. This should give excellent drainage. For transplanted trees, special beds are not necessary, but the trees should be planted slightly higher than previously planted. Many transplanted trees are lost because they are planted too deeply and watered excessively.

Beds and trees should be watered only when needed, which might be once per week in a hot, dry summer, or possibly only once every 2 weeks for well-established trees in summers with normal rainfall. However, when plants are watered, apply at least 1 inch of water. Drip irrigation is an excellent way to water beds and trees (Duble and Welch, 1985; Parsons et al., 1985). Inexpensive drip irrigation kits can be purchased at most nurseries or hardware stores. The pressure gauge should be set to apply about 2 gallons per hour at each emitter. About 62 gallons of water per 100 ft^2 equals an inch of surface water. Sprinkler irrigation is the most commonly used method of irrigating turfgrass. Sprinklers should be operated in short enough time frames that runoff does not occur. If runoff begins, stop the irrigation and allow standing water to soak in, then apply subsequent waterings until the desired amount has been applied.

Literature Cited

Baker, M. L. 1987. Trees, shrubs, vines and ground covers for north central Texas. TX Agri. Ext. Serv. Mimeograph. Dallas.

Collins, O. B., F. E. Smeins, and D. H. Riskind. 1975. Plant communities of the Blackland prairie of Texas. *In* M. K. Wali (ed.). Prairie: a multiple view. Univ. North Dakota, Grand Forks, 320 pp.

Duble, R. L., and W. C. Welch. 1985. Texscape for conservation. TX Agri. Ext. Serv. B-1498. Texas A&M Univ., College Station.

Garrett, Howard. 1975. Plants of the metroplex. Lantana Press. Dallas, TX, 90 pp.

George, Steven. 1991. Recommended landscape plant materials for north central Texas. TX Agri. Ext. Serv. Mimeograph. Dallas.

Hallmark, C. T., L. T. West, L. P. Wilding, and L. R. Drees. 1986. Characterization data for selected Texas soils. TX Agri. Exp. Sta. MP-1543. Texas A&M Univ., College Station, 239 pp.

Hipp, B. W., and B. J. Simpson. 1986. Influence of sulfur on soil pH and growth of cenizo [*Leucophyllum frutescens* (Berl.) I. M. Johnst.]. J. Environ. Hort. 4(4): 142-144.

Hipp, B. W., and B. J. Simpson. 1988. Thirty-five years of farming systems research in the Texas Blackland. TX Agri. Exp. Sta. B-1604. Texas A&M Univ., College Station, 24 pp.

Hipp, B. W., B. J. Simpson, and P. S. Graff. 1988. Influence of nitrogen and phosphorus on growth and tissue N and P concentration in *Salvia greggii*. J. Environ. Hort. 6(2):59-61.

Hipp, B. W., B. J. Simpson, and P. S. Graff. 1989. Influence of phosphorus on nitrogen fertilizer requirement of *Melampodium leucanthum* (blackfoot daisy) grown in perlite-vermiculite medium. J. Environ. Hort. 7(3): 83-85.

Hipp, B. W., M. C. Engelke, and B. J. Simpson. 1991. Use of resource efficient landscape plants to reduce urban runoff. *In* Ric Jensen (ed.). Symposium on water quality of the upper Trinity River. Texas Water Res. Inst. Texas A&M Univ., College Station, 274 pp.

Knoop, Bill. 1988. Don't bag it. Lawn care plan for north central and central Texas. TX Agri. Ext. Serv. L-2456. Texas A&M Univ., College Station.

Laws, W. D. 1961. Farming systems for soil improvement in the Blacklands. Texas Res. Found. Bull. 10. Renner Research Foundation, Renner, TX, 26 pp.

National Oceanic and Atmospheric Administration. 1977. Local climatological data, Dallas - Ft. Worth, TX, and Asheville, NC.

Native Plant Society of Texas. 1990. A beginner's list, native plants for landscape use in Dallas and Fort Worth. Georgetown, TX.

Parsons, J., S. Cotner, and R. Roberts. 1985. Efficient use of water in the garden and landscape. TX Agri. Ext. Serv. B-1496. Texas A&M Univ., College Station.

Simpson, B. J. 1964. Wheat production in farming systems for north central Texas. Texas Research Foundation Bulletin 19. Renner Research Foundation, Renner, TX, 31 pp.

Simpson, B. J. In press. The modern urban Blacklands, from tallgrass prairie to soccer fields. *In* O. T. Hayward and Joe C. Yelderman (eds.). The Texas Blacklands: a land, its history, and its culture. Blackland Symp. Baylor Univ., Waco, TX.

Simpson, B. J., and B. W. Hipp. 1984. Drought tolerant Texas native plants for amenity plantings. *In* M. A. Collins (ed.). Water for the 21st century: Will it be there? Southern Methodist Univ., Dallas, 869 pp.

Simpson, B. J., and B. W. Hipp. 1986. Native Texas flora with urban erosion control potential. Proceedings of Conference XVII. International Erosion Control Assoc., Dallas, 303 pp.

Smith, R. M., D. O. Thompson, J. W. Collier, and R. J. Hervey. 1954. Soil organic matter, crop yields, and land use in the Texas Blackland. Soil Sci. 77:377-388.

Soil Survey Staff. 1951. Soil survey manual. U.S. Department of Agriculture - Soil Conservation Service Handbook 18. U.S. Government Printing Office, Washington, D.C., 503 pp., illus.

Soil Survey Staff. 1987. Keys to soil taxonomy (third printing). SMSS Tech. Monograph No. 6. Cornell Univ., Ithaca, NY., 280 pp.

U. S. Department of Agriculture. 1969. Soil survey of Collin County, Texas. U. S. Department of Agriculture - Soil Conservation Service. U.S. Government Printing Office, Washington, D.C., 55 pp., illus.

U. S. Environmental Protection Agency. 1975. Maximum contaminate levels. Federal Register, V. 40, No. 248, pp. 59566-59588.

Glossary*

Aggregate. Many fine soil particles held in a single mass or cluster, such as a clod, crumb, block, or prism.

Alkaline soil. Generally, a soil that is alkaline throughout most or all of the part occupied by plant roots. Precisely, any soil having a pH value greater than 7.0; practically, a soil having a pH above 7.3.

Anion. Any ion carrying a negative charge. Common soil anions are bicarbonate, sulfate, chloride, and nitrate.

Available water capacity (available moisture capacity). The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field capacity (-1/3 Bar) and the amount at wilting point (-15 Bars).

Calcareous soil. A soil containing enough calcium carbonate (often with magnesium carbonate) to effervesce (fizz) visibly when treated with cold, dilute hydrochloric acid.

Cation. Any ion carrying a positive charge. Common soil cations are calcium, magnesium, sodium, and potassium.

Cation exchange capacity. The total amount of exchangeable cations that can be held by the soil, expressed as milliequivalents per 100 grams of soil.

Chalk. A soft, white or light-gray, unindurated limestone consisting principally of skeletons of *Foraminifera* in a matrix of finely crystalline calcite.

Clay. Individual mineral soil particles less than 0.002 millimeter in diameter. As a textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Clay film. A thin coating of clay on the surface of a soil aggregate; clay coat, clay skin.

Concretions. Grains, pellets, or nodules of various sizes, shapes, and colors, consisting of concentrations of compounds or of soil grains cemented together. The composition of some concretions is unlike that of the surrounding soil. Calcium carbonate and iron oxide are examples of material commonly found in concretions.

Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers. The following terms are used to describe consistence:

Loose. Noncoherent; will not hold together in a mass.

Friable. When moist, easily crushes under gentle pressure between thumb and forefinger and can be pressed together into a lump.

Firm. When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Plastic. When wet, readily deforms by moderate pressure but can be pressed into a lump; will form a wire when rolled between thumb and forefinger.

Sticky. When wet, adheres to other material; tends to stretch and pull apart rather than to pull free from other material.

Hard. When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Soft. When dry, breaks into powder or individual grains under slight pressure.

Cemented. Hard and brittle; little affected by moistening.

Depth, soil. In soil descriptions, the following depth classes are used:

Very shallow. 3 to 10 inches of soil over bedrock or another impervious layer that severely restricts growth of roots.

Shallow. 10 to 20 inches of soil over bedrock or another impervious layer that severely restricts growth of roots.

Moderately deep. 20 to 40 inches of soil over bedrock or another impervious layer that restricts growth of roots.

Deep. 40 to 60 inches of soil over bedrock or another impervious layer.

Very deep. More than 60 inches of soil over bedrock.

Gilgai. Typically a succession of microbasins and microknolls in nearly level areas; similar to hogwallow land.

Horizon, soil. A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes. These are the major soil horizons:

Ap horizon. A plowed surface horizon. The plow layer of agricultural soils.

A horizon. The mineral horizon at the surface or just below an Ap horizon. Living organisms are most active in this horizon, and it is therefore marked by the accumulation of humus. The horizon may have lost one or more soluble salts, clay, and sesquioxides (iron and aluminum oxides).

---

*Adapted from Soil Survey Manual (1951).

B horizon. The mineral horizon below an A horizon. The B horizon is partly a layer of change from the overlying A to the underlying C horizon. The B horizon also has (1) distinctive characteristics caused by accumulation of clay, sesquioxides, humus, or some combination of these; (2) prismatic or blocky structure; (3) redder or stronger colors than the A horizon; or (4) some combination of these. The combined A and B horizons are usually called the solum, or true soil. If a soil lacks a B horizon, the A horizon alone is the solum.

Specific types of soil horizons:

Bk - Indicates the accumulation of calcium carbonate in the B horizon.

Bss - Indicates the presence of slickensides in the B horizon.

Bw - Indicates the development of color and/or structure with little or no apparent illuvial accumulation of material in the B horizon.

C horizon. The weathered rock material immediately beneath the solum. In most soils, this material is presumed to be like that from which the overlying horizons were formed. If the underlying material is known to be different from that in the solum, an Arabic numeral precedes the letter C. Difficult to excavate.

Cr horizon. Root restrictive layers of soft bedrock. Excavation difficulty is low or moderate.

R layer. Consolidated rock beneath the soil. The rock typically underlies a C horizon but may be immediately beneath an A or B horizon. Difficult to excavate.

Loam. The textural class name for a soil that is 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand.

Marl. A mixture of clays and calcium carbonate.

Matrix. The natural material in which a fossil, metal, gem, crystal, or pebble is embedded.

Microrelief. Minor surface configurations of the land.

Mohs' scale. A scale of hardness for minerals in which 1 represents the hardness of talc; 2 of gypsum; 3 of calcite; and on up to 10 of diamond.

Mottled. Irregularly marked with spots of different colors that vary in number and size. Mottling in soils normally indicates poor aeration and lack of drainage. Descriptive terms are as follows: *abundance* - few, common, and many; *size* - fine, medium, and coarse; and *contrast* - faint, distinct, and prominent. The size measurements are these: *fine* - less than 5 millimeters (about 0.2 inch) in diameter along the greatest dimension; *medium* - ranging from 5 millimeters to 15 millimeters (about 0.2 to 0.6 inch) in diameter along the greatest dimension; and *coarse* - more than 15 millimeters (about 0.6 inch) in diameter along the greatest dimension.

Munsell notation. A system for designating color by degrees of the three simple variables hue, value, and chroma. For example, a notation of 10YR 6/4 designates a color with a hue of 10YR, value of 6, and a chroma of 4.

Parent material. The disintegrated and partly weathered earthy material from which a soil has formed.

Ped. An individual natural soil aggregate, such as a crumb, a prism, or a block, in contrast to a clod.

Permeability or hydraulic conductivity. The quality of the soil that enables water to move downward through the profile, expressed as inches per hour through saturated soil. The following terms describe permeability:

Very slow .... less than 0.06 inches/hour

Slow.............. 0.06 to 0.20 inches/hour

Moderately slow ...... 0.2 to 0.6 inches/hour

Moderate........... 0.6 to 2 inches/hour

pH value. A numerical means for designating relatively weak acidity and alkalinity in soils. A pH value of 7.0 indicates precise neutrality; a higher value, alkalinity; and a lower value, acidity.

Potential evapotranspiration. The rate at which water, if available, will be removed from the soil surface. Expressed as a depth of water.

Profile, soil. A vertical section of the soil through all its horizons and extending into the parent material.

Reaction, soil. The degree of acidity of alkalinity of a soil expressed in pH values. A soil that tests to pH 7.0 is precisely neutral in reaction because it is neither acid nor alkaline. In words, the degrees of acidity or alkalinity are expressed thus:

	pH		pH
Extremely acid	below 4.5	Neutral	6.6 to 7.3
Very strongly acid	4.5 to 5.0	Slightly alkaline	7.4 to 7.8
Strongly acid	5.1 to 5.5	Moderately alkaline	7.9 to 8.4
Moderately acid	5.6 to 6.0	Strongly alkaline	8.5 to 9.0
Slightly acid	6.1 to 6.0	Very strongly alkaline	9.1 and higher

Relief. The elevations or inequalities of a land surface, considered collectively.

Runoff. The part of the precipitation upon a drainage area that is discharged from the area in stream channels. The water that flows off the surface without soaking in is called surface runoff; water that enters the ground before reaching surface streams is called ground-water runoff.

Sand. Individual rock or mineral fragments in soils having diameters ranging from 0.05 to 2.0 millimeters. Most sand grains consist of quartz, but they may be of any mineral composition. The textural class name of any soil that is 85 percent or more sand and not more than 10 percent clay.

Shale. A sedimentary rock formed by the consolidation (hardening) of clay deposits.

Silt. Individual mineral particles in a soil that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). Soil of the silt textural class is 80 percent or more silt and less than 12 percent clay.

Slickensides. Polished and grooved surfaces produced by one mass sliding past another. In soils, slickensides may occur at the base of a slip surface on a relatively steep slope; in swelling clays they may occur where moisture content changes markedly.

Soil separates. Mineral particles less than 2 millimeters in equivalent diameter and ranging between specified size limits. The names and sizes of separates recognized in the United States are as follows: *Very coarse sand* (2.0 to 1.0 millimeter); *coarse sand* (1.0 to 0.5 millimeter); *medium sand* (0.5 to 0.25 millimeter); *fine sand* (0.25 to 0.10 millimeter); *very fine sand* (0.10 to 0.05 millimeter); *silt* (0.05 to 0.002 millimeter); and *clay* (less than 0.002 millimeter). The separates recognized by the International Society of Soil Science are as follows: I (2.0 to 0.2 millimeters); II (0.2 to 0.02 millimeter); III (0.02 to 0.002 millimeter); and IV (less than 0.002 millimeter).

Solum. The upper part of a soil profile, above the parent material, in which the processes of soil formation are active. The solum in mature soil includes the A and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the underlying material.

Stratified. Composed of or arranged in strata, or layers. The term is confined to geological material. Alluvium is commonly stratified, and its strata inherit characteristics of the parent material. Layers that are the result of the soil-forming processes are called horizons.

Structure, soil. The arrangement of primary soil particles into compound particles or clusters that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil particles. The principal forms of soil structure are *platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular*. *Structureless* soils are (1) *single grain* (each grain by itself, as in dune sand) or (2) massive (the particles adhering without any regular cleavage, as in many claypans and hardpans).

Subsoil. Technically, the B horizon; roughly, the part of the profile below the plow depth.

Substratum. Any layer beneath the solum, either conforming (C or R) or unconforming.

Surface layer. Technically, the A horizon; roughly that part of the profile above the subsoil; includes the plow layer.

Surface soil. The soil ordinarily moved in tillage or its equivalent in uncultivated soil, about 5 to 8 inches in thickness; the plowed layer.

Terrace. An embankment, or ridge, constructed across sloping soils on the contour or at a slight angle to the contour. The terrace intercepts runoff so that the water soaks in the soil or flows slowly to a prepared outlet. Terraces in fields are generally built so they can be farmed. Terraces intended mainly for drainage have a deep channel that is maintained in permanent sod.

Terrace (geological). An old alluvial plain, ordinarily flat or undulating, bordering a river or lake. Stream terraces are frequently called *second bottoms*, as contrasted to *flood plains*, and are seldom subject to overflow.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. (See also *Clay*, *Sand*, and *Silt*.) The basic textural classes, in order of increasing proportion of fine particles, are sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay, and clay. The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

Well drained. Water is removed from the soil readily but not rapidly. Moisture is available to plants throughout most of the growing season, and wetness does not inhibit root growth for significant periods during most growing seasons.

[Blank Page in Original Bulletin]

Figure 4. Typical profile of Austin silty clay at TAES-Dallas.

Figure 5. Typical profile of Houston Black silty clay at TAES-Dallas.

Figure 6. Typical profile of the Stephen-Eddy complex at TAES-Dallas.

Copies printed: 4,000