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D. F. Slusher
Iowa State University

R. W. Arnold
Iowa State University

R. Protz
Iowa State University

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Extent and Distribution of Soils in Depressional Areas in the Clarion-Nicollet-Webster Soil Association in Iowa[1]

D. F. Slusher, R. W. Arnold, and R. Protz[2]

Abstract. The extent and distribution of soils that occur in depressional areas in the Clarion-Nicollet-Webster soil association have been estimated for Iowa counties from a randomly selected sample. The sample consisted of detailed soil maps of approximately 1000 quarter-section (each about 160 acres), or about 2 percent of the total land area. The data from the soil maps of the samples were projected to give estimates of soil conditions by counties and for the area as a whole. The acreage of depressional soils is estimated to be 4.8 percent of the total soil association area with significant variation between counties. The following data are reported by counties for mineral and organic soils: (1) percentage of quarter-sections with depressional soil areas, (2) average number and acreage of depressional areas per quarter-section, and (3) size class distrbiution of depressional areas.

The Clarion-Nicollet-Webster soil association (Aandahl, et al., 1960) corresponds to the region covered by the most recent glacier in Iowa, the Cary[3] (Ruhe and Scholtes, 1959). (See Figure 3.) The area consists of an undulating drift plain (Kay and Graham, 1943) only slightly dissected by headward extension of a well defined drainage system. The relief is low with numerous knolls and swales and with frequent occurrence of saucer-like basins or depressional areas. The smaller basins are known locally as "potholes." Although the acreage of the depressional areas in only about 5 percent of the total, they are quite significant beyond their extent because of their frequent occurrences and the unique soil management problems associated with them.

The size of the depressional areas ranges from less than one-half acre to as much as 1500 acres. Prior to drainage by tile or open ditches these areas contained ponded water much of the time. The depth of water depended on the depth of the depression or size of the drainage area and ranged from a few inches to several feet. Under native conditions the shallower ponds became dry in dry seasons but deeper ones contained water throughout the year.

Discussion of Soils

Soil scientists have mapped, described, and classified the soils

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[2] Soil Scientist, Soil Conservation Service, U.S.D.A., Ames, Iowa; and Research Associates, Agronomy Department, Iowa State University, Ames, Iowa.

[3] In earlier publications the Cary has been referred to as the Des Moines lobe of the Wisconsin drift, the Mankato, or the Cary-Mankato drift.

in this region and published their findings in numerous soil survey reports. Early workers recognized the occurrence of different soils in the depressional areas but did not separate them from the nearly level soils with which they occurred. In more recent soil surveys made by the Soil Conservation Service and the Iowa Agricultural Experiment Station, the soils in the depressional areas have been mapped and classified principally as the Glencoe, Okoboji, Wacousta, and Rolfe series, or as muck or peat. These soils have been described in detail in recent soil survey reports (McCracken, 1960; Richlen, et al., ca 1961).

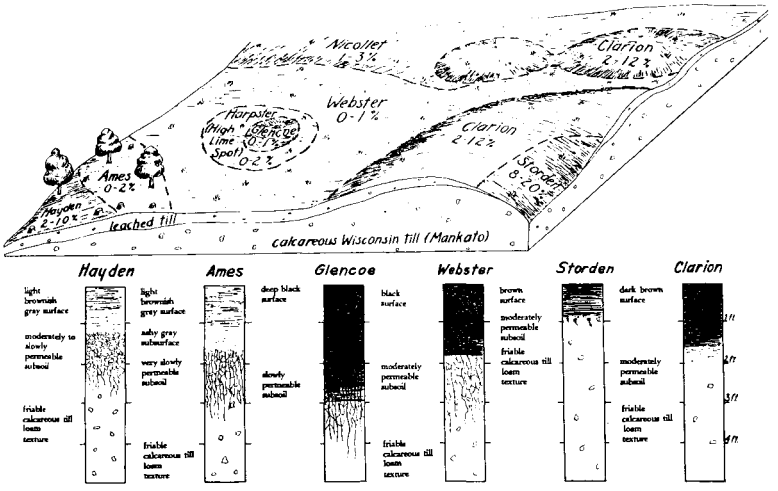

Figure 1. Relationship of major upland soils in the Clarion-Nicollet-Webster soil association to slope and native vegetation.

The soils in depressional areas occur typically in the uplands in association with the nearly level Webster, Nicollet, or Harpster soils (Figure 1). A narrow band or rim of the calcareous Harpster soils frequently surrounds the Glencoe, Okoboji, Wacousta, and peat or muck soils. Areas of Rolfe soils surrounded by Harpster soils are not known to occur. Some chemical and physical properties of the Glencoe, Rolfe, and Webster soils are given in Table 1.

The Glencoe, Okoboji, and Waucousta soils have developed from sediments of local origin. This material was probably deposited in the depressional areas by glacial melt waters or as a result of erosion and sedimentation in post-glacial times. The native vegetation was water-tolerant grasses and sedges. The parent material of the associated Clarion and Nicollet soils is glacial till. The muck and peat soils have formed in deposits of organic materials.

Table 1. Particle Size, Organic Carbon, and pH of Rolfe, Glencoe, and Webster Soils*

Soil	Horizon	Depth	Particle size (in millimeters) Sand 2.0-.05	Silt .05-.002	Clay <.002	Organic carbon	Total nitrogen	Bulk density	pH
		in	%	%	%	%	%		
Glencoe silty clay loam (P524), 100 yards south and 90 yards east of the northwest corner of the NW¼ NW¼ sec. 32,, T. 92 N., R. 27 W., Humboldt Co., Iowa.	A_p	0-7	8.6	56.8	34.6	5.52	0.479	...	7.0
	A_{11}	7-11	8.7	56.3	35.0	5.28	0.456	1.07	7.0
	A_{12}	11-14	10.3	59.7	30.3	2.31	0.262	1.18	7.1
	A_{13}	14-17	11.2	56.8	32.0	1.62	0.182	...	7.1
	A_3	17-20	8.4	56.3	35.3	1.42	0.142	...	7.1
	B_1	20-23	6.2	55.8	38.0	1.19	0.114	...	7.2
	B_{21}	23-26	6.1	53.6	40.3	1.04	0.106	1.23	7.2
	B_{22}	26-30	6.0	54.2	39.8	0.89	0.104	1.20	7.2
	B_{23}	30-34	5.5	54.3	40.2	0.77	0.108	1.23	7.2
	B_{31}	34-38	4.9	56.5	38.6	0.58	0.124	1.21	7.3
	B_{32}	38-44	4.5	56.6	38.9	0.47	0.128	...	7.3
	B_{33}	44-49	3.3	58.5	38.2	0.45	0.131	...	7.4
	C_{g_2}	49-56	2.9	67.6	29.5	0.35	0.073	..	7.6
Rolft silt loam (P521), 110 yards west and 8 yards north of the southeast corner of the SE¼ SW¼ sec. 1, T. 92N., R. 29 W., Humboldt Co., Iowa.	A_p	0-9	17.0	57.0	26.0	4.36	0.341	1.00	6.3
	A_2	9-16	23.5	61.7	14.8	1.00	0.055	1.40	5.8
	$A_3B_{g_1}$	16-20	18.5	55.4	26.1	0.73	0.054	...	6.0
	$B_{g_{21}}$	20-26	17.2	39.5	43.3	0.66	0.066	1.37	6.1
	$B_{g_{22}}$	26-29	32.5	29.3	38.2	0.39	0.047	...	6.4
	$B_{g_{23}}$	29-36	27.2	30.2	42.6	0.32	0.042	...	6.7
	$B_{g_{31}}$	36-41	45.0	25.3	29.7	0.24	0.031	1.49	6.9
	$B_{g_{32}}$	41-48	44.0	27.0	29.0	0.22	0.029	...	7.0
	C_{g_1}	48-55	46.3	30.7	23.0	0.18	0.024	1.47	7.4
	C_{g_2}	55-62	51.5	30.3	18.2	0.04	0.006	...	7.9

Table 1.—Continued

Soil	Horizon	Depth	Particle size (in millimeters) Sand 2.0-.05	Silt .05-.002	Clay <.002	Organic carbon	Total nitrogen	Bulk density	pH
		in	%	%	%	%	%		
Webster clay loam, Humboldt Co., Iowa.	A	0-8	26.1	39.1	34.2	4.12	0.404	...	7.4
	A	8-13	27.8	38.5	33.7	3.71	0.387	...	7.1
	A	13-17	29.6	35.6	34.8	1.91	0.207	...	6.5
	B	17-21	33.0	33.0	34.0	1.10	0.150	...	6.7
	B	21-26	38.0	30.3	31.7	0.52	0.109	...	6.8
	C_1	26-31	40.1	31.8	28.1	0.29	0.082	...	7.7
	C_2	31-37	40.2	35.6	24.2	0.17	0.071	...	8.0
	C_3	37-43	36.7	39.3	24.0	...	...	...	8.0
	C_2	43-50	36.2	39.2	24.6	...	...	...	8.0
	C_2	50-60	39.9	35.8	24.3	...	...	...	8.0

* See Soil Survey of Humboldt County, Iowa (Richlen, et al., 1961).

The Glencoe and Okoboji soils are the most extensive of those that occur in depressional areas. Rolfe and Wacousta soils are very minor in area.

The major characteristics of the soils that occur in depressional areas are summarized briefly as follows:

Glencoe soils. These soils have black silty clay loam surface layers 24 to 36 inches thick. The subsoil is a firm, olive-gray to dark olive-gray silty clay loam to silty clay. The underlying material is variable but typically ranges from silty clay loam to loam. The sub-soil is slowly to moderately slowly permeable. Glencoe soils are usually neutral to slightly acid and occasionally are calcareous. These soils have thicker dark surface layers, finer textured (more clayey) subsoils, and lower sand content than Webster soils. Glencoe soils are classified as Wiesenbodens (Humic Glei) that intergrade to Alluvial soils (Thorp and Smith, 1949), or as Cumulic Haplaquolls according to a newly proposed classification scheme (Soil Survey Staff, 1960).

Okoboji soils. These soils have black, friable silt loam surface layers 18 to 36 inchs thick. The subsoil is a friable to firm grayish brown to olive-gray silt loam or light silty clay loam. The underlying material is silt loam, loam, or light silty clay loam. The subsoil is moderately to moderately slowly permeable. The Okoboji soils are usually neutral to slightly acid and are occasionally calcareous. Okoboji soils are similar to Glencoe soils but are not as fine textured (clayey) or as slowly permeable. They are classifield as Wiesenbodens (Humic Glei) that intergrade to Alluvial soils ,Thorp and Smith, 1949), or as Cumulic Haplaquolls.

Wacousta soils. These soils have black, friable silt loam surface layers about 8 to 12 inches thick. The subsoil is moderately to moderately slowly permeable, gray to grayish brown silt loam or silty clay loam. Wacousta soils are usually neutral to slightly acid but, as the Glencoe and Okoboji soils, may be slightly calcareous. The Wacousta soils are similar to the Okoboji soils but have thinner dark colored surface layers. They are not as fine textured as the Glencoe soils. Wacousta soils are classified as Wiesenbodens (Humic Glei) that integrade to Alluvial soils (Thorp and Smith, 1949), or perhaps as Entic Haplaquolls.

Rolfe soils. These soils have black to very dark gray, loam or silt loam surface layers about 6 to 12 inches thick and gray to dark gray loam or silt loam subsurface layers. The subsoil is a firm, dark gray to gray silty clay loam to clay that is slowly to very slowly permeable. The underlying material is loam to clay loam. These soils are usually medium acid. The Rolfe soils usually occur in shallower depressions and in higher landscape

positions than is typical for the Glencoe, Okoboji, or Wacousta soils. Rolfe soils are classified as Planosols (Thorp and Smith, 1949), or perhaps as Orthic Argalbolls according to a new scheme (Soil Survey Staff, 1960).

Muck and peat. Muck and peat soils are high in organic material but may contain small amounts of mineral matter. When the organic material has decayed so that fragments of leaves and stems are no longer visible it becomes muck. The less well decomposed organic material is called peat. The muck or peat deposits normally range from about 8 to 48 inches thick over mineral matter but thicker depoits are known to occur. Muck and peat were formed at the bottom of shallow lakes by the accumulation and decay of various kinds of aquatic plants. These soils occur in the deeper depressions that were probably covered with water a greater percentage of the time. Muck and peat are quite variable in reaction and range from neutral to strongly acid. Some areas are calcareous.

Other soils. The Ames, Cullo, and Orio are other soils that occur in depressional areas. These soils are so minor in extent that they are not considered in this study.

Significance to Soil Management

From an agricultural point of view the soils in depressional areas present unusual management problems. The soils are very poorly drained and are often ponded after heavy rains. Although most of the soils have been drained by tile and are used for cultivated crops, the "potholes" are often wet for long periods after surrounding soils are suitable for tillage. The small depressions are considered to be "nuisance areas" by many farmers. In some years the farmers plant the surrounding soils and leave the potholes idle. At other times crops planted in the potholes are flooded due to heavy summer rains. Legumes usually winterkill when the potholes collect water from mid-winter thaws and then are frozen for several weeks to several months. Yields of corn and soybeans are high in favorable years but the crops may be a total failure in others. Corn and soybeans grown on peat and muck soils are more often subject to damaging early freezes than on adjacent higher-lying soils.

Tile drainage is partially effective in removing subsurface water but surface drainage is usually needed to supplement the tile if drainage is to be completely effective. French drains, open intakes to tile, or surface ditches are often used. Tile outlets are often difficult to obtain as the potholes are lower in elevation than the surrounding soils. Outlets can usually be ob-

tained but may require relatively deep placement of tile for a considerable distance.

Method of Study of Size and Distribution of Potholes

In 1947 the Soil Conservation Service and the Iowa Agricultural Experiment Station undertook a study to estimate the soil and land conditions in Iowa. This inventory is based on a 2 percent sample consisting of three randomly selected one-quarter sections (approximately 160 acres each) of land in each legal township. Each quarter section was traversed on foot and

Figure 2. Soil map of a one-quarter section sample (NW¼ sec. 13, T. 84 N., R. 23 W., Story County, Iowa).

6-0-0	Glencoe silty clay loam
29-2-1	Clarion-Nicollet complex, 2 to 5 percent slopes
55-2-0	Nicollet loam
95-1-0	Harpster loam
107-1-0	Webster silty clay loam
107a-1-0	Webster silty clay loam, calcareous variant
138-2-1	Clarion loam, 2 to 5 percent slopes
138-3-1	Clarion loam, 2 to 5 percent slopes
138-3-2	Clarion loam, 2 to 5 percent slopes, moderately eroded
329-1-0	Webster-Nicollet complex
329-2-0	Webster-Nicollet complex
G	Glencoe silty clay loam (too small to map out)
Ca	Storden loam (too small to map out)

the soils examined and classified by soil scientists of the Soil Conservation Service. Using 4-inch-to-the-mile scale aerial photographs the soil scientists plotted boundaries and recorded the soil types found on each quarter section. Approximately 1000 quarter-section samples were mapped in the Clarion-Nicollet-Webster soil association. A quarter-section sample showing different kinds of soils is shown in Figure 2.

The acreage of each soil on each quarter-section sample was measured and then expanded, using a proportionate factor for each county. The expanded acreages from all the quarter-section samples were then totaled to arrive at the estimated acreage of each soil in that particular county. The estimates of soil and land conditions obtained in this manner have been shown to be reasonably accurate (Taylor, 1958). The acreage of soils of major extent is estimated more correctly than that of minor soils. As the acreage of soils in depressional areas is only a small percentage of the total for the area, the estimates may be subject to considerable sampling error in some counties. This is particularly true in the border counties where only a few samples occurred in the Clarion-Nicollet-Webster soil association. For example, in Marshall County the estimated acreage is based on data from only three quarter-sections. The estimates for the entire soil association and for counties entirely within the area are considered to be the most reliable. As the organic soils are less extensive than the mineral soils, the estimates are subject to a greater sampling error.

In addition to the acreage estimate of each soil, the quarter-section sample maps were examined to determine the number, size, and kinds of soils occurring in depressional areas. When a depressional area was bisected by the quarter-section boundaries, it was recorded as occurring within the quarter-section. The size of the depression, however, was recorded only as that part that occurred within the quarter-section boundaries. This method of recording and the expansion of the data tends to give a somewhat higher number of depressional areas than actually occur and to show a somewhat smaller size. As the majority of the depressional areas were entirely within the quarter-section boundaries, the data are considered to be a fairly reliable estimate of their size.

Discussion of the Data

A summary of the extent, distribution, and size of depressional areas by counties is given in Table 2. The data are given for two groups of soils—mineral and organic. The mineral soils are the Glencoe, Okoboji, Wacousta, and Rolfe. Muck and peat are the organic soils. Although there are important distinctions be-

tween soils within the groups, these distinctions are in part overshadowed by the common characteristics of their occurrence in depressional areas. It is the objective of this discussion to emphasize the depressional characteristics of the Clarion-Nicollet-Webster soil association rather than the characteristics of the individual soils within the depressions. By combining the soils into two major groups, the reliability of the characterization is increased.

In considering numbers or acres of depressional areas for any given county it should be kept in mind that potholes smaller than about one-half to three-fourths of an acre were not shown on the maps of the quarter-section samples as separate soils. These depressions were shown by a special symbol, and acreages were not considered in the expansion of the data. As a result of this, a somewhat larger number, as well as acreage, of depressional soils is expected to occur than is estimated in Table 2 and Figure 3. The number of depressional areas too small to show by the conventional method averaged 0.8 per quarter-section over the soil association area and 4.1 per quarter-section on the samples where they were present.

To make comparisons between counties or between general regions within the Clarion-Nicollet-Webster soil association in Iowa, the data can be analyzed from at least three points of view: (a) the average acreage of depressional areas (mineral or organic) per unit area, (b) the average acreage of depressional areas (mineral or organic) in relation to the quarter-section samples on which they occur, and (c) the percentage of the quarter-section samples where depressional soils (mineral or organic) are present. Comparisons between counties by numbers of depressional areas or total acreage has limitations because the counties are not of equal size and the Clarion-Nicollet-Webster soil association occurs in only a fraction of many border counties. Total acreages and total numbers are useful in the analysis of agricultural problems within individual counties, however.

The average estimated acreage of mineral and organic soils in depressional areas per quarter-section by counties is given in Figure 3. In Kossuth County the average acreage per quarter-section of mineral soils in depressional areas is 7.5 acres compared with 3.1 acres in Boone County. In Kossuth County it is estimated that 78.1 percent of the quarter-sections have mineral soils in depressional areas, compared to 54.2 percent in Boone County (Table 2). If only the quarter-sections where the soils occur are considered, the average is 9.9 acres in Kossuth County compared to 5.7 acres in Boone County. It is apparent

Table 2. Extent, Size, and Distribution of Depressional Areas in the Clarion-Nicollet-Webster Soil Association in Iowa by Counties

County	No. of ¼ sections[a]		¼ sections having depressional areas (%)[b]	Estimated soil acres[c]	Estimated no. of areas[d]	Depressional areas per ¼-section where present[e]		Depressional areas within given acre-size classes (%)[f]				
						Av. no.	Acres	½-2	2-5	5-10	10-20	>20
Boone	2292	a)	54.2	7105	2814	2.3	5.7	67.8	23.8	6.8	...	1.6
		b)	12.5	2871	621	2.2	10.0	15.4	38.5	30.7	15.4	...
Buena Vista	1618	a)	70.6	9109	3851	3.4	8.0	77.8	12.3	7.4	2.5	...
		b)	2.9	128	47	1.0	2.7	...	...	100.0	...	...
Calhoun	2292	a)	68.7	16693	5214	3.3	10.6	67.8	21.1	6.4	3.7	1.0
		b)	8.3	1257	190	1.0	6.6	...	50.0	50.0	...	...
Carroll	1149	a)	16.7	339	239	1.2	1.8	80.0	20.0	...	...	...
		b)	...	....	....	..	...	...	...	...	...	...
Cerro Gordo	691	a)	80.0	4117	2073	3.7	7.4	96.7	3.3	...	...	...
		b)	45.0	5512	311	2.9	17.7	7.7	46.2	34.6	11.5	...
Clay	574	a)	41.2	6601	473	2.0	27.9	50.0	28.6	21.4	...	...
		b)	...	....	....	..	...	..	...	...	...	...
Dallas	1910	a)	29.3	2672	1213	2.2	4.8	73.0	15.4	11.6	...	...
		b)	2.4	930	94	2.0	20.3	50.0	...	...	50.0	...
Dickinson	1407	a)	46.9	5971	1449	2.2	9.0	63.7	24.2	6.0	3.1	3.0
		b)	15.6	3230	484	2.2	14.7	27.3	36.3	27.3	...	9.1
Emmet	1752	a)	50.0	7839	2111	2.4	8.9	65.8	9.8	14.6	9.8	...
		b)	8.8	3802	257	1.6	24.6	20.0	...	20.0	40.0	20.0

Table 2.—Continued

County	No. of ¼ sections[a]		¼ sections having depressional areas (%)[b]	Estimated soil acres[c]	Estimated no. of areas[d]	Depressional areas per ¼-section where present[e] Av. no.	Acres	Depressional areas within given acre-size classes (%)[f] ½-2	2-5	5-10	10-20	>20
Franklin	1641	a)	80.0	8516	9403	7.1	6.5	88.2	7.7	2.8	1.3	...
		b)	12.0	4733	197	1.0	24.0	....	67.0	...	...	33.0
Greene	2276	a)	60.4	14291	3553	2.6	10.3	66.6	18.6	5.3	6.7	2.8
		b)	4.2	1913	141	1.5	20.0	...	...	...	100.0	...
Guthrie	715	a)	40.0	1578	573	2.0	5.5	91.6	8.4	..	...	...
		b)	....	....	....	..	...	...	...	...	...	..
Hamilton	2312	a)	75.0	12518	7433	4.3	7.2	83.4	8.4	7.7	0.5	...
		b)	16.6	5931	626	1.6	15.4	53.8	...	...	38.4	7.8
Hancock	2288	a)	52.1	7918	3620	3.0	6.6	73.7	25.0	...	..	1.3
		b)	29.2	13244	810	1.2	19.8	17.6	12.0	52.8	17.6	...
Hardin	1722	a)	58.8	6529	3589	3.5	6.4	70.5	23.9	4.2	1.4	...
		b)	11.7	1191	355	1.7	5.9	14.8	42.9	28.6	14.7	...
Humboldt	1740	a)	94.5	23594	8839	5.4	14.3	73.8	18.0	5.5	2.2	0.5
		b)	16.6	4597	576	1.8	15.9	...	27.2	54.4	9.2	9.2
Jasper	294	a)	20.0	403	235	4.0	6.8	50.0	25.0	25.0	...	...
		b)	....	....	....	..	...	...	...	...	...	...
Kossuth	3916	a)	78.1	29441	11889	3.9	9.9	73.9	20.0	4.4	1.7	...
		b)	24.4	16377	2099	2.2	17.1	29.6	29.6	25.0	13.6	2.2

Table 2.—Continued

County	No. of ¼ sections[a]		¼ sections having depressional areas (%)[b]	Estimated soil acres[c]	Estimated no. of areas[d]	Depressional areas per ¼-section where present[e]		Depressional areas within given acre-size classes (%)[f]				
						Av. no.	Acres	½-2	2-5	5-10	10-20	>20
Marshall	344	a)	66.7	192	802	3.5	0.8	85.7	14.3	...	...	...
		b)	66.7	326	229	1.0	1.4	100.0	...	...	..	...
Osceola	1194	a)	14.3	1224	426	2.5	7.2	40.0	40.0	20.0	..	...
		b)	...	....	....	..	...	...	...	...	...	...
Palo Alto	2268	a)	47.9	12155	4071	3.7	11.1	69.8	18.6	5.8	3.5	2.3
		b)	6.2	3418	284	2.0	24.3	...	16.6	16.6	50.0	16.8
Pocahontas	2324	a)	72.9	17081	4601	2.7	10.1	78.8	6.3	7.4	3.3	4.2
		b)	14.5	3405	532	1.6	10.1	36.4	27.2	27.2	...	9.2
Polk	1782	a)	19.4	891	941	2.7	2.6	89.6	10.4	...	...	...
		b)	2.8	271	50	1.0	5.4	...	100.0	...	...	...
Sac	1159	a)	62.5	5240	2510	3.5	7.2	78.8	7.7	11.5	2.0	...
		b)	0.4	2010	483	1.0	4.3	...	...	...	...	100.0
Story	2272	a)	58.3	6003	3029	2.3	4.5	78.1	10.9	7.8	1.7	1.3
		b)	12.5	2990	472	1.7	10.5	40.0	30.0	20.0	10.0	...
Webster	2872	a)	81.8	26648	9564	3.7	11.3	77.0	10.0	7.0	3.0	3.0
		b)	12.1	7137	523	1.5	20.5	...	66.6	16.7	...	16.7
Winnebago	1608	a)	76.5	9758	5660	4.7	7.9	84.5	9.8	3.2	2.5	...
		b)	41.2	11177	1373	2.1	16.8	37.9	31.1	6.9	10.3	13.8

Table 2.—Continued

County	No. of ¼ sections[a]		¼ sections having depressional areas (%)[b]	Estimated soil acres[c]	Estimated no. of areas[d]	Depressional areas per ¼-section where present[e] Av. no.	Acres	Depressional areas within given acre-size classes (%)[f] ½-2	2-5	5-10	10-20	>20
Worth	481	a)	65.1	8001	1467	4.7	25.5	73.8	19.7	3.3	1.1	1.1
		b)	40.0	8559	240	1.2	44.4	. .	30.0	20.0	10.0	40.0
Wright	2308	a)	65.9	13408	6592	4.3	8.8	77.6	13.4	5.2	2.2	1.6
		b)	14.9	5201	540	1.6	15.1	36.4	27.2	. . .	18.2	18.2
TOTAL OR AVERAGE	49201	a)	72.9	265836	108234	3.3	8.3	74.1	16.4	6.9	1.8	0.8
		b)	18.8	110321	11534	1.6	15.0	20.3	28.3	22.1	17.0	12.3

[a] Approximate number of ¼-sections within the Clarion-Nicollet-Webster soil association. Determined by dividing the acreage of the county within the soil association (exclusive of incoporated cities and towns) by 160.

[b] Number of ¼-section samples having mappable areas of mineral and organic depressional soils divided by the total number of ¼-sections in the county sample. a) mineral soils (Glencoe, Okoboji, Wacousta, and Rolfe); b) organic soils (muck and peat).

[c] Projected acreage of mineral and organic soils obtained from county summaries of conservation needs inventory.

[d] Number of depressional areas in the sample projected for the county area.

[e] Average number and acreage of depressional areas for only the ¼-sections containing such areas. Flood plains, outwash areas, terraces, and steep land are, in general, excluded from consideration.

[f] Based on the frequency of above specified soils in depressional areas per county sample (approximately one ¼-section sample for every 48 ¼-sections).

that the magnitude of the problems associated with the mineral soils in depressional areas is considerably greater in Kossuth County than in Boone County.

The acreage and frequency of mineral soils in depressional areas in Humboldt County is high in comparison to surrounding counties. This is attributed in part to a greater detail in mapping made possible by the use of 8-inch-to-the-mile scale aerial photographs as field sheets. This enabled the soil scientists to show a greater proportion of the smaller-sized depressional areas.

Comparisons of regions within the soil association show that

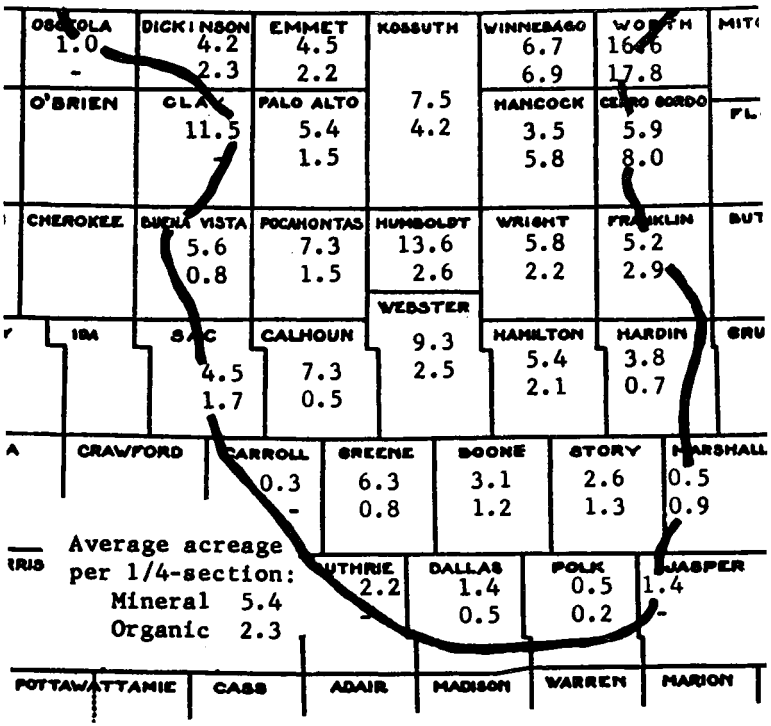

Figure 3. Average estimated acreage of mineral and organic soils per quarter section by counties in the Clarion-Nicollet-Webster soil association.

the largest acreage and the largest percentage of quarter-sections with depressional areas occur in the central, north central, and northeastern part of the Clarion-Nicollet-Webster soil association in Iowa. In general these areas correspond to the major portion of the large Algona and Humboldt moraines (Kay and Graham, 1943) and the integrated morainal complex in Worth, Winnebago, Hancock and Cerro Gordo counties. Areas with the fewest depressional soils correspond to a general pattern of annual recessional moraines (Gwynne and Simonson, 1942).

The percentage of quarter-section samples with depressional areas is shown in Table 2. Most depressional areas occur in the uplands rather than on bottomlands or stream terraces. Where the dissection of the landscape by advancement of streams and establishment of well defined drainage systems has been the greatest, the potholes are less likely to occur. Areas of greater dissection generally parallel the major streams.

From the agricultural standpoint the probability of locating farms in Iowa without the troublesome potholes is greatest along the southern and western margins of the Clarion-Nicollet-Webster soil association area.

Mineral soils in depressional areas occurred on 72.9 percent of the quarter-section samples, whereas only 18.8 percent had organic soils. Over the soil association area the ratio of the acreage of mineral to organic soils is approximately 2.5 to 1. In all but Hancock, Cerro Gordo, Winnebago, and Worth counties the acreage per quarter-section of mineral soils exceeds that of organic soils (Fig. 3). In the Clarion-Nicollet-Webster soil association in Worth County the average acreage per quarter-section of organic soils is 17.8 compared to 0.5 acre in Calhoun County and 2.3 acres for the area.

Of the mineral soils in depressional areas 74.1 percent are in the ½- to 2-acre size class, compared to 20.3 percent of the organic soils (Table 2). A comparison of the size frequency distribution in selected counties is shown in Figure 4. As the size class of the mineral soils increases, the number of depressional areas per class decreases. Although there are differences between counties in the percentage of mineral soils in the ½- to 2-acre size class, the greatest deviation from the average occurs in counties where only a few of the quarter-sections sampled had depressional soils. In Jasper County 50.0 percent of the depressional areas were in the ½- to 2-acre size class compared to the average of 74.1 percent. As only a small part of the county occurs in the Clarion-Nicollet-Webster soil association, a considerable part of this deviation is attributed to sampling error due to inadequate sample size. Some of the difference between counties in the larger size classes of mineral soils is also attributed to sampling error as relatively few depressional areas occur in the larger size classes.

The organic soils occur in larger depressional areas than the mineral soils (Fig. 4) and are more uniformly distributed among size classes. The organic soils range from a high of 28.3 percent in the 2- to 5-acre size class to a low of 12.3 acres in the > 20-acre size class. By contrast the mineral soils range from 74.1 percent in the ½- to 2-acre size class to a 0.8 percent in the

> 20-acre size class. Although the size classes of organic soils are representative of the quarter-sections sampled, the actual size of the areas is somewhat larger due to the bi-section of many of the larger depressions by the quarter-section boundaries. Comparisons between counties on the basis of size classes of organic soils have considerable limitation due to their relatively infrequent occurrence and consequently a larger sampling error.

The estimated acreage of the different soil types that occur in depressional areas is given in Table 3. The relatively minor extent of the depressional soils is evident in that they amount to only 4.8 percent of the total Clarion-Nicollet-Webster soil association. The acreage of mineral soils is more than double the

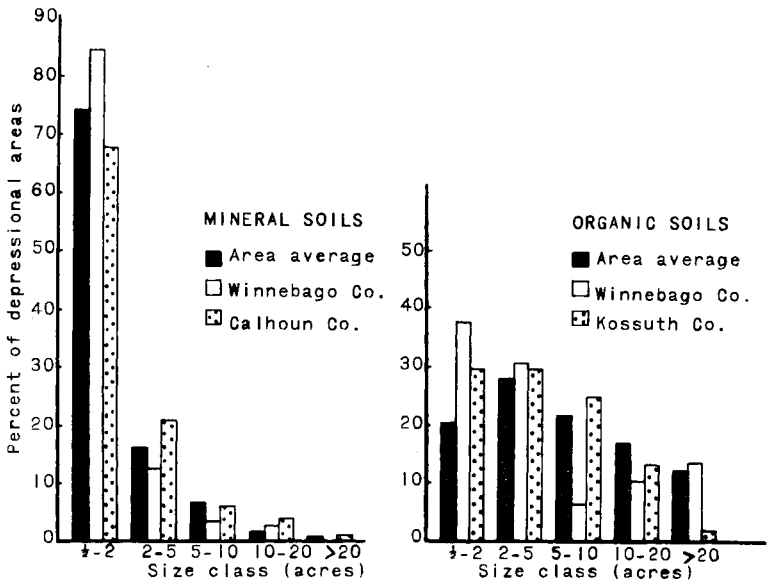

Figure 4. Size frequency distribution of soils in depressional areas in selected counties in the Clarion-Nicollet-Webster soil association.

acreage of organic soils. Of the acreage of mineral soils in depressional areas the Glencoe and Okoboji soils are predominant and in approximately equal proportions. Although the Glencoe soils occur most frequently, the Okoboji soils tend to occur in the larger depressions. This explains the nearly equal total acreage of the two soils.

In the earliest mapping of the quarter-section samples the Wacousta soils were included with the Okoboji and the acreage of Wacousta may be somewhat underestimated.

The organic soils also tend to occur in the larger depressions and although the ratio of number of organic soil areas to min-

eral areas is about 1 to 10, the ratio of total acreages is 1 to 2.5 (Table 2).

Table 3. Estimated Acreages by Soil Series in Depressional Areas in the Clarion-Nicollet-Webster Soil Association

Soil	Estimated acreage	Percent of "depressional area" soils	Percent of Clarion-Nicollet-Webster soil association
Mineral soils			
Glencoe	127,109	33.7	1.6
Okoboji	117,940	31.4	1.5
Wacousta	15,340	4.1	0.2
Rolfe	5,447	1.4	0.1
Organic soils			
Muck	90,043	24.0	1.1
Peat	20,278	5.4	0.3
Total mineral soils	265,836	70.6	3.4
Total organic soils	110,321	29.4	1.4
TOTAL	376,157	100.0	4.8

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