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Soil Survey

of

Kalkaska County, Michigan

By

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Bureau of Chemistry and Soils

In cooperation with the Michigan Agricultural Experiment Station
and the Michigan Department of Conservation

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SOIL SURVEY OF KALKASKA COUNTY, MICH.

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COUNTY SURVEYED

Kalkaska County is in the northwestern part of the southern peninsula of Michigan. (Fig. 1.) The northwestern corner of the county lies inland from Grand Traverse Bay, an arm of Lake Michigan, a distance of about 10 miles. Kalkaska, the county seat, is approximately 160 miles, by rail and automobile highway, north of Grand Rapids. The total land area is 559 square miles, or 357,760 acres.

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

Nine fairly well-defined topographic and vegetal divisions are recognized in the county as follows: (1) A low-lying sandy lake-bed plain, of rather small total area, in the extreme northwestern part; (2) a strongly rolling or hilly sandy upland, rising abruptly southeast of the first division and originally covered with hardwood forest; (3) high sandy plains, which are mainly dry but contain a few lakes and small swamps, bordering the second division on the southeast and east and featured in places by low terrace escarpments and benches; (4) a gently rolling upland, originally in hardwood forest, occupying most of the southwestern part of the county and extending northward as a narrow belt through the central part; (5) nearly level high sandy hardwood plains occupying most of the central and eastern parts of the county; (6) a series of dry sandy pine and hardwood hills bordering the fifth division on the east; (7) next in succession on the east an extensive belt of dry sandy pine plains, interspersed with extensive swamps; (8) in the southeastern part of the county, a low swell of gently rolling upland which stands above the adjacent sand plains; and (9) a dry flat sand plain similar to parts of the seventh division, together with a low swell of upland in the extreme southeastern corner.

Physiographically, the area embraced in the county is part of a great plain, the surface features of which were constructed during the glacial period. There are inequalities of local significance on the surface but no relief of magnitude. The extreme difference in elevation is about 700 feet, ranging from about 600 feet above sea level in the northwestern part of the county to a little more than 1,300 feet in the northeastern and southeastern parts, but local differences

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between hill or ridge crests and adjacent streams, lakes, swamps, or valleys, in general, range from 50 to 150 feet. The relief is characterized by constructional forms of glacial origin, such as level plains, low rounded hills and swells, shallow basins, broad valleys, and old lake-bed plains, none of which has been greatly altered by stream erosion since its formation. Numerous swamps and widely distributed lakes occur.

At the time of first occupation by white men, the county, except an inconsequential acreage of bog or marsh and some open land in the drier sand plains, was covered by a dense forest. Lumbering of pine on a large scale began about 1875 and of hardwoods about 1890. At the present time the original forest has been largely removed, although a few large tracts of hardwood and swamp forest remain. The following types of forest or tree associations were represented: (1) The hardwood forest in which sugar maple (*Acer saccharum*), beech, yellow birch, and hemlock were the dominant species, and elm, ash, basswood, and white pine were subordinate species; (2) the mixed deciduous and coniferous forest, in which such species as elm, ash, red maple, aspen, and yellow birch were intimately associated with white pine, hemlock, spruce, and fir; (3) the pine forests in which white pine, red (Norway) pine, or red and jack pine predominated; and (4) the peat and muck swamp forests in which the dominant species were arborvitae, spruce, balsam fir (*Abies balsamea*), and tamarack. Much of the former forest land is now desolate stump land, covered with a dense growth of brush, briers, and grass, or has grown up to aspen, oaks, and red maple, with very little natural reproduction of the original dominant species. In the swamps the forest remains intact in places, but most of this land also has been partly logged over. Some of the dry sandy plains land supports a scattered growth of jack pine, low blueberries (mainly species of Vaccinium), the sweetfern (*Comptonia asplenifolia*), and bracken, together with various grasses the most common of which are Canada bluegrass (*Poa compressa*), oatgrass, locally called "buffalo" grass (*Danthonia* sp.), and little bluestem (*Andropogon scoparius*). The more acid bogs have a dense cover of heath shrubs such as blueberries, leatherleaf, and Labrador-tea, (*Ledum* sp.) with some scattered black spruce and tamarack, and in other places the marsh growth consists of various sedges and bluejoint (*Calamagrostis canadensis*).

It is estimated that about 20 per cent of the cut-over forest land has been cleared of trees and stumps for use as farm land, although a considerable part of this has subsequently been abandoned.

An abundant supply of wholesome water can be obtained from wells less than 100 feet deep throughout the greater part of the county, and flowing artesian wells have been obtained in a few places. Streams are perennial in flow and carry clear water. In the northwestern part of the county are a few springs which are of some consequence as sources of water supply.

The population according to the United States census of 1920 was 5,577, but preliminary figures for 1930 show a marked decrease.[1]

[1] Soil survey reports are dated as of the year in which the field work was completed. Later census figures are given whenever possible.

This is probably owing to the decline of the lumber industry which reached its peak about 1910. Kalkaska, the county seat, has an estimated population at the present time of about 1,000. A number of small towns and villages are scattered throughout the county.

Agriculture has replaced lumbering to only a very small extent, and no manufacturing industries have been established. The attractiveness of the country for hunting and fishing and for summer cottages and camps on the lakes is a very considerable commercial asset.

The Grand Rapids & Indiana Railway of the Pennsylvania Railroad system passes through the western and north-central parts of the county and provides access to outside cities and markets. State trunk-line highways enter the county and provide facilities for automobile traffic. The roads are passable throughout the year except at times during the winter, when they are filled with snow, or during spring thaws. Some remote sections in the eastern part of the county are reached with difficulty.

CLIMATE

The main features of the climate of Kalkaska County are an average precipitation of about 30 inches annually (including melted snow); a snowfall of about 75 inches; an average annual temperature of 43.1° F.; rigorous winters; short mild summers; fairly high humidity; a large number of cloudy days and small percentage of possible sunshine; and low evaporation.

The precipitation is fairly well distributed throughout the year in that there are no marked wet and dry seasons, but it is slightly higher for the 6-month period, May to October, than for the remainder of the year. The rainfall occurs mostly as slow and prolonged rains, or as frequent showers, but rarely as destructive downpours. The amount is ample ordinarily for the production of the staple crops grown in this region, except on some of the more pervious and nonretentive sand soils, as the evaporation is comparatively low and extended periods of drought are rare. Hailstorms are of very rare occurrence.

The snowfall is heaviest from November to March, but light falls and flurries may occur in April and May and during October. A blanket of snow may be depended on during the winter, and this affords protection to fall-sown grain.

The temperature records show an extreme range of 141°, from −35° to 106° F. The extremes probably have very little direct influence either on health or on agriculture. The average frost-free season, as shown by the average dates of the last killing frost, May 24, and the first, September 23, is 122 days. It should be understood, however, that hay, small grain, and some native plants may start and continue growth before and after the dates of killing frosts as given by the Weather Bureau. Killing frosts have been recorded in every month of the year. Corn does not always reach maturity as the growing season is short and the cool nights are unfavorable for the crop, but by the selection of hardy and early-maturing varieties grain is produced, and the crop always yields forage or silage. In the

swales or low places and in wetter situations, all crops are susceptible to damage from late freezes and early autumn frosts. Occasional losses in handling potatoes, one of the chief cash crops, may be expected because of very cold weather in October and November, but ordinarily there is sufficient time to harvest this and all other crops grown before excessively cold weather and heavy snows set in.

The maximum cloudiness is in the winter and spring. It is believed that this condition is really favorable for agriculture [2] as the moist atmosphere and cloudiness exert a protective influence on fruit trees and also prevent thawing of wheat and rye fields during the day. The summer is characterized by a large number of clear days and a fairly high percentage of the possible sunshine.

The only climatic data for the county is that compiled from records of the United States Weather Bureau station at Ivan in the southwestern part. It is reasonably certain that in the extreme northwestern part, adjacent to Lake Michigan, the mean annual temperature is as much as 2° higher and that the frost-free season is possibly as much as 20 days longer than in the extreme eastern and southeastern parts. It is probable that the western part of the county has some agricultural advantages both in more favorable climate and in the soils.

Table 1 gives the more important climatic data, as recorded by the United States Weather Bureau station at Ivan.

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation at Ivan, Mich.*

[Elevation, 1,000 feet]

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1915)	Total amount for the wettest year (1898)	Snow, average depth
	° *F.*	° *F.*	° *F.*	*Inches*	*Inches*	*Inches*	*Inches*
December	23.0	59	−24	2.20	2.69	3.62	16.6
January	18.3	54	−26	2.08	.66	5.00	18.5
February	16.7	54	−35	1.50	1.48	2.61	13.4
Winter	19.3	59	−35	5.78	4.83	11.23	48.5
March	26.6	82	−20	1.86	.34	3.08	7.0
April	41.6	88	6	2.11	.76	1.90	3.8
May	53.1	94	17	3.26	1.77	3.27	1.0
Spring	40.4	94	−20	7.23	2.87	8.25	11.8
June	64.3	106	28	2.72	2.33	3.80	.0
July	68.0	104	32	2.70	2.67	.39	.0
August	65.3	103	32	2.97	2.72	4.90	.0
Summer	65.9	106	28	8.39	7.72	9.09	.0
September	58.8	97	25	3.17	4.93	2.09	.1
October	46.7	87	9	2.89	2.44	5.84	2.4
November	33.8	68	−4	2.60	2.15	1.99	10.8
Fall	46.4	97	−4	8.66	9.52	9.92	13.3
Year	43.1	106	−35	30.06	24.94	38.49	73.6

[2] SEELEY, D. A. MICHIGAN AGRICULTURE, 3. CLIMATE. Mich. Dept. Agr. Bul. 15, 46 p., illus. 1922.

AGRICULTURE

Settlement began in the western part of Kalkaska County about 1860. Very few of the early settlers depended entirely on agriculture for a living, as lumbering, the manufacture of charcoal iron, the cutting of hemlock bark for tanning purposes, and trapping were also sources of livelihood. The population remained sparse, by 1880 having increased to only about 2,900, but considerable farming was carried on to supply the needs of individual homes and lumber camps. In this early farming, hay (timothy and red clover), wheat, potatoes, and corn were the chief crops, together with such fruits and garden vegetables as could be grown and which the conditions demanded. The amount of land under cultivation on each farm was necessarily small on account of the labor involved in removing trees and stumps. The Grand Rapids & Indiana Railway was extended into the eastern part of the county about 1878 and was followed by large-scale lumbering which brought with it an increase in population and a moderate increase in farming operations.

From 1880 to 1910 there was a fairly continuous increase in the number of farms and in the acreage of land improved, but according to census statistics both the number of farms and the population decreased during the decade 1910 to 1920, following the removal of the larger part of the forests and the beginning of the decline in the lumber industry. At the present time (1927) the acreage of land being abandoned probably exceeds that being cleared for farms. In addition to other causes the comparatively small acreage of naturally highly fertile and productive soil, the long distance from large city markets, and the depletion of the timber resources have adversely affected agriculture, and as no other industries equal in importance have arisen to replace lumbering, the population has decreased, and local markets and the incentive for farming consequently have been affected.

The present type of farming is not intensive, nor is farming extensively carried on. The first cost of the land is low, but because of the expense of clearing it of stumps and trees, and also to some extent because of the unfavorable relief, the production of crops of low value per acre on an extensive scale on the individual farm is impractical. Natural conditions are unfavorable for the development of extensive grazing and livestock raising, as this region is not natural grassland and pastures are artificial in that they have to be made by clearing the land of trees and brush. On the other hand intensive farming has not been highly developed, as the factors are lacking which bring about such farming, namely, scarcity or high price of land, large local population, or proximity to large market centers.

The trend of farm development during the last few years has been toward an increase in the acreage of forage crops, such as alfalfa and sweetclover, and the development and extension of dairying which has proved to be the most profitable adjunct of general farming under present economic conditions. In addition there has been increased specialization in the growing of cash income crops—potatoes, beans, and seed crops. It would seem that possible further expansion in agricultural industry will result through specialization

on the quality of products, the growing of garden vegetable seed and seed potatoes, vegetable growing for local canning factories, the adoption of economical methods for greatly increasing yields through the judicious use of commercial fertilizers and improvement in tillage methods, in concentration on those crops which are naturally best suited to the soils and climate, and in the elimination of the less suitable crops except where some advantage results in supplying local markets and home needs.

Agriculture has not yet proved to be sufficiently profitable to warrant the utilization of more than a small part of the arable land of the county. Only about 21 per cent of the total land area is in farms, and only about 10 per cent of the land is actually cultivated land, according to the United States census of 1925. The total value of all crops and livestock products amounted to $521,874 in 1924, according to the United States census report.

Table 2 shows the acreage and yields of the principal crops grown in the county. This data has been taken from the United States census reports and from the Michigan crop reports.

TABLE 2.—*Acreage and yield of selected crops in Kalkaska County, Mich.*

Crop	1919 [1]		1924 [1]		1926 [2]	Average acre yield for 10-year period [2]
	Acres	*Tons*	*Acres*	*Tons*	*Acres*	*Tons*
Hay	6,917	3,872	8,190	6,277	8,290	
Alfalfa	387	307	[3] 1,539			
		Bushels		*Bushels*		*Bushels*
Corn, total acreage			5,635		5,300	
Corn harvested for grain	4,710	121,741	1,355	32,815		24.8
Rye	7,117	65,716	1,266	14,906	1,330	12.5
Oats	1,364	11,144	1,888	51,012	2,060	17.1
Wheat	1,252	12,566	578	8,359	640	11.6
Buckwheat			1,851	21,927	1,640	14.4
Beans	253	2,143	601		640	8.4
Potatoes	4,362	414,581	2,393	292,604	2,110	88.0

[1] United States census report.
[2] Crop report for Michigan, Annual Summary, 1926, Mich. Dept. of Agr.
[3] Included in hay acreage.

Other field crops of less importance, but grown with some success are sweetclover, field peas, radishes as a seed crop, red clover as a seed crop, cucumbers, barley, and sweet corn.

Hay and forage crops occupy a greater acreage than any other field crop, and ordinarily the total value is greater than that of any other one crop or group of farm products. The hay is principally timothy and red clover mixed, although considerable timothy alone is grown. Fairly successful yields of clover are obtained on the better sandy loam and clay soils without liming the land, but red clover apparently can not be successfully grown under present conditions on the deeper sands of the hills or the plains. The acreage of alfalfa has increased greatly during the last few years and is superseding red clover to some extent. Alfalfa has been most successful on the heavier soils, but when the best recognized methods for growing this crop are followed, fair results are obtained

on the better sandy soils such as Emmet sandy loam. Ordinarily only one cutting a year is obtained with a yield of 1½ or 2 tons an acre on the soils naturally best adapted to this crop. It is, perhaps, inadvisable to attempt to grow alfalfa on the lighter, drier, and more acid sands, such as Grayling, Roselawn, and Rubicon sands. The acreage of sweetclover has also increased during the last few years, and this crop can, perhaps, be successfully grown on much of the hilly sandy land. Other crops grown for forage are corn, rye, oats, barley, and vetch. Most of the forage crops are consumed on the farms where grown, and little is sold as a cash crop or shipped from the county.

Corn is grown for grain, for dry forage, and for silage, and both dent and flint varieties are planted. This crop is susceptible to damage from early frosts, particularly in the lower situations and in the eastern part of the county where the growing season is shortest and grain may fail to mature. Yields ranging from 30 to 35 bushels of grain to the acre are obtained on the more productive soils in the western part of the county.

Rye occupies a comparatively large acreage because it can be grown fairly successfully on the lighter sandy soils. It is grown for grain, also for forage and as a green-manure crop.

Oats are fairly successful throughout the county on practically all soils except the lightest and driest sands. Acre yields ranging from 35 to 40 or more bushels are obtained on the more productive Emmet and Onaway soils. Mixtures of oats and barley and of oats and vetch are grown.

Winter wheat can be grown, but the yields are low because most of the soils are too sandy, and as extensive farming here is impractical wheat can hardly be considered a profitable crop. The acreage seems to be decreasing.

Buckwheat is an important patch and catch crop as it does fairly well on a diversity of soils. It is grown as a sale crop and for feed for poultry and work animals on the farm where grown.

Potatoes are the most important cash income crop throughout the county, as they can be grown successfully on the sandy soils, such as the Emmet, Kalkaska, and Mancelona. Climatic conditions are well suited to this crop, and the tubers are of high quality. A number of growers specialize in the production of seed potatoes on a large scale.

Navy or white beans are also an important cash crop and may be grown with a fair degree of success on the better sandy lands. The acreage on individual farms is nearly everywhere small.

A variety of fruits can be grown throughout the county, but climatic conditions are most favorable in the extreme northwestern part, near the lake. Apples are the principal orchard fruit. Cherries, pears, peaches, grapes, plums, strawberries, and other small fruits are grown, but not on an extensive commercial scale for outside markets.

The total value of all livestock, according to the census of 1925, amounted to $342,384. Extensive feeding or raising of livestock is not engaged in. The principal source of income is from dairy cat-

tle and dairy products, but a few beef cattle, sheep, and hogs are kept on some farms. The sale of poultry and eggs is an important supplementary source of income on most of the farms.

Very little commercial fertilizer and lime are used. The total value of commercial fertilizer (including lime) sold in the county during 1924 amounted to only $2,143 according to the census. Liming of land is not common; lime apparently is not necessary for potatoes, and on most of the land under cultivation at present little difficulty has been experienced in obtaining good stands of red clover, alfalfa, and sweetclover. Although liming would very probably be beneficial on all the soils, on the more acid sandy soils, such as the Grayling, Rubicon, and Roselawn, it is regarded as essential. Barnyard manure, where available, is generally used, and green-manure crops, such as rye, are grown and turned under for the purpose of maintaining productiveness. Commercial fertilizers can probably be successfully used for increasing yields, especially of potatoes, for which crop complete fertilizers, such as a 3–12–4,[3] 4–16–8, or 2–12–6 mixture would give good results, especially on the sandier soils. Experimental tests on similar soils and under similar climatic conditions at the Michigan Agricultural Experiment Station farm at Mancelona have indicated that small grains, sweetclover, and alfalfa will respond to commercial fertilizers on the well-drained soils, and that their use will increase profits.

The production of seed crops is locally rather important, and the tendency is toward an increase in this kind of specialized farming. The principal crops now grown for seed are potatoes, red clover, sweetclover, alfalfa, and radishes.

Rotation, or the practice of changing crops on the same piece of land, is observed, although no definite plan is in common use. On most of the farms it is perhaps the most common practice to follow small grain with red clover, and the clover crop with potatoes or corn. Alfalfa and sweetclover are usually followed by potatoes and corn.

A surprising diversity of crops can be grown in Kalkaska County with fair yields and a good quality of products, yet at this time (1927) less than 25 per cent of the land has been improved for agricultural purposes and 30 per cent of the farmed land has been abandoned. A very large acreage of comparatively cheap raw land has been available for agricultural occupation for many years but has not yet been utilized. The causes for this condition and the economic factors to be considered are hardly within the scope of a soil survey report. It is apparent, however, from the soil classification here made that a large acreage of land, such as Emmet sandy loam, Kalkaska sandy loam, and Mancelona gravelly sandy loam, is naturally moderately productive and otherwise favorable for agriculture, but it is also apparent that a larger acreage is inferior because of low fertility, low moisture content, poor drainage, low productiveness, and because of no known successful crop adaptation for such soils as Grayling, Roselawn, Saugatuck, and Rubicon sands, and the peats. On the assumption that the present inferior lands are

[3] Percentages, respectively, of nitrogen, phosphoric acid, and potash.

not likely to be used for the production of food crops in the near future, the logical solution is that such lands should be devoted to forestry, recreation parks, and game preserves.

The character of the soils, in conjunction with their relief, has exerted a striking influence on the distribution of the farming population and to some extent on the particular crops grown and the type of farming pursued. A close correlation also exists between natural divisions and the assessed valuation of land.[4] The greater part of the developed agricultural land is in the southwestern part of the county on the level or only moderately rolling Emmet sandy loam and the associated Onaway, Selkirk, and Ogemaw soils which are underlain by clay and are more fertile and durable. A small agricultural development is on Kalkaska loamy sand east of Kalkaska in the central part of the county, a small farming community on Roselawn sandy loam in the southeastern part, and some development in the extreme northwestern part where climatic conditions are more favorable for fruit and where Emmet, Onaway, and Antrim soils occur. Elsewhere throughout the level pine plains, the sandy hilly land originally occupied by pine and oak, the peat swamps, and poorly-drained land, there is practically no agricultural development and only a sparse population, or none at all. This undeveloped land includes all or the greater part of such soils as Grayling sand, Rubicon sand, Roselawn sand, the hillier parts of Emmet sand, and the peat and muck soils.

Although farming is not intensive and land values are not high, there is some adaptation of crops to soils as is evidenced by the selection of the well-drained sandy loams and loamy sands for potatoes, of the poorer sands for rye and vetch, of the limier sandy loams such as Emmet sandy loam for alfalfa, and of such soils as Selkirk loam, Bergland loam, Bergland clay loam, and Ogemaw sandy loam for pasture and small grain.

All the land not occupied by virgin forest or especially valued for the tourist and resort business is comparatively cheap at present. The average assessed valuation of land in farms is $11.80 an acre and of wild or cut-over land $4.70. The assessed value of unused cut-over land, such as is embraced in Grayling, Rubicon, Saugatuck, and Roselawn sands, is about $3 an acre, and of the better farm land, such as Emmet sandy loam, is approximately $14.

A broad agricultural classification showing the present (1927) agricultural condition and the extent of occupation of the land in Kalkaska County is set forth in Table 3. It must be remembered, however, that in the land classification here shown the classes of land are relative only as applied to this county. First-class land here may not be comparable to first-class land in other parts of the United States, or even to first-class land in other parts of Michigan.

[4] DEVRIES, W. CORRELATION OF PHYSICAL AND ECONOMIC FACTORS AS SHOWN BY MICHIGAN LAND ECONOMIC SURVEY DATA. Jour. Land and Pub. Utility Econ., 4: 295–300, illus., 1928; and Jour. Farm Econ., vol. 1, no. 4, Oct., 1928.

TABLE 3.—*Agricultural classification of land in Kalkaska County, Mich.*

Classes of land	Soil types	Approximate acreage	Present condition and extent of occupation
A.—Moderately productive and durable soils, stone free or not excessively stony; not excessively hilly for general farming; or hilly land favorably situated for orchards. Retentive clay subsurface soil, first-class or fair pasture where cleared of brush and second-growth trees.	Greater parts of Onaway sandy loam, Emmet sandy loam, and Selkirk loam; very small acreage of other soils.	50,000	Greater part in small farms; farming not highly prosperous but comparatively successful; estimated that from 25 to 30 per cent is cultivated land; remainder in second-growth forest or stump pasture.
B.—Low or moderate natural fertility; deep clay subsurface soil; in part wet, in part dry and well drained; moderately hilly and sloping or flat; not excessively stony; reclamation possible within practical costs; pasture value from fair to poor; marginal farms, and farms which provide homes but only a part of the income or family living.	Greater parts of Roselawn sandy loam, Ogemaw sandy loam, Emmet sand, Bergland loam, Bergland clay loam, Kalkaska sandy loam, Antrim sandy loam, Blue Lake loamy sand, Mancelona gravelly sandy loam, and Kalkaska loamy sand.	115,000	Estimated that less than 10 per cent has been cleared and placed under cultivation; limited use for potatoes, grain and hay crops, and fruit; wild land mainly in pine stumps with second-growth aspen, oaks, and other hardwoods; in part in virgin hardwood and recent slash.
C.—Low to moderate fertility; very dry or excessively wet and swampy; land lowest in assessed valuation and submarginal for farming, or nonagricultural under present conditions.	Greater part of Roselawn sand, Grayling sand, Rubicon sand, Saugatuck sand, Newton loamy sand, Eastport sand, Wallace fine sand, Griffin sandy loam, and peat and muck.	193,000	Estimated that less than 1 per cent is in cultivation; large amount of farm abandonment; pastures poor or fair; part in State forest reserve or State owned in scattered tracts; excepting parts of swamps all is cut-over land, and pine stumps remain; fair second growth of oaks, aspen, and pines.

SOILS

The soils of Kalkaska County show a wide range in texture, structure, chemical characteristics, productivity, and moisture content, all natural factors which bear a relation to plant growth and agricultural use. They also show a lack of uniformity, having textural and other variations within very short horizontal distances, which is a condition common to the soils of the State as a whole.

In texture, the surface layers, beneath the covering of natural forest mold, range from loose incoherent nearly pure sand to moderately heavy silt loam and clay loam. The greater part of the mineral soils are sands and light sandy loams to depths of more than 2 feet. The sands comprise about 70 per cent and the sandy loams about 13 per cent of the total area, and those soils which have a loam, silt loam, or clay loam texture in the plow soil comprise only about 2 per cent. The greater part of the land of the county, exclusive of swamp, is arable; it is estimated that less than 5 per cent would be nonarable or difficult to manage because of extreme stickiness, toughness, and stoniness, susceptibility to blowing, and excessively rough relief and steep slopes. Muck and peat soils, which have their own peculiar tilth characteristics and problems of management, occupy 10.7 per cent of the county.

The content of humus, or organic matter, in the plow layer of the greater part of the soils is, or would be if cultivated, comparatively low. The mold and humus layer in the well-drained virgin soils is, or was originally, nearly everywhere thin, not exceeding 4 inches.

Some of this material is lost in clearing the land and the remainder is not durable under cultivation. The soils are deep, however, considered as to penetrability, the underlying material being unconsolidated glacial drift to a great depth.

In reaction, probably 95 per cent of the soils are acid in the natural surface horizons of mineral soil or in the plow layer. It is estimated that about 70 per cent of the soils are acid to a depth of 40 or more inches, that from 20 to 25 per cent contain sufficient calcium and magnesium carbonates or other bases at a depth ranging from 24 to 40 inches to give an alkaline reaction, and that about 3 per cent are nonacid under natural conditions. Most of the organic soils are neutral or moderately acid, and about 6 per cent are extremely acid raw peat.

Most of the soils are naturally fairly well drained as the water table is not high and the slope is sufficient to provide free run-off. It is estimated that 20 per cent of the land in the county is characterized either by a high water table or by a permanently swampy condition.

The fertility and productivity of the soils, according to the standards for Michigan, are medium or low. Analyses of the dominant types of soils represented in this county do not show evidence of abnormally high or unusually small amounts of the mineral constituents ordinarily determined. Much of the soil is poor because of a combination of low content of plant nutrients and deficiency of moisture, as in the pine-plain sands; and a considerable proportion because of low content of mineral plant food, as in some of the muck and peat.

For purposes of mapping and correlation, soils are grouped in soil series on the basis of common characteristics of color, consistence, texture, chemical characteristics, and thickness of the soil profile. The soil series are divided into soil types, the unit of mapping, which are differentiated on the basis of texture of the surface soil, or plow layer of mineral soils, or on the basis of some other single distinguishing specific difference within the series group. Each soil type is given a geographic name for convenience of reference and description. In interpreting or drawing conclusions from the soil map it should be understood that soil types are rarely sharply separated in character but grade into each other, so that mathematically accurate lines of demarcation are not to be expected. Many inclusions of other soils and slight variations from the typical soil occur in each soil division shown, so that each color or pattern on the soil map must be understood as representing a dominant soil condition and not 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 the map. 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.

The acreages of the various types of soil mapped in Kalkaska County are given in Table 4; their distribution is shown on the accompanying soil map; and a description of the individual soils and their agricultural relations and utilization are given in the following pages of this report.

TABLE 4.—*Acreage and proportionate extent of the soils mapped in Kalkaska County, Mich.*

Type of soil	Acres	Per cent	Type of soil	Acres	Per cent
Emmet sandy loam	43,328	12.1	Bergland loam	832	0.2
Emmet sand	33,920	9.5	Newton loamy sand	10,432	2.9
Onaway sandy loam	192	.1	Ogemaw sandy loam	1,408	.4
Roselawn sandy loam	2,944	.8	Selkirk loam	1,088	.3
Roselawn sand	32,256	9.0	Eastport sand	832	.2
Kalkaska loamy sand	56,640	15.8	Antrim sandy loam	2,176	.6
Kalkaska sandy loam	8,512	2.4	Echo loamy sand	1,152	.3
Mancelona gravelly sandy loam	1,152	.3	Granby sand	1,152	.3
Blue Lake loamy sand	15,424	4.3	Griffin silty clay loam	576	.2
Wallace fine sand	704	.2	Griffin sandy loam	1,856	.5
Barker loam	640	.2	Bridgman fine sand	1,152	.3
Grayling sand	14,592	4.7	Rifle peat	21,632	6.1
Gravelly phase	2,304		Lupton muck	13,568	3.8
Rubicon sand	67,136	18.8	Greenwood peat	2,368	.7
Saugatuck sand	16,704	4.7	Houghton muck	448	.1
Bergland clay loam	640	.2	Total	357,760	

EMMET SANDY LOAM

Emmet sandy loam comprises most of the better-grade gently rolling upland, or hardwood land, of the county. It is a light sandy soil underlain at a depth ranging from 2 to 3 feet by a pervious gravelly or stony sand-clay mixture. The soil in forest or cut-over land consists of the following layers: (1) A dark surface layer of mold or a loose mixture of sand and more or less humified organic matter, 2 or 3 inches thick; (2) a light-gray loose loamy sand layer, 2 or 3 inches thick; (3) dull-yellow or brown loamy sand, 4 or 5 inches thick; (4) pale-yellow or bleached reddish-yellow sandy loam; and (5) a limy substratum of gravel, sand, and clay. The presence of sandy clay material at a slighter depth is the chief distinction between the sandy loam and the sand members of the Emmet series. Probably the average amount of moisture held by the sandy loam is a little higher than in the sand. The soil is commonly acid in reaction down to the clay substratum except in the more stony and gravelly material.

This soil occurs in fairly large bodies, in the western half of the county, mainly in the central, northwestern, and southwestern parts. The land is undulating or moderately rolling, and the steeper slopes, if placed under cultivation, would probably be susceptible to both wind and water erosion. Scattered bowlders and cobbles occur in places but the soil as a whole is not excessively stony for agriculture.

The land originally supported a dense forest of such hardwoods as maple, beech, elm, yellow birch, and basswood, along with considerable hemlock. The unused cut-over land has largely grown up to aspen, pin cherry, red maple, oaks, and white birch, with here and there clumps and scattered trees of the original species. Most of the land is thickly set with stumps.

The greater part of the farming in the county is being carried on on this soil, and a large number of the farms are self-supporting and moderately profitable. The productiveness of this soil is greater than that of the deep sands of the Emmet and Roselawn series. Potatoes, timothy and red clover, oats, rye, and corn (mainly for forage or silage) are the principal crops, and alfalfa, sweetclover,

cucumbers, and radishes (for seed) are also produced. Potatoes are the most dependable cash crop. Apple orchards produce well where favorable sites are selected.

The rolling relief is unfavorable for extensive farming, and the cost of clearing the land of stumps and stones retards the more extensive agricultural development of this soil. Because of its loose sandy texture and low content of organic matter it is not likely that the soil will be very durable unless care is taken to maintain or increase the organic-matter content by turning under green crops or applying manure. When the land is first brought under cultivation there seems to be no necessity of liming in order to obtain stands of red clover, sweetclover, and alfalfa, although applications of limestone would be beneficial. Commercial fertilizers are not extensively used at present, but experience has shown that the soil responds to their use and that they can be profitably employed, particularly for potatoes.

EMMET SAND

Emmet sand comprises most of the deep sand soil of the upland, or hardwood hills, particularly in the western part of the county. This soil under forest consists of the following layers: (1) A surface layer of mold and humus 2 or 3 inches thick; (2) a light-gray loose leached sand layer ranging from 6 to 10 inches in thickness; (3) a dark-brown or dull-yellow loamy sand layer from 6 to 15 inches thick; (4) a thin layer of pale-yellow sand grading into (5) the parent glacial sandy drift. In the cut-over land the layer of forest litter and mold originally present has been consumed by fires, and the surface soil consists of 2 or 3 inches of loose sand mixed with sufficient humus and charred organic matter to produce color shades of gray or light brown. The cultivated soil is light brownish-gray loamy sand consisting of a mixture of the first three layers of the virgin profile. Most of the sand is medium or fine in texture, and a few scattered cobbles and bowlders occur in it.

The soil is low in fertility as compared with the clay soils of the State but apparently contains a little higher content of calcium and magnesium than similar sands, such as Roselawn sand, and possibly holds slightly more moisture, owing to the strong development of the brown third layer, as compared with sands where this layer is absent or only weakly developed. In most places the soil reaction is acid, but in some areas is nearly neutral or slightly alkaline in one or more layers.

The areas shown as Emmet sand on the soil map are fairly uniform of the soil as described, but in places some slightly more silty or clayey soil sufficient to make a sandy loam or loam the same as or similar to Emmet sandy loam and Onaway sandy loam may have been included, also some land that is moderately stony. The sandy soil with clay at a slight depth has proved to be the more productive.

Emmet sand is one of the more extensive soils of the county, comprising 33,920 acres.

The relief is strongly rolling or moderately hilly, most of the land having smooth, long, broad, sweeping slopes, but in a few places it is choppy and broken. The land is dry and well drained owing to the texture and structure of the soil and underlying drift

and to the generally sloping surface. The water table in most of this soil lies at a great depth.

The land originally supported a fine forest consisting of a mixture of the common hardwoods, hard maple, beech, elm, and yellow birch, and hemlock. It is probable that a much greater proportion of hemlock and white pine grew on this soil and a smaller proportion of ash, elm, and basswood than on Emmet sandy loam. With the exception of a few small remaining tracts the trees have been cut for lumber. The land at present consists of desolate burned-over slashing, old cut-over land covered with charred stumps, briers, grasses, and weeds or a small scrubby growth of cherry, aspen, white birch, and small oaks. Only a very small part is well stocked for a new forest.

A few small farms have been developed on the smoother land. Rye, oats, timothy and red clover, potatoes, buckwheat, and sweet-clover have been grown. Probably most of the land is too far from Lake Michigan to be successfully used for large commercial orchards. General agricultural conditions, absence of a large local population, distance to outside markets, and competition from other more suitable lands both here and elsewhere have prevented an extensive development of this land for agriculture. Many farms have been abandoned. The more open and less brushy land affords a short season of fair pasture for cattle and sheep.

ONAWAY SANDY LOAM

Onaway sandy loam occurs on the gently rolling hardwood uplands in the western part of the county. It is characterized by a light-brown or grayish-brown loam or sandy loam surface layer, underlain at a slight depth by gritty pale-red very limy clay loam material. In detail the soil under forest consists of the following layers: (1) A surface cover of mold and dark-colored humous soil from 1 to 3 inches thick; (2) a leached gray or pale-lavender layer composed mainly of sand and silt from 3 to 6 inches thick; (3) a leather-yellow or dull-brown fine sandy loam layer from 4 to 10 inches thick; (4) a pale-red clay loam layer, from 12 to 20 inches thick; and (5) a substratum of calcareous gritty or sandy clay loam, containing small stones and scattered bowlders. The cultivated soil consists of a mixture of layers 1, 2, and 3 and is fine sandy loam or light loam containing sufficient organic matter and coloring from the third layer to produce a light brownish-gray color. There is some variation in the amount of silt and clay in the surface soil and considerable variation in the depth to the red clayey subsoil layer. The greater part of the land has very few stones on the surface.

Onaway sandy loam is moderately fertile. It is fairly retentive of moisture, apparently holding sufficient available moisture for good plant growth. The reaction of the surface layer is generally medium acid; of the gray layer, from medium to strongly acid; of the yellow layer, No. 3, strongly acid; and of the clayey layer directly beneath from slightly acid to alkaline. Carbonates, particularly calcium carbonate, are present in large amounts in the parent glacial drift but have been rather well leached out in the soil-forming processes to a depth ranging from 20 to 30 inches below the surface.

Onaway sandy loam is the least extensive soil in the county. The principal area lies in sections 6 and 31 about 3½ miles southwest of South Boardman. Small bodies are included with mapped areas of Emmet sandy loam. The land is gently undulating or but moderately rolling with smooth slopes. With the exception of small included swales between the hills, there is sufficient slope to provide good natural drainage.

This soil originally supported a dense hardwood forest, consisting principally of hard maple and beech, with elm, basswood, white ash, yellow birch, and hemlock as other common species.

Onaway sandy loam constitutes valuable land for general farming, and such crops as timothy and red clover, potatoes, beans, rye, wheat, oats, barley, corn for silage or forage, alfalfa, sweetclover, and buckwheat can be grown with a fair degree of success. Among the orchard fruits, apples yield well and are of good quality. Dairying or the feeding of livestock is carried on in a small way on perhaps the greater number of farms on this soil. Onaway sandy loam is not quite so easily plowed as the lighter sandy soils but offers no special tillage difficulties. Fertilizers are not used so extensively, and good stands of alfalfa and clover may be obtained without liming.

ROSELAWN SANDY LOAM

Roselawn sandy loam is characterized by a light sandy loosely coherent surface soil over a friable somewhat red sand and clay mixture which occurs at a depth ranging from 20 to 40 inches. This soil is similar to Onaway and Emmet sandy loams, differing primarily in its more acid character and less limestone influence in the underlying drift. A typical profile of the virgin soil follows: (1) A layer of loose mold and humous soil from 1 to 3 inches thick; (2) light-gray or pale-lavender incoherent sand from 2 to 6 inches thick; (3) a layer of yellow sand or sandy loam, somewhat yellowish brown at the top, from 18 to 30 inches thick; (4) a moderately compact but friable penetrable reddish-brown clay and sand mixture; and (5) a substratum of coarse sandy clayey drift containing only a small proportion of limestone. The plow soil of cultivated land is variable in color and texture, but in most places is grayish-brown or light-brown sandy soil containing sufficient silt, clay, and organic matter to produce a loamy feel and slight coherence. The content of organic matter is low and not very durable under cultivation. The soil is pervious but contains sufficient clay at a slight depth to check slightly the free downward movement of water and, therefore, it retains a little more water for plant use and has slightly higher natural fertility than Grayling sand and Roselawn sand. The soil is medium to strongly acid in all layers to a depth of 3 or 4 feet, but it is not probable that the amount of lime is abnormally low, as calcium carbonate is present in appreciable amounts in the parent drift.

Roselawn sandy loam does not occupy a very large aggregate acreage. It occurs in small bodies in T. 25 N., R. 5 W., in the southeastern part of the county. The relief of most of the land is gently rolling, with smooth and not excessively steep slopes, and a part of it is nearly level.

The original forest cover apparently consisted of the hardwood association of this region, hard maple, beech, elm, and basswood, together with variable amounts of hemlock and white pine. White and red (Norway) pines were evidently more abundant on the more sandy areas.

The old cut-over land is covered with stumps of hemlock and pine, and a shrubby growth of aspen, sumac, witch-hazel, fire cherry, and briers or is occupied by a second growth or by culled wood lots of the original dominant forest species. Oaks apparently make a more thrifty growth than on Grayling and Roselawn sands with which this soil is associated. A considerable acreage of the land has been placed under cultivation but some of this has been abandoned during the last few years. The land has some intrinsic value for agriculture but at the present time is disadvantageously located.

Where the land has been farmed, oats and rye (planted alone or with vetch), timothy and red clover, beans, buckwheat, and potatoes have been grown, potatoes probably being the most successful money crop. The land is not naturally so well adapted to red clover, alfalfa, and sweetclover as the better soils in the western part of the county, but these crops can be grown. Apple trees make a fair growth.

In the management of the land it is probably most important to turn under green crops where manure is not available. Commercial fertilizers could be profitably used on the older land, especially for potatoes. Liming would probably be beneficial, although under existing conditions it may not be economically practical.

Included with mapped areas of Roselawn sandy loam is some Roselawn gravelly sandy loam, indicated on the soil map by gravel symbols, which is more gravelly and stony both at the surface and in the underlying red sandy clay which occurs at a depth ranging from 2 to 4 feet. It has perhaps slightly less agricultural value than the sandy loam, which is a little more loamy in the surface layers and a little more retentive of moisture.

Another inclusion is a heavy phase of Roselawn sandy loam which includes areas of soil similar to typical Roselawn sandy loam except that they have more silt and clay in the surface soil and subsoil, indicating somewhat higher average moisture and a little more fertility, with corresponding greater agricultural value. One conspicuous area of this heavier soil lies north and west of Fletcher School in T. 25 N., R. 5 W.

ROSELAWN SAND

Roselawn sand comprises the loose yellow sand, dry to a depth of 4 feet or more, on the pine and oak hill lands. The deeper underlying material consists mainly of sand but contains scattered gravel and bowlders and in places pockets of clay. The virgin soil in cut-over areas consists of the following layers: (1) A surface layer, ranging from 1 to 3 inches in thickness, of mold or a loose mixture of gray sand, charred organic matter, and plant roots; (2) light-gray leached incoherent sand from 2 to 6 inches thick; (3) dull-yellow or straw-colored slightly loamy sand, slightly darkened by organic colloidal matter; (4) a gradation from the loamy sand into loose very pale-yellow sand; and (5) parent glacial drift material consisting

mainly of sand with some scattered gravel and bowlders and here and there a pocket of clay. The soil is dominantly a fairly uniform mixture of medium sand and fine sand, with little silt and clay. The land is for the most part free from stones, but a few bowlders are present. The content of organic matter is uniformly low and not durable. Where the soil occurs under grass cover on old cut-over land, the darkening from organic matter or humus extends to a greater depth than under a tree cover. The moisture-holding capacity and the average water content are low, but it is probable that a high proportion of the moisture present is available. The total content of essential plant-food elements, such as calcium, magnesium, phosphorus, and potassium, is lower than in the heavier soils and those containing a greater proportion of limestone, as in the western part of the county, but there is no evidence of an abnormal deficiency of these elements. The low fertility is compensated to some extent by the penetrability of the soil and the greater freedom of root development as compared with clay, hardpan, and swamp soils. The reaction is rather uniformly strongly acid to a depth ranging from 3 to 5 feet. The gravelly areas, those areas in which some clay is present between depths of 3 and 5 feet, and the dry valleys or swales between hills which receive a small amount of wash, may be slightly more productive than the typical soil.

Roselawn sand is one of the more extensive soils in the southeastern and eastern parts of the county. Its total area is 32,256 acres. It occurs as low swells or smooth rounded ridges and hills with broad valleys between, many of which are dry and without streams. Although there are but few streams or natural drainage ways, the land is dry or well drained owing to the perviousness of the soil and free downward percolation of water.

The original forest on this soil consisted dominantly of red pine with perhaps a few scattered white pine, oaks, and jack pine. The forest has been almost entirely removed by lumbermen, and the old cut-over land has grown up to a fair growth of small scarlet, red, and white oaks, together with red maple, aspen, and white birch, and most of the pine stumps left by the lumbermen remain. Bracken, sweetfern, and low blueberry are common, and in places there is a dense thicket of briers.

None of the soil is cultivated in this county, but in adjacent counties a very small acreage has been cleared for farming, and rye, oats, corn, potatoes, timothy, and buckwheat have been grown. The yields are low under ordinary farming methods, and in a number of places cleared land has been abandoned after a few years of hopeless farming. The chief deficiencies of the soil seem to be average low moisture content, low fertility, and high acidity. Red clover is not successful, and it does not seem probable that good stands of alfalfa or sweetclover can be obtained without liming. Several species of grasses and weeds of forage value grow, but the cover of shrubs and trees depreciate the value of the land for pasture, and the bluegrass dries up in the middle of the summer. The logical use of this land is mainly for forestry, game refuges, and hunting preserves.

KALKASKA LOAMY SAND

Kalkaska loamy sand includes the lighter and deeper sand soil of the dry sandy plains and valleys, which supported a hardwood forest. The chief visible differences from the sands of the pine plains is in the dark-brown or umber-colored layer which underlies the light-gray leached layer at a depth of a few inches and in the characteristic slight cementation. Beneath this layer, beginning at a depth ranging from 12 to 20 inches, is pale-yellow or gray loose penetrable comparatively dry sand which extends to a depth ranging from 8 to more than 10 feet. The soil is not highly fertile and is moderately or strongly acid to a depth of 30 or 40 inches, but apparently has a little higher average moisture content and hence is a little more productive than the sands of the pine plains.

Kalkaska loamy sand is one of the more extensive soils of the county and occurs in fairly large and uniform bodies in the central northern and northwestern parts. The land is nearly level but is pitted here and there with shallow dry depressions and lake basins and is featured by low terrace escarpments.

The original forest cover consisted principally of hard maple, beech, yellow birch, hemlock, elm, and ironwood, together with a few scattered large white pine. A few tracts of virgin forest still remain, but the greater part has been cut over and has grown up to a second growth of maple, elm, and other species of the original forest, or, where more severely burned over, the growth is more largely aspen or the land is covered with grass. A considerable acreage has been cleared for farming.

Potatoes, oats, timothy and clover hay, alfalfa, sweetclover, beans, and buckwheat have been grown in places with moderate success, but on the whole farming has not been so profitable as on the better soils, such as Onaway sandy loam and Emmet sandy loam, and a number of farms have been abandoned. The soil is easily plowed, is nearly free from cobbles and large stones, and large bodies are comparatively uniform. Its chief deficiency is probably low moisture content. The sand has some tendency to blow in cleanly cultivated fields, and, as on most of the sandy soils in this part of the State, fields are likely to be infested with quack grass. Heavy manuring is essential, and it is probable that liming and the use of commercial fertilizers would increase yields.

KALKASKA SANDY LOAM

Kalkaska sandy loam comprises sandy soil on the hardwood plains and valleys very similar to Kalkaska loamy sand but differs from that soil in that it contains a slightly greater amount of silt and clay in the brown subsurface layer, sufficient to produce a light sandy loam in the plow soil where the land is farmed. The soil on forested or cut-over land consists of the following layers: (1) A layer of mold and humus, 1 or 2 inches thick; (2) a light-gray or lavender leached layer, from 2 to 8 inches thick; (3) an umber-colored or dark-brown sandy loam layer, from 4 to 15 inches thick; and (4) a pale-yellow or gray loose sand and gravel layer which is pervious and dry and extends to a depth of several feet.

The soil is of low or only medium fertility and is acid to a depth of 30 or 40 inches, but it has a small content of limestone gravel and

crusts of calcium carbonate in the underlying sand and gravel. The moisture content is probably slightly higher than in Kalkaska loamy sand, but deficient moisture is probably the limiting factor in large yields of farm crops.

This soil covers a total of 8,512 acres, occurring chiefly on the high plains in the central and northern parts of the county. A small acreage remains in virgin forest consisting of hard maple, beech, yellow birch, elm, and hemlock; the greater part is cut-over land, either recent slashing or old stump land grown up to grasses and briers, with a fair second growth of the original species.

The relief, drainage, and texture of the soil are favorable for cultivation, but where farmed only moderate success has been attained and some farms have been abandoned. Potatoes, hay, oats, rye, buckwheat, beans, alfalfa, and sweetclover have been grown.

Manuring is essential, and liming for alfalfa and sweetclover probably would be profitable especially on land which has been cultivated several years. Commercial fertilizers have not been used to an appreciable extent, although they are probably necessary for the most profitable yields.

MANCELONA GRAVELLY SANDY LOAM

Mancelona gravelly sandy loam includes comparatively dry soil, occurring as smooth or nearly level hardwood land. The underlying gravel contains a higher proportion of limestone and shale and is coarser or more cobbly than the Kalkaska soils which this soil closely resembles.

Under forest or in wood lots the soil consists of the following layers: (1) A layer of forest mold or dark-gray turf and humous soil, 2 or 3 inches thick; (2) a layer of light-gray or ash-colored loose sand or sandy loam, from 3 to 8 inches thick; (3) a brown gravelly layer, in places cemented and containing appreciable amounts of clay, from 6 to 20 inches thick; (4) a thin gradational layer which is coarser, less coherent, and more gravelly than the layer above; and (5) a pervious substratum of sand, gravel, and cobbles. The cultivated surface soil is gray or very light brownish-gray sandy loam or light loam, loose in structure and easily plowed and maintained in good tilth. The surface soil in places is moderately gravelly, and in places cobbles are abundant.

The content of organic matter is not high but apparently is a little more durable than in associated sandy soils. Layer No. 3 is sufficiently compact and clayey to impede the downward movement of water to some extent and to retain moisture, so that the soil is not excessively droughty, notwithstanding the coarse, pervious character of the substratum to a great depth, as are some of the other sandy soils. In most places the soil layers are acid in reaction, but in some places they are alkaline, and there is evidence that, for a sandy soil, an unusual proportion of calcium, magnesium, and other bases are present. In many places fragments of shale and limestone occur in layers 3 and 4, and in some places are abundant in the substratum or parent geologic formation.

Mancelona gravelly sandy loam comprises 1,152 acres, occurring mainly in the vicinities of Westwood and Leetsville in the north-central part of the county. The land is nearly level except for occa-

sional potholes or shallow depressions. Natural drainage is good, owing to the perviousness of the underlying deposits and the great depth to the water table.

The land was originally forested mainly with hard maple, beech, elm, and yellow birch, together with some hemlock and an appreciable quantity of white pine. Practically all the merchantable timber has been cut, and the unused cut-over land is occupied by a brushy growth of aspen and pin cherry, and culls or poor second-growth hardwoods. Most of the land is rather thickly set with stumps.

This is perhaps the most productive soil on the dry sandy plains. A considerable acreage is under cultivation, and fair yields of potatoes, red clover, alfalfa, sweetclover, oats, corn, and beans have been obtained, potatoes being the most dependable money crop. Yields of the crops mentioned are not high mainly because of lack of abundant moisture at critical times during the growing season. Fertilizers might be profitably used, especially on potatoes. Alfalfa and sweetclover may be grown without liming, although applications of some form of lime would probably be beneficial and advisable. The nearly level surface is favorable for extensive farming, and the soil is easily worked and kept in good tilth.

BLUE LAKE LOAMY SAND

Blue Lake loamy sand comprises the smoothly rolling or moderately hilly deep sands of the hardwood lands in the northeastern part of the county. This soil is similar to Kalkaska loamy sand, differing from that soil in its slightly greater variation in texture and the presence of a few bowlders. It is also similar to Emmet sand, but the underlying sandy drift is not quite so limy.

The greater part of this soil consists of a cover of forest or grass mold, 2 or 3 inches thick, underlain by leached light-gray or lavender sand to a depth ranging from 4 to 8 inches, and this layer, in turn, by brown or umber-colored loamy sand slightly cemented or coherent. The substratum in most places is loose yellow sand containing a few thin layers of sandy clay and scattered bowlders.

The relief, texture, and structure of the soil, also the drainage, are favorable for farming, but, because of low or only medium fertility and remote location, most of the land remains unused. The original forest, a few virgin tracts of which still remain, consisted of a moderately heavy stand of hard maple, beech, yellow birch, hemlock, and a few scattered white pine. The present land cover is recent or old slashing, second-growth hardwoods, or aspen, cherry, briers, and grapes, with various amounts of old stumps and charred tree trunks remaining. As on most of the logged-over land, the surface has the usual pit and mound features caused by the overthrow and uprooting of large trees.

WALLACE FINE SAND

Wallace fine sand comprises dry fine sand occurring as low ridges or moundlike elevations, representing old dunes or beach ridges. The soil is characterized by a thick yellow or brown layer, from slightly to firmly cemented, beginning at a depth ranging from 8 to 20

inches below the surface. It differs from other loose dry sand soils in its greater uniformity in texture to greater depths and in the greater thickness of the brown layer. This soil is strongly acid and low in productiveness. Only a few small areas are mapped in the west-central part of the county, and northeast and southwest of South Boardman. The soil has little or no agricultural value at present because of low fertility, strong acidity, and tendency to drift or blow under wind action.

The original forest growth was white pine and red pine, with an undergrowth of blueberries, bracken, sweetfern, and grasses.

BARKER LOAM

Barker loam is a well-drained upland soil underlain by a massive clay or sandy clay substratum. It differs from the Onaway and Emmet soils primarily in the pale-yellow, buff, or olive color of the soil layers and of the underlying glacial drift. This soil occupies a very small acreage in the vicinity of Barker Creek in the northwestern part of the county. It occurs on high bench land which in places has a choppy or broken surface relief owing to stream erosion.

The typical soil consists of gray floury silty loam beneath the humous soil layer, or forest mold, which is underlain at a depth ranging from 6 to 12 inches by buff or olive-colored firm plastic clay. Drab or chocolate-colored clay containing a high proportion of lime occurs at a depth ranging from 30 to 40 inches. The areas shown on the map are by no means uniform, as in places plastic untillable clay appears at the surface, and in other places the plow soil is, or would be under cultivation, loam or sandy loam, and the underlying drift, instead of being massive clay, is yellow or grayish-yellow sandy clay, or a friable mixture of fine sand, silt, and clay. A few spots of wet soil have also been included.

The land was originally forested with a good growth of hard maple, beech, basswood, ash, elm, and yellow birch, but probably the greater part of it has been cleared. The heavier soil is moderately fertile and durable, but shows some tendency to clod and bake and is cold and backward in the spring. Fair yields of timothy and clover hay, alfalfa, and small grain have been obtained. Some of the land is poor farm land because of unfavorable relief and erosion.

GRAYLING SAND

Grayling sand comprises the deep yellow sand soil of the drier pine plains. The distinguishing characteristic of this soil is its loose incoherent sandy or single-grain structure, and its pervious nonretentive character to a depth of 6 or more feet. The average content of moisture is low, and the fertility is low. The reaction ranges from medium to strongly acid to a depth of 4 or more feet.

This soil is fairly uniform throughout the county, but there is some slight variation in the texture of the sand and in the amount of gravel in the soil. These variations may have some significance, though perhaps slight, in relation to average moisture content and plant nutrients affecting plant growth. In the open grass-covered areas the thickness of soil colored by humus or organic matter is

appreciably greater and the tint darker than in the soil under jack pine or oaks, but the humous soil layer is thin under any conditions.

Grayling sand is one of the more extensive soils in the county. It occurs in large bodies extending several miles southwest from Kalkaska and includes much of the dry level sandy land in the southeastern part of the county.

The land, though level or slightly uneven, is well drained or dry, owing to the perviousness of the soil and the underlying geologic formation.

The natural tree growth on this soil probably consisted mainly of red pine and jack pine (*Pinus banksiana*), and there were probably a few white pine and oaks. The present growth consists mainly of jack pine, in thickets or scattered, in association with small oaks and aspen. In the more open areas the characteristic and more common shrubs and herbs are blueberry (*Vaccinium* sp.), low willow (*Salix humilis*, Marsh), sweetfern (*Comptonia asplenifolia*), bracken, a sedge (*Carex* sp.), a species of bluegrass (*Poa* sp.), wild oatgrass (*Danthonia*), and the bunchgrass (*Andropogon* sp.). The pasture value of the land is small, and the rate of tree growth is apparently slow.

Grayling sand has very little agricultural value under present economic conditions. A few small farms are located on this soil, but attempts which have been made to cultivate the land have been attended with poor success. The chief deficiency of the soil is apparently a low content of moisture during the growing season, in addition to low or only moderate fertility and high acidity. Several years experiments at Grayling, Mich., on this type of soil have shown that by the liberal use of manure or the growing of green-manure crops, by liming, and by applying fertilizers, it has been possible to obtain fair yields of sweetclover, alfalfa, potatoes, turnips, rye, and other crops.[5] Thus it would seem that under exceptional conditions and by following scientific methods, possibly some of the land can be successfully used for cultivated crops, but for the greater part there would be doubtful profit in competition with naturally more productive or more favorably located soils in this and other States. The pasture value of the land is low as the valuable forage grasses become dry and unpalatable in late summer or early fall. The most logical use of the greater part of this land seems to be for forestry and recreational purposes, at least until some other more economic use for it is discovered. The sale of wild blueberries provides some income.

Grayling sand, gravelly phase.—This phase of Grayling sand differs from the typical soil mainly in its greater content of rounded gravel on the surface and throughout the soil. The higher gravel content may indicate a greater diversity of minerals entering into its composition, and this phase may be naturally slightly more fertile than typical Grayling sand. The relief, drainage, and natural vegetation are similar on the two soils, and the possibilities for utilization are practically the same.

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[5] McCool, M. M., and Weidemann, A. G. The soils of Michigan—Grayling sand. Mich. Agr. Expt. Sta. Spec. Bul. 180, 24 p., illus. 1929.

RUBICON SAND

Rubicon sand consists of deep comparatively dry sand. In detail it consists of the following layers: (1) A layer from 1 to 3 inches thick of forest mold or gray sand mixed with charred organic matter and plant roots; (2) light-gray leached sand, from 4 to 10 inches thick; (3) sand or sandy loam, from 6 to 12 inches thick, which is stained dull yellow or dark brown by organic colloids; and (4) pale-yellow incoherent pervious sand.

The land is level and drainage and average moisture conditions are intermediate between Saugatuck sand and Grayling sand. There is a corresponding intermediate development of the gray and yellowish-brown subsurface layers characteristic of most soils of this region.

The soil is highly acid and low in fertility, but probably supports a little heavier growth of vegetation than Grayling sand because of slightly higher average moisture content.

The original forest growth probably consisted dominantly of white pine and red pine. At present there is a fair second growth of oaks, aspen, and jack pine, together with a few widely distributed individuals or clumps of white pine and red pine, and stumps of the original pines.

The land is of practically no agricultural use, as the pasture value is only fair. Wild blueberries and possibly a few other wild plants, such as wintergreen, ground pine, and arbutus, are of some value. The more gravelly areas are similar to Antrim gravelly sandy loam, and the more strongly acid areas to Kalkaska loamy sand. Such areas seem to be a little more productive than typical Rubicon sand. Fair crops of potatoes, alfalfa, sweetclover, oats, and hay have been obtained on this kind of land near Rapid River in the northwestern part of the county.

SAUGATUCK SAND

Saugatuck sand is a wet sandy soil characterized by a brown sandy hardpan. Over most of the county the soil consists of the following layers: (1) A dark-colored layer of mixed peaty organic matter and sand; (2) a layer of gray or dingy-white loose sand, from 6 to 12 inches thick; (3) a dull-yellow or coffee-brown sand layer, in places cemented into a hardpan, from 6 to 15 inches thick; grading into (4) grayish-yellow or mottled gray and yellow sand. In many places the soil is water-soaked within a few inches of the surface, and it is permanently saturated at a depth of 3 or 4 feet. Clay, if present in the substratum, in most places lies at a greater depth than 4 feet. The sand consists dominantly of medium and fine particles.

The soil is strongly acid in reaction or low in lime and is low in fertility under cultivation. Where this kind of soil has been plowed and cultivated elsewhere in the State, the organic matter has been rapidly depleted leaving the soil lighter in color, looser, and less loamy in a few years.

Soil of this kind is widely distributed, but it occurs principally in small bodies or in long strips in or bordering swamps. The areas shown on the map are not uniform but include dry hummocks or nar-

row short ridges of Rubicon and Wallace soils, spots of muck, and patches of Newton and Ogemaw soils. The land is for the most part flat, wet, and semiswampy. The surface is pitted by shallow depressions and mounds, caused by the overthrow of large trees during lumbering.

The wetter spots are covered with a dense shrub or thicket growth of aspen, willow, alder, and white birch, together with bracken, blueberries, and a ground cover of wintergreen. The original forest growth over most of this land was white pine, with red pine on the drier sandy spots and some spruce, hemlock, fir, and cedar on the wetter land; some hardwoods, particularly yellow birch, were originally present but these trees were not dominant. But little reproduction of the original species has taken place since the land was logged over by lumbermen. Many large white pine stumps remain.

This land has very little agricultural value under present conditions, either for cultivated crops or for pasture, but under natural conditions it appears to support a fairly heavy growth of vegetation.

BERGLAND CLAY LOAM

Bergland clay loam includes the heavier mineral soils of the county which have developed under conditions of poor drainage. It occurs as swampy lands in swales, on slopes where there are seepage springs, and on the borders of peat and muck swamps. The surface soil to plow depth is dark gray or nearly black owing to the high content of organic matter, and in texture is loam or clay loam. It is underlain by a gray or drab plastic clayey layer, which, in turn, is underlain by bluish-gray or gray and yellow clay showing the physical and chemical characteristics common to clay soils existing under permanently wet conditions. At a depth ranging from 2 to 5 feet the red color common to clay of the glacial drift of this region is noticeable. The soil appears to be fertile and is alkaline or nearly neutral in reaction. However, very little of it has been used for agriculture because of its occurrence in small bodies and the excessive cost of draining and clearing. Natural grasses, alsike clover, and timothy afford good pasturage where the land has been cleared of trees and brush.

This is an inextensive soil in Kalkaska County, but it is widely distributed in small bodies mainly in association with the heavier soils, such as the Onaway, Selkirk, and Ogemaw. The cover of natural vegetation was dense and consisted of elm and ash as the typical species, along with various quantities of soft maple, basswood, spruce, fir, hemlock, and white pine. Small open spots are covered with cattails, flags, and sedges.

BERGLAND LOAM

Bergland loam is similar in occurrence and other respects to Bergland clay loam, but it includes soil which is on the whole sandier, although it contains considerably more clay than Newton loamy sand or Granby sand, and it is wetter than Ogemaw sandy loam. The sandy layer overlying the clay may be slightly acid. Practically none of the land is utilized for agriculture, but it should afford good pasture and be good hay land where cleared of trees and brush.

NEWTON LOAMY SAND

Newton loamy sand consists of dark-gray or nearly black loamy sand or sandy loam soil underlain by gray or dingy-white wet sand, and at a greater depth by gray and yellow mottled sand or soft sandy clay. The dark color, due to organic matter accumulated under wet conditions, extends to a depth ranging from 3 to 15 inches. Most of the soil is medium or strongly acid in reaction and does not show evidence of high fertility other than that resulting from the organic matter in the surface layer.

This soil occurs on poorly drained sand plains, on the flat wet borders of shallow lakes, and on the borders of swamps. Mapped areas include considerable shallow muck, also small bodies of Saugatuck sand and Rubicon sand.

Most of the land at present is covered with a dense thicket growth of alder, willow, and aspen. The original tree growth consisted mainly of white pine with more or less white cedar, white spruce, and balsam fir; locally yellow birch, red maple, ash, elm, and aspen were abundant.

The land is considered of very little agricultural value under present conditions. A few acres are used for pasture and hay land. Artificial drainage is necessary for any other use.

OGEMAW SANDY LOAM

Ogemaw sandy loam is characterized by a dark-colored surface soil and a yellow or coffee-brown sandy subsoil, cemented in places and underlain by clay at a depth ranging from 24 to 40 inches. The basal part of the sandy soil is more or less permanently wet, and the average content of moisture is higher than in other sandy soils, such as Grayling, Roselawn, and Rubicon sands, and the fertility is a little higher. Most of the surface soil is acid, although in a few places it may be nearly neutral or slightly alkaline, the sandy subsoil is strongly acid, and the clay substratum is alkaline, owing to the presence of lime or calcium carbonate.

This soil occurs in small nearly level areas in association with other heavier soils, such as the Bergland and Selkirk. Locally the land may be very uneven, owing to small mounds and pits caused by the uprooting of trees. Most of the soil is naturally wet or semiswampy. The high average moisture content is shown by the darker color and greater accumulation of organic matter as compared with the drier sandy soils. The present vegetal cover and the composition and character of the original cover also indicate the higher average moisture content and greater fertility.

The original tree growth consisted mainly of white pine, some of which must have been very large, judging from stumps, with a variable mixture of hemlock and the hardwoods, such as elm, ash, basswood, and beech, and more or less spruce, fir, and arborvitae. The land has been completely cut over by lumbermen. The present cover of the wild land consists of a dense brushy growth of aspen, alder, willow, and briers, with scattered clumps or individuals of the hardwoods and other original species.

Small patches here and there are farmed, but the greater part remains as wild land or stump pasture. The soil is easily plowed and

tilled when cleared of stumps and roots and leveled. Potatoes, corn, oats, rye, timothy and alsike-clover hay, and other crops have been grown with fair results. Plant growth is not uniform, however, owing to variations in the water content and in the amount of organic matter. The cut-over land is for the most part thickly set with stumps, and the cost of clearing and leveling is high. Where the brushy second growth has been kept down by fire or other means, the land affords good grazing for cattle and sheep.

SELKIRK LOAM

Selkirk loam is characterized by surface layers which are dark-gray, ash-gray, and yellowish-gray silty loam or loam, and comparatively impervious pale-red or chocolate-colored clay occurs at a depth ranging from 6 to 20 inches. The average moisture content is high, owing to the flat surface and the heavy underlying clay, but the land was not originally so swampy or so permanently wet as the Bergland soils. On the older fields the thoroughly mixed cultivated surface soil is gray moderately heavy loam or fine sandy loam, which coheres strongly and clods if worked when wet. New land may have a variegated appearance of dark gray, light gray, and yellowish brown or reddish brown.

The surface soil is generally acid in reaction to a depth ranging from 6 to 12 inches, but the subsoil clay is alkaline, and the deeper underlying clay contains a high proportion of lime in the form of calcium carbonate. The soil is very fertile and with proper drainage and tilth can be made productive. The subsoil is not so easily penetrated by plant roots as are the sands and other well-drained mineral soils, and under natural conditions the vegetation is comparatively shallow rooted. The land is nearly flat or but gently undulating and includes numerous shallow wet depressions and swales between low swells of higher land.

In mapped areas of this soil considerable variation occurs in the thickness of the leached or gray surface soil. Numerous small bodies of a darker-colored and wetter soil in shallow swales or depressions and small spots of Ogemaw sandy loam, which could not be shown separately because of small size, are included.

Selkirk loam is not an extensive soil, but it offers some possibilities for agricultural development under present conditions. Much of the land is too wet and cold in the spring for the most successful farming and would have to be improved by artificial drainage.

The original forest growth consisted dominantly of white pine in association with hardwoods. In the wetter situations the growth consisted of elm, ash, basswood, and a smaller amount of hemlock, balsam fir, and white spruce. Practically all the merchantable timber has been removed by lumbermen. The pine stumps remain and the land has in part grown up to aspen and in part is open and comparatively free from brush and is used for grazing cattle and sheep.

A few small fields are under cultivation. The land seems to be naturally best adapted to timothy and alsike clover hay which is the principal crop. Other crops grown are corn, oats, beans, peas, and barley. The brush-free stump pasture land supports an excellent growth of bluegrass, timothy, alsike clover, and redtop, in addition to natural grasses and weeds.

EASTPORT SAND

Eastport sand comprises the gray or pale-yellow loose sand on low-lying level sandy plains or benches representing former lake beds or beaches. A small body borders the southern end of Torch Lake, and narrow strips border some of the larger inland lakes in the northeastern part of the county. The sand is in places dry and similar in appearance to Grayling and Rubicon sands but does not show so much yellow coloration and presumably is not so strongly acid. The total acreage is small, and the land apparently is of very little agricultural value in this county. It has, however, sufficient moisture and fertility to support a fairly thrifty growth of trees and an undergrowth of grasses and shrubs. The original forest growth consisted largely of red and white pines, with a small admixture of the common hardwoods. The present growth is largely red pine or a second growth of aspen, red and scarlet oaks, cherry, red maple, and white birch.

ANTRIM SANDY LOAM

Antrim sandy loam is characterized by a dark grayish-brown surface soil over a brown or reddish-brown mixture of sand, gravel, and a variable amount of clay, which is underlain by a basal soil, or substratum, of more pervious sand, or sand and gravel. The middle layer contains sufficient clay to produce a coherent sandy loam or coarse sandy clay loam. The soil is similar to Kalkaska sandy loam and Mancelona gravelly sandy loam, but contains a little more organic matter, is darker in color, and contains a slightly higher average amount of moisture. In places there is evidence of poor subsurface drainage between depths of 2 and 3 feet. Most of the land is gravelly or cobbly at the surface. In a few places the soil is alkaline or neutral in reaction, but most of it is moderately acid.

This soil occurs in filled-in valleys and on gentle slopes or benches bordering lakes and streams. At the mouths of ravines or streams issuing from the adjacent higher land it is composed in part of wash, but most of it has a definite soil profile.

The original vegetation consisted dominantly of hardwoods, such as hard maple, beech, elm, ash, and yellow birch, with scattered white pine. Very little merchantable timber remains.

Antrim sandy loam occurs in small bodies but occupies a considerable aggregate area in the northwestern part of the county.

Where the land is farmed good crops of corn, alfalfa, and potatoes have been obtained. Apples, cherries, and small fruit have also produced fairly well.

ECHO LOAMY SAND

Echo loamy sand includes the lighter sandy soils, loamy sands, and light sandy loams in narrow dry valleys and dry basins or swales. It occurs in association with deep sandy soils such as Roselawn sand and Emmet sand. Land in such situations has received more or less sandy wash from the adjacent higher land, but it is not strictly alluvial. The soil is perhaps a little more productive than the associated higher sandy land, but because of the small size and location of the separate bodies it is of little agricultural importance. Most of the land apparently originally supported a growth of hardwoods, hemlock, and large white pine. The grass cover and pasture value of the more open land ranges from fair to good.

GRANBY SAND

Granby sand includes soils with black or dark-brown surface material of more or less thoroughly decomposed organic matter, containing grains of quartz, underlain at a depth ranging from 3 to 10 inches by gray or dingy-white moist incoherent sand, generally neutral or alkaline in reaction.

The surface layer varies in thickness and is not uniform over any large area. In places, on the slightly higher ridges, the surface layer is dark-gray loamy sand or fine sandy loam underlain by loose gray sand. The content of organic matter in these areas is low in comparison to that in wetter areas. The texture of the subsoil varies, also, and different borings show a range from fine to coarse sand. In some included depressions muck is underlain by gray sand at a depth of only 12 or 15 inches, but it was impractical to differentiate these areas on the soil map.

Only a very small total area of Granby sand was mapped in Kalkaska County. It is used but little for agriculture at present. The natural vegetation is a dense second growth of small trees including alder, willow, poplar, birch, cedar, spruce, and fir. Where adequately drained the land returns fair yields of truck and general farm crops.

GRIFFIN SILTY CLAY LOAM

Griffin silty clay loam includes the alluvium along Manistee River in the southwestern part of the county, which in places consists of gray or bluish-gray and yellow mottled compact silt and silty clay to a depth ranging from 2 to 4 feet. Most of the land is only from 2 to 3 feet above the mean level of the river and is permanently moist or even swampy. The soil, because of unfavorable location and topographic situation, has very little agricultural value, although there is evidence of comparatively high fertility. At one place small fields have been cleared and used for the production of timothy and clover hay, and in other localities the land has some pasture value.

The forest growth is, or was originally, elm, ash, red maple, balsam poplar, aspen, hemlock, and white pine, the trees attaining large size.

GRIFFIN SANDY LOAM

The streams of the county for the most part flow through peat swamps, but some of the larger ones along their lower courses are bordered by comparatively narrow strips of wet or semiswampy bottom land composed of alluvium carried by the streams and deposited during occasional overflows. These alluvial deposits have been correlated as Griffin sandy loam. Most of the alluvium is not thick and consists of gray and yellow or rust-colored sand or sandy loam. The water table is high, and the soil contains a large proportion of organic matter, in fact is an alluvial muck in places and is comparatively fertile, but because of poor drainage and narrowness of the bottoms has no agricultural value under present conditions.

The bottoms originally supported a dense growth of mixed hardwood and coniferous trees, together with a dense shrubby under-

growth. Elm, ash, red maple, balm-of-Gilead poplar, and aspen were dominant species, with some cedar, white and black spruces, fir, tamarack, alder, and willow.

BRIDGMAN FINE SAND

Bridgman fine sand in virgin areas consists of the following layers: (1) A 1 or 2 inch layer of organic material over dark-gray fine sand colored by humus; (2) a layer of ash-gray fine sand, from 4 to 10 inches thick; (3) a layer of light-brown or yellowish-brown slightly loamy fine sand, from 12 to 20 inches thick; and (4) the deep substratum of pale-yellow incoherent sand.

Bridgman fine sand has developed on quiescent dunes which occur as irregular or broken ridges. They are variable in height, ranging from 8 to 30 feet. Included with Bridgman fine sand are areas which are of recent development or in which the cover of organic material has been removed, " blowholes " are common, and the sand easily shifts with the wind. Such areas have developed no soil profile and occur as knolls or low ridges. The sand has an acid reaction.

White pine, poplar, red maple, cherry, white birch, small oaks, huckleberry, bracken, and sweetfern constitute the chief vegetation on Bridgman fine sand. The soil has little value for pasture, because the grass is sparse and dries up in hot, dry weather. It is too droughty and infertile for agricultural use.

ORGANIC SOILS (MUCK AND PEAT)

The organic soils are composed dominantly of plant matter and in this respect constitute a distinct class when compared with soils composed dominantly of mineral or inorganic matter. In Kalkaska County the organic soils occur in swamps, heath bogs, and marshes. The deposits have accumulated in permanently wet situations as follows: (1) In irregular flat areas where the underdrainage is obstructed and in stream valleys; (2) on slopes permanently wet from seepage springs; and (3) in certain types of lakes, some of which have been completely filled by vegetation. The deposits composing the soil, or from which the soil has been derived, range in thickness from 1 foot to as much as 40 feet; differ in the character of the mineral substratum, whether marl, sand, or clay; and differ in the average depth of the water table, in age, stage of decomposition of the plant matter, ash content, and amount of admixture of foreign mineral matter. The organic soils comprise 10.7 per cent of the total area of the county. They have very little agricultural value at present and there seems to be little probability of any extensive use, because of their location and the economic factors to be overcome in their development.

On account of the great amount of time and labor involved and the slight economic justification, no attempt has been made to show on the map more than a few subdivisions of the organic soils which it is possible to make in a soil classification, but fairly well-defined types or groups are recognized, although boundaries between them can not be expected to be so accurately drawn as between mineral

soils. The less decomposed and coarser material is designated as peat, and the more decomposed is designated as muck.

Rifle peat.—Rifle peat is a brown or dark-brown coarse woody or loamy material very high in organic matter (75 per cent or more), which is underlain at a depth ranging from 6 to 20 inches either by fibrous material or by a coarser-textured woody mass of plant matter showing very little decomposition. The mineral substratum in most areas is sand. The average depth of the water table is probably between 10 and 20 inches. Rifle peat gives an acid or nearly neutral reaction.

The vegetation consists of a dense growth of arborvitae (locally called white cedar), black spruce, and tamarack, with an occasional balsam fir, hemlock, and white pine. On included islands in the swamps there was originally or still remains considerable maple, birch, and aspen. Where the swamp land has been logged off and burned over, the land has grown up in places to dense thickets of aspen, alder, willow, and white birch, and treeless open spaces have a heavy cover of sedge (such as *Carex filiformis*) and bluejoint grass. In places vegetation of the more acid-bog type (Greenwood peat), such as leatherleaf, Labrador-tea, blueberry, and laurel, is found in association with the tree growth.

The land has little or no agricultural worth and its value, for the present at least, is chiefly in the tree growth which it is capable of producing and its use as game refuges. In a few places some sedges and grass are cut for hay.

This type of peat occupies the largest aggregate acreage, about 57 per cent, of the muck and peat land of the county. It occurs throughout the county both in the stream-valley and the lake-filled swamps. The largest individual bodies and the largest acreage in any one locality is in the southeastern part of the county extending north and east from Sharon along Manistee River and its tributaries.

In the larger bodies very small islands of Saugatuck, Rubicon, and Newton soils probably remain unmapped, because of the impenetrability of the swamps and the difficulty of drawing accurate boundaries.

Lupton muck.—Lupton muck is black or brown granular loamy muck, high in organic matter, comparatively high in ash content, comparatively fine in texture, and showing evidence of marked physical change and decomposition of the parent plant matter to such an extent that botanical identification of the plants is difficult or impossible. This material may extend to a depth ranging from 2 to 3 feet before the usual yellow or brown coarser more fibrous and less decomposed peaty material is reached. Most of the Lupton muck areas are nearly neutral or only slightly acid in reaction. The water table under natural conditions probably lies at an average depth between 18 and 30 inches. The vegetation now includes or originally included a large proportion of elm, black ash, aspen, and soft or red maple, in association with the characteristic coniferous species of the swamps of this region, such as cedar, spruce, and tamarack, a small amount of hemlock and white pine, and an occasional basswood.

This type of muck occupies a comparatively small acreage and most of it occurs in small bodies in the valleys of the larger streams

or in association with the more clayey soils and more calcareous glacial deposits. In a few places it is underlain by marl, but in most places the substratum is sand or clay.

The land has practically no agricultural value at present in this county, although a similar type of muck has been used with some success for special crops, pasture, and a few of the general farm crops in the southern part of the State. Where cleared the land produces fair pasture and is capable of producing a thriftier tree growth than other types of organic soils.

A small amount of muck, which really constitutes a separate type (Kerston muck), as it may contain as much as 50 per cent or more of mineral matter, is included with Lupton muck, particularly in areas adjacent to the larger streams which carry some sediment.

Greenwood peat.—Greenwood peat is fibrous or coarse-textured, loose or uncompacted, brown or yellow material which shows very little decomposition of the plant matter even at the surface. This type of peat is uniformly strongly acid in reaction. The water table is at or within a few inches of the surface, although in very dry periods it may sink to a foot or two. Much of the material is underlain by a watery substratum and is semifloating, and would be subject to great shrinkage in thickness if the land were drained.

Greenwood peat is characterized by open heath bogs of leatherleaf, Labrador-tea, blueberry, laurel, cranberry, cotton grass, and Sphagnum moss; in places there is a small dwarfed growth of tamarack and black spruce; and a few red and jack pines grow. Some of the more open land is marsh or meadow covered chiefly with sedges.

This highly acid soil occurs in widely distributed small bodies most of which are associated with the more sandy soils and less limy glacial-drift soils. It represents the sites of small lakes which have been filled in by the accumulated remains of vegetation, and also occurs in larger bodies as recent accumulations on poorly drained sandy flats. The land has no agricultural worth except the remote possibility of use for growing such crops as blueberries and cranberries. The Sphagnum moss and blueberries which the bogs yield under natural conditions may have some present or possible future value, but the tree growth is of practically no value.

Houghton muck.—Houghton muck consists of dark-brown or nearly black finely fibrous plant remains which are loose or not compact, nearly neutral or moderately acid, and contain very little admixed mineral matter. The underlying material may be black, fine in texture, and pasty or cheeselike. The water table under natural conditions is very near the surface. The plant matter of this type of muck is somewhat less loamy and decomposed at the surface than that of Lupton muck, and the material is less strongly acid, more altered, and finer in texture than Greenwood peat. The total acreage of Houghton muck is small, and the small bodies are widely scattered through the county. The natural vegetation is of a marsh type, consisting dominantly of wire grass (*Carex filiformis*), bluejoint grass, and in places a few stunted alder, willow, and aspen.

The land has no agricultural value at present, but may have some value as breeding and feeding grounds for muskrats and birds.

CLASSIFICATION AND ORIGIN OF THE SOILS

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

The mineral soils comprise 88.3 per cent of the total land area, and the organic soils 10.7 per cent; water surface, or water soils, comprise about 1 per cent, and barren rock soils are practically negligible in extent.

The mineral soils are grouped in two major taxonomic divisions, based on the average amount of water in the solum, as follows: (1) A division including soils containing the normal moisture for the region, which is equivalent to a division of well-drained soils; and (2) a division in which free water exists permanently, or for considerable periods, to the point of complete soil saturation and water logging. The first division is estimated as occupying about 89 per cent of the total mineral soil area, and the second about 11 per cent.

The group of well-drained mineral soils which have completely developed profiles are podsolic, though true podsols cover a small part of the area. They are all podsolic in that leaching and the translocation of sesquioxides, particularly the removal of calcium and magnesium carbonates, are dominant in the soil-forming processes. Some of the soils are transitional in character, for example, Roselawn sand and Roselawn sandy loam, but none is exactly comparable to the soils of the extreme southern part of Michigan or to the soils of the forested region of central-eastern United States, which comprise the group of gray-brown forested soils of the United States.

A description of the generalized profile for the virgin soil of normal moisture content and of mature soil profile in northern Michigan follows: (1) An accumulation of litter and acid peaty forest mold; (2) a very thin humous soil layer; (3) a highly leached gray layer; (4) a layer marked by an accumulation of brown or yellow humic and iron oxide colloidal matter; (5) a layer of maximum clay content; and (6) the parent material or geologic substratum.

This group is represented by three subgroups differentiated on the basis of the texture and consistence of the successive layers in the profile, or soil section, as follows: (1) A subgroup of soils underlain by clay, comparatively dense and impervious in layers 4, 5, and 6 of the generalized profile given above; (2) a subgroup of soils underlain by sand and gravel or comparatively loose and pervious material in layers 4, 5, and 6; and (3) a subgroup of soils having more clay colloid material in layers 4 or 5, whereas layer 6 is less clayey and more pervious.

These groups are still further differentiated into soil series and types, which are described in preceding and succeeding pages of this report, on the bases of differences in color, texture, structure, chemical characteristics, and thickness of the various layers.

Layer 3, representing the layer of maximum eluviation, and layer 4, the layer of humic coloring, are the outstanding features of the complete profile. It appears that these layers reach their maximum development in thickness, intensity of coloring, and removal of inorganic colloids where the parent material is sandy, and under condi-

tions of moderately high average moisture; whereas the minimum development occurs where the parent material is comparatively impervious clay or very dry sand and gravel. The normal thickness of layer 3, the gray highly eluviated layer, is from 4 to 8 inches, but under exceptional conditions may be from 18 to 24 inches. The thickness of the brown, or humic, layer (layer 4) is commonly from 6 to 12 inches, and the maximum is 36 inches, although the base of this layer is not sharply marked especially where the parent material is loose sand; also, under certain conditions, layers 4 and 5 coalesce as a single layer, in which the maximum intensity of humic coloring is ordinarily at the top of the layer. Field observations tend to indicate that the darkest-brown or umber color occurs where the sand or gravel contains the largest amounts of calcium carbonate or magnesium carbonate, although it is apparent that a certain moisture condition is the dominant or controlling factor. The maximum content of iron oxide and maximum cementation in this layer appear to exist in soils like the Saugatuck, where there is frequent saturation and a high water table, also a wide range or fluctuation in the amount of water throughout the year.

The thickness of surficial litter and mold under an old forest and under conditions of good drainage is normally from 3 to 4 inches. It increases as moisture conditions approach those of swamp, whereas at the other extreme there is little more than 1 inch of fluffy sandy mold as on Grayling sand on the driest sand plains. True humous soil, such as occurs in soils of the subhumid prairie region of the United States and in some of the gray-brown forested soils of the central and eastern parts, is absent or is developed only as a very thin layer. The greatest amount of humus is present, other conditions being the same or similar, where the parent material is most limy or basic and the moisture comparatively high but not to the point of saturation.

Layer 5 is weakly developed and shows no evidence either of marked clay concentration or of intense coloring by ferric oxides developed in the soil-forming processes. A layer containing a higher proportion of clay or colloids than the parent material is less evident than in the southern part of the southern peninsula of Michigan and notably less than in the central and southern parts of the United States. The development of such a layer in northern Michigan is most noticeable in coarse gravelly calcareous material. Only a slight intensification of ferric oxide coloring over that of the parent material occurs in the heavy clay.

The depth to which carbonates have been removed in the soil-forming processes is in general from 30 to 48 inches, but varies, of course, with the amount originally present, the texture of the parent material, the surface configuration, and the age of the soil. In dense clays complete removal has taken place to a depth ranging from 18 to 30 inches, whereas in some sands there appears to have been complete removal to a depth of 5 or 6 feet. In some other soils, in which the parent material consists predominantly of sand, gravel, cobbles, and bowlders, 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 also present in appreciable amounts in layer 4. Where the parent material is friable sandy clay drift and a compact layer 5 is developed, a secondary leached layer, between layers 4 and 5, is present. The thickness of the solum is generally from 30 to 40 inches and so far as this is indicated by alteration or development of color due to weathering, it appears to be no thicker in the loose driest sands than in the densest most impervious clays.

The mineral soils developed under conditions of poor drainage or excessive moisture have the following generalized profile: (1) A comparatively thick dark-gray or black surface layer consisting in part of accumulated organic matter; (2) a gray or drab layer, not colored or but slightly colored by organic matter; (3) a layer containing a maximum amount of clay colloids 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, and this layer reaches its greatest 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, that is, where the parent material is the same. 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 shows 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, especially where there are alternately distinctly wet and comparatively dry conditions in layers 1 and 2.

Mineral soils with incompletely developed profiles are of minor occurrence in Kalkaska County, and are represented mainly by recent alluvium occurring in the valleys of the streams. Most of this material has a high average moisture content or occurs as swampy or semiswampy land. The alluvium is purely local in origin, and commonly contains a high proportion of organic matter, sufficient to mask the rock color at the surface. In many places the deposits consist of alternate layers of mineral alluvium and muck, in which the muck or peat is partly transported but mainly accumulated in place. Areas of colluvial sandy wash in dry valleys (Echo loamy sand), blow sands, beach deposits, and the wave-washed strand along lake shores, are of small extent in this county. Soils having incomplete profiles, due to erosion under natural conditions, also occur, but their total acreage is almost negligible.

The group of organic soils is represented by a number of types which range considerably in chemical and physical properties; both young and old soils are represented, although none of the soils appears to have developed quite so complete alteration or alteration to as great depths as these soils in the southern part of Michigan. Practically all are high in organic matter, that is, they contain 75 per cent or more of material combustible on ignition. The greater number and greater total area of deposits appear to have been accumulated in valleys or on permanently wet flats as land-laid deposits, rather than in lakes, although the lake-filled deposits are also represented. Deposits in general do not reach a great thickness, but in most places are more than 4 feet thick, and in places the lake-filled

deposits are more than 30 feet thick. Most of the thinner deposits are underlain by sand, and the deeper lake-filled deposits present the common sectional characteristics, and consist of pasty or gelatinous material from aquatic plants at the base, in many places an accumulation of marl resting on the mineral substratum, overlain by material representing successive stages of vegetation ranging from grass and sedge, through shrub, to forest.

More or less complete alteration, represented by almost black or dark-brown color and complete destruction of the botanical character of the plant remains, in the oldest deposits generally does not exceed 10 or 15 inches and there is practically no development of doppleritic muck, which is fine and cheeselike when wet and hard and horny when dry, although fine greenish-gray gelatinous material occurs at the base of some of the deposits. In the most acid peat type, Greenwood peat, there is practically no alteration, although there is a much greater range in fluctuation of the water table than in the darker-colored more woody and less acid types, such as Lupton muck and Rifle peat. A small part of the muck and peat is nearly neutral in reaction and comparatively high in lime, but the greater part is moderately acid or very strongly acid. In general, the most acid organic soils are associated with the sands and the least calcareous phases of the glacial deposits, but in a number of places the acidity seems to be dependent on the height of the water table and on the rawness or lack of decomposition of the plant matter, as the adjacent soils and drift may be limy and the drainage waters alkaline. The characteristics of organic soils like the characteristics of mineral soils are probably in the last analysis determined by the climate modified to greater or less extent by the influence of the geologic formations and the physiography of the region in which they occur. Thus it seems probable that the oldest organic soils in this region can not reach so complete a stage in decomposition as organic soils in regions farther south, and that the texture and consistence of the organic soils differ because of the differences in temperature and in the plant species composing the parent material.

In the classification and mapping of soils the lakes are largely of academic interest at present, but, nevertheless, justify some consideration as an economic factor, as they support vegetation which has a food or protective value for fishes, aquatic birds, and mammals; and in addition they have some possibilities for the production of feed for farm animals and for the production of certain plants otherwise useful to man. Thus considered the lakes, with their bottoms, may be regarded as consisting of three master layers as follows: (1) The surface layer which is the aqueous or liquid member; (2) the cumulose or sedimentary intermediate layer, consisting, for example, of an ooze or a soft gelatinous mobile mass of animal or plant remains, of peat, or of a soft penetrable mineral mass representing recent sedimentation or precipitation; and (3) the old geologic substratum. The lake materials thus can be subdivided most logically on the basis of physical and chemical differences which theoretically have a determining influence on the kind and character of plant growth. The chemical composition of the water, particularly whether acid, alkaline, or saline; the thickness or depth of the water covering; the chemical characteristics of layers 2 and 3, considered as to fertility; and their lithologic character and texture, whether

marl, peat, sand, clay, or hard rock, serve as bases for subdivision to whatever degree it may be practical to carry a classification. No attempt has been made in this survey to classify and show the distribution of the different types of lake materials on the map, although some facts of an observational nature can be stated.

The lake waters are generally clear or free from mineral matter in suspension, and are generally alkaline in reaction, due, very probably, to the presence of calcium and magnesium bicarbonates. Sand and peat bottoms are most common; marl occurs in a number of places, but probably is not so widely distributed as in the central-southern part of the State; and hard-rock bottoms are absent. Lake levels are comparatively uniform. In most of the bogs occupied by such plants as leatherleaf (*Cassandra*), blueberry, and Sphagnum moss, the standing water is acid in reaction and the coarsely fibrous or stringy underlying peat is highly acid. The stream waters are predominantly alkaline in reaction, and are clear, that is, they are generally free from suspended mineral sediment, but where issuing from or flowing through peat swamps, they commonly have a brown or straw-colored tint caused by suspended or dissolved organic matter. The bottoms of most of the stream channels are sand or peat. The streams have a moderately rapid flow after leaving their sources in swamps and lake basins and in general are not subject to rapid rises or fluctuations in level.

Common hydrophytic plants in Kalkaska County are white and yellow pond lilies, pondweed (*Potamogeton*), bladderwort, chara or musk grass, water milfoil, arrowhead, bogbean (buckbean), lake bulrush (*Scirpus*), cattails, and sedges (species of *Carex*).

All the soils which have been differentiated here occur in a gradational series according to the difference in the moisture or drainage conditions under which the soil has developed. This gradational character of soil types is universal, and under such conditions the limits established for each soil type must necessarily be arbitrary and each type must include soil of a transitional character.

In Kalkaska County a more or less complete moisture series can be recognized for each of the following classes or groups of parent material: (1) Moderately pervious stony and sandy friable clayey drift; (2) loose incoherent sand; (3) massive fine-grained compact clay; (4) sand over impervious clay; (5) pervious unconsolidated sand, gravel, and cobbles; and (6) peat. The degree to which alteration of the parent material has taken place under the different moisture ranges possible, is determined by the climatic conditions and the period of time during which soil-making processes have operated. In each of the parent-material groups listed there is a fairly wide range of moisture conditions and a corresponding range or gradation in chemical and physical differences which constitute the bases of differentiation of the soils into types. For example, where the parent material is sand, conditions may range from swamp, in which the sand is covered with muck or peat and bleached or mottled beneath (Newton loamy sand) to the driest materials, in which the mold and humus is extremely thin and dry and where little or no development of gray and brown layers or leaching of iron oxide color has taken place (Grayling sand).

A knowledge of the lithologic character and of the forms of the glacial deposits becomes important in the explanation of facts

regarding the chemical and physical character of the soils and their geographic distribution, and for speculation on their evolution. In this county, the drift contains the usual admixture of detritus from the rocks of the northern part of Michigan and from Canada, but perhaps less rock from purely local sources than in other parts of the State where the glacial deposits are much thinner. Here the covering of unconsolidated deposits over the old Paleozoic formations is from 300 to 600 feet thick.[6] However, there is an appreciable influence from limestone and shale from the Devonian formations underlying this and adjoining counties. This influence is strongest in the western part of the county and decreases eastward, consequently the soils as a whole are more basic in the western part than in the eastern, as may be inferred from the soil map in the greater acreage and restricted distributions of Emmet, Onaway, Mancelona, and Antrim soils. The glacial clays are moderately or highly calcareous, as is general in Michigan, and show only a slight red color which increases slightly in intensity eastward. Clays, however, are of small extent. The more arenaceous or coarser-textured drift is gray or yellow and covers a much greater area. Consequently there is less evidence of marked red color and shades of red than in some other parts of northern Michigan and a great predominance of sands and sandy loams over loams and clays.

The diversity of soils, their intimate association in many places in small bodies, and the textural gradation of one soil into another are traceable to the lithologic heterogeneity and range in texture of the parent soil material, to the variations in thickness of comparatively pervious material over comparatively impervious material, resulting in a wide range in moisture conditions. There is also a diversity in the surface configuration of the Pleistocene formations, such as moraines, outwash plains, till plains, old glacial drainage valleys, and glacial lake beds.

The surface formations were laid down during the last stages of the glacial period (the Wisconsin[7]), therefore the land surface configuration is comparatively young and is almost entirely constructional, as streams have not yet had time to develop complete dendritic systems, so that large areas remain flat or water covered, and a comparatively large aggregate of mineral soils has developed under conditions of excessive moisture, together with the accumulation of peat deposits. On the other hand, soils developed under conditions of low moisture have been possible because of the perviousness and thickness of some of the glacial deposits, notwithstanding the surface may be level. This is particularly true of the outwash plains. Various wet and dry conditions on the moraines are the result largely of differences in the texture of the glacial débris rather than the result of stream erosion or slope of the land surface, and the generally moister condition on the till plains is ascribed to the more clayey character of the underlying deposits and to the smoother, less rolling relief.

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[6] LANE, A. C. [MAP SHOWING] GEOLOGICAL FORMATIONS AND ROCK SURFACE OF THE SOUTHERN PENINSULA OF MICHIGAN. REVISED FROM STATE REPORTS AND UNPUBLISHED DATA. In Leverett, F., and others. Flowing Wells and Municipal Water Supplies in the Middle and Northern Portions of the Southern Peninsula of Michigan. U. S. Geol. Survey Water Supply and Irrig. Paper 183, map between pp. 8 and 9., 1906.

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

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 effect of soil differences. In this county the whole area, excepting the very small acreage of lake surface, marsh, and peat bog, was originally forested. Most of the forest cover was dense, even junglelike in some of the wetter situations, but on some of the drier areas, as the dry sand plains, there was a comparatively open growth of pines with a shrub and herbaceous undergrowth. The woody character of the surface accumulation of organic matter, the thinness of the humous soil, and the underlying gray and brown layers, if not wholly, at least in part, are attributable to the forest vegetation. Any constant relationship of thickness or intensity of coloring of layers to a particular type of forest vegetation is not apparent, but the texture of the soil material and the average moisture content seem to be the dominant controlling factors. Equally strong or equally weak development of the various layers occur under all the different types of forest other than the swamp type and the dry pinelands type. The composition, textures, and other physical properties of the organic soils are clearly related to the kind of vegetation growing on these soils; and on the dry sand soils, such as Rubicon, Grayling, and Roselawn sands, the grasses and other 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. Influence from types of vegetation which preceded the present may be assumed although too little is known about the plant successions and histology, as shown in the soil profile, to venture a statement as to the specific character of such influences, except in the peat deposits.

The progressive changes in the present soil profile are probably toward continued leaching and, therefore, toward an increase in the thickness of the eluviated solum. In some of the sandy soils, the leaching process, resulting in the development of a gray layer beneath the forest mold, is as nearly complete as possible, at least in thickness, so that uninterrupted leaching would result in increment to the brown humic layer and further eluviation of the deeper layers. In the sandy clay material, the present processes if 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 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.

There is a suggestion of retrogression in profiles 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, as, for example, in Wallace fine sand. There is also, in a number of places, evidence of a rise in the water table through continuous accumulation of water on flats and seepage slopes, and the accumulation of peat, with a consequent change in the profile of bordering soils which were at one time comparatively dry. As evidence of this, some of the larger swamps contain numerous low islands of dry sand; and the presence of jack pine on peat and wet

mineral soils, such as the Newton and Saugatuck soils, might be considered indicative of a former drier condition. On the other hand, there is evidence of a general physiographic change because of accentuated stream cutting, resulting in the lowering of the water table in wet flats and peat swamps and consequent changes in soil, owing to land elevation and tilting.

In a glaciated region, such as the southern peninsula of Michigan, where there is a comparatively thick covering of glacial drift from a variety of sources, with a diversity of topographic forms and drainage conditions, without, however, any relief features of magnitude and no sharply separated physoiographic divisions, a blending or intergradation of soil types and also of the larger groups of soils would be predicted from these basic facts and from the postulations of pedology. A complete range exists in size of soil particles from the finest measurable to stones; in soil of a given texture, the amount of moisture is constantly gradational from a saturated or water-logged condition to the dryness of the jack-pine sand plains; a wide range exists in the quantity of the separate elements and in the quantity of a particular compound, for example, calcium carbonate; and, finally, the degree of profile development ranges from practically no change in the parent material to the most maturely developed soil profile of the region. It follows, therefore, that in practice the permissible range or latitude in texture, moisture content, composition, and thickness, or their tangible expressions, must to some degree be arbitrary. From the nature of things, the soil type, the unit of soil mapping, as at present defined, is not permanently fixed but rather is empirical and is designed to meet the present needs of a soil classification.

The various soils differentiated in this county, taxonomically considered, are discussed in the following paragraphs.

Soils of the Roselawn series consist of yellow sand and light sandy loam to a depth of more than 3 feet, underlain by a heterogeneous substratum of sandy drift. These soils in Kalkaska County present some divergence from the Roselawn soils of the western part of the northern peninsula of Michigan in that the gray or leached layer is less strongly developed, less red iron oxide coloring appears, and the parent drift contains more limestone. With increase in the lime content, these soils grade imperceptibly into the Blue Lake and Emmet soils and with increase in the clay content, into the Nester soils (mapped in Crawford County). They are essentially sandy in texture, strongly acid in the solum, and contain a low amount of limestone in the C horizon.

The Grayling soils are essentially sands, both in the solum and in the C horizon, yellow in color, low in moisture, strongly acid in the solum, and have only a very small amount of limestone in the parent drift. The gray and brown layers are weakly developed. The soils of the Grayling, Rubicon, Saugatuck, and Newton series constitute a moisture series differing in degree of development of the gray and brown layers, the amount of surface organic matter, and the degree of bleaching or leaching, but grading into each other imperceptibly. All are sands in texture, and all are low in lime or strongly acid. Maximum eluviation in the gray layer and maximum cementation and thickness in the brown layer appear in the Saugatuck soils, and the maximum accumulation of organic matter on the

surface occurs in the Newton soils. In the Newton soils the underlying sand is pale or bleached, due to permanent water logging, and the brown layer, represented by pale-yellow or smoke-colored sand, is only feebly developed.

Soils of the Selkirk series are essentially clay in texture with only a very small quantity of particles of sand size; the clay is calcareous or basic in reaction. The Selkirk soils differ from the Ontonagon soils of the northern peninsula in that the clay is not so red but is rather chocolate color or faded red, and it loses its red tint almost entirely when dry. It is a transitional soil between the Nappanee and Kent soils of the southern part of the State and the Ontonagon soils of the northern part. The Selkirk soils grade into the Onaway soils, which are widely distributed in the lake-shore counties to the northwest and northeast and in the eastern half of the northern peninsula.

The Emmet and Mancelona, the Blue Lake and Kalkaska, the Roselawn, Grayling, and Rubicon soils constitute a series of sandy and gravelly soils, arranged according to the amount of limestone in the parent material and the degree of acidity, the first containing the highest amount of limestone and the least total acidity. The difference between Blue Lake loamy sand and Roselawn sand is in the darker shade of color and higher proportion of colloids in the brown layer of the Blue Lake soil; the difference between the Kalkaska soils and the Grayling and Rubicon soils likewise lies mainly in the darker shade of color and greater loaminess of the brown layer of the Kalkaska soils and also the greater accumulation of organic matter on the surface.

The Bergland soils are underlain by a clay substratum the same as, or similar to, that underlying Selkirk loam, but the Bergland soils have developed under poor drainage. These soils are nearly neutral or alkaline in reaction throughout the solum. The Ogemaw soils have a thin covering of sand over clay, and have developed under moderately poor drainage. The appearance of the sandy layers of the Ogemaw soils is similar to that of the Saugatuck soils.

The Griffin soils comprise recent stream alluvium, gray or light brown in color, with a variable amount of yellow or rust-colored spotting and streaking. The primary basis of differentiation is the high average moisture content, to the point of saturation, at a slight depth. There is consequently a wide range in texture, in organic matter, and in mineral composition.

The Echo soils comprise recent wash from adjacent slopes or alluvium which has not been transported for a considerable distance. Locally the material is less variable in texture than the Griffin soils.

The organic soils (muck and peat) include four types or classes of material. Lupton muck includes the older, darker, more decomposed, and loamy muck, which is generally nearly neutral in reaction and is underlain by deposits of peat more than 4 feet thick. Greenwood peat includes the raw, undecomposed, coarse-textured, yellow or brown highly acid organic soil materials, which generally support a heath-bog type of vegetation. Rifle peat occupies an intermediate position between Lupton muck and Greenwood peat in physical and chemical characteristics and depth of water table. Houghton muck includes brown, dark-brown, or black, coarse-textured, fibrous or stringy muck.

The study of the natural vegetation in relation to soil types has a purely scientific interest as a part of soil science and ecology, a significance in relation to problems of forestry and silviculture, and may have considerable value in the reconstruction of the original vegetal cover in detail. It has a direct application to agriculture in a region like this, because the vegetation can be used as a criterion, within certain evident limitations, of the agricultural value of the land and its crop adaptation; and, further, it has a bearing on the cost and methods to be followed for the reclamation of cut-over land, inasmuch as the kind of stumps on the land and the present growth are known or may be inferred. The relation of soils and natural vegetation in this county, based on observational and qualitative studies, is presented in Table 5.

TABLE 5.—*Correlation of soil with natural vegetation in Kalkaska County, Mich.*

Soil type	Characteristics	Original and present vegetation
Onaway sandy loam	Loam and sandy loam, underlain by medium-textured alkaline glacial drift at a slight depth; fertile and durable well-drained soil.	Dense stand of hardwoods, principally hard maple, beech, elm, basswood, ash, yellow birch, and scattered hemlock; original forest almost entirely removed; small wood lots of hard maple and beech; land mostly in farms, part in stump-land pasture, with good growth of natural and introduced forage plants.
Emmet sand and Emmet sandy loam.	Deep, penetrable sandy soils; fair moisture retention; slightly to moderately acid; fair content of calcium and other bases; strongly developed brown layer in the sand.	Dense stand of hard maple, beech, elm, yellow birch, hemlock, white pine; stumps on old cut-over land mainly white pine and hemlock; heavy growth of grasses and briers on open stump land; hard maple chief species in second growth; growth of aspen, cherry where land is most severely burned over.
Mancelona gravelly sandy loam.	Sandy loam and loam, gravelly or cobbly, underlain by brown loamy or clayey layer, and coarse gravelly substratum; alkaline or not highly acid; level land, moderately productive; moisture low to medium.	Hard maple, beech, elm, yellow birch, hemlock, and white pine; white pine and hemlock stumps on old cut-over land; good growth of grasses on open stump land; second growth mainly hard maple.
Rubicon sand	Very thin organic layer; dry; strongly acid sandy soil; low fertility; level land.	White and red (Norway) pine, mainly conifers of fairly large growth; hardwoods only poor growth; cut-over land thickly set with pine stumps; second growth principally aspen and small oaks; sweetfern, bracken, and blueberry common; bluegrass and wild oat grass principal grasses.
Saugatuck sand	Dark sandy surface soil; brown sand at a slight depth, and in places a hardpan; highly acid; low to medium fertility; generally poor drainage; fluctuates from saturated to very dry in surface gray sand.	White pine abundant with variable quantity of red pine, arborvitæ, spruce, balsam fir, aspen, red maple, yellow birch, ash, and elm in the original cover; very large pine stumps on cut-over land; second growth mainly aspen, with variable quantity of conifers, bracken, blueberries, and wintergreen.
Antrim sandy loam	Dark sandy soil underlain by sandy gravelly loam or by clay at a greater depth; fair moisture; not highly acid; moderately productive; level or gently sloping land in valleys and on benches.	Mainly beech, hard maple, basswood, elm, and ash, with variable quantity of white pine and hemlock; cut-over land thickly set with stumps; second growth mainly hard maple.
Eastport sand	Loose sand, dry to moist; not highly leached since deposition.	Mixed growth of hardwoods and conifers; present cover mainly oaks, red pine, and white birch.
Newton loamy sand.	Dark-colored sandy surface soil, or thin mucky covering over sand; high moisture; fertility mainly in organic matter at surface; water table generally at a depth ranging from 1 to 2 feet.	White pine, spruce, fir, cedar, white birch, aspen, red maple, hemlock, yellow birch; present growth dense cover of aspen, willow, alder, with remnants of the original forest.
Bergland loam and Bergland clay loam.	Dark soils at the surface comparatively high in organic matter, in part underlain by clay; alkaline or only slightly acid; fertile; poor drainage; shallow wet swales and valleys; level land along borders of lakes and swamps.	Arborvitæ, white spruce, fir, and aspen with some elm, ash, maple, white pine, hemlock, and basswood; fair second growth and remnants of original forest; in places, aspen, alder, willow, or open meadowland grasses, sedges, cattail, iris, and rush (*Juncus*).

TABLE 5.—*Correlation of soil with natural vegetation in Kalkaska County, Mich.*—Continued

Soil type	Characteristics	Original and present vegetation
Kalkaska loamy sand and Kalkaska sandy loam.	Comparatively dry sands, characterized by a moderate thickness of mold and humus and a well-marked brown layer of loamy sand or sandy loam; appreciable amount of limestone and shale in the substratum; acid soil.	Virgin forest chiefly hard maple, beech, yellow birch, elm, and hemlock, with a few scattered white pine; second growth chiefly maple and elm; on the more severely burned-over land aspen, cherry, red maple, and a few scattered oaks; fairly heavy cover of grasses, briers, and bracken.
Blue Lake loamy sand.	Comparatively dry sand characterized by a well-marked brown subsurface layer of loamy sand; deep substratum sand, gravel, clay, and bowlders; acid soil.	Virgin forest hard maple, beech, yellow birch, elm, and hemlock, with a few scattered white pine; second growth mainly maple and elm; old cut-over land scattered to moderately thick growth of aspen, red maple, cherry, and a few oaks; heavy growth of grasses and briers.
Roselawn sand	Yellow dry acid sand; deep substratum mainly sand but with some gravel, bowlders, and clay; thin covering of humus or forest mold.	Original forest dominantly red pine, with smaller proportion of white pine and clumps of hardwoods; present growth on burned-over land, sprout growth of scarlet, jack, white, and red oaks, aspen, red maple, and a few old red pine; ground cover of sweetfern, bracken, blueberries, and grasses.
Roselawn sandy loam.	Light sandy loam and sand over friable sand clay mixture; acid soil, low in lime; medium moisture; low to medium fertility.	Original forest of hard maple, beech, elm, yellow birch, hemlock, scattered white and red pine; present growth, remnants of the hardwoods and fair growth of red, white, and scarlet oaks, and aspen.
Grayling sand	Yellow excessively dry acid sand; very thin or no covering of organic matter; low fertility.	Original cover open growth of red pine, jack pine, oaks, blueberries, sweetfern, grasses, sedge; present growth jack pine scattered and in thickets; a few red pine, scattered oaks, small aspen, blueberries, sweetfern, bracken, mosses, lichen, bluegrass, oat grass, bluestem, and weeds.
Ogemaw sandy loam.	Thin cover of moist sand over clay; fair organic matter; medium fertility; sand, acid; clay, limy or alkaline.	Original cover, mixed conifer-hardwood, white pine, white spruce, black spruce, fir, cedar, hemlock, elm, ash, basswood, yellow birch, beech; present cover, aspen, alder, willow, and variable amount of original species.
Selkirk loam	Thin layer of gray and yellow silt loam or fine sandy loam over plastic clay; high average moisture; cold soil; medium fertility.	Original cover, mixed conifer-hardwood, elm, ash, basswood, yellow birch, aspen, white pine, white spruce, balsam fir; present cover, dense growth of aspen and fair second growth of original species.
Barker loam	Gray silty loam over buff, yellow, or chocolate-colored plastic clay; high in lime; medium to high fertility.	Original cover, maple, beech, elm, ash, basswood, yellow birch, cedar; present cover, aspen and second growth of original species.
Griffin sandy loam and Griffin silty clay loam.	Loam or sandy loam, mainly alluvial, in stream valleys; variable texturally; not highly acid; fair to poor drainage; moderately fertile; high organic matter.	Mixed growth of elm, ash, balm-of-Gilead poplar, aspen, red maple, white pine, hemlock, arborvitae, spruce, balsam fir, tamarack; alder and willow on stream banks.
Lupton muck	Dark loamy decomposed high-lime muck; deep or underlain at a slight depth by clay or by marl; water table from 1 to 3 feet below the surface.	Conifer swamp; intermingled white pine, hemlock, ash, elm, red maple, basswood, and aspen; white pine and arborvitae attain large size; dense growth; very little herbaceous growth; cedar, white pine, hemlock, and basswood have been largely removed in logging operations.
Rifle peat	Brown coarse loamy or woody peaty material underlain at a slight depth by fibrous or less thoroughly decomposed peaty material; nearly neutral to strongly acid; water table from 1 to 2 feet below the surface.	Swamp with dense growth of conifers, arborvitae, tamarack, black spruce; sedges, leatherleaf, and blueberries in undergrowth; a large part of the arborvitae (white cedar) has been removed in logging operations.
Greenwood peat	Brown peat, fibrous, spongy or felt-like; very slightly decomposed; highly acid; water table at or very near the surface.	Principally grown up with heath shrubs such as leatherleaf, Labrador-tea, and blueberries, a variety of sedges, stunted tamarack, and black spruce trees; Sphagnum moss common.
Houghton muck	Fine-textured brown muck or peat, more or less permanently water covered.	Marsh, sedges (*Carex* sp.) dominant, stunted aspen, willow, and scattered tamarack.

SUMMARY

Kalkaska County is situated in the northwestern part of the southern peninsula of Michigan. The area is 559 square miles, or 357,760 acres.

The surface features are of glacial origin and consist of level sandy plains, low hills and ridges, and plateaulike uplands. The slopes are long and smooth and the valleys broad and shallow. Lakes and swamps are widely distributed. The elevation above sea level ranges from about 600 to 1,300 feet.

It is estimated that about 70 per cent of the total area of the county is naturally well drained or dry, and that about 30 per cent is poorly drained or swampy.

The area was originally densely forested with hardwoods, white and red (Norway) pines, and in the swamps white cedar, spruce, fir, and tamarack.

The population of the county in 1920 was 5,577, but it has decreased considerably since that time. Agriculture and lumbering are the principal industries.

Transportation facilities are afforded by a line of the Pennsylvania Railroad system and by State trunk-line highways.

The main features of the climate are an average precipitation of about 30 inches annually, including nearly 75 inches of snowfall; and a mean annual temperature of about 43.1° F. The winters are very cold and long and the summers short and mild. The growing season is short but is generally sufficient for the growth and maturity of potatoes, small grains, and hay.

Settlement of the county began about 1860, but farming remained subordinate to lumbering while the virgin forests were being cut, and subsequently only a small part of the cut-over land has been cleared for agricultural purposes. The present farming consists mainly in the growing of hay, oats, and potatoes, with dairying as an adjunct. Potatoes and milk are the chief sources of cash income. The amount of land in cultivation on individual farms is small, but farming is not intensive and yields are low or only moderate. Land is low in price.

The soils are diverse in physical and chemical characteristics, but the greater part are sands and sandy loams of low to medium fertility.

Practically none of the land is so rough or so excessively stony as to be nonarable, although about 20 per cent is swampy or poorly drained. The greater part is in small second-growth trees and stumps.

The more productive sandy loam soil is classified as Emmet sandy loam and occupies moderately rolling hardwood upland. Kalkaska loamy sand and Kalkaska sandy loam are the more extensive soils on the hardwood plains. These soils are easily tilled and are capable of producing moderate yields. The more extensive soils on the pine plains are Grayling and Rubicon sands. These soils are excessively dry and low in fertility. Most of the sands on the pine and oak hills are Roselawn sand and Roselawn sandy loam, and on the hardwood hills Emmet sand and Blue Lake loamy sand. The peat and

muck soils cover 10.7 per cent of the total area of the county. They have very little or no agricultural value at the present time.

The well-drained soils having mature profiles are podsolic in character. Textural and chemical variations are closely related to the lithologic variations in and forms of glacial deposits which cover this region. These deposits are from 300 to 600 feet thick; comprise sands, clays, and gravel; and are represented by moraines, till plains, outwash plains, and old lake beds. The soils developed from these deposits in the western part of the county show some influence from limestone and shale rock, but this influence diminishes eastward with a corresponding difference in the soils. The mineral soils developed under swampy or wet conditions constitute about 10 per cent of the total area. Alluvial soils are not extensively represented as the land surface is comparatively young and streams have not yet had time to develop wide flood plains. Inland waters, which together with the subaqueous or solid material, support vegetation and in a comprehensive sense are properly soils, constitute about 1.5 per cent of the total area. The waters are generally alkaline in reaction. The bottom or solid part of the lake beds is peat, marl, clay, or sand.

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[PUBLIC RESOLUTION—No. 9]

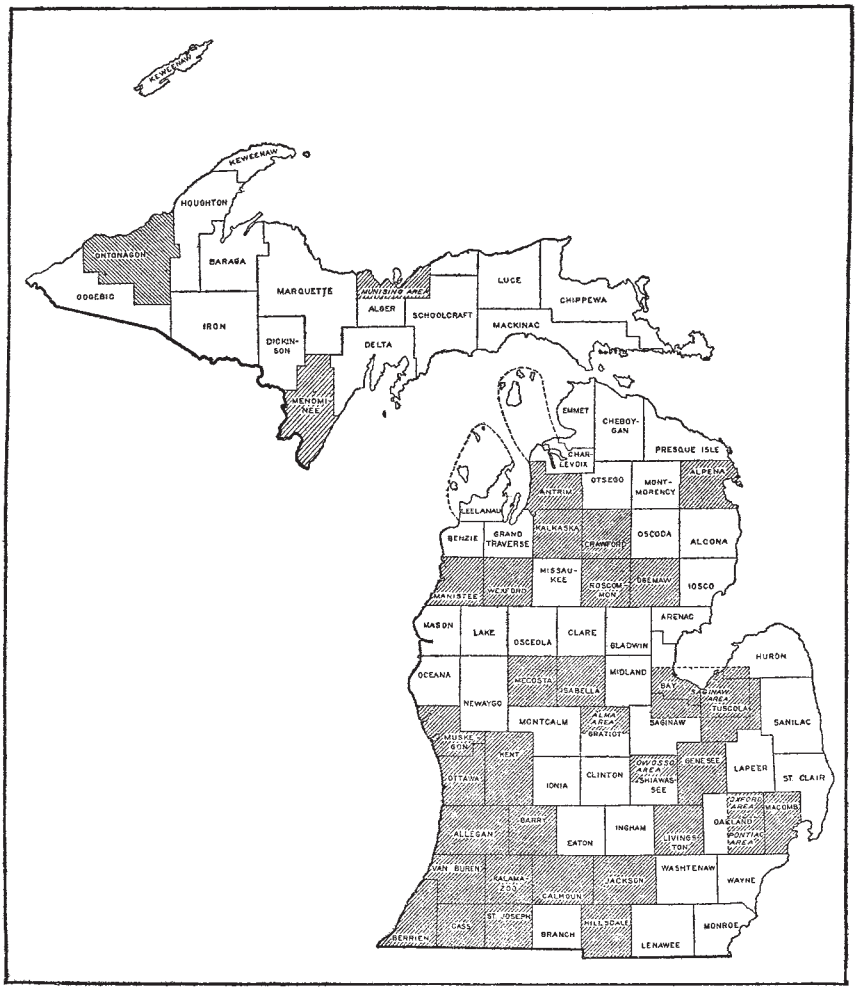
JOINT RESOLUTION Amending public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, "providing for the printing annually of the report on field operations of the Division of Soils, Department of Agriculture."

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, be amended by striking out all after the resolving clause and inserting in lieu thereof the following:

That there shall be printed ten thousand five hundred copies of the report on field operations of the Division of Soils, Department of Agriculture, of which one thousand five hundred copies shall be for the use of the Senate, three thousand copies for the use of the House of Representatives, and six thousand copies for the use of the Department of Agriculture: *Provided,* That in addition to the number of copies above provided for there shall be printed, as soon as the manuscript can be prepared, with the necessary maps and illustrations to accompany it, a report on each area surveyed, in the form of advance sheets, bound in paper covers, of which five hundred copies shall be for the use of each Senator from the State, two thousand copies for the use of each Representative for the congressional district or districts in which the survey is made, and one thousand copies for the use of the Department of Agriculture.

Approved, March 14, 1904.

[On July 1, 1901, the Division of Soils was reorganized as the Bureau of Soils, and on July 1, 1927, the Bureau of Soils became a unit of the Bureau of Chemistry and Soils.]



Areas surveyed in Michigan, shown by shading

U. S. GOVERNMENT PRINTING OFFICE: 1931

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