

SOIL SURVEY OF PALO ALTO COUNTY, IOWA.

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DESCRIPTION OF THE AREA.

Palo Alto County is situated in the northwestern part of Iowa, in the fourth tier of counties east of the State of South Dakota and in the second tier south of the Minnesota State line. It is a square in outline and embraces 16 full townships. It has an area of 561 square miles, or 359,040 acres.¹

Physiographically, Palo Alto County consists of a broad, treeless, drift-covered plain whose surface has been altered very little from its original constructional form by the erosional action of a rather indefinite drainage system. The topography of the greater part of the county is gently undulating to rolling. Throughout the four northeastern townships and those parts of the four southeastern townships lying to the east of the West Fork Des Moines River the topography varies from very gently undulating to rolling. Here the differences in surface configuration are slight, and the country approaches a broad, flat plain with low hills rising here and there to break the monotony of the landscape. West of the river the general topography varies from undulating to rolling, the relief becoming more pronounced as one proceeds west until it culminates in the morainic belt that extends through the four western townships. Throughout this belt the surface is more or less irregular, being made up of a succession of hills and intervening depressions. Many of these low places are occupied by small lakes, and others by Peat deposits that represent the beds of former lakes and ponds. Along the Emmet County line, in secs. 1, 2, 3, 4, and 8, T. 97 N., R. 34 W., the topography is quite rough and broken, many of the hills rising from 50 to 100 feet above the depressions. Here the slopes are steeper and the hill crests sharper than in most of the morainic region. Other small areas having similar rough topography are en-

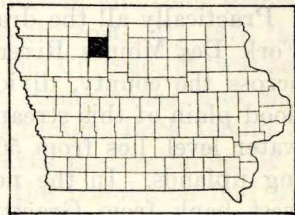


FIG. 32.—Sketch map showing location of the Palo Alto County area, Iowa.

¹ Planimeter measurement. Differs slightly from official figures given by census in table on p. 1138.

countered in secs. 23 and 24, T. 96 N., R. 34 W., in sections 1 and 12, T. 95 N., R. 34 W., and in secs. 30 and 31, T. 97 N., R. 33 W. Narrow strips of rough broken country extend along both sides of the West Fork Des Moines River and Jack Creek in the vicinity of Graettinger. Throughout the county broad first bottoms and here and there second bottoms are developed along the river and the larger creeks, while narrower bottoms occur along all the smaller streams and intermittent drainageways.

In elevation above sea level Palo Alto County ranges from approximately 1,500 feet a few miles north of Ruthven to 1,150 feet where the West Fork Des Moines River leaves the county. The elevation of the greater part of the county, however, varies from 1,200 to 1,320 feet above sea level. The elevation at Ruthven is 1,434 feet, at Graettinger 1,252 feet, at Emmetsburg 1,234 feet, at Cylinder 1,194 feet, and at West Bend 1,203 feet. The prevailing slope is toward the southeast.

Practically all the drainage of the county is carried by the West Fork Des Moines River, which flows in a southeasterly direction across the county, dividing it into two nearly equal parts. The flood plain of this stream, which is some 10 to 25 feet above normal water level, lies from 50 to 100 feet below the level of the adjoining uplands. In the neighborhood of Graettinger and along the west bank from Graettinger to Emmetsburg the river bluff is quite abrupt, with a few draws cutting back into the bordering country, while throughout the rest of its course the banks are not so steep and generally have an even, gentle slope. The river, which varies in width from 30 to 80 feet, has a sluggish flow and meanders back and forth through the bottoms, cutting many channels. Within the last two years a new channel has been cut from Emmetsburg south which will take care of the water and reclaim a large acreage of valuable agricultural land.

The main tributaries of the West Fork Des Moines River are Jack, Silver, Cylinder, Prairie, Beaver, and Pilot Creeks. Formerly these streams had a very sluggish flow, and some were intermittent, but recently the channels have been dredged and straightened in a number of places and the work is gradually being extended. The drainage waters of a small area in the northwest corner flow westward out of the county, finally emptying into the Little Sioux River.

Lack of drainage is the greatest drawback to the full utilization of the soils of the county. Where the surface is more strongly undulating to rolling drainage is generally sufficient, but even here the intervening low places and old pond areas are often without natural outlets. Throughout all other parts of the county there are

numerous depressions, flat areas, and sections having gently undulating topography where natural drainage is either entirely lacking or else poorly established. Large sums of money have been spent both by the county and the individual farmer in straightening and deepening the channel of the river and a number of the creeks, in cutting ditches and laying tile lines. A large number of farms have been thoroughly tiled and drained, and each year a constantly increasing acreage is reclaimed and improved in this way.

There are five lakes in the county, four of them along the western boundary in the morainic belt, named according to size, Lost Island, Medium, Silver, Rush, and Virgin Lakes. Formerly there were a number of small shallow lakes and ponds; these have been drained and the reclaimed land either put in cultivation or left for pasture.

Palo Alto County was created in 1851. Four years later, or in May, 1855, the first settlement was made on the east bank of the West Fork Des Moines River near the present town of West Bend. The early settlers were mostly Irish or of Irish descent and came principally from Illinois and the older country to the east. By 1870 the population had increased to 1,336. In 1878 the Chicago, Milwaukee & St. Paul Railroad was built through to Emmetsburg, and this line was followed four years later by the Chicago, Rock Island & Pacific. The advent of these two roads marks the beginning of a period of rapid development, and by 1890 the population had increased to 9,318. According to the census of 1900 and 1910 the population in those years was 14,354 and 13,845, respectively, showing a decrease of 509 for the decade, which was probably due to the moving out of dissatisfied farmers after the three years' crop failure caused by grasshoppers. The 1920 census gives the population as 15,486, of which 82.2 per cent is classed as rural.

The population of Palo Alto County is made up largely of persons of foreign birth or extraction. The northeast and northwest quarters of the county are inhabited mostly by Norwegians and Danes, with a few Germans around the town of Fairville. Germans predominate in the southeastern part around the towns of West Bend and Mallard, while a large percentage of the population of the southwest quarter is Irish. Throughout other parts of the county the population is mixed, being composed mostly of descendants of the original settlers.

Emmetsburg, situated 2 miles north of the center of the county, is the county seat and largest town, having, according to the 1920 census, a population of 2,762. West Bend with a population of 969, Ruthven with 809, Mallard with 431, Graettinger with 779, Ayrshire with 361, Curlew with 204, Cylinder with 174, Rodman with 158, and Osgood with 75, are the principal towns enjoying railroad facilities. Depew, Fairville, and Fallow are small inland towns.

Transportation facilities are good. A division of the Chicago, Milwaukee & St. Paul Railroad runs practically through the center of the county from east to west, while the Dakota Division of the Chicago, Rock Island & Pacific Railroad crosses it in a general northwest-southeast course, making a junction with the former system at Emmetsburg. A branch of the Minneapolis & St. Louis Railroad runs diagonally across the southwestern quarter of the county, while a small area in the extreme northeast corner is served by the Chicago & North Western.

The county roads are generally good during the summer months. Most of them are well graded and, as a rule, dragged after heavy rains, but owing to the lack of a gravel surface they become very slippery and bad in periods of wet weather and dry out quite slowly. Two State highways cross the county, one from north to south and the other from east to west.

The domestic water supply is obtained from wells which vary in depth from 20 to 150 feet. The shallow wells frequently go dry, but an adequate, lasting supply of water can be obtained at from 80 to 150 feet.

Schools are located at 2-mile intervals over most of the county, and the system compares favorably with that in other sections of the State. In some localities consolidated schools have been built, and the children are transported back and forth in busses during bad weather. The rural schools are open 7 months or more, while the town schools continue 9 months in the year. Churches are conveniently located throughout the county.

Telephones are in general use. A number of the farmers have their homes equipped with electricity, the current being supplied from Emmetsburg. Rural mail routes extend throughout all parts of the county.

Chicago is the principal outside market, although some produce is shipped to Minneapolis and St. Paul.

CLIMATE.

Palo Alto County has a climate that is characterized by rather wide variations in temperature. The winters are long and often very severe, extremes of -20° to -36° F. having been recorded. Mild winter weather with temperature around 54° F. is not uncommon, but periods of this kind are of short duration. The mean annual temperature is 45.4° F., the mean for the winter months being 18° F., for the spring 45.7° F., for the summer 70.5° F., and for the fall 47.4° F. July is generally the hottest month, and extremes of 100° and 104° F. have been reached. However, periods of extremely hot weather do not last long, and the summers are generally cool and pleasant.

Some precipitation occurs throughout the year, but normally two-thirds of the rainfall comes in the months from March to August, inclusive, and crops seldom suffer from drought. In some years planting is hindered by rains, but this is the exception rather than the rule. The mean annual precipitation is 29.62 inches. Hail occasionally injures crops, but the damage is usually confined to relatively small areas. Most of the precipitation in winter is in the form of snow, which is often heavy.

The average date of the last killing frost in spring is April 28, and of the first in fall is October 12. The date of the latest recorded killing frost in spring is May 31, and of the earliest in fall is September 12. The average growing season therefore is a little more than five months, or, to be exact, 166 days.

The following table compiled from the records of the Weather Bureau station at West Bend, located in the southeastern corner of the county, gives the normal monthly, seasonal, and annual temperature and precipitation of Palo Alto County:

Normal monthly, seasonal, and annual temperature and precipitation, at West Bend.

Month.	Temperature.			Precipitation.		
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year (1910).	Total amount for the wettest year (1908).
	°F.	°F.	°F.	Inches.	Inches.	Inches.
December.....	21.8	54	-22	1.23	0.36	0.75
January.....	14.6	52	-36	.93	1.25	.47
February.....	17.5	58	-20	.89	.10	1.12
Winter.....	18.0	58	-36	3.05	1.71	2.34
March.....	30.8	82	-20	1.67	.14	1.62
April.....	47.2	93	14	2.84	.35	2.51
May.....	59.2	92	24	4.00	1.59	6.63
Spring.....	45.7	93	-20	3.51	2.08	10.76
June.....	68.2	100	38	4.17	3.25	9.28
July.....	73.0	104	44	3.56	1.32	3.00
August.....	70.4	98	38	3.89	2.61	6.04
Summer.....	70.5	104	38	11.62	7.18	18.32
September.....	61.6	96	24	3.07	1.68	.57
October.....	48.1	87	12	1.93	.88	3.27
November.....	32.5	72	-5	1.44	.19	1.41
Fall.....	47.4	96	-5	6.44	2.75	5.25
Year.....	45.4	104	-36	29.62	13.72	36.67

AGRICULTURE.

Agriculture in Palo Alto County dates from 1855. The first settlers took up land along the West Fork Des Moines River, growing only subsistence crops, and engaging in trapping and hunting. As settlement advanced cultivation extended to the prairie section, and corn, oats, flax, buckwheat and rye were produced on a larger scale. Milk cows and cattle were kept by most of the farmers, and in 1875 butter to the value of \$50,000 and cattle worth \$100,000 were exported. In 1876 the first agricultural society was organized. The building of the railroads soon after made outside markets more accessible and gave added impetus to the settlement and agricultural development of the county.

The agricultural growth of the county was steady and gradual up to 1900. During the next decade three successive crop failures, the result of devastation by grasshoppers, discouraged many of the farmers and they left the county. This check was only temporary, and soon settlement and development was resumed.

There has been little change in the kinds of crops grown or the character of farming for the last 30 or 40 years. Corn, oats, and flax have been the principal crops, with flax always planted on the sod ground. The extension of the cultivated area in the past was confined mostly to the higher, better drained areas, as it was almost impossible to grow crops successfully on the low ground where water either stood the year around or for long periods after each rain. As drainage conditions were improved much of this low land was tilled and rendered valuable for agriculture. The last five years have been marked by an increased interest in farming.

The following table, compiled from reports of the last five censuses, gives the total population, tenure of farms, number of farms, proportion of total acreage of county in farms, average size of farms, and percentage of improved land per farm :

Population, tenure of farms, number and acreage of farms, and improved land in farms, censuses 1880 to 1920, inclusive.

Year.	Total population.	Farms operated by owners.	Farms operated by tenants.	Farms operated by managers.	Total area of county.	Total farms.	Proportion of total area in farms.	Average size of farms.	Proportion of improved land on farms.	Average improved acreage per farm.
	<i>Number.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Acres.</i>	<i>Number.</i>	<i>Per cent.</i>	<i>Acres.</i>	<i>Per cent.</i>	<i>Acres.</i>
1880...	4,131	87.2	12.8	.....	359,335	573	22.4	141	44.4	62.5
1890...	9,318	79.11	20.89	.....	359,335	1,139	56.0	177	61.1	108.9
1900...	14,354	60.1	39.6	0.3	359,335	1,661	95.3	206.2	95.4	196.78
1910...	13,854	50.7	48.3	1.0	359,335	1,607	90.3	201.9	89.1	179.9
1920...	15,486	45.0	54.3	0.7	359,040	1,815	93.1	184.2	86.6	159.6

The population of Palo Alto County showed an increase of 125.5 per cent from 1880 to 1890, while the total number of farms increased 98.7 per cent. During this period the number of farms operated by owners decreased and the number of tenants increased. For the next 10 years the population and total number of farms showed an increase of 54.04 per cent and 45.8 per cent, respectively. More acreage was reclaimed and put in cultivation each year, the 1900 census showing the size of farms to be 206.2 acres, with 95.4 per cent improved land. From 1900 to 1910 the population decreased 509, and the total number of farms 54. The farms operated by tenants increased from 39.6 per cent in 1900 to 48.3 per cent in 1910. From 1910 to 1920 the population increased 1,632, and the total number of farms 208. Farms operated by tenants increased from 48.3 per cent to 54.3 per cent. This was probably due to the movement of owners from the farms into the towns of the area.

The following table, compiled from the same source as that preceding, shows the changes in value of farm property for the same period:

Value of farm property.

Year.	Per farm.						Per acre.
	All prop- erty.	Land.	Build- ings.	Land and buildings.	Imple- ments.	Domestic animals.	Land values.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Dollars.</i>
1880.....	\$2,579.85	.....	.....	62.9	7.4	29.7	.....
1890.....	4,491.16	.....	.....	74.6	4.5	20.9	.....
1900.....	7,928.42	71.2	10.8	.....	3.4	14.6	27.37
1910.....	16,530.32	76.2	11.3	.....	2.7	9.8	62.36
1920.....	46,447.00	80.9	9.5	.....	3.6	6.0	203.96

From this table it appears that the value of all property increased 74.8 per cent from 1880 to 1890; 76.4 per cent from 1890 to 1900; 108.4 per cent from 1900 to 1910; and 181 per cent from 1910 to 1920. This increase has resulted mainly from the phenomenal rise in the price of farms, which was particularly marked in the final decade, the per-acre value of land showing an increase of \$141.60 from 1910 to 1920.

The table below, showing the total acreage and production of the most important crops, was compiled from the census reports of 1880 to 1920.

Acreage and production of principal crops.

Year.	Corn.		Oats.		Barley.	
	<i>Acres.</i>	<i>Bushels.</i>	<i>Acres.</i>	<i>Bushels.</i>	<i>Acres.</i>	<i>Bushels.</i>
1879.....	16,505	540,504	4,403	148,215	826	13,919
1889.....	43,081	1,400,984	24,311	925,184	1,858	49,157
1899.....	78,668	2,566,666	61,071	1,907,590	10,269	253,950
1909.....	73,783	2,332,169	61,134	1,470,241	985	15,557
1919.....	95,390	3,393,901	87,235	2,923,546	1,464	28,115

Acreage and production of principal crops—Continued.

Year.	Flaxseed.		Wheat.		Tame hay.		Wild hay.	
	<i>Acres.</i>	<i>Bushels.</i>	<i>Acres.</i>	<i>Bushels.</i>	<i>Acres.</i>	<i>Tons.</i>	<i>Acres.</i>	<i>Tons.</i>
1879.....		2,617	4,019	37,646			19,353	38,238
1889.....	6,326	60,740	3,194	50,810			73,231	95,980
1899.....	4,578	45,010	15,291	165,370	16,884	21,754	56,599	72,825
1909.....	429	2,985	536	7,143	22,399	28,631	35,174	44,498
1919.....	648	4,282	1,273	16,052	16,937	21,066	20,720	23,305

The yields of corn per acre for the four census periods were practically the same, averaging 32 bushels, but in 1920 it was 35.6 bushels per acre. This may have been due to seasonal conditions, but improved drainage and better cultivation probably influenced the results to some extent. The oat acreage has increased steadily from year to year, but the yields have fluctuated all the way from 24 bushels per acre in 1909 to 35.5 bushels in 1920.

The agriculture of Palo Alto County to-day, as in most of the prairie region of the State, consists principally of growing grain for sale and home use, hog raising, the raising and feeding of a few beef cattle, dairy farming, and the growing of vegetables for home use. Corn is the crop of first importance, with oats a close second, followed by flax, barley, and wheat, named in the order of their respective acreages. Rye, buckwheat, potatoes, timothy, clover, and truck crops are also grown to some extent.

Corn occupies the largest acreage and is the principal cash crop. According to the 1920 census, 95,390 acres were in this crop in 1919, from which there was harvested 3,393,901 bushels, or an average yield of 35.6 bushels per acre, as compared with 35 bushels for the State, and 24.3 bushels for the United States. Some corn is grown each year for ensilage, and the fodder and a large part of the grain is utilized for feeding the work stock, hogs, and cattle on the farm. The rest is either sold to the elevators in the county, who in turn ship it to outside markets, or else it is shipped direct by the grower. Chicago is the principal market.

The acreage of oats in 1919 was 87,235 acres, and the production 2,923,546 bushels. This crop finds an important place in the rotation on practically every farm in the county. Most of the oats is fed on the farm, the rest, approximately one-third of the crop, being sold to the elevators and shipped to outside markets.

Flax is considered an important crop. It is always planted on sod ground, and is used the first year on reclaimed swamp and bottom land. The report quoted above gives the area in flax in 1919 as 648 acres, on which there was produced 4,282 bushels. All the grain is thrashed and shipped out of the county. Minneapolis is the principal market for flaxseed.

Barley is grown on a number of farms each year. Most of the crop is fed to hogs, although a small proportion is sold at the local elevators. In 1919 1,464 acres planted to this crop produced 28,115 bushels.

Wheat is not an important crop. In 1919 there was 1,273 acres in this crop, from which the harvest was 16,052 bushels. The grain is all sold and shipped to Chicago.

Timothy, the leading cultivated hay crop, is grown alone or with clover. Where sowed with clover it does not attain its maximum yield until the second year. The general practice is to sow a mixture of timothy and clover, timothy predominating, with oats as a nurse crop. In the year of harvesting the oats the clover is pastured, and hay is obtained from the timothy for several years following. As reported in the 1920 census, 4,888 acres were devoted to timothy alone, and 10,458 acres to timothy and clover mixed, producing 5,742 tons and 13,067 tons, respectively. Practically all the hay is used for feeding the work stock and cattle on the farm, only a small part being shipped.

A small area is devoted to clover alone, the census of 1920 reporting 564 acres with a production of 725 tons. Red clover is generally planted with oats as a nurse crop. As in the case of clover and timothy mixed, the clover gives some pasture the same year that the grain is harvested. The general practice is to cut the clover twice for hay the following year, although a few cut once and turn the sod under as a manuring crop. This practice is recommended and should be more generally followed. All the hay is used on the farms in feeding the work stock and beef cattle.

Wild hay is grown on quite a large acreage in the county, nearly all of the river-bottom land and poorly drained areas along streams being devoted to it. In 1919 23,305 tons were cut from 20,720 acres. Nearly all this crop is baled and shipped to various points throughout the State and to Chicago.

Irish potatoes were grown on 726 acres in 1919, the production being 27,567 bushels. Small patches are found on nearly every farm. The entire crop is used within the county and supplies only a part of the local demand.

A small acreage is devoted to pop corn. Most of this product is used locally. Rape is often sown between the rows of corn at the last cultivation and used for pasturing hogs. A number of large fields were observed during the progress of the survey. Small fields of rye are often planted for early pasture, although the crop is sometimes thrashed. Apple orchards are maintained on most farms, but as the trees are rarely sprayed or properly cared for, results are poor. Sweet corn, millet, sorghum, strawberries, and all kinds of garden truck are grown to help supply the local demand. Sugar beets do

well, but the absence of a market prevents the crop from being a profitable one.

Hogs are raised on every farm, and constitute the principal live stock, the census of 1910 reporting 32,290 sold or slaughtered. The 1920 census reports 63,571 head of hogs in the county, with a total value of \$1,413,093. The number of hogs per farm varies from 60 to 100 head. There are a few breeders of pure-bred stock, as well as a few who raise and feed hogs on an extensive scale. The hogs, after those needed to supply the home and the local market have been withdrawn, are shipped either by the grower or else by buyers to the Chicago market. The most popular breeds are the Duroc-Jersey, Chester White, Poland-China, and Hampshire.

There are in the county eight cooperative dairies, which devote their entire time to butter making. The census of 1920 reports the income derived from the sale of dairy products, exclusive of home use, at \$435,971. Most of the butter is shipped out, some of it going to the United States Navy at New York City. Usually the dairy herds contain from 6 to 20 cows. Holstein and Jersey cattle are preferred, although grades of these are most common. Many of the farms are equipped with silos, the dairying being of the all-year type.

Some feeders are shipped into the county each year, but this is not a universal practice. These cattle are bought on the Omaha and Sioux City markets, fed a few months, and then shipped to Chicago. On a number of the farms small herds are maintained, and a few fat animals sold each year to buyers. The census of 1920 reports a total of 21,095 head of beef cattle in the county, with a value of \$1,026,872. The favorite breeds are the Shorthorn and Aberdeen Angus.

According to the census of 1920 the value of wool, mohair, and goat hair sold was \$12,646. There were 4,622 sheep and 11 goats in the county January 1, 1920. At present only 5 per cent of the farmers have flocks of sheep. Some western sheep are bought and turned into the cornfields to forage till cold weather, and then sold and shipped.

The poultry industry is developed in a small way on nearly every farm and is a source of considerable income. The value of poultry and eggs produced in 1919 amounted to \$578,283.

The farmers of Palo Alto County recognize only in a general way the adaptability of crops to soils. They know that corn and small grain give the best average yields in the Clarion and Webster soils. The O'Neill loam and fine sandy loam produce good crops in wet seasons but very poor ones during dry years. The Cass, Lamoure, and Wabash soils, when well drained and reclaimed, are recognized as well adapted to corn, but the crop is always preceded by flax on sod ground. A large acreage of the Cass loam and silt loam, Lamoure

silty clay loam, and Wabash silty clay is devoted to natural pasture and wild hay. Grass grows rank, owing to the natural richness of the soil and the high moisture content. Rye gives better results than any other small grain crop on Peat.

In growing corn after small grain or on sod, the land is plowed from 3 to 6 inches deep in the fall, and the following spring is thoroughly disked and harrowed. Where corn succeeds itself the stalk land is pastured during the winter, then thoroughly disked, plowed, and harrowed before planting. Sometimes the land is well disked and the corn planted without replowing. Corn is generally planted in $3\frac{1}{2}$ -foot checkrows, although a small amount is drilled in each year. Planting is done from May 5 to 25, and the crop receives from three to five cultivations, the first deep and the rest shallow. Most of the corn is husked in the field, a small acreage is harvested with a binder, and a further small acreage is cut green for ensilage. Oats generally follow corn, the seed being sown and the land then thoroughly disked and harrowed. Where the crop is drilled, the ground is well disked before sowing and harrowed afterwards. Red clover and timothy are generally seeded with oats.

Farm dwellings are for the most part of an ordinary type, though there are some fine houses in different parts of the county. In contrast to the houses are the barns, which are large and substantial, many of them with stone foundations and of hollow-tile or brick construction. Silos are found on a number of farms. The fences are generally good and consist mostly of hog-tight woven wire. The work stock consists of medium to heavy draft horses and a few mules. The farm machinery in general use includes disk harrows, 14 and 16 inch plows, harrows, riding cultivators, mowing machines, hay rakes, corn and small grain binders, hay loaders, manure spreaders, and planters. Windmills are in general use. Small gas engines, used for pumping water and running machines of various kinds, are found on most farms. Several thrashing outfits are owned in the county. On many farms gasoline tractors supply power for plowing and other work. Gang plows pulled by four or six horses are in general use.

Crop rotations are in more or less common use. One system employed rather generally consists of corn 3 to 5 years, oats 1 year, and timothy and clover 2 years. Farmers of the most progressive type do not leave the land in corn so long, rotating the crops as follows: Corn 2 years, oats 1 year, followed by red clover, which is seeded with the oats. After the oats are harvested the clover remains and the second year is cut once for hay and the later sod is turned under.

So far the soils of the county have not required applications of commercial fertilizers. The census of 1920 reports their use on only 18 farms, the total amount expended being \$2,587, or \$143.72 per farm.

Most of this was on ground rock phosphate and acid phosphate. Stable manure is used wherever it is available, and on most farms the supply is carefully husbanded. The practice of liming is not at all common.

Owing to the great number of farmers called to war and to the attraction of high wages in industrial centers, farm labor is at present (1918) somewhat scarce. In 1910, when conditions were more nearly normal, 710 of the 1,607 farms in the county employed labor at an average expense of \$193.91 per farm. The 1920 census reports 1,111 farms employing labor with a total expenditure of \$474,165, or an average of \$426.80 per farm. In 1918 farm laborers were receiving from \$2.50 to \$4 a day, or from \$50 to \$60 a month. In the latter case the laborer, if married, is given the use of a house and supplied with firewood. During the husking season the laborers receive so much per bushel in addition to their board and lodging.

The farms range in size from 50 acres to 500 acres, the average in 1920 being 184.2 acres. Of the land in farms 86.6 per cent is improved. In the matter of tenure, 45.0 per cent of the farms were operated by owners, 54.3 per cent by tenants, and 0.7 per cent by managers. Leases usually run for periods of 1 and 3 years. Most of the tenanted farms are operated on shares, the owner usually receiving two-fifths to one-half of the corn, two-fifths of the small grain, but in many cases from \$5 to \$7 per acre is paid for land not in crops. Farms rented for cash bring from \$7 to \$9 an acre.

According to the census of 1920, 93.1 per cent of the county was in farms. The average value per acre was \$203.96. Values vary greatly according to location, drainage, topography, and the condition of the improvements. Along the river, where drainage is poor, the price per acre ranges from \$75 to \$125, while in other sections, where the physical condition is better and the land improved, the range is from \$175 to \$200. Well-improved farms near the principal towns of the county have recently (1918) sold for \$210 to \$250 an acre.

SOILS.²

Palo Alto County lies within the boundaries of the last invasion of the great ice sheet that reached Iowa. With the advance and retreat of the ice great quantities of heterogeneous material were brought down from regions farther north and deposited in a thick layer of

² Palo Alto County adjoins Clay County on the west. In certain cases the soil names do not agree along the boundaries. This is due to changes in correlation resulting from a fuller knowledge of the soils of the State. The types mapped with the Clarion series were in Clay County classed with the Carrington series. One area on the boundary mapped as Carrington silt loam has been included with the Webster silt loam in this area on account of its small extent. The Shelby loam of Clay County has in this area been called Clarion loam, gravelly subsoil phase.

glacial till. The forces of nature acting on this mantle have given rise to the present soils, which are separated on the basis of origin and process of formation into the following divisions: 1, Soils derived from glacial till; 2, terrace or ancient alluvial soils; 3, lake-bottom soils; 4, recent alluvial or river-flood plain soils; and 5, soils derived from organic accumulations.

The soils derived from glacial till occupy practically 80 per cent of the total area of the county. Since the deposition of this material the county has been subjected to more or less erosion, which has resulted in differences of surface configuration, varying from gently undulating to rolling, with a few strongly rolling areas in the northwest corner. In the western part of the county the materials and topography indicate a morainic origin.

The glacial drift varies in thickness from a few inches to 80 feet or more, the depth being less on the hill crests, where erosion has been more active. This material is a part of the Wisconsin drift, which in this part of Iowa is characterized by a large proportion of limestone. The material consists of a heterogeneous mixture of boulders, sand, silt, and clay. The larger fragments are mainly of granite, limestone, or quartzite. A few large limestone boulders occur, but the principal part of the limestone, as in the unweathered drift, is present in a finely ground state. The large proportion of lime-bearing rocks in the original drift is indicated by the highly calcareous composition of the unweathered material. The subsoils throughout the drift area usually give a reaction with hydrochloric acid at a depth of 30 inches or less. Surface boulders are present on the lower gentle slopes and throughout flatter areas. They measure in many instances 3 to 4 feet in diameter.

The drift has been converted into its present state as a productive soil by the processes of weathering and by the accumulation of organic matter in the surface soil. The most noticeable changes due to weathering that have taken place are the slight accumulation of clay in the upper subsoil and the leaching and partial removal of lime from the weathered upper zone. On the more level upland areas weathering in a more advanced stage, under conditions of imperfect drainage, has resulted in a mottling of the lower subsoil. The factors which have favored the accumulation and retention of the organic matter, which imparts the black color to the surface soil, are a prairie condition with abundant vegetation, an adequate amount of lime, and a moderately heavy rainfall.

The glacial soils, separated on a basis of color, topography, and drainage, are included in the Clarion and Webster series.

The surface soils of the types included in the Clarion series are dark brown to black. The upper subsoil grades downward from a

dark brown into a brown, and the texture is heavier than that of the surface soil, usually a silty clay loam. The lower subsoil is a grayish brown to gray, approaching the color of the glacial drift from which it is derived. This is sufficiently calcareous to effervesce with acid, and streaks of lime and lime concretions are common. The Clarion fine sand, fine sandy loam, and loam, the latter with a gravelly subsoil phase, are mapped.

The Webster series includes types with dark-brown to black soils, underlain by grayish-brown to brownish-gray subsoils. Like the Clarion series, it is derived from the weathering of the underlying drift, but differs from it in having a more level or gently undulating topography and in being less well drained. The subsoils are generally calcareous. The Webster loam, silt loam, and silty clay loam are the only types mapped.

The deposits which form the terrace or more ancient alluvial soils were laid down when the present river valley and larger drainage ways served as outlets for the glacial waters. As these waters receded and reached present levels new and narrower channels were cut, leaving the old flood plain some 3 to 5 feet higher. These soils are classed with the O'Neill series.

The O'Neill series includes types with dark-gray, dark-brown, or nearly black soils and light-brown subsoils resting upon a substratum of sand and gravel. The soils are derived, through weathering, from terrace material or the deposits in glacial outwash plains, and the topography varies from nearly level to very gently sloping. Two types occur in the county, the O'Neill loam and fine sandy loam.

The lake bottom soils were formed from material that was transported from the surrounding country and deposited in shallow lakes. These lakes have since been drained and the beds reclaimed. Only two such areas have been mapped, and the soils were correlated with the Rogers series.

The types included in the Rogers series have gray to brown soils and gray or drab, highly calcareous, subsoils. They occupy poorly drained stream valleys and depressions, principally in glaciated semiarid regions.

Recent alluvial or river flood plain soils are formed of materials transported from the glacial uplands, reworked and deposited by the streams during periods of overflow. Included with this division are many depressions and old pond areas throughout the uplands where drainage is either entirely lacking or else poorly defined. The alluvial soils are classed with the Lamoure, Cass, and Wabash series.

The soils of the Lamoure series are dark brown to black, and the subsoils yellowish brown to gray, dark drab, or mottled gray and

brown. The series represents material that has been washed from calcareous soils and deposited along the courses of streams. Often this material has weathered where there is a low rainfall, and the resulting soils themselves are calcareous. Overflows occur at intervals. The Lamoure silty clay loam is the only type of the series mapped in Palo Alto County.

The Cass series comprises types with dark-brown to black soils, underlain by yellowish-brown to grayish-brown or brown subsoils. A substratum of loose sand or gravel is normally present at depths of 2 feet or more. The soils are developed in the first bottoms and are subject to overflow. Two types, the Cass loam and silt loam, are mapped.

The Wabash soils are prevailingly dark brown to black, and the subsoils dark drab to gray and quite heavy. The surface material is generally rich in organic matter, and both soil and subsoil are non-calcareous. The soil represents material that has been washed from the glacial and loessial soils of the Central Prairie States and deposited along the first bottoms of streams. The soils are subject to overflow. One type, the Wabash silty clay, has been mapped.

Soils formed principally of organic matter occupy the beds of numerous shallow lakes, ponds, and depressions scattered throughout the county. These have supported a luxuriant growth of water-loving plants for years, and the soil represents the remains of these plants with an admixture of a little mineral material. Conditions have been favorable for the preservation of these remains, and the result is a mass of material ranging from brown fibrous Peat showing more or less the structure of the plants to a more thoroughly decomposed material in which all trace of such original structure has been lost. The latter soil is what is known as Muck.

The following table gives the actual and relative extent of the various soils mapped in Palo Alto County:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Clarion loam	132,992	37.7	Webster silt loam	6,272	1.7
Gravelly subsoil phase	2,624		O'Neil fine sandy loam	6,144	1.7
Webster loam	100,352	28.0	O'Neill loam	5,888	1.6
Lamoure silty clay loam	51,648	14.4	Cass silt loam	5,312	1.5
Wabash silty clay	13,632	3.8	Clarion fine sand	576	0.2
Cass loam	12,736	3.6	Rogers silt loam	512	0.1
Webster silty clay loam	9,984	2.8	Clarion fine sandy loam	448	0.1
Peat and Muck	9,920	2.8			
			Total	359,040	.....

CLARION FINE SAND.

The Clarion fine sand consists of a light-brown to grayish-brown fine sand, 18 to 20 inches deep, underlain by a yellow loose-textured fine sand.

Less than 1 square mile of this type occurs in Palo Alto County. It lies east of the West Fork Des Moines River as a narrow strip where the uplands break to the river bottoms. The largest body is found between Emmetsburg and Osgood. The areas lie 20 to 30 feet above the level of the river flood plains, and drainage is good. The surface is gently undulating to rolling.

All the type is under cultivation. The crops grown are corn, oats, wheat, and clover, the largest acreage being in corn. The land is farmed with adjoining areas of Clarion loam and is handled in practically the same way as the latter soil. The crop yields, however, are slightly less.

Owing to the heavy substratum, in most places lying at from 3 to $4\frac{1}{2}$ feet below the surface, the type is fairly retentive of moisture. It is sufficiently porous, however, to allow water to pass down readily, and during long dry spells crops are likely to suffer. It can be plowed under a wide range of moisture conditions. The soil warms up early in the spring, and the planting and maturing of crops are therefore in advance of those on the Clarion loam.

Suggestions for the improvement of the Clarion loam apply equally well to the Clarion fine sand. The incorporation of more organic matter is very essential. The type is always sold in connection with the Clarion loam, but is not considered as valuable.

CLARION FINE SANDY LOAM.

The surface soil of the Clarion fine sandy loam is a dark-brown fine sandy loam extending to a depth of 8 to 10 inches. This rests upon a grayish-brown, rather compact fine sandy loam, which grades below 24 inches into either a light-brown fine sand or a grayish-yellow silt loam resembling the subsoil of the Clarion loam. Unless the lower subsoil is very sandy it is highly calcareous at a depth of less than 30 inches.

This type is important in Clay County, where it occurs in many scattered bodies with a total area of more than 20,000 acres, but only small areas of it reach the county line and they extend only a short distance into Palo Alto County. The type gradually changes in texture toward the east and merges into the Clarion loam. Several areas of the fine sandy loam have been included with the loam on account of their small extent and slight difference in texture.

The type occurs on low ridges and hills, and drainage is everywhere good. About 80 per cent of the type is cultivated, the re-

mainder being in pasture. The same crops are grown as on the Clarion loam, and the yields on the two are about the same, the textural difference being slight.

CLARION LOAM.

The surface soil of the Clarion loam consists of a brown to dark-brown mellow loam, 16 to 20 inches deep. The content of silt, fine sand, and medium sand is sufficiently high to render the soil friable and free from stickiness, even when wet. The subsoil is a grayish-brown to grayish-yellow heavy fine sandy loam to clay loam. Faint gray mottlings or a solid gray color are not uncommon in the lower subsoil, and this color is that of the original unweathered drift. In the vicinity of Fairville and Depew, as well as near Lost Island and Virgin Lakes, the surface soil has a lighter color, and in places approaches a very fine sandy loam in texture. Throughout the morainic belt, which forms the four western townships, the surface soil is a lighter brown to brown loam, 12 to 18 inches deep, underlain by a friable clay loam to fine sandy clay loam. Some boulders, stones, and gravel often are encountered on the surface and throughout the soil section. Where the surface is more strongly rolling the soil covering is shallower and the gray glacial till is often encountered within the 3-foot section. The lower subsoil is nearly everywhere sufficiently calcareous to effervesce with acid. Included with the type are small areas of Clarion loam, gravelly subsoil phase, and Clarion fine sandy loam too small to separate on the map.

The Clarion loam is the most extensive of the soils of Palo Alto County. It is typically developed in all parts of the county. In the northeast quarter it is developed as comparatively small disconnected bodies, in the southeast quarter it occupies about half the uplands, while in the western half it forms practically 90 per cent of the total upland area.

The topography ranges from undulating to rolling, with a few strongly rolling areas in the neighborhood of streams and lakes. Throughout the northern part of the extreme northwest township, especially along the Emmet County line, the surface is rolling to strongly rolling. The greater part of the type is from 1,210 to 1,430 feet above sea level. The land of this type is all well drained.

This is agriculturally one of the more important soil types as well as the most extensive; practically all of it is in cultivation or pasture. It is typically a prairie soil, and the forested areas are confined to windbreaks that have been planted on the north and west sides of dwellings, and to a few small belts of maple, willow, ash, walnut, cottonwood, and oak, along the river.

Corn, oats, and hay are the most important crops on this soil. Corn occupies the largest acreage and is the principal cash crop, but part

of it is fed to the work stock, hogs, and cattle on the farm. Oats and hay rank second and third in point of acreage. A large part of these crops is fed on the farm to the work stock, beef cattle, and dairy cattle, and the rest is sold. Fields of rape were observed during the progress of the survey. The rape is generally planted between the rows of corn at the last cultivation, and after the corn is husked is used as hog pasturage. Barley, rye, wheat, millet, sorghum, apples, and all kinds of garden truck are grown by most of the farmers for home use and to supply the local demand. A small amount of the barley and rye and all of the wheat is sold and shipped out of the county. Alfalfa is grown on a few farms, and the results would indicate that the acreage in this crop could be profitably extended. No special crops are grown.

The crop yields³ on the Clarion loam are—corn, 35 to 60 bushels per acre, with the average around 36 bushels; oats, 35 to 60 bushels; wheat, 15 to 25 bushels; barley, 20 to 35 bushels; and hay, 1 to 1½ tons.

The main live-stock industries are the raising of hogs, the feeding of a few beef cattle, and dairying. Several farmers raise hogs on a very extensive scale and ship in carload lots direct to market. There are some purebred hogs in the county. Dairying is conducted on a cooperative plan, the farmers generally keeping from 6 to 20 milk cows. A few small flocks of sheep are kept, and in addition western sheep are often shipped in, fed a few months, and sold.

The Clarion loam is easily cultivated, the content of fine sand, medium sand, and silt being sufficiently high to make plowing and handling possible under a considerable range of moisture conditions. The soil is naturally rich in organic matter, and by the use of systematic crop rotations and proper methods of cultivation it can easily be maintained in a high state of productiveness. The farmers of the county practice a rather broad general system of crop rotation, in that they grow corn for a varying term of years, after which oats are grown one year, and timothy and clover one or two years. A rotation in use by the more progressive farmers consists of corn 2 years, oats 1 year, and clover 1 year. A very small amount of acid phosphate and ground rock phosphate has been used. Stable manure is carefully saved and applied to the fields.

The value of farms located on the Clarion loam ranges from \$155 to \$250 an acre, depending upon the location and condition of improvement. Some land of this type situated within a few miles of Emmetsburg recently (1918) changed hands for a consideration of \$210 and \$250 an acre.

The Clarion loam is naturally a rich, productive soil, and the yields should be much higher than are now obtained. The practice

³ The crop yields are based on information obtained from the farmers.

of cropping to corn, or corn and oats alone, without the use of clovers and legumes as green manuring crops, soon exhausts the supply of organic matter and reduces the productiveness of the land to such an extent that it requires years to restore it to its naturally productive state. A more thorough preparation of the seed bed and a gradual increase in the depth of plowing until a tilth 8 to 11 inches is obtained, will allow the soil to take up a large amount of water without detriment to the crops, and act as a reservoir for moisture during dry years.⁴ Systematic crop rotations in which the clovers and legumes play an important part should be used. A rotation that is recommended and should give excellent results is, corn 2 years, oats 1 year, and clover 1 year.

Clarion loam, gravelly subsoil phase.—The surface soil of the Clarion loam, gravelly subsoil phase, consists of a light-brown to brown light-textured loam, 7 to 9 inches deep, underlain by a pale-yellow to brownish-yellow fine sandy loam to fine sandy clay loam subsoil faintly mottled with gray. Some gravel is scattered through the subsoil, the quantity increasing with depth. On the crests of the sharper, higher hills, where erosion has been more active, the surface layer is shallower, and the parent glacial till is in many places encountered within the 3-foot section. The content of fine sand is in places relatively large in the surface soil, and the phase includes small areas of fine sandy loam texture.

This phase of the Clarion loam occurs as small disconnected areas confined to the crests of the sharper ridges in the rougher sections of the county. The topography varies from rolling to strongly rolling. The drainage is good to excessive.

The total extent of the phase is small, and it is not of great importance. The type is natural prairie and grasses make a fair growth. Owing to the character of the surface the largest part is left in an uncultivated state and used as pasture.

The cultivated areas of the phase occupy the more even slopes and rounded hill crests. They generally are farmed in conjunction with the typical Clarion loam, but the yields are lower than on the latter.

The phase is subjected to severe erosion. Contour plowing should be practiced and cover crops should be maintained wherever possible to prevent loss from this cause. The type can be improved by the use of the methods suggested for the typical Clarion loam. The soil is deficient in organic matter, and green manuring crops, preferably the legumes, should be grown and turned under. The excellent condition of a few fields of red clover would indicate that the growing of this crop could be profitably extended.

⁴ Iowa Agricultural Experiment Station Circular No. 10.

WEBSTER LOAM.

The surface soil of the Webster loam is a very dark brown to black heavy loam, 15 to 18 inches deep, containing a high percentage of organic matter. The subsoil is a grayish-brown to drab silty clay mottled with gray, brown, and yellow. Iron stains are common in the lower part of the profile. In a number of areas there is a zone of transition between 18 and 22 inches, in which the material consists of a dark-brown to almost black heavy loam to silty clay loam. Where the surface is more gently undulating the content of clay is slightly higher than in areas of more pronounced relief, and is more sticky when wet.⁵ Included with the type are small bodies of Webster silt loam and silty clay loam too small to separate on the map.

Most of this type is found in the northeastern part of the county, although small bodies are scattered throughout other sections. The surface of the type is very gently undulating to gently rolling and occupies a position lower than the Clarion loam. The more level to gently rolling topography and the heavier texture of the subsoil have resulted in poorer drainage conditions and the accumulation of a larger amount of organic matter. The tiling of much of this type has improved its physical condition and increased the yields.

In extent and agricultural importance this soil type ranks second in the county. It is highly prized and all devoted to farming. It is natural prairie, the only tree growth consisting of a few maples, ash, cottonwood, elm, and Lombardy poplars, which have been planted on the north and west sides of farm dwellings to serve as windbreaks.

Corn, oats, and hay are the principal crops, and by far the largest acreage is in corn. After supplying the needs of the farm, the surplus corn and oats are sold to the local elevators. All the hay, which consists principally of clover or clover and timothy mixed, is fed to the work stock, beef cattle, and dairy cows. Silos are in general use, and a considerable acreage of corn is cut each year for ensilage. Small acreages of wheat, rye, flax, barley, millet, sorghum, and rape are grown. The wheat and flax are all sold for shipment out of the county. Rye is grown principally for early spring pasturage, although some is thrashed and sold each year. The barley, millet, and rape are used on the farm for feeding stock, rape being sown with the corn and pastured by hogs. Some of the sorghum is made into sirup. The principal live-stock industries are the raising of hogs, the raising and feeding of cattle, and to a limited extent dairying. Gardens are planted by all farmers for home use.

Under ordinary conditions corn yields 35 to 40 bushels per acre, although returns of 89 to 90 bushels are often obtained on the best

⁵ One-half mile north of Osgood a small area resembles closely in appearance a high terrace. Had this spot been sufficiently large it could have been separated and correlated as the Waukesha loam.

farms in favorable years. Oats yield 35 to 50 bushels, wheat 10 to 20 bushels, barley 18 to 30 bushels, and hay 1 to 1½ tons per acre.

The Webster loam is handled in very much the same way as the Clarion loam, although it can not be worked under such a wide range of moisture conditions. When wet it is inclined to clod, but when neither too wet nor too dry it works up into a friable, mellow seed bed. Definite crop rotations, in which clover is introduced as a green-manure crop, are in use on the best farms. Barnyard manure is generally saved and applied to the land.

The price of land of the Webster loam type varies from \$155 to \$200 an acre, depending upon the improvements, the state of drainage, and the location with reference to towns and railroads.

Deeper plowing wherever practicable is very essential, as a deep, well-cultivated seed bed not only conserves moisture better but is able to absorb heavier rainfalls without waterlogging. Ditching and tiling of the flatter, more poorly drained areas is necessary for best results. More consideration should be given to crop rotation and the introduction of systems providing for the growing of clovers. Preferably the clover should be cut once for hay and the succeeding growth turned under as green manure.

Care should be exercised in selecting seed that is adapted to the needs and conditions found in this county. The comparatively short growing season demands an early maturing corn, and the two varieties that give best results are the Silver King and Minnesota No. 13. The Wimples Yellow Dent also is grown extensively but is frequently caught by early frost. Great trouble has been experienced in the past from the lodging of oats on this type, but this is now largely avoided by planting Iowa 105, a yellow oat, and Iowa 103, a white oat, both of which are especially adapted to rich lands. These varieties were originated by the Iowa Agricultural Experiment Station.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of the Webster loam:

Mechanical analyses of Webster loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
332718.....	Soil.....	1.6	5.1	4.6	23.7	9.4	43.2	11.9
332719.....	Subsoil.....	1.6	4.6	4.6	22.1	13.5	40.1	13.4

WEBSTER SILT LOAM.

The Webster silt loam consists of a black, heavy silt loam, 8 to 12 inches deep, underlain by a black silty clay loam to silty clay, which grades at 22 to 24 inches into a mottled yellow, gray, and brown

plastic silty clay, typically calcareous. Numerous iron stains are present in the subsoil. The surface soil contains a relatively large quantity of organic matter, and in virgin areas the surface material to a depth of 1 or 2 inches consists of a black slightly fibrous Muck. The type is free from gravel, but in many places boulders are embedded within the soil mass or protrude above the surface. About 10 square miles of this soil occurs in the county. The largest connected body lies along the county line east of Cylinder. The rest of it occurs in small disconnected areas. The areas occupy a position slightly higher than the adjoining Lamoure soils. Although of different origin, the Webster residual and the Lamoure alluvial, the two soils are similar in appearance, and the determination of boundaries is difficult. The topography is flat to gently sloping, and natural drainage is poor.

The Webster silt loam is relatively unimportant, as only a few small areas, which have been artificially drained, are in cultivation. The larger part of the type is in its natural state and supports a luxuriant growth of wild grass; most of this area is cut for hay, which is fed on the farms. A small number of steers and a few milk cows are pastured. Corn and oats are the principal crops. Very small acreages are in barley, flax, and rye. Corn yields 30 to 40 bushels per acre and oats 35 to 45 bushels.

The Webster silt loam is handled in practically the same way as the Webster loam and silty clay loam. Stable manure and commercial fertilizers are never used. The methods suggested for the improvement of the Webster loam and Clarion loam can be equally well applied to this type. When well drained it should prove very productive and especially well suited to the production of corn.

WEBSTER SILTY CLAY LOAM.

The surface soil of the Webster silty clay loam is a very dark brown to black silty clay loam, 14 to 16 inches deep, containing a high percentage of organic matter. The subsoil is a yellowish-brown, drab or gray tenacious silty clay loam to silty clay mottled with gray and yellow, the mottlings becoming more pronounced with depth. Iron stains are also numerous in the lower subsoil. Small granite and quartzite boulders are scattered throughout this type, and in some places it has been necessary to remove these to make cultivation easier.

The Webster silty clay loam is confined mainly to the northeastern part of the county, although small scattered bodies occur in other sections. The type is developed as comparatively small disconnected bodies occupying the flatter undulating sections of the uplands or the gentle slopes to drainage ways. The topography varies from un-

dulating to gently sloping. Natural drainage is generally deficient, but a large acreage has been tiled and drained. The soil is retentive of moisture and crops do not suffer from drought.

The Webster silty clay loam when properly drained is a rich, productive soil, and probably 85 per cent of it is in cultivation. The undrained areas are covered with a growth of native grasses, which are either cut for hay or pastured. The only tree growth consists of a few straggling willows.

Although relatively inextensive, the type is important in the agriculture of the county. Corn occupies the largest acreage and is the principal cash crop, although a part of the grain is used on the farm to feed the work stock, hogs, and the few head of cattle usually kept. Where the land is well drained corn yields from 35 to 60 bushels per acre. Oats, the crop of second importance, yield from 40 to 55 bushels per acre. The Iowa 105 and Iowa 103 do best, lodging less than other varieties. The product is all fed on the farm. Flax, grown on the sod ground, produces from 8 to 12 bushels per acre. Wheat, barley, and rye are grown on a small scale.

The Webster silty clay loam is always farmed in conjunction with the adjoining loam, and the methods employed on the two soils are the same. Suggestions for improving the Webster loam apply to this type. Improvement of drainage is the most essential step.

Land of this type is nearly always sold in farms with the Webster loam. It is not considered quite as valuable as the latter type.

O'NEILL FINE SANDY LOAM.

The O'Neill fine sandy loam consists of 12 to 16 inches of brown to dark-brown loamy fine sand or fine sandy loam, underlain by a light-brown to yellowish-brown, loose-textured fine sandy subsoil, which grades into a strata of sand and gravel at 20 to 26 inches. In many places the surface soil grades directly into a light-brown to yellowish-brown loamy sand which in turn passes at about 24 inches into the sand and gravel. A few small areas of O'Neill loam, too small to separate on the map, are included.

The O'Neill fine sandy loam occupies the second terraces along the West Fork Des Moines River, the largest areas being found in the neighborhood of Emmetsburg and Osgood. The type lies from 15 to 20 feet above the normal river level and above overflow. The topography is level to gently sloping. Drainage is excessive, and crops suffer during dry spells.

Approximately 80 per cent of this type is in cultivation; the rest supports a growth of wild grasses and is used for pasture. Corn is the principal crop, and oats the second in importance. When moisture conditions are favorable the returns from oats are satisfactory. Some rye is also sown. It is either used for an early pasture and

turned under or allowed to mature grain. A few cattle are pastured and fed on most farms, but the raising of hogs constitutes the chief live-stock interest.

The yields of this type are practically the same as on the O'Neill loam, corn giving 20 to 35 bushels per acre, oats 30 to 42 bushels, and rye 22 to 37 bushels. A small acreage of popcorn is grown for sale.

The O'Neill fine sandy loam is cultivated in practically the same way as the O'Neill loam and adjoining upland soils. Stable manure is used, spreaders commonly being used in distributing. Definite crop rotations are followed on some of the farms. The one in more or less general use consists of corn 1 year, oats 1 year, timothy and clover 2 years, and return to corn. Land of this type sells for \$100 to \$140 an acre.

On the O'Neill fine sandy loam a deep mellow seed bed is easily maintained. The methods recommended for the improvement of the O'Neill loam apply equally well to this soil. Clovers should be used more extensively in the rotations. Alfalfa probably could be grown successfully.

O'NEILL LOAM.

The surface soil of the O'Neill loam consists of a dark-brown to chocolate-brown, light-textured loam 8 to 10 inches deep. The subsoil is a reddish-brown to yellowish-brown sandy loam resting at 18 to 24 inches on a stratum of yellow sand or sand and gravel. The surface soil often contains a considerable amount of organic matter. Where it has been modified by wind action the content of fine sand is often high. Included with the type are a few areas of O'Neill fine sandy loam that were too small to map.

The type is confined to the terraces of the West Fork Des Moines River, and Cylinder, Pilot, and Beaver Creeks. The town of Cylinder is located on one area of it, and it reaches its greatest development along Cylinder Creek in this vicinity. The next largest areas lie 1 mile west of Emmetsburg and 2 miles south of Graettinger. In general the areas have a nearly level to slightly sloping surface, and a position from 2 to 5 feet above the adjoining first bottom soils. They are above overflow and excessively drained.

The O'Neill loam is a relatively inextensive type. Owing to droughtiness it is not as highly prized as the upland soils, but about 95 per cent of it is in cultivation and has been for years. The only tree growth consists of a few willows.

The principal crops are corn and oats, with the largest acreage in the former. Wheat, rye, millet, sorghum, popcorn, and Irish potatoes are produced on a small scale. Vegetables are grown on nearly every farm to help supply the home demand. The live-stock industry consists of the raising of a few hogs and cattle.

Crop yields are somewhat lower on this soil than on the adjoining upland soils. They also vary considerably, as the soil is very droughty and yields are poor in dry years. In seasons of ample rainfall corn yields 20 to 40 bushels per acre, and oats 30 to 40 bushels.

The O'Neill loam is handled in very much the same way as the Clarion and Webster loams except that plowing is slightly deeper. The land is generally broken in the fall, and in many cases tractors are used for this purpose. Stable manure is applied to the fields wherever it can be had.

The price of land of this type ranges from \$100 to \$150 an acre, according to location and improvements.

Deeper plowing, especially in the fall, more thorough preparation of the seed bed, and the more general use of crop rotations including legumes, would prove beneficial. The type is well adapted to the growing of Irish potatoes and other vegetables.

ROGERS SILT LOAM.

The surface soil of the Rogers silt loam consists of a grayish-brown to gray silt loam, 18 to 20 inches deep, of smooth velvety feel when wet and floury structure when thoroughly dry. The subsoil is a greenish-brown to brownish-gray silt loam. Both soil and subsoil are highly calcareous.

This type occupies the beds of former shallow lakes now drained. Only two areas have been mapped in the county, one just south of Ruthven and the other south of Mallard. The topography is practically level, and the drainage is scarcely sufficient for best results.

Approximately 50 per cent of this type was put in cultivation this year (1918) for the first time. The remainder supports a growth of water-loving vegetation. With further improvement of drainage and proper cultivation this type will no doubt prove a valuable corn soil.

The following table gives the results of mechanical analyses of samples of the subsoil of the Rogers silt loam:

Mechanical analyses of Rogers silt loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
332714.....	Soil.....	1.4	10.0	4.1	14.2	5.7	51.3	13.3
332715.....	Subsoil.....	4.7	17.5	5.7	16.4	6.7	37.4	11.4

LAMOURE SILTY CLAY LOAM.

The surface soil of the Lamoure silty clay loam is a black silty clay loam to heavy silt loam 12 to 16 inches deep. The subsoil is

a yellowish-brown, drab, or mottled gray, yellow, and brown silty clay loam, marked in the lower depths in many areas with iron stains. In most cases the subsoil is calcareous, but a number of tests for lime showed no reaction.

Included with the type are many bodies of Lamoure silt loam, but on account of their great variability and intricate association they were not separated in mapping. In the depressions or pond-like areas throughout the uplands, where drainage is either entirely lacking or else poorly defined, the surface soil is extremely dark colored and contains more organic matter than typical, in many places the first inch or so of virgin soil being a dark-brown Peat or black fibrous Muck. The texture of such areas varies from a silt loam to a silty clay, and the black color often extends to 3 feet or more.

The type is developed in the bottoms of the West Fork Des Moines River, along all the streams and intermittent drainageways of the county, and in poorly drained, depressed areas throughout the uplands. It usually occurs in narrow belts along the streams, widening out slightly near the headwaters, where the general topography is flatter.

The surface of the Lamoure silty clay loam is normally flat, with a slight slope toward the stream. The areas are subject to overflow, drainage is poor, and water stands in the depressions after rains, the soil drying out very slowly.

Naturally this is a rich, productive soil, but up to the present time little of it has been reclaimed from its undrained state. A large area is devoted to the production of wild hay. Corn and oats are grown on a small area. During favorable years corn yields are slightly higher than on the adjoining uplands. Most varieties of oats lodge badly, but Iowa 105 and Iowa 103, which are adapted to rich soils, give good returns. Some buckwheat has been grown with good results. Flax is grown on newly reclaimed land. A few hogs, beef cattle, and dairy cows are pastured on the undrained areas.

Corn yields from 30 to 50 bushels per acre, oats 30 to 55 bushels, flax 8 to 10 bushels, and hay 1 to 1½ tons. No commercial fertilizer or stable manure is used on this type.

The Lamoure silty clay loam is always sold with adjoining types. Prices are much less than for the Clarion and Webster loams. The land could probably be bought for \$65 to \$100 an acre.

Wherever this soil is cultivated it is farmed in connection with the adjoining upland types. The methods suggested for the improvement of the Cass loam and silt loam can be applied with equally good results to this type. The straightening and deepening of the drainageways and the laying of adequate systems of tile drains in the depressed areas are essential for best results.

CASS LOAM.

The surface soil of the Cass loam, to a depth of 10 to 15 inches, consists of a dark-brown to black loam, high in organic matter. The subsoil is a yellowish-brown sandy loam to sandy clay loam, which grades into a substratum of sand or sand and gravel below 30 inches. In some areas the surface soil is a black heavy loam to silty clay loam, while in others the texture approaches a fine sandy loam, these areas being too small and unimportant to separate on the map. When the soil is in the virgin state the surface material to a depth of 1 or 2 inches is a black muck. The color and texture of the soil and subsoil is remarkably uniform throughout the county, and the stratified sand and gravel layer always lies within the 3-foot section.

The type is developed in the first bottoms of the West Fork Des Moines River and along Cylinder and Pilot Creeks; the largest connected body occurs west and south of Rodman.

The topography is level to gently sloping, and drainage is inadequate. In the past overflows have rendered soils of this type valueless, but since the cutting of a new river channel this condition has been remedied. During the year of the survey the drainage of this type was greatly improved, and a considerable acreage was reclaimed and put in cultivation.

When well drained the Cass loam becomes a strong and valuable soil, but at present only a small portion is farmed. In its natural state it supports a luxuriant growth of wild grasses and weeds, and parts of it are devoted to the production of hay or used as pasture. A few wooded areas occur, the tree growth consisting mostly of elm, maple, and willow.

Hay, corn, oats, and flax are the principal crops. Hay, which consists of the wild grasses, occupies the largest acreage. Some of the hay is fed; the rest is shipped to outside points. Corn and oats occupy the better drained areas. Sod ground is always seeded to flax. Small acreages of barley, rye, and buckwheat are grown. On most farms a small number of cattle are pastured.

On well-drained land of this type corn yields 30 to 50 bushels, oats 30 to 45 bushels, flax 8 to 10 bushels, and hay from 1 to 1½ tons per acre.

The Cass loam is easily tilled and does not clod even when plowed in a wet condition. Its productiveness can readily be increased. At present, crop rotations are practiced only in a general way, and shallow plowing is the rule. Very little stable manure is applied, though its use would prove beneficial. The type is usually handled in the same way as the upland and terrace soils.

Land of the Cass loam type varies in price from \$75 to \$155 an acre, depending on the improvements and the location with reference to towns and railroads.

The methods suggested for the managing of the O'Neill loam apply equally well to this type. Drainage should be improved and a deep, well-pulverized seed bed maintained.

CASS SILT LOAM.

The Cass silt loam consists of a black heavy silt loam to silty clay loam, 6 to 8 inches deep, underlain by a dark-brown to grayish-brown sandy loam to sandy clay loam, which grades at 20 to 30 inches into a loose-textured yellow sand or mixture of sand and gravel. In a number of uncultivated areas the surface inch of soil is a black Muck. As mapped, the type includes a few small areas of Cass loam and silty clay loam, too small to be shown separately.

The Cass silt loam is confined to the first bottoms of the West Fork Des Moines River, Cylinder Creek, and Prairie Creek. In the river bottom it usually lies next to the uplands, being here developed in association with the Cass loam, though occupying a slightly lower elevation. The surface, which is practically flat, is 10 to 13 feet above the normal level of the river. Along the creeks the land lies from 2 to 5 feet above the water level. Drainage is inadequate, water standing on the surface for long periods. Before the river was straightened the areas along its course were subject to frequent overflows.

Only a small area of this type occurs in Palo Alto County, and of this but little is in cultivation. Most of it supports a growth of wild grasses which are either cut for hay or pastured. The hay is baled, and the surplus left after supplying local needs is shipped to outside markets. The yield of hay is 1 to 1½ tons per acre. Corn and oats are grown to some extent, and during dry years fair yields are obtained, but the production falls off greatly in wet seasons. A few head of cattle are kept on most of the farms.

The Cass silt loam is handled in practically the same way as the adjoining uplands and is generally cultivated in conjunction with them. The improvement of drainage conditions, the use of systematic crop rotations in which legumes such as mammoth clover and red clover find a place, deeper plowing, and a more thorough preparation of the seed bed are all requisite for the best results on this type. Land of this type sells at from \$75 to \$110 an acre.

WABASH SILTY CLAY.

The Wabash silty clay consists of a dark-brown to almost black silty clay, 12 to 15 inches deep, underlain by a dark-slate or black

waxy clay, in some places faintly mottled with yellow and gray below 24 inches.

Minor textural variations are characteristic of this soil. Along Prairie Creek, from West Bend south, the surface soil approximates a silt loam and the subsoil is a gray to dark-brown silty clay. Included with the type are small areas in secs. 26, 27, and 28, T. 95 N., R. 32 W., in which the surface soil is lighter in texture than typical and the subsoil passes into a sandy loam or loamy sand below 30 inches.

The Wabash silty clay is developed principally in the first bottoms of the West Fork Des Moines River. A narrow strip occurs along Prairie Creek. The surface is uniformly flat with a slight slope toward the stream and in the direction of its flow. The type lies from 8 to 12 feet above the normal water level of the river. Natural drainage is poor and the soil is subject to overflow.

A very small area of this type, probably 10 per cent, is in cultivation, the larger part either being used as pasture for a few hogs and cattle found on the farms composed in part of this soil, or devoted to the production of wild hay. A few forest areas occur along the river, the growth consisting principally of elm, oak, willow, and ash. Hay is the most important crop, and yields of 1 to 1½ tons per acre are obtained. After supplying the farm need the rest is sold locally or shipped to outside markets. Since the straightening of the river, corn has proved a valuable crop, and in 1918 some yields of as much as 80 bushels per acre were reported. Flax, grown on the newly broken sod ground, yields from 8 to 10 bushels per acre.

The Wabash silty clay is generally farmed in the same way as the adjoining terrace and upland soils, but more care is necessary in plowing and other cultural operations. Moisture content must be favorable or the physical condition of the soil will be impaired. Improvement of drainage is the most important step in reclamation. The methods recommended for the improvement of the Cass loam and silt loam apply equally well to this type.

Land of the Wabash silty clay sells at from \$75 to \$125 an acre, the price varying with the location, state of drainage and character of improvements.

PEAT AND MUCK.

Peat, as mapped in this county, consists of a brown fibrous mass of partially decomposed vegetation containing only a small percentage of mineral matter. The physical characteristics of the material are variable, owing to differences in the degree of decomposition, which is dependent mainly on the state of drainage, though influenced also, in those areas farmed, by the length of time they have been under cultivation. In most of the areas the depth of mate-

rial is 18 to 24 inches, although in a few bodies organic deposits extend to a depth of 3 feet. The material underlying this deposit ranges from a black silty clay to a brownish-gray or gray fine sand or sand. Included with the type are certain areas where the vegetable matter has become thoroughly decomposed and mixed with a greater proportion of mineral materials washed in from the adjoining soils. Such bodies would have been separated as Muck had they been sufficiently numerous and extensive.

Areas of Peat and Muck are distributed over all parts of the county, the largest body occurring north of Lost Island Lake. They occupy depressed areas in the uplands and along intermittent drainage ways, where the presence of water has favored a rank growth of vegetation, its partial decay, and consequent accumulation.

The surface of the areas is flat. Where ditches have been cut the drainage conditions have been greatly improved, but in other areas water stands for long periods and the material is saturated for the greater part of the year.

The areas of Peat have been drained and cultivated only within the last few years. During the progress of the survey a few areas were in oats, which grew and filled out well but lodged badly. Rye seems to be well adapted to the soil. Irish potatoes do well, and a number of large fields were planted in 1918. Wild hay is cut on a few areas.

Peat is never sold alone but is included in farms composed chiefly of Clarion and Webster soils. Its value is comparatively low.

The areas of Peat that are in cultivation are handled in the same way as the adjoining soils. With proper drainage and the application of plenty of stable manure the productiveness can be greatly increased.⁶ Onions, celery, potatoes, cabbage, lettuce, and some other vegetables are crops giving especially good returns on soils of this kind.

SUMMARY.

Palo Alto County, Iowa, is located in the northwestern part of the State. It has an area of 561 square miles, or 359,040 acres.

The topography varies from gently undulating to rolling, with a few strongly rolling areas along the western boundary, and in the northern part of the extreme northwestern township. The general slope is toward the southeast. Broad flat bottoms are developed along the West Fork Des Moines River and some of the larger creeks, while narrower strips lie on all the smaller streams and intermittent drainage ways.

The elevation of the county above sea level varies from 1,150 to 1,500 feet, the greater part lying between 1,200 and 1,320 feet.

⁶ Iowa Agr. Expt. Sta. Bulletin No. 157.

The county is drained by the West Fork Des Moines River and its tributaries. Throughout the more rolling sections the natural drainage is good, but it is inadequate over the greater part of the county.

According to the census of 1920 the population was 15,486, and 32.2 per cent is classed as rural. The principal towns are Emmetsburg, Ruthven, Graettinger, Mallard, Ayrshire, Curlew, West Bend, Cylinder, Rodman, and Osgood.

Railroad facilities are good. The county roads are well graded, and are usually in good condition the greater part of the year. Telephones are in general use, and rural mail routes extend to all parts of the county. Schools and churches are conveniently situated and in sufficient numbers to serve the needs of the several communities.

Chicago and Minneapolis are the principal outside markets, the former receiving the bulk of the surplus products.

The climate of Palo Alto County is marked by wide variations in temperature. The mean annual temperature is 45.4° F., although extremes of -36° F. in winter and 104° F. in summer have been recorded. The mean annual precipitation is 29.62 inches. There is an average growing season of 166 days.

The agriculture of Palo Alto County consists of the growing of corn, oats, and hay, for home use and for sale, the raising of hogs, the feeding of a few cattle, and, to a limited extent, dairying.

While there are many fine farm houses the average structure is not as substantial as the productiveness of the land would seem to justify. The barns are large and well built, and some silos are in use. The work stock consists of medium to heavy draft horses. Improved machinery, including a number of tractors, is in general use.

Crop rotations are practiced by the more progressive farmers, and stable manure is always saved and applied to the fields, but only a very small amount of commercial fertilizer has been used.

During 1918, and for a few preceding years, farm labor has been scarce and wages high.

The size of farms varies from 50 to 500 acres, and the average size, according to the census of 1920, is 184.2 acres.

Farm land sells at from \$75 to \$250 an acre (1918), the prices varying with location, drainage, and improvements.

Palo Alto County lies within the glaciated region, and the soils have been derived through the weathering of the underlying Wisconsin drift. Thirteen soil types, embraced in seven series, in addition to the miscellaneous type, Peat and Muck, are mapped. The Clarion and Webster soils are derived from the weathering of the drift. The alluvial deposits along streams are classed with the O'Neill, Cass, Lamoure, and Wabash series.

The Clarion loam and Webster loam are the most important soil types in the county, and are practically all in cultivation. Corn,

oats, and hay are the principal crops. The raising of hogs, the feeding of a few cattle, and dairying on a small scale constitute the main livestock industries.

The soils of Palo Alto County are comparatively new and rich in organic matter. Their productiveness can easily be maintained and increased by deeper plowing, more thorough cultivation, and the use of systematic crop rotations in which leguminous crops are given their proper place.

The climate of Palo Alto County is marked by wide variations in temperature. The mean annual temperature is 54.7 F., although extremes of -36 F. in winter and 104 F. in summer have been recorded. The mean annual precipitation is 30.92 inches. There is an average growing season of 166 days.

The agriculture of Palo Alto County consists of the growing of corn, oats, and hay, for home use and for sale, the raising of hogs, the feeding of a few cattle, and to a limited extent dairying. While there are many fine farm houses the average structure is not as substantial as the productivity of the land would seem to justify. The barns are large and well built, and some also are in use. The work stock consists of medium to heavy draft horses. Improved machinery, including a number of tractors, is in general use.

Crop rotations are practiced by the more progressive farmers, and stable manure is always saved and applied to the fields, but only a very small amount of commercial fertilizer has been used. During 1918, and for a few preceding years, farm labor has been scarce and wages high.

The size of farms varies from 50 to 500 acres, and the average size, according to the census of 1930, is 184.3 acres. The price of farm land sells at from \$750 to \$2500 an acre (1915), the prices varying with local conditions, and improvements.

Palo Alto County lies within the glacial region, and the soils have been derived through the weathering of the underlying Wisconsin drift. Thirteen soil types, embraced in seven series, in addition to the miscellaneous type, best and black, are mapped. The Clarkston and Webster soils are derived from the weathering of the drift. The alluvial deposits along streams are classed with the Owell, Cass, Lamoure, and Webster series. The Clinton, Iowa, and Webster loam are the most important soil types in the county, and are practically all in cultivation. Corn,

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