SOIL SURVEY

Otoe County Nebraska

Series 1940, No. 6

Issued August 1950

UNITED STATES DEPARTMENT OF AGRICULTURE
Agricultural Research Administration
Bureau of Plant Industry, Soils, and Agricultural Engineering
In cooperation with the
UNIVERSITY OF NEBRASKA
Conservation and Survey Division

How to Use THE SOIL SURVEY REPORT

FARMERS who have lived in one locality for a long time come to know about the soil differences on their own farms and on those of their immediate neighbors. What they do not know, unless a soil survey has been made, is how nearly their soils are like those at experiment stations or in other localities from which higher yields are reported. They do not know whether these higher yields are from soils like their own or so different that they could not hope to get equally high returns, even if they adopted the practices followed in these other places. These similarities and differences among soils are known only after a map of the soils has been made. Knowing what kind of soil one has and comparing it with soils on which new developments have proved successful will remove some of the risk in trying new methods and varieties.

SOILS OF A PARTICULAR FARM

To find what soils are on any farm or other tract of land, locate it on the soil map, which is in the envelope inside the back cover. This is easily done by finding the township, section, and quarter section the farm is known to be in and locating its boundaries by such landmarks as roads, streams, villages, and other features.

Each kind of soil is marked with a symbol on the map. For example, all soils marked Mlv are of the same kind. To find the name of the soil so marked, look at the legend printed near the margin of the map and find Mlv. The color where Mlv appears in the legend will be the same as where it appears on the map. The Mlv means Marshall silt loam, level phase. A section of this report (see table of contents) tells what Marshall silt loam, level phase, is like, for what it is mainly used, and some of the uses to which it is suited.

How productive is Marshall silt loam, level phase? Find this soil name in the left-hand column of table 6 and note the expectable yields of the different crops opposite it. This table also gives estimated yields for all the other soils mapped so that the different soils may be compared.

Read the section on Soil Series, Types, and Phases to learn what are good uses and management practices for this soil.

SOILS OF THE COUNTY AS A WHOLE

If a general idea of the soils of the county is wanted, read the introductory part of the section on Soils. This tells where the principal kinds are found, what they are like, and how they are related to one another. Then study the soil map and notice how the different kinds of soils tend to be arranged in different localities. These patterns are likely to be associated with well-recognized differences in type of farming and land use.

A newcomer who considers purchasing a farm in the county will want to know about the climate as well as the soils; the types and sizes of farms; the principal farm products and how they are marketed; the kinds and conditions of farm tenure; kinds of farm buildings, equipment, and machinery; availability of schools, churches, highways, railroads, electric services, and water supplies; industries; and cities, villages, and population characteristics. This information will be found in the section on General Nature of the County.

Students and others interested in how the soils of the county were formed and how they are related to the great soil groups of the world should read the section on Morphology and Genesis of Soils.

This publication of the soil survey of Otoe County, Nebr., is a cooperative contribution from the—

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Series 1940, No 6 Issued August 1950

SOIL SURVEY OF OTOE COUNTY, NEBRASKA

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United States Department of Agriculture in cooperation with the University of Nebraska, Conservation and Survey Division

CONTENTS

[1] Part of the field work for this survey was done while the Division was a part of the Bureau of Chemistry and Soils.

THE predominantly agricultural economy of Otoe County is based largely on diversified farming. Most of the soils are well suited to cultivation, and more than 97 percent of the area is in farms used for livestock raising and grain and feed production. Corn, wheat, oats, and alfalfa are the leading crops; minor crops include rye, barley, potatoes, and fruits. Livestock and livestock products are the principal source of income on many farms. Quarrying, the excavation of sand and gravel, and the manufacture of brick and tile are the chief nonagricultural industries. Feed and flour mills, creameries, a canning factory, and a meat-packing plant are in Nebraska City. Syracuse, Nebraska City, and a number of smaller towns and villages serve as trading points and shipping centers. To provide a basis for the best agricultural uses of the land a cooperative soil survey was begun in 1940 by the United States Department of Agriculture and the University of Nebraska.

GENERAL NATURE OF THE COUNTY

LOCATION AND EXTENT

Otoe County, in the southeastern part of Nebraska, lies adjacent to the Missouri River, the main channel of which forms the eastern boundary of the State. Nebraska City, the county seat and largest town, is centrally located in the extreme eastern part of the county (fig. 1); it is 45 miles east of Lincoln, the State capital, and 40 miles south of Omaha. Norfolk is 120 miles to the northwest, and Grand Island and Hastings are both 130 miles to the west. The roughly rectangular county extends approximately 36 miles from east to west and about 18 miles from north to south and covers an area of 387,840 acres.

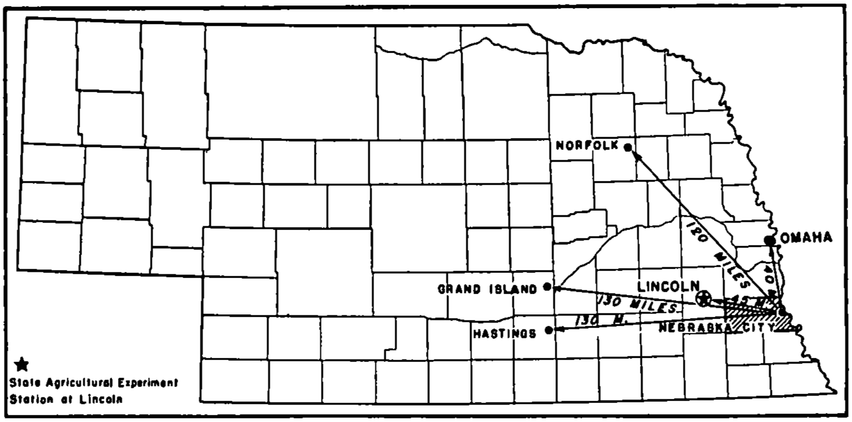

FIGURE 1.—Location of Otoe County in Nebraska.

PHYSIOGRAPHY, RELIEF, AND DRAINAGE

The county lies within the Dissected Till Plains section of the Central Lowland province in the Interior Plains division.[2] It is part of an eroded glacial drift plain known as the Kansan, which was covered by two wind-deposited formations, the first formed by Loveland loess and the second by Peorian. Most of the county is covered by Peorian loess, a pale-brown (buff-colored) floury silt that may lie directly on any one of the other geologic formations. Loveland loess, a reddish-brown slightly sandy silt, was largely removed by erosion before the Peorian loess was deposited, but some of it was covered by the later deposit. Loveland loess is exposed in many deep road cuts and gullies throughout the uplands, but it has given rise to few soils. Most of the valleys are partly filled with alluvium washed from higher lying areas.

In places, probably where the relief was most irregular prior to any loess deposition, are Permo-Pennsylvanian limestone, Dakota sandstone, and Kansan drift, named in the order of their deposit. These formations have remained at the surface or have been exposed by recent erosion (*1*).[3] The Kansan drift, a heterogeneous mixture consisting mainly of clay, considerable sand and silt, and numerous pebbles, stones, and boulders, is located principally in the western part of the county on valley slopes along the larger streams and their more deeply entrenched tributaries. The bedrock formations outcrop on only a few of the steepest slopes and are of minor extent.

Physiographically, the county is part of a thoroughly dissected plain that slopes gradually eastward. It includes three distinct topographic divisions—uplands, terraces, and flood plains, or first bottoms. Most of the land consists of a succession of undulating and well-rounded upland divides separated by many relatively narrow valleys with gently sloping sides and nearly level bottoms.

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[2] FENNEMAN, N. M. PHYSIOGRAPHIC DIVISIONS OF THE UNITED STATES. (Map). U. S. Geol. Survey, 1930.

[3] Italic numbers in parentheses refer to Literature Cited, p. 87.

The relief ranges from nearly level to steeply sloping, largely the result of water erosion. Most slopes range between 5 and 40 rods in length and between 4 and 10 percent in gradient. The longer and more gradual slopes are commonly some distance from the larger drainageways. The relief corresponds only in a general way to that of the old drift plain. Originally, this plain was undulating or gently sloping, but it was severely eroded by water before any loess was deposited, and it therefore became strongly rolling to hilly. The irregularities of the old eroded drift plain were reduced by the loess cover but were effaced only where they were least pronounced. Most of the minor surface features, as gullies, bluffs, deep V-shaped ravines, and narrow flood plains, have been produced largely by water erosion that occurred after deposition of the loess.

Nearly level areas are limited chiefly to flood plains and stream terraces. Relatively smooth uplands are on or near the axis of some of the principal divides, where the surface of the old drift plain presumably was least rugged and the loess cover effaced many of the irregularities. The tops of many of these divides have practically the same elevation and resemble remnants of an old, nearly level plateau or plain; but even in these localities, few nearly level tracts exceeding 100 acres remain.

Areas of greatest relief form an almost continuous strip of rough severely dissected land adjacent to the Missouri River flood plain in the eastern part of the county. This strip ranges from less than half a mile to about 3 miles in width and consists of a series of sharp-topped divides separated by an intricate network of deep narrow V-shaped valleys with steeply sloping sides, most of which range from 15 to 20 percent or more in gradient. The most pronounced relief within this strip occurs where the Missouri River flows close to the uplands. Here the land level rises approximately 200 feet in a horizontal distance of about 30 rods. Additional strips of steeply sloping severely dissected land lie adjacent to the flood plains along some of the other deeply entrenched streams, but most of these strips are narrower, less continuous, and less extensive. Ordinarily, the smaller strips occur within narrow steep-sided ravines or gullies and are under 20 rods in width.

The uplands in the southwestern part of the county, where most of the drift occurs, are moderately hilly. In these areas the divides are well rounded; numerous drainageways are more or less deeply entrenched; and most slopes are shorter and steeper than the average, although a few are less than 15 rods in length and more than 15 percent in gradient.

Alluvial lands include the stream terraces and flood plains, which occur principally along the Little Nemaha River and its larger tributaries and along the Missouri River. They constitute only a small part of the county.

The terraces, or benches, took shape before the streams became so deeply entrenched and are at several levels. The highest, or oldest, terraces lie 30 to 40 feet above the present bottom lands and are not subject to overflow. They were formed before loess was deposited and were covered, principally by the Peorian loess, at the same time as the uplands. Only their basal parts are water-laid. The lower, or younger, benches lie only a few feet above the present flood plains, but few of them are subject to inundation except during stages of unusually high water. All the lower terraces are water-laid, and most of them are composed chiefly of loessal material washed from adjoining or similar loess-covered uplands.

Most of the terraces are almost level except near their outer margins and along drainageways that issue from the uplands and cross the benches to reach the flood plain of the trunk stream. A few of the higher terraces have been dissected sufficiently by such drainageways to become gently sloping or undulating. The transition between the terraces and the first bottoms is marked in most places by a short, steep slope, but the gradient between the benches and the uplands generally is more gradual. Only the most sloping terraces are subject to rapid runoff or abnormal erosion, and they lose only a negligible quantity of soil material and moisture in this manner.

The first bottoms, or flood plains, occupy broken or continuous strips along all of the larger and most of the smaller streams. The strips along the Missouri and the Little Nemaha Rivers are more than a mile wide in several places, but those elsewhere are only a few rods to about half a mile wide. Except where they are modified by slight elevations, shallow depressions, and barely perceptible sags along abandoned stream channels, the first bottoms are nearly level, although they generally have sufficient downstream slope for adequate surface drainage. The first bottoms lie only a few feet above the present stream levels and are subject to frequent overflow, but inundation seldom is sufficient to destroy crops in any but local areas. None of the bottom land is subject to abnormal erosion.

The average elevation of the uplands is about 1,200 feet above sea level and that of the bottom lands along the Missouri and the Little Nemaha Rivers, 920 and 1,000 feet, respectively. The highest point, about 1,400 feet, is on the uplands in the western part of the county; the lowest, about 908 feet, on the Missouri River flood plain in the southeastern corner. The total range in elevation is therefore approximately 492 feet. The general slope is to the southeast. The elevation (*2*) at Nebraska City is 961 feet; at Dunbar, 1,044; at Syracuse, 1,048; at Unadilla, 1,078; and at Palmyra, 1,142.

The county as a whole is well drained. In most places, runoff is not rapid and erosion is not severe. Sluggish and overloaded, the Missouri River is building up its flood plain in many places, but most of the smaller creeks and branches are swift flowing and are actively deepening their channels. Gullies are becoming a problem in many places, but only areas having considerable slope are excessively drained. Poorly drained tracts are confined mainly to local areas on the flood plains and to small widely scattered depressions on the smoothest parts of the uplands and terraces. Very little of the land is too wet for cultivation.

Many low-lying areas are drained by open ditches, and a few are tile-drained. The main channel of the Little Nemaha River and the lower courses of its larger tributaries have been dredged and straightened in places. A few of the minor drainageways are in ditched channels across the flood plains of the trunk streams. The Missouri River is confined by revetments designed to prevent bank erosion and to deepen and straighten its channel for navigation. Dikes have been constructed in many places along the flood plains of the larger streams to prevent the land from being flooded during periods of high water. Although much of the bottom land is subject to frequent overflow, very little of it ever remains under water long at a time. Excess water seldom destroys crops, as it usually drains off readily after the streams subside.

Drainage from approximately the western five-sixths of the county flows southwestward to the Missouri River through the Little Nemaha River and its tributaries, chief of which are North and South Forks and Muddy, Russell, Owl, Silver, Hooper, Brownell, Sandy, and Rock Creeks. Most of the water from the rest of the county flows eastward directly into the Missouri River through Camp, Four Mile, Walnut, Squaw, North Table, and South Table Creeks, each of which is approximately 5 miles long.

CLIMATE

The climate of Otoe County is continental and temperate. The comparatively wide variations in temperature and precipitation between winter and summer are typical of this region, but the climate is well suited to the production of grain, vegetables, and hay crops and to the raising of livestock. The cool rainy spring weather favors rapid growth of winter wheat and spring-planted small grains, and the warm days and nights of the long summer season are especially favorable to the growth of corn. Autumns—long and pleasant, with only occasional periods of rainy weather—give the farmer ample time to prepare and seed the land for winter wheat and to harvest the corn crop. Short periods of extremely cold weather in winter are commonly accompanied by snow, which protects winter-grown crops from serious injury. Temperatures are usually cold enough to kill many destructive insects.

The normal monthly, seasonal, and annual temperature and precipitation in the central part of the county, as compiled from records of the United States Weather Bureau station at Syracuse, are shown in table 1.

The average date of the last killing frost is April 24, and that of the first, October 8. The average frost-free season of 167 days is ample for the maturing and harvesting of all the commonly grown crops. Killing frosts have occurred as late in spring as May 25 and as early in fall as September 13, but during the 20 years from 1895 to 1914 there were only 4 years when the frost-free season was 15 days or more shorter than average (*8*). The average grazing period (April 15 to October 15) is approximately 6 months.

About 80 percent of the mean annual precipitation falls in the 7 months from April to October. In summer the rainfall usually takes the form of heavy thundershowers, but torrential rains are rare. Droughts are almost unknown in May and June, but short dry periods sometimes occur in the latter part of July and in August. Crops properly tended are seldom injured by lack of moisture. Hail may damage crops over small areas in some years, but injury from it is local and does not reduce the total county yields to a great extent.

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation at Syracuse, Otoe County, Nebr.*[1]

[Elevation, 1,574 feet]

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total for the driest year	Total for the wettest year	Average snowfall
	°F	°F.	°F	Inches	Inches	Inches	Inches
December	27. 8	78	−33	0. 97	0. 72	2 74	5. 9
January	24. 0	67	−28	. 79	. 45	1. 45	6. 3
February	27. 2	79	−29	1. 10	1. 60	. 12	7. 3
Winter	26. 3	79	−33	2. 86	2 77	4. 31	19. 5
March	39. 5	91	−16	1. 39	. 70	. 76	6. 3
April	52. 2	98	3	2. 52	1. 35	1. 69	2. 2
May	62. 3	100	24	4. 10	1. 88	6. 39	(2)
Spring	51. 3	100	−16	8. 01	3. 93	8. 84	8. 5
June	72. 1	105	40	4 47	4. 88	7. 97	0
July	77. 8	112	42	3. 48	. 59	9. 01	0
August	75. 7	111	37	3. 25	. 44	4. 73	0
Summer	75. 2	112	37	11. 20	5. 91	21. 71	0
September	67. 8	108	22	3 41	2 86	4. 31	0
October	55. 2	94	−7	2. 24	3. 33	3 58	. 8
November	39. 9	82	−10	1 31	. 22	2. 92	2. 3
Fall	54. 3	108	−10	6. 96	6 41	10 81	3. 1
Year	51. 8	112	−33	29. 03	[3] 19. 02	[4] 45. 67	31. 1

[1] Data from U. S. Weather Bureau records.
[2] Trace.
[3] In 1894.
[4] In 1902.

From about October 1 to April 1 the prevailing wind is from the northwest; the rest of the year it is from a southerly direction. Strong winds are common, but tornadoes are rare. According to U. S. Weather Bureau records (*6*) the average annual wind velocity is between 8 and 10 miles an hour. The relative humidity is fairly regular, the average for the year being about 70 percent. During the 20-year period 1895 to 1914 the number of clear days ranged between 120 and 160 annually (*5*).

WATER SUPPLY

Good but medium-hard water in sufficient quantities for family and livestock needs is obtained readily in most of the county. Throughout the uplands palatable water is usually reached at depths of 50 to 250 feet, mainly from lenses and channels of sand and gravel buried in the drift deposits and from sandstone bedrock. In places a limited and uncertain supply is obtained from limestone and sandy shale formations. At a depth exceeding 300 feet the water generally is too salty to drink. The depth to water in any particular locality depends partly on relief and thickness of the loessal cap, but mainly on the thickness and textural composition of the drift deposits and on the depth to suitable water-bearing parts of the bedrock.

A limited supply of good water can be obtained from numerous springs at or near the places where the drift and bedrock formations are in contact; but few farms except those along the valley sides of major streams depend on this source, and those mainly because the bedrock is near the surface and wells are rather uncertain. An abundance of good water can be obtained from the sandy stream-laid sediments in the broad bottom lands, ordinarily within a depth of 20 to 30 feet.

Open or dug wells are common, and on many farms little thought is given to their location and care. Water may be contaminated by moving over and through polluted ground. Shallow open wells often receive sediments and surface runoff from surrounding land, drainage from feed yards, or other sources of contamination. Wells in most schoolyards and on many of the better managed farms are drilled.

The supply of underground water is sufficient for small-scale pump irrigation on many of the bottom lands, and a few farmers on the Missouri River flood plain report that such irrigation gives beneficial results in certain years. Over the county as a whole, however, irrigation is neither essential nor practical, except on the bottom lands and some of the terraces. During years of normal or nearly normal precipitation, irrigation of most crops probably would not increase yields enough to justify the cost.

Numerous small artificial lakes and ponds scattered over the county afford facilities for recreation as well as water for livestock. There are no natural lakes.

VEGETATION

Otoe County is in the Prairie soil region of the United States. Before the arrival of the white man practically all the uplands supported a luxuriant growth of prairie grasses. Trees grew chiefly on the bottom lands along most of the larger and many of the smaller streams and on numerous steep valley slopes. The northward facing and lower lying slopes usually supported the most luxuriant growth and the greatest variety of trees and shrubs, but even in these localities grasses usually predominated. Except on some of the steeper or more stony areas and in many of the narrower and less accessible bottom-land strips, nearly all the soil has been in crops or orchards, and most of the remaining forested areas have been cut over many times.

The grasses in scattered virgin areas on the uplands consist mainly of little bluestem, big bluestem, needlegrass, side-oats grama, junegrass, and dropseed. On the better drained uncultivated areas of the bottom lands big bluestem, tall panic grass, Indian grass, and wildrye are abundant; whereas in more poorly drained sections sloughgrass, sedges, and cattails are common. Saltgrass and wheatgrass grow on parts of the poorly drained bottom lands.

The present forest growth, occurring mostly in small irregularly shaped areas or as scattered clumps of trees, is limited chiefly to a few steep slopes and the many narrow flood-plain strips along meandering stream channels. Elm, ash, walnut, hackberry, cottonwood, boxelder, and willow grow mostly on the bottom lands and lower slopes, whereas bur, red, and black oaks, ironwood, linden, hickory, honeylocust, black cherry, and redcedar are dominant on the higher upland slopes. The trees are mostly too small for lumber, but are valuable for posts and fuel and as shade for livestock.

Elm, ash, maple, walnut, Osage-orange, redcedar, and other trees are grown on a few farms either as scattered individuals or in small groves along fence lines and near building sites, chiefly for shelter purposes. On most farms, however, the number of trees could be increased considerably to good advantage, as the protection they provide livestock from the hot sun in summer and cold wind in winter is important.

ORGANIZATION AND POPULATION

The first permanent settlement in the area now included in Otoe County was made in 1844, when the Federal Government established an army post on what is now the site of Nebraska City. Prior to that date the Territory was in possession of the Indians, who objected to the visits of itinerant fur traders. The Territorial legislature organized the county in 1854 from part of what was then Pierce County (*10*). In 1856 the present boundaries were fixed and Nebraska City was made the county seat.

The early settlers came mainly from Iowa, Indiana, Illinois, Missouri, and other States to the east. Most of them staked claims to 160-acre tracts under the Preemption Act and located on bottom lands, where fuel and water were most plentiful. Settlement of the uplands did not begin until the more desirable valley land had been homesteaded, but from then on the occupation was comparatively rapid.

The population of the county in 1940 was 18,994, of which 61.4 percent was classed as rural, with an average of 19 persons to the square mile. Except in the immediate vicinity of the towns, the population is more or less evenly distributed, although the rougher parts are more sparsely settled.

Nebraska City (population 7,339) and Syracuse (982) are the largest towns and serve as important wholesale and retail centers for manufactured goods and farm produce. Other towns, with less than 500 inhabitants each, are Palmyra, Unadilla, Douglas, Dunbar, and Talmage. These and a number of smaller towns or villages serve as trading centers for farm implements and supplies and shipping points for produce.

TRANSPORTATION AND MARKETS

Transportation, at first inadequate, has improved rapidly with the development of the county. Both transportation and market facilities are now excellent. Railroads and State and Federal highways cross the county in all directions and furnish good connections with outside markets, especially at Lincoln and Omaha, where the demand for farm products is good. No part of the county is more than 10 miles from a railroad, and the farm-to-market road system is sufficiently developed to enable trucks to reach nearly all sections most of the year. Every town is on both a railroad and a paved, oiled, graveled, or stone-surfaced highway. Many of the minor roads are unpaved but well maintained, and for the most part they are graded and have steel or concrete culverts and bridges. A toll bridge crosses the Missouri River at Nebraska City. Roads usually follow section or land lines, but in the rougher parts they conform to the relief. A few freight boats navigate the Missouri River and dock at Nebraska City. Air transportation is available at Lincoln and Omaha.

PUBLIC FACILITIES AND FARM AND HOME IMPROVEMENTS

The public grade- and high-school systems are well developed, and churches are conveniently located throughout the county. Rural mail routes reach all communities.

As a rule, farm buildings are kept painted and in good repair and improvements and equipment are adequate to the needs. Most of the houses are two-story wooden structures, and many of them have running water, electricity, furnaces, refrigerating units, telephones, and radios. In 1945, 1,207 farmhouses had electricity and 1,531 had telephones. Natural gas is piped through parts of the county and is available in some of the towns and on a few farms.

Most of the barns and other outbuildings are large enough to house the livestock, the more expensive machinery, and all the crops except hay, which generally is stacked in the field or near the barnyards. Most farms have barbed-wire fencing but many have woven-wire fencing, especially around feed lots and pastures.

INDUSTRIES

The local demand for farm produce is good. At Nebraska City—one of the important gateways for overland travel westward since early days—feed, cereal, and flour mills, creameries, a canning factory, and a meat-packing plant process a limited quantity of the agricultural products raised in the county and adjoining areas. All surplus crops are marketed readily at Lincoln and Omaha. Grain elevators and loading docks for livestock and other freight are in all the towns and at numerous other points scattered throughout the county.

The chief nonagricultural industries are quarrying, the excavation of sand and gravel, and the manufacture of tile and brick. Stone is quarried in various places from the limestone and sandstone bedrock formations, largely for use in road surfacing and in the construction of buildings, bridges, culverts, and revetments to control the channel of the Missouri River. Though much of the stone is considered too soft for use as such in large structures, it makes excellent building material when crushed and mixed with cement. The limestone would be suitable for improving soil fertility if the soils in the county needed such an amendment. The tile and brick are made from Fuson shale, which outcrops near Nebraska City. Sand and gravel of excellent quality for construction purposes are obtained from the alluvial lands along the Missouri River and from drift deposits in many places. The drift deposits are less desirable for building purposes but can be used to advantage in surfacing roads.

AGRICULTURE

EARLY AGRICULTURE

Otoe County is primarily agricultural. All the land originally supported a luxuriant cover of prairie grasses, with a scattered growth of trees along all the larger and many of the smaller streams. The Indians who then lived there subsisted largely on wild game, fish, and native fruits and nuts, and the more industrious supplemented this diet by growing small quantities of corn and garden vegetables.

Pioneer farmers grew chiefly the crops necessary to supply home needs, as corn, potatoes, and other garden vegetables. The climate was considered too dry for large-scale production of corn, and much of the cleared land was planted to wheat, which was the chief source of cash income. Oats, barley, and rye were grown in the early days but on more or less limited acreages. The first settlers also attempted to grow flax, buckwheat, tobacco, and broomcorn on small areas but found these crops unprofitable.

The farmers soon learned that the land was well suited to corn, and even prior to 1880 they had begun to plant most of their cultivated land to that crop. Wheat, nevertheless, remained the leading cash crop.

Very little livestock aside from that required for home needs and farm power was raised. The animals subsisted largely on the luxuriant grass of the open range.

PRESENT AGRICULTURE

As the population increased, more land was cultivated and greater numbers of livestock produced. The present agriculture is diversified, on most farms consisting of raising and fattening livestock, chiefly cattle and hogs, and growing grain crops, hay, and forage.

Approximately 65 percent of the total land area, or practically all the arable land, is now in grain, forage, tame hay, and other common crops. Uncultivated areas include only those tracts on which drainage is either excessive or too poor for cultivation or land difficult to farm because it lies adjacent to meandering streams. Most of these areas are used mainly for pasture and support considerable grass and scattered timber. The few wild-hay meadows that remain are chiefly on poorly drained tracts and on the smoother parts of the steeply sloping uplands. None of the land is used exclusively for woodland. Most timbered areas are pastured.

CROPS

The chief crops, in about the order named, are corn, wheat, oats, alfalfa, and clover. Minor crops include barley, rye, potatoes, sorgo, kafir, spelt, Sudan grass, millet, melons, fruits, and vegetables. The total acreages of the principal crops grown in the county in certain years are given in table 2.

As the number of livestock increases and the acreage used for grazing diminishes, more feed crops are required. The climate and most of the soils are well suited to growing oats, and because this crop

TABLE 2.—*Acreage of the principal crops and number*[1] *of fruit trees and grapevines in Otoe County, Nebr., in stated years*

Crop	1919	1929	1939	1944
	Acres	*Acres*	*Acres*	*Acres*
Corn	120, 794	132, 179	112, 609	138, 204
Wheat	73, 786	50, 700	70, 977	53, 765
Oats	35, 752	37, 705	31, 232	30, 021
Rye	408	158	1, 053	354
Barley	226	210	4, 073	145
Potatoes	1, 122	799	534	164
All hay and forage	37, 320	35, 719	22, 645	31, 559
Alfalfa	8, 726	10, 240	11, 159	18, 503
Clover and timothy	10, 670	12, 107	689	5, 092
Coarse forage	4, 440	643	2, 171	(2)
Other tame hay and forage crops	754	514	726	600
Wild hay	12, 730	12, 215	7, 900	7, 364
	Number	*Number*	*Number*	*Number*
Apples trees	53, 761	14, 034	29, 599	13, 729
Peaches do	3, 854	8, 540	6, 042	17, 699
Cherries do	4, 053	8, 017	14, 790	5, 576
Pears do	1, 803	2, 210	770	1, 154
Plums do	793	1, 829	680	520
Grapes vines	24, 735	49, 149	17, 936	12, 256

[1] The number of fruit trees and grapevines of bearing age given for all years except 1944, the 1944 figures are for all ages.
[2] Data not available.

furnishes excellent feed for livestock, the acreage has increased at the expense of other small grains. In most years, wheat acreage ranks second to corn; oats, third.

Wheat acreage was largest during and shortly after World War I, when the demand for wheat was especially great. During that period, practically all the arable land in the county was cultivated, and the acreage in corn, oats, and many other crops was reduced in order to grow more wheat. Owing to the adoption of soil-conservation practices, the acreage of such soil-depleting crops as corn and wheat has been restricted somewhat in recent years; and the acreage of such soil-improvement crops as clover and alfalfa has been increased. The acreage used for forage and tame hay has increased gradually along with the increase in the number of livestock, but it varies annually according to the number of animals raised and the quantity of other feed on hand or being produced.

The drought of 1934 caused a sharp reduction in the cultivated acreage. The area in forage crops alone was not reduced, and as the drought continued into succeeding years the total acreage of coarse forage crops, particularly sorghums, was increased. As the sorghums were more drought-resistant than many of the feed crops commonly grown during years of normal precipitation, they provided subsistence for livestock when other crops failed. In 1939, 7,204 acres of sorghums produced 26,556 tons of silage, hay, and fodder.

Crop yields differ greatly from year to year and from place to place, partly with differences in the soils but mainly with differences in the amount and distribution of precipitation and the length of the growing season. For the county as a whole, the average yields of crops over long periods are fairly uniform.

Most of the nearly level to undulating well-drained land is now cultivated. Corn is grown to a greater or less extent on all the arable land not only for livestock feed but also because it is adaptable to a wide range of soil and moisture conditions. Ordinarily most of the corn is planted on well-drained bottom lands rather than on uplands, as it is better adapted than small grains to bottom-land conditions. Corn is likewise planted on a large area of the steeply sloping arable uplands, where small grains would do well but are difficult to harvest.

Small grains are grown mainly on the smoothest parts of the uplands and terraces, where the slopes commonly do not exceed 7 percent and where binders, combines, and such large machinery can be used easily. Alfalfa and sweetclover are grown most extensively on the terraces and flood plains, where moisture is most abundant. Frequently these legumes are grown in rotation with grain crops on rolling and steeply sloping lands to aid in retarding runoff and erosion and in restoring nitrogen and other essential plant nutrients to the soil. Most of the smooth, nearly level areas are used more or less continuously for grain production. The minor feed crops are usually grown wherever it is most convenient.

Most farmers produce fruits and garden vegetables for home use only, but many tenant farmers do not grow enough fruit for family needs. Only a few farms in the eastern part of the county are used exclusively for growing fruits and vegetables for sale. Apples, cherries, peaches, strawberries, raspberries, blackberries, and grapes are the principal fruits. The chief truck and vegetable crops are potatoes, sweetpotatoes, tomatoes, sweet corn, beans, and melons.

Wheat and some of the corn are grown as a cash crop on most farms, but in a large part, other crops are consumed on the farm where produced or within the immediate community. Wheat has remained the principal cash crop since early days. During the drought in 1934, when the majority of crops failed and feed was scarce, the bulk of the corn crop was cut for fodder or silage, and the oats from 3,838 acres were cut and fed unthreshed. In addition many of the oat fields were pastured that year.

Permanent pastures are confined mainly to irregularly shaped tracts along meandering streams and in the rough uplands and constitute less than 20 percent of the total county area. Bluegrass has replaced the native bluestem on most of the uncultivated land and now is the leading grass. The better managed pastures contain considerable white clover and limited quantities of bluestem and dropseed. The saltgrass and western wheatgrass grown in the poorly drained areas are of inferior quality but occupy only a small part of the total pasture acreage. Recently (1940) many pastures have become infested with weeds, shrubs, and grasses of inferior quality as a result of severe drought and overgrazing. Most timbered areas are used for pasture because in only a few places are the trees so thick that they prevent the growth of luxuriant grasses. The more progressive farmers grow tame grasses and legumes to supplement the native pasture.

AGRICULTURAL PRACTICES

Cropping practices in Otoe County are much like those of other southeastern Nebraska counties. Corn, the principal crop, is planted in May, either in checkrows with a planter or in furrows with a lister. The land ordinarily is plowed, and a seedbed is prepared before planting. The crop is cultivated at intervals of 2 or 3 weeks until early in July, after which it receives little attention until harvest. Corn matures in September or by the middle of October. Many farmers cut part of the crop for fodder or silage, and a few reduce the cost of harvesting by fencing off small acreages of unhusked corn for fattening cattle and hogs.

Hybrid corn has been grown on a rapidly increasing acreage. The cost of seed often makes this corn expensive to plant, but in most years its greater yield more than offsets the outlay for seed. Ordinarily, hybrid corn yields 10 to 20 percent more than open-pollinated corn.

The treatment of seed corn is not generally practiced. Smut and root rot are the chief corn diseases. Smut is carried over from year to year in the fields, and the treatment of seed is therefore more or less ineffective in controlling the disease, especially where corn is grown in consecutive years on the same ground.

Practically all the wheat is of the winter varieties, chiefly Cheyenne and Turkey Red. Winter wheat ordinarily follows oats, but it is occasionally seeded between the rows of standing corn or on land from which the corn has been removed for fodder or silage. The seed is sown with a press drill in September. The crop usually makes good growth before killing frosts occur and it remains practically dormant during winter, resumes growth in spring, and matures early in July. It is cut either with a binder or combine. When cut with a binder, it is shocked or stacked for threshing. A combine cuts and threshes the crop in one operation. Most of the grain is hauled to market directly from the threshing machine.

Wheat yields may be reduced by bunt or stinking smut, which gives the kernels an offensive odor and retards their normal growth or destroys them. This form of smut can be controlled by treating the seed before planting with copper carbonate powder at the rate of 2 ounces of powder to a bushel of grain (7). Ordinarily, the hessian fly is not a serious pest in this county, but it may cause some damage to fields of wheat seeded very early. Injury from this pest is best avoided by delaying seed sowing until after the fly-free date.

Early preparation of the seedbed is of prime importance to good yields. Experiments at the Nebraska Agricultural Experiment Station, at Lincoln, show that the yield of winter wheat on land prepared early in the season and kept free from weeds until seeding time is approximately double that produced on similar land plowed late. The moisture and nitrates otherwise used by weeds are retained for the new wheat crop if the seedbed is prepared early.

Oats are not very profitable but are grown fairly widely as feed for work animals and young livestock and as a nurse crop for legumes and tame grasses. The highest yields are obtained on the nearly level uplands and terraces. Oats ordinarily follow corn in the rotation, but they are grown on all the arable soils whenever they are needed as a nurse crop. Early maturing varieties, chiefly Kherson or strains of this variety, and some Burt usually are grown.

Part of the land to be used for oats is plowed before planting, but ordinarily it is disked thoroughly and the seed broadcast or drilled late in March or early in April. The oat crop matures the later part of June or in July and is harvested in much the same manner as wheat. Most of it is fed to stock on the farms where produced.

Oat yields may be reduced by smut, especially during prolonged periods of damp weather. Smut injury can be controlled by fanning or cleaning the seed and before planting, treating it with a solution of 1 pint of commercial formaldehyde to 35 gallons of water (*7*).

Barley is grown, harvested, and used in much the same manner as oats. It fits in most rotations as well as oats and is an equally good nurse crop for legumes and grasses. It ranks next to corn in acre yield and produces about a third more feed than oats. Many farmers are reducing their acreage in oats in favor of barley with profitable results. A reasonable acreage in barley will insure some feed for livestock when drought or other unfavorable weather conditions reduce the corn crop. Barley is more drought-resistant than oats. The chief varieties are Spartan and Oderbrucker.

Rye, not an important crop, is grown to some extent for grain but mostly to provide temporary spring and fall pasture for brood sows and small pigs. When grown for grain, it is planted and harvested in the same manner as wheat. Rosen is the chief variety.

Alfalfa, the leading hay crop, is sown in a thoroughly prepared seedbed during April or early in May or during August or early in September and usually with a small-grain nurse crop. A press drill is used, and the seed is sown not more than an inch deep. Alfalfa seeded in fall should be in the ground as soon after a heavy rain as possible. Seed sown in spring generally produces a better stand because there is more moisture in the soil. The standard seeding rate is 15 pounds an acre. Only pure certified seed from the most hardy varieties obtainable should be used. Grimm, Common, and Cossack varieties, all reasonably resistant to drought and winterkilling, are recommended.

Alfalfa is ordinarily grown for as many years as it yields profitably, generally 4 or 5 years on uplands and 5 or 6 years on bottom lands. The crop is rarely frozen out once it becomes established, but it cannot be left many years on upland fields, as the subsoil moisture is usually exhausted after 4 or 5 seasons and the common result is low yields not only of alfalfa but also of the crops that follow. On uplands alfalfa seems unable to make optimum growth with the annual precipitation, and its roots draw heavily on the subsoil moisture, which is replenished very slowly. Because most crops require more moisture during the growing season than the ordinary precipitation affords, their yield is greatly reduced, especially during drier years, if they are planted on upland fields that have been a long time in alfalfa.

The Nebraska Agricultural Experiment Station has found that the exhaustion of the deep-seated moisture also affects subsequent plantings of alfalfa, usually causing yields to be much lower than those from the first planting (*4*). Such results commonly do not occur on bottom lands and terraces, where the moisture supply is more abundant nearer the surface and within reach of most plant roots.

Clover and timothy are commonly sown with oats or barley in spring in much the same manner as alfalfa. They are then pastured lightly in fall after the small-grain crop has been harvested, allowed to remain untrampled during winter, and used for either pasture or hay the following year. They are sometimes sown on wheatland late in winter or early in spring, the seed being harrowed or rolled in. As winter wheat is not so good a nurse crop as oats or barley, the stand of grass is more often poorer than that produced when the seed is sown with a spring-planted small grain. Varieties of sweetclover and red clover are most commonly sown.

Sweetclover has an unusually wide adaptation, and its use as a soil builder is increasing, especially for green manure on eroded uplands. Many farmers prefer sweetclover to alfalfa for soil improvement because it is adapted to much shorter rotations, thrives well on fine- or coarse-textured soils or wet or dry soils, and has large and vigorous roots that decay rapidly at the end of the second year's growth. Sweetclover is used chiefly for pasture but to some extent for hay and seed. When hay is desired, sweetclover is cut the first year before it becomes coarse and woody. In the second year, the crop may be allowed to reseed itself or it may be cut with a binder or combine for seed. The permanence of a stand of sweetclover depends mainly on its ability to reseed, for being a biennial, it dies at the end of the second season after producing seed. If a stand is to be maintained, care must be taken not to graze the crop too closely the second year. Overgrazing will not leave enough mature plants to reseed the land.

Tests fail to show that liming and inoculation of alfalfa or sweetclover are necessary to insure successful production on most soils. Although many soils are leached of their lime to a considerable degree, apparently all still contain enough to allow fair to good growth of crops requiring lime. Inoculation of the seed gives leguminous plants the power of fixing atmospheric nitrogen in the soil through the nodules on their roots. Nitrogen is an essential plant nutrient, but most of the soils are inherently fertile and contain enough organic material, or nitrogen and other plant nutrients, to produce as much vegetative growth annually as the normal moisture supply allows.

Definite systems of crop rotations are not generally followed. The more progressive farmers follow certain crop systems of their own, but these are subject to numerous substitutions. On most farms the choice of crops is usually determined by the requirements of the soil. The smooth nearly level parts of the arable lands are used almost continuously for growing one or another of the grain crops. Legumes, tame grasses, and grain crops frequently are rotated on the more rolling and steeply sloping cultivable areas, but with more or less irregularity.

Little commercial fertilizer is used, except by some of the truck gardeners, and its quantity and composition vary greatly. A great deal of barnyard manure is produced on most farms, but more could be used advantageously. On many tenant farms little care is taken to apply the manure where needed, most of it going to the fields nearest the feed yards. On the better managed farms, manure commonly is applied to the lighter colored and sandy soils and to eroded areas. Most farmers manure the garden site and truck patch.

Little attention is given to the management of pastures. These are commonly small and are used only to provide grazing for a few milk cows and work animals. Many are overgrazed.

LIVESTOCK AND LIVESTOCK PRODUCTS

Livestock and livestock products are the principal sources of income. The number of livestock kept depends on the quantity of food produced. The number of domestic animals, poultry, and beehives in stated years is shown in table 3.

TABLE 3.—*Number of livestock, poultry, and beehives on farms in Otoe County, Nebr., in stated years*

Livestock	1920	1930	1940	1945
	Number	*Number*	*Number*	*Number*
Horses	11, 915	9, 159	6, 240	5, 271
Mules	3, 533	3, 333	1, 817	1, 126
Asses and burros	18	20	(1)	(1)
Cattle	31, 237	30, 633	22, 623	40, 147
Swine	29, 397	59, 460	18, 878	33, 086
Sheep	8, 159	5, 329	2, 743	2, 491
Goats	17	123	38	138
Poultry	211, 864	[2] 260, 889	214, 640	313, 838
Bees ... hives	300	794	234	(1)

[1] Number not reported.
[2] Chickens only.

The beef cattle raised locally are usually from small herds of grade Herefords and Shorthorns, and a few others are shipped in for fattening from outside points. The cattle fattened for market are fed corn and alfalfa for 60 to 90 days and are then hauled to the Omaha or Lincoln markets. Many farmers fatten one to five carloads of cattle each year. A few fatten calves for sale as baby beef. Calves are ordinarily fed oats when first weaned; later, corn and alfalfa. They are sold when 14 to 18 months old.

Purebred dairy cattle, chiefly Holstein-Friesian, Guernsey, and Jersey, are kept on a few dairy farms, but the greater part of the dairy products are obtained from small herds of mixed beef and dairy breeds. The milk from the 5 to 10 cows ordinarily kept is collected at the farm by the purchaser. Milk routes are established over all parts of the county, and a cream station is maintained in nearly every town.

Most farmers raise 20 to 60 hogs annually, and some have herds of 100 or more. The hogs are usually of good breeding and many are purebred. Duroc-Jersey, Poland China, and Hampshire are the leading breeds. Hogs are ordinarily fattened on corn and alfalfa and alfalfa meal, though ground barley and rye frequently are added to the ration. Young pigs generally receive some oats. Nearly all the hogs are fattened on the farms where raised and are then sold at the Lincoln or Omaha markets. Cholera and necro-bacillosis, which formerly affected hog raising, have been almost eliminated through vaccination and improved sanitation.

Sheep raising is not general, but some farms buy a carload or two of sheep in fall, fatten the animals on ground corn and alfalfa, and sell them at the Omaha or Lincoln markets when the price is up, usually in spring after the wool has been sheared.

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Raising horses and mules has been of minor importance in recent years and is limited mainly to breeding enough work animals to meet the local demand for farm power. Nearly all work animals are of heavy-draft or general-purpose type and are well suited to farm work. An average of about eight head of work animals is kept on each 160 acres where tractors are not used. Farmers who use tractors for heavier work usually keep only about four head. Recently (1940), sleeping sickness and extreme summer heat reduced the number of horses and mules considerably, but the number of work animals remaining is usually sufficient.

The chickens raised generally supply home needs; any surplus is usually sold or traded for farm supplies in the local towns. Many farmers have flocks of several hundred, usually of purebred Plymouth Rock, White Leghorn, or Rhode Island Red. Many flocks are maintained by purchasing certified baby chicks from hatcheries in Omaha, Lincoln, and Nebraska City. Each summer a few farmers raise and fatten large numbers of turkeys for sale.

Practically all crops, except wheat and surplus truck and garden vegetables, are used on the farm where produced or on neighboring farms for raising and fattening cattle and hogs and for feeding work and brood animals. Enough feed is ordinarily produced for the livestock raised on each farm. Farmers who raise and fatten many cattle and hogs purchase additional corn and oats either from neighbors who have a surplus or from outside markets.

LAND USE CHANGES

Crop acreages have increased gradually with population growth and the general development of the county. In 1945 (census reports) 96.9 percent of the land in the county was farmed. Of this area, 300,395 acres, or 79.2 percent, was classed as improved cropland. The farms numbered 2,016 and averaged 188 acres each.

Practically all the arable land is cultivated. Although the acreage used for different crops varies from year to year with fluctuations in the demand for farm products and the price, the relative acreages of the different crops remain fairly uniform over long periods. The area in corn, wheat, and other soil-depleting crops has recently been restricted somewhat because of the need for soil-conservation practices, including more extensive use of such soil-improvement crops as clover and alfalfa.

FARM TENURE

In 1945, 45.3 percent of the farms in the county were operated by owners; 54.4 percent by tenants; and 0.3 percent by managers. Both cash and share-rental systems, or a combination of the two, are followed.

About 46 percent of the tenant farms are rented for a share of the crops. Under this system the owner usually receives two-fifths of the grain delivered to the crib or granary, half the alfalfa hay stacked in the field, and an agreed sum per acre for the pasture land and building site. On some farms the owner receives half the corn crop. All seed, labor, machinery, and power commonly are furnished by the tenant, regardless of the rental basis.

Under the cash-rental system the tenant usually pays an agreed rate per acre for use of all the land, including the hay and pasture areas and building site. On some farms the tenant pays a higher rate for the best grade of farm land. Only a small part of the land used for grain crops rents for cash. Most of the large, irregularly shaped tracts suited only to pasture rent for a lump cash sum, and the price per acre depends mainly on the type of soil, the quality of the grass, and the accessibility of water for livestock. Bottom-land pastures generally rent highest. On farms having small and poor pastures the tenant frequently is allowed the use of pasture land rent free.

FARM INVESTMENTS AND EXPENDITURES

The selling price of individual farms varies considerably, depending upon general economic conditions, the character of the soil, surface features, improvements, and location in relation to markets. With due consideration for economic fluctuations, the value of farm property, including land, has remained comparatively high, mainly because the county is close to good markets for all farm products. Location and improvements being equal, the highest priced land is on the well-drained silty stream terraces, and the cheapest is in the rough and most eroded parts of the uplands.

Farm machinery is of the most modern and labor-saving types. Operating equipment in 1945 included 1,656 tractors, 721 trucks, and 2,165 automobiles, besides corn binders, grain threshers, combines, corn shuckers, hay balers, ensilage cutters, cream separators, incubators, and silos. The more expensive farm machinery is commonly kept under shelter.

Cash wages paid for hired labor totaled $392,584 in 1944, with 1,410 farms reporting. In 1945, 90.7 percent of the farms reported the purchase of feed for livestock, at an average cost of $537.06.

TYPES AND SIZES OF FARMS

With a few exceptions, the type of farming prevailing on any one farm has not changed significantly for a considerable period, although it does vary somewhat in certain localities according to differences in the character of the soil and relief, in the size and location of the farm, and in the financial status of the farm operator.

A cash-grain type of farming is practiced on most farms and on the largest acreage. It is practiced where the annual farm income is chiefly from the sale of grain and more by tenant farmers than by owner-operators. General farming is more common on the owner-operated farms. Growing hay and feed crops in addition to grain has an important place on these farms. Enough livestock also is usually raised or fattened to consume most of the crops produced, and more satisfactory crop-rotation systems are possible than where grain crops are more or less continuously produced on all the arable land. In addition to general farming, several farms specialize in raising purebred livestock and a few buy and feed a number of cattle, hogs, or sheep over and above the stock they normally raise for market. No farms are used exclusively for stock raising or feeding, and only a few small ones are given over completely to dairying, poultry raising, or growing fruit and vegetable crops.

Both the general and cash-grain types of farms occur in all parts of the county. Cash-grain farms are most common on the deep friable soils of the gently undulating and rolling uplands, whereas general farms or livestock farms are more often found on the terraces and silty bottom lands and on the rougher uplands. Most orchards are on friable, moderately deep, and rather steeply sloping silty soils in the eastern part of the county, and the larger truck farms are mainly on the sandy bottom lands adjacent to the Missouri River.

The farms range in size from about 70 to 400 acres, with only a few of more than 400 acres or less than 50. The average size is 188 acres. In the immediate vicinity of towns many farms are small. Some have been combined into larger units by loan companies, and the more prosperous farmers have increased their holdings by purchasing more land.

SOIL SURVEY METHODS AND DEFINITIONS

In making a soil survey the soils are examined, classified, and mapped in the field and their characteristics recorded, particularly in regard to the growth of various crops, grasses, and trees.

The soils and the underlying formations are examined systematically in many locations. Test pits are dug, borings made, and highway or railroad cuts and other exposures studied. Each reveals a series of distinct soil layers, or horizons, and the entire section from the surface down to the weathered but otherwise unmodified parent material is known as the soil profile, or solum. The classification is based on such internal characteristics of the soil profile as the thickness of each horizon, its color, structure, texture, consistence, and reaction,[4] and its content of lime, salt, and organic matter, and on such external features as drainage, relief, stoniness, and degree of erosion.

The plant cover—both native vegetation and farm crops—is studied with relation to the soils. In this way their natural productivity can be determined or estimated with a fair degree of accuracy. In classifying virgin lands that may later be brought under cultivation, the observation of like soils now being farmed is an important part of the work.

The soils are classified according to their characteristics, both internal and external, with special emphasis on the features that influence the adaptation of the land to the production of crop plants, grasses, and trees. On the basis of these characteristics the soils are grouped in the following classification units: (1) Series, (2) types, (3) phases, (4) complexes, and (5) miscellaneous land types.

The series is a group of soils having the same genetic horizons—similarity in important characteristics and arrangement in the soil profile—and having similar parent material. Thus, the series comprises soils having essentially the same color, structure, natural drainage, and other important internal characteristics and the same range

[4] The reaction of a soil is its degree of acidity or alkalinity expressed mathematically as the pH value. A pH value of 7 indicates precise neutrality, higher values, alkalinity, and lower values, acidity Indicator solutions are used to determine the chemical reaction The presence of lime is detected by the use of a dilute solution of hydrochloric acid, and the total content of readily soluble salts is determined, when necessary, by the use of the electrolytic bridge.

in relief. The texture of the upper part of the soil, including that commonly plowed, may vary within a series. The series are given geographic names taken from localities near which they were first identified. Sharpsburg, Marshall, Carrington, Waukesha, Butler, Pawnee, Knox, Sogn, Wabash, Lamoure, and Judson are names of some of the soil series in Otoe County.

Within a soil series are one or more soil types, defined according to the texture in the upper part of the soil, generally to about the depth of plowing. The name of the soil texture to this depth, as sand, loamy sand, loam, silt loam, clay loam, silty clay loam, or clay, is added to the series name to give a complete name to the soil type. Sharpsburg silty clay loam and Carrington loam are soil types within these two series. Except for differences in the texture of the surface soils, all soil types of the Sharpsburg series have reasonably similar external and internal characteristics. The same holds true for all types of the Carrington or any other series. The soil type is the principal unit of mapping, and because of its specific character it is usually the unit to which agronomic data are definitely related. In comparisons of the type and phases of that type, to avoid the repetition of their complete names, the type is sometimes referred to as the normal phase.

A soil phase specifically named is a variation within the type, differing from the normal phase in some feature, generally external, that may be of special practical significance but not differing in the major characteristics of the soil profile. For example, within the total range of relief of a soil type some areas may have slopes that allow cultivation and the use of machinery, and others may not. Differences in relief and degree of accelerated erosion may be shown as phases. Even though no important differences may be apparent in the soil profile or in its capability for the growth of native vegetation throughout the range in relief, there may be important differences in respect to the growth of cultivated crops. In such instances, the more sloping parts of the soil type may be shown on the map as a rolling or a hilly phase. Similarly, soils having been so altered by erosion as to cause marked differences in productivity and other important characteristics are designated as eroded phases. Sharpsburg silty clay loam, eroded rolling phase, is an example of a phase in the Sharpsburg series.

In some places, two or more soil units may be in such intimate or mixed pattern that they cannot be clearly shown separately on a small-scale map but must be included as a complex. Examples of soil complexes are found in Crete-Sharpsburg silty clay loams and in Judson-Wabash silt loams.

Some areas that have little or no true soil are termed miscellaneous land types. Examples in this county are Made land and Riverwash.

The soil surveyor makes a map of the county or area, showing the location and extent of each of the soil types, phases, complexes, and miscellaneous land types in relation to roads, houses, streams, lakes, section and township lines, and other cultural and natural features of the landscape.

Some of the terms mentioned in the preceding paragraphs are in common use and need no explanation. Others have special meanings in soil science. Three of these are structure, texture, and consistence.

Structure refers to the arrangement of the individual soil particles or grains within the soil mass. Structure affects the tilth of the soil and the rate at which moisture can be absorbed. Common soil structures are granular, cloddy, platy, columnar, and prismatic. Soil material having no definite structure is designated as single-grain, if incoherent; and as massive, if coherent.

Texture is concerned with the coarseness or fineness of the particles in the soil mass as determined by the relative percentages of silt, clay, and the various sizes of sand. Clay, silty clay, silty clay loam, clay loam, silt loam, loam, fine sandy loam, sandy loam, loamy fine sand, and fine sand, named in the order of increasing content of coarse material and decreasing content of clay, are the main soil textures in this county.

Consistence is related to firmness or looseness of the soil mass and its resistance to crushing or distortion. Common terms applied to consistence are incoherent, as in sand; friable, as in most silt loam; and plastic, dense, or compact, as in many clay soils.

SOILS

All the soils in Otoe County except those occupying the most steeply sloping uplands and those developing on the most recently deposited light-colored alluvium have developed under the influence of a luxuriant tall-grass vegetation. Trees grew on many of the bottom lands and rougher upland slopes, but they were too widely spaced to prevent the growth of some grasses or to influence soil character appreciably. The annual decay of grass roots over a long period produced an abundance of black well-decomposed organic matter. Nearly all soils except those on steep or severely eroded slopes or those on very recently deposited light-colored stream sediments have accumulated enough organic remains to make the surface layer dark, regardless of the color of the underlying parent soil material. The intensity of the dark color and the depth to which it has penetrated depend primarily on relief, drainage, and the length of time the soils have lain in their present position undisturbed by abnormal erosion.

Except in areas covered by recent light-colored alluvium, decomposed organic material has penetrated deeply into the soils. It is present in largest quantity in the most nearly level parts of the county, although as a rule it is a little deeper in well-drained than in poorly drained soils. On the steepest slopes there is not so much of this material, because less has accumulated or more has been removed after it has decomposed, and the soils are rather light-colored, even at the surface. Between these extremes of drainage and relief, the content of organic matter and the depth of its penetration varies mainly with the degree of slope. Organic accumulations are least abundant on steep slopes along deeply entrenched drainageways, on the shoulders of hills or narrow ridge tops where cultivation has promoted accelerated erosion, and on areas of recently deposited light-colored alluvium. The total area of light-colored soils in this county, however, is not large.

In addition to their usually dark color, most of the soils are characterized by a granular structure in their upper layers. This feature persists to a greater or less extent in all soils except the most sandy. It is best developed on the more nearly mature soils of the well-drained uplands and terraces, where a distinctly granular or crumblike structure commonly exists to a depth of 24 inches or more.

A third fairly uniform characteristic of most of the soils is the occurrence of lime in a form available to plants and in a quantity sufficient for all crop needs. This characteristic is less pronounced than the dark color and granular structure. None of the soils has an appreciable quantity of free lime carbonate in the surface layer, and few have an abundance of this material in the subsoil. Nevertheless, no crops grown on any of the soils indicate serious lime deficiency, and in only occasional fields are increased yields obtained when lime is applied. Thick limestone layers outcrop at several places in the county, and they will afford an ample supply of easily obtained lime for use when the soils begin to respond more favorably to applications of this material.

With only a few exceptions, the soils of the county are friable and easily penetrated by air, roots, and water. In places a claypan subsoil restricts downward moisture penetration, but the heavy soils having this layer ordinarily lie nearly level and have a friable thick surface layer that absorbs moisture readily. Thus the deleterious effects of the claypan are less than if it occurred near the surface.

Nearly all the soils have a high moisture-holding capacity; however, few are porous enough to absorb more than a part of the precipitation as rapidly as it falls. The result is much loss of rainfall through runoff and evaporation. Over the county as a whole, the runoff alone probably removes more than 25 percent of the mean annual precipitation before it becomes available to plants. Runoff has considerably thinned the surface soil on many of the cultivated fields, but only a few of the soils on the steepest slopes have been rendered unfit for cultivation by erosion brought about by improper farming practices. Though practically no erosion damage has occurred on the more nearly level areas, improper management of some of the cultivated fields having slopes exceeding 5 percent has caused soils to be rather badly gullied.

Except in small scattered areas, the depth of soil material over bedrock or mantle rock exceeds 3 feet. For the greater part the soils overlie loess or drift, and in most places throughout the county both contain enough of the essential plant nutrients, except nitrogen, for the satisfactory growth of all the commonly produced grain and tame hay crops. On land not too steeply sloping for cultivation, the addition of nitrogen is all that is necessary to make a shallow soil over these parent materials productive, and the nitrogen can easily be supplied through legumes or manure. A few small areas are too stony for feasible cultivation because limestone bedrock or glacial drift is at or near the surface; but even these areas support considerable grass and many trees, and they can be used advantageously for pasture land and the production of timber.

From the standpoint of crop production, valuable assets of the soils of the county are the high organic content and granular structure of the surface soil and the presence of sufficient lime for crop needs in the subsoil. Organic matter—a potent absorbent of both heat and moisture—increases the moisture-absorption rate and the water-holding capacity of the soil and assists in maintaining a uniform soil temperature. It also promotes favorable tilth, retards water erosion, and is the chief source of nitrogen, an important plant nutrient. The granular structure facilitates root penetration and the free movement of air and water, all of which act to change the raw vegetal and mineral constituents of the soil into nutrients for growing crops. Although most of the soils have little or no lime in the form of calcium carbonate, none is sour or acid enough to impair the granular structure.

SOIL SERIES AND THEIR RELATIONS

The soils of the various series represented in the county differ considerably in many of their internal and external characteristics, and correspondingly in their use capability and producing power. It is possible, nevertheless, to classify them according to use capability and productivity, and on this basis they are placed in eight general groups: (1) Dark deep silty soils of well-drained loessal uplands; (2) dark deep or moderately deep soils of well-drained glacial uplands; (3) dark deep silty soils of well-drained terraces and colluvial slopes; (4) dark deep and moderately deep claypan soils of imperfectly drained uplands and terraces; (5) moderately dark shallow soils of uplands; (6) dark soils of bottom lands; (7) light-colored soils of bottom lands; and (8) miscellaneous land types.

Agricultural practices are not strictly uniform on the soils of each group, nor are the soils of a group equally productive. Within each soil group there are some variations in drainage, slope, moisture, texture, stoniness, and content of lime and organic matter that more or less determine their agricultural use. Farming systems and the kind of crops grown on a particular soil may differ somewhat among the different soils of a group or even on the same soil in different localities, depending on differences in the requirements of the individual farmer and in the quantity and distribution of the local precipitation. None of the soil groups is confined to any particular part of the county. On many farms, moreover, the soils of one group are interspersed with or surrounded by areas belonging to a different group.

DARK DEEP SILTY SOILS OF WELL-DRAINED LOESSAL UPLANDS

The dark deep silty soils of well-drained loessal uplands are more extensive than those of any other group. They occupy nearly level to hilly land and are for the most part undulating to rolling. In most places they are characterized by a deep almost black mellow surface layer, a deep dark friable well-oxidized subsoil, an abundance of all essential plant nutrients, and a high water-holding capacity. In productivity they rank high, especially for corn, oats, wheat, and alfalfa. They are easily managed and have stood almost continuous cropping without benefit of fertilization or other soil-improvement practices over a relatively long period without serious reduction in yields. Yields have been reduced only on parts of some of the steepest slopes, where the land is most susceptible to and most severely damaged by accelerated water erosion; and even in these localities the soils have only recently begun to respond well to fertilization.

Although they are susceptible to considerable runoff in places, especially on the steepest slopes, severe water erosion has made practically none of these soils unsuitable for general farming. Gullies brought about by improper farming practices have become a menace in some places; but with improved soil management—chiefly greater conservation of moisture and plant nutrients through better control of runoff—the soils of this group should remain indefinitely among the most productive on the uplands of the county or of the State. The group includes soils of the Marshall and Sharpsburg series.[5]

DARK DEEP OR MODERATELY DEEP SOILS OF WELL-DRAINED GLACIAL UPLANDS

The dark deep or moderately deep soils of well-drained glacial uplands have attained about the same stage of development and thickness as the dark deep silty soils of well-drained loessal uplands, but they have formed in glacial drift instead of loess, contain some sand and gravel, and usually have a smaller percentage of silt and more clay in the profile. Consequently, they are a little heavier, less pervious, and less retentive of moisture than the loess-derived soils and are somewhat less easily managed. Those having a larger proportion of sand than clay, however, are more porous. Under comparable conditions, all except the most sandy soils are nearly as productive as any of the soils occupying similar topographic positions on the loessal uplands. The group includes soils of the Carrington, Burchard, and Dickinson series.

DARK DEEP SILTY SOILS OF WELL-DRAINED TERRACES AND COLLUVIAL SLOPES

The dark deep soils of well-drained terraces and colluvial slopes are friable and usually silty. They contain an abundance of all the essential plant nutrients, have high water-absorbing and water-holding capacity, are easily managed, and are productive of a wide variety of crops common to the area. They occupy the well-drained parts of both high and low terraces and the colluvial slopes.

The high terraces are mostly adjacent to and approximately 30 to 40 feet above the broadest bottoms and are capped with loess of Peorian age, as are most of the uplands. Only their basal parts are water-laid. The soils on the high terraces do not differ appreciably in profile from those of the well-drained loessal uplands, but they occupy terrace or benchlike positions and are more productive of a greater variety of crops.

Most of the low terraces lie adjacent to and only about 10 or 15 feet above the narrower bottoms and have been formed since the loess was deposited. They consist mainly of silty stream-laid sediments washed from the adjacent uplands and deposited on the bottoms when the streams were flowing at higher levels than at present.

The soils on colluvial slopes are developing in recent colluvium or local alluvium washed or rolled from the adjoining uplands. This alluvium has accumulated on terraces and valley floors, either at the base of slopes near the mouths of short intermittent drainageways or along small streams in narrow upland valleys.

[5] Some areas of soil mapped in this county as Sharpsburg silty clay loam may join areas mapped in Cass County as Marshall silty clay loam It has been recognized for some time that the soils called Marshall in this part of Nebraska are heavier than the more representative Marshall silt loam, particularly in the subsoil, and are probably derived from a somewhat different kind of parent loessal material. These differences have been taken into consideration in the soil nomenclature for Otoe County by the recognition of the Sharpsburg series, which was established after the Cass County survey was completed.

The greater part of the terrace land is nearly level. Exceptions are areas bordering bottom lands and crossed by drainageways that issue from the uplands. In these localities, the relief has been modified by stream action and in places is undulating to gently sloping. Locally, the transition from terraces to bottom lands is marked by a short steep slope, but slopes to uplands are usually gradual. Most of the colluvial slopes have less than 5 percent gradient.

Although they are not among the most extensive in the county, the soils of this group are among the most important from the agricultural standpoint because they have a wide range in use suitability and high productivity. They are more productive of a greater variety of crops common to the area than the soils of any other group, chiefly because of their better moisture relations. All are well drained both internally and externally. As they have smoother relief, most of them are less injured by loss of moisture through runoff and are better situated to absorb water than many upland soils and, in addition, most of them receive considerable supplemental moisture through runoff from higher levels. Unlike many bottom-land soils, they are subject to overflow or flooding only on the rare occasions when exceedingly high floodwaters cover some of the lowest terraces for a short period. Moisture relations are generally also superior to those on the uplands because the ground water table below the terraces is frequently within reach of plant roots, especially those of deep-rooted crops grown on the lower parts of the terraces.

Owing to mild relief, the soils of this group generally are not subject to seriously destructive water erosion except where cutting occurs along stream banks and where runoff is rapid along some of the steepest terrace edges. In such areas, especially in narrow upland valleys partly filled with colluvium or local alluvium, gullies often become serious where proper precautions are not taken to control the runoff.

Practically all these soils have been and are used almost continuously for growing crops common to the area. They have stood severe cropping under rather poor management without serious reduction in yields, but continuing such practices will eventually lead to serious soil deterioration. All the soils respond well to improved management practices and many produce higher yields when so managed. Properly managed, they will remain indefinitely among the most productive soils of the county.

The group includes soils of the Waukesha, Bremer, and Judson series. The Waukesha soils are mostly on high loess-covered terraces; the Bremer on low stream-laid terraces; and the Judson on colluvial slopes.

DARK DEEP AND MODERATELY DEEP CLAYPAN SOILS OF IMPERFECTLY DRAINED UPLANDS AND TERRACES

The dark deep and moderately deep claypan soils of imperfectly drained uplands and terraces are distinguished by dense heavy claypan in the upper part of the subsoil and a layer of lime enrichment in the lower part. They occur on all the imperfectly drained parts of the nearly level to gently sloping uplands and terraces. Because of the character of the upper subsoil, internal drainage is slow or imperfect. Surface drainage is commonly slow but sufficient to remove surplus precipitation without injury to crops.

The claypan probably is largely the result of deposition of much fine material carried by percolating waters from the surface. The claypan absorbs and releases water slowly, thus retarding the movement of moisture within the soil and causing slow internal drainage. Probably the lime in the lower part of the subsoil was also carried from the layers above by percolating waters and deposited in root and insect cavities in concretionary form. The layer of lime enrichment, or deposition, indicates the approximate average depth to which moisture penetrates. Moisture can pass freely through the claypan for only short periods following dry weather. The drying causes deep cracks to form, but as soon as the moisture is absorbed they are closed by the swelling of the soil.

All the soils have a deep dark friable surface layer, and most of them contain sufficient quantities of all the essential plant nutrients. As they are easily farmed, practically all are cultivated. They usually occur at lower levels, have slower external drainage than soils of uplands, lose less moisture through runoff, and are less susceptible to water erosion. In most years, however, they are less productive, especially of corn, than better drained upland soils because they do not provide so abundant a supply of moisture during the growing season. The clay subsoil does not release moisture fast enough to meet the requirements of most crops during the drier months, and the surface soil is unable to store enough water to sustain them for more than short periods.

Small grains commonly do better than corn because they mature early in summer, largely on moisture stored in the surface soil. Corn requires more moisture than the surface soil can provide in any except the seasons of unusually abundant and evenly distributed precipitation. Alfalfa and sweetclover do almost as well on these soils as on the better drained upland soils.

The group includes soils of the Butler, Pawnee, Rokeby, and Crete series. The Butler and Pawnee soils are on the loessal and glacial uplands, respectively, and the Rokeby soils are on both high and low terraces.

MODERATELY DARK SHALLOW SOILS OF UPLANDS

Moderately dark shallow soils represent the earlier stages of soil development on the uplands. They are immaturely developed on the most hilly and steeply sloping areas, where runoff is rapid enough to prevent or greatly restrict normal soil development. Water erosion has either thinned or seriously retarded development of the surface soil in many places, and in others the raw unaltered parent material is exposed at the surface.

Where most fully developed, the soils have a moderately dark friable surface layer, 6 to 8 inches thick, which rests on the parent formation or is separated from it by a thin light-colored and very immature subsoil. In most places the soils have not been notably leached of lime and are calcareous from at or near the surface downward.

Much of the area represented by this group is too steeply sloping for cultivation. The soils suffer great loss of moisture and organic matter through rapid runoff over their steep slopes and are difficult to manage when cultivated. They usually contain enough of the essential plant nutrients to produce as much vegetative growth annually as the moisture supply allows. During seasons of abundant precipitation, especially in the first few years of cultivation, they produce good yields of all crops. In most years, however, the yields are low, and unless extreme care is taken to conserve moisture and organic matter through efficient control of runoff, the soils soon become too severely eroded to be desirable for further cultivation.

Soils not too steeply sloping for the use of light farm implements are usually cultivated. This is done because immediate returns from cultivation are greater than can be obtained from other uses of the land. Considering the deleterious effects of erosion on such steeply sloping land, it is doubtful whether cultivation will prove profitable on many of the soils over a long period of years. Uncultivated areas support thick stands of grass and numerous trees and are used chiefly for pasture. Grasses on these soils are occasionally injured by drought during midsummer, but they thrive in spring and fall and provide a protective cover throughout the year. The grass cover reduces runoff and improves the productivity of the soils by conserving moisture and organic matter.

The group includes soils of the Hamburg, Knox, Nuckolls, Steinauer, and Sogn series. The Hamburg and Knox soils are developing in Peorian loess, the Nuckolls in Loveland loess, the Steinauer in Kansan glacial drift, and the Sogn are on limestone and shale bedrock of Permo-Pennsylvanian age.

DARK SOILS OF BOTTOM LANDS

The dark soils of bottom lands occur in bodies and strips of various sizes on the first bottoms or flood plains along all of the larger and many of the small streams. The largest bodies are more than a mile wide in places and occur chiefly along the Little Nemaha River and the lower courses of its principal tributaries. The narrower strips are along the smaller streams and vary in width from a few rods to about half a mile.

The soils lie nearly level except where traversed by abandoned and active stream channels or on slight elevations or in shallow depressions. They are subject to frequent overflow, but surface drainage is sufficient to remove all surplus water soon after floods subside. Poorly drained areas are limited mainly to a few shallow depressions and old abandoned stream channels. Soils suitable for cultivation are usually artificially drained either by open ditches or by tile drains. In the majority of places the water table lies 4 to 15 feet beneath the surface and the subsoil is kept well supplied with moisture, even during the drier years. Variations in relief are not sufficient to affect noticeably the agricultural value of the land. The soils are subject to damaging erosion only in places along streams that are actively deepening or changing their channels.

The soils of this group are formed of recent alluvium and are young in the sense that they have not developed the profile characteristics generally found in soils that have remained long undisturbed. All have accumulated an abundance of organic matter and are dark-colored to a considerable depth. Their remaining profile features are determined chiefly by the character of the alluvial sediments from which they are formed. The sediments deposited by streams issuing from the loessal uplands are uniformly silty in texture. More variable in texture are those laid down by the more deeply entrenched streams that have cut through the loess and into the underlying drift and bedrock formations. The mixing and reassorting of the fine and coarse materials also produces a diverse assortment of sediments, and many of the soils vary considerably in texture within comparatively short distances. These more extreme variations occur especially on the bottom lands along the Missouri River, as the materials there originate not only in the adjacent loessal, glacial, and residual uplands but also in areas outside the county, chiefly those to the north and west.

The group includes the Wabash, Lamoure, and Cass series. The Wabash and Lamoure soils are developing in deep deposits of fine-textured alluvium, chiefly silt and clay; the Cass soils, which occur principally near the Missouri River, have both sandy and fine-textured material underlain by sand and gravel. The Lamoure soils are calcareous at or near the surface, but the Wabash and Cass do not react noticeably with dilute hydrochloric acid. All three contain enough lime to meet the demand of any crop, including alfalfa and sweetclover. The Wabash and Cass are well drained, whereas the Lamoure are imperfectly and poorly drained.

These soils are naturally better supplied with moisture than those on uplands and terraces. The precipitation they receive is supplemented to a considerable extent by runoff from higher levels and by moisture brought up from the underlying water table through capillary action. They are easily managed and are used chiefly for growing corn and alfalfa. Except for soils on colluvial slopes they produce better yields of these crops than any of the other soils in the county. Small grains grow well, but owing to the abundant supply of organic matter and moisture, they generally make excessive vegetative growth at the expense of the grain, and they mature rather late. Alfalfa and sweetclover can be grown many consecutive years without danger of depleting the supply of deep-seated soil moisture. The sandy soils are excellent for truck and vegetable crops and are used for such purposes in many places.

Uncultivated areas are confined mainly to poorly drained places and to narrow strips so severely dissected by stream meanders as to be undesirable for cultivation. They support luxuriant grass and a wide variety of trees and are used advantageously for the production of pasture grasses, hay, and timber.

LIGHT-COLORED SOILS OF BOTTOM LANDS

The light-colored soils of bottom lands differ from those of dark color mainly in having a shallower, lighter colored, and, in most places, coarser textured surface layer and in being closer to the Missouri River than most other bottom-land soils. Their external features, including relief, drainage, and topographic position, are comparable with those of other bottom-land soils. In most places the water table is within 3 or 4 feet of the surface.

The soils represent the earlier stages of soil development in light-colored alluvium. None has accumulated enough organic matter to darken the surface layers. They consist largely of alluvium that has been deposited rather recently by the Missouri River and hence comprise an assorted mixture of soil materials originating mostly in areas outside the county, chiefly those to the north and west.

None of these soils is highly desirable for farming. They have a low nitrogen content, are rather unstable, and are subject to frequent overflow because they lie only a few feet above the normal level of the river. To a limited extent they are used for corn and alfalfa, which give profitable yields in seasons when weather conditions are satisfactory. In wet periods, however, corn and hay are often destroyed by floods; and, during dry years, seed planted in the more sandy soil fails to germinate because of lack of moisture in the porous surface layer. The young plants, moreover, are often seriously injured by shifting wind-blown sand. The soils respond favorably to applications of manure and are well suited to truck and garden crops, especially melons or others that mature quickly.

Uncultivated areas supporting grass and many small trees are used chiefly for pasture. Extreme care must be taken not to overgraze the pastures, especially where the soil is sandy, for if a good protective sod is not maintained, the surface soil material is subject to considerable shifting by the wind.

The group includes soils belonging to the Plattsmouth, Sarpy, and Barney series. Part of the Plattsmouth soils are silty-textured, and the rest are sandy. The Barney and Plattsmouth soils are calcareous, and the Sarpy are partly calcareous.

For purposes of comparison, the soil series occurring in the county are listed in table 4 to show parent material, topographic position, natural drainage, subsoil texture and consistence, subsoil lime content, and depth.

SOIL SERIES, TYPES, AND PHASES

The soil series, types, phases, complexes, and miscellaneous land types of Otoe County are described in detail in the following pages, and their agricultural importance is discussed. Their distribution is shown on the accompanying soil map; and the acreage and proportionate extent of each unit mapped are given in table 5.

BARNEY SERIES

Barney fine sandy loam, the only type of its series mapped in the county, is most important from an agricultural standpoint. It occurs in fine sandy light-colored calcareous alluvium transported largely from areas to the north and west outside the county. It is chiefly on the Missouri River flood plain in association with Cass, Plattsmouth, and Sarpy soils. It lies nearly level and is poorly drained because the water table is near the top of the ground.

It has a higher lime content than the Sarpy soils and is more sandy and incoherent than those of the Plattsmouth series. It consists chiefly of grayish-brown or light grayish-brown slightly coherent fine sandy loam to a depth of 6 to 8 inches, and from that point downward to an indefinite depth, of alternating layers of loose incoherent variously textured sands. Thin seams of silt, clay, or gravel may occur in the substratum and, as in all poorly drained soils, mottlings are common in the vicinity of the water table or within 2 feet of the surface. Both the surface soil and substratum are calcareous.

TABLE 4.—*Outstanding characteristics of the soil series in Otoe County, Nebr.*

Soil series	Parent material	Topographic position	Natural drainage		Subsoil texture and consistence	Subsoil lime	Total depth of soil
			Surface	Internal			
							Inches
Barney	Recent alluvium	Nearly level bottom lands	Medium to slow	Rapid	Loose sand	High	([1])
Bremer	Alluvial silt	Nearly level low terraces	do	Medium	Friable silty clay loam	Low	30-36+
Burchard	Kansan glacial drift	Rolling to steeply sloping uplands	Medium to rapid	Medium to slow	Moderately heavy clay loam and sandy clay.	High	24-30
Butler	Peorian loess	Nearly level to undulating uplands	Slow to medium	Very slow	Heavy clay and silty clay	Moderate	30-36+
Carrington	Kansan glacial drift	Nearly level to rolling uplands	Medium to rapid	Medium to slow	Moderately heavy clay loam and sandy clay	Low	30-36+
Cass	Recent alluvium	Nearly level bottom lands	Medium to slow	Medium to rapid	Loose sand	do	([1])
Crete	Peorian loess	Nearly level to undulating uplands.	Slow to medium	Very slow	Heavy clay and silty clay	Moderate	30-36+
Dickinson	Kansan glacial drift	Rolling to steeply sloping uplands	Medium to slow	Medium to rapid	Loose sandy loam	Low	24-36+
Hamburg	Peorian loess	do	Medium to very rapid	Medium	Friable silt loam and silty clay loam	Moderate	8-20
Judson	Colluvial silt	Gentle colluvial slopes	Medium	Medium to slow	do	Low	30-36+
Knox	Peorian loess	Rolling to steeply sloping uplands.	Medium to very rapid	Medium	do	Moderate	8-20
Lamoure	Recent alluvium	Nearly level bottom lands	Slow	Very slow	Heavy clay and silty clay	High	([1])
Marshall	Peorian loess	Nearly level to rolling uplands	Medium to slow	Medium	Friable silty clay and silty clay loam.	Low	30-36+
Nuckolls	Loveland loess	Rolling to steeply sloping uplands	Medium to very rapid	do	Friable silty clay loam and sandy clay.	Moderate	8-20
Pawnee	Kansan glacial drift	do	Medium to rapid	Very slow	Heavy clay and sandy clay	do	24-36+
Plattsmouth	Recent alluvium	Nearly level bottom lands	Medium to slow	Slow	Variable	High	([1])
Rokeby	Peorian loess and alluvial silt	Nearly level high and low terraces	Slow to medium	Very slow	Heavy clay and silty clay	Moderate	30-36+
Sarpy	Recent alluvium	Nearly level bottom lands	Medium to slow	Rapid	Loose sand	Low	([1])
Sharpsburg	Peorian loess	Nearly level to rolling uplands	do	Medium	Friable silty clay and silty clay loam	do	30-36+
Sogn	Permo-Pennsylvanian limestone and shale	Hilly to steeply sloping uplands	Very rapid	do	Stony	High	12
Steinauer	Kansan glacial drift	do	do	Medium to slow	Moderately heavy clay loam and sandy clay.	do	12
Wabash	Recent alluvium	Nearly level bottom lands	Medium to slow	do	Friable silty clay loam and clay	Low	([1])
Waukesha	Peorian loess and alluvial silt.	Nearly level high and low terraces	do	Medium	Friable silty clay loam	High	30-36+

[1] Undetermined.

TABLE 5.—*Acreage and proportionate extent of the soils in Otoe County, Nebr.*

Soil	Acres	Percent	Soil	Acres	Percent
Barney fine sandy loam	636	0.2	Marshall silt loam	12,543	3.2
Bremer silt loam	277	.1	Eroded rolling phase	1,521	.4
Burchard clay loam	355	.1	Level phase	127	(1)
Burchard-Carrington complex	20,103	5.2	Rolling phase	14,074	3.6
Hilly phases	3,992	1.0	Nuckolls-Carrington clay loams	12,727	3.3
Butler clay	73	(1)	Nuckolls clay loam	1,364	.4
Butler silty clay loam	1,754	.5	Pawnee clay loam	2,885	.7
Carrington clay loam	2,280	.6	Plattsmouth fine sandy loam	505	.1
Eroded phase	274	.1	Plattsmouth silt loam	287	.1
Eroded rolling phase	28,943	7.5	Riverwash	3,190	.8
Rolling phase	11,241	2.9	Rokeby silty clay loam	83	(1)
Carrington loam	26	(1)	Sarpy fine sand	2,090	.5
Eroded phase	335	.1	Sarpy fine sandy loam	638	.2
Eroded rolling phase	4,687	1.2	Sarpy loamy fine sand	668	.2
Rolling phase	151	(1)	Sharpsburg silty clay loam	66,510	17.2
Cass fine sandy loam	90	(1)	Eroded rolling phase	1,102	.3
Cass silty clay loam	540	.1	Level phase	338	.1
Crete silty clay loam	6,970	1.8	Rolling phase	79,890	20.6
Crete-Sharpsburg silty clay loams	5,088	1.3	Sogn stony loam	327	.1
Dickinson sandy loam	583	.2	Steinauer loam	4,508	1.2
Hamburg silt loam	4,394	1.1	Wabash fine sandy loam	15	(1)
Hilly phase	4,714	1.2	Wabash silt loam	43,992	11.4
Judson silt loam	153	(1)	Wabash silty clay	1,739	.4
Judson-Wabash silt loams	27,265	7.0	Waukesha silty clay loam	687	.2
Knox silt loam	4,817	1.2			
Rolling phase	1,672	.4			
Steep phase	2,295	.6			
Lamoure silty clay	2,267	.6			
Made land	55	(1)	Total	387,840	100.0

[1] Less than 0.1 percent.

The Barney soil is used in about the same way as Sarpy soils and requires about the same type of management. It is also similar to them in its productivity and desirability for farming.

Barney fine sandy loam.—This soil includes many small intricately associated areas having textures varying from loamy fine sand to very fine sandy loam, but it is usually fine sandy loam. In most internal and external features it is similar to Sarpy fine sandy loam, although it has a somewhat higher water table and contains sufficient lime to react freely with dilute hydrochloric acid.

It is used and managed in the same manner as Sarpy fine sandy loam and is about equal to that soil in productivity, although it is much less extensive.

BREMER SERIES

The silt loam, the only soil of the Bremer series mapped, is similar to the Wabash soils but occupies higher positions and consequently is less subject to overflow. It occurs in silty stream-laid sediments on nearly level low terraces or benches on the higher parts of the bottom lands and is subject to overflow only during unusually high water. Although slow, surface drainage is usually sufficient to remove readily the surplus precipitation. Internal drainage is medium to good. Erosion is negligible.

The Bremer soil has a very dark friable silty surface layer 12 to 15 inches thick, underlain by alternating dark and moderately dark sedimentary layers of silt loam, clay, or silty clay. The underlying layers commonly are somewhat heavier than the surface soil and in places are moderately compact, although they have no claypan. The soil has no free lime carbonate but is not deficient in calcium so far as crop needs are concerned.

The soil is deep, despite the fact that it is still young and immaturely developed. Unlike the Waukesha soil, which also occurs on the low terraces, it has no distinctly developed clayey subsoil layers, as the materials in which it is being formed have not been acted upon sufficiently long by normal soil-forming processes. If allowed to remain in this position long enough, however, it should develop a normal profile comparable with that of the Waukesha soil in a similar position.

This soil is easily managed and admirably suited to cultivation. It is fairly productive and nearly as well suited to all the crops commonly grown in the area as any of the other soils on the terraces. Wheat and oats frequently make excessive vegetative growth at the expense of the grain and consequently do not yield so well as on the Waukesha soil. Corn, alfalfa, and sweetclover can be grown for more consecutive years without danger of exhausting the deep-seated moisture supply than is possible on any of the other soils on the uplands or terraces.

Bremer silt loam.—The largest areas of this soil are chiefly along the Little Nemaha River and the lower courses of its principal tributaries. Practically all of it is cultivated, chiefly to corn, alfalfa, and sweetclover. The crop yields are about the same as those on the well-drained silty soils of the bottom lands, but in wet seasons, when the crops on the lowlands are damaged or destroyed by floods, the yields, especially of corn, are good or better than ordinary.

BURCHARD SERIES

The soils of the Burchard series occur in rolling to steeply sloping areas of calcareous Kansan glacial drift. They are intermediate in development between the Carrington and Steinauer soils. The Burchard soils differ from the Carrington in being a little less deeply developed and in having an abundance of lime in the lower part of the subsoil. They are more deeply developed and have lower lying lime than the Steinauer.

All the Burchard soils are well drained and in some places are subject to rather rapid surface runoff and to moderate water erosion. They are characterized by a dark granular friable and moderately

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deep surface layer and a light-colored friable or moderately heavy subsoil, the basal parts of which are highly calcareous. The subsoil merges with limy glacial drift, usually at depths of 24 to 30 inches.

Burchard soils are used extensively for the production of all the cultivated crops commonly grown in the area. Where most fully developed, they are about as well suited to these crops as the corresponding types of Carrington soils. They occupy rougher areas than the typical Carrington soils, however; are more subject to water erosion; lose more moisture through runoff; and are less productive. Considerable care is necessary to control runoff and conserve soil moisture and organic matter if highest yields are to be obtained. The nonarable areas of Burchard soils support scattered trees and thick stands of tall grasses and are used advantageously for pasture.

The only soils of the series recognized in the survey of this county are Burchard clay loam and the Burchard-Carrington complex and the hilly phases. In places, textural variations are sufficient to cause slight differences in the agricultural value of the land, but the total area of these soils is not large, and the variations are of such minor extent and importance that only the dominant soil type is mapped. For similar reasons, sloping and eroded phases of the Burchard soil are not recognized. In places, however, small areas of Burchard clay loam and Carrington clay loam are so intricately associated that their separate delineation is not practical.

Burchard clay loam.—This soil is on limy glacial drift in rolling to steeply sloping areas where most of the slopes range from 5 to 10 percent[6] and has good to excessive surface and internal drainage. In places on the steeper slopes runoff is so rapid that erosion is severe. Drainageways are numerous, and most of them are too deeply entrenched to be crossed with farm machinery.

The soil is similar in profile to the eroded phases of Carrington clay loam, except that it contains lime in the lower part of the subsoil. In most places the dark grayish-brown or almost black surface layer is 6 to 12 inches thick and contains considerable sand and numerous small stones and pebbles, but the prevailing texture is clay loam. The layer is friable throughout.

The upper part of the subsoil is dark-brown or brown friable or moderately friable silty clay loam about 8 inches thick. It is a little more clayey and slightly more compact than the layer above but has enough sand and gravel to prevent extreme compaction and to facilitate easy penetration of air, roots, and moisture. The subsoil, which gradually becomes coarser and lighter colored with depth, consists of brown or light-brown limy sandy clay loam in the lower part. At 24 to 30 inches below the surface it merges with the parent drift, which is composed of a limy mixture of sand, silt, clay, and gravel.

The principal variations in this soil occur in places where it is in close association with Steinauer loam and the Carrington soils. Near areas of the Carrington soils, the surface layer is somewhat darker and thicker than normal, and in places the lower part of the subsoil is noncalcareous. Near areas of Steinauer loam, this soil has a lighter

[6] A slope, or gradient, of 5 percent is one in which the land rises or falls 5 feet in a horizontal distance of 100 feet. Other slope-gradient percentages are rated similarly.

colored surface soil, is shallower, and has lime closer to the top of the ground than usual.

Much of the soil is under cultivation and it shows good productivity when planted to any of the crops commonly grown. Where most deeply developed and efficiently managed it is almost as productive of corn, wheat, oats, alfalfa, and sweetclover as the rolling phase of Carrington clay loam, which occupies areas of similar relief. Most of the soil, however, has greater relief than typical Carrington clay loam; is more severely eroded; loses more moisture through runoff; and is about 15 percent less productive, especially of corn and small-grain crops. All this soil is well suited to trees and native grasses, and much of it is included in pastures and farm woodland.

The cropping and land-management practices now used are about the same as those followed on soils less subject to erosion. The land is difficult to cultivate because of its sloping relief, and during seasons of abundant precipitation, when yields of all crops are highest, it is seriously injured by erosion under current management. Much soil and moisture conservation is required in all areas if satisfactory yields of cultivated crops are to be obtained. Pastures on the steeper slopes should not be overgrazed, because the soil rapidly loses its dark surface layer and becomes severely eroded and gullied when the protective cover of vegetation is destroyed.

Burchard-Carrington complex.—Included in this complex are bodies of Burchard and Carrington clay loams so intricately associated that their separate delineation on a map of the scale used in this survey is not practical. The relief and drainage of this complex are much like those described for Burchard clay loam and the rolling phase of Carrington clay loam. The profile features are practically the same as on one or the other of the included soil types, but in some places they represent a transition between the two. As a rule the soils have not been damaged seriously by erosion.

Cropping practices, use capability, and management requirements for all areas of the complex are similar to those for Burchard clay loam. Many areas mapped as part of this complex are cultivated, and owing to the greater fertility of the Carrington soil the yields usually are a little better than those from Burchard clay loam. Uncultivated areas produce good grass and numerous trees and are used advantageously for pasture.

Burchard-Carrington complex, hilly phases.—In this separation are areas of this complex with slope gradients exceeding 10 percent. The soils differ from those in the complex of normal phases in having a slightly thinner profile. In the few small areas that have been cultivated erosion is rather severe. This complex is best suited to woodland and pasture, but overgrazing starts sheet erosion and deep gullies.

BUTLER SERIES

The Butler soils occur chiefly on the highest and broadest level of loessal uplands. They have slow surface runoff and are not subject to more than very slight water erosion. Internal drainage is slow and imperfect because the subsoil is heavy clay.

These claypan soils are developed in Peorian loess. They are characterized by a dense heavy claypan in the upper part of the subsoil and a layer of lime enrichment in the lower part. The surface layer is nearly black, finely granular, and friable to a depth of about 14 to 16 inches. It merges abruptly with the dense very dark clay of the upper subsoil. Neither the surface layer nor the upper subsoil is noticeably calcareous. From about 24 to 36 inches below the surface the subsoil is yellowish-brown or grayish-yellow limy moderately compact silty clay or silty clay loam. Floury Peorian loess similar to that beneath the Marshall and Sharpsburg soils is 3 to 4 feet below the surface. It contains little or no free lime. A layer of leached light-gray silt about 2 inches thick is not uncommon in the lower surface soil; it occurs between the dark layer above and the claypan, or upper subsoil, below.

Butler soils in most places lose little moisture through runoff, and they have not been damaged appreciably by erosion. All crops common to the area are grown successfully and easily on most of them, but the yields of many are frequently slightly lower than those obtained on Marshall and Sharpsburg soils, chiefly because of the less abundant supply of moisture during the growing season. During seasons of above normal or high precipitation, Butler soils produce good yields of all crops. They are usually uniform throughout their extent in this county. Butler silty clay loam and Butler clay are mapped.

Butler silty clay loam.—This soil occurs chiefly in the southwestern part of the county on the broadest and smoothest parts of the loessal uplands, where slopes commonly are less than 1 percent. Surface drainage is rather slow but sufficient to remove all surplus water. Erosion is practicably negligible. Internal drainage is slow and imperfect owing to the low permeability of the subsoil.

The surface soil is very dark grayish-brown or nearly black fine granular silty clay loam having an average thickness of about 16 inches. In many places its lower 2- to 4-inch layer contains many particles of light-gray silt from which the organic matter has been leached. Although very dark when moist, this layer has a somewhat lighter shade than the overlying material when dry. Immediately beneath the surface soil there is a layer of very dark grayish-brown or almost black heavy massive clay. This layer usually is 10 to 14 inches thick and is a true claypan. None of the surface soil or the upper part of the subsoil is noticeably calcareous. The lower part of the subsoil consists of grayish-brown or pale-brown limy and only moderately heavy silty clay loam. The soil rests on light grayish-brown or pale-brown slightly oxidized floury silt loam of the parent Peorian loess at a depth of about 4 feet. The loess may or may not be slightly alkaline and commonly is not.

The surface soil contains a little more clay than the corresponding parts of most of the other soils on the loessal uplands and cannot be cultivated without injury under so wide a range of moisture conditions, a fact well demonstrated in fields that include both Butler and Sharpsburg soils. If such fields are cultivated as soon after rains as moisture conditions in the Sharpsburg soils become favorable, the associated Butler soil invariably puddles, bakes, becomes cloddy, and loses an excessive quantity of moisture through evaporation.

All crops common to the general area are grown on this soil, but small grains usually do better than corn because they mature early in summer, chiefly on moisture stored near the surface. Corn requires moisture for a longer period. The dense claypan layer in the subsoil holds little moisture that is rapidly available to plants, and when the supply in the surface soil is depleted, crops are usually injured by drought. Successful crop production therefore depends largely on conservation of the moisture in the surface soil. During seasons of normal or abundant precipitation all crops yield nearly as well as on the more friable soils of the uplands, but in dry years they are usually injured by drought. Because of its insufficient moisture supply, long-time yields of most crops commonly grown in the county are 15 to 20 percent lower on this soil than on Sharpsburg silty clay loam. Alfalfa and sweetclover do nearly as well as on the Sharpsburg soil.

Butler clay.—Only a few small areas of this soil have been mapped in the county. It differs from Butler silty clay loam in having a thinner black clay-textured surface soil 8 to 12 inches thick. This material is fairly well granulated when nearly dry but becomes very sticky and puddled when wet. The rest of the profile resembles that of Butler silty clay loam.

This soil should be plowed and cultivated only when moisture conditions are ideal. Otherwise it will remain cloddy and intractable until freezing and thawing break up the heavy clods. The soil has a large water-holding capacity, but plants cannot extract the water fast enough in dry weather to make their best growth. If dry periods are prolonged, crops are injured or killed even sooner than on Butler silty clay loam, and for this reason the soil is best suited to small grains and grasses.

CARRINGTON SERIES

The soils of the Carrington series are developed in Kansan glacial drift. In many respects they resemble the silty stone-free Sharpsburg soils but differ chiefly in containing more clay, some sand and gravel, and a smaller percentage of silt throughout the profile. Where normally developed, the two soils have comparable relief; but the Carrington soil has slightly more rapid runoff and, owing to its higher clay content, is a little more susceptible to erosion. The heavier soil is less pervious, absorbs water less readily, and is a little less easily managed.

The Carrington soils are characterized by a very dark granular surface layer 12 to 15 inches thick. The upper subsoil layer is brown or slightly reddish-brown cloddy and moderately heavy but fairly friable gritty silty clay or sandy clay that merges downward into the lighter brown or light-gray massive gritty clay of the lower subsoil layer. This in turn rests on the parent Kansan glacial drift at a depth of 30 to 36 inches. In most places the drift is a pale-yellow or light yellowish-brown mixture of silt, clay, sand, gravel, and occasional boulders, the finer textured material predominating. The soil above the drift also contains gravel and scattered boulders, but the coarse material is not abundant enough to interfere with cultivation or to alter noticeably the moisture capacity. The soil has been leached of free lime, but as yet no crop grown on it seems to be benefited markedly by applications of lime. The parent drift may be limy below 3 feet, but commonly it is not.

The Carrington soils are used mainly for growing the same crops as those produced on the soils of the Sharpsburg series, but they are slightly less productive than the Sharpsburg, largely because they lose more moisture through runoff. As a whole the Carrington soils occupy more sloping areas than the Sharpsburg, but they are subject to slightly greater runoff even on comparable relief. If optimum yields are to be obtained, more care must be taken to control erosion and conserve soil moisture than is required on most Sharpsburg soils. The majority of the Carrington soils, however, are suitable for cultivation.

In places the texture of these soils varies sufficiently over large enough areas to cause differences in the agricultural value of the land. Hence, both Carrington clay loam and Carrington loam are mapped. The yields on both, as on other highly arable soils on the uplands, vary with differences in relief, the yields being greatest on areas having the least slope and losing less precipitation through runoff. There has been enough water erosion in places, especially on the steeper slopes, to cause rather distinct differences in profile features and productivity. Slope and erosion phases of both the loam and clay loam types are therefore recognized.

Carrington clay loam.—This soil occurs chiefly in the west-central and northwestern parts of the county on gently undulating well-drained glaciated uplands of 2- to 5-percent slope. Many areas included with the type have less than 2-percent slope; some have a slope exceeding 5 percent, but these are too small and unimportant agriculturally to justify separate delineation on the soil map. Where the slopes exceed 5 percent over a significant area the soil is mapped as a rolling phase. Although the slope range of this soil is the same as that of Sharpsburg silty clay loam, its areas are for the most part less smooth. Both surface and internal drainage are moderate in all except a few places having rather rapid runoff.

The dark surface soil, in places almost black, is a friable and granular clay loam containing an abundance of organic matter and ranging from 10 to 14 inches in thickness, except in places where somewhat thinned by water erosion. Ordinarily, a few sand grains and small pebbles are scattered over the surface. Occasional gullies have developed, but practically all are short and shallow and interfere little with cultivation. The upper part of the subsoil—a dark-brown moderately compact gritty silty clay loam—becomes increasingly lighter colored and more clayey with depth. It is fairly friable and moderately easily penetrated by air, roots, and moisture and rests on the lime-free upper part of the Kansan glacial drift at a depth of about 30 inches. The transition in color and consistence between the different parts of the profile is very gradual.

The principal variations in this soil occur where it is closely associated with Pawnee, Burchard, and Steinauer soils. Near Pawnee soil its upper subsoil layer contains a little more clay and is slightly more compact than normal, and where it joins the Burchard or the Steinauer soils its subsoil may have small quantities of free lime within a depth of 3 feet. Most areas of these variations are so small and unimportant agriculturally, however, that they are mapped with the dominant soil.

The soil has a high water-holding capacity, but owing to its higher clay content it absorbs water a little less readily than the Sharpsburg soil and thus loses more moisture through runoff. It is used principally for growing the grains, crops, and legumes common to the area. During seasons of normal or abundant precipitation crops yield about the same as on Sharpsburg silty clay loam, but in drier years they average a trifle lower.

Cropping and land-management practices on this soil are similar to those followed elsewhere in the area. As on other soils, yields depend largely on the conservation of the moisture supply through proper management. The slightly heavier character and lower absorption rate of the subsoil make moisture conservation practices a little less efficient than on Sharpsburg silty clay loam, but the soil is considered easy to manage and ranks high in suitability for farming.

Carrington clay loam, eroded phase.—The soil of this phase differs from the normal phase chiefly in having a thinner surface layer. Runoff has been rapid enough to damage the soil more or less seriously. The surface soil averages about 4 or 5 inches thinner than that of the normal phase, but the rest of the profile is identical. Gullies are numerous, but interfere little with the usual types of farm machinery. Severe soil thinning occurs only in the immediate vicinity of the gullies.

Nearly all the soil is used in about the same manner as the normal phase but with poorer results. Enough surface soil has been lost through accelerated water erosion to cause a reduction in yields, and a change in management is necessary if the soil is to remain desirable for cultivation. Yields of all crops are best increased by greater conservation of moisture and organic matter. More of the total area should be used for small grains, alfalfa, sweetclover, and tame grasses and less for corn. Alfalfa and sweetclover yield about as well as on the normal phase.

Corn crops on this phase show a deficiency of nitrogen and phosphorus, especially in areas where the partly exposed subsoil is slightly reddish brown. Response can be expected from applications of manure and commercial fertilizer high in phosphorus.

Carrington clay loam, rolling phase.—The rolling phase differs from the normal phase mainly in having less even relief. It occurs on well-drained glacial uplands in areas where the relief is almost identical with that of the rolling phase of Sharpsburg silty clay loam. The land slopes in all directions, with gradients chiefly between 5 and 10 percent. Both surface and internal drainage are good. In a few places runoff is rapid enough to cause moderately severe erosion, but except for these the soil has not been appreciably eroded. The gullies, though more numerous and deeper than in the normal phase, are usually crossable with all types of farm machinery.

The soil is identical with the normal phase in profile features, and is used in practically the same manner. Yields of the majority of crops usually average about 10 percent lower than those on the normal phase, chiefly because there is a greater loss of moisture through runoff. For optimum yields more care is required in controlling runoff than on the normal phase. When properly managed this rolling phase compares with that of Sharpsburg silty clay loam in much the same manner as the normal phase of Carrington clay loam compares with that of Sharpsburg silty clay loam.

Much of this phase is planted to intertilled crops. It is more suited, however, to hay and close-growing crops. Continuous clean cultivation leads to rapid depletion of the soil by erosion.

Carrington clay loam, eroded rolling phase.—The soil of this phase differs from the rolling phase mainly in having a thinner surface layer. Conditions of relief and drainage are comparable to the rolling phase, except that runoff has been a little more rapid, and as a result, there has been greater erosion of the surface soil (pl. 1, *A*). Gullies are more numerous and so much deeper than in most other areas of Carrington soils that in many places they cannot be crossed.

The profile features are almost identical with those of the eroded phase. Surface soil thinning within areas of this phase has been a little more severe and a little more common than in the normal phase, but the soil has not been eroded severely, except on the steepest slopes and in the vicinity of gullies. Such places, however, represent only a small percentage of the total area mapped.

The soil is used to some extent for corn, alfalfa, and sweetclover, but mainly for grasses. Although inherently productive of all crops common to the area, it is not very desirable for grain production, because of unfavorable relief and the eroded condition caused by mismanagement. When farmers practice greater conservation of moisture and organic matter than now they will find the productivity greatly improved. Conservation practices should include some attempt at gully control, contour farming, and strip cropping with terraces. Alfalfa and sweetclover grow nearly as well on this soil as on the rolling phase, and these crops or legume-grass mixtures can often be used to advantage in rotations.

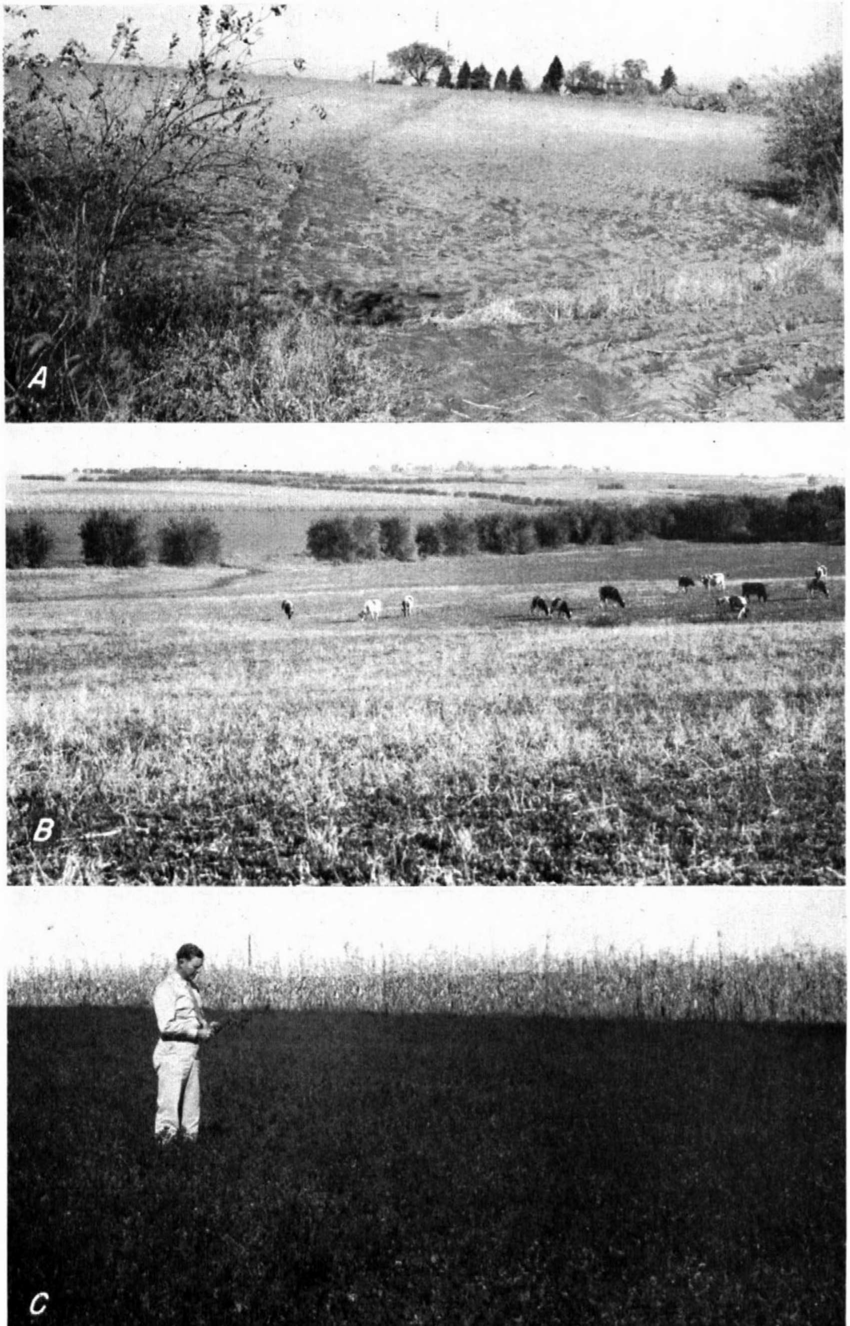
Corn on the phase may show a deficiency of nitrogen and phosphorus (pl. 1, *B*) on eroded areas and especially where the subsoil is slightly reddish brown. In such areas a satisfactory response can be expected from the use of nitrogen and phosphorus.

Carrington loam.—This soil differs from Carrington clay loam chiefly in having more sand and gravel in the surface layer. It is most typically developed on gently sloping to undulating glaciated uplands, where the gradients range chiefly between 2 and 5 percent. Both surface and internal drainage are good. Except in a few places on the steeper slopes where runoff is moderately rapid, the soil has not been damaged noticeably by erosion.

The surface soil is friable granular loam, 10 to 12 inches thick. It has an abundance of organic matter and is very dark or almost black. In places the surface layer contains numerous small stones and sufficient sand or gravel to make it a little coarser in texture than a typical loam. Areas having this textural variation are not large enough, however, to justify mapping them separately.

The rest of the soil profile is almost identical with that of Carrington clay loam, except that the sand and gravel content in the lower layers is a little more variable. The subsoil becomes increasingly lighter colored with depth. It is moderately friable and easily penetrated by air, roots, and moisture. The parent drift is a mixture of sand, silt, clay, and gravel, the finer textured constituents predominating. It is usually not limy within a 3-foot depth.

A, Terraced field seeded to winter wheat. Carrington clay loam, eroded rolling phase, in foreground; Burchard-Carrington complex, hilly phases, in center.
B, Landscape of loess-drift hills. Carrington clay loam, eroded rolling phase, in foreground, Crete-Sharpsburg silty clay loams in middle background; Sharpsburg silty clay loam in far background. Corn is in foreground, alfalfa at left across draw, fallow at right of alfalfa, winter wheat at right of fallow.
C, Rill and gully erosion on Hamburg silt loam, hilly phase, on field of winter wheat, alfalfa in foregound.



A, Knox silt loam on hill slope showing effects of sheet erosion; erosion is active on light-colored soil along slope break.
B, Dairy cattle in clover pasture on Marshall silt loam; Osage-orange fence row in center, winter wheat and corn in background.
C, Alfalfa and corn on Marshall silt loam.

The principal variation in this soil, aside from slight local differences in the texture of the surface soil and subsoil, occurs where it is closely associated with Burchard or Steinauer soils. In these localities the parent glacial drift may contain small quantities of free lime within a 3-foot depth, but such areas are small and not typical. As mapped, the soil also includes a few small areas in which the surface is thickly strewn with gravel.

Practically all of Carrington loam is cultivated. It is used mainly for corn, but smaller acreages are in wheat, oats, and alfalfa. Most of the more gravelly areas are used for pasture, and they support considerable tall grass and numerous bur oak trees.

The soil does not differ significantly from Carrington clay loam in its use capability and productivity. The crops commonly grown in the area, especially corn and alfalfa, do about equally well on both soils. Owing to the higher sand and lower clay content in the surface layer, this type can be cultivated under a slightly wider range of moisture conditions than the clay loam, and it absorbs precipitation a little more rapidly. In most places, however, the surface layer contains more stones than the clay loam, and its cultivation therefore involves higher expenditures for the maintenance of tillage implements.

Carrington loam, eroded phase.—This eroded phase differs from the normal phase of the type in having a thinner surface layer as the result of accelerated water erosion. Relief and drainage conditions are comparable with those of the normal phase. Mismanagement through improperly controlled runoff has allowed much of the original surface soil to be lost. Gullies are numerous, but ordinarily the majority can be crossed by farm implements. Although the surface soil has been thinned considerably by erosion, it has not been damaged severely, except in the immediate vicinity of the gullies and on some of the most sloping areas.

The soil is used in about the same manner as the normal phase, but the yields, except for alfalfa and sweetclover, are somewhat lower. The productivity of the soil for all crops can be best maintained, if not increased, by growing enough legumes and tame grasses in rotation with grain crops to replenish organic-matter supplies as rapidly as they are diminished. Greater conservation of both soil and moisture can be obtained through better control of runoff. Use of well-constructed terraces and strip cropping and the more frequent raising of close-growing crops in all rotations are means by which runoff can be reduced.

Nitrogen and phosphorus deficiency symptoms in corn are noticeable on the more severely eroded areas and especially where the exposed subsoil has a slightly reddish-brown color. Barnyard manure supplemented by commercial fertilizer high in phosphorus can be expected to benefit crops.

Carrington loam, rolling phase.—This phase differs from the normal phase mainly in having greater relief. Its profile features are identical with those of the normal phase, and its relief and drainage correspond to those of the rolling phases of Carrington clay loam and Sharpsburg silty clay loam. The slopes are in all directions and range mostly between 5 and 10 percent. Drainage is everywhere good, and runoff has not been rapid enough to cause more than moderate erosion, except in places on some of the steepest slopes. Gullies are deeper and more numerous as a rule than in the normal phase, but they can usually be crossed by farm machinery.

Use capability and management requirements are about the same as on the rolling phase of Carrington clay loam. The soil is used in about the same manner as that soil.

Carrington loam, eroded rolling phase.—This phase differs from the rolling phase in that it has lost more surface soil. Much of the original surface soil, particularly on some of the steepest slopes and where there are gullies, has been severely damaged if not completely lost by erosion. In many places the gullies cannot be crossed with heavier farm machinery.

The relief and drainage features are comparable with those for most rolling soil phases. The condition of the soil is largely the result of poor management. The more or less inefficient attempts at controlling runoff have resulted in a gradual year-to-year lowering of yields, and the soil is now considered generally undesirable for cultivation.

The present use, use capability, and management requirements of the soil are much like those discussed for the eroded rolling phase of Carrington clay loam.

CASS SERIES

The soils of the Cass series occur in both fine- and coarse-textured noncalcareous alluvium, chiefly on the Missouri River flood plain. They differ from those of the Wabash series in having a less uniformly deep dark surface layer and loose incoherent or only slightly coherent sandy or gravelly light-colored substrata. They are nearly level and subject to frequent overflow, but the floodwaters commonly disappear soon after the streams subside. Internal drainage is good to excessive because of the porous character of the substratum, but the water table usually is within 3 or 4 feet of the surface and therefore within reach of most plant roots.

To depths of 6 to 30 inches the alternating layers of very dark grayish-brown or almost black soils consist of fine or moderately fine-textured alluvium washed mainly from the adjacent uplands. The deposits are of various depths on the coarse light-colored materials of the substratum that came largely from areas outside the county to the north and west. The substratum and the lower part of the soil profile often contain numerous rusty-brown or light-brown spots, streaks, and splotches, indicating a continual moist condition in the lower part. The soil profile may be slightly more than 30 inches deep in places, but where the dark-colored surface material exceeds 3 feet over a significant acreage, the soil generally is mapped as belonging to the Wabash series.

The Cass soils, which as a rule are easily worked, are cultivated chiefly to corn, alfalfa, and sweetclover. Like most alluvial soils, they are best suited to such crops. They produce nearly as good yields of all crops as any of the soils on the bottom lands. Uncultivated areas support luxuriant grasses and numerous trees and are used mainly and advantageously for pasture, hay crops, or woodland.

In this county the Cass soils vary in texture but are predominantly fine sandy loam and silty clay loam and are mapped as one or the other of these two types.

Cass fine sandy loam.—This soil, the most typical of the Cass series, occupies irregularly shaped areas, chiefly on the Missouri River flood plain. It lies nearly level and is subject to frequent overflow but has sufficient drainage to remove all surplus water as fast as the streams subside. The water table lies within about 3 or 4 feet of the surface.

The soil has accumulated an abundance of organic matter in its upper part, and to depths of 6 to 30 inches it consists of alternating layers of very dark grayish-brown or dark-brown fine sandy loam or very fine sandy loam, the sandy loam predominating near the surface. The solum is underlain by additional alternating layers of loose incoherent or only slightly coherent light grayish-brown or almost white materials. These vary in texture from fine sand to coarse gravel, although the more sandy texture predominates.

The color and texture of the soil and substratum depend partly on the organic content and partly on the origin of the alluvium of which they are a part. They are the result of the reassorting of dark-colored silty materials washed chiefly from the adjacent uplands and mixed with the coarser lighter colored materials transported by the Missouri River from areas outside the county. The depth of the soil profile depends mainly on the depth of the accumulated material washed from the adjacent uplands. Numerous mottlings occur in the lower part of the soil and throughout the substratum in places. The mottlings owe their development to the close proximity of the water table. No part of the soil section is noticeably calcareous.

The soil is friable and easily penetrated by air, roots, and water. It contains an abundance of most of the essential plant nutrients and of moisture, warms earlier in the spring, and can be worked under a wider range of moisture conditions than Wabash silt loam. It is slightly less productive than that soil, however, apparently because of the higher sand and lower organic-matter content in its substratum. As with other soils on the bottom lands, it is best suited to corn, alfalfa, and sweetclover, all of which yield well even during years of prolonged drought. The soil responds favorably to applications of manure and is one of the best in Nebraska for growing truck and garden crops. Uncultivated areas include tracts that have been made so inaccessible by stream meanders and overflow channels that they are undesirable for cultivation. Such areas, however, support luxuriant grass and numerous trees and can be used advantageously as pasture land or hay meadows.

Cass silty clay loam.—This soil differs from Cass fine sandy loam mainly in having a heavier and finer textured surface layer. It occurs chiefly in shallow depressions and old abandoned stream channels or sloughs on the Missouri River flood plain, where it is subject to frequent and rather prolonged inundation. Drainage is slow, partly because of the relief and texture of the surface soil and partly because the water table is frequently so near the top of the ground as to keep the substratum continually wet or moist in all except the driest seasons.

The surface 8- to 10-inch layer is almost identical with that of Wabash silty clay, except that it contains enough sand to make it silty clay loam. The very dark-gray or almost black heavy silty clay loam is sticky and plastic when wet and hard and brittle when dry. This layer may overlie alternating layers of slightly lighter colored and less silty material containing considerable organic matter or it may rest on alternating layers of brown or light grayish-brown sandy material containing very little organic matter. Regardless of the character of the subsurface layers, the substratum below a depth of 30 inches is loose incoherent gray or grayish-white sand interbedded with fine and coarse gravel. The substratum and the lower part of the soil contain many rust-brown, brown, and yellowish-brown mottlings, which are indicative of poor drainage. The soil is noncalcareous.

The soil is nearly as fertile as others in the Wabash, Lamoure, or Cass series, but little of it is cultivated because of the heavy intractable character of the surface layer and its excessive moisture. In dry years it produces good corn, but in wet ones all cultivated crops suffer. Alfalfa and sweetclover do well in the best drained areas, but their root system is commonly damaged severely in winter by excessive freezing and thawing. Artificial drainage is made difficult by lack of suitable outlets.

The areas having a native cover of tall grasses and numerous willows are best used either as pasture land or as wild hay meadows.

CRETE SERIES

The Crete series occur on the uplands, where slopes range chiefly from 2 to 5 percent. Where they form part of a complex with Sharpsburg soils, however, the slopes reach a maximum of about 15 percent. External drainage, or runoff, on Crete soils is moderate to rapid according to the slope. Internal drainage is retarded considerably by the claypan subsoil, which is only slightly less heavy and more permeable than that of the Butler soils.

The Crete are claypan soils developed largely in Peorian loess. In some places the claypan subsoil is made up of heavy layers of much older soils developed in the underlying Loveland loess or locally in Kansan drift.

The surface soil, 10 to 16 inches thick, ranges from dark grayish brown to very dark brown. It has a granular structure that affords excellent tilth when cultivated under proper moisture conditions. The transition from the surface soil to the subsoil is less abrupt than in the Butler series. To depths averaging about 30 inches, the subsoil is brown heavy silty clay or clay that breaks naturally into sharply angular granules and small sharp-edged blocks. These structural aggregates, if not disturbed, keep their form under a fairly wide range of moisture conditions. When the soil is wet the clay in this claypan layer swells and almost prevents the further downward movement of water. Beneath the claypan layer the soil is pale-brown blocky to massive silty clay loam in which there are streaks, spots, and small concretions of lime carbonate that extend 3 to 4 feet below the surface. This layer grades in turn to pale-brown, usually nonlimy, loess of silt loam or silty clay loam texture. In many places, where iron oxide has been segregated, it is mottled with small dark-brown spots.

The Crete soil is used for growing practically all crops common to the area. It is more suitable for wheat than for corn but is used extensively for both. The yields average less on this than on the Sharpsburg soils.

The silty clay loam is the only type mapped. It occurs by itself in fairly large areas, especially on very gentle slopes, and in complex association with Sharpsburg silty clay loam.

Crete silty clay loam.—This soil differs from Butler silty clay loam mainly in having less even relief and in being browner. It occurs on undulating or gently sloping loessal uplands where most of the gradients range between 2 and 5 percent. Variations of more or less than those percentages do not occur over significant acreages. The soil has medium to good surface drainage, but runoff is not rapid enough to cause severe water erosion in any locality. Drainageways are more numerous than in areas of the Butler silty clay loam, but most of them are shallow and crossable at all places with heavy farm machinery. Internal drainage is slow.

The profile of this soil from the surface to the parent material is as follows:

Granular friable silty clay loam; dark grayish brown when dry and very dark brown when moist: 4 to 6 inches thick.

Granular silty clay loam, grading downward to silty clay in the lower part; brown when dry, very dark brown when moist; 8 to 12 inches thick.

Blocky silty clay or clay; an almost impermeable claypan when wet but cracked and permeable when dry; brown or light brown, but slightly darker when moist; 12 to 20 inches thick.

Pale-brown blocky to massive silty clay loam with streaks and spots of silty carbonate of lime and hard concretions of the same material; 10 to 20 inches thick.

Friable light silty clay loam or silt loam loess with little or no carbonate of lime and no well-defined structure; pale brown mottled with dark brown and light gray in the lower part; 1 or 2 inches to 2 or 3 feet thick.

The surface soil is plastic and sticky when wet but is cultivated easily when moist or dry. The subsoil is extremely sticky and plastic when wet but very hard when dry. Where the subsoil is exposed by erosion it is very difficult to manage.

Nearly all areas of Crete silty clay loam are cultivated. The soil is as well suited to the principal crops of the areas as Butler silty clay loam, and alfalfa and sweetclover yield about as well as on that soil. The yields of other crops are slightly lower because more moisture is lost in the runoff from its undulating surface. Crop yields depend mainly on the supply and conservation of the surface soil moisture, factors that are determined partly by the quantity and distribution of precipitation and partly by tillage methods.

Crete-Sharpsburg silty clay loams.—The soils of this complex are so intricately associated that separate delineation on a map of the scale used is not practical.

Over most areas, relief and external drainage conditions resemble those of Sharpsburg silty clay loam, except that any one soil body commonly slopes in only one direction instead of in several, as in the case of the Sharpsburg. Most of the soils of this complex occupy single slopes having about a 5- or 6-percent gradient. Gullies are numerous, but they can be crossed, at least in places, by most types of farm machinery.

The profile features and internal drainage conditions of the Crete member of this complex are almost identical with those of Crete silty clay loam, whereas the profile and drainage of the Sharpsburg soil correspond to those of Sharpsburg silty clay loam. In places on some of the steeper slopes and near gullies the surface soil has been thinned somewhat through erosion, but as yet it has not been damaged enough to affect greatly the agricultural value of the land over significant acreages.

Cropping practices, use capability, and management requirements for the soils mapped in this complex are essentially the same as those given for Crete silty clay loam. Owing mainly to the insufficient moisture supply in the Crete soil, long-time yields are about 20 percent lower than are obtained on Sharpsburg silty clay loam. They also are about 5 or 10 percent lower than on Butler silty clay loam because of the greater loss of moisture through runoff over the more sloping surface. Alfalfa and sweetclover, however, yield about as well on either of the soils in this complex as on the Butler and Sharpsburg soils.

DICKINSON SERIES

The sandy loam, the only type of the Dickinson series mapped, is on rolling to steeply sloping upland areas of deep sands originally deposited by glaciers or by water. It rapidly absorbs most of the precipitation that falls on it and therefore allows little loss of moisture through runoff. It does not have high water-holding powers, however, and supplies crops with less moisture than finer textured soils.

The Dickinson soil is characterized by a dark-brown friable surface layer 8 to 12 inches thick; a dark-brown slightly heavier, though friable, upper subsoil layer of sandy clay loam; and a lower subsoil layer and substratum of incoherent or only slightly coherent fine to medium sand. The soil commonly is not calcareous, although in places it may be slightly alkaline below a depth of about 4 feet. The total area is not large and variations in relief, texture, and degree of erosion are slight.

Where best developed, a large part of the soil is used for corn, small grains, and clover, although its agricultural importance is only minor. Many areas are too steeply sloping to be well suited to cultivation or have such a thin unstable surface layer that they are better suited to legumes and tame grasses than to grain crops.

Dickinson sandy loam.—This soil is chiefly on slopes of 5 to 10 percent, with a few small areas exceeding 15 percent. The soil is developing from sandy deposits left by the Kansan glacier or long-abandoned streams. Later accumulations of organic matter are responsible for a dark surface layer, and the downward movement of the fine soil particles has produced a slightly heavier though friable upper subsoil layer. Any lime that the parent sandy deposit may have contained has long since been removed.

Where least disturbed by wind erosion, the surface soil consists of dark-brown or grayish-brown friable sandy loam 10 to 12 inches thick. The upper part of the subsoil is dark-brown or brown fine sandy loam or sandy clay loam about 14 inches thick. The rest of the area becomes increasingly loose and sandy with depth, and it consists of incoherent light-gray sand below 4 feet. Gravel and small pebbles are scattered over the surface and throughout the soil.

The principal variations in this soil occur in cultivated fields where wind and water erosion have removed the greater part of the dark surface layer from many of the steeper slopes and narrower ridges. In these localities the lighter colored upper subsoil or the light-gray sand of the lower subsoil and substratum is exposed.

The soil is friable and can be worked under a wide range of moisture conditions. In most places it contains sufficient quantities of the essential plant nutrients to grow any crop common to the area. During seasons of abundant precipitation it produces average yields, but in years of normal or subnormal rainfall it is unable to store enough moisture to allow optimum plant growth over a long period. Consequently, the majority of crops, especially corn, yield considerably lower than on the associated less sandy soils of the group. Alfalfa and sweetclover usually do well because their roots penetrate to deep-seated moisture. The soil warms up sooner in spring than the finer textured soils on the uplands, and small-grain crops and grasses thrive early in the season. As a rule, however, grasses are injured by lack of moisture in summer, and pasture is soon greatly diminished if not exhausted.

Strong summer winds remove organic matter from the surface soil once the protective plant growth is destroyed. It is therefore necessary to maintain a permanent vegetative cover. The rotation of legumes and small grains serves well for this purpose because it not only increases the organic content of the soil but also helps to conserve the moisture supply. Where the soil is used for pasture it should be kept under a heavy sod at all times and protected from overgrazing.

HAMBURG SERIES

The Hamburg series includes thin light-colored soils on the steep bluffs along the Missouri River subject to rather rapid erosion. In Otoe County these soils may be largely regarded as severely eroded phases of the Knox soils. In many places they contain more or less carbonate of lime; in others the parent silty loess has lost whatever lime it may have had when it was first deposited.

Hamburg soils have such steep slopes that they are not suitable for clean cultivation; nevertheless, large areas have been cleared of their natural cover of brush, trees, and grass, and have been used for corn, small grains, and fruit. Soils of this series should be used almost exclusively for pasture and woodland. Hamburg silt loam and its hilly phase are mapped.

Hamburg silt loam.—Closely associated with Knox silt loam, this soil normally occurs on slopes exceeding 15 percent and on a few bluffs having some gradients of 30 to 60 percent.

The 3- to 8-inch surface soil is pale-brown or light-brown friable crumb-structured silt loam of approximately neutral reaction. It is underlain by light yellowish-brown to pale-yellow massive friable silt loam, which may be noncalcareous to a depth of 2 or 3 feet. Beneath this layer is very pale-brown or very light yellowish-brown friable loess of silt loam texture. This loess is largely calcareous and is mottled in places with light gray and dark brown.

In many places the slightly darker surface soil has been washed away. Some of it is calcareous from the surface to the deep subsoil, and some of it is noncalcareous to depths of 8 to 10 feet. Much of the soil may be regarded as a severely eroded phase of Knox silt loam from which the usual surface soil and subsoil have been washed away.

Hamburg silt loam is suitable only for pasture and woodland but is used in places for fruit and cultivated crops.

Hamburg silt loam, hilly phase.—This soil consists almost entirely of Knox silt loam from which the surface soil and subsoil have been eroded to a depth of 10 to 20 inches, leaving only a thin layer containing a very small quantity of organic matter. The soil is less steep (gradients about 8 to 15 percent) than the normal phase.

All of this phase has been cleared at some time and has been under cultivation. The deep friable fertile loessal silt loam that forms its parent material makes the soil fairly productive and easily improved by good practices. It is highly susceptible to water erosion, however, and therefore difficult to manage. Where gullies are kept under control it produces fair to good yields of alfalfa, corn, small grains, and tree and cane fruits (pl. 1, *C*). Exhaustion of organic matter necessitates the use of barnyard manure, green manure, or commercial fertilizer to produce fair to good yields. Apples, raspberries, and other tree and cane fruits planted on northerly slopes yield particularly well, despite the variable climatic conditions.

JUDSON SERIES

The soils of the Judson series consist of dark fine-textured soil materials washed or rolled from the dark surface layers of higher lying soils. The material has accumulated as fanlike deposits at the mouths of short intermittent drainageways or along small intermittent stream courses in narrow valleys. It occurs at the base of slopes, either on terraces or on valley floors. Although the areas lie nearly level or have but a gentle slope toward the streams their drainage is excellent. None is subject to overflow except for short periods of runoff from the adjacent higher lying areas. Erosion is negligible, except for stream meanders.

These soils are friable and uniform in color, texture, and consistence to depths exceeding 3 feet, a feature that distinguishes them from all other soils in the county. They vary slightly in different localities but show no major change within a given profile. The soils are not calcareous but they are well supplied with moisture and all the essential plant nutrients, and being friable they are easily penetrated by air, roots, and water. They rank among the most fertile and productive soils in the county. Their total area is small, however, and they are of only local agricultural importance. Like the Bremer soils, they are better suited to corn, alfalfa, and sweetclover than to small-grain crops and are excellent for garden vegetables.

Owing to their very limited extent and to their uniform characteristics, all areas of typical Judson soils in the county are classed as Judson silt loam. In the narrow valleys, however, some are so intricately associated with soils of the Wabash series as to make separate delineation impracticable and in these localities they are mapped as Judson-Wabash silt loams.

Judson silt loam.—The small widely scattered areas of this soil occur as fanlike deposits on terraces and broad valley floors at the base of slopes near the mouths of short intermittent drainageways. Most of it lies nearly level except for a slight slope toward the streams. Drainage is excellent; erosion, negligible.

The soil includes dark grayish-brown or almost black friable finely granular silt loam, mellow silty clay loam, or very fine sandy loam. The surface texture depends largely on the origin of the soil material, but it continues downward without change to a depth of 3 feet or more in all places and is predominantly silt loam.

Practically all the areas are cultivated, usually in connection with associated arable areas, but their small extent makes them of minor agricultural importance. Many are used as truck patches and gardens, and locally the luxuriant grass on uncultivated areas is used for pasture or hay.

Judson-Wabash silt loams.—Where Judson and Wabash silt loams in numerous narrow valley strips are closely associated in small intricate areas and their separate delineation is not practicable, they are mapped as a complex. Surface features, drainage conditions, and land use suitability for both members of the complex are typical of these soils in similar well-drained bottom-land positions. In places the soil is fine sandy loam, but the silt loam texture predominates. The areas are so narrow and so severely dissected by stream meanders that they are difficult to cultivate. They support trees, and their luxuriant grasses, of highly nutritional value, are used mainly for pasture, hay crops, and woodland.

KNOX SERIES

The soils of the Knox series occur mainly in hilly or steeply sloping areas of Peorian loess, where external drainage is excessive and more or less constant water erosion has either removed much of the surface soil or retarded its development. Where most fully developed, as in virgin areas, the surface soil is dark grayish brown and moderately thick, and the subsoil thin and light-colored. In localities where the slopes are not too steep the surface soil usually has been considerably darkened through the accumulation of organic matter. Where the soils have been cultivated and thinned considerably by erosion they are dark brown or brown in the upper part. In many cultivated fields the raw unleached loess is exposed at the surface. The soils are commonly limy or at least slightly calcareous.

Much of the total area of these soils is too steep and irregular for the use of heavy farm machinery. Owing to greater losses of moisture and organic material through rapid runoff, the average yields under ordinary practices are usually much lower than on the deeper and darker well-drained soils of gentler slope. Despite this, a large percentage of the total area is cultivated, chiefly to corn, alfalfa, and sweetclover. These crops are grown mainly because the immediate returns are greater than can be obtained through any other use.

Alfalfa and clover do nearly as well as on any soil on the uplands. Where contour farming, strip cropping with legumes, and other practices designed to conserve moisture and organic material are followed, the better soils yield nearly as well as the deep dark soils on similar upland slopes. Even in areas where all the surface soil has been re-

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moved by erosion, crop plants that receive sufficient moisture obtain enough of the essential nutrients from the silty Peorian loess alone to be fairly profitable.

Because they are difficult to farm, Knox soils are for the most part not highly desirable for cultivation except for special crops. Much care is required to control runoff and to conserve the moisture and organic matter needed for optimum production. Northward-facing slopes are admirably suited to orchards and vineyards, and those in the eastern part of the county near Nebraska City are used rather extensively for this purpose.

These soils vary in texture from silty clay loam to very fine sandy loam, but areas in which the fine- and coarse-textured soils occur are small and widely scattered. The predominant texture is silt loam. Variations in relief are sufficient over a significant area to cause some differences in use capability and management requirements. The soils of the Knox series are the silt loam and its rolling and steep phases.

Knox silt loam.—This light-colored soil developing in Peorian loess occurs mostly in the eastern part of the county on slopes of 8 to about 15 percent, with steeper slopes in a few small areas. In most places runoff is rapid and the soil is subject to severe water erosion (pl. 2, *A*). The numerous gullies can be crossed in places with lighter farm machinery.

The virgin soil is usually very dark grayish-brown or dark-brown friable silt loam to a depth of 6 or 8 inches, but in forested areas the lower part of the surface soil is a 4- to 6-inch layer of platy light-gray silt from which most of the organic material has been leached. The subsoil, where developed, is brown or light-brown friable silty clay loam about 4 inches thick and transitional between the surface soil and the parent material. In many places the dark surface soil rests directly on Peorian loess, a light yellowish-brown or very pale-brown wind-deposited silt. In many cultivated fields the surface soil has been thinned considerably by erosion and is brown or dark brown. In most places where it has been removed so completely that either the subsoil or the parent loess is exposed it is mapped as Hamburg silt loam. The soil and soil material may be limy, but commonly both are slightly to moderately alkaline near the surface. Where the soil occupies the lower parts of the steepest slopes, mainly in the deeper loessal strata, it is usually calcareous throughout.

This soil is relatively fertile, even where it is most severely eroded. Many of the more gentle slopes can be cropped under ordinary practices with fairly profitable results. Excessive loss of moisture and organic matter renders much of the soil desirable for only certain cultivated crops unless extreme care is taken to control runoff. The immediate returns from cropping are greater than from the production of grass and timber, and for this reason general cropping probably will continue where possible until the loessal formation either has been removed by erosion or has been damaged so severely that it will become nonarable. On the other hand, most of the soil, especially on northward-facing slopes, is well suited to fruits, and in many localities is so used.

Part of the soil type has been allowed to remain under a native cover of trees and grasses and is used for the production of pasture, hay, and timber. This part supports thick stands of a variety of trees and is best used as pasture land. The grasses may be injured by drought in midsummer, but they thrive early in spring and late in fall and provide considerable pasture of good quality. Furthermore, they furnish a growing cover in the seasons when the rainfall is greatest and thereby protect the soil from erosion and further loss of organic matter (pl. 3).

The productivity of the cultivated soil may be maintained or increased best by conserving moisture and organic matter through contour farming, strip cropping, and growing legumes in rotation with other crops once in every 3 or 4 years (pl. 4). The fertility of the soil can be further improved by plowing under green cover crops and by generous applications of barnyard manure every 2 or 3 years.

Knox silt loam, rolling phase.—This phase occupies elongated and generally narrow areas on top of the well-rounded hills and ridges. As slopes ordinarily do not exceed 7 percent, the relief is considerably less extreme than that of the normal phase and heavy farm machinery can be used with comparative ease.

The profile features of the soil vary somewhat but are similar to those of the normal phase. In many places the soil is rather severely eroded, but it has not been damaged sufficiently to lessen its use suitability. Gullies are shallow and uncommon.

Practically all the soil can be used for the crops commonly grown in the area. Measures should be taken, however, to conserve moisture and organic matter. Where sufficient moisture is maintained, crop yields are only slightly lower than on Sharpsburg silty clay loam and Marshall silt loam of similar relief. As in all Knox soils, the supply of available organic matter and nitrogen is ordinarily less abundant than in the deeper and darker Sharpsburg and Marshall soils, but the soil and even the parent loess alone contain enough of all the essential plant nutrients to produce almost as much growth annually as the moisture supply allows. Owing chiefly to the slower runoff over the less steeply sloping terrain, the soil is more productive and more easily managed than the normal phase. It is more desirable for growing small grains and hay than the normal phase and is used more extensively for these purposes because the relief is more favorable for the use of the heavier farm machinery.

The productivity of this phase is best maintained or increased by practices similar to those recommended for the normal phase. The soil can thus be made and kept about as desirable for general farming as upland soils of similar relief.

Uncultivated areas support thick stands of grass and numerous trees. They are used in about the same manner and with about the same success as are those of the normal phase, although owing to their lesser slope they are a little more desirable for hay land.

Knox silt loam, steep phase.—This phase consists of a few small areas of Knox silt loam in which the gradients exceed 20 percent. Profile characteristics of the two are the same. Nearly all the steep phase remains uncleared and is in a mixed growth of trees, shrubs, and grasses. Its best use is for pasture and woodland. When cleared and cultivated it soon loses its upper layers through accelerated erosion, and deep gullies develop.

LAMOURE SERIES

The soil of the Lamoure series, the silty clay, unlike soils of the Wabash, is limy and usually has a lighter colored substratum. It occupies nearly level and rather poorly drained sags or swales on the broad flood plains along the larger streams and is subject to frequent overflow. Most of the areas are surrounded by higher lying areas of Wabash soils. They remain inundated longer after floods than the surrounding land and are too wet for cultivation unless artificially drained. Such drainage is frequently impossible and in many places impracticable. The water table is commonly within 4 or 5 feet of the surface.

Near the surface the soil is moderately friable and ordinarily becomes heavier and more massive with depth, though it has no claypan layer. The mottlings, ordinarily within 10 or 12 inches of the surface, indicate poor internal drainage resulting from the close proximity of the water table.

Although moderately friable, the Lamoure soil cannot be worked under so wide a range of moisture conditions as the better drained soils of the bottom lands. It requires heavier machinery and more power for tillage. Like most alluvial soils, it has an abundance of organic matter and moisture; is better suited to corn and alfalfa than to small grain crops; and, where drained, it is nearly as productive as any of the soils on the bottom lands. Most of it is too wet for cultivation, and as it cannot be drained artificially without prohibitive expense, it is used mainly for pasture and native hay. All virgin areas support a luxuriant growth of grasses and have considerable timber near the stream channels.

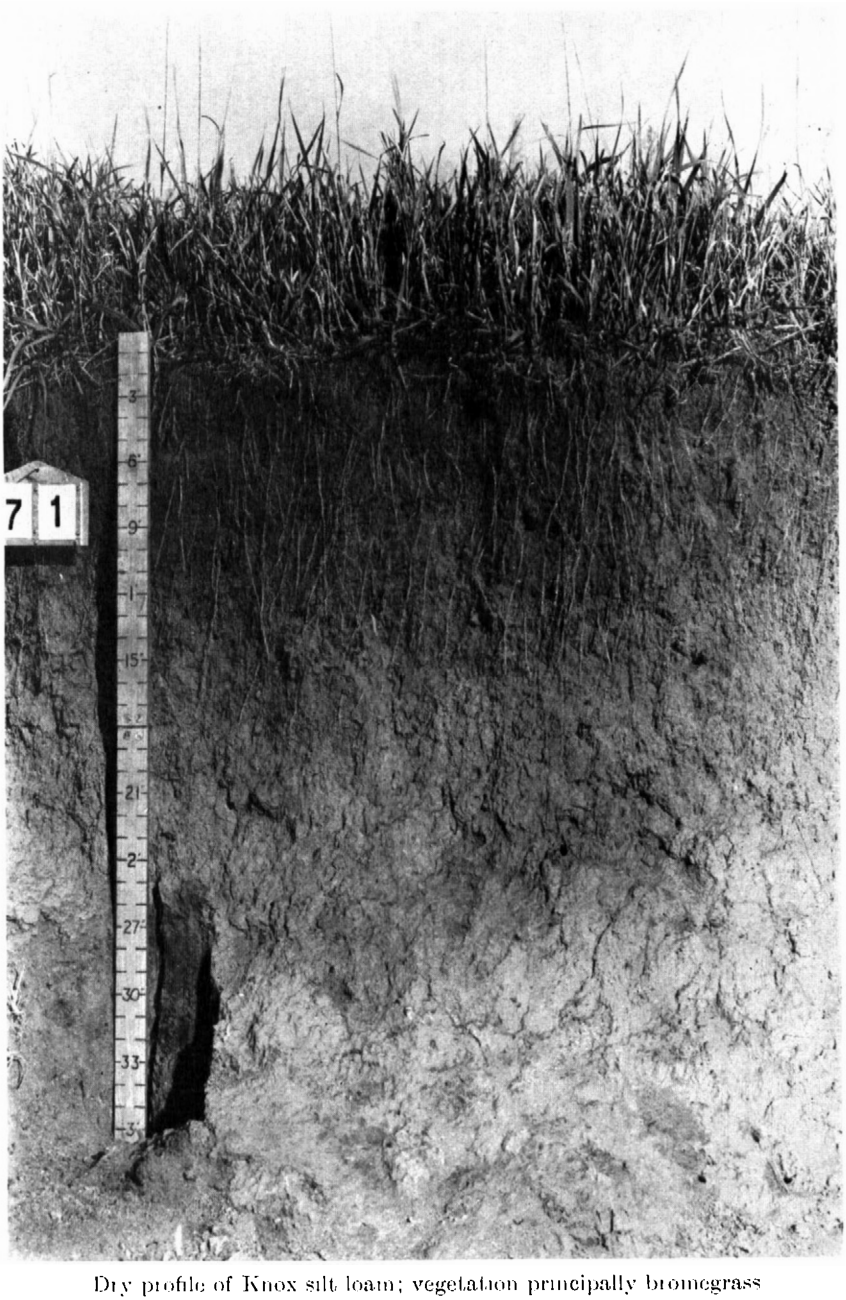
Lamoure silty clay.—The soil occupies nearly level poorly drained depressions on the broad bottoms along the major streams, where it is subject to considerable overflow. In places it is artificially drained, but most of it is too wet for economical artificial drainage because the water table is within a depth of 4 feet.

The surface soil is almost black heavy silty clay to a depth of about 12 inches. The rest of the soil consists of alternating layers of dark-gray and light-gray or gray silty clay or clay and is more massive than the layer above but has no claypan characteristics. It contains numerous gray, yellow, brown, and dark-brown streaks, spots, and splotches, indicating poor internal drainage. The soil is limy. In places there is enough sodium chloride, sodium sulfate, and sodium carbonate in the 12-inch surface layer to be injurious to vegetation, but areas containing these saline materials are of such small extent and minor agricultural importance that their separation on the soil map is not feasible.

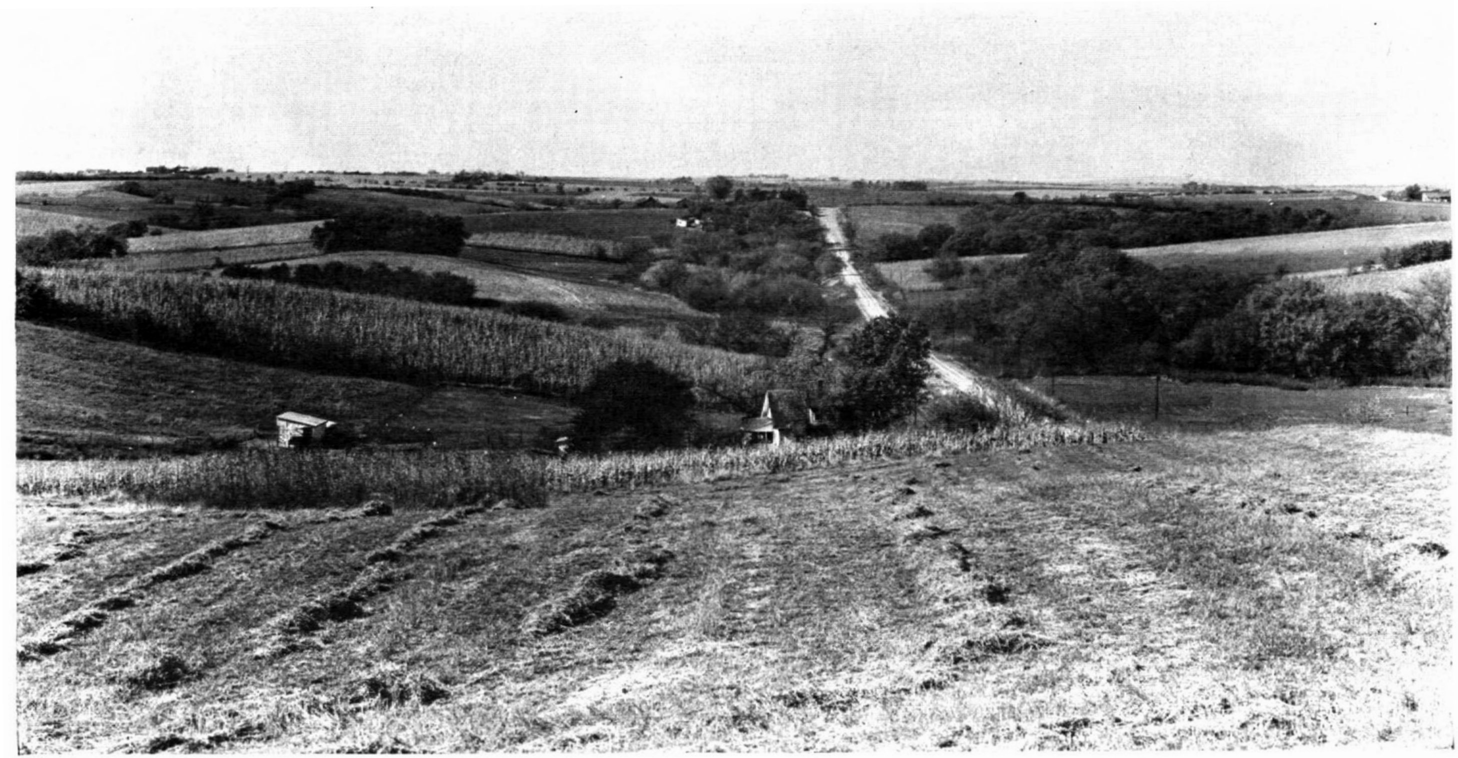
Where adequately drained the soil is as well suited as any of the Wabash soils to all crops common to the area, but most of it is too wet for cultivation and should remain in pasture or native hay meadow. Most virgin areas support thick stands of tall nutritious grasses, which provide excellent pasture or hay.

MADE LAND

Made land consists chiefly of refuse from quarries and occurs in the vicinity of the larger rock quarries and the brick and tile factory



Dry profile of Knox silt loam; vegetation principally bromegrass



Knox and Marshall soils southeast of Nebraska City. Crop pattern includes corn, winter wheat, alfalfa (windrows in foreground); erosion is active on light-colored ridge crests at right center.

at Nebraska City. Only the larger areas are indicated on the soil map, and even some of these had to be somewhat enlarged to be clearly discernible. As a result, the area shown on the map includes not only the refuse from the quarry but also a large part of the quarry itself.

MARSHALL SERIES

The Marshall series includes deep dark-colored friable silty Prairie soils developed in deep silty loess, more silty and less clayey than in Sharpsburg soils. During and following rainstorms runoff water is excessive only on the more steeply sloping areas, but on these, sheet and gully erosion are constant sources of trouble to the farmer.

These soils are more fertile and productive than any other extensive soils of the uplands except possibly the Sharpsburg, and practically all are cultivated. They are high in organic matter and plant nutrients, absorb and hold a large quantity of water for the use of plants, and are easy to till. Corn and most other crops common to the area produce consistently high yields on them. Marshall silt loam and its level, rolling, and eroded rolling phases are the only members of the series mapped.

Marshall silt loam.—This soil occurs in the eastern third of Otoe County. Slope gradients normally range from 2 to 5 percent, and external and internal drainage are excellent. Runoff is not sufficiently rapid in most places to cause severe erosion, but a small quantity of soil is lost in every heavy rain.

The surface layer is finely granular friable porous silt loam 10 to 18 inches thick and brown to dark grayish brown when dry. In plowed fields the uppermost 6 inches is slightly lighter colored, but considerably darker when wet. The subsoil to depths of 30 to 40 inches is brown friable granular light-textured silty clay loam and this grades into light yellowish-brown friable massive silt loam at depths up to about 70 inches. At greater depths, the soil material is pale-brown massive porous friable silt loam loess mottled with light gray and dark brown. The depth of the loess varies from about 10 to more than 30 feet. In places it contains silty carbonate of lime at 8 or 10 feet below the surface.

The soil is developed in loess of about the same geologic age as that in which Sharpsburg soils have developed, but in most places the clay content of the loess is lower than that beneath the Sharpsburg. Areas of this soil grade almost imperceptibly into those of Sharpsburg silty clay loam, and therefore the boundaries shown on the map between the two represent approximately the middle of the transition zone separating them. Small areas of each soil are probably included on the map with larger areas of the other.

Marshall silt loam is productive of all crops commonly grown in the area. It is the best soil of any considerable area on the uplands for corn, and it will also produce good yields of oats, wheat, alfalfa, and clover (pl. 2, *B* and *C*). Tree and cane fruits do well on northerly slopes (pl. 5, *A*). In most years the soil will supply enough plant nutrients to balance available moisture and so produce maximum yields. In years when the moisture is higher than average, however, some response can be expected from the application of commercial fertilizer high in nitrogen and phosphorus. Under the best of conditions corn yields 70 to 80 bushels an acre, but the average under good management probably approximates 43 bushels. Alfalfa can be expected to produce about 5,000 pounds an acre.

Although runoff is not rapid, some erosion is taking place, and the loss will be reflected eventually in decreased crop yields and the formation of gullies. Some are already beginning to appear on the edges of areas of this soil adjoining steeper areas below, and these are eating their way back into the gently sloping uplands. In many places, however, decreased yields and gullying can be forestalled by contour cultivation and planting grass on the natural waterways that lead to the lowlands. Terraces are recommended only for diverting water from the lower parts of the fields to grassed waterways. Terraces cause runoff water to collect, and if they become clogged with snow or wind-drifted soil, the water is likely to break over and make deep gullies in the land below.[7]

Marshall silt loam, level phase.—This phase consists of only a few small areas on level ridge tops in the eastern part of the county. Slopes range from nearly level to 2 percent. This phase differs from the normal phase in having a slightly thicker and darker colored surface layer, a somewhat duller colored and slightly more clayey subsoil, and less slope. Very little water runs off during rainstorms, and therefore the soil usually provides more moisture for plants.

This level phase is slightly more productive of all crops than the normal phase. Corn yields are only slightly lower than on Wabash and Bremer soils of the bottom lands.

Marshall silt loam, rolling phase.—This soil occurs on rolling land with slope gradients of 5 to 8 percent. Runoff from clean-cultivated areas is rapid, and the soil is subject to noticeable erosion following heavy rains. At the time the survey was made, however, erosion had caused only a few shallow gullies and required the reworking of only a small part of the surface soil.

Practically all of this soil is cultivated periodically, but its maintenance with a minimum of loss from erosion and consequent reduction in crop yields requires contour cultivation, diversion terraces, production of close-growing crops, and other conservation practices. Erosion is already noticeable. Terracing entire fields is not recommended, for the same reasons that make the practice inadvisable for the normal phase. Attention also should be given to the maintenance of soil fertility, which can be accomplished through use of stable manure, green manure, commercial fertilizer, and crop rotation.

Marshall silt loam, eroded rolling phase.—This soil is in the eastern part of the county on slopes of 5 to 8 percent and is subject to severe erosion. It has been cut by deep gullies, many of which cannot be crossed with heavy farm machinery, and in addition, sheet erosion removes much of the rich dark-brown surface soil and exposes the somewhat less fertile subsoil.

This phase, almost all of which is under cultivation, is used for the same crops as are grown on the normal phase, but with consider-

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[7] COLLINS, W. PRESENT STATUS OF THE TECHNIQUES OF ABSORBING WATER INTO THE LAND. *In* Proceedings of the Meetings of the Northern Great Plains Advisory Council, Silver Lake, S. Dak., pp. 44–55, 1945. [Processed.]

ably reduced yields, especially of corn. Complex practices are needed to repair the damage caused by erosion and to keep future erosion at a minimum. In many fields it is advisable to fill deep gullies by using bulldozers, and to plant the natural waterways with grass. Diversion terraces at the top and bottom of slopes will divert water to grassed waterways, but terracing whole fields should be avoided. Special attention should be given to the use of close-growing crops to hold the soil and to the use of manure and commercial fertilizer.

NUCKOLLS SERIES

The soils of the Nuckolls series are developed in Loveland loess as small areas or narrow strips, commonly on the lower part of rather steep slopes. They are well to excessively drained, and erosion has exposed either the Loveland loess or a formerly buried surface soil that developed before the Peorian loess was deposited. The brown or reddish-brown subsoil and substrata distinguish them from other soils on the loessal uplands.

The surface layer is usually a trifle darker and a little thicker than that of most Knox soils. Ordinarily, it is dark grayish-brown or dark-brown fine-crumb or imperfectly granular clay loam to depths of 4 to 10 inches. The reaction may be neutral or mildly alkaline. The subsoil, where developed, is imperfectly formed and usually is brown or light reddish-brown moderately friable sandy clay loam about 6 to 8 inches thick. It has fine cloddy or nutlike structure and may be mildly alkaline or calcareous. The parent Loveland loess, a friable or moderately friable light reddish-brown silt loam or silty clay loam with a slightly gritty feel, usually is mildly alkaline. In most places this loess merges with the underlying Kansan drift at depths of 2 to 5 feet.

The Nuckolls soils are moderately well supplied with plant nutrients and have a rather high water-holding capacity, but their sloping surface subjects them to considerable loss of moisture through runoff. Ordinarily they are about 15 percent less productive than most Sharpsburg soils. Accelerated water erosion has damaged them to a greater or less extent. For optimum yields, they will require more care in controlling runoff than most Marshall soils. They are best suited to pasture land. Nuckolls clay loam and Nuckolls-Carrington clay loams are mapped.

Nuckolls clay loam.—This soil, developed in reddish-brown Loveland loess, occurs in small areas and narrow strips on the lower part of rather steep slopes. The gradient may vary above or below the usual 5 and 10 percent, but not in areas extensive enough to warrant separate recognition. In most places runoff is rapid and water erosion is more or less severe. Gullies are numerous and some cannot be crossed with heavy farm machinery. Internal drainage is medium but thorough.

The surface soil is very dark-brown or dark-brown friable clay loam 6 inches thick and moderately rich in organic matter but does not react noticeably to dilute hydrochloric acid. The subsoil to a depth of about 14 inches is reddish-brown moderately compact but friable silty clay loam and mildly alkaline. Below this depth is light reddish-brown Loveland loess. Both the subsoil and parent loess contain enough fine sand to give them a slightly gritty feel. Except in the immediate vicinity of widely scattered lime concretions the parent loess is noncalcareous. It merges abruptly with glacial drift about 3 or 4 feet below the surface.

Aside from slight differences in relief, the principal variations are in color, texture, and depth of surface layer. On the steeper slopes, where runoff is rapid and erosion has been rather severe, the surface soil may be less than 3 or 4 inches deep and light brown. The parent loess is exposed near some of the gullies, but the eroded soil is not extensive enough to warrant recognition of eroded phases. Where the Loveland deposit is shallow over the glacial drift, enough sand, small stones, and pebbles have become mixed with the loessal material to give the surface soil a pronounced gritty feel and to class it as sandy clay loam. None of these variations, however, is sufficient to effect noticeably the agricultural value of the land.

The soil is easily tilled, moderately well supplied with plant nutrients, and rather high in water-holding capacity, but its runoff causes considerable loss of moisture and it is about 15 percent less productive than Sharpsburg silty clay loam. To obtain optimum yields, more care is required to control runoff than on Sharpsburg and Marshall soils. Many deeply entrenched gullies make farming difficult; most areas are best suited to pasture.

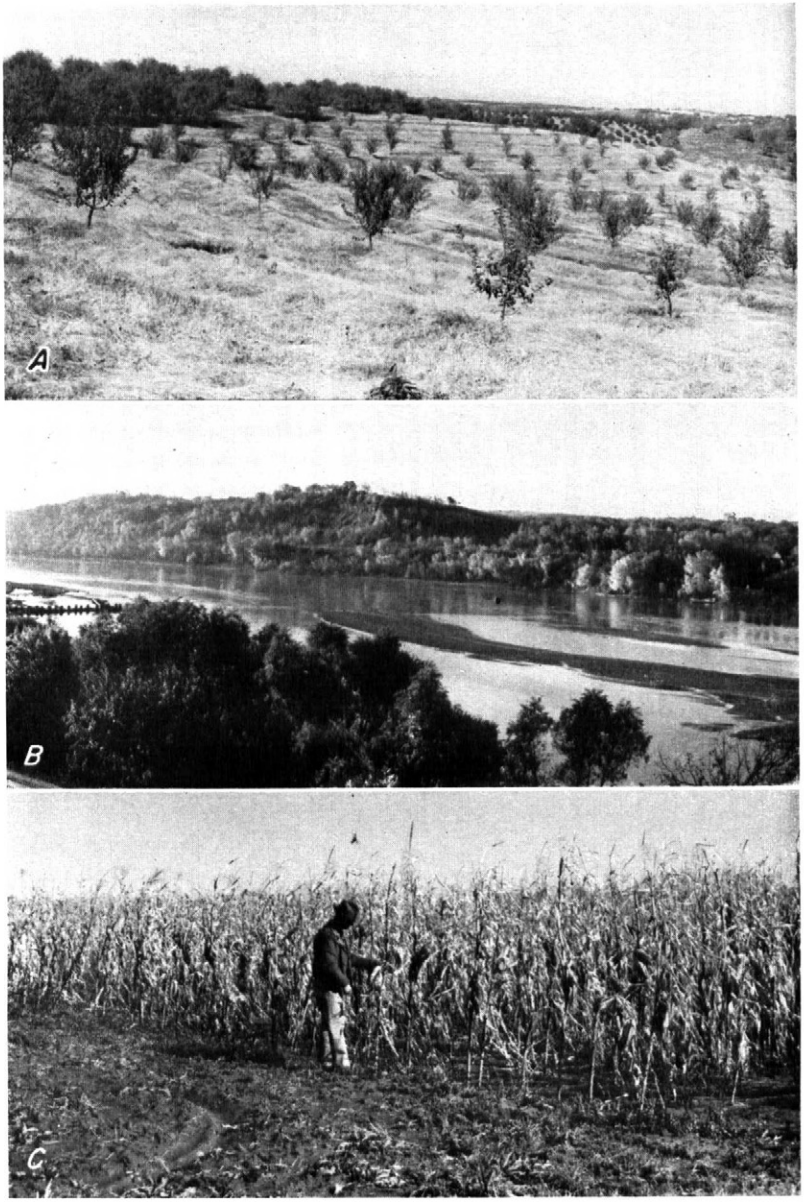
Nuckolls-Carrington clay loams.—The Nuckolls and Carrington clay loams, which make up this complex, are too intricately associated to permit separate delineation on a map of the scale used.

Over most areas of this complex, relief and drainage conditions are similar to those of Nuckolls clay loam and the profile features resemble either one or the other of the soils of the two series. In a number of places, however, the profiles have characteristics resembling both Nuckolls and Carrington soils. Where the Loveland loess deposit is shallow the surface soil and the upper part of the subsoil is like Nuckolls, except for numerous sand grains, small stones, and pebbles; whereas the lower part of the profile consists of reddish-brown noncalcareous moderately heavy drift. In other places the soil definitely is developed in glacial drift and is almost identical with Carrington clay loam, except for its pronounced reddish-brown color, which is typical of Loveland loess or Nuckolls soil material. The presence of drift material—sand grains, small stones, and pebbles—in the shallow loess deposits probably is attributable to erosion, tillage operations, or the activity of rodents.

Cropping practices, use capability, and management requirements for the soils of this complex are much like those for Nuckolls clay loam. Many small areas better suited to pasture, hay, or woodland are cultivated.

PAWNEE SERIES

The Pawnee soil, represented by the clay loam only, occurs on undulating to gently rolling areas of heavy glacial drift, chiefly in the western part of the county. It differs from soils of the Crete series mainly in having a little sand and gravel and considerably more clay throughout the profile and a substratum of drift instead of loess. As a whole it occupies slightly less even relief than the Crete soils. External drainage is good; internal drainage, poor. Drainageways are



A, Young apple trees on terraced slopes of Marshall silt loam (slopes face north in foreground, east in center), older plantings along crest of hill at left on Sharpsburg silty clay loam, rolling phase, and Carrington loam, rolling phase.
B, The Missouri River from Iowa side, just opposite Nebraska City, sand bars (Riverwash) in stream channel at center right; part of a jetty at left; loess bluffs of Hamburg silt loam form stream banks in background
C, Corn on Sarpy fine sandy loam on the Missouri River bottom lands, this soil represents first stage of development from sandy riverwash.

A, Farmstead in area of Sharpsburg soils.
B, Winter wheat in foreground on Sharpsburg silty clay loam.
C, Alfalfa in foreground and corn in background, all on Sharpsburg silty clay loam.

more pronounced than in most areas of Crete soils, and in places the soil is deeply gullied.

The soil has a dark grayish-brown or almost black granular and friable surface layer 8 to 15 inches thick, underlain by a slightly lighter colored silty subsurface layer 1 to 3 inches thick. The surface soil merges abruptly with the upper part of the subsoil, which consists of brown, dark brown, or almost black heavy dense clay 10 to 20 inches thick. The upper subsoil, or claypan, merges gradually with light grayish-brown relatively friable highly calcareous clay loam or sandy clay of the lower subsoil layer. This layer rests on parent drift similar to that underlying Carrington soils. It is much heavier than the upper subsoil underlying any of the other drift-derived soils.

The Pawnee soil has about the same crop adaptations as the Crete, but is a little less productive because there is a greater loss of moisture over its slightly rougher terrain.

Pawnee clay loam.—This soil is on undulating to gently sloping glacial uplands, chiefly in the western part of the county. The soil occupies small widely scattered tracts, where most slopes range from 5 to 8 percent. Surface drainage is everywhere thorough, and in places on the steeper slopes runoff is rapid enough to cause considerable erosion. Drainageways are numerous and some are gullied, but nearly all can be crossed at some points with any type of farm machinery. Internal drainage is negligible beause of the almost impervious subsoil.

This soil differs from Burchard or Carrington clay loams mainly in having a much more clayey and compact upper subsoil, but the lower subsoil differs from that of the Carrington soils in being limy. In most of its profile features this soil resembles Crete silty clay loam, but it has less silt, more sand, and more gravel and clay throughout the soil profile, and its substratum is rather heavy glacial drift instead of the floury loess of the Crete soil.

The surface layer is dark grayish-brown or almost black friable granular clay loam or silty clay loam 8 to 12 inches thick. In many places the basal 2- or 3-inch part of the layer is light-colored or gray and more or less leached of organic matter. The upper part of the subsoil consists of brown, grayish-brown, or black dense massive clay containing enough sand to give it a decidedly gritty feel. This claypan layer is 10 to 14 inches thick and is almost impervious to moisture and greatly restricts air and root penetration. The transition between the friable surface soil and the dense claypan is abrupt. The lower part of the subsoil is light-brown or yellowish-brown moderately compact gritty clay loam containing numerous small hard lime concretions and mottlings of gray and dark brown. At a depth of 30 or 40 inches it merges with glacial drift similar to that beneath the Carrington soils. The upper part of the drift is not commonly calcareous. In all areas of the soil, gravel, pebbles, and an occasional boulder occur on the surface as well as in any part of the soil or the parent drift.

The principal variation in this soil occurs on slopes, where it is in close association with one or another of the Crete soils. In places the Crete and Pawnee soils are difficult to distinguish, and it is necessary to draw arbitrary lines to separate them on the map. Many small areas of Crete silty clay loam too small and unimportant agriculturally to justify separate recognition are included with this soil.

Most of this Pawnee soil is used for the crops common to the area. Corn occupies the largest acreage, and in most years oats, wheat, and alfalfa follow in the order named. The soil contains the essential plant nutrients and is as well adapted to each of the various crops as Crete silty clay loam, but its greater loss of moisture through runoff reduces the yields of most crops about 5 percent. Alfalfa and sweetclover do about equally well on the two soils. Although active in places, water erosion has not been sufficient to cause any serious reduction in yields. The soil, however, is considered a little more difficult to manage than Crete silty clay loam, mainly because of its greater slope. The control of runoff necessary to conserve the supplies of moisture and organic matter requisite for optimum yields is more difficult to obtain on this soil than on the Crete. Other management requirements for maximum production include contour farming, strip cropping, and keeping the land in legumes and small grains at least two-thirds of the time.

PLATTSMOUTH SERIES

The Plattsmouth series includes light-colored calcareous imperfectly drained soils on the fine-textured or only slightly sandy alluvium that occurs chiefly on the Missouri River flood plain. These soils differ from the Lamoure in having a lighter colored surface layer and from the Barney mainly in being finer textured, especially in the substratum. They lie nearly level, but the slope usually is sufficient to carry off all surplus surface water soon after the streams recede. Most of the soils are excessively wet for a part or all of the year because the water table is commonly only 3 feet down and during wet seasons may rise to the surface.

The 6- to 8-inch surface layer consists of grayish-brown silt loam or fine sandy loam, underlain by a 4-inch layer of grayish-brown or light grayish-brown coherent loam or sandy clay loam. Alternating layers of fine- and coarse-textured light- and dark-colored sedimentary materials commonly are below a 12-inch depth. The lighter colored finer textured materials predominate. Both the surface soil and the underlying material commonly are calcareous but do not contain enough salt to prevent the growth of vegetation.

The Plattsmouth soils are used to a greater or less extent for corn but mainly for tame hay and pasture grasses. Owing to the coarser texture of the surface soil, they are more easily cultivated in normal seasons than any of the other more poorly drained soils occupying similar positions. They are less productive of corn than any of the darker colored soils on the bottom lands, chiefly because of their lower organic content, and are not considered very desirable for cultivation. Alfalfa and sweetclover do about as well as on any of the alluvial soils except during wet seasons, when all cultivated crops on poorly drained soils are injured by excessive moisture.

Uncultivated areas support a luxuriant growth of coarse grasses and forbs and numerous small cottonwood and willow trees and are used mainly for pasture. The better drained parts of these areas, where properly managed, make very desirable hay land. Plattsmouth silt loam and fine sandy loam are mapped.

Plattsmouth silt loam.—This soil is most typical of the Plattsmouth series. It is developing on light-colored silty alluvium, some of which washed from areas outside the county, that has been deposited chiefly on the Missouri River flood plain. The relief is nearly level, and both surface and internal drainage are slow.

The surface soil varies slightly in color, texture, and depth, but it is usually grayish-brown silt loam to a depth of 6 to 8 inches. Underlying the surface soil and continuing to a depth of 30 inches are alternating layers of grayish-brown or light grayish-brown loam, silty clay loam, or sandy clay loam. Lower layers vary considerably in color, texture, and thickness, but the materials are predominantly fine and light-colored. Rust-brown, brown, and yellow mottlings, indicative of poor internal drainage, are numerous in all parts of the soil below the surface layer. The soil is calcareous and low in organic matter.

Much of the soil is used for corn, alfalfa, and sweetclover, but as with most Plattsmouth soils and the most poorly drained alluvial soils, even these crops are more or less uncertain in any except the seasons offering ideal growing conditions. The soil supports luxuriant growths of native lowland grasses and is best suited for use as pasture land or wild hay meadow.

Plattsmouth fine sandy loam.—This soil is differentiated from the silt loam by the quantity of fine sand in the surface layer. Conditions of relief, drainage, and development are typical of other soils of the Plattsmouth series.

To a depth of about 8 inches the soil consists of grayish-brown or light grayish-brown fine sandy loam or very fine sandy loam, the fine sandy loam predominating. The rest of the profile does not differ materially from that of the silt loam, though the subsurface layer may be a little more sandy in places. The color and texture of the surface layer depend mainly on the organic-matter content. All layers are calcareous.

The soil is used in much the same manner as the silt loam. It can ordinarily be worked under a slightly wider range of moisture conditions and absorbs water a little faster than the finer textured soil, but owing to the generally wet condition of its subsurface layer it is no more productive and is not considered very desirable for cultivation. During the driest years the water table commonly remains within 3 feet of the surface; in wet seasons it is within a few inches of the surface for long periods. The soil supports a fair grass cover and numerous forbs and shrubs or small trees. It is best suited to wild hay and pasture grasses or to such trees as can be used for fence posts and fuel.

RIVERWASH

Riverwash consists of sand bars, islands, and flats adjacent to and within the channels of the Missouri River (pl. 5, *B*). It represents the first stages in the formation of an alluvial soil, and with the gradual accumulation of organic matter it may ultimately develop into soil. Areas of this material are very unstable, as they lie only a few inches above the normal level of the water and their boundaries change with each rise and fall of the streams. Even during normal flow the material is shifted about, added to, or carried away by changes in the course of the current. In places it has a thin surface layer of organic matter. Its texture ranges from clay to coarse gravel. Only the larger areas are shown on the soil map. Most of the Riverwash supports a fairly dense growth of small willows but practically no grass. The greater part of it is included in pastures, but it is regarded by most farmers as wasteland.

ROKEBY SERIES

The only soil of the Rokeby series, a silty clay loam, is made up of some of the heaviest terrace soils in the State. It occupies nearly level to gently undulating high and low terraces in positions similar to those of the Waukesha soil. It differs from soils of the Butler series, which are on the uplands, only in position, and from the Waukesha soil mainly in having a claypan and a layer of lime enrichment in the upper and lower parts of the subsoil, respectively, and is stone-free and fine-textured throughout. Although internal drainage is slow because of the heavy subsoil, it is everywhere adequate for the production of cultivated crops. Erosion is negligible.

The soil is characterized by a very dark grayish-brown or almost black finely granular and friable silty clay loam surface layer 10 to 18 inches thick, underlain by a lighter colored but otherwise similar subsurface layer about 4 inches thick, from which a part of the organic matter has been leached. The subsurface layer rests abruptly on dark-brown or almost black dense massive clay forming a claypan 8 to 20 inches thick. The claypan gradually gives way to the lower subsoil layer, a pale-brown or light-gray friable or moderately friable silty clay containing lime, chiefly in the form of small hard concretions. Parent silty loesslike material similar to that beneath the Waukesha soil is about 4 feet below the surface; it usually is not limy enough to react with dilute hydrochloric acid.

This soil is used for growing the principal crops of the area. Because of the greater supply of moisture on the terraces, most crops ordinarily yield better on this soil than on the Butler soils of the uplands. The yields are lower than those obtained on the well-drained Waukesha, however, which has no claypan and is usually better supplied with moisture. The claypan in the Rokeby soil does not allow water to penetrate deeply, hence most of the moisture readily available for plants must be supplied by the surface soil, which is not thick enough to supply the plants during periods of prolonged drought. In seasons of normal or above-normal precipitation, however, the Rokeby soil is almost as productive as the more friable soils of the terraces. Erosion damage has been slight. Variations in relief and in surface soil texture are negligible.

Rokeby silty clay loam.—Areas of this soil are on the more nearly level parts of both high and low terraces, or benches, commonly in places of less than 2-percent slope. The soil is most extensive on the higher loess-capped terraces. Surface drainage is slow but adequate in most places. Internal drainage is very slow because of the almost impervious layer in the subsoil. In places the soil occupies slight depressions and rather poorly drained sags within larger areas of Waukesha silty clay loam, but none of it is too wet for cultivation. It loses little moisture through runoff and has not been damaged appreciably by erosion.

On the higher terraces, this soil is almost identical with Butler silty clay loam of the uplands. It differs from Waukesha silty clay loam chiefly in having a claypan in the upper part of the subsoil and a layer of lime enrichment in the lower part. The surface layer is very dark grayish-brown finely granular silty clay loam about 16 inches deep. It contains enough organic matter to be mellow and to facilitate moderately rapid moisture absorption. Ordinarily the lower 2 to 4 inches of the layer is noticeably lighter colored than the rest because part of the organic matter has been lost through leaching.

The upper subsoil layer, or claypan, contacts the surface soil abruptly and consists of dark grayish-brown compact clay 10 to 16 inches thick. The lower part of the subsoil is grayish-brown friable or only moderately compact clay loam containing scattered small hard lime concretions. This layer continues to a depth of about 48 inches, where it merges with the parent Peorian loess. As is true for Waukesha silty clay loam, the lower subsoil of this type is darker on the lower terraces than on the high. The parent material commonly is not calcareous.

The soil is high in plant nutrients and can stand severe cropping over long periods without serious reduction in yields. It is easily cultivated, and practically all of it is used for growing the crops common to the area. The yields are a trifle higher than on Butler silty clay loam because moisture conditions are more favorable on the terraces, but they average about 10 percent lower than those obtained on Waukesha silty clay loam. The claypan restricts deep root development, and the surface soil is unable to store enough moisture to sustain crops during prolonged drought. As on all imperfectly drained soils, small grains do better than corn. Alfalfa does about as well on this soil as on the more friable ones of the uplands and terraces because its roots are able to penetrate the claypan and obtain the deeper seated moisture.

This soil is easily cultivated, and in most places it has sufficient slope to carry off surplus water. It cannot be worked so early in spring or so soon after heavy rains as the more friable soils, because of the relative impermeability of the subsoil. During seasons of normal or above-normal precipitation the yields of most crops are almost as high as are obtained on Waukesha silty clay loam.

SARPY SERIES

Sarpy soils occur in light-colored sandy and gravelly sedimentary materials washed mainly from areas outside the county to the north and west, chiefly on the broad bottom lands nearest the Missouri River. They differ from the Cass soils mainly in having a lighter colored surface layer; from the Barney in having little lime carbonate; and from the Plattsmouth in having a coarser textured less calcareous substratum. They lie nearly level and are subject to frequent overflow, but their loose consistence gives good to excessive drainage. The water table commonly is within 3 to 6 feet of the surface.

These soils represent early stages of soil development in light-colored sandy alluvium. In most places they consist of grayish-brown loose and incoherent or only slightly coherent sand, fine sand, or loamy fine sand to a depth of about 6 inches. Beneath this to indefinite depths are alternating layers of light grayish-brown or light-gray loose in coherent fine and coarse sand or gravel of various grades. Rust-brown stains, streaks, and splotches are common below a 30-inch depth. Both the soils and soil materials may be slightly calcareous, but commonly they are not. The color and texture of the surface layer depend mainly on the content of organic matter.

Sarpy soils absorb water readily, warm early in spring, and are easily cultivated under a wide range of moisture conditions. Owing to their unstable character and low organic-matter content, they are not very productive of most cultivated crops. Nevertheless, they are used to a more or less limited extent for corn, alfalfa, sweetclover, and vegetables. In seasons when growing conditions are ideal they produce fairly profitable yields of these crops, especially where plenty of farmyard manure is applied. During dry years, however, either the seed fails to germinate as a result of a lack of moisture in the porous sandy surface soil or the young crop plants are destroyed by shifting wind-blown sands. Furthermore, as the soils lie only a few feet above the normal level of the river, they are subject to short but frequent intervals of overflow during which crops are often ruined.

Most areas of these soils are uncultivated and support a thin stand of coarse grasses and small native trees. They are used mainly for pasture and hay land, but the grasses provide only a limited stand of pasture or hay. Sarpy fine sandy loam, fine sand, and loamy fine sand are mapped.

Sarpy fine sandy loam.—This soil is the most fully developed, extensive, and typical of the Sarpy series. It has accumulated only a small quantity of organic matter but enough to make the surface layer moderately coherent light-brown or grayish-brown fine sandy loam or in some places sandy loam. The rest of the soil material consists mainly of loose incoherent light-gray sand similar to that in other Sarpy soils. The sand contains rust-brown spots, streaks, and splotches below a depth of 2 feet and occasional thin seams of fine or moderately coarse gravel below 3 feet. As a rule the soil material is not calcareous.

All of this soil lies only a few feet above normal stream levels. It is subject to frequent overflow but drains readily and is used to a greater or less extent for corn (pl. 5, *C*), alfalfa, and sweetclover. As on all light-colored sandy soils on the bottom lands, crop yields vary greatly, partly with differences in the organic content of the soil and partly with seasonal differences in precipitation. The precipitation determines not only damage done by floods but also the moisture condition of the surface layer at planting time. Deep-rooted leguminous crops do nearly as well as on the dark sandy soils occupying similar positions, provided a good stand is obtained. Truck and garden crops yield profitably, especially where liberal quantities of barnyard manure are applied. Much of the soil is used for grazing. It produces a fair growth of native grasses and numerous forbs and shrubs if not grazed too heavily.

Sarpy fine sand.—This is the most extensive soil of the series, and it differs from the fine sandy loam chiefly in having less coherent silty material in the upper part. It represents the first stages of soil development on sandy noncalcareous alluvium. To a depth of about 6 inches the soil consists of very light grayish-brown slightly weathered fine sand. Either the soil has not accumulated enough organic matter to darken noticeably its surface layer or it has lost a considerable part of that layer through wind erosion. In many places the surface layer does not differ appreciably from the underlying strata, which consist of alternating layers of fine and coarse gray sand to indefinite depths. The substratum commonly contains mottlings below 2 feet. In places, seams of fine and moderately coarse gravel occur below 3 or 4 feet.

Owing to its low organic content and sandy unstable character, practically all the soil is used for woodland, grazing, or hay. It supports thin stands of tall coarse grasses, numerous small cottonwood and willow trees, and many shrubs and forbs. The trees are of local value for posts and fuel, and the grasses provide rather limited pasture and hay. Owing to the unstable character of the soil, much care must be taken in managing the pastures if a protective sod cover is to be maintained.

Sarpy loamy fine sand.—This soil is intermediate in character between the fine sand and the fine sandy loam. In some places it includes small areas where both these soils are so intricately associated that their separate delineation is impracticable. In most places, however, it contains only enough organic matter to make it a grayish-brown or light grayish-brown loamy fine sand. The surface soil contains a little more silty material and is a little more coherent than the coarse-textured fine sand and is less stable than the fine sandy loam. The rest of the soil is typical of the Sarpy series.

The present use, use capability, and management requirements are about the same as those for the fine sand, though possibly this soil can be planted to truck and garden crops, uses to which the coarser textured soil is only poorly suited. It responds favorably to generous applications of manure, and if such practice is followed regularly, this soil probably can be made as productive as the darker colored sandy soils on bottom lands that have similar relief and drainage.

SHARPSBURG SERIES

The soils of the Sharpsburg series are maturely developed in silty stone-free Peorian loess. The most extensive of any soils in the county, they occupy the greater part of the undulating and gently rolling uplands. They have good drainage and excellent tilth.

The surface layer—deep dark silty clay loam—contains an abundance of organic matter and has a highly developed finely granular structure. As a rule this layer is a trifle deeper and a little darker than that of most of the other upland soils. The thick and well oxidized subsoil contains a little more clay than the surface soil but is friable throughout when dry or moist. The upper part, next to the surface soil, is dark brown, and the color gradually becomes lighter with depth. It merges with the parent Peorian loess about 3 feet below the surface. The loess, a floury mottled light-gray and dark-brown wind-deposited silt loam, exceeds 6 feet in depth in most places, and throughout many of the Sharpsburg soil areas it is more than 10 feet deep. Neither the surface soil nor the subsoil react noticeably to dilute hydrochloric acid; the loess usually does not contain free lime, but there are places where lime appears in the form of concretions.

Practically all the Sharpsburg soils are cultivated (pl. 6, *A*). They are more productive of all crops common to the area than any of the important upland soils except the Marshall. They are high in plant nutrients, have a high water-holding capacity, absorb and release moisture fairly readily, and are easily managed, provided reasonable care is taken to control erosion and conserve moisture. Owing to surface irregularity and the moderately heavy texture of the surface layer, they are subject to considerable loss of moisture through runoff, especially during heavy rains; but normally runoff is not rapid, and in most places the soils have not been damaged seriously by water erosion.

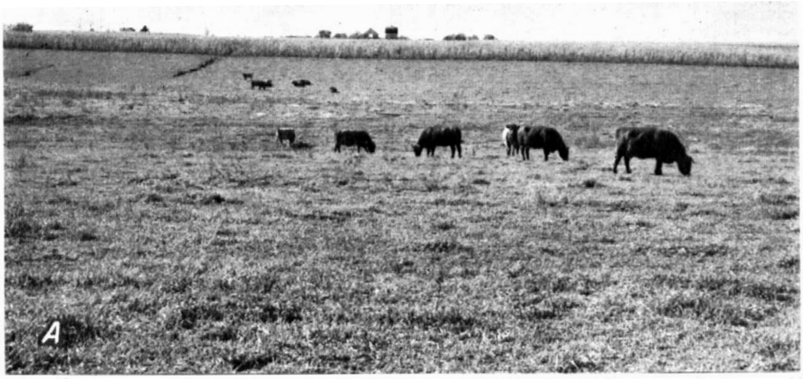
The yields of all crops are determined mainly by the quantity and distribution of precipitation. Under conditions of equal precipitation, similar farming practices, and comparable erosion, yields on the Sharpsburg soils vary chiefly with differences in the degree of slope. The slope in large measure determines the quantity of water that will be available to the crop plants. Variations in the surface texture are negligible and are not sufficient to affect noticeably the agricultural value of the land. In a few places on the steeper slopes enough surface soil has been removed through erosion to reduce the crop yields. The Sharpsburg soils are mapped as Sharpsburg silty clay loam and its level, rolling, and eroded rolling phases.

Sharpsburg silty clay loam.—This is the most extensive soil in the county and occurs on nearly all parts of the loessal uplands, chiefly and typically on slopes of 2 to 5 percent. In places the slopes are a little more or less than this, but where the variations occur over a significant acreage, either a level phase or a rolling phase of the type is shown on the map. The soil has excellent surface and internal drainage. Except locally, runoff has not been rapid enough to cause much erosion.

The surface layer, of mellow fine-granular silty clay loam, contains an abundance of organic matter and works easily under a fairly wide range of moisture conditions. It is dark grayish brown when dry and almost black when wet. Normally it is 12 to 16 inches thick, but in some places its depth has been reduced slightly by erosion. A few short, shallow gullies have developed in several areas.

The upper part of the subsoil is dark-brown moderately compact but granular or fine blocky silty clay loam that contains more clay and is a trifle heavier than the layer above. It is friable and easily penetrated by air, roots, and moisture. It becomes gradually lighter in color and more silty with depth and in the lower part consists of friable brown or yellowish-brown silty clay loam. At 30 to 36 inches below the surface the subsoil gradually merges with slightly altered Peorian loess, a very pale-brown friable but heavy silt loam with mottlings of yellowish brown. Except in localized areas the soil material within a depth of 10 feet does not contain enough lime to produce noticeable effervescence when dilute hydrochloric acid is applied, but the native vegetation and field crops do not indicate serious lime deficiency. Applications of lime, however, will probably increase the yields of alfalfa and clover on some areas.

The principal variations in this soil, aside from slight differences in surface features and in the thickness of the dark surface layer, occur where the soil is in close association with Crete silty clay loam. Here



A, Cattle on bromegrass pasture, Crete-Sharpsburg silty clay loams on slopes leading down to drainageway in center, small gullies on slope at left background, cornfield in background on Butler silty clay loam, house in background on Sharpsburg silty clay loam.

B, Terraced slopes on Sharpsburg silty clay loam, rolling phase, seeded to winter wheat.

C, Bottom lands along west side of the Little Nemaha River. Hereford cattle grazing on bluegrass pasture on Wabash silty clay in foreground, hay meadow on Wabash silty clay in center; corn on Wabash silt loam in background. Trees along the stream course include cottonwood, elm, and ash.

the upper part of the subsoil is similar to the typical soil in color but contains a little more clay and is slightly more compact. The increased compaction is almost negligible as compared with Crete soils. In a few places the surface soil is sandy clay loam. None of these variations have any noticeable effect on the agricultural value of the land.

Although well suited to any crop commonly grown in the county, the soil is used principally for corn, oats, wheat, alfalfa, (pl. 6, *B* and *C*) and clover, and in most years the acreages rank in about the order named. The average yields—slightly higher on the smoother than on the more sloping areas—are a trifle lower than those on the level phase of Marshall silt loam, but are nonetheless among the best obtainable on the uplands.

In seasons of normal or above-normal precipitation many farmers obtain 60 to 70 bushels of corn an acre on this soil. Over a period of years the average acre yield is about 43 bushels. Ordinarily wheat and oats yield about 20 and 30 bushels, respectively. None of the crops other than alfalfa produce so well as on Marshall silt loam in western Iowa, where precipitation is higher.

The cropping and land-management practices used on this soil are in the main similar to those followed elsewhere in eastern Nebraska. The soil is strong and productive and, without serious reduction in yields, it has stood a relatively long period of severe cropping under rather poor management. It has not been damaged appreciably by erosion except locally (pl. 7, *A*). For maximum yields, however, more care is required in controlling runoff and conserving moisture than is necessary on soils of the more level parts of the uplands and terraces. When properly managed the soil will remain indefinitely one of the best for crops on the uplands. A good response is obtained in moist years from applications of fertilizer rich in nitrogen and phosphorus.

Sharpsburg silty clay loam, level phase.—This phase differs from the normal phase mainly in having more even surface features and in being a little more deeply developed. It occurs throughout the well-drained loessal uplands in areas where the slopes do not exceed 2 percent. Many areas too small to justify separate delineation were included in mapping. Although the soil has good drainage, runoff is not rapid enough to cause appreciable erosion.

The surface and subsoil layers are a trifle thicker than in the normal phase, and the surface soil is friable and finely granular to a depth of about 18 inches. The subsoil is similar to that of other Sharpsburg soils in color, structure, and consistence, and it merges with the parent loess at a depth of 40 to 48 inches.

The soil has an abundance of organic matter, is easily penetrated by air, roots, and moisture, and has a high water-holding capacity. Because of gentler slope, water is absorbed a little more readily than in the normal phase. Practically all areas are cultivated.

With the exception of Marshall silt loam, level phase, this is the most highly prized soil on the uplands. Because it is subject to less loss of water through runoff it is slightly better for growing grain crops than the normal phase and considerably better than the rolling phase. It seems to have little or no advantage over either of these soils for alfalfa and sweetclover.

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Sharpsburg silty clay loam, rolling phase.—This phase differs from the normal phase mainly in having less even relief. It dominates the well-drained loessal uplands, where the land surface slopes in many directions. The gradients range between 5 and 10 percent, although in places, as on the top of the lower and more rounded ridges, they may slightly exceed either of these limits. Few slopes, however, exceed 10 percent.

This soil has rather rapid surface drainage but has not been damaged greatly by accelerated water erosion. Gullies are fairly common, but many of them are crossable with any type of farm machinery.

The dark surface soil layer is typical of the normal phase. It is friable, finely ganular, and moderately thick except locally on the steepest slopes and in the vicinity of gullies, where part of it has been removed through erosion. Where enough soil has been removed by erosion to cause distinct differences in characteristics and in productivity over a significant acreage, an eroded rolling phase is mapped. The subsoil is almost identical with the normal phase in color, structure, consistence, and depth. It commonly merges with the parent loess within a 30-inch depth. The surface soil in places is sandy clay loam, but this variation is of minor extent and importance and does not warrant separate recognition.

Nearly all of this soil is cultivated and used for growing the same crops as are produced on other Sharpsburg soils. As proved during seasons of ample precipitation, it contains enough plant nutrients to give high crop yields; but it loses considerable moisture through runoff, and during most years the crop yields average about 10 percent below those obtained on the normal phase. Response can be expected from the use of commercial fertilizer. In many small areas glacial drift underlies the soil at a depth of 4 or 5 feet, and by retarding downward percolation somewhat increases the subsoil moisture supply during certain periods. Such areas are too small to have any except a locally beneficial effect on crops.

The present cropping and land-management practices are much like those on the normal phase (pl. 7, *B*). The rolling soil can be cultivated under a fairly wide range of moisture conditions, but for maximum yields more care in controlling erosion and conserving soil moisture is necessary than on the smoother lying Sharpsburg soils. Where soil- and moisture-conserving practices are followed, including contour farming and strip cropping with legumes, the soil is almost as productive as the normal phase.

Sharpsburg silty clay loam, eroded rolling phase.—This phase differs from the rolling phase mainly in having a thinner surface layer. It has rather rapid external drainage and has been damaged somewhat by accelerated water erosion.

The dark surface soil averages about 4 inches thinner than that of the normal phase, but the rest of the profile is almost identical. Gullies are common, but many of them can be crossed with most types of farm machinery. Severe surface soil thinning occurs only in scattered areas on the steeper slopes and near gullies, but these are rarely larger than 4 or 5 acres.

Nearly all the soil is used for the same kinds of crops as are produced on other Sharpsburg soils. Although considerable organic matter has been eroded from its surface layer, the soil still contains enough plant nutrients to produce fairly good crop yields. Like other soils having similar relief and texture, it loses considerable moisture through runoff and is about 15 percent less productive than the normal phase.

The present cropping and management practices are similar to those on other Sharpsburg soils, but if cultivation of this soil is to continue to be profitable over a long period, greater care must be exercised in controlling erosion and conserving soil moisture than in the past. Where soil- and moisture-conserving practices are followed, including contour farming and strip cropping with legumes, the soil of this phase probably will remain almost as productive as that of the rolling phase.

SOGN SERIES

The only mapped soil of the Sogn series, the stony loam, has developed from residual limestone and limy shale of Permo-Pennsylvanian age. It occupies steeply sloping land, has rapid runoff, and is therefore subject to severe water erosion and to excessive loss of moisture and organic matter.

The surface layer is shallow and varies from almost black to light yellowish gray, the color depending on the organic content. Ordinarily the surface soil contains numerous fragments of partly weathered limestone and enough organic matter to make it loamy and dark grayish brown. The subsoil, where developed enough to be called such, is yellowish-brown silty clay loam. In most places the dark surface soil rests directly on the parent formation within a 6-inch depth. Exposures of the bedrock are numerous.

The Sogn soil is topographically unsuited to cultivation and is used almost entirely for pasture and woodland. It contains enough of the essential nutrients for optimum plant growth, but is subject to such severe loss of moisture through runoff and is so shallow that it is not very productive. Trees and grasses thrive during years of abundant precipitation, but in dry seasons the grasses are considerably injured and produce limited or uncertain pasture.

Sogn stony loam.—This soil, formed from weathered limestone and limy shale, occurs in areas of rugged relief, chiefly in the eastern part of the county. Small widely scattered areas too small to map are included with adjoining areas of more extensive soils. Such small areas are indicated on the soil map, however, by a rock-outcrop symbol. Most of the soil occupies slopes of 10 to 20 percent. Runoff and erosion are everywhere excessive.

The surface layer varies from very dark grayish brown to light yellow, depending upon its organic content. Ordinarily it is dark grayish-brown friable loam or silt loam about 6 inches deep, with many fragments of partly weathered limestone and considerable organic matter. The subsoil, if present, is yellowish-brown silty clay loam, 4 to 8 inches thick. It rarely exceeds this thickness and is in many places absent, the surface layer resting directly on the limestone bedrock. The depth of the soil depends partly on the resistance of the limestone to weathering but mainly on the degree and severity of erosion during and subsequent to its development. The soil material is limy.

The land is not well suited to cultivation, because it is stony and rugged in relief. It is difficult to manage, and cultivated steep slopes are subject to severe losses of organic matter and moisture. Almost all of it is used for pasture and woodland. Grasses grow luxuriantly during seasons of normal or high precipitation and provide excellent pasture, but late in summer, they are commonly injured by drought, and pasture becomes rather limited and uncertain. The soil should have a permanent vegetative cover, which should not be overgrazed. Destruction of sod-forming grasses leads to serious erosion.

STEINAUER SERIES

The soil of the Steinauer series represents the first stage of soil development on limy glacial drift. It occupies the most severely eroded parts of the glaciated uplands where the land is hilly to steep and the runoff rapid.

It differs from soils of the Burchard series mainly in having a slightly lighter colored and thinner surface soil, a thinner subsoil, and lime near the surface. The surface soil varies considerably in texture, color, and depth, but in most places it consists of dark grayish-brown to brown loam 4 to 8 inches thick. The subsoil, about 4 inches or less in thickness, consists of light-brown or yellowish-brown friable or moderately friable clay loam. The subsoil represents a transition layer between the surface soil and the parent drift and is not everywhere developed. The drift, a heterogeneous mixture of sand, silt, and clay, is exposed at the surface in many places. The soil commonly contains numerous stones and boulders and is limy either throughout the profile or from a few inches below the surface to the parent drift.

Nearly all of this soil is either too steep or too stony for cultivation and is best suited to pasture or to the growth of hay and timber. It produces a variety of trees and good grass during spring and fall. Steinauer loam is the only type mapped.

Steinauer loam.—The small widely scattered areas of this soil usually occupy narrow excessively drained and severely eroded ridge points, where slopes range from 5 to 10 percent or more, but the steeper areas are of too minor importance to warrant separate recognition. Gullies too deep to be crossed with ordinary farm machinery are numerous on the steeper slopes.

This soil is the thinnest and least developed of any on the glacial uplands. The surface layer varies considerably in color, texture, and depth but in most places consists of dark-brown loam about 6 inches thick. Where best developed, the subsoil is merely a transition layer about 4 inches thick between the surface soil and the parent drift. It is usually light-brown or yellowish-brown clay loam. The surface soil usually rests directly on the slightly altered drift, which consists of a heterogeneous mixture of light yellowish-brown, light grayish-brown, or slightly reddish-brown sand, silt, and clay; in many places the drift is exposed. Both the subsoil and the parent formation vary somewhat in texture and consistence, but they contain enough silt and clay to be coherent and enough sand and gravel to be gritty. Ordinarily the highly calcareous soil contains many stones and boulders throughout.

The principal variations are in the color, texture, and depth of the surface layer. Where the soil adjoins areas of Burchard or Carrington soils, the surface layer is a trifle darker, finer textured, and thicker than where it has typical development. In other places the soil has been removed or is greatly thinned by erosion. Some of it is noncalcareous. None of these variations, however, greatly affects the agricultural value.

The soil is too steep, too stony, or too shallow and severely eroded to be well suited to farming; nearly all of it is in pasture or woodland. It is friable and easily penetrated by air, roots, and water but is subject to excessive loss of moisture through runoff. The yields of most crops on the few areas cultivated are about 25 percent lower than on most Carrington soils of comparable relief. Alfalfa and sweetclover, however, do nearly as well as on either Carrington loam or Carrington clay loam.

Permanent vegetative cover should be kept on this soil to retard runoff and reduce erosion. After the native vegetation is destroyed, the shallow surface soil soon erodes and exposes the parent drift. The land is well suited to grazing and, under proper management, will support an abundance of nutritious pasture grass. Care should be taken, however, not to overgraze the pastures. All trees suited to the climate do well on this soil.

WABASH SERIES

The soils of the Wabash series are more extensive than any other soils on the bottom lands. They are nearly level and are subject to frequent flooding, but in most places have sufficient drainage to remove all surplus water soon after the streams subside.

These soils occur in deep deposits of dark fine-textured alluvium washed mainly from the adjacent uplands. They are friable or only moderately heavy and in most places are easily penetrated by air, roots, and moisture. The very dark, almost black, surface layer is 12 to 18 inches thick; and the equally dark or only slightly lighter colored friable substratum is composed largely of silty clay loam. Thin seams of sandy sedimentary material are fairly common in the lower part of the soil. The soils do not have enough lime to react noticeably when dilute hydrochloric acid is applied, but none of them seems too deficient in lime for crop needs.

The Wabash soils are among the most productive in the Plains region and are used chiefly for corn, alfalfa, and sweetclover, which can be grown many consecutive years without danger of exhausting the soil moisture supply. They are used also to a considerable extent for wheat and oats. As on most soils on the bottom lands, however, these crops have a tendency to grow ranker, mature later, and yield lower than on the well-drained soils of the uplands and terraces.

Most of the uncultivated Wabash soils are either in poorly drained localities or in narrow strips so thoroughly dissected by stream meanders as to be difficult to farm. They support a luxuriant growth of grasses, with trees along the streams, and are used chiefly for pasture and hay land, uses to which they are well suited.

The Wabash and Judson soils are so intricately associated in many of the narrower valleys that separate mapping is impracticable.

In such places the soils belong chiefly to the Judson series, with smaller proportions of the Wabash. They are mapped as Judson-Wabash silt loams (p. 49). Three types of the Wabash series—the silt loam, the fine sandy loam, and the silty clay—are mapped. The predominant type is the silt loam.

Wabash silt loam.—This is the most extensive soil of the bottom lands and occurs in more or less continuous strips of irregular widths on the flood plains along practically all the smaller and many of the longer streams. The largest areas are along the Little Nemaha River and its tributaries. The soil lies nearly level, except where modified by active or abandoned stream channels or where there are slight elevations and shallow depressions. Most of it is subject to overflow from the main streams, but all of it has sufficient slope to afford adequate surface drainage. The water table is usually 6 to 10 feet below the surface, and internal drainage is therefore adequate.

This soil consists of dark silty noncalcareous alluvium that has not been greatly modified by soil-forming processes. In virgin areas the surface soil consists of almost black finely granular and friable silt loam to a depth of 10 to 15 inches. In most places tillage has partly destroyed the granulation in the upper 5- or 6-inch layer. The rest of the soil, to depths of 3 to 10 feet or more, consists of sedimentary deposits, most of which are dark-colored and silty or clayey, though layers of lighter colored or coarser textured material are fairly common in the substratum below a depth of 3 to 4 feet.

The soil is well supplied with moisture, easily managed, and as productive of corn, alfalfa, and sweetclover as most other soils in the general area. During most years corn yields 40 to 55 bushels an acre, and alfalfa, 2 to 3 tons. As with all soils on the bottom lands, small-grain crops make rank vegetative growth at the expense of the grain and mature rather late. Crop failures occur only in occasional years when the bottom land is flooded for unusually long periods. The only uncultivated areas are some narrow strips traversed by meandering stream channels. These areas support an abundance of grass and considerable timber, and good pastures can be developed and maintained.

Wabash fine sandy loam.—This soil differs from Wabash silt loam only in having more fine sand in the surface layer. The dark noncalcareous recent alluvium forming that layer has been washed mainly from the more sandy soils of the uplands. Surface and drainage features do not differ appreciably from those of Wabash silt loam.

Practically all of the soil except that in the narrower stream valleys is used for the same crops as Wabash silt loam and is about equally productive. The soil has a slightly greater water-absorbing capacity than the silt loam or silty clay and is more easily worked under a wider range of moisture conditions but it is no more productive. Corn and alfalfa, the best crops for this soil, occupy the largest part of the cultivated acreage. The uncultivated areas produce luxuriant sod-forming grasses and considerable timber and are used mainly for pasture, hay crops, and woodland.

Wabash silty clay.—For the most part, this soil occupies shallow pockets, sags, and swales on the broad bottoms along the larger streams, surrounded by slightly higher lying areas of other Wabash soils. They are subject to rather frequent overflow, and because they remain inundated longer than the surrounding land, they are too wet for cultivation. The water table is usually within 4 to 6 feet of the surface. The soil differs from Wabash silt loam and Wabash fine sandy loam chiefly in its finer textured surface soil and less adequate surface drainage.

The surface layer is almost black heavy silty clay about 12 inches thick. The rest of the soil consists of alternating layers of dark fine-textured soil material almost identical with that in Wabash silt loam except that it has a slightly higher clay content and contains more rusty-brown, yellow, and gray spots, splotches, and streaks that indicate poor internal drainage. Though not noticeably limy, the soil contains enough lime for all crop needs. The lower subsoil or substratum has a rather high clay content but is not compact. The soil may contain enough saline material in its upper 10- or 12-inch layer to preclude satisfactory plant growth, but areas in which these salts occur commonly are of such small extent and minor agricultural importance that separate mapping is not practical. The salts consist chiefly of chlorides and sulfates of sodium and calcium and in some localities a small quantity of sodium carbonate.

In common with most of the other Wabash soils, this one contains an abundance of organic matter and is well supplied with moisture. Where adequately drained, it is as productive of all crops common to the area as Wabash silt loam. It is not so easy to manage, however, as it remains wet later in spring and longer after rains and cannot be cultivated under so wide a range of moisture conditions. It is very difficult to plow when dry, and if worked when wet it bakes and forms large lumps or clods that require subsequent wetting and drying or freezing and thawing to restore favorable tilth. During periods of drought the soil shrinks and cracks considerably, thus breaking many of the plant roots, and unless favorable tilth is maintained considerable moisture is lost through evaporation.

The soil is better suited to corn and alfalfa than to small grains. Only a small percentage of the area is cultivated. The grain yields depend mainly on drainage conditions and, during most years, are considerably lower than on the silt loam. Even in the cultivated areas, most of which are artificially drained, the crops are commonly injured by prolonged inundation.

As most areas of this soil cannot be drained artificially without considerable expense, they are left with their luxuriant native cover of trees and grasses and are used principally and most advantageously for pasture and the production of wild hay (pl. 7, *C*).

WAUKESHA SERIES

The only soil of the Waukesha series mapped—the silty clay loam—occupies both high and low nearly level to undulating well-drained stream terraces not subject to overflow. Most of it is developed on high terraces in silty stone-free Peorian loess similar to that in which the Sharpsburg soils are developed. It does not differ appreciably in profile features from these soils but occupies terrace or benchlike positions. Some of the Waukesha soil is on low terraces or benches in silty loesslike material washed mainly from the adjacent loessal uplands.

The Waukesha soil has a deep dark finely granular silty clay loam surface soil and a rather dark well-oxidized moderately compact but friable subsoil. That on the low terraces has a slightly darker subsoil as a rule than that on the high terraces. At a depth of about 4 feet the soil rests either on loess or loesslike material. Neither the soil nor the underlying material is noticeably calcareous.

The Waukesha soil is admirably suited to any crop common to the area. It is easily managed and is cultivated almost continuously in nearly all places. It is better suited to and more productive of a wider variety of crops than any of the other soils in the county. All crop yields are higher than on the best soils on the uplands, chiefly because of the greater moisture supply on the terraces.

Waukesha silty clay loam.—Although this soil occurs on the nearly level to gently undulating well-drained areas of both high and low terraces, it is best developed and most extensive on the high terraces. In these localities it does not differ materially from Sharpsburg silty clay loam.

The surface soil consists of mellow finely granular silty clay loam about 14 inches deep, with an abundance of organic matter. It is very dark grayish brown when dry, or almost black when wet. The subsoil, in its upper part, is brown or dark-brown coarsely granular silty clay loam, slightly heavier than the layer above but friable throughout. It gradually becomes lighter colored and more silty and friable with depth and at about 30 inches consists of light-brown or light yellowish-brown silt loam. It merges with the parent Peorian loess about 4 feet below the surface. On the low terraces the soil is about the same as on the higher ones, but the subsoil may be darker to depths of more than 4 feet and may be underlain by alternating layers of silty or fine sandy alluvium. None of the soil or underlying material is noticeably calcareous.

In a few small areas near the base of glacial upland slopes and near the mouths of intermittent streams, which usually issue from the glacial uplands, the surface soil, containing a large quantity of sandy material washed from the adjoining lands, is fine sandy loam. Areas of this variation, however, are too small and unimportant to warrant separate recognition. Agriculturally, the coarser textured variation is similar to typical areas of this soil, and in most places it is farmed with them.

This soil is well suited to any of the crops commonly grown and is considered the best general-farming soil in the county. It has excellent drainage and is not subject to destructive erosion. It is easily managed and on many farms has withstood severe cropping over long periods without serious reduction in productivity. Practically all of it is cultivated. Corn is the principal crop, and in most years wheat, oats, and alfalfa rank next in the order named. Although most of the soil is planted to corn, a larger proportion of it than of any other soil in the county is used for wheat. Owing chiefly to the greater supply of moisture, all crops yield higher on the terraces than on the best soils of the uplands. Alfalfa can be grown a longer time on the terraces than on the uplands without depleting the deep-seated soil moisture.

SOIL MANAGEMENT

General-farming practices and the kinds of crops grown have not changed markedly in the past 20 years. The proportionate crop acreages, however, have varied from year to year in accordance with differences in market conditions, and the average acre yields of some of the crops have been considerably increased by the development of new and improved plant varieties.

The greatest use of the land in the county is for the production of livestock feed. On cash-grain farms this feed is sold; on livestock farms it is fed on the farm where produced. Where the grain is fed on the farm, much of the fertility of the soil lost through cultivation can be returned through animal manure.

Nearly all the soils in the county are fertile enough to produce good yields of the crops for which they are suited without the addition of commercial fertilizer, provided the crop refuse is returned to the land and an adequate moisture supply is maintained. Some of the soils, including those of the Steinauer, Burchard, Knox, Sogn, and Nuckolls series and the eroded rolling phases of the Carrington, are on slopes too steep to justify the expense of maintaining either the fertility or the moisture supply at levels suitable for continued production of cultivated crops. These are among the less extensive soils, however, and are well suited to woodland and the growing of the native grasses necessary to supply pasture for work and dairy animals.

The only areas too wet for cultivation are the most poorly drained parts of the bottom lands and a few small widely scattered depressions on the smoothest parts of the uplands and terraces. Most of these areas, however, support a luxuriant growth of native grasses and can be used as pasture land or for the production of hay.

The remaining soils of the county occupy 80 percent or more of the total area, and with few exceptions are well suited to cultivated crops. The principal factor determining the productive capacity of the upland soils is the availability of moisture. Even the steeper slopes and the shoulders of hills where the dark surface soil has been removed are reasonably productive if the moisture supply is adequate and legumes are grown often enough to maintain sufficient nitrogen. The Sharpsburg and Marshall soils, developed in loess and by far the most extensive in the county, are in this category. The loess itself contains enough of all plant nutrients except nitrogen to produce higher yields of all the common crops than the usual moisture supply permits.

Adequate nitrogen is easily maintained by rotating the grain crops with legumes, and therefore facilities to conserve the precipitation for plant use become the chief requisite for increased crop production. Approximately 30 percent of the precipitation that falls on the arable soils of the uplands and terraces in this county probably runs off the land, and because of prevailing farming practices another 30 or possibly 40 percent evaporates before it can be of significant benefit to crops.

Part of the water wastage resulting from runoff is prevented on a few farms by terracing and cultivating the land on contours. These measures are used especially in fields shaped to facilitate such cultivation. The use of contour farming, however, has made relatively little progress in the county, chiefly because it results in an excessive number of short rows. Cultivation of short rows is more time consuming, and large-type farm machinery cannot be used so conveniently as on long straight rows. For the same reason, strip cropping, with alternate strips of close-growing and row crops extending at right angles to the slopes, is practiced in only a few areas.

The most progressive farmers generally agree that yields of crops grown on the contour or in alternate strips between terraces extending around hills are usually notably larger than those produced by the conventional straight-row method of farming up and down slopes. The larger yields are chiefly due to the greater conservation of soil moisture through better control of runoff. These farmers also believe that the larger returns from the increased yield will ordinarily more than offset the extra time and effort required for tilling and harvesting on the contour. Farming on the contour requires much less power to operate machinery than is necessary for working up and down slopes, and contour cultivation is therefore considered especially favorable where tractors are used, as it not only saves fuel but also causes less wear and tear on the motor. Contour tillage does require more effort on the part of the operator when more turns are necessary.

Mulching cultivated fields with enough undecomposed or partly decomposed vegetable matter to facilitate rapid water absorption is widely used as a moisture-conservation practice. This method alone is satisfactory but probably would be more effective if accompanied by some form of contour farming.

Although the available moisture supply is the principal factor in determining the yield and consequent profit from crops, the quantity of nitrogen available for plants is also important. In seasons of abundant precipitation the corn yield in particular is greater when the crop follows a legume in the rotation. In dry years, however, the large nitrogen supply left in the soil by a crop of alfalfa or sweetclover may cause corn to produce such an unusually rank early vegetative growth that it cannot be supported by the available subsoil moisture late in summer.

A better rotation in dry seasons therefore is legumes, small grains, and corn. Most farmers consider listed corn more drought-resistant than that planted in checkrows. Checkrows are generally used on the bottom lands, terraces, and more level parts of the uplands because they allow cultivation of the crop in two directions and thereby facilitate the control of weeds. Provided the soil is in favorable tilth, any cultivation beyond that necessary to eradicate weeds is considered unprofitable and is usually avoided. Weeds grow rapidly on the bottom lands, and consequently more cultivation is necessary for corn grown on alluvial soils than for that grown on uplands and terraces.

PRODUCTIVITY

The factors influencing the productivity of land are mainly climate, soil characteristics, and surface configuration. Proper management of the land, however, also is important. Crop yields are a more or less reliable expression of the agricultural capacity of the soil under a particular set of management practices. If the management becomes better or worse, the yields increase or decrease accordingly.

The average acre yields to be expected from the more important crops on the different soils of Otoe County under prevailing management practices are shown in table 6. On the arable lands prevailing farming practices include the occasional use of alfalfa and sweetclover and of a not too fixed system of rotating crops of corn, wheat, and oats. Corn occupies the greater part of the arable land for half the time or more.

TABLE 6.—*Estimated average acre yields of the principal crops on each soil in Otoe County, Nebr., under prevailing management*

Soil	Crop								
	Corn	Oats	Wheat	Rye	Barley	Hay			Pasture
						Alfalfa	Sweetclover	Wild	
	Bu.	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Lb.*	*Lb.*	*Lb.*	*Cow-acre-days* [1]
Barney fine sandy loam	(2)	(2)	(2)	(2)	(2)	5, 600	2, 800	1, 400	70
Bremer silt loam	45	35	18	18	26	6, 800	3, 400	1, 800	110
Burchard-Carrington complex	20	16	9	9	12	4, 000	2, 000	1, 000	70
Hilly phases	(2)	(2)	(2)	(2)	(2)	3, 000	1, 400	1, 000	30
Burchard clay loam	14	16	8	8	12	3, 800	1, 800	1, 000	65
Butler clay	(2)	(2)	(2)	(2)	(2)	4, 000	2, 000	1, 000	90
Butler silty clay loam	30	32	16	16	26	4, 800	2, 400	1, 400	90
Carrington clay loam	30	30	15	15	24	4, 800	2, 400	1, 300	85
Eroded phase	26	28	14	14	22	4, 800	2, 400	(3)	85
Eroded rolling phase	(2)	(2)	(2)	(2)	(2)	------	------	(3)	------
Rolling phase	25	24	13	13	20	4, 200	2, 000	1, 200	75
Carrington loam	24	18	10	10	14	4, 200	2, 000	1, 200	70
Eroded phase	18	16	8	8	12	4, 000	2, 000	(3)	70
Eroded rolling phase	(2)	(2)	(2)	(2)	(2)	3, 600	1, 200	(3)	30
Rolling phase	16	16	8	8	12	3, 800	1, 800	1, 000	65
Cass fine sandy loam	40	24	11	13	19	6, 800	3, 400	1, 600	100
Cass silty clay loam	(2)	(2)	(2)	(2)	(2)	6, 800	3, 400	2, 000	120
Crete-Sharpsburg silty clay loams	20	20	10	10	16	4, 200	2, 000	1, 200	80
Crete silty clay loam	28	30	15	15	24	4, 800	2, 400	1, 400	90
Dickinson sandy loam	14	10	4	4	8	3, 200	1, 200	800	40
Hamburg silt loam	(2)	(2)	(2)	(2)	(2)	3, 200	1, 400	600	30
Hilly phase	----	----	----	----	----	3, 600	1, 400	1, 000	40
Judson silt loam	45	40	20	20	30	6, 800	3, 400	1, 600	100
Judson-Wabash silt loams	45	38	19	19	19	6, 800	3, 400	1, 800	110
Knox silt loam	16	12	8	8	10	3, 600	1, 600	1, 000	60
Rolling phase	20	16	10	10	14	4, 000	2, 000	1, 200	70
Steep phase	(2)	(2)	(2)	(2)	(2)	3, 600	1, 200	600	30
Lamoure silty clay	(2)	(2)	(2)	(2)	(2)	6, 800	3, 400	2, 000	120
Made land	(2)	(2)	(2)	(2)	(2)	------	------	------	------
Marshall silt loam	42	28	20	20	30	4, 900	2, 400	1, 400	90
Eroded rolling phase	25	22	12	12	18	4, 400	2, 000	1, 200	75
Level phase	44	30	20	20	30	5, 000	3, 000	1, 600	95
Rolling phase	30	30	15	15	24	4, 800	2, 400	1, 400	90
Nuckolls-Carrington clay loams	14	16	8	8	12	3, 600	1, 600	1, 000	60
Nuckolls clay loam	14	12	6	6	10	3, 600	1, 600	1, 000	60
Pawnee clay loam	12	14	8	8	12	3, 600	1, 600	1, 000	60
Plattsmouth fine sandy loam	(2)	(2)	(2)	(2)	(2)	6, 000	3, 000	1, 600	80

See footnotes at end of table.

TABLE 6.—*Estimated average acre yields of the principal crops on each soil in Otoe County, Nebr., under prevailing management*—Continued

Soil	Crop								
	Corn	Oats	Wheat	Rye	Barley	Hay			Pasture
						Alfalfa	Sweetclover	Wild	
	Bu.	*Bu.*	*Bu.*	*Bu.*	*Bu*	*Lb.*	*Lb.*	*Lb.*	*Cow-acre-days* [1]
Plattsmouth silt loam	(2)	(2)	(2)	(2)	(2)	6, 400	3, 200	1, 800	90
Riverwash	(2)	(2)	(2)	(2)	(2)	1, 000	1, 000	600	40
Rokeby silty clay loam	30	32	16	16	26	5, 600	2, 800	1, 400	90
Sarpy fine sand	(2)	(2)	(2)	(2)	(2)	3, 800	1, 800	1, 200	60
Sarpy fine sandy loam	(2)	(2)	(2)	(2)	(2)	5, 600	2, 800	1, 400	70
Sarpy loamy fine sand	(2)	(2)	(2)	(2)	(2)	3, 800	1, 800	1, 200	60
Sharpsburg silty clay loam	40	28	18	18	28	4, 800	2, 400	1, 400	90
Eroded rolling phase	24	22	12	12	18	4, 200	2, 000	(3)	80
Level phase	43	30	20	20	20	4, 800	2, 400	1, 400	90
Rolling phase	26	26	14	14	22	4, 600	2, 200	1, 200	80
Sogn stony loam	(2)	(2)	(2)	(2)	(2)	3, 200	1, 400	800	30
Steinauer loam	(2)	(2)	(2)	(2)	(2)	3, 600	1, 200	800	30
Wabash fine sandy loam	40	25	12	14	20	6, 800	3, 400	1, 600	100
Wabash silt loam	45	30	16	16	24	6, 800	3, 400	1, 800	110
Wabash silty clay	(2)	(2)	(2)	(2)	(2)	6, 800	3, 400	2, 000	120
Waukesha silty clay loam	43	40	20	20	30	6, 400	3, 200	1, 500	90

[1] Cow-acre-days, used to express the carrying capacity of pasture land, is the product of the number of animal units carried per acre multiplied by the number of days that animals can be grazed without injury to pasture; for example, a soil that supports 1 animal unit for 360 days rates 360; a soil supporting 1 animal unit on 2 acres for 180 days rates 90; and a soil supporting 1 animal unit on 4 acres for 100 days rates 25.
[2] No yields given; soil generally unsuitable for cultivation.
[3] Wild hay meadows do not occur on eroded soil areas.

MORPHOLOGY AND GENESIS OF SOILS [8]

The soils of Otoe County have developed under midcontinental climatic conditions characterized by the high summer and moderate to low winter temperatures of the western part of the Prairie soils zone of the United States. The mean annual precipitation of about 29 inches, over 80 percent of which falls in the 7 months from April to October, supports a luxuriant growth of typical prairie grasses. Prairie beardgrass, known locally as little bluestem; bluejoint turkeyfoot, or big bluestem; Kentucky bluegrass; porcupine grass, locally called needlegrass; prairie dropseed; and side-oats grama, named in the approximate order of dominance, grow on the well-drained up-

[8] Prepared by James Thorp, principal soil correlator, Great Plains States, Division of Soil Survey, Bureau of Plant Industry, Soils, and Agricultural Engineering, in collaboration with G. E. Condra, Director, Conservation and Survey Division, and E. C. Reed, associate State geologist, University of Nebraska.

lands and terraces. The same species grow more luxuriantly and in a somewhat similar order of dominance on the bottom lands and in other moist areas. Narrow strips along some of the streams are in forest, but the tree cover is nowhere sufficiently dense to prevent the growth of grass or to influence greatly the character of the soils. Organic matter, derived principally from decayed grass roots, has produced very dark, and in places almost black, surface layers in all except the local areas where soils are developing on the most recently exposed geologic materials.

Except in areas where runoff is rapid or a claypan restricts downward water movement, the precipitation has been sufficient to remove the readily soluble salts from the entire solum and, in most places, from the upper part of the underlying formation; but nowhere has acidity developed to the point where it greatly inhibits the growth of any farm crop common to the area. Most of the surface soil is slightly acid to neutral, and the rest of the solum is neutral or slightly alkaline. In a few steeply sloping and severely eroded places, where the parent material is at or near the surface of the ground, the soils are moderately calcareous. A limy layer occurs in the lower part of the subsoil of the few soils in which a claypan has developed, but the parent material beneath this layer is not everywhere appreciably calcareous.

The granular structure of the surface layer characteristic of most soils in the Prairie soils zone is typically developed in all except the more sandy, severely eroded, and least developed soils of the county.

Almost all the soils have good surface and internal drainage. The exceptions are flood-plain soils having a high water table or subject to frequent inundations and a few upland soils that have developed a claypan that inhibits internal drainage.

The soils of the county are here discussed under three physiographic heads: (1) Soils of uplands; (2) soils of terraces and colluvial slopes; and (3) soils of first bottoms, or flood plains. Under the first two headings, the soils are grouped according to the kinds of parent material from which developed; under the third, they are grouped according to color in addition to kind of parent alluvium.

SOILS OF UPLANDS

The soils of uplands are developed from five principal kinds of parent materials, as follows:

(1) Yellowish loess, part somewhat coarse-textured and part finer textured. The older part is called Peorian loess, and the youngest, the later loess (*1*). (2) Reddish loess and loesslike material considerably older than the yellowish loess just mentioned. This is known as the Loveland loess. (3) Calcareous glacial till, some of it leached free of lime to considerable depths and some remaining essentially unleached. (4) Sandy deposits of complex alluvial-aeolian deposition. (5) Limestone residuum.

SOILS DEVELOPED IN PEORIAN AND THE LATER LOESS

The yellowish loess is partly fairly coarse-textured; that is, it contains a fairly large proportion of coarse silt and some very fine sand. This coarser part occurs in a belt that parallels the Missouri River and extends westward only a few miles. The heavier textured part lies farther back from the river and is mostly west of the belt of coarse-textured loess. The upper part at least of the coarser textured loess was probably deposited later than most of the fine-textured loess, this upper part being the later loess (*1*). The details have not yet been worked out by the geologists, however, and no attempt is made here to make definite correlations with the coarse loess of other areas of eastern Nebraska.

The soils developed from this coarser loess form what might be considered a catena, in which Hamburg silt loam is the least well-developed member, Knox silt loam the somewhat more strongly developed, and Marshall silt loam the truly well-developed member. Though parent materials are essentially alike, some objection might be raised to calling this geographic association a catena, because the natural vegetation on the Hamburg and Knox soils includes more or less forest growth, chiefly elm, oak, and ash trees. The forests are nowhere very dense, however, and grasses are common in the glades between the trees.

Marshall silt loam is characteristic of the moderately to gently sloping uplands of the eastern part of the county. It is a typical Prairie soil of the kind that shows relatively little differentiation in texture between the A and B horizons. Following is a profile description:

A_{11}. 0 to 3 inches, dark grayish-brown fine-granular friable and porous silt loam with a high content of the coarser grades of silt and a relatively low content of clay; the fine granular aggregates are soft and easily crushed; neutral to slightly acid.

A_{12}. 3 to 15 inches, dark grayish-brown (dry) to black (moist) fine- to medium-granular silt loam, mostly in the medium range of that texture, the lower part containing slightly more clay than the upper part and grading almost imperceptibly into the layer below; slightly acid.

B_1. 15 to 30 inches, brown to somewhat yellowish-brown coarse-granular material of a light silty clay loam texture, darker in the upper part and becoming lighter colored with depth.

B_3. 30 to 70 inches, a light yellowish-brown friable nearly massive silt loam; reaction, neutral.

C. 70 to 120 inches +, pale-brown massive porous and friable silt loam loess mottled with light gray and dark brown to a depth of 30 feet or more and in some places containing silty carbonate of lime below 8 to 10 feet.

The above profile is typical of Marshall silt loam, but as mapped the soil grades almost imperceptibly into Sharpsburg silty clay loam within a distance of a mile or two. The Sharpsburg soil contains more clay throughout than the Marshall. Under cultivation the A horizon of the Marshall soil has become considerably lighter, partly because of erosion and partly because the supply of organic matter has been exhausted by crop withdrawals and oxidation. The burrows of pocket gophers, other small animals, and insects are filled with dark-colored soil in the lower horizons and often with light-colored silt in the upper ones.

The Knox soils, listed as members of the same catena as the Marshall, have a profile somewhat like the Marshall soils as far as texture is concerned, but they lack the thick nearly black A_1 horizons of that series. Generally, the dark-colored A_1 horizon of the Knox soils seldom exceeds 10 inches, and nearly everywhere it is not so dark as that of Marshall silt loam. The comparative shallowness and lighter color of the Knox soils is due partly to the fact that they have been under partial cover of forest, and partly possibly to their greater slope. Depth to carbonate of lime in the Knox soils is rather variable, and lime appears at or near the surface in some areas that became severely eroded when the land was brought under cultivation.

In practical mapping work and in correlation, it seemed advisable to allow the Knox soils more flexibility than in the ideal definition of a soil series. For this reason Knox silt loam as mapped is more variable than would normally be permissible in one soil series, and it must be considered that mapped areas of this soil make up a complex in which Knox silt loam is associated with other soils that have not yet been named.

Hamburg soils are light-colored and very weakly developed, largely because they lie on very steep slopes where both geologic and accelerated erosion have been active. Furthermore, many areas of Hamburg soils have a fairly thick cover of trees and bushes and relatively little grass. Under virgin conditions there is a thin dark-colored surface soil in places that have not been disturbed by landslides and other forms of erosion.

A few miles west of the Missouri River, Marshall, Knox, and Hamburg soils grade into the catena composed of the Sharpsburg, Crete, and Butler soils. The Sharpsburg is a typical member of the Prairie great soil group. Sharpsburg silty clay loam is considerably heavier textured throughout than Marshall silt loam, and Crete silty clay loam is still heavier than Sharpsburg silty clay loam, especially in the B horizon. Butler silty clay loam and Butler clay are Planosol members of this catena. They are developed on practically level or slightly depressed uplands where effective moisture has been greater than on the Sharpsburg and Crete soils.

The western part of the county lies only a few miles west of the border between the Prairie and Chernozem soils, and it therefore seemed permissible to correlate the Crete series—a heavy-textured Chernozem—in the same general geographic region as the Sharpsburg, which is a typical Prairie soil.

The Crete soil here has something in common with the more typical Crete farther west in Nebraska and with the Grundy soils of southwestern Iowa and northwestern Missouri. The heavy claypan in this Crete soil and the slightly to moderately acid reaction of its A horizon in some parts suggest a close relation to the Grundy soils of Iowa. On the other hand, an imperfectly developed horizon of lime-carbonate accumulation below its claypan tends to throw the Crete soil of this county into the same group as the Chernozem farther west, and from the standpoint of its effectiveness in holding moisture for plant production, it is also more like the heavy Chernozems to the west than the heavy Prairie soils farther east. In other words, it seems logical to recognize Chernozems among heavy-textured soils farther east than would be done with lighter textured soils and soil materials. A similar statement could be made for the Butler soils, which are classified as Chernozemic Planosols.

Sharpsburg silty clay loam observed in a virgin hay meadow, on a well-drained divide with a 3-percent slope gradient, 1,555 feet west of the northeastern corner of section 20, township 7 north, range 9 east, has the following profile:

A_{11}. 0 to 4 inches, dark grayish-brown or almost black friable fine-granular silty clay loam, the granules small and poorly defined in the upper half but for the most part distinct in the lower part, though soft and easily broken, the subangular aggregates averaging about 1/16 inch in diameter. There is considerable single-grain material and an abundance of organic matter intimately mixed with the mineral soil constituents; little color change occurs when the lumps are crushed.

A_{12}. 4 to 12 inches, dark grayish-brown friable granular silty clay loam; the granules slightly larger and a little firmer than in the layer above, and in the lower part thinly coated with well-decomposed organic matter and becoming slightly lighter in color when crushed.

A_3. 12 to 18 inches, dark grayish-brown to dark-brown friable coarsely granular silty clay loam, with a gradual transition in color, texture, and consistence from the A horizon to the subsoil, as represented by this 6-inch horizon.

B_{21}. 18 to 24 inches, dark grayish-brown or dark-brown moderately heavy though coarsely granular and friable silty clay loam, the firm granules averaging about 1/8 inch in diameter and coated with organic matter, and when dry easily crushed to a brown or light-brown powder. This upper part of the subsoil is the heaviest horizon in the profile, but its increased heaviness is scarcely noticeable except through close comparison with the horizon above and the one below.

B_{22}. 24 to 36 inches, brown coarsely granular to cloddy friable silty clay loam or silty clay, the granules in the upper part similar to those in the overlying layer but giving way to an ill-defined cloddy (nuciform) structure below, the material easily crushed to form a pale-brown powder.

C_1. 36 to 48 inches, pale-brown or light yellowish-brown friable slightly altered silt loam or silty clay loam of the parent loess, containing numerous brown and dark-brown spots, splotches, and streaks.

C_2. 48 to 96 inches, light yellowish-brown or grayish-yellow floury silt loam of the Peorian loess, with scattered lime concretions at places in the lower part of this horizon, but not consistently present; except at the concretions the loess does not react noticeably with dilute hydrochloric acid.

The organic matter practically disappears at a depth of about 30 inches. Insect casts are numerous in the A_{12} and B_{21} horizons, and the B_{22} horizon contains many filled old root, worm, and insect holes, which appear as crooked rodlike forms about one-fourth inch in diameter and of varied lengths, and are lighter or darker than the surrounding matrix. There are also a few dark earth-filled rodent burrows, known technically as Krotovinas, in the lower subsoil horizons in these areas.

Crete soils, with their heavy clay subsoil, are developed in shallow leached and weathered loess in the south-central and southwestern parts of the county and are connected geographically with larger areas of Crete soils in southeastern Lancaster and northern Gage Counties and thence into Saline County, where they were first recognized and mapped.

From the facts presented, it seems that of the soils developed in loess, those containing more clay are generally farther from the theoretical source of the loess and are developed in thinner deposits of that material than those with less clay. This statement holds true for soils having good natural surface drainage, but not for claypan soils of the Butler and Rokeby series that occur on level or slightly depressed land, where there is practically no runoff.

The loess of eastern Nebraska seems to have several sources. The major source near the Missouri River seems to have been the flood plains of that river—plains that probably were nearly bare of vegetation during the excessively windy periods when glacial ice occupied the country north and east of Otoe County. The Platte River Valley and valleys of the Elkhorn and tributary streams doubtless contributed some of the dust that fell in this county, and it is also possible that some dust was blown all the way from the Sand Hills of Nebraska. It seems probable that the greater part of the loess from which the Marshall, Knox, and Hamburg soils are formed was blown out of the flood plains of the Missouri River, whereas loess in the western part of this county probably came largely from the more distant Platte River Valley and possibly from the Sand Hills. Thus, it seems reasonable to suppose that the main sources of the thinner loess of this county were more distant than those of the thicker loess deposits.

In studies of the soils developed in the loess of Illinois, Smith (*9*) pointed out that soil development has advanced further in areas of thin but uneroded loess than in thick loess deposits of the same age. Accumulation of loess was so slow in areas distant from the source that the leaching of lime carbonate and the hydrolysis of clay-forming minerals in the loess was continuous during the period of deposition as well as after deposition was complete. In areas where the loess is very thick, accumulation was too rapid for these processes to advance significantly until after deposition was essentially complete.

The field studies of Hayes (*3*) on soils of loessal origin in Nebraska, combined with observations made by others, suggest that the principles outlined by Smith (*9*) hold good in Nebraska. It is suggested tentatively, therefore, that the differences among the soils of the Hamburg, Knox, Marshall, Sharpsburg, and Crete series may be due in considerable part to differences in the time factor and therefore in the stage of development. To this must be added the fact that the loess in which the first three soils are developed is somewhat coarser than that in which the last two are developed. Whether the coarser loess is also younger than the finer loess remains to be worked out.

Butler soils are classified as Planosols on the basis of the development of a heavy claypan in the subsoil and a grayish, lighter colored horizon in the lower part of the A layer. It is recognized that this Planosol is not so strongly developed as Planosols like the Cherokee silt loam in Kansas, for in that soil nearly all of the A horizon has taken on a light-grayish tint despite its prairie vegetation. Butler soils, like the Crete, usually have a horizon beneath the claypan in which carbonate of lime has accumulated in the form of concretions. Beneath this the loess may or may not be calcareous, but in this county it is usually noncalcareous or only slightly calcareous.

SOILS DEVELOPED IN LOVELAND LOESS

The lower part of the yellowish Peorian loess rests unconformably on an old buried soil that formed during and after the time of Illinoian glaciation on the loessal deposit of Illinoian age, called Loveland loess. Where this deposit is exposed in deep road cuts, it seems evident that its reddish color developed in subsoil of the ancient buried soil. In other parts of eastern Nebraska, as in Washington County, where this material is many feet thick, it can be seen that the reddish color of the Loveland deposit fades out with depth into a yellowish color not significantly different from that of the Peorian loess. The ancient soil in places retains its original A horizon and in some areas has a rather dark color, suggesting a former grassy vegetation. The upper part of the B horizon of this old soil in most places has a silty clay or silty clay loam texture, but the lower part is less heavy and more friable and, in many places, contains a fair proportion of sand.

In the present cycle of soil development, Nuckolls clay loam is a fairly young soil, although its B horizon is in old leached material. Where exposed by recent erosion, the old reddish material has proved to be low in available phosphorus. This soil occupies very small areas and is in complex association with other soils; because of this, it was impossible to map it accurately and to exclude other minor soils with which it is associated. In most morphologic respects this clay loam resembles the more typical Nuckolls silt loam occurring two or three counties farther west in Nebraska, but it does not have the consistent horizon of lime accumulation characteristic of the Nuckolls. In northwestern Missouri and southwestern Iowa small patches of this same soil have been included in mapping with soils of the Shelby series, although it is recognized that it does not properly belong in that series.

It is of further interest to note that an old soil was developed on the Kansan glacial till deposit before the Loveland loess was laid down. The B horizon of this ancient soil also is reddish brown in places. Nuckolls clay loam, as shown on the soil map, includes a few small spots of the ancient soil that developed in Kansan glacial till.

SOILS DEVELOPED IN CALCAREOUS GLACIAL TILL

In the second invasion of Nebraska by glacial ice, which probably occurred a few hundreds of thousands of years ago, a thick deposit of calcareous glacial till was laid in this part of the country. After this till was deposited, there appears to have been a long period of leaching and soil formation that converted the upper part of the glacial till into a catena of strongly developed soils. Parts of these soils and of the glacial till beneath them were washed away at various times, and now only remnants of the various soils are left.

The various soils developed in glacial till in this county owe their characteristics partly to their different ages, which have been determined by the various time periods that have elapsed since erosion was active on the Kansan glacial till. The original soil on the Kansan till, and possibly another one that developed at the same time as the old soil on the Loveland loess, had very strongly developed clayey B horizons. Lime carbonate beneath these heavy horizons was leached to depths of many feet. In this county the old soils with these strongly developed claypans are classified as Pawnee clay loam. Apparently erosion took place after Loveland loess had been deposited and the soil known as Pawnee had developed on it. Some time after the erosion occurred, another soil began to develop, one having a less heavy clayey horizon than that of the Pawnee, and one considerably more fertile and productive.

The exact geologic date when this (Carrington) soil began to form has not been determined, but it was no doubt some time after the deposition of the Loveland loess and the erosion of the soil that developed from that loess. Development may have been contemporaneous with or after the deposition of Peorian loess. This younger series includes Carrington clay loam and Carrington loam. Mechanical analyses indicate rather clearly that the A horizon of Carrington loam developed in a thin loessal deposit that probably fell after the soil began to develop.

At a still later date (the exact geologic time is not yet known) another soil (Burchard clay loam) began to form on glacial drift that apparently was exposed by erosion after the Carrington soil began to develop. The B horizon of Burchard clay loam is somewhat less strongly developed than that of Carrington loam, and the soil is leached to a depth of about 30 inches, as compared with 5 feet or more of leaching in the Carrington.

In areas that are now rather hilly it seems that there was still another period of erosion during which areas of Burchard and Carrington soils were cut away to expose glacial drift. A new soil began to form on the glacial drift following the erosion, and this soil (Steinauer loam) is still in a very young stage of development, much of it being calcareous from the surface to the parent material. Steinauer loam consists primarily of a surface soil a few inches thick and somewhat darkened by organic material that lies directly on calcareous till that has been relatively little modified. In a few places where the soil is slightly older there is a brown transitional horizon a few inches thick between the A and the C horizons, but even in these slightly more developed areas the material is either calcareous throughout or at least to within a few inches of the present land surface.

Typical of normal soil development on glacial drift is an area of Carrington clay loam 2,550 feet south of the northwest corner of section 17, township 9 north, range 9 east. Following is a profile in that area as it occurs in a virgin hay meadow on a well-drained gently sloping divide having a 4-percent gradient:

A_{11}. 0 to 6 inches, dark grayish-brown finely granular and friable clay loam containing an abundance of organic material intimately mixed with the mineral soil constituents, numerous small pebbles, and a noticeable amount of sand, the granules fairly well formed, averaging about 1/16 inch in diameter, and a little darker in their natural form than when crushed.

A_{12}. 6 to 16 inches, dark grayish-brown to dark-brown coarsely granular clay loam, moderately rich in organic matter and containing occasional small stones and pebbles; granules larger and firmer than in the immediately overlying horizon and coated with organic material, and when crushed forming a powder only slightly lighter colored than the granular mass.

B_{21}. 16 to 24 inches, dark-brown coarsely granular heavy but moderately friable silty clay loam containing numerous small stones and pebbles, some sand, and considerable clay. This layer has a distinctly gritty feel and although much heavier than the overlying horizon is easily penetrated by air, roots, and water; granules average about 1/8 inch in diameter and are relatively firm.

B_{22}. 24 to 36 inches, brown to light yellowish-brown heavy and moderately compact silty clay containing numerous stones and pebbles, the upper part similar to the one above it, but the granules gradually becoming larger and less distinct with increased depth and giving way to a massive or ill-defined cloddy or nuciform structure in the lower part.

B_3. 36 to 42 inches, light-brown or yellowish-brown heavy clay containing numerous stones, scattered boulders, and enough sand to be gritty.

C_1. 42 to 60 inches, yellowish-brown or grayish-yellow leached and weathered sandy clay glacial drift; parent formation contains a little more sand than the horizon just above it and is not so heavy.

None of the soil contains enough free lime to react noticeably with dilute hydrochloric acid. The transition from the A horizon to the subsoil is gradual.

Carrington clay loam, as mapped, includes a few areas containing remnants of the old soil developed on Kansan till. These remnants make the B horizon light reddish brown. Field observations show that where the reddish-brown B horizon is exposed by erosion, corn crops show a marked phosphorus deficiency, apparently more marked than in similarly eroded areas of typical Carrington clay loam. Physical properties are otherwise much the same in the two soils. In mapping the county it was almost impossible to separate typical Carrington clay loam from the soil having the reddish-brown B horizon.

SOILS DEVELOPED IN OLD SAND DEPOSITS OF COMPLEX ALLUVIAL-AEOLIAN DEPOSITION

During the advance and retreat of Kansan ice the water that melted flowed around the glacier and deposited sandy and gravelly materials. Some of the sand in this material was blown about and drifted by the wind to some extent. It is also possible that some of the sand deposits may have been blown up from flood plains of rivers at a still later date, but information on this point is not exact. In any case much of the sand was buried by Loveland, Peorian, and possibly by still later loessal deposits, and the sand is present as a soil-forming material in relatively few places. Areas of Dickinson sandy loam occur where sand deposits are exposed at the present surface.

SOILS OF LIMESTONE RESIDUUM

In a few places Pennsylvanian limestone has been exposed by erosion, and a very shallow soil (Sogn stony loam) has developed on it. This soil may be classified as a Lithosol although in places it has the dark color characteristic of Prairie soils.

SOILS OF TERRACES AND COLLUVIAL SLOPES

During each of the stages of ice advance in North America, the streams were flooded by water melting from the ice, and their rate of flow to the ocean was affected by the changes in sea level. These phenomena resulted in a number of different stream terraces in and around the area formerly covered by ice. On a few remnants of such terraces in this county certain soils are developed. Most of the alluvial deposits of the terraces have been buried to varying depths by loess and colluvial materials, and therefore the areas of soils developed directly from the alluvium are relatively small. The soils of the terraces and colluvial slopes may be placed in two groups: (1) Soils developed in Peorian loess over alluvium and (2) soils developed in colluvium or thin loess over alluvium.

SOILS DEVELOPED IN PEORIAN LOESS OVER ALLUVIUM

Waukesha silty clay loam and Rokeby silty clay loam are the two soils developed in Peorian loess over alluvium. To a depth of several feet the profile of the Waukesha soil differs little from that of Sharpsburg silty clay loam of the uplands, and in certain respects it is accurate to term it a terrace phase of the Sharpsburg soil. The Waukesha has been retained as a separate series, however, for two main reasons: (1) Because of precedent in other areas in Iowa and eastern Nebraska; and (2) because the underlying alluvial deposits have an important effect on the ability of the soil to support certain kinds of plant growth. Specifically, alfalfa will survive better during dry periods on much of Waukesha silty clay loam than on Sharpsburg silty clay loam, for the deep tap roots are able to reach down into porous alluvial strata, where there is an abundance of moisture. In the Sharpsburg soils there are no such strata capable of holding adequate water supplies.

Rokeby silty clay loam is similar in many respects to Crete silty clay loam of the uplands, although its surface is generally more nearly level. As mapped it actually includes soil profile characteristics ranging from those of the Crete series to those approximately equivalent to the Planosol known as Butler silty clay loam. The total area involved, however, is so small that the two soils were not mapped separately.

SOILS DEVELOPED IN COLLUVIUM OR THIN LOESS OVER ALLUVIUM

Along the borders of natural terraces and at places where uplands and bottom lands merge, a considerable thickness of colluvium has accumulated where slopes grade from the steeper to the gently sloping areas. In addition to the colluvium, there is also material that probably should be classified as loess because of its silty character and probable wind-laid origin.

Where slopes grade from fairly steep to nearly level, as they do in areas where soils of this group occur, runoff water from the hills slows down and much of it is absorbed in the soils; further, there may be places where there is seepage in wet weather. As a result of these moisture conditions, the natural grassy vegetation is much more luxuriant than on the steeper slopes. The mat of grass roots is more dense because of the more abundant growth, and therefore much more organic matter accumulates than is typical of the normal soils of the uplands or terraces.

The A_1 horizon in these (Judson) soils is thicker and darker than in any of the others except those of the bottom lands. Probably some of the dark surface soil may be attributed to gradual deposition of material washed down from the dark soils of the slopes, but the formation of humus in place is the more important factor in its color development. Evidence in support of this can be noted in the immediate surface soil of cultivated fields where accelerated erosion is bringing down and depositing soil material from the uplands. In these fields the soils are lighter colored than in virgin areas. One type, Judson silt loam, was recognized in mapping.

SOILS OF FIRST BOTTOMS, OR FLOOD PLAINS

The soils of first bottoms, or flood plains, are placed in two categories—dark soils and light-colored soils of bottom lands.

DARK SOILS OF BOTTOM LANDS

The dark-colored Alluvial soils of this county are of two catenas. The first consists of Wabash and Lamoure soils; the second of Cass.

The Wabash series includes dark-colored silty to clayey alluvial soils, moderately acid to approximately neutral. In general profile characteristics the Wabash soils resemble the Judson. Wabash silt loam and fine sandy loam generally occur at slightly higher levels than the silty clay and are therefore somewhat better drained. As with Judson soils, the dark color of the Wabash probably results as much from development of humus in place through the decay of grass roots as from the accumulation of dark-colored alluvium washed from the uplands. Both are contributing factors.

Lamoure silty clay is less well drained than any of the Wabash soils, though not greatly different from Wabash silty clay in this respect. The other chief difference between the two silty clays is that the Lamoure is calcareous throughout, or at least in the lower horizon.

The Cass soils are about as dark as those of the Wabash and Lamoure series but are developed primarily in very sandy alluvium. Cass fine sandy loam is sandy throughout. Cass silty clay loam has a surface horizon about the same as Wabash silty clay loam, but in contrast to the medium-textured subsoils of the Wabash series it has a very sandy subsoil and substratum.

LIGHT SOILS OF BOTTOM LANDS

In this county the light-colored Alluvial soils are made up of younger deposits than those of dark color, though possibly the deposits may not be older than the uppermost few inches of material in the dark-colored soils. The light-colored Alluvial soils have considerably less organic matter and in general have higher water tables than the Wabash soils of that group. Three series are in the light-colored group: (1) Barney fine sandy loam—sandy to very sandy in the substrata and calcareous throughout; (2) Plattsmouth silt loam and fine sandy loam—both calcareous throughout and of medium to moderately heavy texture in the subsoil; and (3) Sarpy soils—sandy to very sandy in texture throughout and generally noncalcareous or only slightly so.

All the soils of this group are subject to occasional heavy flooding by the Missouri River, and every time the river is in flood details of their characteristics are modified to a greater or less extent. A field check made after this soil survey was completed shows that many areas of the Barney, Plattsmouth, and Sarpy soils were considerably different from what they were when mapped, consequently frequently flooded alluvial plains cannot be considered as permanent.

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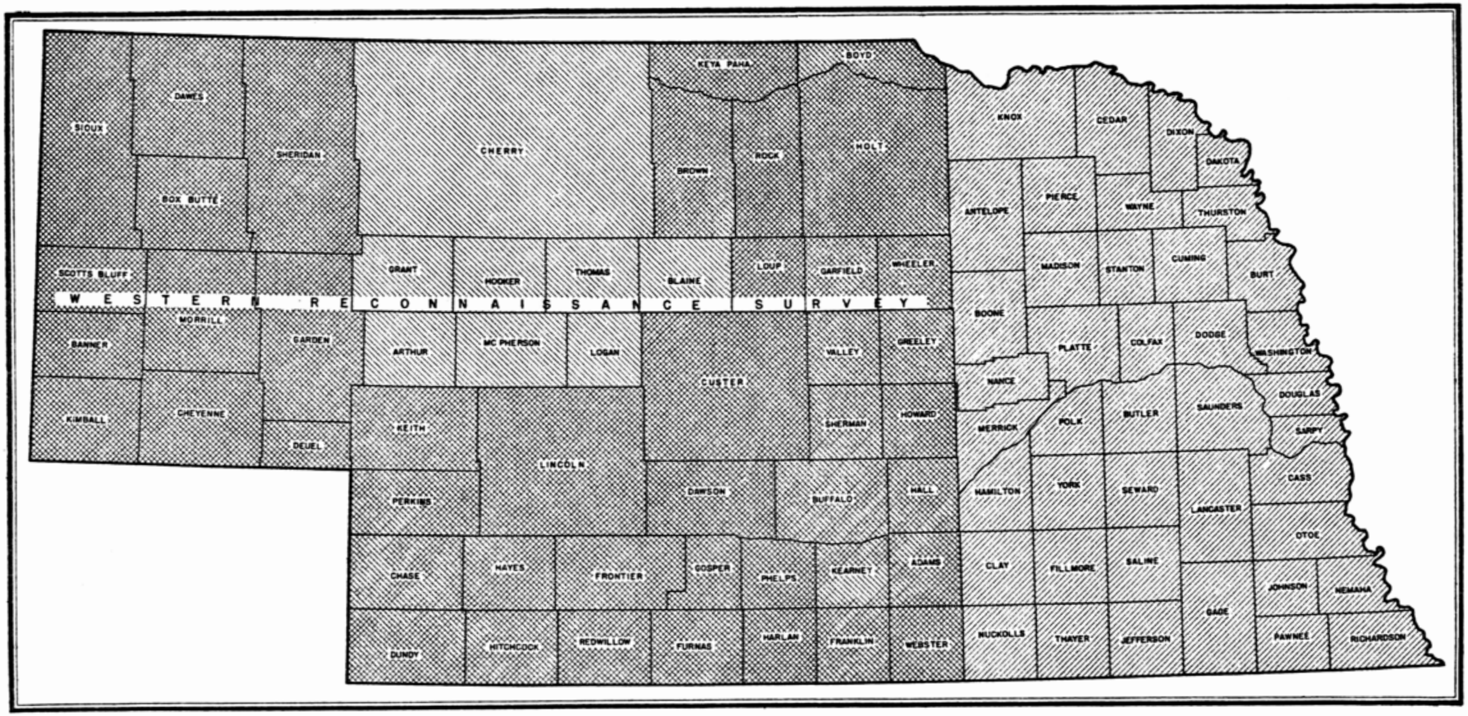

Areas surveyed in Nebraska shown by shading. Detailed surveys shown by northeast-southwest hatching; reconnaissance surveys shown by northwest-southeast hatching; crosshatching indicates areas covered by both detailed and reconnaissance surveys.

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