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Soil Survey

of

Luce County, Michigan

By

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Michigan Department of Conservation

and

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United States Department of Agriculture

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SOIL SURVEY OF LUCE COUNTY, MICHIGAN

By J. O. VEATCH,[1] Michigan Agricultural Experiment Station, in Charge, L. R. SCHOENMANN, and C. E. MILLAR, Michigan Department of Conservation, and A. E. SHEARIN, United States Department of Agriculture

COUNTY SURVEYED

Luce County is in the eastern part of the Upper Peninsula of Michigan (fig. 1). The county extends to Lake Superior on the north, and the southern boundary lies inland from 12 to 20 miles distant from the north shore of Lake Michigan. Newberry, the principal town and county seat, is approximately 65 miles west of Saulte Ste. Marie. The area of the county is 908 square miles, or 581,120 acres.

Luce County lies in the eastern or lowland-plains division of the Upper Peninsula. The present surface relief has resulted from glacial deposition on an old eroded lowland underlain by southward-dipping Paleozoic sediments, which was characterized by elevations and northward-facing scarps of the more resistant rocks, with broad intervening belts of lowlands, or valleys, underlain by the less resistant rocks. This old surface was entirely covered by glacial deposits, but the present higher land probably marks the location of the preglacial higher land masses. The features which are peculiarly of glacial origin include a number of plains and terraces lying at successive levels, representing stages in the level of glacial lakes, together with a few small isolated hilly areas of morainic deposition, which stood above the highest lake stage, the Algonquin.[2]

FIGURE 1.—Sketch map showing location of Luce County, Mich

Some of the higher land divisions appear as bold features, although there is in reality no relief of magnitude, as the highest elevations are only about 400 feet above Lake Superior, and local differences in elevation, as the height of a hill or plain above an adjacent swamp, lake, or valley, are in few places more than 100 or 150 feet. However, a number of distinct topographic divisions of local significance and a variety or minor land forms lend diversity and picturesqueness to the landscape.

The northern part of the county bordering Lake Superior is for the most part a smooth plain covered with sand representing lacus-

[1] Mr. Veatch acted in an advisory capacity during the progress of the survey and is responsible for the writing of the report. Mr Schoenmann was in charge of the field work.

[2] LEVERETT, F MORAINES AND SHORE LINES OF THE LAKE SUPERIOR BASIN U S Geol Survey Prof. Paper 154 : 1–72, illus. 1929.

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trine deposition. There is evidence of different levels and old shore lines, which mark the successive stages of glacial lakes, although these features are not outstanding. This section, as a whole, is comparatively dry, although a number of small swamps and a large number of lakes are distributed over it. The shore line of Lake Superior is almost straight, without any deep embayments or promontories. As a result of wave action the waters of the lake are actively cutting into the land and have made low bluffs facing the lake. Consequently, very little low or marshy land occurs along the lake shore. A wide wave-washed strand of sand and cobbles, beach ridges, and dunes are also shore-line features.

The central and eastern parts comprise a great swampy plain. A large low-lying peat swamp, ranging from 4 to 10 miles in width, traversed by Tahquamenon River and its tributaries, extends entirely across the county in an east-west direction; a broad wet plain extends northwest from Newberry to the western boundary of the county; and a third swamp division, surrounding Betsey Lake in the northeastern part, extends southwestward, coalescing with Tahquamenon Swamp. Rising from 20 to 75 feet above the lower lying peat swamp levels are terraces, broken plains, and low islands, and bold plateaulike masses of highlands rise from approximately 100 to 200 feet above the lowest levels. The higher land is for the most part nearly level, but it is marked by depressions, lakes, and other slight inequalities inherited from the prelacustrine morainic relief but resulting in part from subsequent lacustrine deposition. There are a few small outstanding high hilly areas, notably a bold broken ridge just south of McMillan, a second area just south of Newberry, and a third extending from the Alger County line a few miles southeastward toward Newberry. These areas are characterized by knobs, steep slopes, deep pit lakes, and deep valleys, in contrast to the generally smooth planate surface relief of most of the higher land.

Lakes are widely distributed and constitute features of physiographic and scenic interest and, in addition, have a very considerable recreational value. Some occupy deep pits, others are in swamps which are caused by stagnation of water or slow drainage in flat areas, others are held in shallow depressions between sand ridges or are due to obstruction of streams by dunes and beach ridges, as along the shore of Lake Superior. The lakes range in size from mere ponds covering an acre or two to expanses several square miles in area, and they present a great variety in depth, kind of water, and kinds of bottoms, ranging from clean sand and marl to peat representing all stages of filling by vegetation.

Streams are comparatively few in proportion to the total land area, as the land surface is comparatively young, and much of it is covered by very pervious sand and gravel. Some of the streams have cut narrow trenchlike valleys in places where they flow from the higher to the lower land, but they have not developed dendritic systems. The larger streams have a notable slackening of the current near Lake Superior and flow more or less parallel to the shore. Tahquamenon River in its eastward course probably occupies one of the old preglacial eastward belts of lowland. The tributary streams flowing into this river from the terraces and high plateaus,

both on the north and south, have moderately rapid fall, but the main river flows sluggishly and tortuously with a gradient of less than 1 foot to the mile. A scenic feature of the river is a fall of about 40 feet on the eastern boundary of the county.

Swamps are an outstanding physiographic and geographic feature. The swamp land occurs in large continuous bodies, such as Tahquamenon Swamp, and is also widely distributed throughout the county in small bodies, such as valley swamps and bodies representing the sites of lakes which have been filled by vegetation. The wet or poorly drained land is for the most part forested, but it consists in part of marsh and bog. The aggregate acreage of swamp comprises about 40 percent of the total area of the county.

The general elevation of the sandy plains in the northern part of the county ranges from 650 to 750 feet above sea level. The swampy lowland in the central part ranges from 700 to 800 feet, and the adjacent high plains and plateaus range from 800 to 875 feet. Two small bodies of highland, one south of McMillan and one along the Alger County line, attain elevations exceeding 900 feet and possibly reach 1,000 feet.[3] Lake Superior is approximately 600 feet above sea level.

The land, with the exception of a few tracts of marsh and bog, was originally densely forested. At present the greater part of the forest has been cut over by lumbermen, although a few large tracts of virgin hardwood forest and swamp timber remain.

The original forest was represented by several types or associations of trees as follows: (1) The hardwood forest, in which the principal species were sugar maple, yellow birch, and beech; (2) the hardwood-conifer forest consisting of the common hardwoods—sugar maple, elm, basswood, ash, and yellow birch—mixed with white pine, balsam fir, hemlock, and spruce; (3) the pine forest consisting of red (Norway) and jack pine on the driest sand plains and ridges, red pine and white pine on the slightly moister sandy soils, and white pine mixed with swamp conifers and hardwoods, such as ash, elm, balm-of-Gilead poplar, red maple, and aspen, on the wetter mineral soil areas; and (4) the coniferous peat-swamp forest consisting mainly of black spruce, white cedar, and tamarack, with less balsam fir and white pine.

As throughout northern Michigan, where the land has been cut over and subsequently burned, much of the country is now occupied by a cover of aspen, fire cherry, and white birch, with only stumps and a few poor remnants of the original forests. On the wetter mineral soils, aspen, alder, and willow are the predominant second-growth species, but in places a fairly thrifty and dense growth of balsam fir, spruce, and considerable white pine grows on the cut-over land. Some of the driest sandy land, such as that along the shore of Lake Superior and the drier parts of the pine plains along the Schoolcraft County line north of Tahquamenon Swamp, probably was never densely covered by forest, and much of the land is characterized by open spaces occupied by blueberries, sweetfern, bracken, reindeer moss, grasses (particularly *Danthonia*, *Andropo-*

[3] Elevations determined during the progress of this survey by S G Bergquist, geologist, using the aneroid barometer

gon, Poa canadensis, Oryzopsis), and sedges. The bogs support a growth of leatherleaf, Labrador-tea, blueberries, cranberries, sphagnum moss, and cotton grass, together with a few scattered small black spruce, and in the marshes, sedges, bluejoint, rushes, and cattails grow.

Potable healthful water can be obtained throughout the county from wells sunk to slight depths, generally less than 100 feet, and in several places flowing artesian wells are obtained. The well water is soft along the Lake Superior shore, but that in the southern part of the county is hard from calcium and magnesium bicarbonates. Practically all the streams are perennial and carry cold water which is rarely turbid but in most of them ranges from slightly to strongly colored, owing to suspended and dissolved organic matter. The water in the lakes is in general clear and cold, and it exhibits a wide range, from very soft to extremely hard.

The population of the county according to the 1930 [4] census is 6,528, all of which is classed as rural. Newberry, the largest town, has a population of 2,465, and most of the remaining population is in the few villages and lumber camps. The principal farming communities are in the southern part of the county in the vicinity of Newberry and McMillan; elsewhere the individual farms are more or less isolated and scattered throughout wild cut-over land and virgin forests. The greater part of the population is native-born American. The 1930 census reports 1,584 foreign-born white persons.

Lumbering and agriculture are the principal industries. Lumbering has declined within the last 10 years, although logging is still extensively carried on in the hardwood forests, and posts, railway crossties, and pulpwood are cut in the swamps. A large lumber mill, wood-distillation plant, and charcoal iron furnace are located in Newberry.

The total value of agricultural products in 1929, according to the Federal census report, amounted to $165,071 and the value of forest products cut on farms, to $35,457.

Luce County attracts large numbers of transient hunters and fishermen, and during the summer the tourist trade constitutes a considerable commercial asset. Commercial fishing in Lake Superior, and wild plants, such as blueberries, ferns, and moss, furnish additional sources of income.

Railway transportation is afforded by the Duluth, South Shore & Atlantic Railway, and three State trunk-line highways provide opportunity for travel by automobile. Parts of the county are difficultly accessible, but county and private roads traverse most of the area. These roads are for the most part unimproved and may be impassable during the winter and spring.

CLIMATE

Luce County lies between parallels 46° and 47° north latitude. The features of the climate are a mean annual temperature of about

[4] Soil survey reports are dated as of the year in which the field work was completed. Later census figures are given in this report.

40° F., a mean annual precipitation (including melted snow) of approximately 30 inches, an average snowfall of about 90 inches a year, high relative humidity, low percentage of possible sunshine, low wind movement, and low evaporation.

The winters are long and frequently extremely cold. The mean temperature is below freezing from November to March, and a minimum of −38° F. has been recorded. The period of warm weather is short and is characterized by moderate temperatures, with a seasonal average from June through August of about 61°.

Variations in temperature and dates of frosts are great enough in different parts of the county to have considerable significance in relation to plant growth. The first killing frosts may be as much as 2 weeks later along the shore of Lake Superior than on higher land from 10 to 20 miles inland. The frost-free season, between the last frost in the spring and the first in the fall averages 113 days at Deer Park and 108 days at Newberry. Light frosts have been known to occur throughout the county in June, July, and August. Although the short growing season and low mean temperature place this county at some disadvantage in competition with southern Michigan, by limiting the diversity of crops and the maturity of corn and fruit, the growth of hay, field peas, and small grain and the length of the pasture season are not greatly affected.

Precipitation is fairly evenly distributed throughout the year but is generally somewhat greater in the fall and summer than in the spring and winter. Rains are slow or continuous, rarely destructive downpours. Considerable variation in the annual amounts is recorded, and short periods of drought sometimes occur. On the coarser sands and on gravels, poor plant growth may be attributed to deficiency of moisture, but on the sandy loams sufficient moisture is generally available, and on the level clay lands there is more likely to be an excess than a deficiency.

The snowfall, which during most years forms a permanent cover from November to April, prevents freezing of the soil to a great depth during the winter and also protects fall-sown grain.

The prevailing winds are westerly. The wind movement is in general low, but at times winds attain high velocity directly along the lake shore.

Tables 1 and 2, showing the more important climatic data, are compiled from records of the United States Weather Bureau stations at Deer Park and Newberry.

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation near Deer Park, Luce County, Mich.*

[Elevation, 630 feet]

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1913)	Total amount for the wettest year (1922)	Snow, average depth
	°F.	°F	°F	Inches	Inches	Inches	Inches
December	21 8	50	−18	3.02	(1)	2.03	25 7
January	16.8	48	−33	2 27	1 10	4 97	20 4
February	15.2	58	−32	1 98	.45	5 51	18.6
Winter	17 9	58	−33	7 27	1 55	12.51	64 7
March	23 9	70	−38	1.75	1 00	2.55	8.2
April	36 5	80	−3	1.72	50	3 00	3 2
May	47.4	96	18	2.86	1.02	3 88	1 1
Spring	35 9	96	−38	6.33	2 52	9 43	12.5
June	56 9	97	25	2.83	2.80	5 04	.0
July	62.6	102	32	2.72	4.25	6.77	.0
August	62.2	96	29	2.29	1 50	2.32	0
Summer	60 6	102	25	7 84	8.55	14.13	.0
September	56.0	92	21	3 46	2 08	2.17	(1)
October	45 6	88	11	2.58	2.45	1 88	8
November	33 9	63	−5	2.58	1 30	2.93	11 1
Fall	45.2	92	−5	8.62	5.83	6 98	11 9
Year	39 9	102	−38	30 06	18.45	43.05	89.1

[1] Trace

TABLE 2.—*Normal monthly, seasonal, and annual temperature and precipitation at Newberry, Luce County, Mich.*

[Elevation, 773 feet]

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1902)	Total amount for the wettest year (1916)	Snow, average depth
	°F	°F.	°F	Inches	Inches	Inches	Inches
December	20 7	51	−22	1 63	1.30	2.17	14.5
January	14 9	51	−29	1 84	1 20	3 05	16.6
February	14 1	48	−32	1 42	1 00	1 03	12.9
Winter	16 6	51	−32	4 89	3 50	6 25	44 0
March	24 1	72	−23	1 84	01	2.00	10 9
April	38 4	82	−2	1 80	1 22	1 93	4 2
May	50 0	92	15	2.46	1 01	3 84	1 1
Spring	37 5	92	−23	6 10	2.24	7 77	16.2
June	59 3	97	22	2.92	2 30	4 43	0
July	64 8	98	28	2.76	3 06	2 19	.0
August	62 6	98	28	2.44	1 10	1 37	0
Summer	62.2	98	22	8 12	6 46	7 99	0
September	55 2	92	22	2 95	2 40	6 03	(1)
October	45 4	82	12	2 83	1 10	6 09	2 0
November	32 3	70	−3	2 43	2 20	1 39	11 2
Fall	44 3	92	−3	8 21	5 70	13 51	13 2
Year	40 2	98	−32	27 32	17 90	35 52	73 4

[1] Trace

AGRICULTURE

Agriculture in Luce County is comparatively recent, and only a very small proportion of the total area is occupied by farms. Some patch farming and gardening were carried on around the earliest settlements and later in the vicinity of the lumber camps and towns, beginning about 1880, and by 1890 the census showed a total of 55 farms.

In the early agriculture, as at present, hay was the principal farm crop, although small fields of oats, peas, and potatoes were grown, and some common garden vegetables were produced, together with maple sirup and maple sugar. During the last 10 years, the tendency has been toward greater diversity of crops, the growing of seed crops, and an increase in dairying. The number of farms increased up to 1910, but the last census (1930) shows a decrease, and less than 5 percent of the total area is in farms. The amount of cleared land on individual farms and separate fields is generally small, because of the cost and labor of reclamation which involves removal of trees, stumps, and stones, and, in places, the installation of drainage; also, because natural and economic conditions are unfavorable for extensive farming. On the other hand, farming even on the small fields is not highly intensive, as the factors inducive to intensive farming, namely, high price and scarcity of land, large population, and local markets, are lacking. Probably most of the farmers depend to some extent on outside employment to supplement the farm income.

The principal crops grown and their respective acreages and yields are shown in table 8.

TABLE 8.—*Acreage and yield of principal crops in Luce County, Mich., in stated years*

Crop	1919		1924		1929	
	Acres	*Tons*	*Acres*	*Tons*	*Acres*	*Tons*
Hay	4,035	3,540	4,391	4,178	3,593	3,947
Alfalfa	35	35	239		344	474
		Bushels		*Bushels*		*Bushels*
Oats	1,397	17,863	1,255	35,795	957	28,136
Potatoes	372	35,804	344	45,970	365	42,893
Rye	431	4,200	312	5,164	85	1,159
Barley	173	1,856	159	3,954	542	11,961
Wheat	417	3,292	46	811	63	1,121

Other crops grown with a measure of success are field peas, buckwheat, garden seeds, rutabagas, turnips, sunflowers, corn (for silage), artichokes, vetch, and millet.[5]

Fruits can be grown for home use, but climatic and other conditions are unfavorable for extensive commercial orcharding. Apples and plums are grown with fair success, and raspberries, gooseberries, and strawberries do fairly well throughout the county. Many of the common garden vegetables—cabbage, onions, lettuce, radishes,

[5] Additional information, applicable to Luce County, on crops, tillage, and agricultural conditions may be obtained from Special Bulletin 215 of the Michigan Agricultural Experiment Station, East Lansing, and from the director of the Upper Peninsula Experiment Station at Chatham

and squash—can be grown throughout the county, and celery is grown on muck land in the vicinity of Newberry.

According to the 1930 Federal census, the livestock in the county on April 1 of that year included 1,758 cattle, 529 swine, 271 sheep, and 307 horses. Milk produced in 1929 amounted to 523,821 gallons, and the value of dairy products sold was $75,637. Poultry and eggs are a supplementary source of income on most farms. The total value of all livestock in 1930 was $147,661.

Both sheep and cattle are pastured on uncleared land. Cut-over land, embracing wet mineral soils and the well-drained soils underlain by clay and clayey sand, where not too densely covered with brush and trees, afford good grazing from May to October or sometimes to the first of November. In addition to native forage plants, timothy, alsike, and red clover grow wild or can be easily introduced on burned-over land by seeding without any soil preparation. The cut-over lands of the sandy plains and deeper sands of the hills afford poor or only fair grazing, and the virgin forests, both swamp and upland, have very little value for pasture.

Commercial fertilizers have not yet been used to a great extent. Most of the land is comparatively new or recently cleared, and many farmers on newly established farms are not in financial condition to buy fertilizers, and, because of economic conditions and the type of farming practiced, the need of greatly increasing yields has not been imperative. However, as none of the soils is unusually productive, it does not seem probable that profitable productiveness can be maintained for a great length of time without the use of some fertilizer, larger applications of manure, and an increase of organic matter. Very little lime has been used, although practically all the sandy soils are acid and would be benefited by lime, especially where it is desired to grow alfalfa.

No common system of crop rotation or generally accepted procedure in handling soils has been developed from experience, as in regions where agriculture has been carried on for a long time. However, the value of changing crops, as opposed to continuous cropping, is recognized by most farmers, and some kind of rotation is followed, although it is not always systematic.

It is generally considered the better practice to plow the heavier soils in the fall rather than in the spring, but the lighter and drier soils may be plowed either in fall or spring. The use of the cultipacker or a roller on the lighter sandy soils is advisable.

The farms are small, most of them ranging from 40 to 160 acres in size, with generally less than half the land in cultivated crops. The small size and irregular shape of fields are attributed to such factors as cost and labor of clearing land of stumps and roots, to variations in soil and surface relief, and to the general distribution of lakes, swamps, and wet land. Most of the land is still held in large tracts by timber and land companies, and 82,349 acres,[6] mainly in the Superior State Forest, is under State ownership.

The character of the soil, together with other factors, such as surface relief, accessibility, and vegetation, that is, whether the land is in virgin forest or in a cut-over condition, has determined the

[6] FONTANNA, S. G. DIVISION OF LANDS. Mich. Dept. Conserv. Bien. Rept. (1929–30) 5: 122. 1930.

present distribution of farming. The greater part of the farming is carried on in the southern and southwestern parts of the county in the vicinities of Newberry, McMillan, and Manistique Lake, where the soils possess the highest fertility and where the relief is not excessively rough, although some of the land is wet and stony. Elsewhere there are only a few small isolated farms. The sandy plains, both hardwood and pine, are of poor or medium fertility and are deficient in moisture, and much of the land is remote and difficultly accessible. The sandy soils of the hills are for the most part of medium or low fertility and have the disadvantage of unfavorable relief. Sandy, silty, clayey soils and level stone-free land, which have a potential value for agriculture, occupy a large aggregate acreage east and northeast of Newberry, but because of such factors as poor drainage, remoteness, cover of forest, and the small size of separate bodies in association with peat swamps, little or no farming has been attempted. Land in general is of low value.

A classification of the land of Luce County into three classes is presented in table 4. This classification excludes values based on standing timber, minerals, urban land, and resort and other recreational uses, and is based primarily on natural fertility of the soil, relief, drainage, vegetal covering, and character of the soil associations. Although the classification is not based primarily on the present money value of the land, it happens that there is in general a fairly close relationship of the three classes to present assessed values. Such classifications as the one here given are, of course, not scientific or precisely quantitative and are subject to change as economic and social conditions and agricultural practices change.

TABLE 4.—*Classification of land in Luce County, Mich*

Soil type	Approximate area	Class and description	Present use and ownership
	Acres		
Greater parts of Trenary loam and Trenary sandy loam, parts of Bergland, Ontonagon, and Brimley soils	50,000	A Soils of medium or high productivity, moisture good, not swampy, slopes not excessively steep, separate bodies large enough to warrant agricultural development, either not stony or other factors sufficiently favorable to warrant clearing of stones and installing drainage	Greater part in farms or land owned in small tracts, estimated that from 30 to 40 percent is cleared land, remainder mainly in second-growth forest or recently cut-over land, small proportion in stump pasture, approximately 10 percent in virgin forest
Mainly Kalkaska sandy loam, Strongs fine sandy loam, Longrie loam, Ontonagon clay loam, Blue Lake loamy sand, Ogemaw fine sandy loam, Bohemian very fine sandy loam, Munuscong fine sandy loam, and most of the Bergland soils	238,000	B Soils of medium productivity, but land value depreciated because of stones, steep slopes, hilly relief, or poor drainage, includes land which is level and soil uniform, but plant growth limited by low moisture content	Less than 2 percent cleared and cultivated, land owned in large tracts and valued chiefly for hardwood timber, cut-over land remains largely under private ownership but is also owned in small part by the State.
Mainly Rubicon sand, Hiawatha loamy sand, Saugatuck sand, Au Train loamy sand, Sheldrake sand, Wallace fine sand, Deer Park fine sand, Newton sand, Strongs loamy sand, Rodman stony loam, and peat and muck soils	300,000	C Land value lowest because of low soil productivity, excessive stoniness, steep slopes, choppy relief, swampy condition and impracticability of drainage, excessive dryness, occurrence in small bodies, or a combination of these factors	Less than 1 percent in farms; valuable forest land still remains largely under private ownership, from 75 to 80 percent is cut-over land which is still held in part in large tracts by land and timber companies but is partly under State ownership in forest reserves and game refuges, small part held by private hunting and fishing clubs

It is evident from the foregoing inventory that a large aggregate acreage of wild land remains, which is arable, moderately productive, accessible, and in sufficiently large bodies of uniform land to offer possibilities for further agricultural development whenever actual need for an increase in food products or for farm homes arises. There seems to be little possibility of use either at present or in the near future for the third-class land, other than for forestry, game preserves, and recreational purposes.

SOILS AND CROPS

The soils of Luce County include a large number of distinct soil types which range widely in texture, structure, thickness, chemical composition, and moisture, and consequently in fertility and natural productiveness. There are some large bodies of comparatively uniform soil, but in general the individual types occur in small bodies in complex associations. Although the different soils exhibit the usual intergradations, in many places abrupt changes in texture and other soil characteristics within short horizontal distances are common. The variable character and the number of distinct soils are attributed to the great variety of rock materials in the glacial deposits which underlie or comprise the soils, to the variety of topographic forms, and to the range in moisture content or in natural drainage, from extremely dry to permanently water-logged or swampy.

In texture, the surface layers of the mineral soils, exclusive of forest mold, range from loose incoherent nearly pure sand to silt loam and clay loam, but most of them are sands, loamy sands, and light sandy loams. The sands comprise about 85 percent of the total area of mineral soils and the sandy loams about 10 percent, and those soils which would have a loam, silt loam, or clay loam texture in the plow soil if cultivated comprise less than 5 percent. Practically all the land, exclusive of swamp, is arable, although it is estimated that about 10 percent would be extremely difficult to reclaim and maintain under cultivation because of extreme stoniness, high water table, susceptibility to blowing, excessively choppy surface relief, or steepness of slope. About 35 percent of the total area of the county consists of muck and peat, which have their own peculiar tilth characteristics and would present difficult problems in drainage and management should attempts ever be made to utilize the larger bodies for cultivated crops.

Most of the soils are, or would be if cultivated, comparatively low in their content of humus, or organic matter. The forest mold layer of the virgin well-drained soils is, or was originally, nearly everywhere thin, not exceeding 2 or 3 inches in thickness, and the layer of highly decomposed organic matter in some soils is so thin as to be scarcely measurable. Most of the organic matter lying on the surface of virgin soils of forested areas is lost in clearing the land, and that remaining is not very durable under cultivation, especially in the sands. Although, in a technical sense, the upland soils are thin, generally the soil mass is deeply penetrable, as the underlying rock material is unconsolidated, consisting of ice-laid and water-laid drift and lacustrine, wind, and alluvial deposits. In a number of local areas hard bedrock and difficultly penetrable hard-

pan lie within a depth ranging from 1 to 3 feet below the surface, although the aggregate area of such land amounts to less than 1 percent of the total area of the county.

Probably 98 percent of the soils are acid in reaction in the surface layer of mineral soil; about 90 percent of them are acid to a depth ranging from 36 to 40 or more inches; and about 10 percent are strongly acid at the surface but contain sufficient calcium and magnesium carbonates or limestone gravel, at a depth ranging from 24 to 36 inches, to give an alkaline reaction. It is hardly probable that more than 2 percent are nonacid or alkaline in the surface layers under natural conditions. Most of the organic soils, which are mainly peats, range from medium to strongly acid.

The mineral soils are for the most part naturally fairly well drained as the movement of water through the soil is free, and the slope is sufficient to provide free run-off. In more than 50 percent of the area of the county the soils become excessively dry at times during the summer, but it is estimated that 40 percent of the land is characterized either by a high water table or by a permanently swampy condition.

The natural productivity of the soils in Luce County, according to the standards for Michigan, range from medium to low. Although analyses of the dominant types of soils do not show any evidence of abnormally small amounts of the nutrient elements ordinarily determined, much of the soil is poor in productivity because of a combination of low or only medium content of plant nutrients and a deficiency of moisture, for example, the pine-plain sands. A considerable percentage is poor because of low content of mineral plant food and excessive water, as in some of the peats and swamp-border mineral soils, such as the Saugatuck and Newton.

For purposes of mapping and correlation, soils are grouped into series on the basis of common characteristics of color, consistence, texture, chemical composition, and thickness of the whole soil and of the separate layers of the soil profile. The soil type, or unit of mapping, is distinguished on the basis of texture of the surface soil, or plow layer, of the mineral soils, or on the basis of some other single distinguishing specific difference within the series group. Each soil series is given a geographic name for convenience of reference and description.

In interpreting the soil map it should be understood that in few places are the soil types sharply separated in character, but rather grade into each other, so that mathematically accurate lines of demarcation are not to be expected. Many inclusions of other soils and small variations in each soil division occur, so that each color or pattern on the map must be understood as representing a dominant soil condition and not in every instance a single type of soil strictly uniform in every respect. The amount of detail which can be shown is, of course, limited by the scale of mapping. The scale here employed is 1 inch to the mile, and on this scale it is not generally practical to attempt to locate accurately separate bodies of soil less than 5 acres in extent.

In the following pages the soils are considered as to their practical agricultural significance and in relation to the value and use of the land, and their taxonomy, morphology, and evolution are discussed in a subsequent separate chapter. The following land groups, recog-

nized on the basis of outstanding soil characteristics, surface relief, drainage, and natural vegetation, are employed for convenience of geographic description: (1) Sands of the dry pinelands, (2) sands of the hardwood plains, (3) loam soils of the southern hardwood uplands, (4) sandy loams and sands of the hardwood hills, (5) sandy and clay soils of the swamps and wet land, (6) stream-bottom soils, (7) lake-shore soils, and (8) organic soils.

In the following pages the soils of Luce County are described in detail, and their agricultural relationships are discussed; their location and distribution are shown on the accompanying soil map; and their acreage and proportionate extent are given in table 5.

TABLE 5.—*Acreage and proportionate extent of the soils mapped in Luce County, Mich.*

Type of soil	Acres	Per-cent	Type of soil	Acres	Per-cent
Rubicon sand	90,816	15.6	Bergland silty clay loam	4,864	0.8
Wallace fine sand	8,768	1.5	Bergland silt loam	960	.2
Au Train loamy sand	50,432	8.7	Munuscong fine sandy loam	7,424	1.3
Kalkaska loamy sand	4,864	.8	Munuscong fine sandy loam, mixed phase	512	.1
Kalkaska sandy loam	5,888	1.0	Griffin loamy fine sand	5,184	.9
Trenary loam	4,736	.8	Griffin very fine sandy loam	576	.1
Trenary sandy loam	6,400	1.1	Griffin silty clay loam	1,024	.2
Blue Lake sandy loam	8,576	1.5	Rubicon fine sandy loam	320	.1
Blue Lake loamy sand	23,296	4.0	Deer Park fine sand	3,904	.7
Rodman stony loam	64	.1	Shelldrake sand	640	.1
Hiawatha loamy sand	6,336	1.1	Coastal beach	512	.1
Strongs fine sandy loam	15,680	2.7	Carbondale muck	84,608	14.5
Strongs loamy sand	39,104	6.7	Lupton muck	1,344	.2
Longrie loam	384	.1	Houghton muck	4,544	.8
Newton sand	13,696	2.4	Kerston muck	2,176	.4
Saugatuck sand	30,592	5.3	Spalding peat	56,192	9.7
Ogemaw fine sandy loam	3,200	.6	Greenwood peat	6,080	1.0
Ontonagon clay loam	4,352	.7	Tahquamenon peat	16,512	2.7
Ontonagon silt loam	1,536	.3	Dawson peat	23,936	4.1
Brimley very fine sandy loam	21,376	3.7			
Brimley silt loam	3,072	.5			
Bruce very fine sandy loam	5,504	.9	Total	581,120	
Bohemian very fine sandy loam	11,136	1.9			

SANDS OF THE DRY PINELANDS

Sand soils which originally supported forests of red (Norway) pine, jack pine, and white pine occupy a very large aggregate acreage. They occur in large bodies in the northern part of the county bordering Lake Superior, in the western part bordering Schoolcraft County, and in smaller bodies in the southern part. Most of the land consists of dry level plains, but in places these are pitted and slightly rolling or billowy. The original pine forest was cut from 40 to 60 years ago, and the land is now partly occupied by jack pine and a scattered growth of red (Norway) pine, but much of it, on account of repeated burning, is treeless and open in aspect, dotted with stumps and characterized by a poor ground cover of grasses, blueberries, bracken, sweetfern, mosses, and lichens, together with a scrubby growth of aspen, fire cherry, willow, and service berry.

In addition to the plains, low sand ridges, widely distributed throughout the swamps and lower lying land, originally supported pine. The soils of the pinelands are mostly deep, dry, loose sands, low in moisture content and fertility, and consequently they have little or no agricultural value. The sands of the plains in Luce County are classified as Rubicon sand, and sands of the swamp and

upland ridges, which are apparently old dunes and lake-beach ridges, as Wallace fine sand.

Rubicon sand.—Rubicon sand is characterized by a surface layer of light-gray loose harsh sand from 3 to 6 inches thick, underlain by dull-yellow sand, which may be slightly cemented, extending to a depth ranging from 18 to 30 inches. Loose gray or faintly salmon colored sand extends to a depth of several feet before the water table or any clayey substratum is reached. In the virgin condition, the dark-colored humous soil is scarcely more than one-half or 1 inch thick, and the underlying sand is acid and low in fertility.

The original forest growth was chiefly white pine and red (Norway) pine, with a small admixture of the common hardwoods near the boundaries. The land at present is occupied by the stumps of the original pines and a growth of aspen, red maple, service berry, and fire cherry, with clumps of jack pine, and a few individual white pines and red pines. The ground cover consists mainly of sweetfern, blueberries, bracken, wintergreen, mosses, and lichens, and locally a fair cover of native grasses and sedges. Reindeer moss (*Cladonia* sp.) is very conspicuous locally in small patches, probably where there has been erosion by water or wind, or where other vegetation and the original surface soil have been destroyed by severe burning.

The land is arable and the surface relief favorable, but, on account of low fertility and excessive dryness at times, the soil has very little or no agricultural value under present conditions. The pasture value is only fair, and tree growth is apparently slow.

Wallace fine sand.—Wallace fine sand comprises dry soil on low dunelike mounds and old lake-beach ridges, both on the swampy plains and on the upland. This soil is distinguished from other sandy soils by a notably thick but irregular development of a brown or yellow cemented layer just beneath the surface soil and by the greater thickness, uniformity in texture, and freedom from gravel and stones of the underlying yellow or faintly salmon colored stratified sand. The soil is strongly acid to a depth ranging from 4 to more than 5 feet, is low in fertility, and is loose and incoherent both at the surface and underneath the brown or yellow cemented layer. The texture varies from uniform fine sand to uniform medium sand. The soil on some of the ridges in the Seney Swamp is of fine sand texture.

This land has no agricultural value, because of the small size of the separate bodies, the surface relief, its occurrence in swamps, and a tendency to blow where vegetation has been removed. The original forest cover consisted mainly of white and red pine, with some trees characteristic of the associated soils, either hardwoods or spruce, fir, and tamarack. The present growth consists of aspen, fire cherry, and red maple, with a few of the original forest species. Bracken, sweetfern, blueberries, and wintergreen form the characteristic undergrowth.

SANDS OF THE HARDWOOD PLAINS

Dry sandy soils covered by hardwood forest and smooth surface relief occupy a large aggregate acreage. Most of this land is level or slightly undulating, but locally it is pitted and marked by dry valleys, which in places have abrupt scarplike slopes.

A number of soils are distinguished on the basis of slight differences in texture, in the thickness and color of the brown or yellow subsurface layer, which is common to all the old soils of this section, and two broad groups are recognized on the basis of the amount of limestone influence. Corresponding to these differences is a slight range in the average moisture content, in the productivity, and in the natural adaptation for plants. All the soils of the group, however, have the same general profile, all are underlain by loose dry yellow and gray sand to a depth of several feet, all are characterized by medium or strong acidity in the surface layers, and all have a thin layer of forest mold and the practical absence of a dark-colored humous surface layer. The principal limiting factor in plant growth is low average moisture content.

The soils in this group are Au Train loamy sand, Kalkaska loamy sand, and Kalkaska sandy loam.

Au Train loamy sand.—Au Train loamy sand is characterized by a thick brown or yellow layer of sand beginning at a depth ranging from 6 to 12 inches, which in most places is cemented and in some places is firmly enough cemented to be designated as a hardpan. This layer is thicker, in most places reaching a depth ranging from 30 to 40 inches, and in places the material ranges from 5 to 6 feet in depth and is consequently more noticeable than in the other sand soils of this group. The soil is strongly acid and very little or no limestone, or calcium carbonate, occurs in the underlying dry sand and gravel.

This soil occurs only in the northern part of the county, where it occupies several detached bodies of nearly level land markedly different in aspect from the associated pinelands and the more rolling and hilly hardwood uplands. The land originally supported a good stand of hard maple, yellow birch, hemlock, and beech, interspersed with scattered white pine and balsam fir. A few small areas of virgin forest remain, but the greater part of the land is now occupied by stumps and second-growth trees of the original species, together with aspen, fire cherry, red maple, and service berry. A fair growth of grass covers the more open cut-over land. The land is arable, but none of it has been placed under cultivation. It is probably capable of producing small or fair yields of cultivated crops, such as potatoes, oats, and root crops, but is regarded as second- or third-class land under present economic conditions. The grazing value is poor or only fair, depending on the density of the second-growth trees and brush.

Kalkaska loamy sand.—Kalkaska loamy sand is distinguished by a small quantity of limestone gravel in the underlying sand and by the dark-brown color and loamy feel of the sand which begins at a depth ranging from 4 to 8 inches. This soil occurs on the level plains, or terraces, and in dry valleys in the southern part of the county. Most of it occurs in fairly large and uniform bodies, but small detached areas are also widely distributed. The original forest consisted mainly of hard maple, yellow birch, hemlock, beech, and elm, with a variable admixture of white pine.

The land is capable of producing small or fair yields of oats, potatoes, and other crops adapted to this section. Yields are most likely to be limited by deficiency in moisture. The soil is easily tilled and not susceptible to serious blowing or water erosion. The

grazing value of cut-over land is only fair. On the whole this soil is regarded as second-class agricultural land. In places the soil is unusually gravelly and cobbly at the surface.

Kalkaska sandy loam.—Kalkaska sandy loam differs from Kalkaska loamy sand in the slightly heavier texture of the surface layer of gray sand and of the underlying brown sand, together with a slightly higher percentage of coarse material (gravel and stones) in the deeper underlying material. The soil is comparatively dry, but the slightly higher percentage of silt and clay in the surface layer is probably the explanation of the somewhat higher agricultural value of the land and slightly greater volume of growth of natural vegetation.

The land is easily tilled, except in local gravelly patches. In the few places under cultivation, it has produced fair yields of timothy and clover hay, oats, potatoes, and root crops. The greater part remains as cut-over timberland, with here and there small tracts of the original forest. Some of the unplowed land is utilized for pasture and has a fair value for this purpose where the growth of trees, brush, and briers following lumbering has keen kept under control. In addition to native grasses and herbaceous plants of some forage value, Canada bluegrass, Kentucky bluegrass, timothy, alsike, and June clover are growing wild.

Where favorably located, this soil is regarded as having some agricultural value, but on the whole it must be regarded as second-class land.

LOAM SOILS OF THE SOUTHERN HARDWOOD UPLANDS

The comparatively smooth upland plains and rolling or hilly uplands which are underlain by the more limy and more clayey glacial drift, as in the country south and west of McMillan and southwest of Newberry, are characterized by somewhat more productive loamy soils that originally supported dense hardwood forests. Much of the land is cleared and farmed, although some of it is excessively stony. The soils of the better drained but smooth land are classified as types of the Trenary and Blue Lake series. These soils are distinguished by limestone as a component of the gravel and stones and by the moderately limy character of the underlying clay, differing in this respect from the more loamy soils north of Tahquamenon Swamp, where limestone as a component of the underlying glacial deposits is absent, or present only in very small quantities.

Two soils, differentiated on the basis of slight textural differences in the surface layers and depth to the clay, are designated as Trenary loam and Trenary sandy loam; the sandier soils in the group are classified as Blue Lake sandy loam and Blue Lake loamy sand; and the stony and cobbly dry soil on knobs or ridges as Rodman stony loam. These soils originally supported a forest consisting mainly of sugar maple, beech, yellow birch, elm, basswood, balsam fir, and hemlock.

Trenary loam.—Trenary loam includes the heavier soil of the group, that which is loam or silt loam in the plow layer. The subsoil clay is also heavier, or less sandy, and is reached at slighter depth, from 10 to 18 inches, than in the other soils of the group.

The undisturbed, or virgin, soil consists of a 2- or 3-inch layer of forest mold and humus, a thin gray silt or fine sandy layer, and a yellow silty layer overlying red clay. When cleared or plowed the soil is variegated, or if thoroughly mixed is brown in color. This soil is fairly well supplied with organic matter, retains moisture well, is not excessively acid, and is otherwise moderately productive. Some of the land is stony but in general not excessively so.

Fair yields of timothy and clover hay, potatoes, oats, and barley are grown. Other crops, which have been or are at present grown in small fields, are corn, sunflowers, wheat, alfalfa, buckwheat, mangels, and rutabagas.

It is estimated that about 25 percent of the land remains as cut-over forest land or wood lots. The value of the land is depreciated to some extent by its occurrence in small bodies penetrated or surrounded by swamp and wet land.

Trenary sandy loam.—Trenary sandy loam consists of friable gray and yellow sandy material to a depth ranging from 20 to 36 inches, where it is underlain by clay. The clay is sandy but is moderately compact and even slightly cemented. This soil is not quite so productive naturally as the loam, but it is easily tilled after the stones are removed, retains moisture, and is capable of producing fair yields of potatoes, timothy and clover hay, oats, and barley. Commercial fertilizers might be profitably used, and in places, as the topsoil appears to be too acid for the successful growth of alfalfa, lime probably should be applied, particularly for this crop.

Blue Lake sandy loam.—Blue Lake sandy loam is a light soil underlain by sand or sand and gravel, but it contains sufficient fine-earth material in the surface layers to be classed as a sandy loam. Some clayey material is present in places at a slight depth. The dark-brown sandy loam, which lies at a depth ranging from 4 to 8 inches in the forest, is turned up when the land is plowed and imparts a brown color to the cultivated fields. The soil is a little more productive than the sand soils, but it seems that moisture is the principal limiting factor in crop production, and for certain crops the strong acidity of the surface layers may also be unfavorable.

The land is level or slightly undulating and is favorable for agricultural use. The soil is easily plowed and maintained in good tilth, with the exception of some more cobbly or stony areas which are indicated on the soil map by stone symbols.

A number of farms are on this soil southwest of Newberry and in the vicinities of McMillan and Manistique Lake in the southwestern part of the county, where fairly successful crops of oats, timothy and clover hay, potatoes, field peas, and garden-vegetable seed crops are produced. The greater part of the land, however, remains in forest or as wild cut-over land. Where the brush and second growth are not too heavy, the land furnishes good pasture for cattle and sheep during the early summer.

The original forest growth consisted of sugar maple, elm, yellow birch, fir, spruce, and white cedar.

Blue Lake loamy sand.—Blue Lake loamy sand is characterized by lavender-gray sharp leached sand beneath the forest mold, underlain at a depth ranging from 6 to 10 inches by brown or umber-colored loamy sand. The deeper underlying material is mainly comparatively dry sand and gravel to a depth of several feet, but it

contains a few boulders and thin layers or masses of somewhat red sandy clay. A moderate limestone influence is evident in the underlying drift, although the soil proper is in general strongly acid.

This land is arable and is a little more productive than similar sand soils, such as the Au Train and Kalkaska loamy sands, because of the slightly loamier character of the brown subsurface layer and the presence of more clay and limestone at a slight depth. A large acreage of this soil is in the southwestern part of the county. The land is nearly level or but moderately rolling, and the soil is easily plowed where stumps have been removed from the fields.

Rodman stony loam.—Rodman stony loam includes the soils of the narrow sharp stony ridges and knolls. The underlying material is a pervious heterogeneous deposit of boulders, cobbles, gravel, and sand, with only here and there sufficient clay to bind the coarse material. The land is capable of supporting a fair growth of hardwood forest and when cleared of trees and brush furnishes fair pasture, but it is of small value for cultivated crops because of stoniness, unfavorable surface relief, and susceptibility to erosion. The total acreage of this land is very small.

SANDY LOAMS AND SANDS OF THE HARDWOOD HILLS

All the sandy soils of the more rolling and hilly parts of the county have the same general soil profile. They are all characterized by gray or leached sand beneath the forest mold and by brown or yellow sand or sandy loam at a slight depth. All are comparatively dry, incoherent, deep, penetrable, low in humus, and strongly acid in the surface layers. They are not highly productive but are in general a little more productive and not quite so deficient in moisture as the plains sands, but, because of such factors as hilly surface relief, stone content, complexity of association with other soils, and remote location, are generally second- and third-class land, when considered as to their present agricultural use.

A number of distinctions are made on the basis of textural differences, of color differences in the underlying sand or sandy clay, and in the amount of limestone influence. The principal soils comprising this group are Hiawatha loamy sand, Strongs loamy sand, and Strongs fine sandy loam. Included with the group because of its association, is a somewhat heavier soil underlain by limestone, designated as Longrie loam.

The principal hilly areas occur in the central and western parts of the county north of Tahquamenon River, south of Newberry, in the southeastern part bordering Mackinac and Chippewa Counties, and south of McMillan.

Hiawatha loamy sand.—Hiawatha loamy sand comprises soil on the higher and more strongly rolling and hilly hardwood land. The deeper underlying material consists mainly of yellow sand, but in a few places pockets of gravel and boulders are present and layers of red clay occur at a depth within reach of plant roots. The surface soil, to a depth ranging from 3 to 4 feet, is less uniform as compared with Strongs loamy sand, from which this soil differs also in surface relief. The loose incoherent character of the soil, its low or only medium fertility, hilly uneven relief, and remote location are depreciating factors, and none of the land is in agricultural use. It is,

however, capable of producing a fair forest growth. The virgin forest consists of a fairly dense stand of sugar maple, beech, and yellow birch, with a variable amount of hemlock and fir, and a small amount of white pine. The cut-over land is occupied by a second growth of the original species or, where more severely burned, by aspen, fire cherry, white birch, grasses, and briers.

Strongs fine sandy loam.—Strongs fine sandy loam is distinguished from the associated sand soils by a slightly finer texture and loamier feel in the surface layers and by the presence of layers or pockets of pale-red clayey sand or friable sandy clay at a depth ranging from 2 to 4 feet. The slopes are smooth and not excessively steep or stony, although scattered boulders are present. This soil holds more moisture and is probably more productive than the sands, judging by the tree growth. However, as the soil in the areas shown on the map is not uniform, and as the soil having clay close to the surface occurs only in small bodies, the land has only a small prospective value for agricultural use. The original forest cover consisted mainly of sugar maple, beech, yellow birch, and hemlock, with a small proportion of elm and basswood. A few patches of virgin forest remain, but most of the land is in slashings and second growth or, where more severely burned, is covered with grasses, weeds, and briers. The more open land has fair value for grazing.

Strongs loamy sand.—Strongs loamy sand occupies comparatively high upland. When viewed from a distance the skyline is even and the land appears as a plain or plateau, although locally pothole depressions and valleys occur, causing the relief to be slightly uneven or rolling. The principal difference from similar sandy soils is the presence, in places, of layers of pale-red sandy clay, silt, pockets of gravel, and boulders in the underlying drift. The surface soil, however, is in most places loose medium and fine sand to a depth exceeding 3 feet. Very little or no limestone is in the underlying drift.

The original forest growth consisted mainly of sugar maple, beech, yellow birch, and hemlock, with some elm, basswood, white pine, fir, red oak, and a few other species. A rather large proportion of the land is still in virgin forest, and the remainder is in slashing or, where severely burned over, has grown up to aspen, fire cherry, oaks, and sumac, together with a fair grass cover.

In Luce County this is second- and third-class land, considered agriculturally. None of it is farmed at present, but it is arable, and the same soil in other parts of the Upper Peninsula has produced fair yields of the staple crops grown. Its chief deficiency lies in its low moisture content. It is probably better adapted to the production of trees than to cultivated crops.

Longrie loam.—Longrie loam is underlain, at a depth ranging from 1 to 4 feet, by limestone bedrock. The soil, or the material from which the soil is derived, is either sand or a coarse mass of sand, gravel, and stones. In the shallower better drained places, the limy material is weathered, resulting in a small amount of clay sufficient to produce a loam or sandy loam texture, and it is dark umber or brown throughout its entire thickness. The soil is fairly well supplied with humus and is fairly productive. The chief depreciating factors affecting the value of the land are stoniness, slight depth to bedrock, and small size of the separate bodies.

Longrie loam occupies small bodies on the tableland, mainly in the extreme southeastern part of the county. The original forest consisted of sugar maple, beech, elm, basswood, and yellow birch. Where cleared of trees and brush, the land supports a good grass cover and affords fair pasture. This soil is not important agriculturally, as it occupies only a very small aggregate acreage.

SANDY AND CLAY SOILS OF THE SWAMPS AND WET LAND

Wet sandy soils occupy narrow strips on the borders of peat swamps and lakes and also comprise larger areas on old flat lake-bed plains where the water table is held up by the underlying clay or bedrock. Drainage conditions of these soils cover a wide range, so that some of the land included in this group is nearly as permanently wet as the peat swamps, and in other places, where the height of the water table fluctuates greatly, the surface may become dry, and evidence of permanent water-logging appears only at a depth ranging from 2 to 3 feet. In these latter situations peculiar rust-colored or brownish-black layers of sand, or sandy hardpan, develop at a slight depth. The soils have a black mucky or peaty surface layer which is directly underlain by a gray or nearly white bleached or leached layer.

This kind of land has little agricultural value, as the natural productivity, durability, and size of the separate bodies are not sufficient to justify the high cost of reclamation which would involve ditching and tiling, in addition to the removal of a dense cover of vegetation and stumps. Under natural conditions, the land supports a dense plant growth as a result of the combination of abundant moisture and a thick surface layer of mucky or humous soil.

Wet land directly underlain by red plastic clay occurs in many bodies. Such land in general included a higher percentage of hardwoods and a larger volume of growth in the original forest, and at present it affords better pasture and offers greater possibilities for agricultural use than the wet sands.

The wet sandy soils included in this group are the Newton, Saugatuck, Brimley, Ogemaw, and Munuscong soils, and the clay and silt soils are the Bergland, Ontonagon, Bruce, and Bohemian soils.

Newton sand.—Newton sand comprises the soil of the wetter sandy swamps, where the water table is but slightly lower than that of the peat swamps.

The soil is characterized by a thin mucky or peaty covering, ranging from 2 to 8 inches in thickness, over gray water-soaked sand which in most places shows smoke-colored stains or rust-yellow splotching. Most of the sand is medium in texture and extends to a depth of more than 3 feet. Normally the water table lies at a depth of 12 or 15 inches, but at times it is practically at the surface.

This soil is widely distributed. It occurs mainly in small bodies as narrow strips bordering swamps and lakes, also in depressions between sand ridges on the low-lying sandy plain bordering the shore of Lake Superior. Some of the soil included on the map is little else than shallow peat of the Spalding or Greenwood type over sand, but in other places it represents a gradation into Saugatuck sand.

Newton sand is strongly acid, and since, other than the surface layer of organic matter, it is merely leached water-logged sand, the productivity is low. Under natural conditions the principal source of fertility lies in the organic surface layer.

The land is not used for cultivated crops and under present economic conditions has practically no agricultural value. Most of it is covered by a dense thicketlike growth of aspen, alder, willow, white birch, black spruce, cedar, and tamarack, together with blueberries and shrubs common to the peats and mucks. Originally it supported considerable white pine. Trees are very shallow rooted, on account of the high water table.

Saugatuck sand.—Saugatuck sand comprises the wet sandy soils characterized by a rust-colored, brownish-black hardpan sand layer at a slight depth. The water table fluctuates from a few inches to 3 feet below the surface, and the sand in most places is 3 feet or more thick. Most of the land is flat and lies at an elevation ranging from only 1 to 5 feet above the adjacent swamp or water surface, although the surface is in general uneven, owing to a pit-and-mound condition, especially on old cut-over land. Although the hardpan sand and water-logged condition are characteristic, they are not everywhere present in the areas shown on the soil map, as slight differences of a foot or two in elevation and small differences in depth to clay cause either a wetter or drier condition and a change in soil. The Newton, Ogemaw, Brimley, Rubicon, and peat soils are intimately associated with Saugatuck sand in many places.

Saugatuck sand is strongly acid, and its productivity is low when the land is placed under cultivation. Under natural conditions, the soil supported a fairly heavy volume of vegetation. Large white pine and hemlock grew on the higher land and a mixture of balsam fir, cedar, spruce, aspen, red maple, elm, birch, and ash on the wetter associated soil.

Ogemaw fine sandy loam.—Ogemaw fine sandy loam is the name applied to the soil of the wet land, which is characterized by a thin cover of fine sand or fine sandy loam, overlying comparatively impervious limy clay. The sand is water-logged at the point of contact with the underlying clay, but the average height of the water table, or upper limit of complete saturation of the ground, is less than that of the more swampy sandy soils, such as the Newton and Saugatuck. The color of the surface layer is dark, owing to an accumulation of organic matter, and a definite rust-colored or brown sand is present at a slight depth.

Ogemaw fine sandy loam, considered as agricultural land, is of comparatively little importance because of the small size of the separate areas. The land, however, is moderately productive and is capable of being utilized for pasture, where cleared of trees and brush, and of producing good yields of hay and small-grain crops if provided with adequate drainage.

Ontonagon clay loam.—Ontonagon clay loam includes the land underlain by red plastic stone-free clay and silt. The soil where undisturbed consists of a surface layer of moist nearly black silty loam over ash-gray silt loam underlain by mottled clay which, in turn is underlain by red dense plastic clay at a depth ranging from 4 to 8 inches. Owing to the impervious character of the clay, a high

percentage of water is held, causing the soil to be wet and cold. A number of fair-sized bodies occur on the low-lying swampy plain south of Soo Junction, and a fairly large area occupies the low-lying terrace plains a few miles southwest of Newberry. None of the land is under cultivation, except a few fields southwest of Newberry along United States Highway No. 28.

This soil can be made productive when properly tile drained. It is suitable for timothy and alsike clover, oats, barley, alfalfa, flax, and root crops. Tillage is at times difficult, on account of the heaviness of the soil. The land originally supported, in association with the Ogemaw, Bergland, and similar soils, a dense stand of a mixed forest growth consisting mainly of white pine, balsam fir, spruce, elm, ash, basswood, maple, and aspen. The cut-over land is thickly set with stumps and grown up to a dense cover of brush and second-growth trees of the original species. Where cleared, it provides excellent wild pasture.

Ontonagon silt loam.—Ontonagon silt loam is the lightest textured soil of the Ontonagon series. The depth to the underlying red clay ranges from 12 to 18 inches, and this clay is a little less plastic and impervious than that underlying Ontonagon clay loam, as it contains a higher percentage of silt and very fine sand.

The profile of a virgin area of Ontonagon silt loam shows a succession of layers as follows: (1) A 2- or 3-inch layer of forest mold and humous soil; (2) a 6- to 12-inch layer of gray silt loam which is nearly white, floury, and ash colored when dry; (3) a 6- to 8-inch layer of yellow or cinnamon-colored friable silt loam; and (4) red clay grading, at a depth ranging from 36 to 40 inches, into the unaltered substratum of laminated or interbedded pale-red clay and silt.

The soil is not high in humus or in phosphorus, but, because of the fine texture and uniform supply of moisture, it is regarded as a fertile soil. Lime carbonate is leached out, and the soil material is generally acid in reaction to a depth ranging from 20 to 30 inches.

This soil occupies level or very gently sloping land. It occurs principally in the low-lying swampy plain south of Soo Junction in the southeastern part of the county. Some of the land is naturally sufficiently well drained for farming, but, as with Ontonagon clay loam, most of it would require tiling or other means of artificial drainage.

Ontonagon silt loam represents an intergradation between the wetter Bergland soils and the sandier Brimley and Bohemian soils, and small bodies of these and other soils are included in areas mapped as Ontonagon silt loam.

The original forest covering consisted of intermingled hardwoods and conifers. The present tree growth on old cut-over land is principally aspen.

This, or a very similar soil, is utilized for growing hay (timothy and alsike clover), small grain, and potatoes in Chippewa County. The comparatively small aggregate acreage, small size of some of the separate bodies, and association with peat swamp and other poorer land, probably do not warrant complete utilization of the land for agricultural purposes in this county, as the cost of reclamation would probably be excessive.

Brimley very fine sandy loam.—Brimley very fine sandy loam occurs as flat or gently sloping wet, but not swampy, land. Most of this soil shows the following profile: (1) A 2- or 3-inch layer of forest mold and humous soil; (2) a layer of gray and pale-lavender leached very fine sand ranging from 2 to 10 inches in thickness; (3) a layer ranging from yellow to dark-brown very fine sand or fine sand, in places slightly cemented, from 3 to 15 inches thick; and (4) a layer of wet yellow or gray, splotched with rust color, fine sand grading into pale-red interstratified silt and clay. The topsoil is strongly acid, but the underlying silt and clay are generally calcareous at a depth ranging from 3 to 5 feet.

This soil occurs both as small islands in the swamps and as fairly large bodies in the eastern part of the county on the low-lying plains traversed by Tahquamenon River. The larger bodies originally supported and are in part still covered by a thrifty forest consisting of a mixture of white pine, balsam fir, white spruce, and hemlock, with which are intermingled yellow birch, elm, ash, basswood, and sugar maple. The present growth on old cut-over land consists chiefly of aspen, but in places a fair reproduction of the original species has taken place.

This soil is utilized to only a very small extent for cultivated crops because of the small size of separate bodies in association with swamps and other poor land and because of unfavorable location. Where properly handled, it is capable of producing fair yields of timothy and alsike hay, oats, wheat, field peas, and potatoes. As the land is free from stones and gravel, it is easily tilled.

The land affords fair pasture, supporting alsike clover and timothy in addition to native grasses, where the brush and tree growth is not too thick.

Brimley silt loam.—Brimley silt loam is very similar to Brimley very fine sandy loam, except that the soil and underlying formation contain a higher percentage of silt. It is slightly more fertile than the sandy soils which are similar in relief and drainage. A number of rather large bodies are along Tahquamenon River northeast of Newberry. This is considered potential agricultural land, but, as it is unfavorably located and still partly in forest, none of it has been cleared for farm crops.

Bruce very fine sandy loam.—Bruce very fine sandy loam is a dark-colored fertile but wet soil which occurs mainly in the Tahquamenon swampy plain northeast of Newberry.

The surface soil is almost black or very dark gray, high in organic matter, and is underlain at a depth ranging from 3 to 8 inches by gray very fine sand, which in places shows yellow coloring at a depth ranging from 10 to 20 inches. The underlying formation is stratified pale-red or salmon-colored very fine sand and silt. Under natural conditions the soil is permanently wet below a depth of 10 or 12 inches. This soil is well supplied with organic matter in the surface soil, is loamy, has good tilth, is not excessively acid, and, as the density and volume of growth of natural vegetation further indicate, it should be moderately fertile and productive under cultivation.

The areas shown on the map differ from one another. Where slightly wetter conditions prevail and the underlying material con-

tains a little more clay, the soil grades into muck and the Bergland soils, and where drainage is a little better it grades into the Brimley and Bohemian soils.

The original forest growth consisted of a dense stand of mixed conifers and swamp hardwoods, mainly balsam fir, spruce, cedar, hemlock, white pine, elm, ash, balm-of-Gilead poplar, and red maple. The present vegetation is a thicket growth of aspen, alder, willow, white birch, and a scattered reproduction and remnants of the original forest.

None of the land has been placed under cultivation. Its location and association with less desirable soils are depreciating factors.

Bohemian very fine sandy loam.—Bohemian very fine sandy loam is composed mainly of very fine sand and silt, characterized by a pale-red or salmon color at a slight depth. The profile is somewhat similar to that of Brimley very fine sandy loam, but the Bohemian soil has developed under less wet conditions.

The soil over most of the areas shown on the map consists of the following layers: (1) A layer of forest mold and humous soil 2 or 3 inches thick; (2) a layer of lavender or gray very fine sandy loam; (3) a layer of yellow or dark-brown silt loam or very fine sandy loam from 4 to 8 inches thick, grading into pale-yellow very fine sand and silt, which in turn grades into (4) pale-red or salmon-colored stratified silt, clay, and fine sand.

The soil is acid, but the parent material is in most places limy at a depth ranging from 4 to 5 feet in the clay and silt layers. The moisture content is sufficient for heavy plant growth without extremes of either wetness or dryness, and the soil is fairly productive, but, as in practically all the well-drained acid soils of this section, it is low in humus and nitrogen, except in the thin surficial layer of forest mold.

The surface relief is mainly level, but in places the areas are dissected by streams. None of the land is under cultivation, because of the small size of separate bodies in association with swamp and less valuable land, broken surface relief, or unfavorable location. This soil is capable of producing fair yields of timothy and alsike hay, oats, potatoes, and other crops adapted to this section of the State.

The original forest consisted of a thick stand of trees, mainly a mixture of sugar maple, yellow birch, hemlock, white pine, balsam fir, and spruce.

Bergland silty clay loam.—The Bergland soils are dark-colored heavy soils closely associated with and closely related to the Ontonagon soils, in that they are underlain by red clay, but they differ from the Ontonagon soils primarily because of poorer drainage. They occupy wet flats and shallow swales.

Bergland silty clay loam is characterized by a 2- to 4-inch covering of mucky organic matter, a layer of dark-gray plastic clay from 3 to 6 inches thick, and a layer of highly plastic gray or drab clay, becoming mottled with yellow at a slight depth and grading into red comparatively impervious clay at a depth ranging from 12 to 20 inches. The soil is in general neutral or alkaline in reaction, and it is highly productive.

The largest bodies occur on the flat level clay plains east of Newberry and south of Soo Junction.

The original forest consisted of a dense stand of trees, chiefly balsam fir, spruce, white cedar, hemlock, and white pine, with various quantities of aspen, elm, black ash, basswood, and red maple. The wild cut-over land is covered thickly with stumps and a dense growth of aspen, alder, willow, and a second growth of the original trees.

The agricultural value of the land is low because of poor drainage and high cost of reclamation. The soil is difficult to cultivate because of its plastic sticky character, especially the areas of thinner soil which are nearly like Ontonagon clay loam. It is cold and wet because of the highly retentive character of the underlying clay.

Bergland silt loam.—Bergland silt loam differs from Bergland silty clay loam in texture, as it contains appreciably more silt and less clay. The plow soil, therefore, is a little more loamy and friable. Drainage conditions and the original and present forest covers are very much the same as on the silty clay loam. Only a few small bodies of this soil are mapped. The land has about the same agricultural value as Bergland silty clay loam.

Munuscong fine sandy loam.—Munuscong fine sandy loam has the dark-gray or black surface soil common to the wet mineral soils. It is characterized by gray fine sandy loam which overlies red plastic fine sandy clay at a depth ranging from 12 to 24 inches. This soil occurs in fair-sized bodies in the eastern part of the county in the flat swampy plain occupied by Tahquamenon River. Only a small percentage of the land is utilized for agriculture and this chiefly for hay and pasture. The soil is not highly acid and is fairly fertile. The land has little agricultural value at present because of the cost of reclamation in clearing and drainage, but it has considerable potential value. Practically all the forest has been cut over, and where the land is not cleared it is thickly set with stumps or is covered by a dense growth of aspen, alder, willow, balsam fir, cedar, spruce, and tamarack, together with a few swamp hardwoods.

Munuscong fine sandy loam, mixed phase.—Munuscong fine sandy loam, mixed phase, is essentially a complex consisting of an intimate association of several soils occurring in small bodies. Deep sands, sandy loams, sandy clays, and gravelly and wet mucky soils are so mixed that it is impractical to make separations on a small-scale map. The soils as a whole are sandy and are members of the Kalkaska, Blue Lake, Ogemaw, and Brimley series and Carbondale muck. This mixed soil lies in the vicinity of Danaher in the western part of the county and on the slopes and broken land bordering the Tahquamenon and East Branch Fox River Swamps. The land has very little agricultural value.

STREAM-BOTTOM SOILS

The stream-bottom, or alluvial, soils occupy only a very small acreage. Most of the streams are short, and in places they have cut narrow trenchlike valleys. Most of the larger streams originate in or flow sluggishly through peat swamps through the greater part of their courses and have not developed true alluvial valleys. The alluvium that has been deposited generally consists of sand or silt and is nowhere very gravelly. It is brown or faint red in color and contains a large percentage of organic matter throughout.

The alluvial soils, except an alluvial muck (Kerston muck) are classified in the Griffin series. Rubicon fine sandy loam is a terrace soil.

Griffin loamy fine sand, Griffin very fine sandy loam, and Griffin silty clay loam.—The alluvial deposits comprising the Griffin soils have only a slight thickness, ranging from 1 to 5 feet, are gray and rust brown in color, and are water-logged at a depth ranging from a few inches to 2 feet below the surface. These soils are fertile. They are in general not limy but in places are distinctly acid. Because of poor drainage, the narrowness of the bottoms, and the meandering of the streams, the land has no agricultural value, except possibly for pasture in a few places. The tree growth is taller and larger than that of the peat swamps, and the original forest contained a high proportion of elm, ash, soft maple, balm-of-Gilead poplar, and aspen, in addition to white pine, hemlock, cedar, balsam fir, alder, and willow.

The three textural distinctions shown on the map may have some significance in relation to the growth of the natural vegetation and may possibly serve some other useful purpose aside from scientific completeness in soil classification, but they probably have little present agricultural significance in this particular county, except that the heavier soils, where cleared, produce better grass and are, therefore, better pasture land than the sandier Griffin soils.

Rubicon fine sandy loam.—Rubicon fine sandy loam represents the soil on low-lying terrace plains, or bench land, along some of the larger streams. The soil material is composed of fine sand, very fine sand, and silt, which range from faintly to distinctly stratified and are free of stone and gravel. The soil resembles in part Brimley fine sandy loam and in part Rubicon sand, but in general it is not so wet at a slight depth as the Brimley soil but holds more moisture and is a little more productive than the Rubicon. It lies above stream overflow and hence shows greater alteration by soil-forming agencies and contains less organic matter than the associated bottom-land soils classified as Griffin.

The land originally supported a fairly heavy growth of spruce, cedar, balsam fir, white pine, elm, aspen, and birch. The soil probably is capable of producing fair yields of farm crops, but as the land is unfavorably located and occurs in small separate bodies, it has little agricultural value.

LAKE-SHORE SOILS

The shore of Lake Superior is bordered by a wave-washed barren strand, by beach ridges, dunes, and low sandy bluffs. Most of the soils are sandy. The land is either excessively dry or excessively wet, the wet land being either marshy or swampy. The soils have very little agricultural value, although climatic conditions are more favorable here because the growing season is longer than in the interior. A few small bodies of fertile loamy soils occur, but most of the land is poor because of a combination of poor wet and dry sand and peat in small bodies and because of shifting of the sand by the wind.

The sand soils are classified as Shelldrake sand and Deer Park fine sand. The included peat soils are mainly the Greenwood,

Houghton, and Spalding types which are described elsewhere. In places where bluffs occur along the lake, the sandy plains occupied mainly by Rubicon sand (described elsewhere) extend to the lake shore without intervening dunes. Small bodies of alluvium at the mouths of the rivers are fertile but are wet and of very small extent.

Deer Park fine sand.—Deer Park fine sand is the name applied to the soil of the old stable dunes composed of gray or yellow fine sand. The sand is mostly fine in texture, colored dark gray by admixed organic matter to a depth ranging from 2 to 8 inches, and the underlying sand is yellow to a depth ranging from 1 to 3 feet. The sand is not appreciably cemented and is so loose that it is likely to shift or "blow out" wherever the cover of vegetation is broken. The surface relief is characteristic of dunes, or wind-blown sand, consisting of knolls or ridges of uneven height and complementary depressions or valleys. The principal area lies directly west of Deer Park and extends to the Alger County line, reaching a maximum width of about 1 mile.

The land originally supported a fair growth of red and white pines. The present tree growth consists of a few red and white pines, and patches of jack pine, red oak, aspen, and white birch. Blueberry, bearberry, sweetfern, bracken, reindeer moss, and wild oats are common.

The land has no present agricultural value, but it is capable of supporting a variety of trees, shrubs, and native herbaceous plants, hence may have value for recreational purposes because of its location along the lake. It can also provide a small amount of pasture and feed for wild life.

Shelldrake sand.—Shelldrake sand represents low ridges and level strips of beach and lake-bed sand lying directly along the shore of Lake Superior. The sand is gray, incoherent, medium or coarse in texture, and contains a noticeable quantity of black heavy mineral matter. The sand is of recent deposition and shows very little change from its original condition, other than a coloring in the surface soil to a depth ranging from 2 to 4 inches, caused by the accumulation of organic matter from the plants growing on it since its deposition. Some included areas of wet sand occur in depressions, in which the sand is water soaked and stained a dirty-gray or smoke color.

Shelldrake sand is acid, being practically free from limestone influence, and in this respect it differs from Eastport sand, which represents similar recent sand soils along the shores of Lake Michigan and Lake Huron.

This is an inextensive soil which has practically no agricultural value. It contains sufficient moisture and is sufficiently fertile, however, to support a fair growth of natural vegetation. On most of the land the original tree growth apparently was fairly dense and originally consisted mainly of conifers, including some white and red pines. The present growth includes white birch and aspen, together with some balsam fir and spruce, and an occasional red oak. In places where the surface soil is shifting under wind action or is covered by recent wind-blown sand, a growth of beachgrasses, such as wild-rye, long-leaved reedgrass, and sea sandreed occurs. Such plants as tall wormwood, beach pea, blueberry, wintergreen, and bearberry are also common.

Coastal beach.—Coastal beach comprises recently uncovered lake bed, together with the strand or wave-washed beach, along the shore of Lake Superior. This land occurs as narrow sloping marginal strips, for the most part ranging from 50 to 100 feet in width. The material consists mainly of medium or coarse sand but in places is composed almost entirely of cobbles. Most of the land is bare of vegetation.

ORGANIC SOILS

Organic soils are composed dominantly of plant matter and in this respect constitute a distinct class, as compared with the more common soils which are composed dominantly of mineral or inorganic matter. In this county organic soils occur in forested swamps, open heath bogs, and marshes. The deposits are composed of the remains of plants which have grown in successive stages on a particular site. They have accumulated in permanently wet or in water-covered areas, such as flat plains or valleys, underlain at a slight depth by clay, or areas in which movement of drainage water has been retarded by other causes; on slopes permanently wet from seepage springs; and in certain types of lakes, such as those in which the water is, or was, comparatively calm and the water level not subject to much fluctuation. Organic soils of the flat plains or valleys predominate in size and aggregate area.

The organic deposits, considered as soils, differ in stratigraphy, or succession of layers, in texture, structure, thickness, depth of water table, age, movement of water, degree of decomposition of the plant remains, and chemical character, but on account of the great amount of time and labor involved and the small economic justification for a complete differentiation, no attempt has been made to delineate on the map all the subdivisions which it is possible to make in a soil classification. Eight fairly well defined types of organic soils are recognized, although, on account of the character of the land, boundaries cannot be so accurately drawn as for the mineral soils. The aggregate area of all the organic soils amounts to 33.4 percent of the total area of the county.

As a class the organic soils are characterized by a low volume weight or low specific gravity, high water-holding capacity, high specific heat, and high shrinkage on drying. They are for the most part high in content of total nitrogen, generally low or deficient in potash, and variable in lime and phosphorus. A wide range in reaction is general in the Michigan mucks and peats—from alkaline to very strongly acid. Under cultivation the organic soils undergo change from their virgin condition much more rapidly than do mineral soils. They are also peculiar as soil in that they are combustible and, when drained or when very dry, are likely to be burned off more or less completely, and under cultivation the finely divided plowed soil is likely to be blown by the wind.

Carbondale muck.—Carbondale muck comprises the dark-brown or black loamy and granular muck soil which is very high in content of organic matter and is nearly neutral or only moderately acid in reaction. The darker colored soil extends to a depth ranging from 1 to 2 feet, where it is underlain by the usual coarser brown or yellow, less decomposed and more peaty material, or to about the average depth of the water table. This type of muck represents the darkest

colored and most productive muck land, although the alteration and decomposition of the peat parent material is nowhere so complete in the Upper Peninsula as in the southern part of the Lower Peninsula. As compared with Spalding peat, Greenwood peat, and other organic soils, the movement of drainage water is freer, the decomposition and disintegration of the plant matter is greater, the color is darker, and the content of lime and of ash on ignition are higher. Most of the deposits of Carbondale muck range from 1 to 10 feet in thickness, and they are underlain mainly either by sand or clay. Areas underlain by marl are much less common than in the southern part of the State.

Land of this kind is mostly in swamp forest. The vegetation is characterized by a dense growth of arborvitae, black spruce, balsam fir, and tamarack, but there is, or was originally, considerable elm, black ash, red maple, white birch, hemlock, white pine, and balm-of-Gilead poplar, intermingled. Individual trees reach a larger size, and the total volume of growth is greater on Carbondale muck than on Spalding peat. In areas where the trees have been cut for lumber or have been destroyed by fire, the second growth includes aspen, alder, and willow.

Carbondale muck comprises 43.4 percent of the total acreage of organic soils. It is widely distributed throughout the county as long narrow strips in stream valleys, as broad plains, in small bodies representing the sites of former lakes, and in very small bodies on seepage slopes.

No agricultural use is made of the land, other than a limited use of stump land for pasture and of a very small acreage for truck crops. Its chief value seems to be in the tree growth which it is capable of producing and for game cover. Celery, carrots, onions, lettuce, and other crops have been produced for several years at Newberry, but under present economic conditions, extensive development throughout the county does not seem to be warranted.

Lupton muck.—Lupton muck is black or brown granular loamy muck which contains a high percentage of organic matter and a comparatively high percentage of ash. It is comparatively fine in texture in the surface layer, shows evidence of marked physical change, and the organic matter is decomposed to such an extent that botanical identification of the parent plant materials is difficult or impossible. This soil may continue to a depth ranging from 2 to 8 feet before the usual coarser, more fibrous, and less decomposed peaty material is reached. Most of the Lupton muck is alkaline, neutral, or very slightly acid to a depth ranging from 18 to 20 inches. The vegetation is characteristically cedar, spruce, fir, and tamarack, with some swamp hardwoods.

Lupton muck occupies a small acreage in Luce County. The land has practically no agricultural value, although a similar kind of muck has been used with success for special crops, pasture, and a few general farm crops in the southern part of the State.

Houghton muck.—Houghton muck comprises brown or dark-brown spongy or feltlike finely fibrous peat or muck. In general no great amount of decomposition has taken place on account of the high water table, although typically the surface soil is dark colored to a depth of a foot or more, and in places the base of the peat

deposit is a black or gray fine pasty mass. Houghton muck differs from the other organic soils in having a finer texture, and it is less strongly acid than Greenwood peat. The deposits are for the most part shallow and are underlain by sand.

The natural vegetation is composed chiefly of sedges and grasses. Therefore this type of organic material, considered as a vegetational feature, constitutes wet prairie or marsh rather than forest swamp or heath bog, although in places some dwarf willow, clumps of aspen and birch, and a few scattered black spruce grow.

None of the land is in agricultural use. As on other organic soils, it is possible to grow cultivated crops, but because of the unfavorable location and cost of reclamation, present agricultural development does not appear to be warranted.

Kerston muck.—Kerston muck lies directly along streamcourses and consists of organic matter and alluvial mineral matter admixed or in alternate layers. Most of this muck is nearly black or brown, either woody or fibrous, and nearly neutral or not highly acid in reaction. The water table in most places is high, and the land is swampy. In a few places, particularly on the banks of streams, mineral matter may predominate over organic matter. Most of the alluvium is sandy.

The tree growth is dense and junglelike, and it consists of cedar, spruce, tamarack, alder, aspen, willow, white birch, elm, ash, balm-of-Gilead poplar, and a few white pine.

The land has no agricultural value at present, although the soil is comparatively fertile and is capable of producing a large volume of plant growth.

Spalding peat.—Spalding peat is a strongly acid organic soil which is brown and disintegrated in its topmost layer but becomes yellow in color, coarse, spongy, fibrous, or woody, and shows very little decomposition at a depth of less than 12 inches. The plant matter in the surface layer is in a stage of decomposition intermediate between that of Greenwood peat and Carbondale muck.

The water table fluctuates from a temporary surface cover to as much as 1 foot or more below the surface, depending on the time of year and variations in precipitation.

These peat deposits represent an accumulation either on flats where drainage has been obstructed or on former lake sites, and they range in thickness from 2 feet to possibly as much as 30 feet. The natural vegetation consists principally of leatherleaf, Labrador-tea, blueberry, sedges, and sphagnum moss, with a tree growth ranging from a scattered or scrubby growth of black spruce to a fairly dense cover of black spruce, tamarack, and cedar.

Spalding peat occurs in large bodies in the Tahquamenon Swamp and in small bodies widely distributed throughout the county. The land has no agricultural value but has some value for the tree growth which furnishes posts and pulpwood; for the wild-plant products, such as blueberries, cranberries, and sphagnum moss; and as a refuge or feeding ground for game.

Greenwood peat.—Greenwood peat is brown or yellow fibrous coarse-textured nearly pure organic matter showing very little decomposition. The material is characteristically very strongly acid in reaction. The water table is normally at or within a few inches

of the surface, although during very dry periods it may sink to a depth ranging from 2 to 3 feet. The deposits are variable in thickness, in places reaching a maximum of more than 30 feet.

This type of peat occurs mostly in heath bogs, characterized by such plants as leatherleaf, Labrador-tea, blueberry, cranberry, sphagnum moss, and sedges. A stunted and open growth of black spruce may occur in places, and in such places the topsoil is composed of a feltlike or spongy mat of sedge roots and mosses.

Greenwood peat has accumulated mostly in lakes, but in part it represents accumulations of organic material, ranging from 2 to 5 feet in thickness, occupying wet sandy flats.

The land has practically no agricultural value, except, perhaps, for the wild blueberries and cranberries it yields and as a refuge for wild life.

Tahquamenon peat.—Tahquamenon peat is a marsh soil. It is characterized by a surface mat of living roots and slightly decomposed dead plant matter from the present vegetation which consists principally of cattails, reedgrass, and coarse sedges. At a slight depth the material may be nearly black or gray fine pasty peat or a soupy fluid mass. Evidence of alluvial or lacustrine deposition and the presence of considerable mineral matter is seen in places. The plant matter itself is acid at the surface, but the associated open water may not be acid. The less acid condition of this peat favors a different type and growth of vegetation from that of other very wet organic soils, such as Dawson peat, Greenwood peat, and Houghton muck. Included with Tahquamenon peat are areas of marshland occupied by a thin or fairly dense cover of sedges, grasses, rushes, and cattails, together with clumps of sweetgale and willow. The surface layer is a tough fibrous mat of living roots and raw undecomposed plant matter, and the underlying soil is a nearly black or gray pasty mass, largely organic, which ranges in thickness from 1 to 4 feet. The surface layer of peat is acid but not so highly acid or so coarse as in Greenwood peat or Dawson peat, and it is less decomposed and thinner than the corresponding layer of Houghton muck. A small body of such peat is in the vicinity of Betsey Lake in the northeastern part of the county. Tahquamenon peat occupies rather large areas along Tahquamenon and Sage Rivers. The land has no present value except, possibly, as a feeding ground and refuge for wild fowl and certain fur-bearing animals.

Dawson peat.—Dawson peat is characterized by a thin layer of sphagnum moss or coarse fibrous and woody acid peat, overlying an almost black or gray fine pasty deposit of organic matter. The coarse peat or moss surface layer ranges from a few inches to a foot in thickness, and the total thickness of the organic deposit ranges from 1 to 4 feet. The organic material rests on sand. This type of organic deposit apparently represents an early stage in a change from the marsh type (Tahquamenon peat) to Greenwood peat and Spalding peat. The deposits have accumulated on wet flats and in shallow expanses of water rather than in deep lakes. The present vegetation is characterized by stunted black spruce, sphagnum moss, and such shrubs as leatherleaf, Labrador-tea, and blueberry. This type of land occupies a large acreage in the northern part of the county and in Tahquamenon Swamp. It has no value other than for the feed and protection it may offer to wild life.

SOILS AND THEIR INTERPRETATION

The taxonomy, morphology, and evolution of the soils of Luce County are discussed in the following pages.

The mineral soils, or those which are dominantly inorganic, disregarding the superficial accumulation of litter and forest mold, are estimated to comprise 64.4 percent of the total area of the county, the organic soils 33.4 percent, and water-covered marsh, lakes, and streams, about 2 percent.

The mineral soils are represented by three major taxonomic divisions, based on the average amount of water in the solum, as follows: (1) Soils containing normal moisture for the region, with free water movement and a water table lying at a great depth; (2) soils which are permanently moist at the surface and in which water exists permanently to the point of saturation and water-logging at a slight depth; and (3) soils in which periods of saturation to the surface are followed by periods of dryness. The first division is estimated as occupying about 60 percent of the total area of mineral soils, the second about 35 percent, and the third, including soils like Saugatuck sand, about 5 percent.

The well-drained mineral soils which have completely developed profiles belong to the podzol family, and those which do not show the typical podzol profile are at least podzolic, in that leaching, particularly the removal of calcium and magnesium carbonates, is dominant in the soil-forming processes.

The generalized profile for the virgin mature soil in the division of normal moisture is as follows: (1) A layer of litter and forest mold; (2) a very thin humous layer; (3) a highly leached gray layer; (4) a layer having brown or yellow humic and iron oxide coloring; (5) a layer of maximum clay content, maximum weathering, and maximum coloring from ferric oxides; and (6) the parent material and geologic substratum. Layer 5 is weakly developed but is typically present, and the soils probably differ from podzols in some other regions where layer 4 rests directly on the parent material.

This division is further represented by the following four groups of soils, determined on the basis of the texture, consistence, and lithologic character of the parent material: (1) A group in which the soils are underlain by clay which is comparatively dense and impervious in layers 4, 5, and 6 of the generalized profile described; (2) a group in which the soils are underlain by sand and gravel or comparatively loose and pervious material in layers 4, 5, and 6; (3) a group including soils having heavier or more clayey material in layers 4 or 5, whereas layer 6 is more pervious and less clayey; and (4) soils having a comparatively loose and pervious solum overlying indurated rock at a slight depth.

These groups are further differentiated into soil series and types on the basis of differences in color, texture, structure, chemical composition, and thickness of the different layers.

Layer 3, representing the layer of maximum eluviation, and layer 4, representing the layer of maximum humic coloring, are the outstanding features of the complete soil profile. It appears, from extensive observations, that these layers reach their maximum development in thickness, intensity of coloring, and removal of in-

organic colloids, where the parent material is loose or incoherent sand and under conditions of moderately high average moisture, whereas, at the other extreme, minimum development has taken place where the parent material is either comparatively impervious clay or very dry sand and gravel. The normal thickness of layer 3, the gray highly eluviated layer, ranges from 4 to 8 inches, but under exceptional conditions it ranges from 18 to 24 inches. The thickness of the brown, or humic, layer 4 commonly ranges from 6 to 12 inches, and the extremes are from 24 to 60 inches, although the base of this layer is not generally sharply marked, especially where the parent material is loose sand. Under certain conditions layers 4 and 5 coalesce as a single layer The maximum intensity of humic coloring is ordinarily at the top of the layer. There is a suggestion, from present field observations, that the darkest, or umber, color is present where the sand or gravel contains the largest amounts of calcium or magnesium carbonate, although it is apparent that a certain moisture condition is the dominant or controlling factor. The maximum content of iron oxide in this layer appears to exist in soils like the Saugatuck, Brimley, and Ogemaw, where there is frequent saturation and a high water table but also a wide range, or fluctuation, through the year. The maximum thickness, in many places in conjunction with strong cementation, is in the Au Train and Wallace soils. The darkest shades of color occur in the Longrie, Kalkaska, and Blue Lake soils.

The thickness of surficial litter and mold under an old forest and under conditions of good drainage is normally 3 or 4 inches. This increases as the moisture conditions approach those of swamp, but at the other extreme little more than 1 inch of fluffy sandy mold occurs on the driest sand plains. True humous soil, such as characterizes the subhumid prairie region of the United States, and the brown forest soil of the central and eastern parts, is absent or is developed only as a very thin layer. It is most noticeable, other conditions being as nearly the same as possible, where the parent material is most limy or basic.

Layer 5 is weakly developed and does not show evidence either of marked clay concentration or intense coloring of ferric oxide developed in soil-forming processes. A layer containing a higher percentage of clay or colloids than the parent material is less evident than in the southern part of the Lower Peninsula and notably less than in the central and southern parts of the United States. However, a perceptible development of such a layer occurs in coarse gravelly calcareous material, and even in the heavy clays, such as the Ontonagon soils, there is a slight intensification of ferric oxide color over that of the parent material.

The depth to which carbonates have been removed in the soil-forming processes is in general between 30 and 40 inches, but it varies with the amount originally present, the texture of the parent material, and the surface relief. In dense, highly calcareous lacustrine clays, complete removal of the carbonates has taken place to a depth ranging from 18 to 24 inches, whereas in some other soils, where the parent material consists predominantly of limestone gravel, cobbles, and boulders, some limestone rock may remain throughout the profile. Phosphorus and potash are also removed in the soil-forming processes but most clearly so in layer 3. Nitrogen

is highest in the surface layer of organic accumulation and is present in appreciable quantities in layer 4. Where the parent material is friable sandy clay drift and a compact layer 5 is developed, a distinct secondary layer of leaching between layers 4 and 5 is present. In most places the thickness of the solum ranges from 30 to 40 inches. Alteration of the parent material appears to be no greater in the driest sands than in the densest, most impervious clays.

The soils developed under conditions of poor drainage or a high water table have the following generalized profile: (1) A dark-gray or black surface layer representing an accumulation of organic matter; (2) a gray or drab layer, either not at all or but slightly colored by organic matter; (3) a layer containing maximum clay and having a maximum degree of coherence or plasticity, or one containing maximum yellow or brown coloration and cementation from iron oxides; and (4) the substratum, or parent material. Leaching is greatest in layer 2 which reaches its maximum thickness where the parent material is sand. These soils are less completely leached of carbonates than the well-drained soils and are generally higher in fertility, measured by the total amount of nitrogen, calcium, phosphorus, and potash present, given the same parent material. Where the parent material is calcic or basic, the soils commonly show an alkaline or neutral reaction from the surface downward. Where the parent material is sand, layer 3 commonly exhibits a marked or even solid yellow or brown color from humic matter and iron compounds, and may be more or less cemented into a hardpan.

Where sand overlies comparatively impervious clay or indurated bedrock at a slight depth, an additional layer, which is bleached or leached through permanent water-logging and lateral movement of water, is present at the line of contact.

The group of soils having incompletely developed profiles is represented mainly by recent alluvium occupying the valleys of the streams. Most of this material is of high average moisture content or occurs in swampy or semiswampy situations. The alluvium, which is purely local in origin, commonly contains a high percentage of organic matter, sufficient to mask the rock color. The soils are classified as Griffin soils. A not uncommon feature of the deposits is alternate layers of mineral alluvium and muck (Kerston muck). The organic matter of these deposits is partly transported and partly accumulated in place. Belonging also in this group are the soils of recent dunes, recently uncovered lake deposits, and the wave-washed strand along Lake Superior. The soils are classified as Deer Park and Shelldrake soils and coastal beach. In this group the soil and rock, or geological formation, are practically equivalent.

The organic soils are represented by a number of types which show a wide range in chemical and physical characteristics, although none of them appears to have developed quite so complete alteration or alteration to such great depths as the organic soils in the southern part of Michigan. Practically all are high in organic matter, that is, they contain 75 percent or more of combustible matter, and most of the deposits and the greater aggregate acreage appear to have been accumulated in valleys or on flat plains where drainage is stagnant, rather than in lakes, although the lake-filled type is extensively represented. The valley deposits and those accumulated on

wet plains and seepy slopes, on the whole, are not very thick. The lake deposits are not so commonly underlain by marl as the deposits in the southern part of the State.

More or less complete alteration, represented by a nearly black or dark-brown color, destruction of the botanical character of the plant remains, and development of a loamy granular crumb structure in the oldest soils, does not generally exceed a depth of 15 inches. In the most acid and peaty type of organic soil, Greenwood peat, practically no alteration has taken place, although the fluctuation of the water table is much greater than in the more woody and less acid soils, Lupton muck and Carbondale muck. A small proportion of the organic material is nearly neutral in reaction and comparatively high in lime, but the greater part ranges from slightly to very strongly acid. In general, the most acid organic soils are associated with sands and the least calcareous rocks and glacial deposits, but in a number of places the acidity seems to depend on the height of the water table, stagnation or slow movement of drainage water, and kind of vegetation, as adjacent soils and drift may be limy and the drainage water alkaline. The broad group characteristics of organic soils are probably, in the last analysis, a function of the climate, as are the group characteristics of mineral soils, with a modifying influence from the geology and physiography of the region in which they occur. Thus it appears probable that the oldest organic soils in this region cannot reach so complete a stage in decomposition as in regions farther south, and that the texture and consistence of the material differ because of the differences in the plant species composing it.

The lake waters which support vegetation are generally clear, with very little matter in suspension, and they are generally alkaline in reaction, owing to the presence of calcium and magnesium bicarbonates, although a few soft-water lakes occur along the shore of Lake Superior. Most of the stream water is alkaline, even where the streams flow through the peat and muck swamps, notwithstanding that much of it has a yellow or brown tint caused by suspended or dissolved organic matter. In most of the more acid bogs and lakes, occupied wholly or in part by such plants as leatherleaf, Labrador-tea, and sphagnum moss, the standing water is acid in reaction. In addition to the chemical composition, temperature, and depth of water, the character of the lake or stream bottom is also a factor influencing the kind of plant growth. Clean sand, clay, gelatinous peat, and coarse peat are common in the bottoms of lakes and marshes, whereas a marl bottom is rare.

The following outline gives the taxonomic scheme of the soils of Luce County:

MINERAL SOILS

1. Comparatively old soils having well-developed profiles.
   - A Podzols developed under low or intermediate moisture conditions
     - 1 Soils in which the parent material is friable, sandy, and stony clayey drift.
       - *a* Soils having a moderate lime influence from the C horizon
         - (1) Soils having red or red-brown material in lower part of B horizon and a B horizon which contains more clay than the C horizon. Trenary loam and Trenary sandy loam.

1. Comparatively old soils having well-developed profiles—Continued
   A. Podzols developed under low or intermediate moisture conditions—Continued
      2. Soils having a sandy and gravelly parent material
         a. Soils having acid low-lime sand or sand-and-gravel parent material.
            (1) Soils having a weaker development of the gray and ortstein or orterde horizons—Rubicon sand.
            (2) Soils having a stronger or thicker development of the gray and ortstein horizons.
               (*a*) Soils having fine or medium uniform texture—Wallace fine sand.
               (*b*) Coarser soils which are less uniform and have a higher moisture content—Au Train loamy sand.
         b Soils having medium limy sand or gravel C horizons.
            (1) Soils having a dark-brown loamy B horizon—Kalkaska loamy sand and Kalkaska sandy loam.
         c. Soils having a high lime content, mainly gravel, cobbles, and stones
            (1) Soils with a brown or reddish-brown clayey B horizon—None mapped.
            (2) Soils with a brown loam B horizon—Rodman stony loam.
      3 Soils having a sandy parent material with stones, gravel, and clay intermixed
         a Soils with less limy parent materials.
            (1) Soils having a uniform solum and a variable clayey substratum—Strongs loamy sand and Strongs fine sandy loam.
            (2) Soils having a variable-textured solum and C horizon—Hiawatha loamy sand.
         b Soils with an intermediate limestone influence.
            (1) Soils having a dark-brown loamy B horizon and a uniform solum and upper part of C horizon—Blue Lake loamy sand.
      4. Soils having a silt and very fine sand parent material.
         a Soils with an acid solum and somewhat red limy C horizon—Bohemian very fine sandy loam.
      5 Soils having sandy parent materials over indurated bedrock.
         a Soils with a strongly developed brown B horizon over limestone—Longrie loam.
   B Wet podzols and soils developed under medium and high moisture.
      1. Soils having impervious clay, silt, and very fine sand parent material.
         a. Soils with a red B horizon and a limy stone-free clay and silt C horizon—Ontonagon clay loam and Ontonagon silt loam.
         b. Soils with a strong brown or rust-colored solum—Brimley very fine sandy loam.
      2 Soils having sand parent material.
         a Deep sand soils with a strongly developed ortstein horizon—Saugatuck sand.
         b Soils in which clay lies at a slight depth—Ogemaw fine sandy loam.
2. Comparatively young soils with incomplete or no profile development
   A Soils developed under dry or medium moisture conditions
      1 Soils having weak A horizons (dune sand)—Deer Park fine sand
      2. Soils having an acid sand and gravel A horizon only (beach deposits)—Shelldrake sand.
      3. Terrace alluvium having a weak B horizon—Rubicon fine sandy loam.

2. Comparatively young soils with incomplete or no profile development—Con.
   B. Soils which are wet or permanently water-logged.
      1. Gray acid water-logged sand---------- Newton sand.
      2. Impervious clay, dark surface soil, well-developed glei horizon------ Bergland silt loam and Bergland silty clay loam.
      3 Silt or very fine sand, dark surface soil, well-developed glei horizon---------- Bruce very fine sandy loam.
      4 Sands over impervious clay------ Munuscong fine sandy loam
      5 Gray and brown wet alluvium---------- Griffin soils.

ORGANIC SOILS

1. Comparatively old soils, organic matter in more advanced stage of decomposition
   A. Soils high in organic matter.
      1. Soils having dark-brown or black surface soils
         a. The least acid soils, black, fine textured, and of maximum decomposition---------- Lupton muck
         b Soils in which coarse peaty material occurs at a depth ranging from 12 to 18 inches------ Carbondale muck
         c. Brown or black fine fibrous material which is compact to a depth ranging from 2 to 3 feet, overlying black or gray pasty peat---------- Houghton muck.
   B Soils in which there is a high percentage of admixed inorganic matter.
      1. Admixed or interlayered alluvium---------- Kerston muck.
      (Other soils too small in area to differentiate)
2 Younger soils, in which little or no decomposition of the organic matter has taken place.
   A Soils high in organic matter.
      1. Soils in which the surface soil consists of moss or sedge mat.
         a. Yellow or brown very strongly acid coarse moss peat ---------- Greenwood peat
         b Soils in which brown mixed woody and fibrous peat occurs at the surface---------- Spalding peat.
         c Moss or coarse acid peat over black or gray pasty matter---------- Dawson peat.
         d A floating mat ranging from fine to coarse material, a fluid mass, or material underlain by flowing water at a slight depth---------- Tahquamenon peat.
   B Soils having a high percentage of admixed inorganic matter
      (Areas too small to differentiate on map)

All the mineral soils differentiated in Luce County occur in a gradational series, according to variations in the moisture or drainage conditions under which the individual soil has developed. This gradational character of soil types is universal, so that, given the textural succession of layers and chemical or lithologic character of the parent material, and knowing the characteristics of the climate, the kinds of soil, or their range in chemical and physical peculiarities, can be predicted. Under such conditions the limits established for each soil in practical mapping must necessarily be arbitrary, and each soil mapped includes soil of a transitional character.

A soil-moisture condition can be recognized for the following classes of soil material: (1) Highly calcareous massive stony and sandy friable clayey drift, (2) stony noncalcareous clayey drift, (3) loose incoherent sands, (4) dense fine-grained lacustrine clays, (5) uniform silt and very fine sand, (6) sand over impervious clay, and (7) pervious unconsolidated gravel, cobbles, and stones.

The degree to which alteration of the parent material has taken place under the various moisture ranges possible is a function of the climate and the period of time that metamorphic processes have

operated. A range in alteration is everywhere possible, from practically no change, or geological equivalence, to the maximum development of the soil profile. In each of the groups of parent material listed there is a fairly wide range of moisture conditions and a corresponding range or gradation in chemical and physical differences, which constitute the basis of differentiation of the soils into types. For example, given parent material of sand, conditions range from swamp, in which the sand is covered with muck or peat, to the driest condition where the surficial organic accumulation is extremely thin and where little development of gray and brown layers or leaching of iron oxide color has taken place.

The lithologic character of the glacial deposits which have directly influenced the chemical and physical character of the soils bears, in turn, a close relation to the old geological formations underlying the glacial material. Although there is considerable admixture of detritus from Canada, the drift is in general influenced by local bedrock. The marked difference in the percentage of limestone gravel and boulders and, therefore, calcium and magnesium carbonates, in the drift and soils in different localities, is in conformity to the direction of the ice movement, the absence of limestone and highly calcareous geologic formations on the north, and the predominance of limestone formations in the central and southern parts of the county. North of Tahquamenon Swamp and extending to the shore of Lake Superior, the soils are influenced by a predominance of red and gray sandstone, quartzite, and acid igneous rocks in the parent material, and the solum has a strong acid reaction throughout. The soils generally become more basic to the southward, owing to the greater influence from limestone in the drift, especially where the deposits are thin over the bedrock. Locally, thick sandy morainic deposits, dune sand, and thick assorted sandy outwash in the southern part of the county show no greater limestone influence than some of the deposits near the shore of Lake Superior. Lacustrine deposits of silt and clay occupy a considerable area, and they are rather uniformly calcareous throughout their areal extent. Because of the origin of the deposits, the distribution of acid and basic soils bears little or no relation to the position of the older underlying geologic formations or to the variation in lithologic character of the underlying ice-laid drift.

The color tints of the soil layers and some chemical characteristics of the solum are also traceable indirectly to the local older geologic formations. The somewhat red color of the clayey drift and the salmon shade of much of the sand are traceable to the red rock color and probably to red preglacial soil of the Lake Superior sandstone formation which lies along the shore of Lake Superior, whereas the color and chemical character of the clayey drift and soil in the southwestern part of the county are traceable to the influence of a mixture of red Cambrian sandstone, calciferous glauconitic sandstone, and purer Ordovician limestone. The red color of the lacustrine silt and clay deposits, intensified to an Indian red when moist, in the clay soils like the Ontonagon, is also further reflected in the lavender tint and cinnamon color of the gray and brown layers of most of the associated soil types.

The great diversity of soil types and their intimate association in many places in small bodies are traceable to the lithological het-

erogeneity of the parent soil material and to the variations in thickness of comparatively pervious material over comparatively impervious clay or impenetrable bedrock, which result in a wide range in texture and moisture conditions. There is a diversity in the topographic expression of the Pleistocene formations, as wave-washed moraines, hilly areas above old glacial-lake levels, outwash plains, lake beds, dunes, and old shore-line features.

Modification of the original morainic surface by the waters of Lake Algonquin, which apparently covered the whole upland, with the exception of two small areas,[7] has indirectly been a cause of greater complexity in soils. The Hiawatha soils on the one hand, and the Strongs and Blue Lake on the other, bear a relation, respectively, to land above and below the old lake levels.

The land formations were laid down during the last stages of the glacial period, so that the land surface is comparatively young. The minor topographic forms are almost entirely constructional, as streams have not yet had time to develop complete dendritic systems. Large areas, therefore, remain flat or free from dissection. A large total area of soils developed under conditions of excessive moisture has been possible because of flat surfaces underlain by clay or bedrock and because of stagnation of drainage in the valley of Tahquamenon River. On the other hand, soils developed under conditions of low moisture have been possible because of the perviousness and thickness of many of the deposits, notwithstanding the land surface may be level. This is particularly true of the high-lying sands of the hardwood and pine plains, which represent outwash deposits, lacustrine sands, or the sandy deposits of wave-washed planate moraines. Dry conditions on the moraines above the old lake levels are attributed to the sandy texture of the glacial debris, rather than to stream erosion or to the slope of the land surface.

The natural vegetation, as is universally true, has been a factor in the development of soil characteristics. But, as is also generally true, the vegetation is both a cause and an effect of soil differences. In this county the whole area, excepting the small percentage of lake surface, marsh, and peat bog, was originally forested. The forest cover was in general dense, even junglelike in some of the wetter situations, but in some of the drier places, as on the dry sand plains, there was a rather open growth of pines, with a shrub and herbaceous undergrowth. The woody character of the surface accumulation of organic matter, together with the thinness of the humous soil, is believed to be a function of the forest vegetation, and the underlying gray and brown layer, if not wholly, at least in part, is also attributable to the forest vegetation. Any constant relationship of the thickness or intensity of coloring of the layers to a particular type of forest vegetation is not apparent from observation, but the texture of the soil material and the average moisture content appear to be the dominant controlling factors. However, in places where hardwood forests and pine forests are contiguous on the same plain, with no observable difference in relief and lithologic character of the underlying parent material, the brown, or orterde, layer under hardwood forest is darker colored and thicker than the corresponding

[7] See footnote 2, p 1

layer under pine forest. The composition, texture, and other physical characteristics of the organic surface layer are clearly related to the kind of vegetation growing on these soils; also, on the dry sandy soils, such as the Rubicon and Wallace soils, the grasses and herbaceous vegetation, together with mosses, lichens, and shrubs, such as blueberry and sweetfern, have had an influence in determining a soil profile different from that of other soils. The influence of types of vegetation which preceded the present may be assumed, although too little is known about the histology of the soil profile to venture a statement as to the specific character of such influences, except in the case of peat deposits.

The progressive changes occurring in the present soil profile are probably toward continued leaching and, therefore, increase in the thickness of the eluviated solum. In some of the sandy soils, the leaching process would result in increment to the brown humic layer and further eluviation of the lower layers. In the sandy clay parent material, the present processes continued could be expected to result in the intensification of the brown humic layer and the further development of a B horizon through addition of clay or in cementation and a consequent increase in a secondary layer of leaching or reduction between this and the brown humic layer. In the heaviest clays there should be an increase in the thickness of the gray eluviated layer and subsequent intensification of the brown humic layer which is at present weakly developed.

A suggestion of retrogression in profiles is evidenced in the partial destruction of the brown humic layer in ridges of deep dry sand which show a profile developed under wetter conditions than exist at present, for example, in Wallace fine sand. Also, in a number of places, there is evidence of a rise in the water table (through continuous accumulation of water on flats and seepage slopes and consequent accumulation of peat) with a consequent change, owing to a higher moisture content, in the profile of bordering soils which were formerly comparatively dry. For instance, some of the larger swamps contain numerous low islands of dry sand, and jack pine grows on peats and wet mineral soils, such as the Newton and Saugatuck.

It is probable that some of the soil in the great swampy plain in the central part of the county is wetter than it was in the past, and that the profile has changed accordingly, on the assumption that southward tilting of land along the shore of Lake Superior is taking place, resulting in stagnation of drainage.[8] On the other hand, on the higher land there is evidence of a general physiographic change which must eventually result in the lowering of the water table in wet flats and peat swamps through stream cutting. The extraordinary thickness, rust color, and cementation in the ortstein layer of Au Train loamy sand might be explained as a development under wetter conditions than those now existing.

The soils of the dunes and recent beach ridges afford an illustration of the rapid change caused by wind action, the blowing out and washing out in one place and deposition in another, so that the existing weakly developed profiles are obliterated in one place and buried in another.

[8] See footnote 2, p 1

SUMMARY

Luce County is in the eastern part of the Upper Peninsula of Michigan. The total area is 908 square miles, or 581,120 acres.

The surface features consist of nearly level plateau plains mantled with sandy glacial drift, small high-lying hilly areas of morainic drift, broad swampy plains and numerous small swamps and lakes, dry level outwash plains of sand and gravel, and lake-shore features consisting of low beach ridges, sand dunes, and lake-shore cliffs.

The elevation above sea level ranges from approximately 600 feet, the level of Lake Superior, to a little more than 1,000 feet.

The land was originally densely forested. The most common trees were sugar maple, yellow birch, beech, hemlock, white pine, red (Norway) pine, jack pine, white cedar, spruce, balsam fir, and tamarack. A large aggregate acreage of virgin hardwood forest remains, but all the pineland and the greater part of the hardwood and swamp land have been cut over.

The population of the county (1930) is 6,528. Agriculture and lumbering are the principal industries. Transportation facilities are available by railway and improved automobile highways.

The climate is characterized by rigorous winters and short summers. The mean annual temperature at Newberry is 40.2° F. and at Deer Park is 39.9° F. The average annual precipitation at these stations is, respectively, 27.32 and 30.06 inches. The average snowfall is about 90 inches. The average period between killing frosts at Newberry is 108 days and at Deer Park is 113 days.

Farming in the county began about 1900. The principal crops now grown are hay, oats, barley, field peas, and potatoes. Dairying is an important source of income on most farms. Less than 5 percent of the total area of the county was in farms in 1930. It is estimated that potentially first-class agricultural land comprises approximately 10 percent of the total area; second-class, or marginal land, 50 percent; and third-class, nonagricultural land under present conditions, 40 percent. It is estimated that about 40 percent of the land is poorly drained or swampy. The unused land is adapted to forestry, recreational parks, and game refuges.

The soils are characterized by great diversity in texture, drainage conditions, chemical composition, and productivity. Some soils are loose incoherent dry sands, whereas others are composed of compact silt and clay. Moderately calcareous or limestone soils occur in the southern part, but throughout the county most of the soils are highly acid and noncalcareous. Sands and sandy loams predominate, loams comprise about 5 percent of the acreage of mineral soils, and silt loams and clay loams include about 10 percent. A small proportion of the land is stony. About 34 percent of the total area of the county consists of organic soils—peats and mucks.

The principal mineral soils having fair or good natural drainage are those of the Trenary, Kalkaska, Au Train, Rubicon, Hiawatha, Strongs, and Blue Lake series.

The Blue Lake, Hiawatha, and Strongs soils constitute the greater part of the gently rolling or hilly upland, and the Kalkaska, Au Train, and Rubicon soils comprise most of the sandy soils of the nearly level sandy plains, terraces, and valleys. These sandy soils are dry and of low or only medium fertility. They are not generally

suitable for agricultural use under present conditions but locally constitute marginal or even profitable agricultural land. Rubicon sand comprises most of the dry poor sandy pineland of the central part of the county and of the northern part bordering Lake Superior.

The mineral soils having poor drainage are classified in the Saugatuck, Bergland, Ogemaw, Newton, Bruce, Brimley, and Ontonagon series. These soils are of small value on account of such factors as low fertility, location, small size of individual areas, high cost of reclamation, and other causes.

The alluvial soils are classified in the Griffin series. They are of small aggregate acreage and little agricultural value.

Eight types of muck and peat are recognized. Carbondale, Lupton, and Kerston mucks are the darker colored, less strongly acid, and more productive types. They are densely forested with spruce, tamarack, white cedar, fir, and a few hardwoods. These soils have little present value for cultivated crops, but they are capable of supporting a good growth of forest trees. Spalding, Greenwood, and Dawson peats are highly acid raw peats which support a bog vegetation and black spruce forest. Houghton muck and Tahquamenon peat comprise slightly decomposed or raw peat. They occupy marshland and have no present agricultural value but are of considerable importance in relation to wild life.

The mineral soils having well-developed profiles belong to the podzol family. A gray ashy leached (bleicherde) layer and a yellow or brown (orterde) layer are present in most places, but they show a wide range in degree of development. The parent material is glacial drift. Alteration of the parent material by soil-forming processes in most places extends to a depth ranging from 30 to 48 inches. This has resulted in the complete removal of carbonates and a slight decomposition and formation of clay colloids in place.

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