MICHIGAN ACADEMY OF SCIENCE, ARTS AND LETTERS

VOLUME XXVI (1940)

CONTAINING PAPERS SUBMITTED AT THE ANNUAL MEETING IN 1940

VOLUME XXVI CONSISTS OF FOUR PARTS:

PART I: BOTANY AND FORESTRY

PART II: ZOOLOGY

PART III: GEOGRAPHY AND GEOLOGY

PART IV: GENERAL SECTION

ANTHROPOLOGY, ECONOMICS
LANGUAGE AND LITERATURE

The annual volumes of Papers of the Michigan Academy of Science, Arts and Letters are issued under the joint direction of the Council of the Academy and of the Executive Board of the Graduate School of the University of Michigan. The editor for the Academy is William C. Steere; for the University, Eugene S. McCartney. Dr. Mischa Titiev served as acting editor for the Academy in 1940.

Previous publications of The Michigan Academy of Science now known as The Michigan Academy of Science, Arts and Letters, were issued under the title, Annual Report of the Michigan Academy of Science. Twenty-two volumes were published, of which those numbered 1, 7, 21 and 22 are out of print. Copies of the other volumes are still available for distribution and will be sent on exchange so long as the editions last. Applications for copies should be made to the University of Michigan Press.

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PAPERS OF THE MICHIGAN ACADEMY OF SCIENCE ARTS AND LETTERS

EDITORS

EUGENE S. MCCARTNEY

MISCHA TITIEV

VOLUME XXVI (1940)
IN FOUR PARTS

"Pusilla res mundus est nisi in illo
quod quaerat omnis mundus habeat."
—SENECA, *Naturales Quaestiones*

ANN ARBOR: THE UNIVERSITY OF MICHIGAN PRESS
LONDON: HUMPHREY MILFORD, OXFORD UNIVERSITY PRESS
1941

Set up and printed,
February, 1941
Published March, 1941

PRINTED IN THE UNITED STATES OF AMERICA
BY THE PLIMPTON PRESS · NORWOOD · MASS.

OFFICERS FOR 1940

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A LIMNOLOGICAL INVESTIGATION OF A PERMANENTLY STRATIFIED LAKE IN THE HURON MOUNTAIN REGION OF NORTHERN MICHIGAN*

LLOYD L. SMITH, JR.

DURING the progress of a fisheries investigation on the waters of the Huron Mountain Club in Marquette County, Michigan, observations were made on an uncommon type of lake. The physical and chemical conditions existing at all seasons of the year indicate permanent stratification, with an incomplete vernal and autumnal overturn. References in the literature to similar American bodies of water are few. Eggleton (1931) gave some evidence that Kirkville Green Lake in New York State may be stagnant or, at least, that permanent stagnation is possible. The physiography of its basin and certain characteristics in the distribution of its bottom fauna point to this conclusion. Welch (1935) mentioned small lakes which show physiographic characters indicating incomplete overturn. Ruttner (1931) discussed similar conditions in a tropical lake. Findenegg (1933, 1937) reported on lakes in central Europe that had incomplete overturn and permanent chemical stratification. Yoshimura (1937) investigated several lakes in Japan with permanent stagnation and lists a group of similar lakes in various parts of the world.

The author wishes to thank Messers Charles H. Hodges, Jr., and Wetmore Hodges, who have made the study possible by their financial support; the management and membership of the Huron Mountain Club for cooperation in the field work; Drs. Carl L. Hubbs and Paul S. Welch for their helpful suggestions and criticism of the manuscript; and Mr. J. P. Harris for assistance in laboratory examinations.

PHYSIOGRAPHY

Canyon Lake is at the western end of an old range of pre-Cambrian granite hills lying adjacent to the southern shore of Lake Superior. The region was covered by the Wisconsin ice sheet, which scoured off the peaks and left rounded knobs that rise 1,000 feet above the present level of the Great Lakes. During the Algonquin stage of the last glaciation the waters impounded by the retreating ice completely covered the basin of Canyon Lake. With the subsequent recession of the waters this lake was isolated, and it now lies 233 feet above the present level of Lake Superior (Scott, 1921; Leverett, 1929).

Geologically the lake belongs to a type infrequent in Michigan. According to Scott (1921), it is a fault lake lying in a depression created by vertical displacement of the rock strata and subsequently dammed with morainic material. The basin is long and narrow, and covers an area of slightly more than ten acres (Fig. 1). Sheer crystalline rock cliffs rise out of the water to a height of 50 feet and form most of the lateral margins. Near the southeast end these walls recede from the water and give place to a swamp which blocks the overflow from the lake. Maximum depth of 22.5 meters is attained near the north end of the lake. As Figure 1 indicates, the shoal area is limited to a small region at the shallow end. All other shores plunge off almost vertically into deep water.

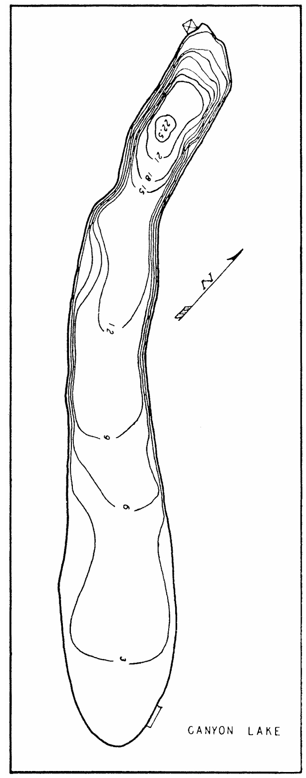

FIG. 1. A contour map of Canyon Lake in the Huron Mountains, Marquette County, Michigan. Contour lines are at 3-meter intervals

The watershed is small and for the most part is composed of granite rock overlain with a thin glacial soil. Except on the bare rock surfaces the area supports a hemlock-hardwood forest. The precipitous banks of the lake give foothold to a few white cedars and pines. Bottom soils are composed more or less uniformly of a grayish green pulpy peat containing much organic detritus from the surrounding forest floor. Submerged aquatic vegetation is sparse and restricted to the first three meters of shoal water at the shallow end.

The high banks and the surrounding hills almost eliminate wave action during the open-water season. An ice sheet formed in late November and remaining until early May closes the lake during the winter months. The ice reaches a thickness of 18 to 24 inches and is covered with 1 to 3 feet of snow.

METHODS AND PROCEDURE

Ten series of observations over a period of two years were taken on Canyon Lake to secure data for all the limnological seasons. A maximum-minimum thermometer was used for all temperature determinations. Dissolved oxygen, total alkalinity, free CO_2 and pH determinations were made in accordance with the procedure outlined in *Standard Methods for the Examination of Water and Sewage* (1933). Ten-liter samples of water from various depths were secured with a two-liter Kemmerer-Juday water bottle and were poured through a no. 25 bolting-silk plankton net to remove free-floating forms. The concentrated plankton was preserved in a 10 per cent formalin solution. Samples of the bottom soil, taken with a 6 x 6-inch Eckman dredge, were mixed with clean water and sieved through no. 40 brass screens, and the concentrated bottom organisms and detritus were preserved in a 10 per cent formalin solution. The minnow population was sampled with a net 6 feet in diameter operated from a boat. The larger species of fish were sampled with experimental gill nets, which ranged from ¾- to 2-inch bar mesh. Inaccessibility of the lake during the winter months limited the observations at that season to chemical analyses.

PHYSICOCHEMICAL CHARACTERISTICS

1. Temperature

Surface temperatures in Canyon Lake vary directly with the air temperature and follow it more closely than they do in the larger adjacent bodies of water. As will be pointed out later, the shallow dept of the epilimnion accounts for this rapid response. Below 8 meters the temperature remains constant at 4.4°C. at all seasons. A thermocline, which may be formed as early as the middle of May (Fig. 2), persists until late September or early October. Its upper limits lie between 2 and 3 meters; the lower ones, between 6 and 8 meters. It is formed near the surface as a relatively thin layer (Fig. 2), but with the advance of summer it gradually increases in thickness by depression of the lower limit (Fig. 3). During the hottest part of the year the thermocline, strictly defined, starts almost at the surface (Fig. 4). The rapid decline of temperature near the surface virtually eliminates the epilimnion and prevents circulation of the surface water. With the cooling of the surface waters in the fall the thermocline becomes less distinct and finally disappears, which allows some degree of circulation in the upper waters (Figs. 5-6). The clarity of the water and the restricted area of the basin would normally cause higher surface temperatures and a lower position of the thermocline, but the abrupt and closely approximated walls of the lake shade the waters except for a short time during midday.

Aside from the shallow position of the thermocline there is nothing particularly significant about the temperature phenomena. The thermal characteristics, however, are the only physiochemical factors which vary normally with the change of the seasons. Unusual chemical conditions exist throughout the year and give strong indication of permanent water stratification.

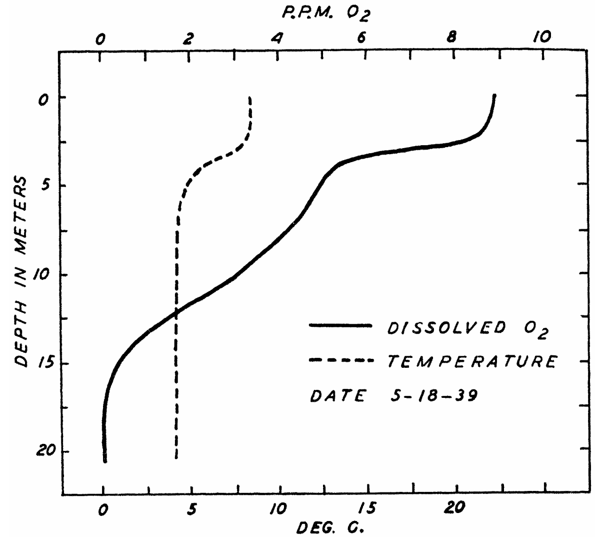

FIG. 2. Temperature and dissolved oxygen concentration from surface to a depth of 22 meters on May 18, 1939

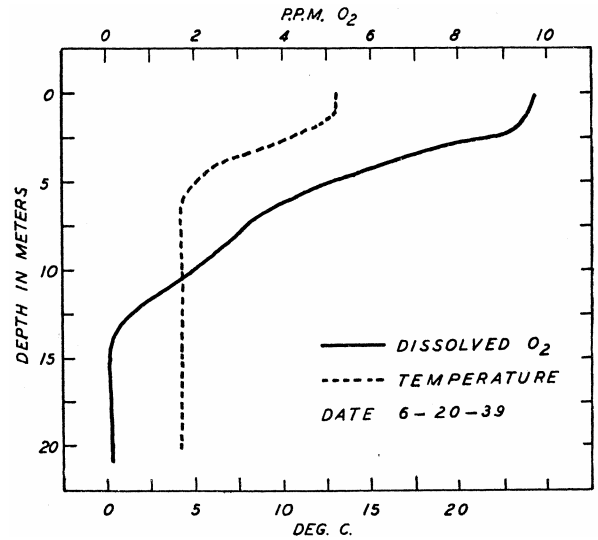

FIG. 3. Temperature and dissolved oxygen concentration from surface to a depth of 22 meters on June 20, 1939

2. Dissolved Oxygen

Dissolved oxygen is not present below 16 meters at any season, and during the summer the last traces are found at 12 meters (Fig. 4). In May oxygen occurs at a depth of 16 meters (Fig. 2). As the season advances it is gradually eliminated from the lower strata until in late July none is found below 12 meters. At this time the curve of oxygen distribution is very irregular in the lower levels of the thermocline because of the operation of biotic factors. By September 1 these irregularities have straightened out, and there is a gradual decrease in concentration from the surface to the 12-meter depth (Fig. 5). By late October the overturn of the upper waters has begun, and oxygen is again present at 15 meters (Fig. 6). It will be noted that the overturn is incomplete and that the distribution of oxygen is not uniform, but shows a gradual decrease from the surface to the point of disappearance. In late winter oxygen in the upper strata is reduced to 3.9 parts per million, whereas the lower strata remain anaërobic (Fig. 7).

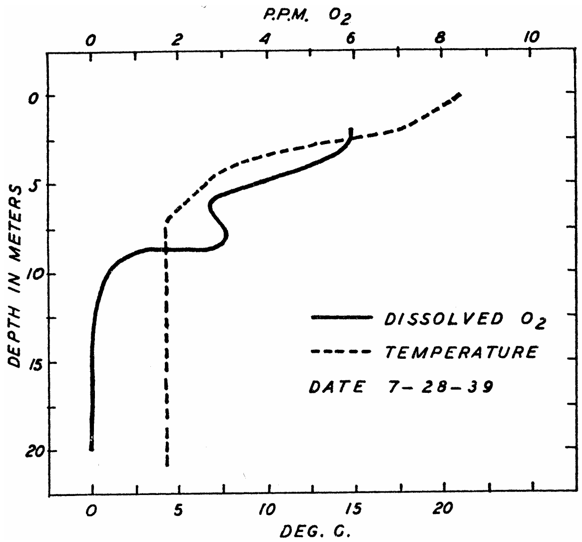

FIG. 4. Temperature and dissolved oxygen concentration from surface to a depth of 22 meters on July 28, 1939. The irregularities near the thermocline are correlated with the density of phytoplankton

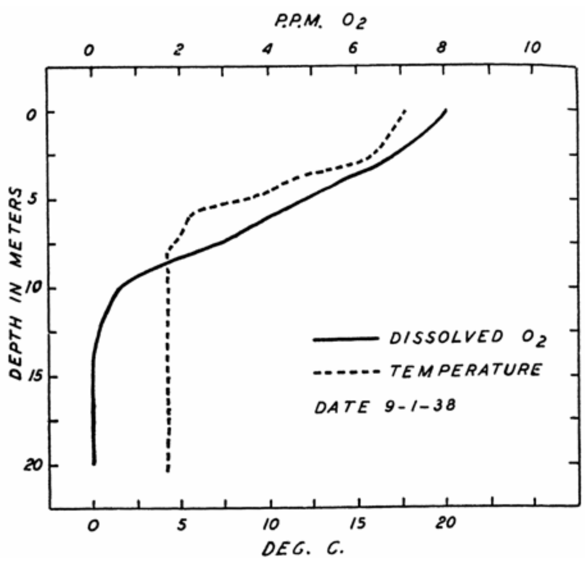

FIG. 5. Temperature and dissolved oxygen concentration from surface to a depth of 22 meters on September 1, 1938

3. Total Alkalinity and Free Carbon Dioxide

Even more marked than the distribution of dissolved oxygen is the extreme variation from surface to bottom of the total alkalinity and the free CO_2. The alkalinity, expressed as parts per million of calcium carbonate, ranges from a minimum of 12 at the surface to a maximum of 270 at the bottom. Down to a depth of 15 meters the concentration increases to approximately three times the value at the surface, and then jumps rapidly to twenty times the surface value at the greatest depth. Minor variations occur during different seasons (Figs. 8-12), but the shape of the distribution curves remains essentially the same. During late July conditions in the thermocline cause irregularities similar to those noted for oxygen.

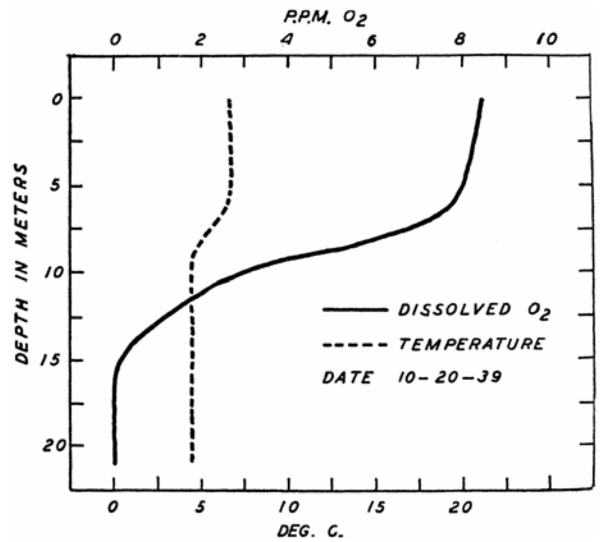

FIG. 6. Temperature and dissolved oxygen concentration from surface to a depth of 22 meters on October 20, 1939

The content of free CO_2 varies from 1 part per million at the surface to a maximum of 232 parts per million at the 21-meter level. The gradual increase in concentration to a depth of 15 meters and the rapid increase below that point are as notable as for the total alkalinity. The curves for free CO_2 remain relatively constant at all seasons and follow the general shape of the alkalinity curves. Winter observations were not made at the maximum depths for either CO_2 or total alkalinity, but the conditions down to 18 meters were very similar to those in late October and May.

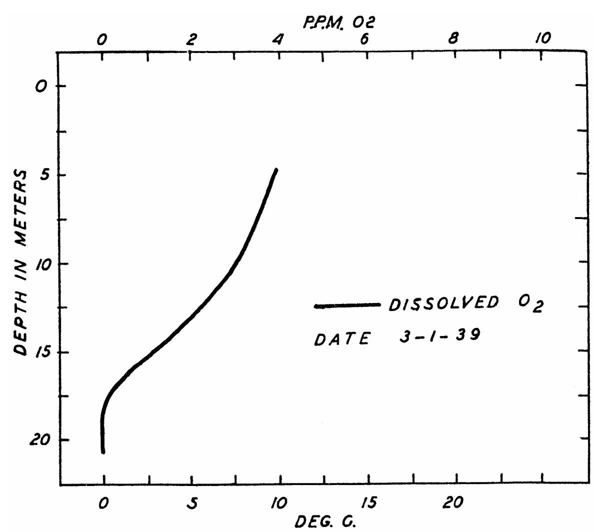

FIG. 7. Dissolved oxygen concentration on March 1, 1939. Eighteen inches of ice covered the lake at the time of this observation

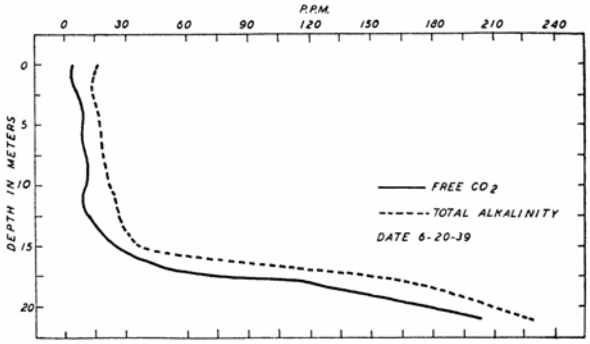

FIG. 8. Total alkalinity, expressed as parts per million of calcium carbonate, and free CO_2 concentrations from surface to a depth of 22 meters on June 20, 1939

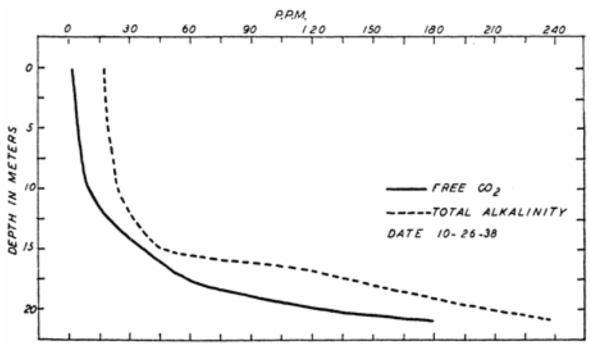

FIG. 9. Total alkalinity, expressed as parts per million of calcium carbonate, and free CO_2 concentrations from surface to a depth of 22 meters on October 26, 1938

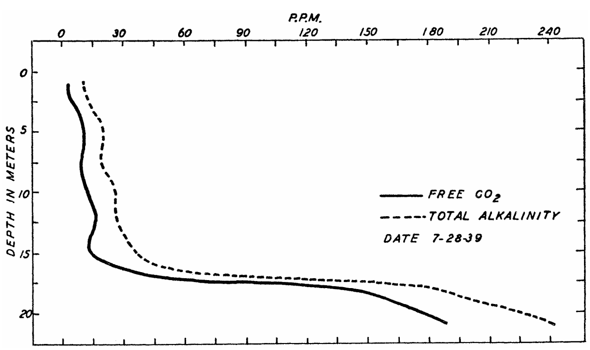

FIG. 10. Total alkalinity, expressed as parts per million of calcium carbonate, and free CO_2 concentrations from surface to a depth of 22 meters on July 28, 1939

When brought to the surface from 18 meters and below the water samples effervesced because the release of pressure and increase in temperature liberated a gas held in solution. No field equipment for the analysis of this gas was available. Since a flame test showed no methane and since no odor of hydrogen sulfide was present, the gas was assumed to be CO_2. The high concentration of CO_2 in the water and the precipitation of ferric salts in sample bottles after a period of standing lend support to this suggestion.

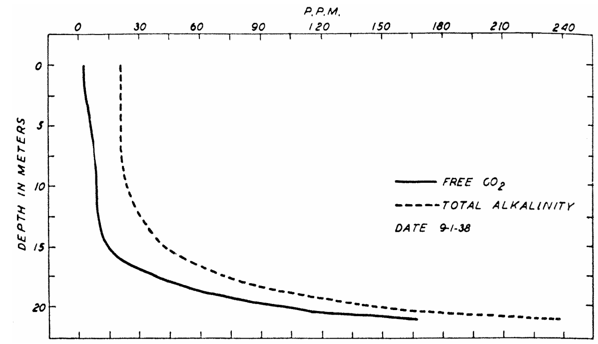

FIG. 11. Total alkalinity, expressed as parts per million of calcium carbonate, and free CO_2 concentrations from surface to a depth of 22 meters on September 1, 1938

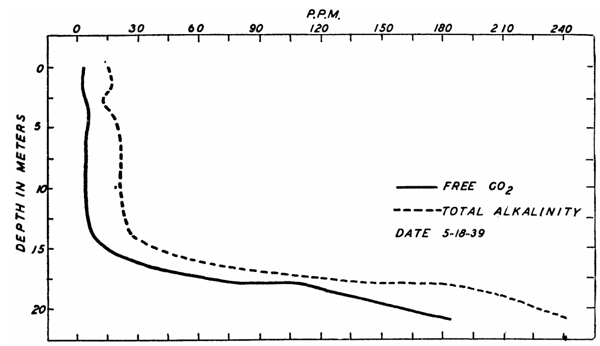

FIG. 12. Total alkalinity, expressed as parts per million of calcium carbonate, and free CO_2 concentrations from surface to a depth of 22 meters on May 18, 1939

4. Hydrogen-Ion Concentration

The pH ranges from 7.0 at the surface to 6.0 at the bottom, with no very significant seasonal changes. The highest hydrogen-ion concentration occurs during the winter and the lowest during the spring and fall (Fig. 13). During midsummer there is a sharp drop of pH in the region of thermal stratification. The relatively high pH associated with the high concentration of dissolved CO_2 is probably to be explained by the action of natural buffers.

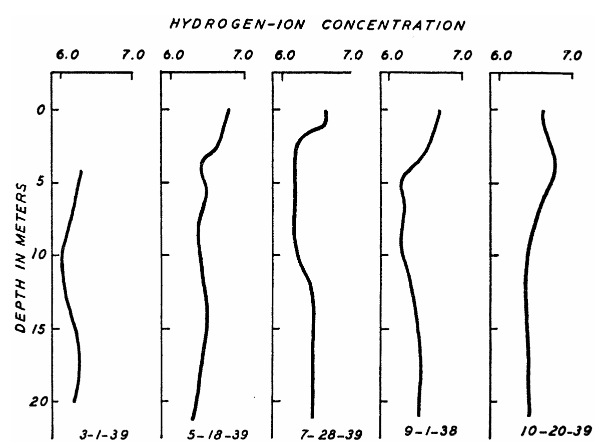

FIG. 13. Hydrogen-ion concentration at different seasons. The depression in July, 1939, is correlated with the activity of the plankton at that level

BIOLOGICAL CHARACTERISTICS

As would be expected from the alkalinity of the surface waters, the biological productivity of the lake is low, with few species and a light concentration of individuals. The fish population consists of the lake chub *Couesius plumbeus*, and the speckled trout, *Salvelinus fontinalis*. Hubbs (1929) lists the chub as the only native species and ascribes the absence of other species to the early isolation of the lake in postglacial time.

There are not many benthic organisms, and the number of species is small. The most prominent species are *Hyalella knickerbockeri* in the shoal waters and *Corethra sp*. and several species of Chironominae in deeper water. At all seasons of the year the bottom soils below 16 meters are free of macroscopic organisms. In midsummer none are found below 10 meters. There is a marked irregularity of distribution, emphasized by two concentration zones. During late July the upper zone lies between 1 and 3 meters and the lower between 6 and 7 meters (Fig. 14). At this time the lower concentration is dominated by Chironominae larvae, but as fall approaches it begins to move down, until in late October it lies at 8 meters, with *Corethra sp*. and Chironominae dominating the population. Along with this downward shift is the appearance of *Corethra* at 15 meters (Fig. 15). Coincident with changes in the location of concentrations are the increase of oxygen in the upper strata and the penetration of traces to 16 meters (Fig. 6). The concentration zone during midsummer lies in the lower stratum of the thermocline, or just below it. With the disappearance of thermal stratification it moves to greater depths. Eggleton (1931) has shown that this phenomenon is more or less typical of eutrophic lakes.

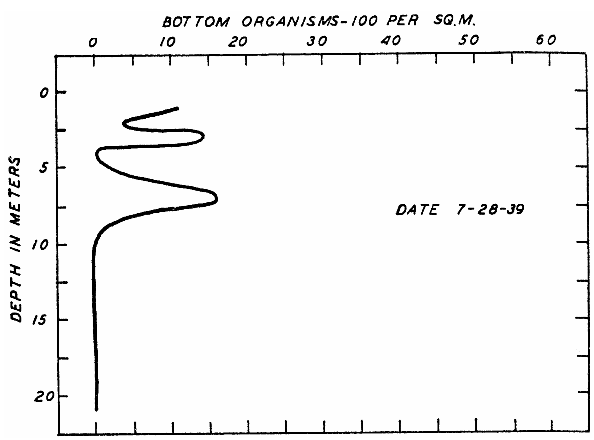

FIG. 14. Distribution of bottom organisms on July 28, 1939. The concentration zone, composed of *Corethra* and Chironominae, lies at a depth of between 6 and 7 meters

In May, shortly after the ice goes out, a concentration zone composed entirely of *Corethra* lies at 14 meters (Fig. 160. As the season progresses the zone moves up to the summer level, and all organisms disappear from the lower strata. The tendency toward downward movement in the fall and the low position of the zone just after the spring break-up suggest that the greatest number of organisms occur at the lower level of available oxygen during the winter months. Eggleton (1931) showed this to be the usual condition in the lakes he studied. A peculiarity which occurs at all seasons is the complete absence of organisms at the 4-meter level. Since there is no apparent temperature or chemical condition correlated with this barren area, the cause may be some peculiarity of the bottom soil.

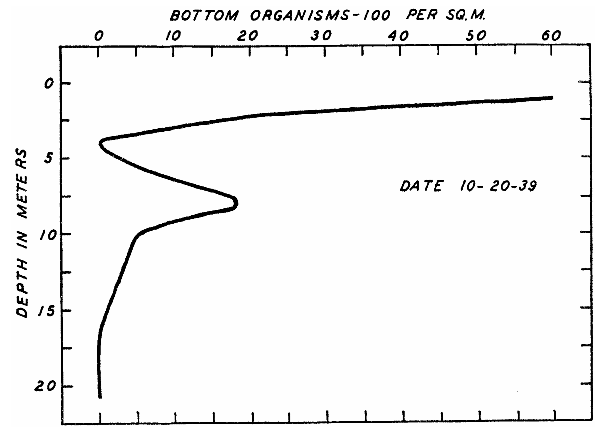

FIG. 15. Distribution of bottom organisms on October 20, 1939. The concentration zone lies at a depth of 8 meters, and organisms have penetrated to 15 meters

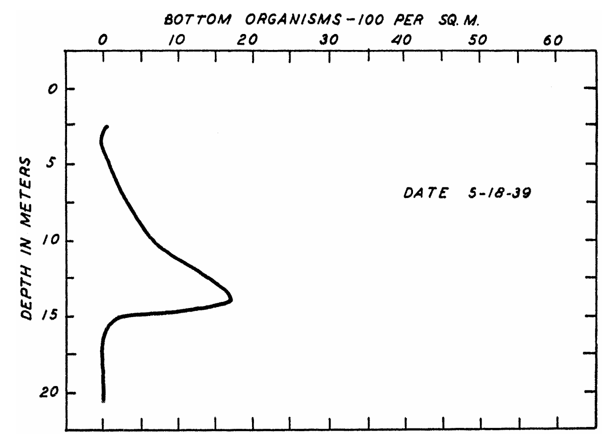

FIG. 16. Distribution of bottom organisms on May 18, 1939. The concentration zone, composed of *Corethra*, lies at a depth of 14 meters

In general, the distribution of the bottom organisms seems to depend on the availability of oxygen. The permanent depletion of oxygen in the lower levels is correlated with the absence of bottom forms, and the seasonal disappearance of life from the middle zone is likewise coincident with oxygen removal.

In this lake there is nothing remarkable about the species of plankton or their distribution, and they tend to bear out the assumptions derived from the other limnological data. The number of both species and individuals is relatively low, and nothing approaching a typical plankton surge has been observed. The zooplankton is dominated by the Rotifera; the phytoplankton, by *Tabellaria sp*., *Dinobryon sertularia*, and *Ceratium cirundinella*. The scarcity of blue-green algae and the small number of phytoplankters may be due in part to the low temperature of the water and the few hours of sunlight which the rock walls permit to strike the water.

The waters of the stagnation zone are dominated at all seasons by *Keratella cochlearis*, *Ceratium hirundinella*, and *Tabellaria sp*. The only cladoceran observed in these strata was *Bosmina longispina*. At one period in late summer a considerable increase in *Dinobryon* occurred and was noticeable as deep as 15 meters. Since there were no apparent physical or chemical changes at this level and since the increase was not reflected by other species, the abundance of this particular form may have been caused by the sinking of individuals from overlying layers. At 20 meters the plankton consisted entirely of *Keratella cochlearis*, *Ceratium hirundinella*, *Tabellana sp*., and *Diatoma sp*. The population is marked by the absence of deep-water forms which are commonly found in cold, soft lakes without stagnation.

From Table I, which shows the total number of plankton forms and the total number of zooplankters per liter at various depths and seasons, it will be noted that the decrease in numbers from surface to bottom is largely due to the decrease in phytoplankton. The irregularity of oxygen distribution in late July previously pointed out is correlated with the concentration of algal forms in the thermocline.

The following list of plankton species, although by no means complete, contains the conspicuous and numerically dominant forms.

ROTIFERA: *Polyarthra platyptera*, *Triarthra longiseta*, *Pedetes saltator, Keratella cochlearis, Keratella quadrata, Notholca longispina, Rattulus sp.*
CLADOCERA: *Bosmina longispina, Daphnia longispina*.
DINOFLAGELLIDA: *Ceratium hirundinella*.
PHAEOPHYCEAE: *Dinobryon sertularia*.
DIATOMACEAE: *Tabellaria sp., Diatoma sp., Fragillaria sp*.

In some of the surface samples *Microcystis*, *Diaptomus sp., Cyclops sp*., and *Ceriodaphnia sp*. were occasionally present. A few other species of phytoplankton and rotifers formed inconspicuous components of the population.

TABLE I

TOTAL NUMBER OF PLANKTON INDIVIDUALS AND TOTAL NUMBER OF ZOOPLANKTERS PER LITER

Depth in meters	July 28, 1938		Sept. 1, 1938		Oct. 25, 1938		May 18, 1939		Oct. 21, 1939	
	Total plank.	Zoo-plank.	Total plank.	Zoo-plank.	Total plank.	Zoo-plank.	Total plank.	Zoo-plank.	Total plank.	Zoo-plank.
0	58,936	21,425	9,918	178	1,115	1,052	91	28	6,836	4,510
2	1,977	279	...	...	...	...	210	60	...	...
3	...	...	4,417	139	293	146	35	28	...	...
4	...	...	1,281	223	...	...	158	52	...	...
5	...	...	...	...	471	339	...	...	...	...
6	448	122	...	...	...	...	36	28	315	289
7	...	...	244	110	...	...	...	...	...	...
8	1,236	710	...	...	...	...	...	...	...	...
10	1,000	1,000	...	...	46	46	77	14	81	44
14	...	...	...	...	...	...	14	12	...	...
15	206	123	1,426	106	50	29	...	...	40	21
18	...	...	...	...	...	...	19	15	...	...
20	42	39	83	35	...	...	...	...	52	20

From consideration of the physical, chemical, and biological data it appears that Canyon Lake has a more or less normal circulation zone extending down to a depth of 15 meters and a permanent stagnation zone below that level. This permanent stratification limits the distribution of macroscopic bottom organisms and strictly aërobic plankton forms to the upper strata of water, and makes the lower strata practically barren.

SUMMARY

1. The deep strata of the lake remain constantly at 4.4° C.

2. There is a sharp thermal stratification, with the upper limits of the thermocline lying between 2 and 3 meters.

3. The lake contains no trace of dissolved oxygen below 16 meters at any time of the year.

4. The total alkalinity and free CO_2 show a great variation from surface to bottom which does not change significantly during the year.

5. The lake is a soft-water type in its upper strata and a modified hard-water type in the lower strata.

6. No macroscopic bottom organisms occur below 16 meters.

7. Above 16 meters the seasonal changes in the benthos are similar to those in a eutrophic lake.

8. The plankton species dominant in the stagnation zone are those which frequently occur in anaërobic conditions.

9. The lake has the appearance of two separate bodies of water, one superimposed upon the other: the upper active and the lower stagnant.

10. Permanent stratification and the resulting physical, chemical, and biological phenomena are caused by the low temperature of the bottom waters, the precipitous banks, and the Tack of wind agitation.

MINNESOTA DEPARTMENT OF CONSERVATION
ST. PAUL, MINNESOTA

* This study was made as a part of a doctoral dissertation presented to the Department of Zoölogy of the University of Michigan.

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A STUDY OF SETTLEMENT AND LAND USE IN LIVINGSTON COUNTY, MICHIGAN

W. BRUCE DICK †

PART I. HOUSE TYPES AND SETTLEMENT

THE settlement of Livingston County, which took place about 1830, is representative of that of most of the southern counties of Michigan (Fig. 1). It was believed that a study of its settlement and of the origin of the immigrants would provide a better understanding of current land problems.

ROUTES OF MIGRATION

This investigation starts with the origin and migration of the settlers. Information concerning the locations of most immigrants' homes was found in old histories, plat books, albums, and the "tract book" containing some of the early Detroit Land Office records. The date and location of each settlement from the beginning to 1839 was secured from the tract-book records especially.

Most of Livingston County's early immigrants came from New York State (Figs. 2-3), particularly from the Genesee Valley counties. A few were from the New England States, New Jersey, Pennsylvania, and Ohio. Each dot on Figure 3 represents one family, an individual who arrived in advance of his family, or a bachelor. The dots were located on the county map with reference to the village names, if they were available, or were distributed at random. A few immigrants who came from Europe directly have not been represented on the map, but there were not enough of them to affect greatly the distribution of the origin of settlers as shown.

There were three main routes which the early settlers of Livingston County used in the fourth decade of the nineteenth century. Dependable information on the exact position of towns through which the routes passed is not available, but we have records of a Canadian route from Buffalo to Detroit, a Lake Erie water route, and a southern overland route, which followed closely the south shore of Lake Erie. Historical sketches and records of the local Pioneer Society indicate that the water route was the one most frequently used. Overland travel was by oxcart or horse or on foot. It usually took one or two months to make the journey overland with horses, and nine or ten days by water.

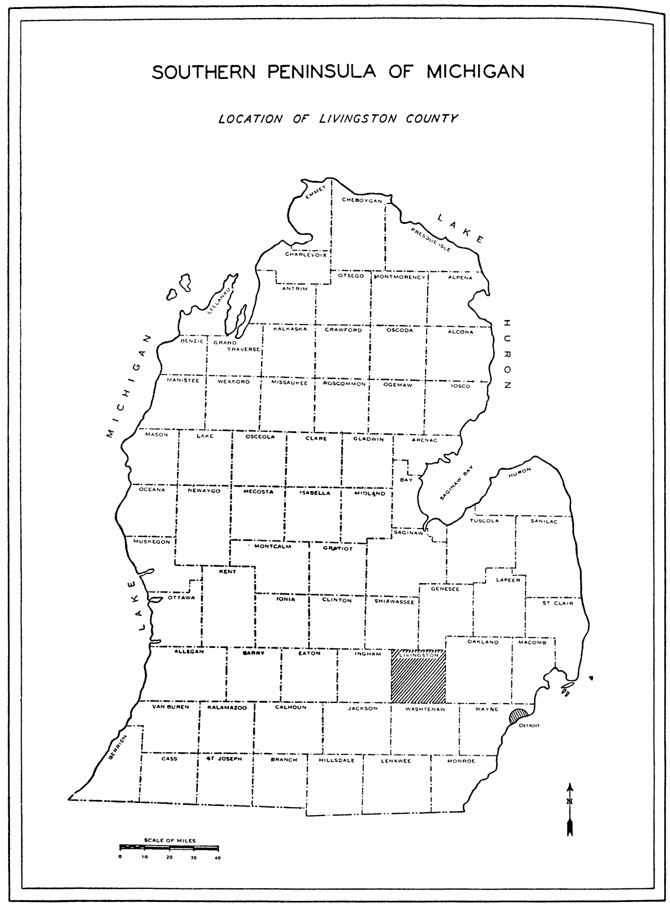


FIG. 1

Immigration focused on Detroit, the seat of the Government Land Office. In the period when Livingston County received its first influx of settlers Detroit had already had a century and a quarter of existence. In 1830 its inhabitants numbered 2,222, and it was a principal commercial center of Michigan, ranking next to the headquarters of the fur trade on Mackinac Island. Before the time of Pontiac, Indian trails had converged on the site of Detroit, and as settlement proceeded it became the chief point from which immigrants entered the unsettled lands of southern Michigan. The Government Land Office in Detroit was the point of origin of trails leading into the wilderness.

From Detroit land seekers set out to view the new territory and to select pieces of property according to individual fancy. Early accounts of Michigan stated that the climate was generally milder than that of corresponding latitudes on the Atlantic Coast. The qualities of the soil were described in the most enthusiastic terms in nonofficial reports. Farmers were easily led to overrate the agricultural possibilities of southern Michigan so far as climate and soil were concerned, for the soils are not more fertile than the average in forested regions, nor is the climate so mild as early reports pictured it. The majority of the settlers came with the idea of found in homes and of supporting themselves by farming. Most of those who engaged in trades and public services arrived after the population had become large enough to justify them in establishing themselves in the new settlements. Land speculators, with their unethical practices, were rampant, but we are here concerned only with people who actually settled in Livingston County.

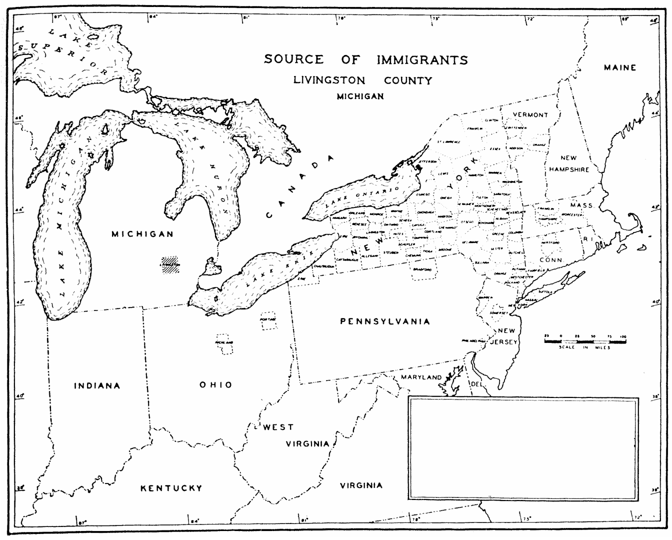


FIG. 2

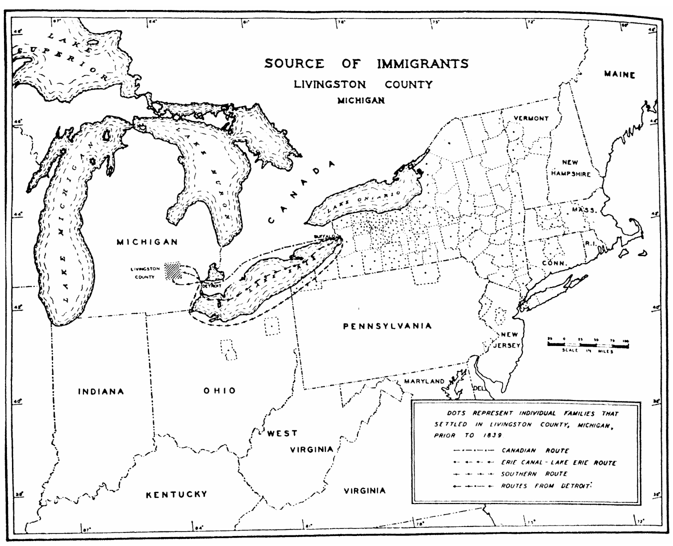


FIG. 3

Settlement was facilitated by Indian trails; the chief ones converged on the straits at Detroit and in turn afforded convenient routes into the territory of southeastern Michigan. The Grand River Trail was an important route from Detroit to Livingston County; it is the middle of three routes running west from Detroit (see Fig. 3). The other two are Indian trails of less importance, but some of the immigrants traveled over them.

The region which is now Livingston County received its earliest settlements in the southern and southeastern sections. Since Detroit was the seat of the land office for Michigan, immigrants seeking new lands in the interior frequently traveled from there by way of Ann Arbor. This route led them ultimately to the southern part of the county. The route from Detroit by way of Royal Oak, Birmingham, and Walled Lake was used at a later date.

Colonel Solomon Peterson was the first white person who made a permanent residence in this county. He settled on Portage Creek in Putnam Township in 1828. Stephen Lee and Benjamin Curtis established homes in Green Oak Township in 1830. Other settlers arrived at Hamburg in 1831 and at Brighton in 1832. Unadilla, the last of the southern string of townships to he settled, received Eli Ruggles as its first resident in 1833. The years 1833, 1834, and 1835 saw at least one permanent settler in each of the remaining townships.

Most of these early settlers were from New York State or southern New England. They were generally the younger members of successful farming families, and they wished to make homes for themselves and to own farms as productive as those of their parents and relatives. Many of them came to Detroit by boat by way of the Erie Canal and Lake Erie, and then continued their journey to Livingston County by oxcart or on horseback. Like any other pioneer people, they had a rough time, but settlement was not so difficult as it had been for their parents and grandparents in New England. The Indians here were quite peaceful after the Indian Wars, and the county abounded in fish and game. There were years of privation, however. In 1876 the Honorable W. A. Clark stated before the Pioneer Society that "Families to my knowledge in 1837-38 lived for days through necessity on boiled acorns, with fish cooked and eaten without salt or fat of any kind. Provisions were then often held at fabulous prices; . . . beef, pork and flour had to be brought from Detroit, at a cost of from one to two dollars per hundred to Brighton, forty miles. It was not so very high, either, for the round trip, with an energetic teamster and an enterprising team, took three to four days, if not longer."[1]

In the year 1838 crop yields were plentiful, and after the harvest wheat fell to a low price. It was so abundant that it sold at less than three shillings a bushel. Cattle prices also dropped.

The marsh grasses along stream banks and upland grasses in the openings afforded very fine natural pastures for cattle. They also provided subsistence for the very first winter or two until land could be cleared for the planting of timothy, clover, and alfalfa.

From the records of the old tract book in the office of the register of deeds at Howell a series of dot maps showing the spread of settlement has been prepared (Fig. 4). Each includes the additional settlements which took place in the years indicated. Every dot represents an individual or a family settlement, and as nearly as possible each one has been placed according to the location of the property settled upon. The first settlement, shown by the heavy dot, occurred in 1828 in Putnam Township, near the site of the present village of Pinckney. There was no recorded settlement in 1829, so far as could be determined. By 1839 the population had spread over the entire county, and the settlement of new land was mainly over.

The map of Howell Township may be taken as an illustration of the way in which the others were constructed. *The History of Livingston County, Michigan* (see note 1) gives a list of people by sections of townships; it includes only those who took up Government land, but it tells where they came from and gives the dates of their settlement. A tract book at the register's office in Howell furnished this information for the authors of the *History*. The land entries for Howell Township were plotted on a map of ownership and were compared with one of 1935. It was thought that some of the present owners of the same name might be descendants of the early settlers, but only one family in Howell, the McPhersons, has remained. The first land entry in Howell was made by Orman Coe, of Genesee County, New York, on May 20, 1833. He took up land on the eastern half of the southwest quarter of Section 27. Settlement was very slow at first, but about 1836 and 1840 it became rapid. By 1860 all the Government land in the township had been taken.

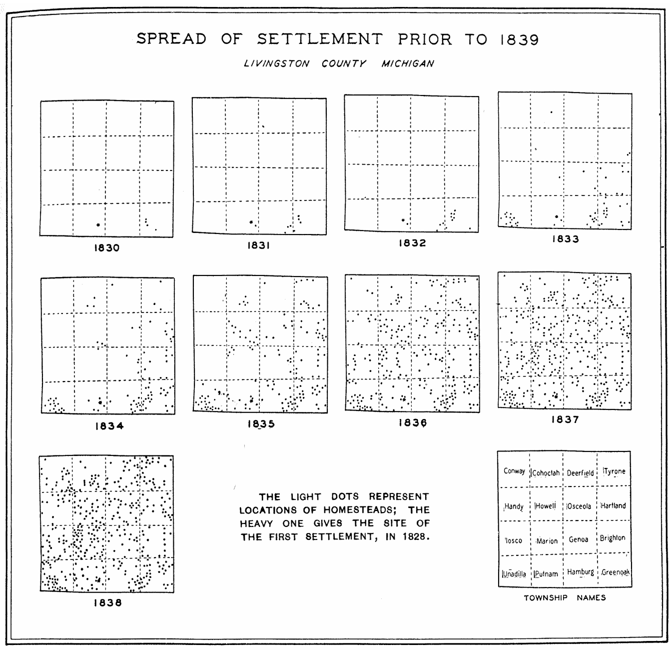


FIG. 4

ADVANCE OF SETTLEMENT

The isochronic map (Fig. 5) shows that the settlement of Livingston County made most rapid progress along an axis which corresponds to the Grand River Trail, mentioned earlier as the principal route used by the settlers journeying from Detroit to the new lands in Livingston County. Today it is the main highway to Detroit.

The settlers sought the oak openings, where the land was well drained, the timber thin, and the trees more easily removed. Soil was light in the upland areas and was readily worked. Continued exploitation of these soils is in part the basis for many present-day farm-management problems. The extensive poorly drained areas were at first avoided because of the difficulty of clearing and draining, and also because of the prevalence of malaria, or "the ague," as it was commonly called. The swamps and stream borders were used for pastures during the period of settlement.

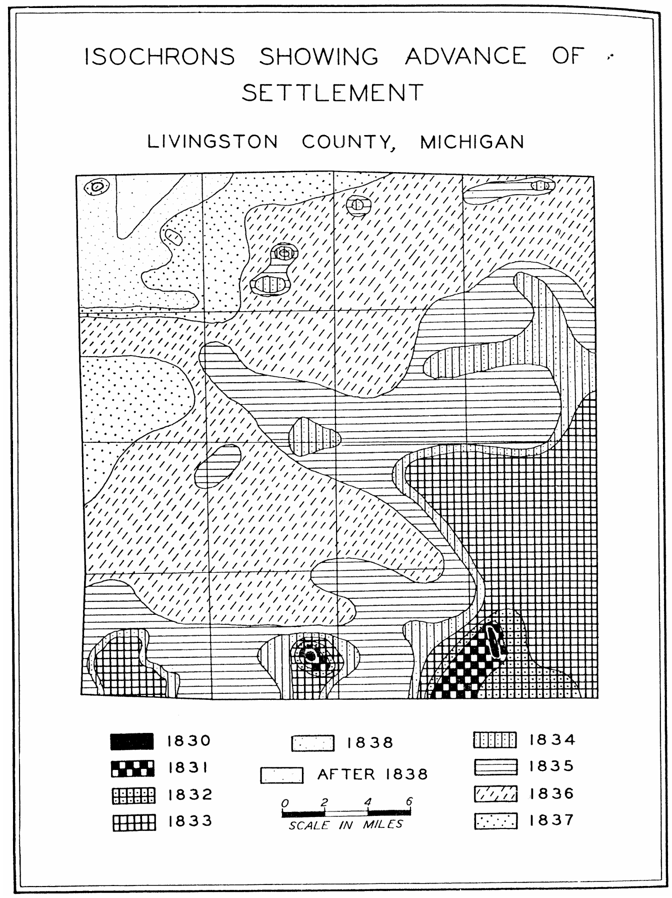


FIG. 5

Today as one drives through the county the construction of many of the old houses and the names of places give evidence of the New York State heritage of the people. The names of this county and the one adjoining it on the north repeat those of neighboring counties in New York. There, too, a river that flows through a part of Livingston County is called Genesee. The county seat of the Michigan Livingston County was named Howell in honor of Thomas Howell, a New York friend of the city's founder, Mr. Crane. More than names have been duplicated, however: houses are built after the fashion of those in western New York (Fig. 6). This type of house, which resembles a T lying on its side, is very common in the rural districts of Livingston County, Michigan, and of neighboring counties. The windows usually have a number of small panes, and the cornices are ornately scrolled. There are roofs over the two front doors. When additional rooms were needed a wing was built, but the old part of the house is usually distinguishable (Fig. 7). Small bedroom windows above the porch on the left wing are very common. The house pictured in Figure 8 is well over a hundred years old; it shows the little windows under the front eaves plainly. There remain in the county a few examples of an old New England type of barn (Fig. 9), with all the buildings strung together. Because of the fire hazard and the farmers' desire to "modernize," barns of this sort are rapidly disappearing.

FIG. 6. Farmhouse in Marion Township, Section 35, on Shafer Road; now rented by an automobile worker

FIG. 7. Farmstead in Unadilla Township, Section 13, on State Highway 36. The house was built in 1865; the right wing was added about 1910

Although the prevailing type of rural house, as described above, was built in accordance with ideas brought from western New York by the early settlers, there is another important type which may be seen here and there in the rural parts of the county. The log cabin (Fig. 10), which had sheltered the pioneers in the first few years of settlement in the wilderness, was replaced by a more commodious structure, eclectic in style and elegant in taste.

The house of eclectic design was either of brick or of wood (Figs. 11-12), whereas the New York type was mostly built of wood. The increase in prosperity during the first few decades after settlement seemed to justify an elaboration of the house, and the eclectic type filled the esthetic and practical needs of the people of the period. There was an increase not only in prosperity, but in population. Part of it came from new immigration, part from additions to families already settled. Whenever it has been necessary to enlarge the original house, the New York type has lent itself readily to addition. As already noted, wings could be added (see Fig. 7) or built up with higher stories (Figs. 13-44).

FIG. 8. Farmhouse in Putnam Township, Section 7, on Pingree Road

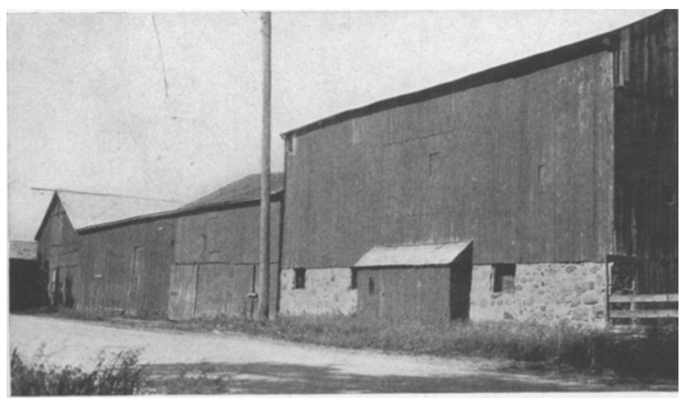


FIG. 9. New England type of barn, Putnam Township, Section 26, on Pinckney Road

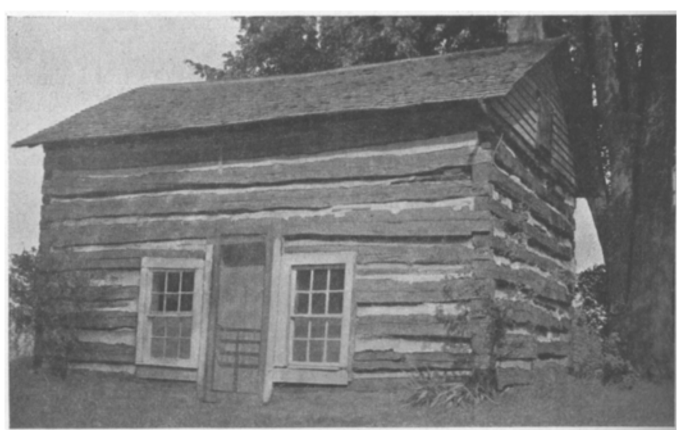


FIG. 10. Log cabin in Genoa Township, Section 21, on Latson Road; built about 1830 by an Indian scout who was not a permanent settler

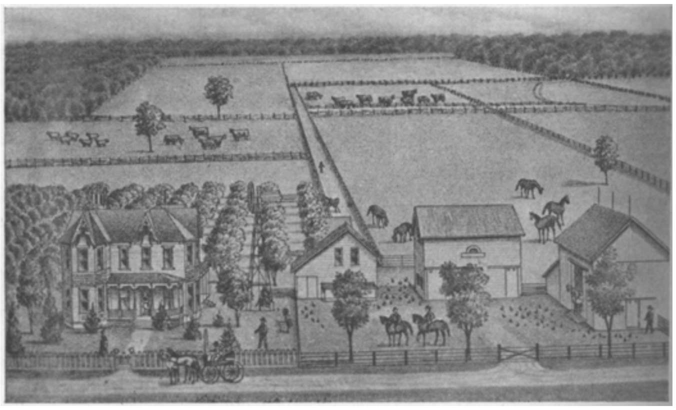


FIG. 11. Sketch of Daniel Gannon's farmstead in 1880; Cohoctah Township, Section 8 (from the *History of Livingston County, Michigan*)

FIG. 12. The old Gannon residence as it now appears

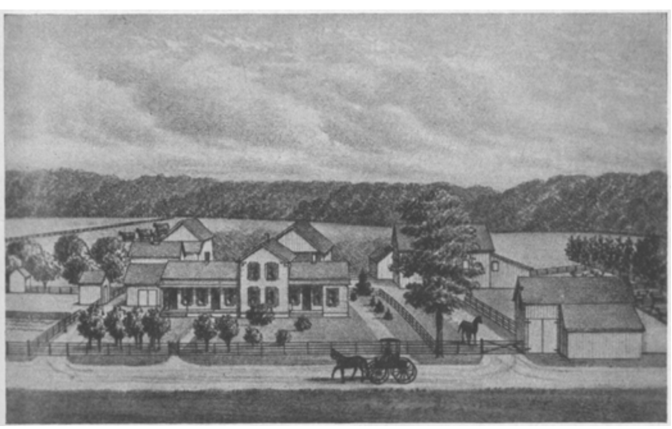


FIG. 13. Artist's sketch of Mrs. Mary J. Jones's residence as it appeared about 1880; Cohoctah Township, Section 25 (from the *History of Livingston County, Michigan*)

It may be shown that most of the settlers came from western New York, and detailed investigation merely confirms conclusions which may be drawn from a consideration of the essential of the characteristic house. It duplicates those found in western New York. Subsequent changes in houses and in other buildings correspond to changes in economic conditions, which have affected all the area in the vicinity of Detroit.

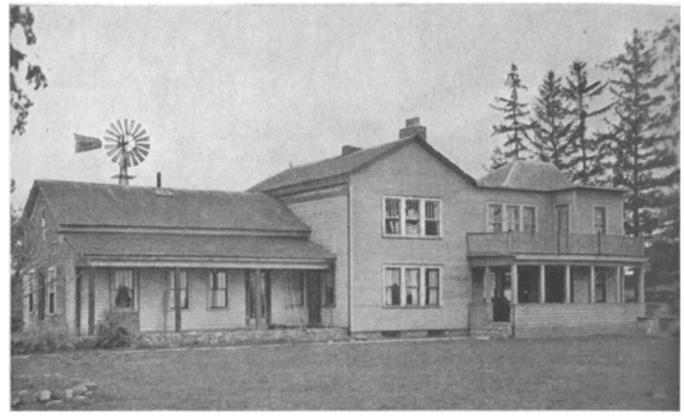


FIG. 14. The Jones house as it is today

PART II. LAND TYPES AND LAND USE

INTRODUCTION

In the past several years much attention has been directed to the use and the abuse of rural land. Various techniques for land classification and crop mapping have been developed. The halting and prevention of soil erosion have been carried on in many areas. Advice on crop management has been freely given to the farmer, and much has been done to assist him in improving the condition of his land.

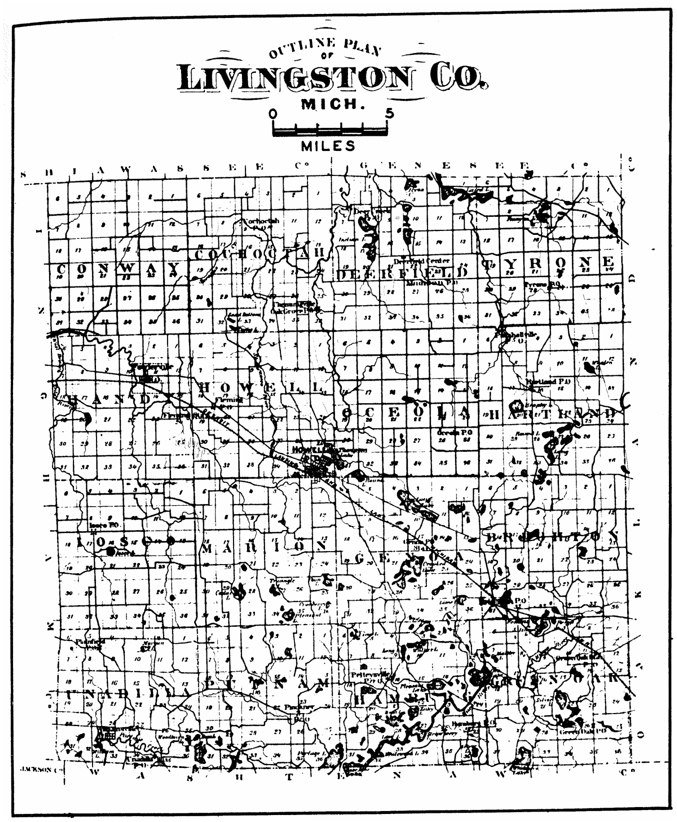


FIG. 15

The following material is an attempt to connect some of the existing conditions and qualities of the land with happenings within the history of land use. In Livingston

County such records are a matter of comparatively recent years. Permanent settlement began little more than a century ago, and large-scale agricultural practices are of even later date. On the farms which have remained under the control of a single family the history of land use comes within the span of three generations.

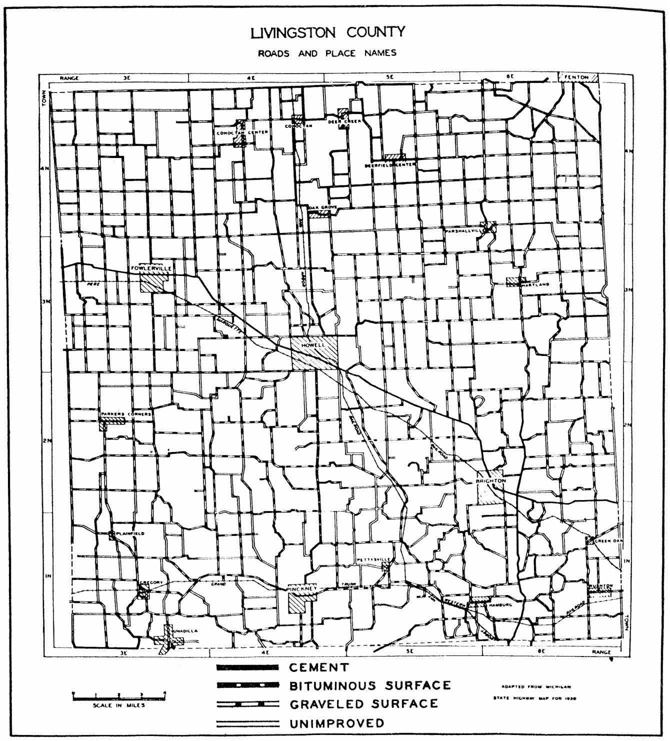


FIG. 16

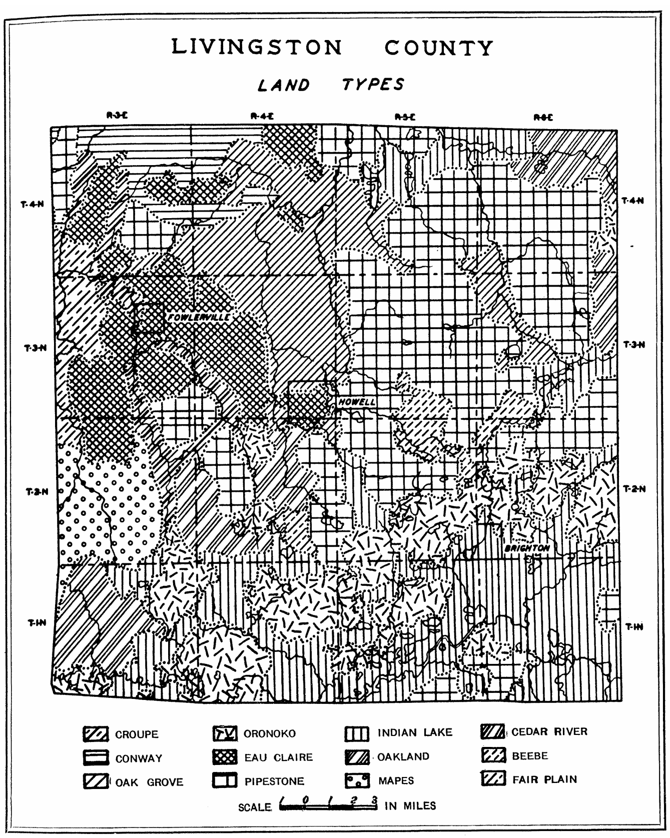


FIG. 17

In a publication that appeared in 1940[2] a classification of land qualities in Livingston County was developed. The present study shows some relations between these qualities and several phenomena of the method of occupance today. In the first part will be discussed a series of representative farms on which erosion and land-use history surveys have been made. These surveys note how past and present use of the land has caused soil erosion. The following sections will treat of the relations of land types to taxation and to financial conditions indicated by direct relief and farm mortgages.

Figure 15, an 1875 outline plan of Livingston County, gives the names and the arrangement of the sixteen townships comprising it. The road-classification map (Fig. 16) is based on recent information and is useful in the orientation of places mentioned in the text. The land-type map (Fig. 17) is the result of field study carried on d the summer of 1939.[3]

SUMMARY OF LAND TYPES

Croupe. — Surface gently rolling, but broken by old river valleys, now cut to a considerable extent by artificial drainage ditches. Some swamp, but very little standing water. No lakes. Only a small amount of wild land. Soils very heterogeneous, mainly of the lighter types. Patches of Hillsdale loam, Plainfield sand, and Fox loamy sand with associated stream-bottom soils.

Conway. — Surface smooth to gently rolling, with large areas of very flat, artificially drained land, which at one time had been wet. Idle and pasture land predominant. Dominant soils Fox series and mucks, some of which have been drained and cleared for agriculture.

Oak Grove. — Rolling to hilly surface. Intermediate in relief. Considerable land in pasture. Soils dominantly Coloma loamy sand with Carlisle muck bordering the streams. Minor soils Miami loam and Plainfield sand. Sandier exposed hills subject to blowing in dry weather.

Oronoko. — Hilly, knob-and-basin terrain. Slopes two to three times the area of level upland; most slopes, 15 to 25 per cent or more; lake basins, dry depressions, and swamp basins. Dominant soils sandy barns mainly Bellefontaine and Hillsdale types, with smaller bodies of Coboma loamy sand, Fox loamy sand and sandy loam, and Miami loam.

Eau Claire. — Gently rolling till or clay plains. Surface similar to Croupe type. Short slopes, few exceeding 7 to 15 per cent; swales and shallow basins. Dominantly Miami and Hillsdale loam soils. May be moderately stony.

Pipestone. — Deeply rolling or broken, pitted or dissected clay land, till plains, or moraines. Slopes greater in area than level land; constructional swales and basins; generally considerable stream dissection. Dominant soils Hillsdale and Miami loams. Some muck and peat.

Indian Lake. — Sand-gravel plains; level surface but containing a large number of dry potholes, lake basins, muck and peat basins, swampy stream valleys, or chains of lakes. Slopes, enclosing basins for the most part, are short, but may have a grade of 25 per cent or more. Dominant soils Fox sandy loam and loamy sand, and Bellefontaine sandy loam. Some Plainfield sand and organic soils.

Oakland. — Intermediate in gradient and height of relief between Eau Claire and Pipestone on the one hand and Oronoko on the other; more Hillsdale and Miami loam soils than are found in Oronoko type. Slopes exceed area of level land; high percentage of slopes of 7 to 25 per cent gradient. Lakes and muck basins common. May be stony.

Mapes. — Level and swampy with interspersed higher areas having slopes generally less than 7 per cent. Dominant soils Carlisle muck and Hillsdale sandy loam. May include some Fox soils. Wild land predominant with patch cultivation on the highlands. Lower relief and fewer lakes than in the Indian Lake type.

Cedar River. — Level, broad valley bottoms. Slow stream drainage, with some artificial drains. Similar to the Mapes type, but with little or no associated Hillsdale soil. Generally sinuous in outline. Soils mainly Carlisle muck. There may be small patches of Rifle peat. Surrounding upland chiefly Miami loam.

Beebe. — Swamp land, mainly Carlisle muck and Rifle peat, with small amounts of poorly drained mineral soils.

Fair Plain. — Smooth sand-gravel plains, slightly pitted or undulating. Few lakes and muck basins. Dominant soils Fox sandy loam and loamy sand.

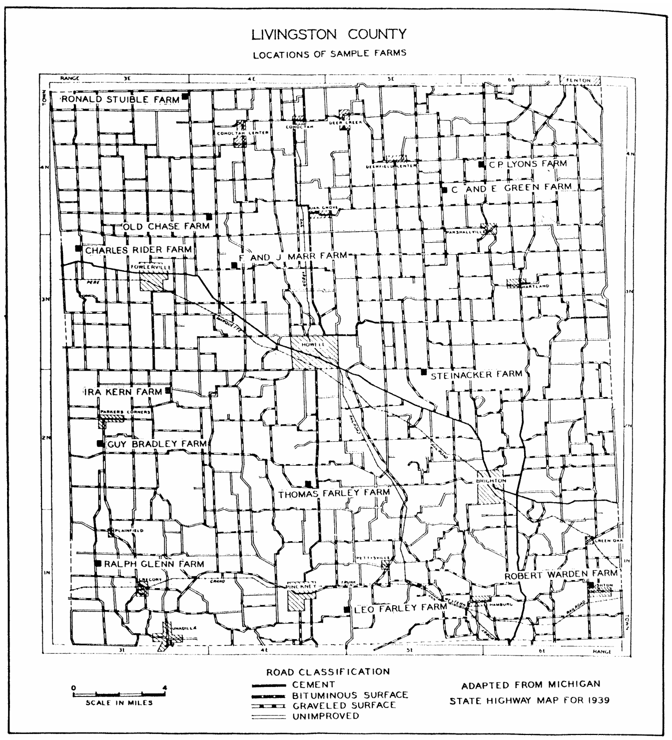


FIG. 18

SUGGESTED EVALUATION OF LAND TYPES FOR FARMING

Eau Claire, Pipestone, and, possibly, Oakland land types contain the major portion of soils which are most productive agriculturally. They are well drained for the greater part and lend themselves in varying degrees to general crop production.

Oronoko, Oak Grove, Fair Plain, and Croupe also are well drained. Within this group are slopes grading from steep in the Oronoko to gentle in the Croupe. Their agricultural possibilities are fewer, primarily because of the predominance of lighter and less fertile soils.

Conway, Mapes, Cedar River, and Beebe include the majority of the poorly drained areas. Their soils are for the most part of an organic nature and must be drained before crops can be grown. This group offers few possibilities for profitable farming.

Indian Lake is a mixture of steep slopes and level land, with both well and poorly drained areas. In general, it does not lend itself well to farming.

RELATIONSHIPS BETWEEN LAND TYPES AND LAND USE

In order that detailed information about land-use practices might be obtained a representative farm was chosen in each of the types (Fig. 18). In almost every case the farm has been under the ownership of the same family from the time of its first permanent settlement. The farms were carefully selected with the assistance of the township supervisors. A map was made for each one, showing cover, slope classification according to percentage groups, direction of slope, and present depth of the A horizon in the soils. A master legend appears on page 366. The amount of erosion for each soil was calculated on the basis of the last item. These plotted on an erosion map for each farm, were obtained by subtracting the present depths of the A horizons from estimated averages of depths that existed in the virgin soils.[4] The accuracy of the estimates is problematic, but they are the best available. A schedule or interview sheet (see p 365) was developed so that the data obtained would be uniform. Items were not taken up in any pre determined order, although all the necessary points were touched upon during conversations with each farmer, which sometimes lasted for several hours. Information obtained is presented on pages 367-390.

INFORMATION ON REPRESENTATIVE FARMS

LAND TYPE............

Name .... Township .... Section ....

Total acreage ....

I. Original settlement on farm
   A. Date ....
   B. By whom ....
   C. Nationality ....
      1. Place of origin of family ....
      2. How did they come? ....
   D. Original homestead
      1. Type of structure ....
      2. Material from ....
   E. Remarks ....

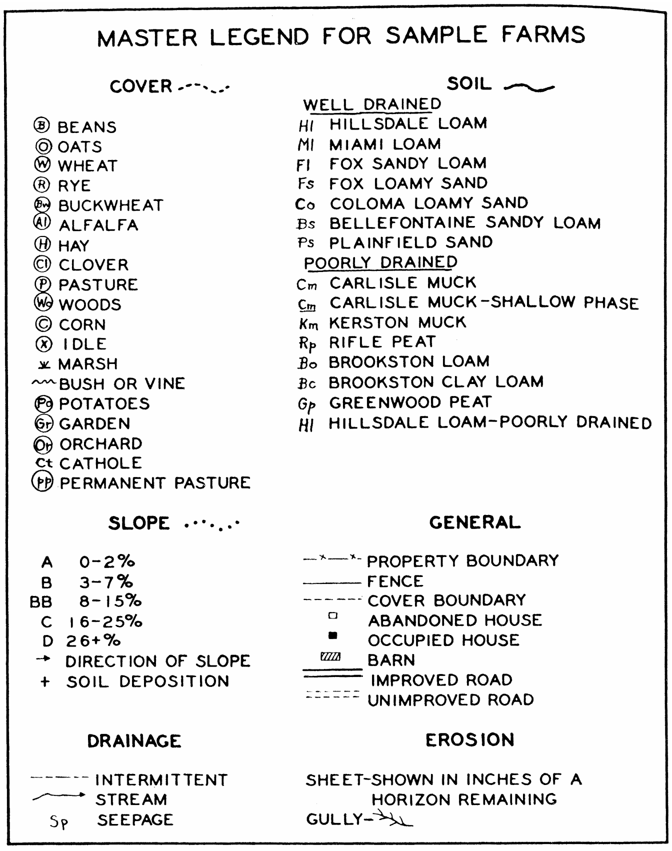
II. Sequence of land use
   A. Clearing of land
      1. Original cover ....
      2. Method of clearing ....
      3. Lumbering operations ....
   B. Early agricultural practices
      1. Type of crops ....
      2. Fertilization ....
      3. Rotation ....
      4. Yields ....
      5. Livestock ....
      6. Market and trading center ....
   C. Later agricultural practices
      1. Changes from earlier practices ....
   D. Present-day agricultural practices
      1. Type of crops ....
      2. Fertilization ....
      3. Rotation ....
      4. Yields ....
      5. Livestock ....
      6. Market and trading center ....

III. Erosion
   A. When first noticed and type? ....
   B. Anything done about it? ....
   C. When did yields decline? ....
      1. What was done about it? ....

IV. Drainage
   A. Artificial drainage ....
   B. Standing water ....
   C. Depth of well ....
      1. Any increase in depth? .... When? ....

V. Recreational use
   A. Lake subdivisions ....
   B. Hunting preserve ....
   C. Miscellaneous ....

VI. General remarks ....



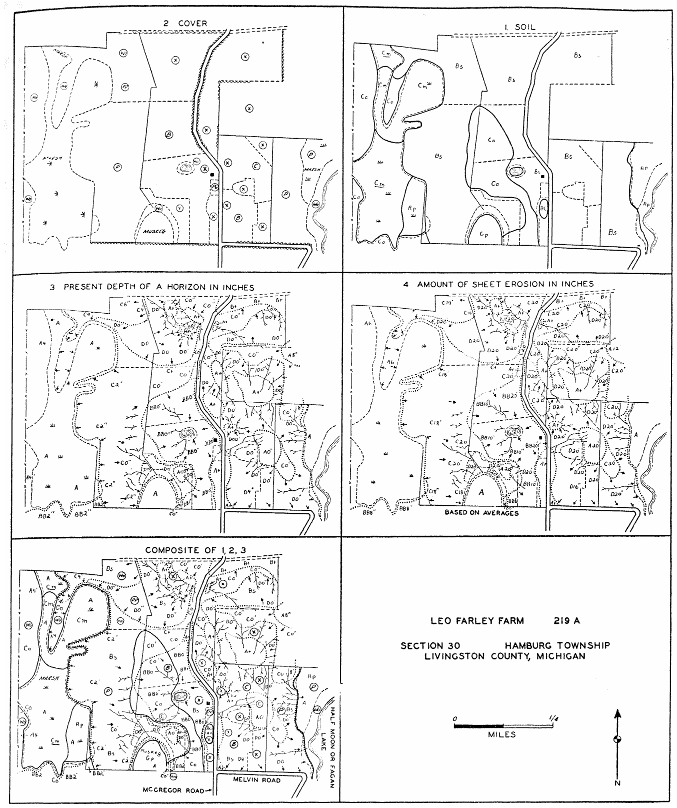


FIG. 19

INTERVIEWS WITH FARMERS

Oronoko Land Type. Leo Farley Farm, Hamburg Township, Section 30. 219 acres (Fig. 19)

This farm was settled during the time of the first permanent occupance in Hamburg Township (about 1830). The grandfather of the man now working the land emigrated from Ireland to New York State. There he worked in a lumber mill at "the Little Falls" long enough to obtain money for his venture into farming in Michigan. He brought his wife and two children to Detroit by way of Canada, working as he could obtain employment along the way. Leaving his family in Detroit, he walked to this area by the Dexter route and investigated the land. He then returned to Detroit and purchased the patent from the Government Land Office. A log cabin was quickly constructed of local timber, and later a frame house, still in use, was built of lumber hauled from Brighton.

The original timber consisted mainly of oak and hickory and was removed by the process of cutting and burning. Almost as soon as the land was cleared wheat was planted. Little fertilization was needed at first, but after a few years animal manures came into use. The usual crop rotation for an individual field included, in the order named, corn, oats, summer fallow, wheat, and clover. Rotation was not rigidly followed. Yields of 30 to 40 bushels per acre were common. Many cattle and horses were kept, and the dairy products were sold along with other produce at Dexter and Hudson Mills, a gristmill on the Huron River not far from Dexter. Between 1870 and 1880 beef cattle and sheep began to assume considerable importance in the farm economy, and more hay was grown. Beans were planted each year, and the use of so-called “land plaster,” a lime fertilizer, became common. This material was brought to Dexter in rock form on the Michigan Central Railroad. Farmers were paid one dollar a ton for hauling the rock to the mill at Dover, farther up the Huron River. There it was crushed and sold for four dollars a ton. Great powers were attributed to this fertilizer, and the land was heavily cropped with wheat and beans in the belief that no harm would result so long as land plaster was freely used. Migrant la borers came to Dexter by the railroad at harvest time. Most of these men were Swedish or English and were paid 50 to 75 cents a day.

FIG. 20. Gully erosion in an idle field; Leo Farley farm, Putnam Township, Section 30

Between the years 1880 and 1890 the farm was rented, and the tenants planted beans and wheat in as great quantities as was possible in order to make a quick profit. Yields declined, and erosion, which had been noticed as early as 1870, began to be a real problem. The soil, which had never contained much organic matter, soon became seriously eroded on the steep slopes and continues so to the present day (Fig. 20). The agricultural practices of today are much curtailed in comparison with those of the past. Corn and beans are raised on the few remaining productive fields. No rotation or fertilization is practiced, and the yields are low. Money is obtained mainly by the sale of colts from a few breeding mares and the wool and meat produced from a flock of about 150 sheep. The present trading center is Pinckney.

Some ditch drains have been put in at the north end of the farm in a marshy plot of considerable extent. The well was originally hand-dug to a depth of 30 feet in sand and gravel, but in recent years has been drilled 30 feet deeper. This would seem to indicate a lowering of the water table. At its southern end the property borders Half Moon Lake and adjoins a real-estate subdivision. The present owner, feeling that there is little profit in the continuance of agriculture, hopes to sell at least this part of the farm for recreational development.

Eau Claire Land Type. F. and J. Marr Farm, Howell Township, Section 8. 150 acres in original plot (Fig. 21)

The grandfather of the two brothers now operating this farm bought it from the Land Office in Detroit in 1837. This family is of Scotch-Irish descent and originally emigrated from Europe to Toronto, Canada. The man who first came to Livingston County was a member of a dissenting political minority in Canada. He was jailed by the government for his actions, but escaped and fled to the United States. The family was reunited in Buffalo and soon after set out for Detroit by boat. They built a log cabin from local timber, and in 1865 made a contract for a house to be built of brick from a brick-yard directly across the road. Owing to a labor shortage because of the Civil War the contract was not fulfilled. The brick-yard was closed at that time and never reopened. In 1870 the present frame house was constructed from lumber brought from Owosso and Howell, and is now occupied by one of the Marr brothers; the other lives in a second frame dwelling built at a later date.

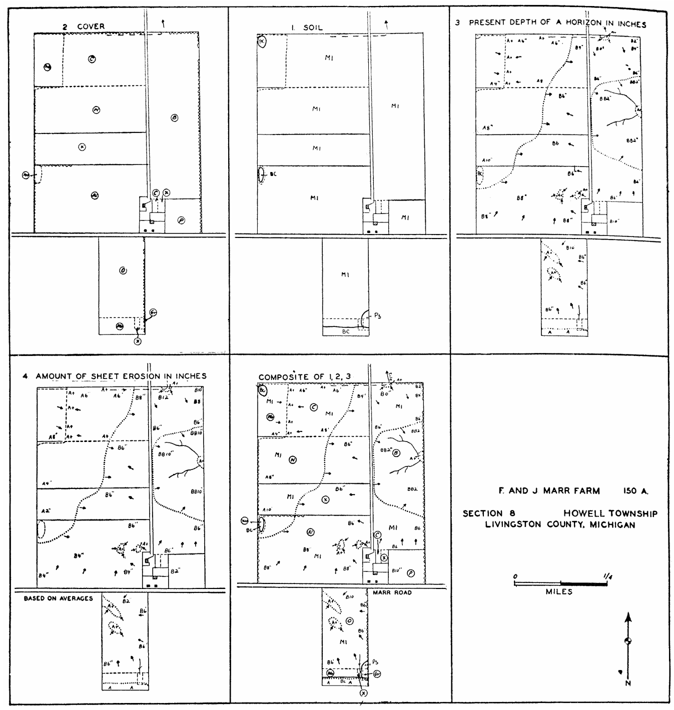


FIG. 21

The original trees, which were mainly oak, hickory, maple, and ash, were killed by girdling, the customary method. They were then cut and burned. Since 1900 several portable sawmills have been brought in. Most of the present timber is third growth. Wheat was planted immediately after clearing, and corn soon followed. Animal manures were used as fertilizer, and little attention was given to crop rotation. Yields were good, the wheat being sold at Dexter and at Hudson Mills. Some trade was carried on at Howell. During the early 1870’s beans and oats became an important part of the crop system. Because of the death of the father of the family in 1872 the land was heavily planted to cash crops, such as beans and wheat, in order that the heirs might be paid off by those who chose to stay on the farm. It was probably due to these practices that yields showed a marked decline about 1890. Land plaster was employed to some extent, but its use was soon discontinued because, in the opinion of the present owners, the results did not justify its cost.

An indefinite system of rotation is now customary. Generally two crops are grown, to be followed by a seeding to clover or alfalfa. The crops consist of corn, wheat, oats, and beans. Both hogs and cattle were raised until an epidemic swept through the stock a few years ago; since that time it has been impossible to maintain a healthy herd. Several horses and a flock of sheep are kept. The crops are fertilized by animal manures and some commercial fertilizer. With careful management the yields remain high. The principal markets arc Howell and Fowlerville. Most of the heavy work is done with the aid of two tractors. Additional family income is gained through the operation of a combine for hire.

Erosion has never been a serious problem on this land, though a few small gullies have been apparent for a number of years. They are easily kept under control by filling with sandbags and brush, which are covered with earth. Tile drains are employed at several places on the farm. The well was originally dug 35 feet deep and encased in wood. Later it was drilled an additional depth of 40 feet, seemingly because of a lowering water table.

Pipestone Land Type. C and E Green Farm, Deerfield Township, Section 25. 80 acres in original plot (Fig. 22)

Two brothers now occupy the farm, which was purchased by their grandfather from the Detroit Land Office in 1837. The family came from England to New York City and thence to Michigan, although the route traversed from New York is not known. A log cabin was built from local materials near a creek now called Cranberry Creek. Farming provided the main source of Mr. Green's income, which was supplemented by the sale of rye whisky made in a still near the creek. When the Government imposed a tax on such liquors this production was discontinued. Later a frame dwelling was built on the site of the log cabin. In 1906 the frame house in which the two families now live was built on higher land some distance from the creek.

The original trees were mainly oak. They were cleared by "cut-and-burn" method then common. Not all of the land was cleared, and as recently as the World War some virgin timber was available. Nearly 40 acres, about 350,000 board feet, were cut by a portable mill at that time. At least one half of this was white oak and was sold to the Government by the contractor for 80 dollars thousand feet. The lumber was hauled to Oak Grove by wagon and shipped by the Ann Arbor Railroad. Most of the timber on the land at present is second-growth oak and hickory.

Early crops were chiefly wheat, rye, and corn. Animal manures were used to fertilize the soil, and rotation was not practiced. Oxen served as draft animals. Howesburg, near the present town Cohoctah, was the leading trading center. About 1890 the owners began to grow beans in considerable quantities. Land plaster mixed with wood ashes was used as a fertilizer; according to Mr. Green, it killed cutworms in corn. Much seeding to clover was done, and the hay was fed primarily to the beef cattle, which by 1900 had assumed considerable importance in the farm economy.

The present-day crops are usually grown in the following rotation system: corn, oats, beans, wheat and clover or alfalfa seeding. Yields of 25 bushels of wheat and 100 bushels of corn to the acre are common. Commercial and animal fertilizers are used. A small herd of milch cows, two horses, sheep, and swine are kept. The heavy field labor is done with a tractor. Trading is carried on at Linden, Howell, and Fenton.

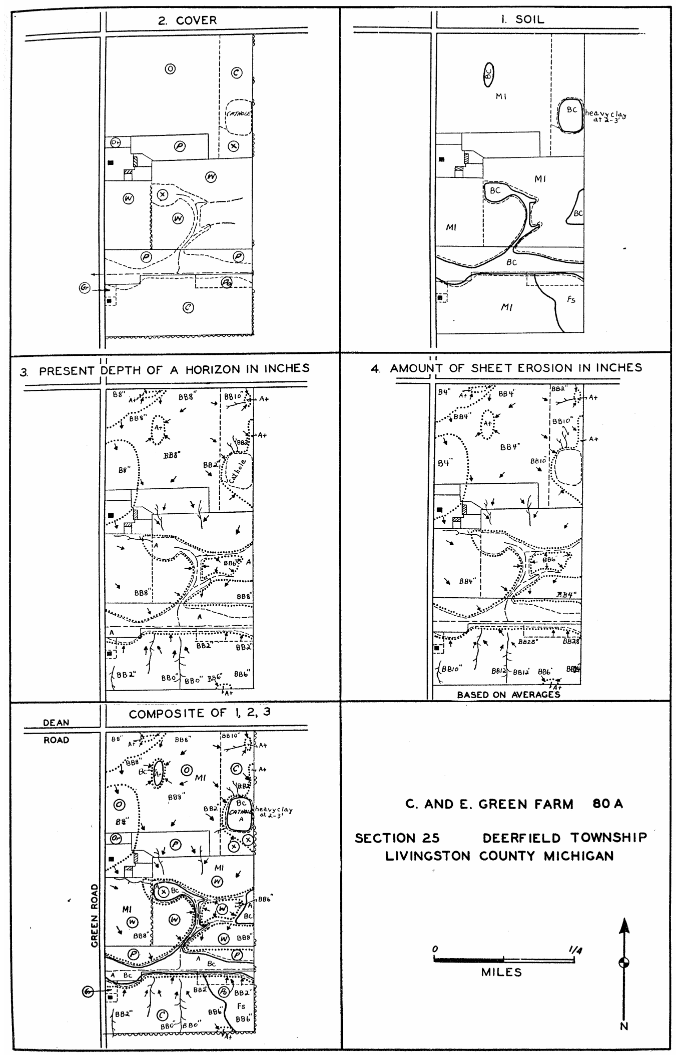


FIG. 22

Erosion first became apparent about 1890, but it has never been serious, and the gullies which formed were easily kept from enlarging by plowing earth into them. Both ditch and tile drains are employed. The well at the site of the homestead was hand-dug to a depth of 18 feet; later on a point was driven some 25 feet deeper. The creek is dry throughout much of the summer, and the water table apparently is at a lower level than formerly.

Fair Plain Land Type. Thomas Farley Farm, Marion Township, Section 26. 160 acres (Fig. 23)

This farm is located in a land type of limited extent Thomas Farley, the present owner, purchased the land in 1882, after it had been cleared and used for some years. The origin of the family is given in connection with the other Farley holding, in Hamburg Township, which is operated by Leo, Thomas' son (see p. 367).

Owing to the pitted land surface in this type agriculture is difficult. Sheep and beef cattle have been the main source of income in the past, with hay and corn grown to feed the animals. It should be noted that this was but the continuation of practices common to both Farley farms. At present, except for a small garden plot near the house, no agriculture is attempted.

Erosion is in evidence, but is scarcely active, being held in check by the native grasses and wild hay. No artificial drainage can be seen, and there are numerous catholes, many of which are dry toward the end of the summer. The original well was quite shallow, but when a new well was recently sunk it was necessary to go considerably deeper to obtain water.

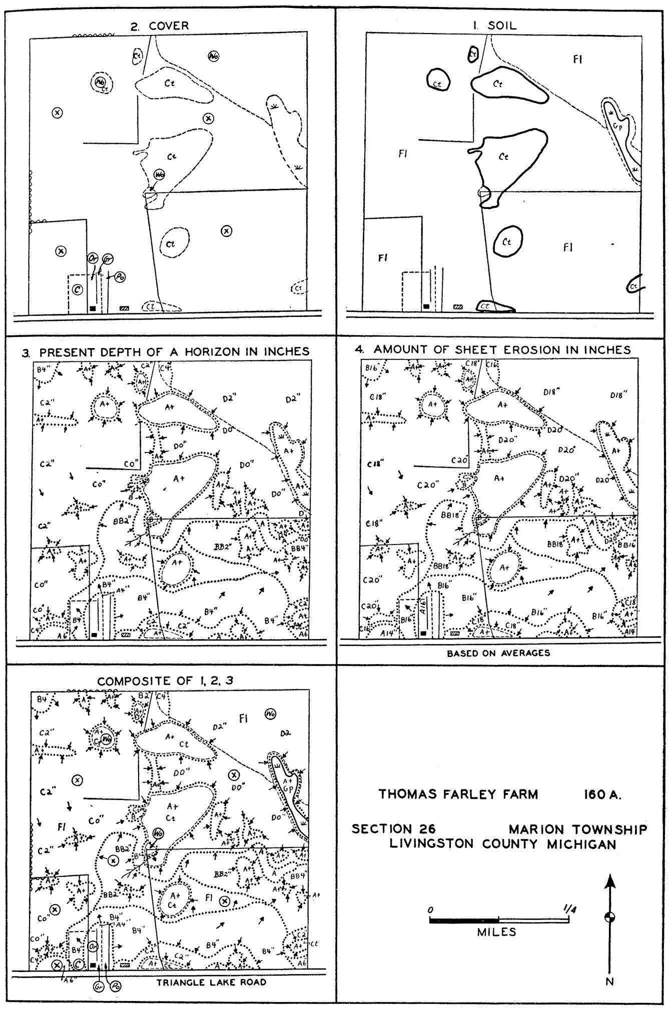


FIG. 23

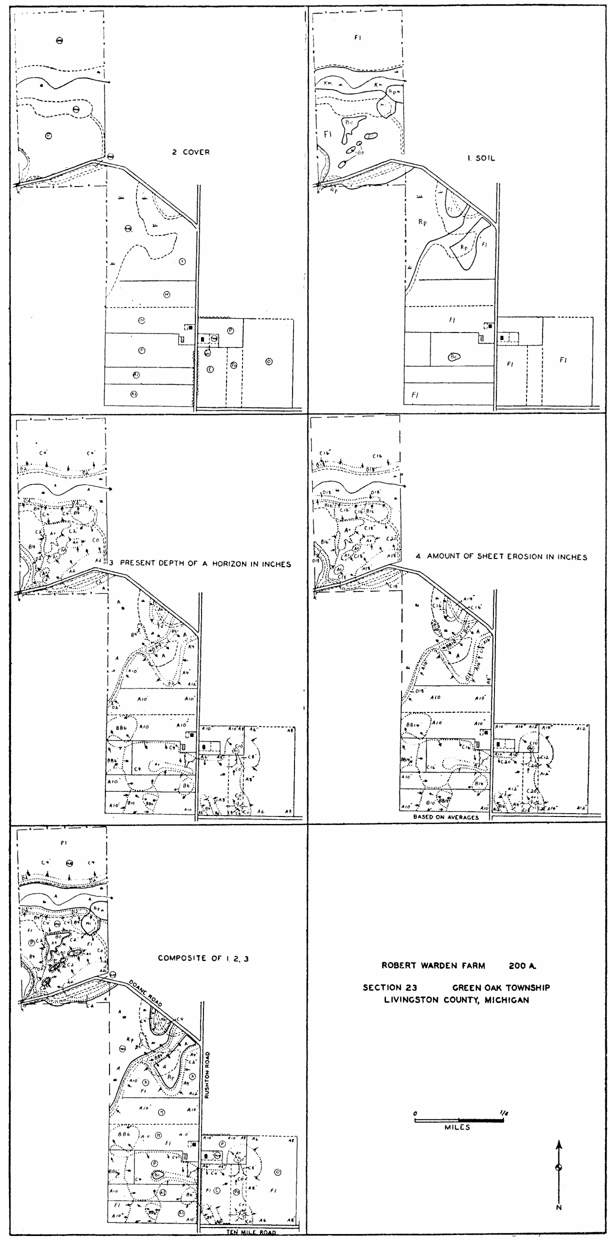


FIG. 24

Indian Lake Land Type. Robert Warden Farm, Green Oak Township, Section 23. 200 acres (Fig. 24)

The patent for this land was purchased from the Government in 1833 by a man interested in reselling it. Some few years afterward it was bought by the father of the present owner, who had emigrated from Scotland in 1832 and came to Michigan by horse and wagon by way of Canada, after having lived in New York State for a short while. The frame house, which was also the original homestead, was built in 1843 of local material.

The virgin timber consisted largely of oak trees, which were girdled and later cut and burned. Fires set by the Indians were frequent then, and considerable timber and marsh grass were destroyed at various times during the early period. A sawmill was built at Rushton in 1833 and another in 1838. Marsh hay played an important part in the early economy because it was useful for feeding until the land was cleared and “tame” hays could be established. The first crops were wheat, buckwheat, corn, and oats. No regular system of rotation was used, and the only fertilizer was animal manure. Wheat generally yielded about 30 bushels to the acre. Only a small number of livestock were kept; oxen served as draft animals. Ann Arbor was the trading center. About 1880 beans were raised in large quantities for the first time, and the land was fertilized by a mixture of ground lime and gypsum. This material was similar to the land plaster employed on farms in other parts of the county. Yields were beginning to decline at that time, and wheat had dropped to between 20 and 30 bushels to the acre.

Previous to the summer of 1939 Mr. Warden’s son, a graduate of Michigan State College, worked this farm. The rotation system was utilized, the crops being corn, oats, wheat, alfalfa, and some potatoes. The only fertilizer necessary to produce good yields was manure. A herd of milch cows was maintained, and a few horses were kept for draft purposes. Since the death of the son early in 1939 the land has been rented in accordance with the regulations of the Agricultural Adjustment Administration. South Lyons has been the trading center since the Pere Marquette Railroad was built through that town in 1871.

Some erosion is to be seen, particularly on the northern part of the farm, which is now used exclusively for pasture. Gullies were first noticed about 1885, but erosion has never been serious so far as agriculture is concerned. No artificial drainage is employed. The well, which is in gravel, is 29 feet deep and has never needed deepening.

Oakland Land Type. Ralph Glenn Farm, Unadilla Township, Section 17. 160 acres in original plot (Fig. 25)

This farm was taken up from the Government in 1840 by the present owner’s maternal grandfather, who was an Englishman. The family came by boat to Detroit, and thence to Livingston County by horse and wagon after the land had been duly inspected by the prospective owner. It was judged to be good for agriculture because of the prevalence of hazel brush, which supposedly was an indicator of good soil. The original home, built from local lumber, was a frame structure.

Oak and hickory were predominant in the original cover, which was cleared by the cut-and-burn method. A number of years ago considerable lumber was sawed at a mill in Plainfield. The last mill to do any sawing in this section was a portable one, which was moved out about 15 years ago. Wheat was the first crop to assume any commercial importance on this farm. Average yields were about 40 bushels an acre. Beans and timothy hay were also grown, in rotation with wheat. At first Dexter was the main trading center, but later Stockbridge rose to primary importance as a place of business for these people. As time passed clover and alfalfa were grown in place of timothy; beans were planted in large quantities in the late 1870’s.

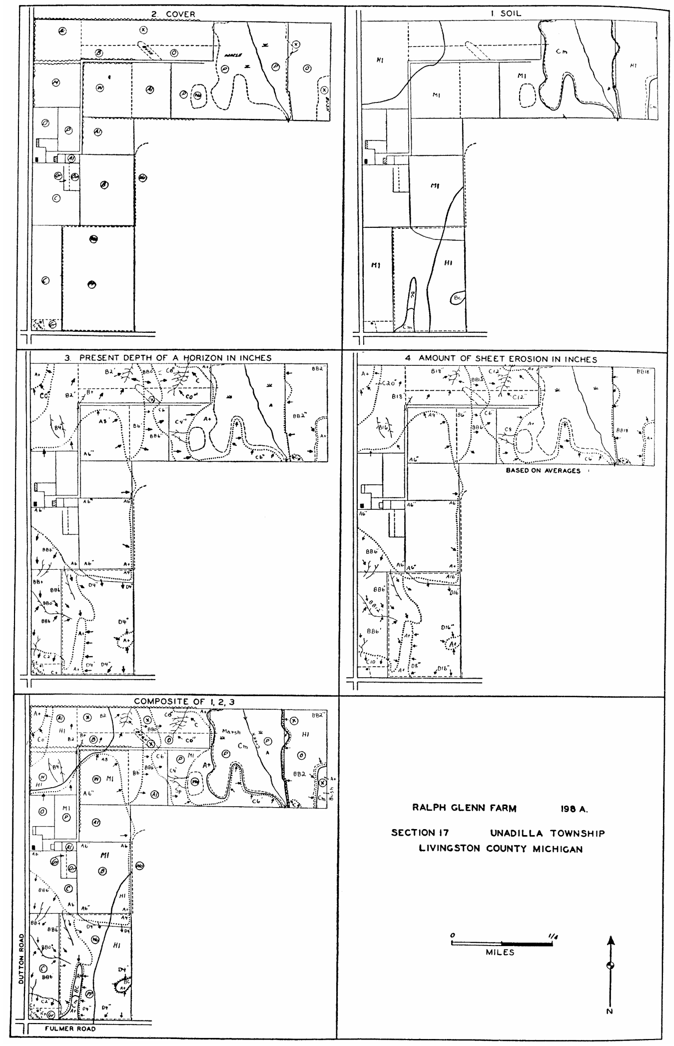


FIG. 25

The cropping system of today rotates corn with oats and wheat. Beans instead of wheat are sometimes planted after oats. Much alfalfa and clover are grown; occasionally these crops are allowed to remain in the soil for the winter, after which they are plowed under. The wheat yields well, usually 30 to 35 bushels an acre. Commercial fertilizer is employed almost exclusively. A tractor supplies power for the plowing and other field preparation. A herd of dairy cattle is maintained, and sheep are kept chiefly for their wool. Stockbridge remains the trading center. The farm is managed in accordance with the program of the Agricultural Adjustment Administration.

Gully erosion was first noticed about 1880, but preventional methods were not taken until some time later. Plowing-in of gullies and retirement of gullied areas from cropping now prevent further erosion. Practically no artificial drains are used. The well at the house is 15 feet deep.

Beebe Land Type. Steinacker Farm, Genoa Township, Section 3. 80 acres (Fig. 26)

The present owner's father bought this farm from the man who took out the land patent. The family came to this section directly from Germany by way of New York City, Lake Erie, and Detroit. The first house was a log cabin, which was later replaced by a frame house built from lumber supplied locally. After it burned some years ago the present frame structure was erected.

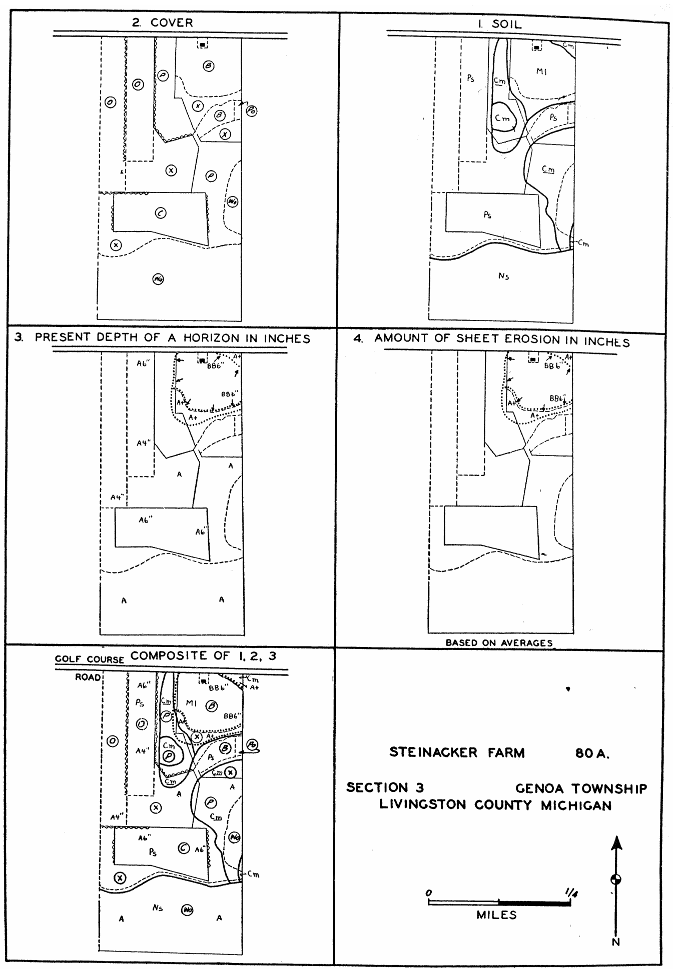


FIG. 26

The original timber was chiefly of the swamp type, but some oak and hickory grew in the drier places. The clearing was accomplished by cutting and burning. A sawmill was built near by in the town of Howell, and portable mills were brought in at various times for the cutting of local timbered areas. Owing to the nature of the soil and surface only 30 of the 80 acres on this farm are useful for agriculture. Some member of the family has always worked elsewhere to supplement the income from the land. Early practices included the growing of rye, oats, and corn. Manure was used to fertilize the soil, and oats yielded about 50 bushels per acre, with corn aver between 60 and 70 bushels. About 1870 land plaster served as a fertilizer along with manure. Beef cattle and sheep were grazed on the marsh hay. Family income was increased by selling eggs at Howell, the market place.

Of recent years farming has become even less important on this land. The owner is too old to be active, and his son obtains part-time employment elsewhere. Beans, corn, oats, and hay are grown in accordance with the stipulations of the farm program of the Agricultural Adjustment Administration. Small amounts of commercial fertilizer are used as they can be afforded. One horse, one cow, and a flock of chickens for the Howell market constitute the livestock. Drainage is greatly needed, since 50 of the 80 acres are poorly drained. There is no noticeable erosion. The well was first hand-dug to a depth of 15 feet and later deepened by driving a well-point an additional 17 feet.

Mapes Land Type. Guy Bradley Farm, Iosco Township, Section 20. 150 acres (Fig. 27)

The early ownership history of the farm is not known. The father of the present owner came to this section about 1850. He bought a 160-acre farm near by and continued to purchase land until at one time he owned 1,200 acres, of which the present 150-acre farm was a part.

The original cover on this land, largely oak, was cleared by the cut-and-burn method. Early crops were wheat, corn, and clover, which were fertilized by animal manures spread on the soil by hand. Fowlerville, the trade center in the early days of settlement, has remained so to the present day. Changes from early practices in agriculture included a great increase in bean growing in the 1880's. Dairy cattle and sheep became increasingly important, and a cheese factory was established locally in the late 1880's, only to be changed to a bean-grading factory within a few years. Land plaster was the fertilizer during this period.

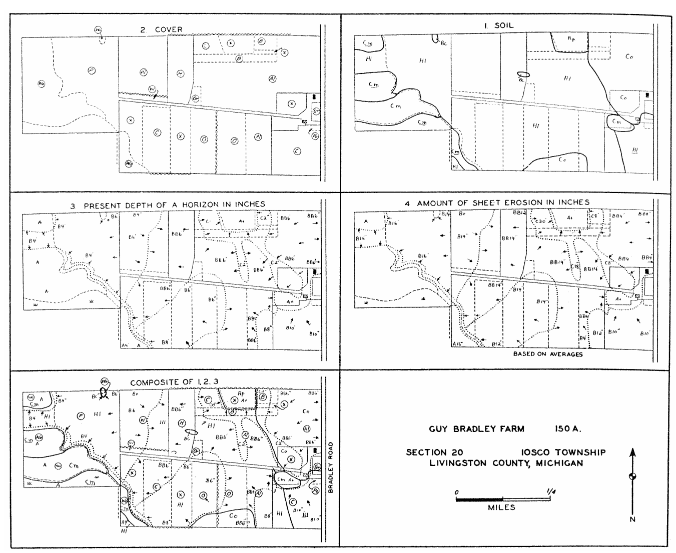


FIG. 27

Today land use includes the rotation of corn, oats, summer fallow or beans, wheat, and alfalfa or clover in the order mentioned. Commercial and animal fertilizers are applied to the soil, but yields are not high. Twelve to 15 bushels of wheat to the acre are usual, and corn generally produces about 50 bushels to the acre. Mules and horses are used for draft purposes, while a herd of milch cows is maintained and some sheep and swine are raised.

Erosion never has been particularly noticeable on this land, but the few gullies that develop are plowed in with earth each spring. Where has been only a small amount of artificial drainage. The house well has been drilled to a depth of 150 feet; a stock well near the barn about a hundred yards distant is only 9 feet deep.

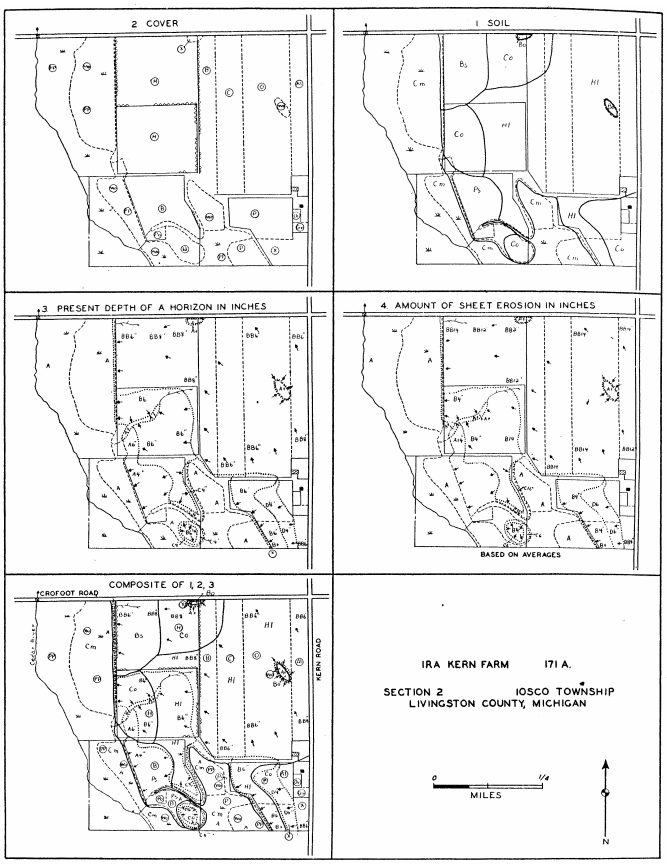


FIG. 28

Cedar River Land Type. Ira Kern Farm, Iosco Township, Section 2. 50 acres in original plot (Fig. 28)

The family of the present owner of this farm did not originally settle or clear the land. The 171 acres shown on the map have been owned by the Kern family only since the late 1800's, but the land-use history of this area was familiar to the individual interviewed. The original living quarters were built from logs cut near by. Later a frame house was constructed.

Oaks, which comprised the original tree cover to a great extent, were cleared by cutting and burning. For a number of years a saw-mill was located within a mile of the farm. In the days of early settlement wheat was the most important crop. Small amounts of manure were used as fertilizer, and rotation was given much attention. Wheat yields were about 40 bushels to the acre and corn about 100 bushels. Livestock was kept only in small numbers, mainly for the use of the family. Wheat was taken for grinding to Birkett's Mill on the Huron River near Dexter. Howell served as a trading center. About 1890 changes occurred in the farm economy with the planting of beans in larger amounts and the use of land plaster as a fertilizer. Sheep and beef cattle increased in numbers.

Tenants now occupy the farm, but the cropping system is carefully observed by the owner. Rotation is in the following order: corn oats, sometimes beans, and wheat. Seeding to alfalfa follows either the wheat or the oats. Yields of 25 to 30 bushels of wheat and 50 to 60 bushels of corn per acre are general. Dairy cows, beef cattle, and sheep are pastured on the abundant marsh grasses. The trade centers are Howell and Fowlerville. A few horses do the lighter labor, but a tractor is used for the heavier field work.

Not much erosion has ever been noticed. The Cedar River was dredged some thirty years ago, and the land is quite well drained, except for the lowland pasture. A small amount of tile drain has been laid. The well, which was originally hand-dug for 30 feet, has since been deepened 70 feet. Mr. Kern feels that the dredging lowered the water table and so caused the lowland muck areas to become dry. These lowland areas formerly provided a large amount of marsh hay and good pasture.

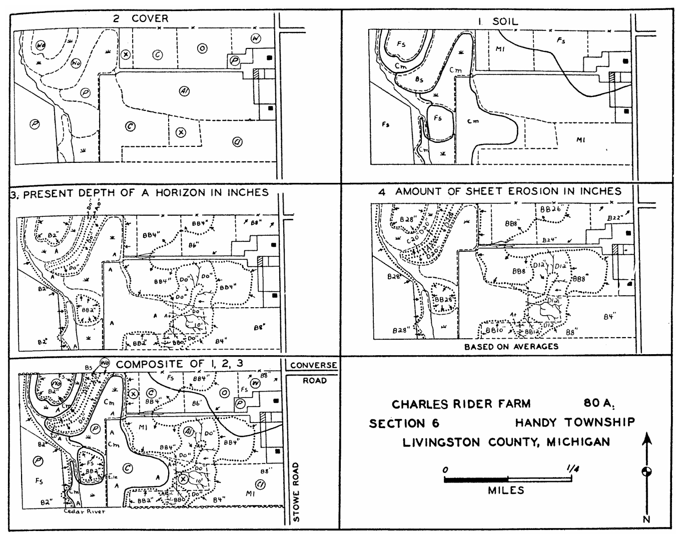


FIG. 29

Croupe Land Type. Charles Rider Farm, Handy Township, Section 6. 80 acres in original plot (Fig. 29)

The Rider family came to Detroit by boat from New York State in 1833, first settling in Oakland County. In 1835 they moved to Genoa Township in Livingston County, from which place the father of the present owner moved when he purchased this farm in 1870. The land patent was taken up in 1843 and passed through other hands before coming into possession of the Riders. During this time the land had remained uncleared except for two acres planted to wheat, but a few trees had been girdled. A log cabin built of local materials was replaced by a frame house in 1889. The lumber, white pine, came from Flint, where it cost 13 dollars a thousand board feet. Within the next year the price of similar lumber rose to 23 dollars a thousand feet. Mr. Rider and his son jointly manage the farm. The son occupies the old house; his father lives near by in a newer one.

The original forest was mainly of oak. Most of it was cut down and burned to start the clearing process, but later some of the better remaining timber was sold to the sawmill in Webberville for 10 dollars per thousand feet. As soon as the land had been cleared, corn, oats, wheat, and clover were planted in a rotation system in the order mentioned. Land plaster and manure constituted the fertilizers, and the yields seem to have been somewhat higher than at present. Many of the farmers had great faith in the powers of land plaster, believing that “you could write your name on the field with ‘plaster’ and later see it in the crops.” Horses and oxen were used for all draft work, and livestock was raised to sell in the Detroit market. In the early days the meat was hauled to Detroit in a wagon drawn by oxen. Wheat was taken for grinding and sale to Dover on the Huron River. Trade was primarily at Fowlerville.

Corn, oats, and wheat now follow one another in the planting system. Beans are sometimes grown before wheat and seeding to clover or alfalfa usually follows the wheat harvest. Manure and commercial fertilizer were used until 1936, when the latter was discontinued because of its expense. Yields of corn remain fairly constant at 80 to 100 bushels an acre. No dairying is practiced, but in the spring of 1939 forty steers were purchased in Iowa to be fattened for the market. The principal center of trade is still Fowlerville.

Gully erosion became apparent soon after the land was cleared. No preventive measures were taken at that time, but for a number of years corn stalks have been thrown into the worst gullies and covered with earth. Since the gullies have lately become larger it is planned to retire the worst areas from cropping and to seed them with hay. Power is obtained primarily through the use of two tractors. Some tile drains have been introduced where needed. Previous to the dredging of the Cedar River in 1916 there was considerable standing water throughout the early summer of each year, but since then surface water remains only during the early spring. The first well, which was hand-dug, was stoned to a depth of 35 feet, but it has lately been drilled an additional 75 feet.

Conway Land Type. Ronald Stuible Farm, Conway Township, Section 1. 211 acres (Fig. 30)

The major part of this farm was purchased from the Government Land Office in 1837. It came into the Stuible family about 1880 through its sale to the grandfather of the present operator. The family is of German origin, but no information is available concerning the route by which they came to Livingston County. The first dwelling was of the usual log type, of local timber. Not long after the Stuibles settled on the farm they built the frame structure which is still in service, although it has been remodeled since that time.

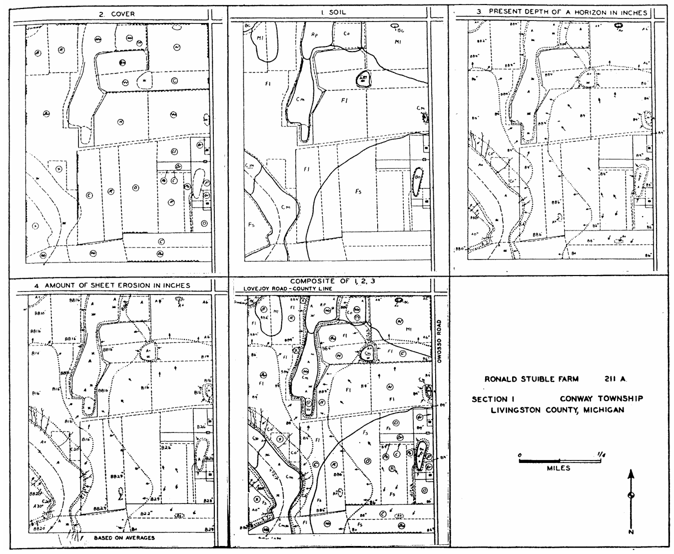


FIG. 30

In the days of early settlement the trees were mostly oak and hickory. Clearing was done by cutting and burning. A sawmill in Cohoctah (then also known as Sprungtown) provided a market for the better timber. Later portable mills were brought into the area at various times. Wheat, oats, corn, and timothy-clover hay were planted with no particular attention to rotation and without any fertilizer. Yields were somewhat higher than are those of today; 40 bushels of wheat and 60 to 70 bushels of oats per acre were common. Sheep and a few dairy cattle were raised. The town of Bancroft in Shiawassee County served as the principal trade center. Dairy cattle and beef stock became more numerous as transportation facilities developed. During the last decade of the nineteenth century land plaster was used along with manure for fertilizer.

Today crop rotation is carefully followed in the planting system. The usual order is corn, oats, wheat, and alfalfa or clover, but sometimes beans are planted before wheat. Rye or buckwheat occasionally replaces the other grains. Of late years both animal and commercial fertilizers have been employed, with the yields remaining at about 25 and 35 bushels an acre for wheat and oats respectively. Only a few animals are maintained; the field work is done almost entirely by power machinery. The farm income is supplemented by the operation of a combine during the threshing season. Most of the trade is carried on at Howell or Fowlerville.

A few gullies have been noticed on the steeper slopes since about 1900. The worst ones have been checked successfully by filling them with straw and earth, and the immediate area has been retired from cropping. Both ditch and tile drains are used, but there is considerable standing water in the marshes during the spring and early summer. The well, which was drilled to a depth of 80 feet, has never been deepened.

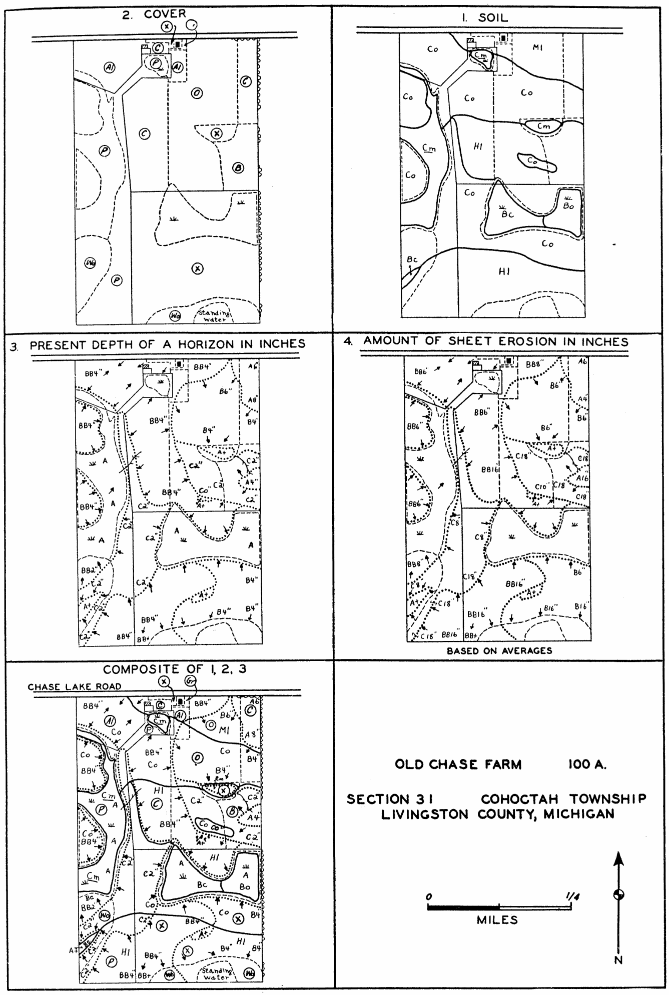


FIG. 31

Oak Grove Land. Type Old Chase Farm, Cohoctah Township, Section 31. 100 acres in original plot (Fig 31)

This land was taken up from the Government in 1834 by the grandfather of the man who was working the farm in 1920 and who owned the farm adjoining. The family, which originated in England, lived in New York State for some years. It came to Michigan by the land route along the south shore of Lake Erie. In 1920 the farm was sold outside the family. Tenants have been operating it for the last twenty years. In 1834 a log cabin was built, but not many years had passed before a frame house was erected. That has since been replaced by another wooden building, in which the present tenant now lives.

White oak, red oak, hickory, and maple constituted the bulk of the virgin vegetation, which was cleared by the usual cut-and-burn method In the days of first settlement there was little lumbering, but later the better white oak brought a good price and was sawed by portable mills. In the early period crops were mainly wheat and corn. Neither rotation nor fertilization was practiced. The wheat was drawn to Birkett's mill on the Huron River, and Howell was the chief trade center. Few animals were raised, but by the late years of the nineteenth century the breeding of both dairy and Hereford cattle had become an important part of the farm economy. Land plaster was used for fertilizer, and beans were planted each year as a cash crop. They usually produced 10 to 15 bushels to the acre soon after their introduction.

In recent times no rigid system of rotation has been practiced. Generally corn, oats, wheat, and hay follow in order, with beans occasionally planted before the wheat. Commercial fertilizer and manure are employed to enrich the soil, but yields have declined. Wheat produces so poorly that it is scarcely worth while to attempt to grow it. Oats, which constitute the main cereal crop, yield 25 to 35 bushels per acre. A herd of milch cows is kept, and 50 pigs are being raised for sale. Howell is the present trading center.

About 1900 gully erosion became noticeable, but little was done to prevent it. Few gullies are to be seen on the farm at present since earth is plowed into them as they form. The first well, which was dug by hand to a depth of 30 feet, has been deepened an additional 90 feet by drilling.

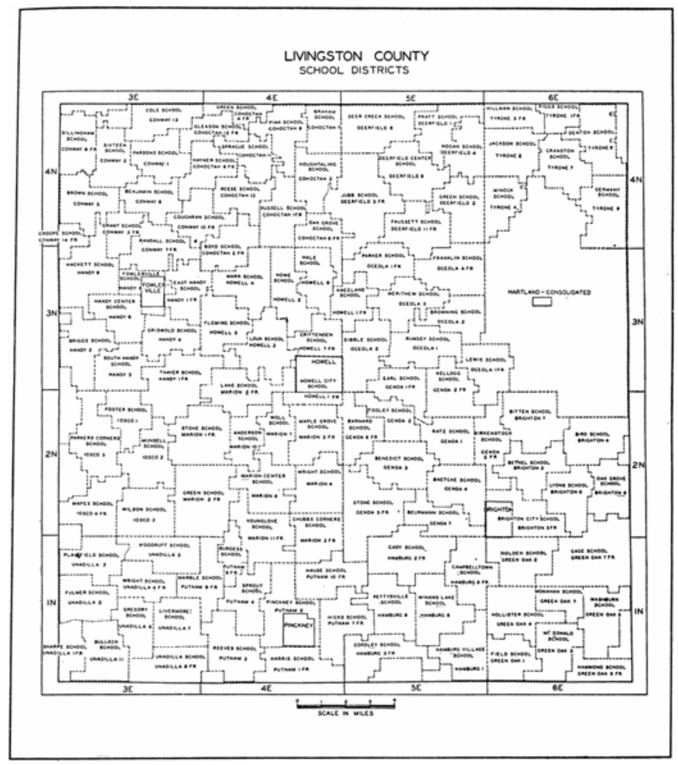


FIG. 32

RELATIONSHIP BETWEEN LAND TYPES AND TAXATION

It is a recognized fact that the farmer has been heavily burdened by taxation. Most of it is in the form of a property tax based on the assessed valuation of his land. "The adoption of the 15-mill constitutional tax rate limitation amendment, the transfer of township roads to the counties and the almost complete shift of the support of rural highways from the property tax to motor taxes, the elimination of the state levy on property, the forced reduction of other property tax levies, the remarkable expansion in state aid for education and welfare purposes, and the forced imposition of the 3-per-cent retail sales tax and other new sources of revenue are some of the changes occurring during the depression that warrant the statement that there has been a tax revolution in Michigan."[5]

As an example of the verity of the foregoing statement school-tax statistics have been used. They are levied on the assessed valuation of property within each school district[6] (Fig. 32). Data on assessed valuation and the tax rate were gathered for six years of the period from 1927 to 1938. By comparing Figure 33 with the land-type map (Fig. 17) it can be seen that the real tax load has fallen on the farmers in the poorer land types, where the land values are lowest. It costs nearly as much to maintain a school in a district composed mostly of poor land as it does in one having mostly valuable land. Thus the farmers whose income is lowest pay a greater percentage of their earnings in school taxes than do their more wealthy neighbors.

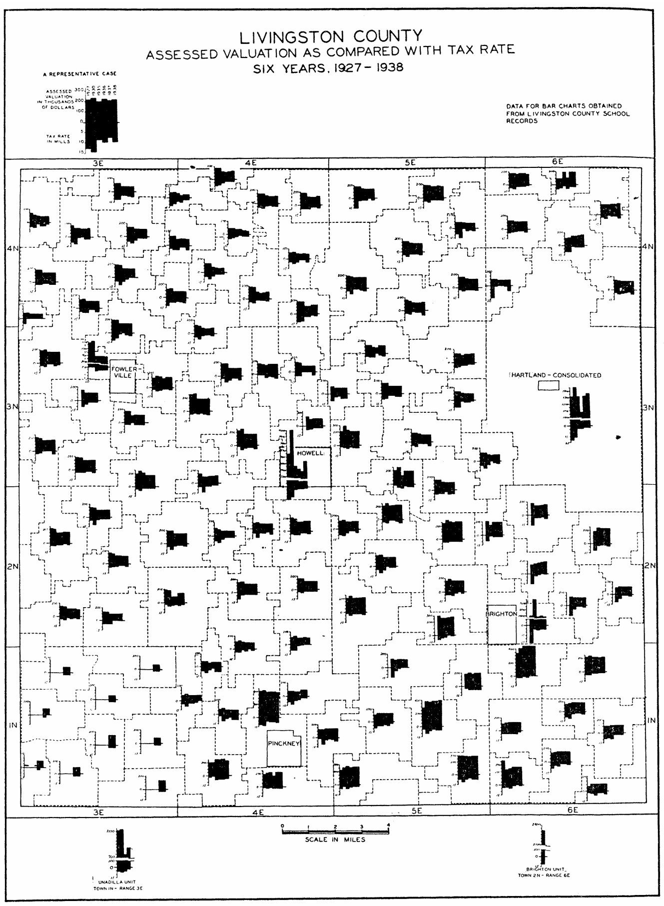


FIG. 33

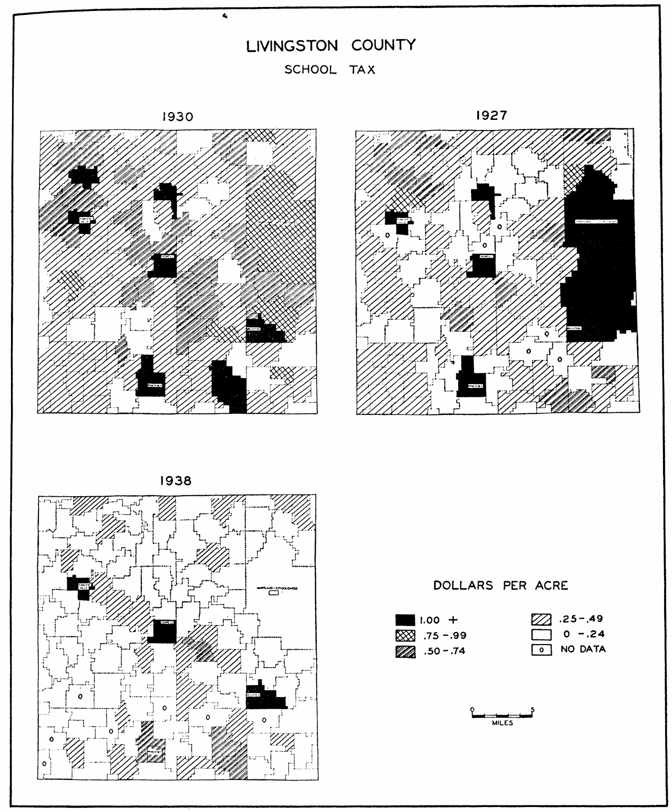


FIG. 34

Choosing three years from the assessment figures the writer carried this investigation further by computing the school tax for each district in dollars per acre (Fig. 34). The year 1927 was selected to represent conditions during predepression years; 1930, to show conditions in the early days of the depression; and 1938, to illustrate the present situation. Districts within the Conway land type in the northwestern part of the county will serve as an example. Agriculture is generally poor in that land type, yet school taxes in several of its districts for the years 1927 and 1930 fall in the relatively high-level group of 50 through 74 cents an acre. Except for areas affected by urban schools similar observations may be made in other parts of the county. It is true that there are places within the better land types which also have a high tax rate. Due consideration must be given, however, to the fact that incomes from farms in these better types far exceed those gained from farms within types less suitable for agriculture. The conclusion is that the tax load was unjustly apportioned. By 1938 the situation was somewhat improved. The map for that year (part of Fig. 34) indicates that taxes are greatly lower over the whole county. Most of the poor land types are now in the low-tax group, whereas land of high agricultural value is in most of the remaining high-tax groups.

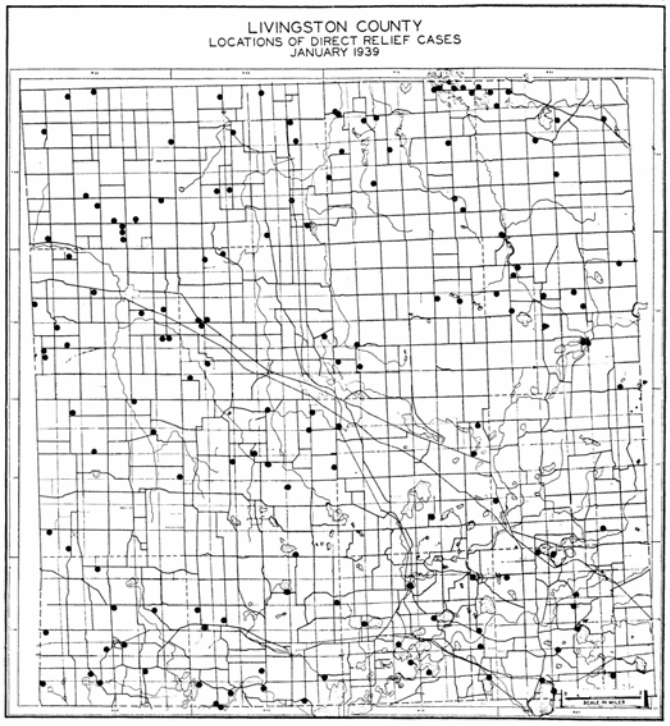


FIG. 35

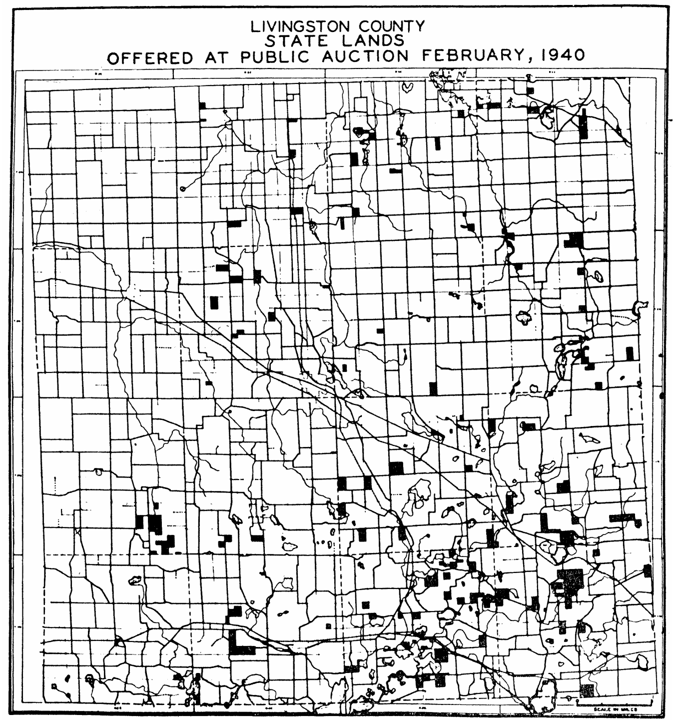


FIG. 37

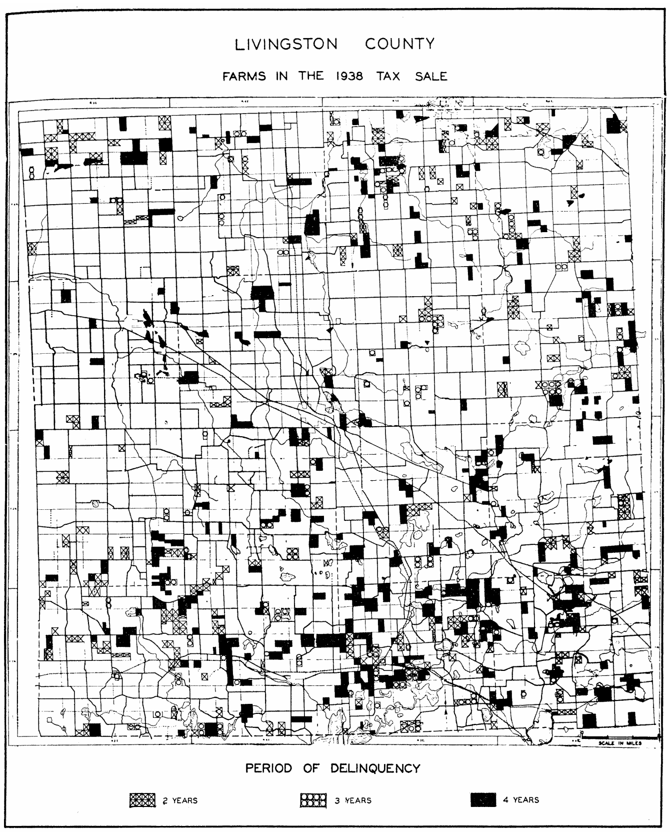


FIG. 36

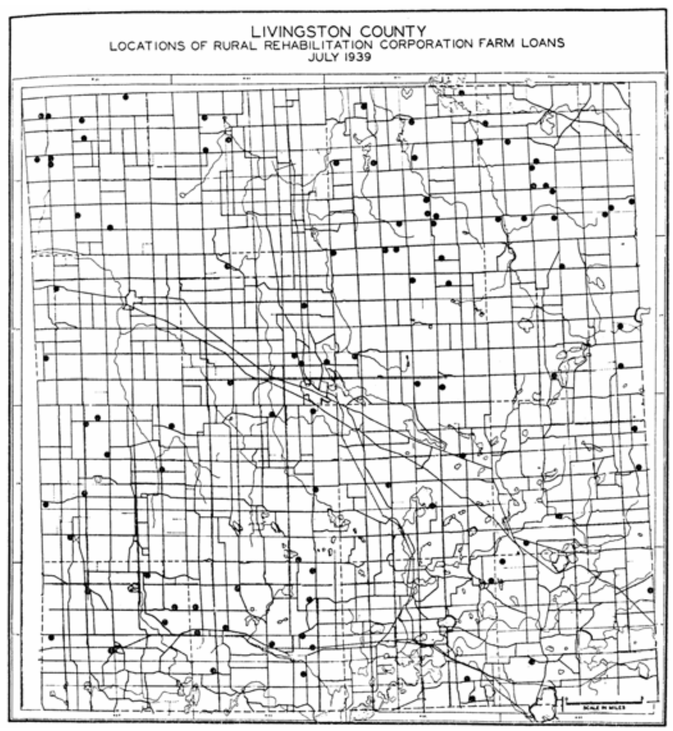


FIG. 38

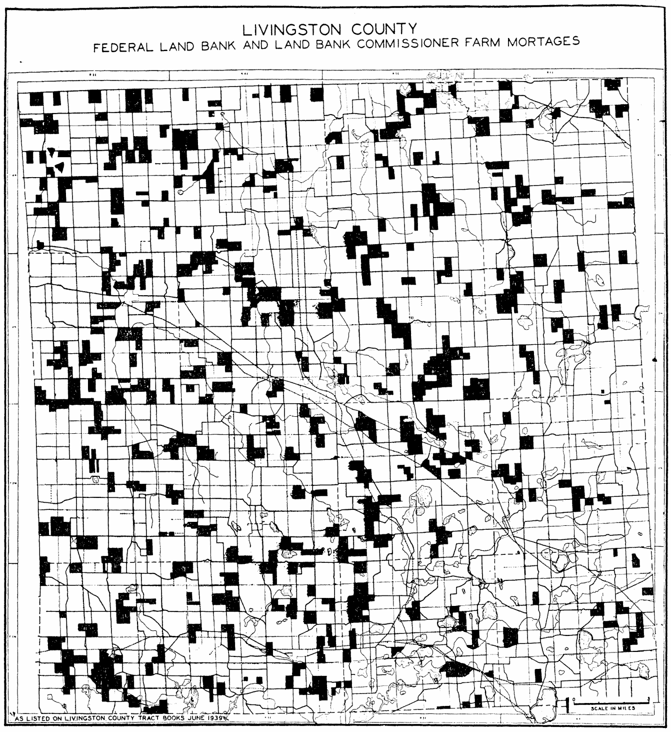


FIG. 39

RELATIONSHIPS BETWEEN LAND TYPES AND FINANCIAL ASSISTANCE TO FARMERS

Even when agricultural produce commands high prices the individual on poor land finds himself at a disadvantage in competition with his more fortunate neighbors. In a number of the Livingston County land types the possibilities of agricultural production are greatly limited. With unfavorable climatic conditions or economic depressions, such as the one just past, the farmers on poor land often find themselves in serious financial straits. A comparison of the map showing direct-relief cases (Fig. 35) with the land-type map (Fig. 17) makes the situation clear. It is true that these cases are not all confined to the farming population. Nevertheless, they are at least fairly representative of the distribution of rural people who are in particularly poor financial condition.

Perhaps more significant is the distribution of rural tax delinquency as indicated by the maps of farms in the 1938 tax sale (Fig. 36) and of state lands offered at public auction in February, 1940 (Fig. 37). Supplementing these illustrations are two maps showing farmland which is under financial obligation to at least one of three federal agencies. Figure 38 records distribution of rural rehabilitation farm loans during the summer of 1939; Figure 39, the locations of mortgages held by the Federal Land Bank commissioner in the summer of 1939. Here again can be seen the recurring pattern of conditions within the poorer land types. Table I will serve to emphasize with actual figures relationships revealed by the maps.

TABLE I

FARM MORTGAGES OF THE FEDERAL LAND BANK AND THE LAND BANK COMMISSIONER

Township	No. of acres in farms	No. of acres covered by mortgages	Percentage of acres covered by mortgages	Assessed valuation of rural land	Amount of F. L. B. mortgages	Amount of F. L. B. C. mortgages	Total amount of mortgages	Percentage of assessed valuation in both kinds of mortgages
Unadilla 1 N. 3 E.	22,023	3,695	16.8	$ 564,650	$ 65,300	$ 26,600	$ 91,900	16.2
Putnam 1 N. 4 E.	21,927	3,264	14.9	693,450	60,400	17,500	77,900	11.2
Hamburg 1 N. 5 E.	21,638	2,182	10.1	1,115,475	34,200	14,200	48,400	4.9
Green Oak 1 N. 6 E.	21,009	1,112	5.3	1,143,700	14,800	11,500	26,300	2.3
Iosco 2 N. 3 E.	22,331	2,796	12.6	663,900	41,500	12,600	54,100	8.2
Marion 2 N. 4 E.	22,600	2,434	10.8	741,325	39,500	29,600	69,100	9.3
Genoa 2 N. 5 E.	21,895	3,695	16.9	1,152,300	70,400	20,900	91,300	7.9
Brighton 2 N. 6 E.	20,209	1,443	7.1	1,025,300	19,500	15,100	34,600	3.4
Handy 3 N. 3 E.	21,067	4,172	19.7	1,497,220	113,600	48,200	161,800	10.8
Howell 3 N. 4 E.	20,840	3,681	17.7	934,350	65,300	33,500	98,800	10.6
Osceola 3 N. 5 E.	23,289	3,908	16.8	890,900	68,500	33,900	102,400	11.5
Hartland 3 N. 6 E.	23,456	2,190	9.4	791,700	51,500	13,100	64,600	8.2
Conway 4 N. 3 E.	23,930	4,037	16.9	863,700	81,600	47,800	129,400	14.9
Cohoctah 4 N. 4 E.	24,450	2,899	11.8	878,200	70,700	32,800	103,500	11.8
Deerfield 4 N. 5 E.	23,505	3,237	13.8	727,900	59,800	32,200	92,000	12.6
Tyrone 4 N. 6 E.	22,257	2,595	11.7	679,850	51,800	21,500	73,300	10.7
COUNTY	356,426	47,340	13.0	$14,363,920	$908,400	$411,000	$1,319,400	9.2

SUMMARY

Agricultural problems in Livingston County, Michigan, are due not only to the qualities of the land itself, but also to the uses to which the land has been put and to the ways in which it has been exploited or abused. The history of settlement is but a prelude to the more intensive study of the development of agriculture and of its problems. This history is readily reconstructed from the records of actual settlement in the early part of the nineteenth century. The origin of settlers is inferred from house types and confirmed from local histories and the tract book of the General Land Office. Subsequent improvements and changes in houses are related closely to the sequences of agricultural practices which have been outlined in Part II of this paper. The development of erosion and concomitant changes in land use have resulted in the present impoverished codition of agriculture in much of the county. It has been shown, too, that taxation has played an important role in this history. The story is not completed here, but the materials presented may aid in the formulation of plans for the better use of the land and for an integration of the farmers of Livingston County in an economy for the United States as a whole that will give them a better living than has been possible in the recent past.

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† EDITORS' NOTE — The untimely death of Mr. Dick on October 28, 1939, occurred while he was engaged in writing a report on a study of Livingston County, Michigan, as a part of his work for the doctor's degree in geography at the University of Michigan. His notes have been collected and the present account edited by Professor Stanley D. Dodge and Mr. Stanton J. Ware.

[1] Ellis, Franklin, *History of Livingston County, Michigan*, p. 22. Philadelphia, 1880.

[2] Dick, W. B., and Ware, S. J., "A Land-Type Map of Livingston County, Michigan," *Pap. Mich. Acad. Sci., Arts, and Letters*, 25 (1939) : 373-384. 1940.

[3] For further information on the method of classification see J. O. Veatch, *Agricultural Land Classification and Land-Types of Michigan*, Agric. Exper. Sta., Michigan State College, Spec. Bull. No. 231, April, 1933; and "Classification of Land on a Geographic Basis," *Pap. Mich. Acad. Sci., Arts, and Letters*, 19 (1933): 359-365. 1934. Seven of the twelve land types had previously been mapped in adjacent Oakland County by J. O. Veatch and N. L. Partridge. The numbers and names used by them are followed in the Livingston County mapping.

[4] The averages were obtained through reference to the original Soils Survey of Livingston County and through consultation with Professor J. O. Veatch, of Michigan State College

[5] Cline, Denzel C., *Michigan Tax Trends as Related to Agriculture*. Agric. Exper. Station, Mich. State College, Spec. Bull. No. 301 (Feb., 1940), p. 77.

[6] The school-district map was constructed by means of material collected by H. T. Smith, "A Survey of Educational Factors of Livingston County as a Basis for Possible Reorganization." This is a master's thesis, still in manuscript, presented to the School of Education, University of Michigan.

EARLY MAPS OF ANTARCTIC LAND, TRUE AND FALSE*

WILLIAM HERBERT HOBBS

IT HAD not been my intention to make reply to the twenty-one-page review by Dr. A. R. Hinks[1] of my monograph on Antarctic discoveries.[2] My view has been, and still is, that the matters treated have been fully covered by me in the original monograph, the half-page erratum sheet for minor corrections issued soon after, and two articles subsequently published.[3] I see no reason to alter because of the review my statements concerning any of the vitally important matters which were discussed. I make reply only to the charges of falsification.

At the top of page 311 of the review Dr. Hinks states: "Professor Hobbs begins by attributing to Bransfield first a share in and later the full authorship of the indifferent map . . . which Foster drew in January 1820 at Valparaiso to illustrate the discoveries of William Smith in 1819. It is so clear that Bransfield had nothing to do with this map that the attempts to father it upon him and the pretence that it represents his voyage in the *Williams* of January and February 1820 must be called deliberate misrepresentation."

Further (p. 313), Dr. Hinks cites as the title of this map: "A View of the Land Discovered by William Smith of the Brig Williams of Blyth Feby. 1819 and taken possession of in the name and on behalf of His Britannic Majesty George III and called New or South Shetland. Henry Foster, Mid^{n} H.M.S. Creole Jany. 1820 . . . ." He later adds: "Professor Hobbs reproduces the map on his Plate I (top), ignores the title, signature, and date January 1820, and labels it Map of the South Shetland Islands by Smith and Bransfield 1819 and 1820."

The title cited refers to a "view" by Foster on the same sheet as the map. This, and not a desire deliberately to misrepresent, was my reason for ignoring it, with its signature and date. It is not definitely known who drew the original map of which this is possibly a copy with notation in the handwriting of Foster,[4] but it corresponds with that authorized for publication in the reports[5] of Smith's cruise, and it can be referred to as the Smith map or, for reasons given below, the Smith-Bransfield map. In the introduction to the extracts which were published in the *Literary Gazette* it is stated that these extracts came in a packet sent from Buenos Aires, and that "There was a map with the packet, but it appears, (with the exception of Dalrymple's chart) to be similar to that in Brewster's Philosophical Journal,[6] *which may be referred to*."[7] Dr. Adam Young also, in his authentic account of the Bransfield cruise, *made use of this same map for reference in place of publishing any new map*, and as there is no other published map of the Bransfield cruise, I have called it the Smith-Bransfield map, for Young's account indicates that the Bransfield cruise was made to confirm Smith's discoveries.

The authentic account of the Bransfield cruise was written by the medical officer of H.M.S. *Slaney* (Young) and was completed at Valparaiso May 26, 1820, or shortly after his return from the cruise (April 14). It was published in the *Edinburgh Philosophical Journal*.[8] There has never been any question of the authorship, and it is stated in the article that Young accompanied the expedition as its medical officer.

This Smith-Bransfield map has been reproduced in many atlases subsequent to the publication of Young's report, and in all these the land mass or continent described is called New South Shetland. Among these publishers were Brué, Paris, 1821; Arrowsmith, London, 1821; Tanner, Philadelphia, 1821 and again in 1823; Stieler, Gotha, 1822; Reichard, Nuremberg, 1822 and again in 1825; Schou, Copenhagen, 1822; Reimer, Berlin, 1824; Weiland, Weimar, 1824; Finely, Philadelphia, 1824; Lichtenstein, Berlin, 1825; Hydrographical Office, Madrid, *ca*. 1825; and Huot, Paris, 1831.

The maps which Dr. Hinks exploits as the genuine ones, but which I have designated as false, were not published, and naturally they were not reproduced. The "Bransfield" map showed Antarctic land, which it named "Trinity Land," with a near-by island named "Tower Island." Though both maps were by their titles ascribed to British navigators with Bransfield, a Royal Navy Master, and both were deposited in the Hydrographical Office of the Admiralty, neither the "Goddard" nor the "Bransfield" map was issued by that office, nor in fact, by anyone. Instead, the Admiralty Chartseller, R. H. Laurie, in 1822 discredited the "Bransfield" map in a published statement[9] and used the Palmer Land map. In 1824 the Hydrographical Office of the Admiralty printed the Palmer Land map on an official chart.[10] Following at once the Admiralty's official use of Palmer Land atlas makers all over the world copied this map to replace the erroneous South Shetland land mass or continent of Bransfield, which was a full degree farther to the north. Some of these publishers were Gardner, London, 1825; Brué, Paris, date uncertain; Denaix, Paris, 1828; Hall, London, 1830; Arrowsmith, London, 1832; Lizar, Edinburgh, 1842; Black, Edinburgh, 1844 and again in 1847.

Not until 1825 was the name "Trinity Land" printed upon any published map. It then appeared on the false map by James Weddell, but was not ascribed to Bransfield, was quite unlike the Antarctic land of the "Bransfield" map, and was referred to as "laid down from the information of respectable commanders of ships." The larger of Weddell's two wholly different maps of "Trinity Land" showed a trilobate schematic pattern convex to the north (the Antarctic coast of the "Bransfield" map was concave to the north). The year 1825 thus marks the first appearance of "Trinity Land" on any known published map, and it was thereafter very widely reproduced from Weddell's larger map in atlases all over the world.[11]

Another outright charge of falsification on my part appears in Dr. Hinks's article, on page 311. He there states:

> Professor Hobbs denounces as a palpable forgery, having himself falsified the photograph of it he obtained from the Admiralty by cutting out a small piece, about one-twelfth, so as to evade the title, the author's name and the date, and sticking on pieces of the original divided border with the longitude shifted five degrees.

> This is the crux of the whole matter. The positive evidence that Bransfield discovered the Antarctic Continent is: first the chart with his signature which is in the Hydrographic Office (Map C[12]); secondly the account of the voyage in the Literary Gazette (Document III[13]); and thirdly the confirmation in Smith's map[14] drawn by Goddard (Map F).

Now as to the alleged falsification. The original map photostat as furnished me by the Hydrographical Office of the Admiralty is 14 by 21½ inches, and the part reproduced in the "falsified" map published in my monograph is 3½ by 4 inches. This was accomplished "by cutting out a small piece, about one-twelfth." Dr. Hinks fails to mention that the eleven twelfths omitted was largely blank paper, or that my map is complete for all that is germane, with the exception of the title printed near the edge of the map and a quite recent notation in the corner, "Received from the Record Office 3rd January 1822."[15]

As regards the title, I much desired to include it, though this would have required a separate plate, and the cost of my map illustrations was already excessive. The omitted title claims that on February 19, 1819, Smith made the discoveries represented upon the map, whereas upon that date, according to the authentic account,[16] he was not even sure that what he saw in the distance was land. The only thing that is honest on this map is the track of the *Williams*. Smith's real map as published with his article was based, not on his February cruise, but on his October cruise of the same year. Even then he could not possibly have made these discoveries, since his map shows that his ship was always on the north side of the islands. If favored by mirage, the Antarctic land might conceivably have "loomed up," but in that case it would have been brought much nearer and not shown in approximately its correct position as later determined. The theory of a mirage could not, however, have accounted for the mapping of the south shores of the islands, which in 1819 would have required the use of our modern aircraft.

To show the latitudes and longitudes on the map, which I reproduced without the surrounding blank paper, it was necessary to paste the divided borders along two sides of the map, and on one of them a shift of five degrees unfortunately occurred, though in the meridians only. This had, however, nothing to do with the questions under review.

It is interesting to note that the Goddard map resembles the Woodbridge Palmer Land maps which were published at Hartford on September 28, 1821,[17] and could easily have been in London weeks before the date of January 3, 1822,

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* Reply to a review by the Secretary of the Royal Geographical Society which was refused publication by that Society.

[1] H[inks], A. R., "On Some Misrepresentations of Antarctic History," *Geog. Journ*., 94 (1939) : 309-330.

[2] "The Discoveries of Antarctica within the American Sector, as Revealed by Maps and Documents," *Trans. Am. Philosoph. Soc*., N. S., 31, Part I (1939) : 1-71, pls. I-XXXI, figs. 1-10.

[3] Hobbs, William H., "The Pack-Ice of the Weddell Sea," *Ann. Assn. Am. Geog*., 29 (1939) : 159-170, map; *idem*, "The Discovery of Antarctica: a Reply to Professor R. N. Rudmose Brown," *Science*, 89 (1939) : 580-582, map.

[4] Foster was not on the cruise with Smith, but was attached to H.M.S. *Creole* stationed at Valparaiso when Smith arrived there. The sketch was therefore made either from descriptions or from some map drafted on board. As regards the map, in a news item sent from Valparaiso to the London *Literary Gazette* (4 [1820] : 524) it is stated: "The only draughtsman in the station, competent to perform the scientific part of the investigation, was Mr. Bone, a son of the distinguished artist of that name; he accordingly went in the Williams and made the drawings of the coast."

[5] Extracts from Smith's log harmonious with the authentic account (*Edinburgh Philosoph. Journ*., 3 [1820] : 367 appeared in the London *Literary Gazette* of October 14, 1820.

[6] Dr. Brewster was chief editor of the *Edinburgh Philosophical Journal*. Dalrymple's chart of Cape Horn was reproduced on the same plate as the Smith map.

[7] Italics mine.

[8] "Notice of the Voyage of Edward Barnsfield, Master of His Majesty's Ship Andromache, to New South Shetland," *Edinburgh Philosoph. Journ*., 4 (1821) : 345-348.

[9] "The *Trinity Land* and *Tower Island* of the first charts in about 63½° South and 60½° West are given up as imaginary . . . ." George Powell, *Notes on South Shetland* . . . (London, 1822), p. 6.

[10] See *Science*, 89 (1939) : 581.

[11] Hobbs, Pl. XIX of article cited in note 2.

[12] Never published and wholly at variance with the authentic report of the cruise by Young and with the map which he cites.

[13] Anonymous and at variance with the authentic report.

[14] This makes Smith discover the Antarctic land on his cruise of February 19, 1819.

[15] In 1913 this map was published nearly complete in the *Geographical Journal* (42 : 365-370), but without this notation. We must therefore conclude that the notation is a later addition.

[16] Reference given in note 5.

[17] Hobbs, as cited in note 2.

A COVER MAP BASED ON AIR PHOTOGRAPHS, EMMET COUNTY, MICHIGAN

OMAR H. LOVEJOY

A STUDY of tax delinquency and related problems in Emmet County, Michigan, suggested the need of a practical cover survey which might be used in connection with further investigations. Federal air photographs, obtainable from the Agricultural Adjustment Administration of the Department of Agriculture, have made feasible a cheaper yet adequate method of mapping land use. It is the purpose of this paper to present the early results of an experiment in land inventory based primarily on air photographs.[1]

The staff of the summer camp of the Department of Geography, University of Michigan, has worked in Emmet County for two seasons and has done a great deal of cover mapping. It was undertaken by field crews using plane tables, compasses, and alidades. Air photographs of the county, which became available in August, 1939, offered an opportunity to begin the new experiments.

The utility and value of photographs quite naturally depend upon the extent to which they can be accurately interpreted or "translated." It is to be noted that in this experiment interpretation had to be made by means of field maps which were not specifically devised or planned for correlation with air photographs. When a new system of mapping is organized chiefly to correlate field data with photographs, the technique will become much more effective.

The photographs obtained from the Department of Agriculture cover the whole county. Successive pictures were taken from an altitude of about 17,000 feet while the airplane was flying in what are called "flight lines." There are twenty-seven flight lines in the county. The photographs overlap considerably, so that it is possible to get complete coverage by using every other picture in each flight. Each photograph is about seven by nine inches and has a scale of 1:20,000, or three inches to the mile. Occasionally pictures are not exactly to scale, but the errors are relatively negligible. A problem arose in securing a map on which individual photographs could be fitted. Only a county road map, based on an early highway survey, was available, yet in spite of inaccuracies it was entirely possible to match photographs and to group them into a map with a minimum of error.

The pictures were fitted together in eight contiguous groups, each containing one or two townships. Then the road pattern of each group was copied by means of tracing paper. With the use of a light table each photograph was then refitted under the appropriate road tracing, which made possible an accurate drawing of the more detailed vegetation boundaries. The field sheets mentioned previously served as an aid in interpretation, which was facilitated by the use of a low-powered stereoscope.

A system of symbols was adapted from those of the Michigan Land Economic Survey. It was designed to indicate cover in areas of hilly uplands, sand dunes, sandy plains, and swamp lands, and also the cleared operated and the cleared abandoned lands. Size of stocking is shown by three general classes, 0-3, 3-6, 6-9 inches; the density of the stand, by the small letters h, m, s, for "heavy," "medium," and "scattered," respectively. The eight maps, done first in pencil, were then inked, blue-lined, and, finally, colored.

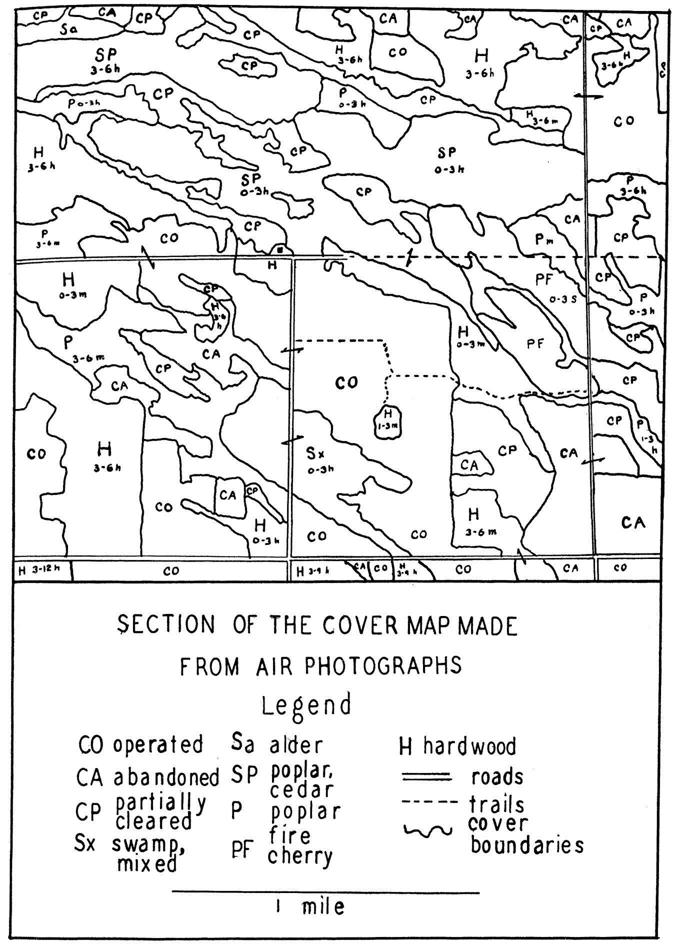

FIG. 1

A legitimate question can be raised in regard to the possibility of reading and accurately interpreting air photographs in such detail. Can one consistently recognize the stocking of the various species and the density differences? Experience is still too limited to give a positive answer to this question. It is doubtful whether all the swamp vegetation boundaries on the map (Fig. 1) have been correctly drawn. A swamp of dominantly cedar cover has definite limits, which are easily detected, but boundaries within swamp areas containing a mixture of spruce, balsam, cedar, and poplar are not readily distinguishable. It is also difficult to determine limits in terms of stocking and density where gradual changes occur. On the other hand, marked differences, such as those between "hardwood

0-3 scattered" and "hardwood 6-9 heavy" are readily noted. Differences in texture usually indicate operated farmland and distinctly nonoperated or abandoned lands. Much of the so-called nonoperated land is only semiabandoned, however, which makes difficult the problem of accurate demarcation of all abandoned lands. Another difficulty in detecting cover differences arises where shadows occur in steep hilly areas. Some manner of field investigation of doubtful areas will probably be found which will eliminate such in accuracies.

The use of this inventory technique has produced a map which least portrays the various patterns of vegetation and cleared lands. They can easily be correlated with land types and with areas in which tax delinquency is prevalent.

As has already been indicated, this method of cover mapping calls for two separate uses of the individual photograph: (1) in the field, to facilitate collection of original data; and (2) in the office, where it is employed for reference in drawing boundaries and, grouped with other photographs, as the basis for the completed map.

It is felt that the results of this experiment with photographs justify further investigation and an effort to create a definite technique. It may well be that developments will lead to a system of mapping which will supersede the more costly method first established by the Michigan Land Economic Survey.

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[1] Two other papers on airplane photographs, both by H. P. Underhill, have appeared in Academy volumes. They are as follows: "Notes on the Assembly of Airplane Photographic Mosaics," 20 (1934) : 415-433. 1935; "Notes on Reading Air Photographs," 21 (1935) : 285-291, 1936.

THE AGRICULTURAL PATTERN OF THE EASTERN HIGHLAND RIM PLATEAU OF TENNESSEE

H. THOMPSON STRAW

NO MATTER where one stands in the Central Basin of Tennessee the valley appears to be surrounded by a line of hills (Pl. I, Fig. 1). Actually, this is the serrated edge of the escarpment of the Highland Rim Plateau, a tableland which rises about 300 feet above the general level of the Basin. In Tennessee this tableland is divided according to its relation to the Central Basin into the eastern, northern, and western plateaus. Thus the Eastern Highland Rim Plateau is the undulating upland, about 25 miles wide and 125 miles long, which extends from the higher Cumberland Plateau on the east and ends in the fringe of high hills which bounds the eastern edge of the Central Basin (text Fig. 1).

When viewed in relation to the adjacent areas the region is essentially one of transition. In elevation it occupies a position midway between the lower Central Basin and the higher Cumberland Plateau. Its soils, although by no means uniform, in general lack the fertility of those derived from the phosphatic limestones of the Central Basin, but are in turn more fertile than the sandy soils of the Cumberland Plateau. The economic and social position of its people might also be classified as transitional between the two adjacent areas. The Basin was developed largely along traditional Southern lines based on plantation economy. In the Cumberland Plateau the majority of the settlers failed to rise much above the level of bare subsistence. The people of the Eastern Highland Rim Plateau belong to neither of these groups, but hold an intermediate position. They are descendants of the group of settlers known as the yeomanry,[1] independent farmers who operated their farms without the aid of much slave labor. The transitional position of the region is shown also by the acreage in farms, by the amount of improved lands, and by the crop yields. Here, too, the region is intermediate between the Central Basin, which is largely a succession of field and improved pasture with only occasional wood lots and cedar glades, and the Cumberland Plateau, with its small clearings scattered throughout an extensive area of forest and cutover land.

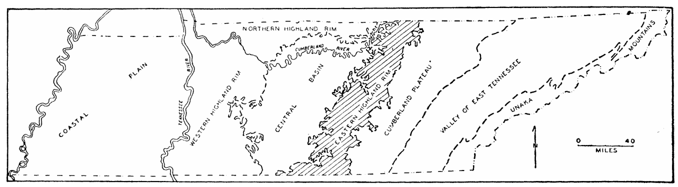

FIG. 1. Surface map of Tennessee, showing location of Eastern Highland Rim Plateau

THE LAND

The gently rolling surface of the Eastern Highland Rim Plateau represents a stage of peneplanation arrived at during Tertiary times. On it are exposed rocks mainly of Mississippian age. Those of early Mississippian age, which are near the western margin and of which the Fort Payne chert is an example, consist of limestones filled with chert and a porous siliceous cement (Fig. 2).[2] Those of a later Mississippian age, which are near the eastern part of the Plateau and of which the St. Louis limestone is an example, consist of much purer limestones, usually massive and fine-grained, with only relatively few beds of chert.

Two other groups of rocks are to be found on the Plateau. The first comes to the surface in but few places. It is the Chattanooga shale which underlies the Fort Payne chert (see cross section in Fig. 2). Since it is soft and weathers easily it is exposed only at the side of the Plateau facing the Central Basin or along the banks of streams which have cut deeply enough into the Plateau to reach it (Pl. I, Fig. 2). The second group of rocks is mainly of Pennsylvanian age. These comprise the Cumberland Plateau, many outliers of which form the flat-topped hills that are especially numerous in the northern part of the region.

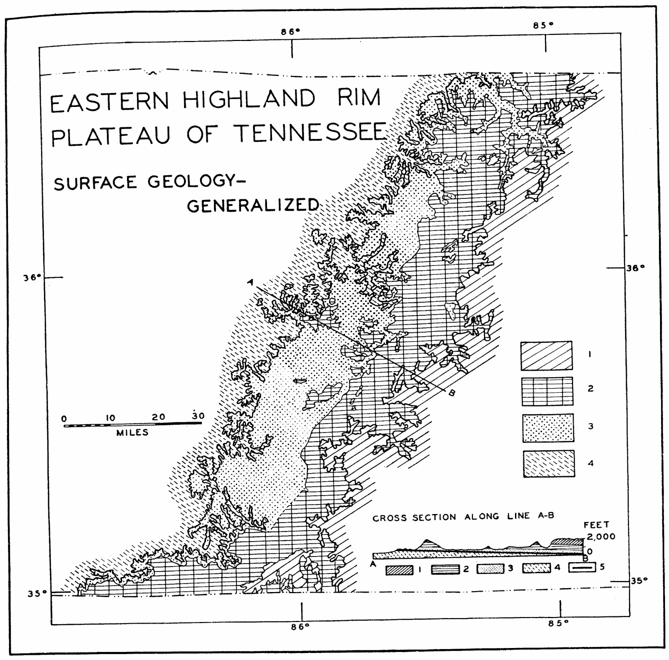

FIG. 2

KEY TO SYMBOLS FOR BOTH MAP AND CROSS SECTION

1. Pennsylvanian strata
2. Upper Mississippian strata — Bangor and St. Louis limestone in the south and Newman limestone and Pennington shale in the north
3. Lower Mississippian strata — Fort Payne chert in the south and Waverly formation in the north
4. Pre-Mississippian rocks
5. Chattanooga shale

The type of surface and the amount of local relief are well correlated with the outcropping of rocks. On the lower Mississippian strata the surface is usually flat to gently rolling. In some areas, especially if underlain by a clay hardpan, the problem of drainage is a serious one (Pl. I, Fig. 3). Soil erosion, except on the few areas where the slope is unusually steep, is not so important a problem as in the area of upper Mississippian rock. Here the relief is greater,[3] since karst development augments the action of river erosion (Pl. II, Fig. 1). The greatest relief is usually associated with the escarpment and outliers of the Cumberland Plateau, where the capping layers of the Pennsylvanian strata resist river cutting but are eroded by the solution of the Mississippian rock which underlies them. The result is flat-topped mesa-like hills with steep sides. Outliers are most numerous in the northern part of the region. There are, however, two other factors which help to explain the extreme hilliness here. The first is a series of small anticlines, which usually have a maximum elevation of about a hundred feet. The second is the more extensive river erosion, owing to the location near the Cumberland River (Fig. 1) and its tributaries.

The majority of the soils of the Eastern Highland Rim Plateau are residual. During the present cycle the rivers, which are generally youthful or in the earliest stage of maturity, have deposited almost no alluvium.[4] These residual soils are young enough to have derived most of their characteristics from parent material[5] and hence they, like the surface features and local relief, are usually related to the underlying strata of rock. Three longitudinal soil belts can be recognized. To the west on the lower Mississippian strata are developed the siliceous, rather infertile "Barrens-type" soils, which range in color from light tan to a light gray that borders on white and which are usually filled with chert fragments. Farther to the east and on the upper Mississippian strata are the more fertile limestone soils, mostly red to reddish brown. A third soil belt may be recognized lying adjacent to the Cumberland Plateau. Here a mixture of the red clay of the upper Mississippian limestone and of the yellow sand from the Cumberland Plateau appears.

To summarize, three broad longitudinal soil and surface belts may be discerned. To the west are "the Barrens," flat to gently rolling, with light-colored rather infertile soils. Soil depletion and, in some areas, poor drainage are the problems faced by the farmer here. East of the Barrens is the red-soil area, gently rolling to hilly. The soil is darker and far more fertile, but there is a continual problem of soil erosion. Gullying, especially near the streams or about well-developed sinkholes, is common (Pl. II, Fig. 2). East of the red-soil area and adjacent to the Cumberland Plateau is the area of steepest slope and greatest relief. Its soil, of medium fertility, is generally somewhat coarser than that of the red-soil area, but the slopes are so steep that coarseness of texture does not save it from erosion.

THE AGRICULTURAL PATTERN

Despite the clear-cut division of the Eastern Highland Rim Plateau into these three belts of surface and soil, there is but little discernible correlation between them and the utilization of the land. The percentage of land in farms is high, averaging from 70 to 80 for much of the area (text Fig. 3). The entire region is essentially one of agriculture, and other land uses occur only on a small scale. Minerals do not exist in sufficient quantities to form the basis of an extensive land use, and the exploitation of forest resources has always been on a small scale and carried on by individual farmers. Urban land use is unimportant, as is indicated by the fact that the largest city in the region, Tullahoma, has a population of barely over four thousand. With agriculture the dominant occupation, with the poorer nonarable land of the region, such as valley slopes, often intermingled with land of better grades, thus necessitating its inclusion in farms, and with a population dense enough to demand virtually all potentially arable land it is small wonder that so large a percentage of the total area is in farms. It will be noted that there is little correspondence between the distribution of farmland and the general soils-surface pattern. As a rule, only in the coves of the Cumberland escarpment and in the outliers of the Cumberland Plateau, where the slope is steep enough to make farming impractical, does the percentage of farmland drop below 50.

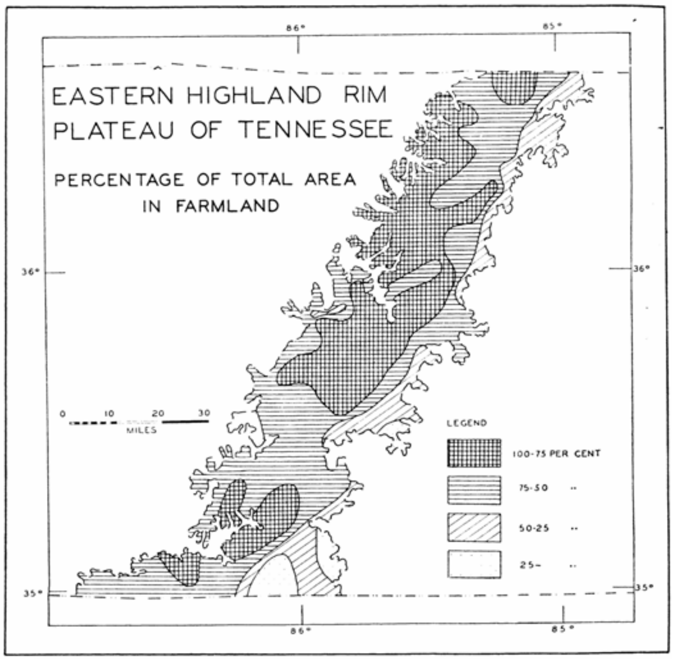

FIG. 3
Compare with Figure 2 and note the small correlation that exists

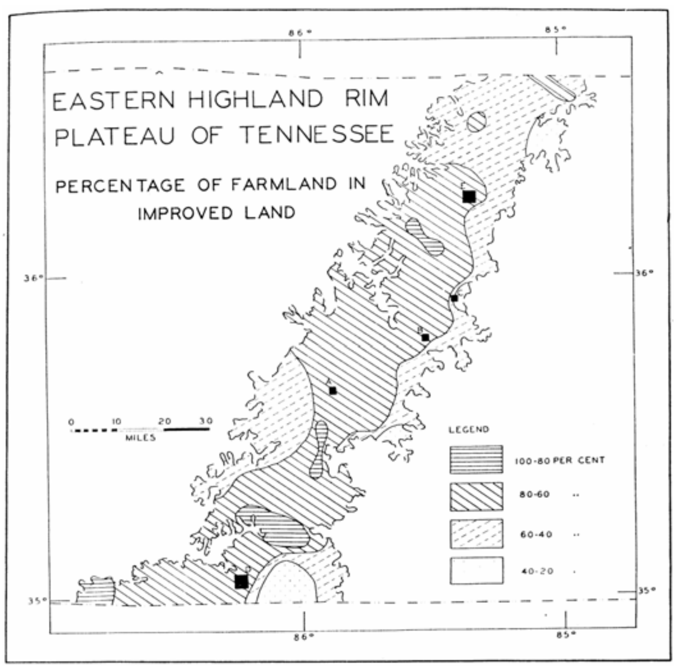

FIG. 4
Compare with Figure 2 and note the slightly better correlation than that between Figures 3 and 2

Like the percentage of total area in farms, the percentage of farms in improved land seems unusually high when the general fertility of the region is considered (Fig. 4). Unimproved land consists largely of that which was originally deemed too steep to clear, scattered areas of wood lot and areas which, although once cleared, were found to be so definitely submarginal that they have been allowed to return to their original forested condition. A somewhat closer adjustment can be seen between improved land and the slope and fertility than could be discerned in the distribution of farmland (cf. Figs. 4 and 2). An extensive area having a low percentage of improved land occurs near the western border of the region, which coincides with some of the poorest soils (known locally as "the Flatwoods") that occur in the Barrens. Other areas having a low percentage of improved land are found near the escarpment of the Cumberland Plateau and are coincident with outliers, as in the southeastern part of the region. The large area to the north is associated with the section of greater local relief, the result of a series of small anticlines and of greater stream erosion, owing to its nearness to the Cumberland River.

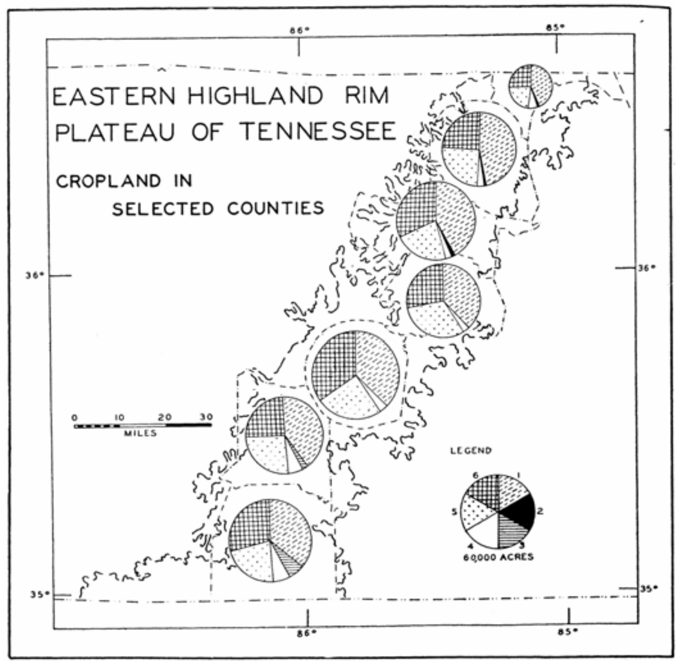

FIG. 5

KEY TO SYMBOLS

1. Corn	3. Cotton	5. Hay
2. Tobacco	4. Wheat	6. Other crops

The major portion of the improved land is not in crops. This land, which is a striking feature of the region, where land is usually cleared only that it may be plowed, indicates the submarginal character of much of it, especially in as much as the region cannot be said to possess an extensive dairy or similar industry which would utilize pasture. A general picture of distribution may be gained from Figure 5. Corn is the most extensively grown crop and, with wheat, the major important grain crop. Hay exceeds wheat in acreage, although in many parts of the region the yields are poor and not in proportion to the acreage devoted to it. Two commercial crops are raised. To the north there is tobacco; both burley and the one-sucker varieties are produced. In the southern part, where a longer growing season permits its production, cotton is raised. Usually more than a quarter of the cropland is devoted to a wide range of miscellaneous crops. These include the hardier grains, vegetables, and sorghum, which allow the farm to fit into the scheme of general self-sufficiency.

Type Studies

A clearer and more detailed picture of the distribution of land use may be gained from the following type studies, the exact locations of the areas of which are shown on Figure 4. Type study A (Fig. 6) is in the Barrens, and the soil is mainly infertile and light-colored. The Barren River is in the stage of youth, with steep valley sides, but iii an earlier cycle developed a valley flat which today is an area of superior soil. Two limestone residuals rise above the usual level of the area. This entire section is in farms and, save for the wooded portions, would be designated by the census as improved land. In reality, much of it has been cleared and later abandoned. The principal crops are corn and small grains; corn and hay occupy the more fertile diluvial terrace. The limestone residuals are either left forested, as in the north, or, if cleared, as in the south, are later abandoned, for sheet erosion removes the top soils and robs them of what little fertility they originally possessed. Over the remainder of the area soil erosion is not a problem, and the abandoned fields are the result of soil depletion.

TYPE STUDY A

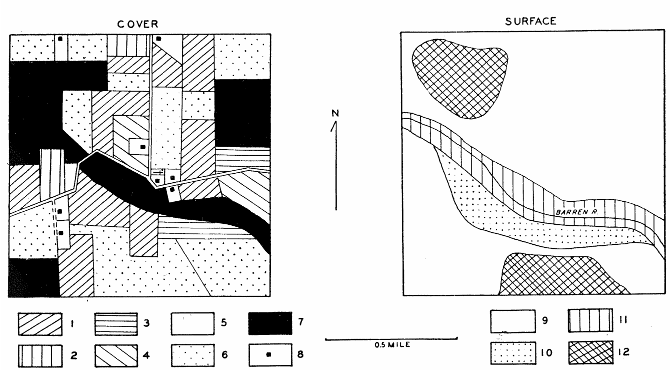

FIG. 6

KEY TO SYMBOLS

1. Corn
2. Small grains
3. Hay
4. Pasture
5. Sorghum
6. Abandoned land
7. Woodland
8. Farmstead
9. Upland
10. Diluvial terrace
11. Valley sides
12. Limestone residuals

Type study B (Fig. 7) is located in the area of red soils underlain by upper Mississippian strata. The upland section is a gently rolling karst area. The valley sides are covered with forest or are devoted to pasture. Where cropping has been attempted it has usually resulted in abandoned fields, because of gullying. The fields are smaller and less regular than those in the Barrens, but the principal crops are of the same type: corn, small grains, and hay. The major problem here is erosion, which is especially prevalent near the streams or near the well-developed sinkholes (Pl. II, Fig. 2).

Type study C (Fig. 8) is in a cove of the Cumberland Plateau. Four divisions of surface may be recognized. To the south is the flat top of the Cumberland outlier; north of it, the slope to the cove bottom which is developed on upper Mississippian limestone and in turn is cut by the steep-sided valley of the Calfkiller River. The valley sides as well as the flat top of the Plateau are largely in forest, save for the small irregular clearings on the plateau. The cove bottom and the slope have been cleared. On this slope not even the coarser soils, a mixture of the sands of the weathered Pennsylvanian sandstone with the clay of the limestones, have kept the fields from erosion. This erosion has resulted, in many instances, in their abandonment. One suspects that much of the area at present in use as pasture is in the process of abandonment, for it was formerly cultivated and has had much of its top soil removed. Crops here are similar to those in the two other type studies, and are most extensively grown on the cove bottom.

TYPE STUDY B

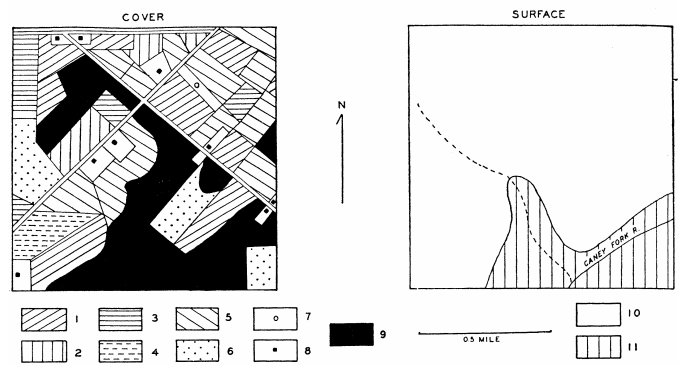

FIG. 7

KEY TO SYMBOLS

1. Corn
2. Small grains
3. Hay
4. Cotton
5. Pasture
6. Abandoned land
7. Orchard
8. Farmstead
9. Woodland
10. Upland
11. Valley sides

TYPE STUDY C

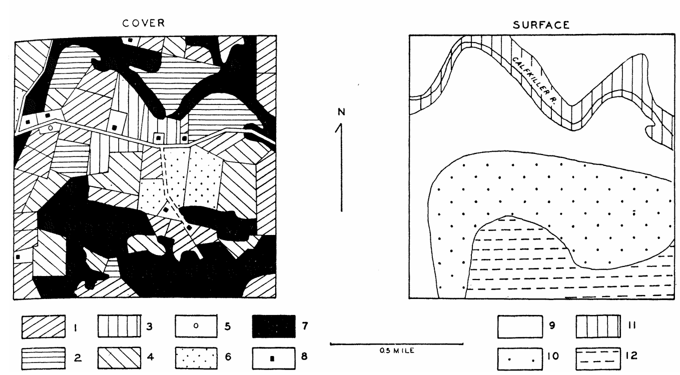

FIG. 8

KEY TO SYMBOLS

1. Corn
2. Hay
3. Small grains
4. Pasture
5. Orchard
6. Abandoned land
7. Woodland
8. Farmstead
9. Cove bottom
10. Ridge slope
11. Valley sides
12. Ridge top

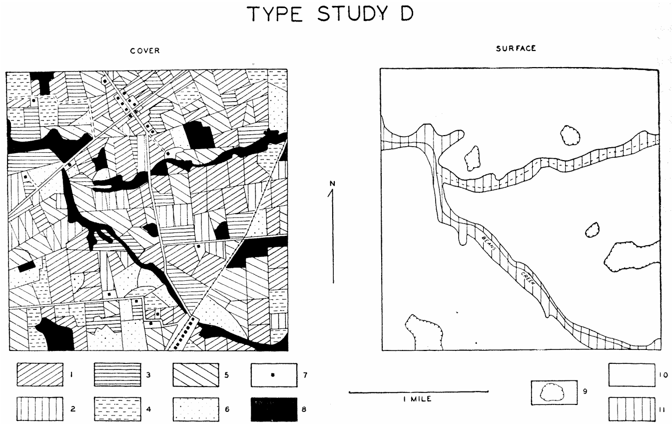

FIG. 9

KEY TO SYMBOLS

1. Corn	5. Pasture	9. Sinks
2. Small grain	6. Abandoned land	10. Upland
3. Hay	7. Farmstead	11. Valley sides
4. Cotton	8. Woodland	

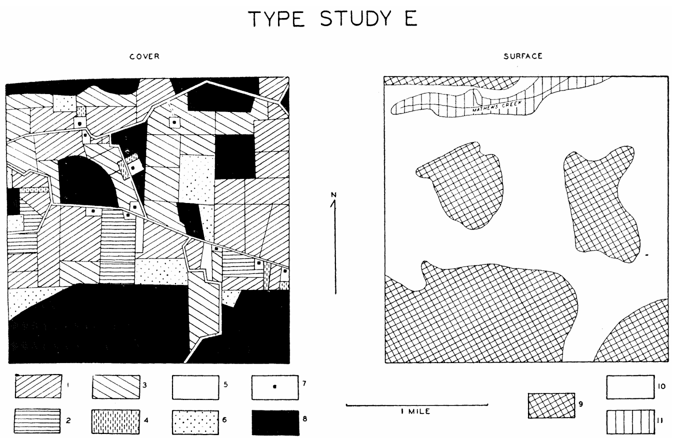

FIG. 10

KEY TO SYMBOLS

1. Corn	5. Sorghum	9. Limestone residuals
2. Hay	6. Abandoned land	10. Upland
3. Pasture	7. Farmstead	11. Valley sides
4. Tobacco	8. Woodland	

Type study D (Fig. 9) is another portion of the red-soil section, but it is farther to the south than that of type study B, and hence cotton is the dominant cash crop. The upland area is in relatively pure limestone, with well-developed sinks upon it. Much of the land along the streams and the sinkholes is in forest. Most of the abandoned fields are also near the sinks and are in each case the result of soil erosion. Cotton shares with corn and small grains the major portion of the land. A greater part of the pasture land is not permanent here, but is in rotation. This represents the portion of the Eastern Highland Rim Plateau which has the most prosperous appearance. Its general aspect and economy more nearly resemble those of the Central Basin than of the remainder of the Plateau.

Type study E (Fig. 10) is located in the northern part of the region, where the area is much dissected by river action. Residuals of upper Mississippian limestone, covered with fertile but easily eroded red soil, rise above the general level of the upland, which is developed on lower Mississippian limestone and covered with a light-colored Barrens-type soil. Much of the surface of the residuals has been left in forest, and where it has been cleared for fields soil erosion has led to its abandonment. The principal crops are corn, small grains, and hay. Small patches of tobacco, usually of poor quality, provide the chief cash crop. This area is entirely unlike the commercial tobacco areas such as are found in the Kentucky Bluegrass. There are 110 tobacco barns, and the crop is usually dried in an empty portion of the stock barn or in an outlying shed. Most of the farming is of the self-sufficient type, and the farmsteads are poorly constructed and maintained.

To summarize, there is a general lack of harmony between the agricultural pattern of the region and the underlying pattern of soil and surface. In the detailed studies what partial correspondence may be seen is apparently not so much the result of a conscious effort on the part of the inhabitant to adjust his use of the land to natural conditions as the result of attempting to clear and cultivate unfit for crops, and later of being forced to abandon it b either soil depletion in the Barrens or soil erosion in the remainder of the region. The explanation of this disharmony between the agricultural pattern and the underlying pattern of soil and surface is to be found largely in the settlement and development of the region.

SETTLEMENT

The Eastern Highland Rim Plateau was settled principally by middle-class farmers or yeomanry. These farmers, most of whom had originally been established in the Central Basin, doubtless moved from there mainly to escape the superior competition of the planter class during the early part of the nineteenth century.[6] But having achieved through this migration[7] freedom from planter competition, they were then faced with the problems inherent in their new location. Isolation resulted from the poor system of transportation, and low educational standards from the lack of any public-supported system of schools. Often unable to export what agricultural surplus could be produced, ignorant of better farming practices or of better economic opportunities which lay outside the region, possessing a high birth rate, as does the remainder of the South, the yeomen faced the problem of overpopulation in comparison with the productivity of the region. In consequence the land has been cleared, improved, and planted with little relation to its natural productiveness. Only where the slopes are steep or where the character of the soil is such that erosion or depletion has rendered them utterly unfit for cultivation have the fields been abandoned and allowed to return to forest.

PRESENT-DAY PROBLEMS AND SUGGESTED SOLUTIONS

Present-day problems in the region result from these general conditions. The problems are exemplified by the heavy relief loads, the nonpayment of emergency crop-loan money,[8] the great amount of state financial aid needed annually for schools, and the large proportion of farms with low incomes and of the self-sufficient type.[9]

The suggested solutions have fallen into two groups.[10] The first is to continue to improve the educational facilities, both schools and other educational services, such as the county farm bureaus and agricultural experiment stations, and the transportation, especially the farm-to-market roads. In this way it is hoped that emigration, which had an all-too-small development during the latter part of the second decade of the present century, will be continued and accelerated. It is also hoped that those who remain will learn better farm practices and by the improvement of roads be able to sell to urban markets outside the region a larger surplus of farm products, and thus raise the standard of living.

The second suggested solution is to develop nonfarm opportunities within the region, through either public or private initiative. The opportunity for mineral exploitation is limited. In the northern part of the region, in what is known as the Spurrier-Riverton oil field, there are a few scattered pools of petroleum caught in the anticlines. Small amounts of limestone and of clay are manufactured into cement (Pl. II, Fig. 3) and brick (Pl. III, Fig. 1) respectively. Even the geodes found in the Fort Payne chert are collected by the farmers in the area, washed, cracked open, and offered for sale to tourists (Pl. III, Fig. 2). None of these exploitations of minerals is extensive enough or gives promise of becoming so to indicate that it would answer the needs of the region for nonfarm occupations.

Forestry and associated industries seem more promising. The entire region was originally covered with a forest of hardwoods in which oak and hickory predominated.[11] The remnants of this early forest are being exploited on a small scale today, and the towns of the region generally have mills using local timber (Pl. III, Fig. 3). Flooring, baseball bats, wagon spokes, and golf-club handles are some of the products made. The growing of timber should be expanded upon much of the area now devoted to agriculture. This is especially true of the northern section with its rugged terrain and the Barrens with their infertile soils. The portions of the red-soil area which are more level and hence less susceptible to erosion and especially much of the southern section, where the growth of cotton as a cash crop produces farm incomes above the average for the region, may well continue in agriculture. But most of the rest might be converted to farm-forest communities with an increase in the woodworking industries in the small towns of the region.

The best way to accomplish this change remains undetermined. Whether it should be by governmental action, which was unsuccessfully tried in one of the northern counties of the region,[12] or by private initiative, aided perhaps by rural zoning and a revision of the tax laws to fit the condition of forest land, remains undecided. Certainly it is true that, however accomplished, the development of the farm-forest communities would greatly improve living conditions.

If the ultimate solution to the problems of the region is found, whether by the improvement of education and transportation on the one hand or the development of nonfarm occupations on the other, it is safe to say that the present disharmony between the agricultural pattern and the basic pattern of soil and surface will tend to disappear. Whatever pattern of land use is developed in the future, it must bear a closer relation to this basic pattern in the region if the current human problems are to be avoided.

WESTERN STATE TEACHERS COLLEGE
KALAMAZOO, MICHIGAN

[1] Den Hollander, A. N. J., " The Tradition of 'Poor Whites,' "Chap. 20, in *Culture in the South*, edited by E. T. Couch. Chapel Hill, N. C.: University of North Carolina Press, 1934.

[2] For a more detailed report of the stratigraphy of the region see R. S. Bassler, *The Stratigraphy of the Central Basin of Tennessee*, Bull. 38, pp. 133-162. Nashville, Tenn.: Division of Geology, 1932.

[3] For a quantitative discussion of the local relief of these areas see H. Thompson Straw, "The Relative Relief of the Eastern Highland Rim Plateau: a Study in the Cartographical Presentation of Surface Configuration," *Journ. Tenn. Acad. Sci*., 15 (1940) : 372

[4] During the previous cycle extensive alluvial flats were developed along the courses of the present-day streams. An example is shown in type study A (Fig. 6). These areas of old alluvium are usually of superior soil.

[5] For a more detailed picture of soils see C. F. Marbut, "Soils of the United States," Part III of *Atlas of American Agriculture*, pl. 5, sec. 7, p. 44. Washington, D.C., 1935. For an even more detailed study of the relationship of soil and surface geology see C. S. Waldrop, "Soil Survey of Putnam County, Tennessee" (Advance Sheets — *Field Operations of the Bureau of Soils*, 1912). Washington, D.C., 1914.

[6] *Preliminary Population Report*, Sec. IA, maps 3 and 4. Nashville, Tenn.: Tenn. State Planning Comm., 1935.

[7] Straw, H. Thompson, "The Population Distribution and Change in the Eastern Highland Rim Plateau of Tennessee" (abstract), *Ann. Assn. Am. Geog*., 30 (1940) : 72-73.

[8] Lucas, Broder F., and Callahan, E. P., *Major Rural Land Use Problems in Tennessee*, p. 12. Nashville, Tenn.: Tenn. State Planning Board, 1936.

[9] *Ibid*.

[10] Bur. Agric. Ec., Bur. Home Ec., and For. Service, *Economic and Social Problems and Conditions of the Southern Appalachians*, U. S. Dept. Agric., Misc. Publ. No. 205, pp. 12, 132. Washington, D.C., 1936.

[11] Sterrett, W. D., "Marketing Woodlot Products in Tennessee." *Resources of Tennessee*, 7 (1917): 111-195.

[12] Collins, W. E., and Matthews, M. T., *Local Rehabilitation for a Tennessee Rural County*, 20 pages (mimeographed). W. P. A. Coöp. Plan, Rural Res. Rep., 1936.

STRAW PLATE I

FIG. 1. View from the Central Basin, showing in the background the like of hills that marks the escarpment of the Eastern Highland Rim Plateau

FIG. 2. Duck River Falls, where the river passes over the escarpment of the Eastern Highland Rim Plateau. Most of the rock is Chattanooga shale, fragments of which can be seen in the lower right-hand corner

FIG. 3. The area underlain by Fort Payne chert. Once cleared for agriculture, it is now abandoned, save for occasional use for pasture. A scrubby stand of sassafras and oak is growing upon it

STRAW PLATE II

FIG. 1. The area underlain by St. Louis limestone. Owing to the karst development the relief is greater than that shown in Plate I, Figure 3. The line of hills in the distant background is the escarpment of the Cumberland Plateau.

FIG. 2. A field in the red-soil area. It has been abandoned because of excessive gullying

FIG. 3. Cement plant near Cowan which uses local limestone for raw material

STRAW PLATE III

FIG. 1. Brick kiln near Algood which produces brick from local red clays. The kiln is in the red-soil area

FIG. 2. Geodes offered for sale to tourists on one of the main routes. They are found in the Fort Payne chert near the western part of the region

FIG. 3. Flooring mill at Tullahoma, typical of small woodworking factories in the region

JURASSIC AND CRETACEOUS STRATA OF THE CAMP DAVIS AREA, WYOMING

ERNEST DOBROVOLNY

CONTENTS

INTRODUCTION

Location

THE Camp Davis area comprises the lower part of the Hoback River drainage system west of Granite Creek in the southwestern part of the Teton National Forest, Wyoming. Camp Davis, located approximately in the center of the area and about 20 miles south of Jackson, is the Geology and Surveying Field Station of the University of Michigan.

Acknowledgments

The field work on which this report is based was done in August, 1938. The writer is indebted to the faculty of the Department of Geology of the University of Michigan for guidance in preparing the manuscript. Dr. R. W. Imlay checked all fossils and identified some and also assisted in measuring the section between Adams and Mumford creeks. Mr. Robert Hatch, of the Mineralogy Department, examined seven thin sections of the sedimentary rocks, and his observations were particularly useful in making formational correlations.

Previous Investigations

There has been little previous investigation of the Mesozoic rocks of the Camp Davis area. In 1878 St. John and Clark (10, pp. 188-189), members of the Wind River Division of the Hayden Survey, completed a geologic and topographic map of an area lying between meridians 109° 30' and 112° and parallels 43° and 43° 15'. During the course of the survey St. John measured a section eastward from the crest of the Wyoming Range to near the junction of Hunter Creek with Willow Creek. In Bulletin 543 of the United States Geological Survey Schultz (11, pp. 55-56) used the section measured by St. John, but added names for the purpose of correlation. This Bulletin contains a 100-foot-contour geologic and topographic map which includes the Camp Davis area. Since these early reconnaissance surveys several detailed sections in adjacent areas have been measured, and it flow appears worth while to supplant the St. John-Schultz section near Camp Davis with a detailed one.

JURASSIC STRATA

Twin Creek Formation

In the Camp Davis area the Twin Creek formation is 725 feet thick and consists of dark-colored calcareous shales and thin- to thick-bedded limestones. The type section 100 miles to the south, near Twin Creek, Wyoming (12, p. 56), measures between 3,500 and 3,800 feet thick and differs from the Camp Davis section in containing a few light-colored sandstones and, apparently, no thick-bedded limestones. Thick-bedded limestones, however, have been reported by Bartram (1, p. 340) near the type locality and by Neely (6, p. 729) at Afton, 40 miles to the south. In the Camp Davis section the basal unit consists of 46 feet of gray limestone that weathers buff.

The Twin Creek formation of the Camp Davis area lies with apparent conformity on the Nugget sandstone, but the abrupt litho logic change from thick sandstone, supposedly in part of subaerial origin, to thick-bedded limestone suggests a break in sedimentation. Mansfield (4, p. 193) reports that in southeastern Idaho erosion occurred at the close of the deposition of the Nugget, and that the Nugget formation thins northward. These observations indicate warping of the geosyncline at the end of Nugget time, though at most places little angular discordance has been noted between the Nugget sandstone and the overlying Twin Creek.

Mansfield (4, pp. 49, 98) also reports thicknesses for the Twin Creek formation in southwestern Wyoming comparable with that of the type section. According to sections measured mainly by Neely (6, pp. 715-770), the formation thins northward in Wyoming from 2,539 feet at Afton to 2,136 feet at Cokeville, 927 feet at South Piney Creek, and 730 feet at Camp Davis. Neely reports only 106 feet in the Lower Sundance (about 40 miles to the north and northeast in the Gros Ventre River section) and 397 feet in the Upper Sundance. The Lower

Sundance of the Gros Ventre River Valley is referred in part to the Twin Creek and Ellis formations and the Upper Sundance to the Stump sandstone (6, pp. 737, 755).

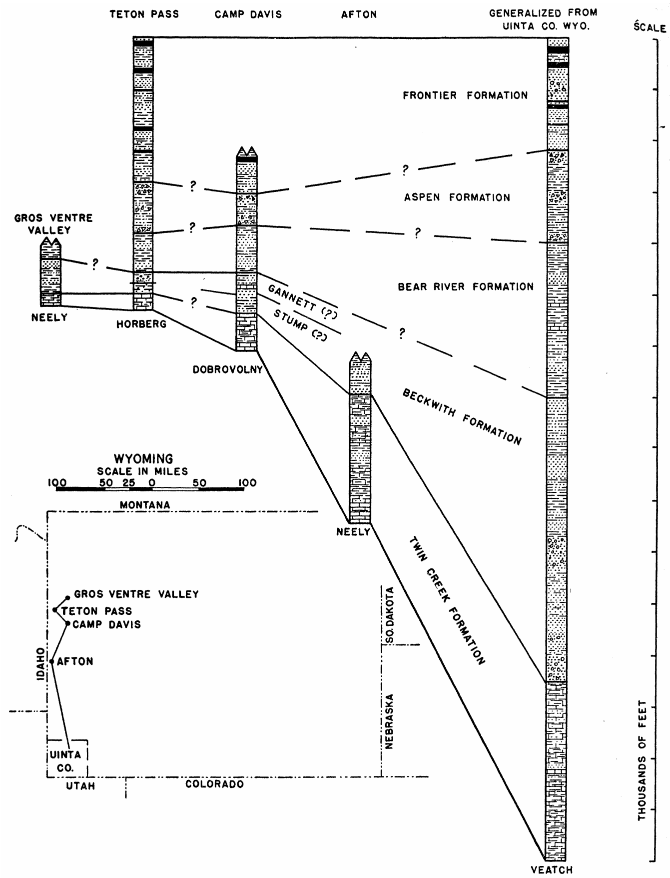

FIG. 1. Columnar correlation chart of Jurassic and Cretaceous strata of western Wyoming. The vertical position of the columns is entirely arbitrary, but chosen so as to illustrate postulated geosynclinal thickening

The boundary between the Twin Creek and the overlying Upper Jurassic rocks in the Camp Davis area has not been definitely located because of the absence of any abrupt change in lithology and the lack of distinguishing fossils. It is arbitrarily placed 725 feet above the top of the Nugget sandstone directly above shales and thin-bedded limestones containing *Gryphea*, *Pentacrinus*, and *Camptonectes*. (See Figure 1 and the descriptions of the stratigraphic units which follow.)

The fossils obtained from Units 7, 8, and 9 of the Twin Creek formation of the Camp Davis area were identified by the writer and checked by R. W. Imlay. They are as follows:

Pentacrinus asteriscus (Meek and Hayden)
Gryphea calceola var. *nebrascensis* (Meek and Hayden)
Pholadomya sp.
Gervillea sp.
Camptonectes sp. (Meek)
Camptonectes bellistriatus (Meek)

These species are abundant in the Twin Creek formation of southern Wyoming and Idaho and in the Sundance formation of central Wyoming. In the Sundance of central Wyoming they are associated with ammonites, which are characteristic of early Upper Jurassic time (7 ; 2, p. 545).

A section on the ridge between Willow Creek and its tributary, Mumford Creek, measured from top to bottom, is described on page 433.

Units	*Thickness in feet*
9. Limestone and shale interbedded. Beds 2 to 10 inches thick. Limestone blue, weathering buff; shale black, weathering gray. Lower limestone beds mainly oölitic. Upper limestone massive, black and gray, oölitic, weathering blue, not cliff-forming. A *Gryphea* zone occurs 180 feet above base of unit. *Camptonectes* and *Ostrea* fragments occur below and above *Gryphea* zone. Other fossils are *Gryphea calceola* var. *nebrascensis* (Meek and Hayden), *Pentacrinus asteriscus* (Meek and Hayden), *Camptonectes sp.* (Meek), *Camptonectes bellistriatus* (Meek), *Pholadomya sp.*, *Gervillea sp.*	330 ±
8. Limestone, shaly, blue. White calcite and chalcedony veins parallel to bedding. Lower 7 feet very shaly. Distinguished from Unit 9 by cliff-forming character	65
7. Shale, calcareous, thin-bedded, blue, weathering red near top, makes distinct contact with limestone below	62
6. Limestone, massive, gray with some white mottling, contains dissolved parts of pelecypods (?), weathers brown. *Camptonectes* and *Ostrea* in lower part	8.5
5. Limestone and shale interbedded, gray, some members weather buff. Limestone becomes more shaly near top	125.5
4. Limestone, dense, coarser than beds below, steel-gray, weathers yellow-buff, oölitic	6
3. Limestone, fine-grained, steel-gray, weathers to blue, very narrow veinlets of calcite	11.5
2. Shale, weathers buff, some beds sandy	70
1. Limestone, gray, weathers to gray and buff, crystalline. H_2S to petroleum odor when freshly broken	46.5
Unconformity (?)	
Nugget sandstone	

Beckwith (?) Formation

Approximately 700 feet of beds in the Camp Davis area above the Twin Creek formation and below the Bear River formation are provisionally assigned to the Beckwith formation, which they somewhat resemble and whose stratigraphic position they occupy. The type locality of the Beckwith formation is in southwestern Wyoming (12, p. 57). The lower 440 feet, however, contain sandstones with fairly characteristic Stump lithology, and the upper 250 feet have characteristic Gannett limestones and shales. These formations are typically developed west of the Beckwith area in southeastern Idaho. The presence of maroon to red shales in both the Stump (?) sequence and the Gannett (?) sequence makes the separation into distinct lithologic divisions a little uncertain. The lack of diagnostic fossils renders precise correlation impossible. It seems preferable, therefore, to use the more inclusive term "Beckwith formation" provisionally at the present time rather than to draw a line within it and recognize two formations.

The lowest member of the Beckwith formation in the Camp Davis area is a massive calcareous sandstone, 41 feet thick, containing *Pentacrinus* columnals. Its highest member is a maroon to lavender sandy shale. Its base is not marked by a conglomerate, as it is in the type section. A limestone bed about 450 feet above the base contains markings that may represent dissolved gastropods or pelecypods. This may be the fresh-water gastropod horizon referred by Horberg (3, p. 11) to the Gannett group of Teton Pass. (See correlation chart, Figure 1.) The Beckwith formation is overlain by the Bear River formation, which contains a fresh-water fauna that is considered to be of lower Upper Cretaceous age. Since the Gannett group is tentatively assigned to Lower Cretaceous age (4, pp. 101-103), the upper part of the Beckwith formation may likewise be Lower Cretaceous. No *Gryphea* zone was found high in the formation, such as that reported at Gros Ventre River and Circle Ranch (6, pp. 729, 737, 755).

The Upper Jurassic Preuss and Stump sandstones in the type section of southeastern Idaho are 790 feet thick, and the overlying Lower Cretaceous (?) Gannett group is 3,120 feet thick (4, pp. 101-103). These formations thin more rapidly to the north than they do to the northeast. For the Teton Pass area Horberg (3, p. 11) gives an average of 125 feet for the combined Preuss and Stump formations and 250 feet for the Gannett group. In the intervening Camp Davis area they are represented by 690 feet of the Beckwith. Neely (6, p. 755) does not mention the occurrence of Preuss sandstone on the Gros Ventre River, but records the Stump (Upper Sundance) as having a thickness of 575 feet.

The following units, which represent the Beckwith formation, were measured between Willow Creek and Mumford Creek, on the hill slope directly above the Twin Creek formation previously described.

Units	*Thickness in feet*
24. Shale, sandy, black, poor exposures, red to maroon in places	25
23. Limestone, fairly fine grained, blue on fresh surface, white on weathered surface, some light blue shale interbedded	50
22. Shale, red to maroon, with some nodular limestone	47
21. Limestone, fine-grained, fractured in lower part, where red shales appear intruded into the limestone, cliff-forming	47
20. Shale, maroon to dull red, some nodular limestone that looks brecciated; about 12 feet above base is a 4-foot gray to pink sandstone; near center is a 3-foot conglomerate of gray, brown, and black limestone pebbles one-half inch in diameter in a lime matrix	73
19. Limestone, thin-bedded, white to light blue, contains fracture septaria, outer part of veins of septaria is red chalcedony and inner part is calcite and quartz	14
18. Sandstone and shale, thin-bedded, cross-bedded, pink to gray	31
17. Sandstone, cross-bedded, fairly fine grained, some interbedded white sandstone	41
16. Shale, maroon to red, with some thin-bedded red to pink sandstone, shales in upper part a blue lavender	129
15. Sandstone, thin-bedded, cross-bedded, coarse-grained, color variable, with pink and gray dominant	10
14. Shale, maroon	38
13. Sandstone, calcareous, fine-grained, thin-bedded, gray to gray-green, contains *Pentacrinus*	51
12. Sandstone, thin-bedded, fine-grained, gray-green	14
11. Shale and sandstone, thin-bedded, fine-grained, light gray, weathers to a yellow gray	82
10. Sandstone, calcareous, massive, sandier in upper part than lower, buff, contains *Pentacrinus*	41

Several units above the red shale and siltstone of Unit 24 were observed by the Camp Davis students along the bed of the Hoback River, near its mouth. Below typical Bear River beds and above Unit 24 occur first some greenish gray shales, then some dark gray lithographic limestones, and below these a number of dark gray quartzitic sandstone beds. This indicates an unconformity at the base of the Bear River formation. It is probable that the sequence and the thickness of beds in the Gannett group also vary greatly within short distances.

CRETACEOUS STRATA

Boundary between Jurassic and Cretaceous Strata

Overlying the Jurassic Beckwith formation in the Camp Davis area are Cretaceous strata about 4,000 feet thick. No variation in attitude or distinct boundary between the systems was observed. To facilitate mapping the top of the Jurassic (Beckwith formation) was arbitrarily placed at the top of the highest red sandy shale and the base of the Cretaceous (Bear River formation) at the bottom of the 12-foot bed of fine-grained buff to gray shaly sandstone which immediately overlies it. Lower Cretaceous rocks are probably not present, but might be included in the upper part of the Beckwith or the lower part of the Bear River formation. Any assumption an unconformity between the systems must be based principally upon faunal differences, as suggested by Schultz (11, p. 54).

All the Cretaceous sections were measured on the west side of Willow Creek, about three quarters of a mile from its mouth, with the exception of Unit 1 of the Bear River formation, which was measured directly across the canyon on the east side.

Bear River Formation

Above the Beckwith formation in the Camp Davis area are beds 970 feet thick belonging to the Bear River formation, which consists of hard, brittle black shales, cross-bedded, buff to gray cliff-forming sandstones, and a few limestones, some of which are composed almost entirely of the shells of *Ostrea haydeni* and *Modiola pealei*. The formation at Camp Davis is quite similar to that in the type locality in southwestern Wyoming and differs only in containing thicker sandstones and less limestone. The fauna indicates that it is a fresh-water deposit. Conspicuous cross-bedding and lensing of the fairly coarse grained sandstones may indicate flood-plain origin.

A fauna characteristic of the Bear River formation of southwestern Wyoming (13, p. 28) was found in Unit 7 about 400 feet above the top of the Beckwith formation. Identified species are as follows:

Compeloma macrospira (Meek)
Corbula cf. *engelmanni* (Meek)
Charydrobia stockei (White)
Pachymelania cf. *chrysalis* (White)
Pachymelania cleburni (White)
Unio vetustus (Meek)
Ostrea haydeni (White)
Modiola pealei (White)

Most of the following section was measured about three quarters of a mile above the mouth of Willow Creek on the west limb of the Willow Creek anticline. Unit 1 was measured on the east side of Willow Creek, three quarters of a mile above its mouth.

Units	Thickness in feet
11. Shale, very sandy, dense, conchoidal fracture, blue-green; basal 4 feet not so sandy and weathers a light yellow buff	106
10. Sandstone, arkosic, medium-grained, gray to white, looks like fine-grained dark granite, weathers to slabs ½ to 3 inches thick. 6 feet	
Shale, very sandy, black to steel-blue, abundant plant remains, contains a gastropod, possibly Pyrgulifera. 4 feet	
Sandstone, arkosic, fine-grained, compact, dense, hard, gray-blue. 2 feet	
Sandstone, fine-grained, gray-green, some narrow black (micaceous ?) bands parallel to bedding, breaks up into platy slabs. 12 feet ...	24
9. Shale, sandy, nodular, black, nonfossiliferous, weathers platy. 15 feet	
Sandstone, arkosic, angular fracture, gray to green, parting surfaces stained red, brown, and yellow. 3 feet	
Shale, very sandy, dense, fractures angular to nodular, black, surface stained brown, some weathered surfaces carry plant remains; forms a small ridge. 10 feet	
Shale, weathers yellow-green at base, less yellow higher in unit, poorly exposed. 40 feet	68
8. Sandstone, arkosic, dense, finely laminated, grayish green, compact, weathers to slabs about one-half inch thick, cliff-forming. 6.5 feet	
Shale, black, indicated by slope. 9 feet	
Sandstone, dense, fine-grained, fine laminations, angular fracture, central and upper part denser, blue-green; cliff-forming. 39.5 feet	
Shale, black, partings contain evidence of plants; not well exposed. 48 feet	
Sandstone, arkosic, dense, angular fracture, grayish green; cliff-forming. 9.5 feet	
Shale, black, not well exposed. 17 feet	
Sandstone, arkosic, dense, grayish green, weathers to slabs about one-half inch thick; most prominent cliff former of the four sandstones in interval 8. 40 feet	169.5
7. Shale, blocky to nodular, brittle, black, stained red and yellow on fractured surfaces, breaks into square fragments; exposures poor. 150 feet	
Sandstone, very argillaceous, indicated by float. 5 feet	
Limestone, composed mainly of fossils, principally *Ostrea haydeni* and *Modiola pealei;* red on all surfaces, both fresh and weathered. 2 feet	
Sandstone, may be a very sandy shale, hard, dark color. 3 feet	
Shale, conchoidal to angular fracture, brittle, black, breaks into rectangular fragments, stained red and yellow in fractured surfaces. The following fossils were found in the lower or middle part of this shale member about 400 feet southeast of Ridge Flag: *Compeloma macrospira* (Meek); *Corbula* cf. *engelmanni* (Meek); *Charydrobia stockei* (White); *Pachymelania* cf. *chrysalis* (White); *Pachymelania cleburni* (White). 90 feet.	
Limestone, highly fossiliferous, gray to black, white to gray on weathered surface; found as float; contains *Pyrgulifera humerosa* and many poorly preserved gastropods. Same fossil bed found on top of ridge one-half mile south of Camp Davis contains: *Unio vetustus* (Meek); *Ostrea haydeni* (White); and *Modiola pealei* (White). 5 feet	
Shale, weathers yellow, not definitely found in place. 5 feet	260
6. Sandstone, lighter in color and coarser-grained than sandstone below, cross-bedded, weathers into rounded blocks, not so prominent a cliff former as sandstone below. 28 feet	
Sandstone, arkosic, fine-grained, dense, light gray, breaks into columns. 34 feet	62
5. Shale, black, fractures conchoidal to angular and disklike, interbedded with 2 to 4 inches inclined or cross-bedded shaly sandstone; contains worm trails (?)	33
4. Sandstone, fine-grained, cross-bedded, white to gray, some black inclusions, buff on weathered surface; most prominent of the three cliff-forming sandstones in this part of Willow Creek, similar to sandstone below	24
3. Shale, nodular, soft, black, has shiny surfaces, feels like soapstone; contains worm trails (?); includes small sandy lenses	3.5
2. Sandstone, fine-grained, fragments angular, cross-bedded, white to gray, weathers to buff-yellow, contains seams of conchoidal black shale with worm trails (?). 12 feet	
Sandstone, fine-grained, blocky, lower part cross-bedded, white to gray, weathers to buff-yellow, cliff-forming. 18 feet	30
1. Shale, conchoidal to angular fracture, somewhat brittle, few secondary stains, some sandier beds form small cliffs. 160 feet	
Sandstone, fine-grained, compact near top, white, angular fracture, toward base more shaly and more nodular. 30 feet	190

Aspen Formation

In the Camp Davis area the Aspen formation consists of 590 feet of gray sandstone, a number of rhyolitic volcanic tuff beds, and some siltstone. It conformably overlies the Bear River formation, from which it may be distinguished by its tuff content. Megascopically the tuff beds resemble porcelain, but microscopically they consist mainly of fine unweathered dust fragments of volcanic glass. Some of the tuffaceous beds have color bands parallel to the bedding. Their conspicuous likeness to porcelain led Horberg (3, p. 11) to call them porcelainite. Rubey (in 9, pp. 2-3) reports vitric rhyolitic tuff from the Aspen formation in southwestern Wyoming and compares it with the tuff found in the Mowry shale of northeastern Wyoming. Since the Aspen at Camp Davis appears to contain considerably more tuff than the Mowry shale it may have been deposited nearer the volcanic source. Probably the gray sandstone, volcanic tuff, and siltstone are equivalent to the splintery and arenaceous shale of the type section in southwestern Wyoming (12, p. 67).

The lowest 8 feet of tuff is considered the boundary between the Aspen and the Bear River formations. For mapping purposes a 28-foot bed of tuff 54 feet higher in the section would be more suitable. The highest unit of the formation, as here determined, is 16 feet of tuff 575 feet above the base.

The following units represent the Aspen formation and were measured on the hill slope directly above the Bear River formation, previously described, about three quarters of a mile from the mouth of Willow Creek.

Units	Thickness in feet
21. Tuff, very fine grained to glassy, angular fracture, blue-black, white specks in places, light blue on weathered surfaces. A band near top weathers to a limonitic color. 16 feet	
Tuff, vitric rhyolite, angular fracture, spotted white and banded gray, matrix green. Some interbedded sandstone near center is cross-bedded and wedges out rapidly, but the tuff remains constant in thickness. 13 feet	
Tuff, very fine grained to glassy, dense, hard, brittle, angular fracture, gray-blue, no inclusions, clear. 6.5 feet	
Tuff, fine-grained to glassy, angular fracture, dense, white to light gray, somewhat spotted, weathered surface looks like a fine quartz sand cemented by silica. 3 feet	38.5
20. Arkose, pyroclastic, medium-grained, fragmental but cliff-forming, quartz, feldspars, chalcedony, and chert present, buff to brown. 5.5 feet	
Sandstone, arkosic, contains more reworked glass than sandstone above and not resistant, banded white with gray, yellow on weathered surface. 8 feet	
Tuff, very fine grained to glassy, angular fracture, blue to blue-gray. About 12 feet above base is a 6-inch banded sandstone. 21 feet ...	34.5
19. Sandstone, arkosic, medium-grained, light gray, contains reworked tuff, quartz, and some biotite. Some plant fragments present. On weathered surface bands of blue tuff (?) alternate with white to gray bands; this is not so apparent on fresh surfaces. 2 feet	
Tuff, fine-grained to glassy, blue to black, small white specks scattered evenly throughout, red stains present locally. 5.5 feet	
Sandstone, arkosic, medium- to fine-grained, blue-gray, laminations have limonitic stain on weathered surfaces. 5 feet	12.5
18. Siltstone or shale, cherty or tuffaceous, gray to black, carbonaceous fragments visible. 42 feet	
Sandstone, medium- to fine-grained, brownish gray, makes small ridge. 1 foot	43
17. Siltstone, chalcedonic, tuffaceous, fine-grained, black to green. Upper part somewhat carbonaceous, but contains mainly reworked and layered tuffaceous material, generally black. Central part tuffaceous and chalcedonic, green. Lower part shaly, black to green,	

Units	Thickness in feet
angular fracture, breaks up into very small fragments, dotlike red stains	108
16. Sandstone, arkosic, evenly fine grained, cross-bedded, greenish gray, contains reworked chert, chalcedony, quartz, and orthoclase; includes white, gray, black, and yellow grains; prominent cliff former	17
15. Tuff, very fine grained to glassy, angular to conchoidal fracture, grayish green, small red stains on weathered surfaces, outcrops poor. Near center of unit a 1-foot green sandstone consisting of well-cemented reworked tuff, magnetite, and quartz (?), outer one-fourth inch weathered brownish	83
14. Tuff, very fine grained to glassy, angular fracture, gray to green. Lower part slightly banded white and light gray-blue. Upper part blue and unbanded	8
13. Sandstone, arkosic, fine-grained, slightly cross-bedded, buff to brown, most crystals white with some bronze and brown, reworked (?) tuff. 5.5 feet Siltstone, limonitic, fine-grained, *black*, small crystal faces reflect light, ganoid scales abundant. 2 feet Siltstone, very fine grained, conchoidal to angular fracture, green to blue, weak. 12.5 feet Tuff, welded, very fine grained, generally a light gray, small black dotlike inclusions, which may be magnetite, hard, resistant. 3 feet	23
12. Tuff, dense, very angular fracture, brittle, gray to black, banded, layers of gray bands 1 to 3 mm. thick alternate with layers of black 2 cm. thick; when broken and weathered looks like shale. 42 feet Tuff, dense, blue to gray; the lower 1 foot is banded, white alternating with blue; the upper part is green and contains disseminated red weathered inclusions about 2 mm. in diameter and 1 to 4 mm. apart. 4.5 feet Tuff, dense, fine-grained to glassy, angular fracture, gray-green, weak. 18 feet Tuff, dense, fine-grained to glassy, angular fracture, gray-green, slightly cliff-forming. 10.5 feet Tuff, dense, fine-grained to glassy, angular fracture, gray to green, weak, but stronger beds 4 to 8 feet thick alternate with 4- to 8-foot beds of weaker rocks. 61 feet Sandstone, arkosic, fine- to medium-grained, includes some reworked tuff, gray; brown-stained bands 1 mm. thick parallel to bedding on weathered surface. 7 feet Tuff, dense, fine-grained to glassy, angular fracture, gray to green, stronger beds 4 feet thick alternate with weaker beds of same thickness. 28 feet Sandstone, arkosic, fine- to medium-grained, gray, includes some reworked tuff, brown-stained bands 1 mm. thick parallel to bedding on weathered surface. 4 feet Siltstone or shale, very sandy, dense, conchoidal fracture, blue-green, outcrops poor. 42 feet Tuff, vitric rhyolite, dense, fine-grained to glassy, angular fracture, shatters when struck with hammer, generally steel-blue; lower 0.5 to 1.0 foot banded, wavy blue and white, and set off sharply from upper unbanded 7.0 to 7.5 feet; banded part not definitely found in place, but not found above this position; contact of banded and unbanded part determined from float; unbanded part contains red specks 1 to 3 mm. in diameter spaced irregularly 1 to 10 cm. apart and in places entirely absent; interval may be 6 or 10 feet thick. 8 feet	225

Frontier Formation

Less than half the Frontier formation exposed at Camp Davis was measured. The measured part consists of gray to buff arkosic sandstones and buff siltstones. This formation conformably overlies the Aspen formation, from which it may be distinguished by the absence of volcanic tuff in distinct beds, although some of its silts contain reworked tuffaceous material. Several small coal seams occur about 500 feet above the last unit measured.

The following section was measured directly above the Aspen formation about one mile south of the mouth of Willow Creek.

Units	Thickness in feet
42. Sandstone, medium- to coarse-grained, more coarsely grained at base, slightly cross-bedded, contains reworked tuff or siltstone, quartz, feldspar, etc., brown to buff, upper part breaks into slabs $\frac{1}{4}$ to $\frac{1}{2}$ inch thick and 4 or 5 inches square. The thickness may be greater than stated because last measurement was taken on top of the hill. 19 feet Conglomerate, coarse-grained, well-rounded pebbles of quartz, siltstone or tuff, and feldspar (?) $\frac{1}{2}$ to $1\frac{1}{2}$ inches in diameter. Pebbles are red, brown, white, and blue with brown cast general, grades into sandstone above. 0.5 foot	19.5
41. Siltstone, sandy, fine-grained, dense, conchoidal fracture, dull gray-brown, feels like soapstone, plant fragments indicated	16
40. Sandstone, very fine grained, cross-bedded, buff to yellow, the lower part is fine-grained and passes upward into a very fine sandstone; the top breaks into slabs $\frac{1}{4}$ to 2 inches thick	40.5
39a. Covered interval, may be part of sandstone above	6
39. Sandstone, conglomeratic to coarse-grained, largest pebbles about one-half inch in diameter consisting of brown cherty siltstone or tuff that is not very abundant, general pebble size ranges from 1 to 3 or 4 mm., buff to brown. The upper part is coarse-grained, textural changes gradational, weathers platy. Near the top a few cross-bedded lenses weather a light brick red	12
38. Covered interval, probably a siltstone	25
37. Siltstone, fine-grained, dense, angular to conchoidal fracture, dull green; the upper 6 inches is a fine-grained green arkosic sandstone	5
36. Sandstone, arkosic, medium- to fine-grained, almost friable, greenish gray, not cliff-forming	12
35. Siltstone, fine-grained, angular to conchoidal fracture, dull green, a few irregular white veins; poor exposures	43
34. Sandstone, arkosic, chalcedonic or cherty, massive, gray to brown	11
33. Siltstone, fine-grained, dense, angular fracture, black; where exposed, beds 4 to 18 inches thick form steps; color variations secondary	117
32. Sandstone, arkosic, chalcedonic or cherty, medium-grained, massive, gray, somewhat cross-bedded, upper part weathers platy, cliff-forming	20
31. Siltstone, dense, angular fracture, generally greenish black to greenish gray, in places spotted white; 6 feet above base is a 1-foot bed of banded fine-grained tuffaceous sandstone; 28 feet above base is a dense, fine-grained, tuffaceous, and red-weathering sandstone about 8 feet thick; the rest of unit is a greenish gray siltstone	149
30. Sandstone, arkosic, fine-grained, cross-bedded, gray and brownish green. The lower 3.5 feet is lithologically identical with the upper 8.5 feet. At the center is a greenish black siltstone. The sandstone lenses into the siltstone	16
29. Siltstone, fine-grained, dense, angular fracture, blue-green, lower part weathers to black, upper part weathers to gray-green; not well exposed	67
28. Sandstone, medium- to fine-grained, most grains green, a few grains black, greenish gray, weathers white; lower part denser and stains a light pink; upper part banded and brown	3
27. Siltstone, very fine grained, angular fracture, green, red stains on exposed surfaces; in places small white veins one-half mm. or less in width form an irregular pattern	6
26. Sandstone, medium- to fine-grained, slightly cross-bedded, gray to white; light blue tuff 1 to 10 mm. thick is banded with light-colored sandstone; more tuffaceous near top	10
25. Siltstone, very fine grained, dense, angular fracture, gray-green to black; contact with sandstone above a wavy line the crest of which is 2 inches high and trough about 2 feet long	8
24. Sandstone, arkosic, medium- to fine-grained, cross-bedded near center, gray-green; some 1-mm. quartz (?) crystals; banded with light blue tuff 1 to 10 mm. thick; slightly speckled on weathered surfaces	8.5
23. Siltstone, angular fracture, fine-grained, blue-green to gray, a few brown and black inclusions on weathered surface	11.5
22. Sandstone, fine-grained, slightly cross-bedded, generally gray to white; reworked tuff, quartz, and biotite (?); white bands alternate with gray tuff 1 to 4 mm. thick	3

CONCLUSION

The Upper Jurassic strata of the Camp Davis area are intermediate in thickness between thicker equivalent strata in southwestern Wyoming and thinner equivalent strata in northwestern Wyoming. The Cretaceous strata do not thin so perceptibly to the north as the Jurassic. In the Aspen formation there are many beds of rhyolite tuff that are good horizon markers.

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NEW SPECIES OF FOSSILS FROM THE MIDDLE ORDOVICIAN OF MICHIGAN

RUSSELL C. HUSSEY

THE only exposures of Middle Ordovician rocks in the State of Michigan are found in the Upper Peninsula, and the principal outcrops occur within a belt about twenty miles wide extending in a general northeasterly direction past the towns of Escanaba and Rapid River. The most complete section of these rocks is that along the Escanaba River, near the village of Cornell, where the contact between the Black River and Trenton formations may be seen. Limestones, dolomites, and calcareous shales are common throughout the sections, and many well-preserved fossils may be found in them, especially in the shaly portions of the rocks. The exact stratigraphic relations of the Middle Ordovician formations of Michigan with rocks of the same general age in other parts of the country have not been determined.

Phylum MOLLUSCA

Class PELECYPODA

Genus WHITELLA Ulrich

Whitella eardleyi, sp. nov.

(Plate I, Figs. 4, 8)

Description. — Shell small, oblique, elongate. Anterior end extending only slightly in front of the beaks, curving very gradually into the ventral margin. Posterior end evenly, strongly rounded. Beaks strongly incurved. Umbones broad, prominent. The strong umbonal ridge, slightly rounded near the beaks, extends almost to the posterior extremity. Hinge line short, extending less than half the length of the shell. Surface markings, where preserved, consist of low, rather widely spaced ridges.

Horizon and locality. — Trenton. Common at several localities, especially along the Rapid River near the village of the same name.

Genus VANUXEMIA Billings

Vanuxemia calveri, sp. nov.

(Plate I, Figs. 11-13)

Description. — Shell moderately large, ventricose. Umbones prominent, blunt, concave on the inner sides. Beaks widely separated. Anterior end short, blunt, extending but a short distance in front of the beaks. Posterior end strongly rounded. Ventral margin broadly, evenly rounded. Anterior muscle scars small, well defined, excavated out of the anterior end of the hinge plate. Posterior scar large, faintly impressed.

Horizon and locality. — Trenton. Escanaba River, near Cornell, Michigan

Genus CUNEAMYA Hall and Whitfield

Cuneamya childsi, sp. nov.

(Plate I, Fig. 15)

Description — Shell large, elongate Posterior end sharply rounded, anterior end truncate. Umbones broad, prominent. Posterior umbonal ridge strong, broadening posteriorly. Anterior umbonal ridge well developed, gradually widening as it extends to the ventral margin. Between the two ridges is a well-defined sulcus extending to the ventral edge, which is indented at the intersection. Strong, somewhat irregular concentric ridges cover the surface and are especially prominent just posterior to the sulcus. Traces of finer concentric lines are seen in a few places on the surface.

Horizon and locality. — Trenton. Groos Quarry, near Escanaba, Michigan.

Class GASTROPODA

GENUS HOLOPEA HALL

Holopea weaveri, sp. nov.

(Plate I, Figs. 9-10)

Description — Shell large, low-spired, volutions expanding rapidly. Tops of the whorl very slightly rounded, flattened in places, sloping sharply down to the suture, which is deeply impressed in the cast. Sides of the last whorl broadly convex. Umbilicus very small

Horizon and locality — Black River, near Trenary, Michigan

GENUS BUCANIA HALL

Bucania buckwalteri, sp. nov.

(Plate I, Figs. 5-7)

Description. — Shell moderately large, high. Slit band bordered on each side by a delicate ridge. On either side of the band the surface is covered by a sharply defined network, with the meshes arranged in rows running in two main directions, one row runs across the volutions somewhat obliquely forward, the other, at a strongly oblique angle backward and inward toward the slit.

Horizon and locality. — Trenton. Escanaba River, near Cornell, Michigan.

GENUS LIOSPIRA ULRICH AND SCOFIELD

Liospira bachmanni, sp. nov.

(Plate I, Figs. 14, 16)

Description. — Shell large, low, three volutions preserved. Periphery of last volution sharply angular; less angular on the other whorls. The slope above the periphery toward the suture is flat or very slightly concave. A low ridge borders the deeply impressed suture. The shell below the periphery slopes strongly and evenly toward the umbilicus, which is moderately large.

Horizon and locality. — Trenton. Groos Quarry, near Escanaba, Michigan.

Phylum ARTHROPODA

Class CRUSTACEA

Subclass TRILOBITA

GENUS AMPHILICHAS RAYMOND

Amphilichas staebleri, sp. nov.

(Plate I, Figs. 1-3)

Description. — Glabella very convex, with the middle lobe strongly elevated above the lateral ones. Posterior slope of the middle lobe straight, except for a slight concavity about one third of the distance down the slope. Curvature of the anterior slope of the middle lobe abruptly downward from about the mid-point. Slopes of the lateral lobes from font to back moderately convex, steepest in front. Palpebral lobes low, separated from the lateral lobes by a furrow that is nearly parallel to the furrow separating the central from the lateral ones. Neck furrow well developed. Surface covered with pustules of various sizes, with the largest ones quite numerous and prominent.

The middle lobe of the glabella is lower with relation to the lateral lobes than in *Amphilichas Cucullus*; the anterior slope of the middle lobe is more abruptly rounded, and the curvature of the lateral lobes is less convex.

Horizon and locality. — Black River, near Trenary, Michigan.

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EXPLANATION OF PLATE I

1-3. *Amphilichas staebleri*, sp. No.
  1. Top view of glabella
  2. Anterior view of glabella
  3. Lateral view of glabella

4, 8. *Whitella eardleyi*, sp. nov.
  4. Left valve
  8. Anterior end

5-7. *Bucania buckwalteri*, sp. nov.
  5. Apertural view
  6. Surface enlarged two times to show markings
  7. Lateral view

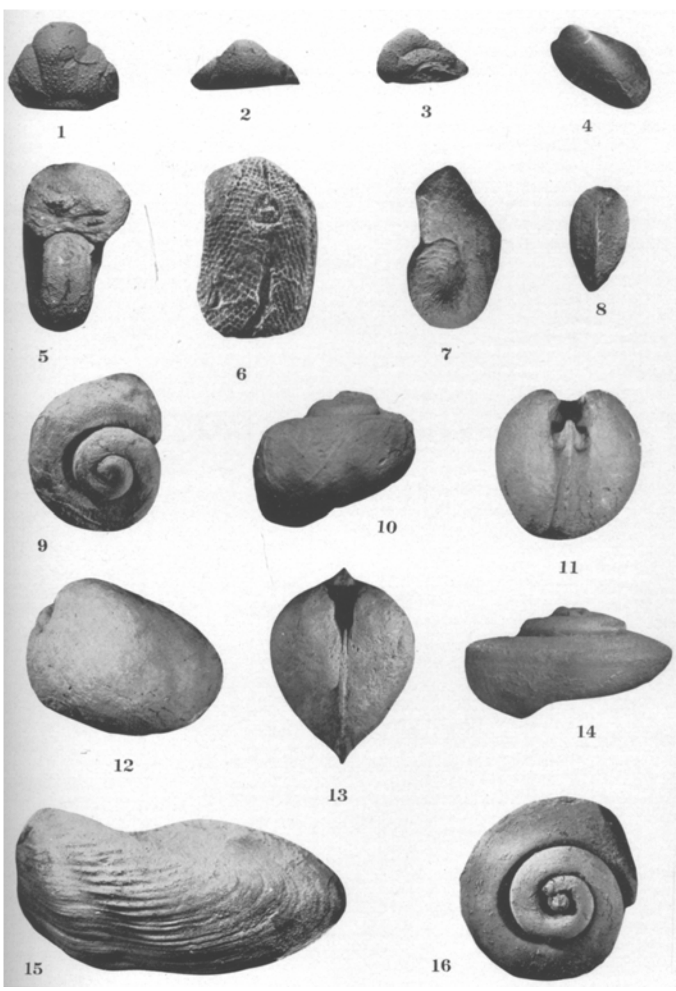
9-10. *Holopea weaveri*, sp. nov.
  9. Apical view
  10. Lateral view

11-13. *Vanuxemia calveri*, sp. nov.
  11. Anterior end
  12. Left valve
  13. Hinge view

14, 16. *Liospira bachmanni*, sp. nov.
  14. Lateral view
  16. Apical view

15. *Cuneamya childsi*, sp. nov.
  15. Left valve

HUSSEY PLATE I



Fossils from the Middle Ordovician of Michigan

POROSITY STUDIES OF ANCIENT POTTERY

FREDERICK R. MATSON

NO SET procedure or group of tests can be established for the technological study of ancient pottery because material from each site presents its own problems. The nature of the raw mate available, the degree of local ceramic development, and the specific technological problems formulated during the archaeological analysis of the pottery control the analytical techniques employed. It would be possible, by making many objective tests of every ware studied, to determine physical properties and compositional variations that might be of interest to some specialists, but they would be of little assistance in the cultural interpretation of pottery. Porosity determinations may belong in this category. During the past six years the porosity of some of the pottery studied at the Ceramic Repository at the University of Michigan has been measured in order to ascertain whether or not this test is useful in the objective description and differentiation of wares. Sufficient data have now been accumulated to permit an evaluation of the results.

Among the factors determining the porosity of a body are the type of clay used, the size and quantity of tempering material introduced, and the temperature to which the product is fired. An increase in the amount of aplastic added to a body will produce, within limits, a greater porosity (3, p. 410). The finer the size of the tempering material employed, the more porous will be the body (3, p. 412; 4, p. 274, fig. 4). Porosity is not affected at the lower temperatures by the degree of heat, but when clay is fired to the point where incipient vitrification is approached, the body begins to shrink and the amount of pore space decreases. When the body is completely vitrified, it has little or no porosity. Many clays have an apparent porosity of 15 to 40 per cent when fired to 1000° Centigrade (8, Chap. XVII, pp. 7-8). As Ries points out (10, p. 240), "Porosity has an important bearing on the strength of a fired clay body, its behavior as an absorbent, and its resistance to weathering, shock, abrasion, erosion, slagging, temperature strain, discoloring agents, efflorescence, chemical attack by gases and liquids, and the destructive action of fungus growths."

"Apparent porosity" is an expression indicating the Percentage of penetrable pore space in a body per unit of its bulk volume. It is determined by immersing the test pieces in water under specified conditions until they are saturated and then weighing them determine the amount of liquid absorbed, the difference between the wet and dry weights being the amount of pore space that could be reached by the water. The bulk volume is determined either by measuring the amount of water or other liquid the saturated object displaces or by the loss of weight of the piece when it is suspended in water. The figure obtained when the pore space is divided by the bulk volume and the product is multiplied by 100, in order to express it in percentage, is termed the apparent porosity.

The procedure followed in securing the data used in this paper was that adopted by the American Ceramic Society (13, p. 456). Bulk volumes were determined by the loss-of-weight method. That loss of small particles from the fractured edges of the sherds while they were being boiled might not affect the measurements, the dry weight of the sherds was determined as the last step. This was particularly necessary when testing sherds from the eastern United States because, even after they had been thoroughly scrubbed, the friable edges of pieces tempered with shell or fine gravel tended to disintegrate. In a series of carefully cleaned sherds from Fort Ancient, Ohio, that were tested to determine the difference in dry weight before and after boiling, the loss in weight of 11 shell-tempered sherds averaged 2.63 per cent of the final weights, with a range of 1.33 to 4.47 per cent. In the 10 grit-tempered sherds the loss averaged 2.21 per cent, with a range of 1.11 to 4.74 per cent. This difference in weight is sufficient to necessitate the measurement of the dry weight after saturation. As Washburn has shown (12, p. 974), the boiling of low-fired clay bodies in water results in their partial rehydration, with an accompanying gain in dry weight. Since, however, the sherds were buried for long periods of time and thus were subjected to the action of ground waters, it seems likely that any partial re hydration that might occur would already have taken place before the pottery was tested. In studying some “Saharan” sherds from Egypt Myers and Earnshaw found that they lost weight after they had been soaked in water because of soluble salts that had been present in them (7, p. 273). This suggests another advantage in the determination of the dry weight after saturation.

When one is considering porosity values, it would be of interest to know the limits of accuracy. Nine surface sherds from Tell Agrab, a site east of Baghdad excavated by the Oriental Institute of the University of Chicago, were tested four successive times. The individual results varied from 0.4 to 1.6 per cent, with an average variation of 0.9 per cent. In four of the sherds the porosity increased during the trials; in the other five it decreased. Apparently the removal of any soluble salts that might have been present in the sherds had little effect on the values. In reporting the apparent porosity of the “Saharan” sherds (7, p. 274) the mean of three de terminations was given for each sherd. In no case was the probable error greater than 1.5 per cent. This agrees quite well with the Tell Agrab tests.

As a further check on the degree of reliability of the measurements the porosity values of sherds that fitted together were compared. When the figures for eight sets of sherds were studied, it was found that the difference between the members of a set ranges from 0.2 to 1.9 per cent, the average difference being 0.8 per cent. In another study the fragments of a large rock-tempered pot found near Clear Lake, Lapeer County, Michigan, were examined. Many of the sherds were badly disintegrated, but 25 in reasonably good condition were selected for testing. The average porosity of these sherds was 33.4 per cent, with a range in values of from 29.3 to 37.3 per cent, a range variation of 8.0 per cent. This pot, however, was an extreme case, for in a crude coarsely rock-tempered pot there may be marked textural variations. In general, it is reasonably safe to assume that the porosity variation between sherds of one vessel will be less than 2 per cent.

The results of the porosity studies of American Indian pottery are summarized in Table I.[1] In the statistical analysis of samples composed of fewer than 30 specimens the corrections given by Parmelee and Kraehenbuehl (9, p. 62, tab. 18) were employed.

The sherds from both Marksville and Coles Creek, Louisiana, are fine-grained and give no visual indication that one set is more porous than the other. This difference might possibly be significant in classifying sherds provided a sufficiently large series should be tested.

TABLE I

Apparent Porosity Studies — Statistical Analysis

All measurements are percentages.

Site	No. of specimens	Average	Range	Range variation	Standard deviation	Probable error	50 per cent of observations will lie between	Probable error of the mean	50 per cent of averages of like-size samples will lie between	Coefficient of correlation
Marksville, La.	28	30.6	24.0–38.5	14.5	3.2	2.2	28.4–32.8	0.4	30.2–31.0	10.4
Coles Creek, La.	29	26.2	21.5–31.3	9.8	2.3	1.5	24.7–27.7	0.3	25.9–26.5	8.7
Northwest Florida coast Sand-tempered	22	34.3	27.2–43.8	16.6	5.2	3.5	30.8–37.8	0.8	33.5–35.1	15.2
Ft. Ancient, Ohio Shell-tempered	22	33.2	29.6–38.6	9.0	2.6	1.8	31.4–35.0	0.4	32.8–33.6	7.8
Ft. Ancient, Ohio Rock-tempered	33	30.5	23.2–35.8	12.6	2.9	2.0	28.5–32.5	0.3	30.2–30.8	9.6
Younge Site, Michigan (5, p. 107) Rock-tempered	37	28.0	20.0–35.0	15.0	2.8	1.9	26.1–29.9	0.3	27.7–28.3	10.0
Hohokam Red-on-Buff, Arizona Mica-schist–tempered	28	30.9	25.0–36.9	11.9	2.8	1.9	29.0–32.8	0.4	30.5–31.3	9.2
Seleucia on the Tigris Figurines	42	31.6	24.4–37.7	13.3	3.5	2.3	29.3–33.9	0.5	31.1–32.1	10.9
Iraq sherds, unglazed	103	34.2	20.6–46.5	25.9	..	..	...	..	...	..
Seleucia, black glaze	17	34.0	27.3–37.8	10.5	..	..	...	..	...	..
Seleucia, red glaze	44	34.9	25.2–40.0	14.8	..	..	...	..	...	..
Karanis, Egypt Straw-tempered	9	33.0	29.2–39.0	9.8	..	..	...	..	...	..

The sherds from the northwestern coast of Florida are tempered with very fine sand. The composition is reflected in the high porosity figure, which is due in part to the fineness of the aplastic. This series could be roughly divided into two groups. The porosity of half of the sherds tested was less than 35 per cent; these had at least the remnants of a slip on the surface and were red to brown. The value of the other sherds was above 35 per cent; they were white, soft, and weathered in appearance, and lacked any evidence of surface finishing. The large value of the standard deviation and the coefficient of correlation may indicate either that there are really two types or that the sampling is not representative.

The shell-tempered pottery from Fort Ancient, Ohio, is more porous than the rock-tempered ware. The difference between the averages, 3 per cent, is small, but it is significant because, although the range of the two groups overlaps, the one is distinctly higher than the other. The shell-tempered group shows less variability; this is indicated by the smaller range variation, standard deviation, and coefficient of correlation.

The rock-tempered Younge site pottery has a relatively low porosity, probably because of the coarseness of the aplastic used. The large range may be due in part to differences in the amount and size of the tempering material in the test pieces.

The mica-schist-tempered Hohokam Red-on-Buff sherds from near the present site of the Coolidge Darn in Arizona form a unit in terms of porosity range and average quite comparable with the pottery from the eastern United States.

The statistical analysis of these five groups of sherds would indicate that the porosity of wares such as those tested has a range variation of about 10 to 15 per cent, a standard deviation of 2.5 to 3, and a coefficient of correlation of 8 to 10 per cent.

In Table I appear also the porosities of sherds from Iraq and Egypt, to serve as a sampling from another part of the world. The figurines from Seleucia on the Tigris that were measured may be considered representative in their properties of the unglazed pottery from the site. They have been reported on in detail elsewhere (6). This series, with its average value of 31.6 per cent, is very similar to the American Indian materials. At Seleucia imported sherds with red and black glazed surfaces were occasionally found. These glazed groups were much alike with respect to porosity, but the high average value, 34 per cent, is a little surprising. A detailed discussion of them is in preparation.

The average porosities of sherds from surface collections gathered at eight other sites in Iraq range from 30.7 to 36.2 per cent, and in several cases the range exceeds 20 per cent. This variability may be accounted for in part by the fact that there are textural differences among the sherds, some being more sandy than others. A few of the sherds had been fired to temperatures sufficiently high to produce lower porosities. Well-vitrified sherds not included in Table I had values as low as 4.7 per cent. The average value for the 103 Iraq sherds is similar to that of the Florida group, but the large range indicates that more than one physical type or firing temperature is included in the series.

The straw-tempered sherds from Karanis, Egypt, that were tested constitute too small a group to be considered definitive, but they indicate a relatively high porosity for this type of ware.

The published reports of porosity measurements summarized in Table II indicate, when considered with the preceding table, that there are regional and type porosity differences. The pottery from the southwestern United States tends to have a lower porosity than that from the eastern part of the country or from the Near East. At a site such as Fort Ancient or Pecos the tempering material used in the pottery may strongly affect the porosity. For the purpose of comparison the porosity range of some modern ceramic products is given in Table III. It will be seen that the porosity of ancient pottery is much greater than that allowable in present-day commercial wares.

It is difficult to correlate the porosity with other physical properties of pottery such as color, hardness, or thickness, since usually even a single ceramic type is far from homogeneous, owing to variations in the body composition and the firing temperature caused by that uncertain human element, the potter.

TABLE II

POROSITY STUDIES — PUBLISHED MATERIAL

All measurements are percentages.

Site	No. of specimens	Average	Range	Range variation	Reference
Armant					
Predynastic	5	..	36.9–68.6	31.7	(7, p. 276A)
"Saharan"	5	..	33.9–41.6	7.7	(7, p. 276A)
Cameron Creek Village					
Mimbres pottery					
Early red paste	..	28.11	23.9–30.6	6.7	(1, p. 34)
Early white paste	..	30.03	22.0–39.0	17.0	(1, p. 36)
Coarse sandy paste	..	26.32	24.9–28.2	3.3	(1, p. 38)
Ashy gray paste	..	27.6	24.4–32.2	7.8	(1, p. 38)
Pecos					
Black on white					
Blue-gray type *	..	27.5	25.0–30.0	5.0	(11, p. 462)
Blue-gray type †	..	31.2	27.2–34.6	7.4	(11, p. 464)
Crackle type	..	24.1	16.8–31.9	15.1	(11, p. 466)
Biscuit ware					
"A" type †	..	36.6	31.8–40.4	8.6	(11, p. 488)
Glaze ware (6 types)	..	23.6–26.2	18.4–31.6	13.2	(11, pp. 498–515)

* Untempered † Tuff-tempered

TABLE III

THE APPARENT POROSITY OF SOME MODERN CERAMIC PRODUCTS

(2, p. 314)

Product	*Percentage*
Common brick	
Surface clay	7–25
Shale	5–10
Drain tile	
Surface clay	7–15
Shale	5–9
Face brick	6–10
Paving brick	3–5
Roofing tile	3–10
Sewer pipe	8
Wall tile	3–5
Floor tile	0.25–0.5
Hotel china	0.5–1.0

In order to determine the porosity of a wane it is necessary to test at least 20 sherds, preferably more, to establish the average and range. This information can then be used in a comparative manner, but as the results presented in the tables have shown, it is impossible to obtain clear-cut divisions between most types in terms of porosity because of the overlapping of the ranges. Consequently, although porosity studies may give interesting information, they are not useful as objective criteria in ceramic classification or description, for after the values are established it is not always possible to test individual sherds and place them in their correct groups. It is conceivable that in detailed stueis of pottery from one site porosity figures might be of importance in demonstrating the differences in firing temperatures. In general, however, since the porosity of most ancient wares, aside from the very high-fired ones like the Chinese porcelains and certain Mediterranean types, ranges approximately from 25 to 35 per cent for both the relatively crude American products and the finer ones of the Near East, it does not appear that porosity studies give sufficient usable information to justify the time taken in making them.

[1] Some of the measurements used in preparing Table I were taken in the Works Projects Administration's Archaeological Laboratory in Detroit, which is sponsored by the University of Michigan and supervised by Dr. Robert H. McDowell, through whose kind cooperation this work was made possible.

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HOPEWELLIAN POTTERY TYPES IN MICHIGAN

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IN MICHIGAN and Indiana there are a number of prehistoric burial-mound sites of sufficient cultural similarity to justify their classification in a single category, which I have elsewhere called the Goodall focus.[1] This focus, which has eight components, seven in Michigan (Brooks, McNeal, Norton, Converse, Gratten, Sumnerville, and Scott) and one in Indiana (Goodall), I assume to belong to the Elemental aspect of the Hopewellian phase.[2]

In order to provide a frame of reference in which to evaluate the pottery I shall first describe briefly the nonceramic traits characteristic of the Goodall focus. Some of these traits are conical earthen burial mounds, situated near rivers, rectilinear subfloor burial pits, the presence of artifacts in graves, extended burials, flexed burials, and bundle burials. The artifacts made of copper are ovate-oblong celts, trianguloid celts with truncated apexes, and awls sharpened at both ends. Large chipped-flint blades, small flint flake knives, and ovate, corner-notched, chipped-flint projectile points are also characteristic. The "ground-stone" objects are polished slate gorgets, four-sided or elliptical, with single biconical perforations, and polished stone platform pipes with curved bases. Other representative traits are split awls made from the metatarsi of deer, *Busycon perversum* shell containers, cut jaws of animals, perforated canine teeth of bear, worked sheet mica, twined fabric impressions, and the use of red ochre.

All of these nonceramic traits occur in any four or more of the eight components and therefore may be considered fifty to one hundred per cent characteristic of the Goodall focus. In addition, there are a number of other assumed Hopewellian traits which occur in any one, two, or three of the components. These traits have been described,[3] however, and need not be considered for the purpose at hand, which is to classify the pottery representative of the Goodall focus.

As used in this essay, "pottery type" represents an average of a group of trait elements selected from a number of specimens which appear to be similar. However, most of the trait elements selected to represent the type can be observed on any specimen of it.

Because sherds are quantitatively different and therefore qualitatively different from whole vessels, an attempt was made in this study to classify the pottery in terms of whole vessels. With the information abstracted from complete specimens the sherds could be classified easily, and with a greater degree of certainty.

This classification is based specifically upon an analysis of thirty-three whole or reconstructed vessels and twenty-two sherds. The pottery groupings may have been affected unintentionally, however, by the writer's perspective on Hopewellian pottery in general. The vessels studied are in the possession of collectors or museums in Michigan and Indiana, and pictures of each artifact are filed in the Museum of Anthropology of the University of Michigan.

The pottery from the eight Hopewellian components belongs to five types, which in this paper have been labeled: "Hopewellian zone-stamped," "Norton crosshatched," "Goodall dentate-stamped," "Sumnerville incised," and "Brooks plain." The last four types are closely related to each other, and on a broader level of classification they could be merged into a single category. A sixth type discussed in this essay is the "generalized Woodland" cord-marked pottery found in these Hopewellian sites.

The diagnostic traits or unique characteristics which separate Hopewellian zone-stamped, illustrated in Plate I, Figure D, from all other types studied by the writer are as follows:

I. Rather abundant limestone tempering, most of which has been leached out of the paste, leaving angular cavities
II. Fine to medium texture
III. Smoothed to burnished surface
IV. Very well executed decorative techniques of:
  A. Fine-line incising
  B. Hemiconical punctating made from the left with a hollow point
  C. Rocked-dentate stamping
V. Very well executed decorative patterns on:
  A. Rim:
    1. Narrow band of fine-line closely spaced crosshatching, confined to convexly thickened or chambered upper rim
    2. Horizontal row of small closely spaced hemiconical punctate impressions made from the left with a hollow point, just beneath upper rim band
  B. Body: curvilinear zones, bounded by narrow shallow rounded incised lines and either empty or filled with units of closely spaced rocked-dentate stamp impressions; mostly confined to body lobes and generally alternate-repeating
VI. Within limits, a shape more or less uniform and differing from others in that these jars:
  A. Are always quadrilobate
  B. Are always convexly thickened or chambered in upper rim
  C. Have bottoms which are rounded or rounded and flattened

The vessels as a group are thin, averaging about 0.4 cm. thick.

The diagnostic features which differentiate Norton crosshatched, illustrated in Plate I, Figures F-G, from all other types are:

I. Poorly executed decorative technique of fine-line incising
II. Poorly executed decorative pattern of rather narrow rim band of closely spaced or somewhat closely spaced fine-line incised crosshatching and, just beneath this, a horizontal row of closely spaced poorly executed hemiconical punctate impressions made from either the right or the left (and not made with a hollow point)

This type seems to be an imitation of Hopewellian zone-stamped, yet, on analysis, it appears to be more closely related to the types Goodall dentate-stamped, Sumnerville incised, and Brooks plain.

The diagnostic traits of Goodall dentate-stamped, illustrated in Plate I, Figure B, are the following:

I. Decorative technique consisting of the use of a thick-toothed dentate stamp (in a few instances thin-toothed dentate stamps are used, and, in one, cord is used in the same way as a dentate stamp)
II. Decorative patterns on:
  A. Rim: rather wide band of closely spaced or somewhat closely spaced vertical (straight or curvilinear) or right-to-left-slanting dentate stamp impressions (cord impressions in one instance)
  B. Body: angular or curvilinear zones bounded by narrow or broad shallow rounded incised lines and either empty or filled with units of closely spaced dentate stamp impressions (in one instance cord impressions are used instead of stamp)
III. Within limits, a shape variable in regard to degree of upper shoulder constriction and bottom form, and with:
  A. Rim generally straight
  B. Lip generally flattened
  C. Thick vessel walls, averaging about 0.9 cm.

For the type Sumnerville incised, illustrated in Plate I, Figure C, the diagnostic traits are:

I. Decorative techniques consisting of:
  A. Rocker incising4
  B. Narrow-line incising (on the rim)
II. Decorative patterns on:
  A. Rim: rather narrow upper rim band of closely spaced rocker-incised lines or of narrow shallow rounded horizontal closely to somewhat closely spaced incised lines
  B. Body: curvilinear zones bounded by narrow shallow rounded incised lines and either empty or filled with units of closely spaced rocker incising; bottom of the vessel generally decorated also

The type Brooks plain, illustrated in Plate I, Figure E, is probably a component determinant, since it occurs at but one site. The diagnostic traits for this type are as follows:

I. Decorative techniques consisting of impressing by means of a stick, either cord-wrapped or plain
II. Decorative patterns consisting of:
  A. Very narrow upper rim band of short vertical impressions which cut into outer edge of lip
  B. Rather short horizontal intermittent sparse impressions along median line of rim

As has already been stated, the types Norton crosshatched, Goodall dentate-stamped, Sumnerville incised, and Brooks plain seem to be closely related to each other typologically. The characteristics which link these types together as a group and yet differentiate them from the type Hopewellian zone-stamped are:

I. Grit tempering
II. Medium or medium-coarse texture
III. Smoothed or roughly smoothed surface
IV. Within limits, more variable shapes, although still in range of small jars

The link traits or common characteristics of all five of these types, however, are evidenced in:

I. Temper: grit, granitic, or limestone
II. Surface treatment: roughly smoothed to burnished
III. Decorative techniques: incising, punctating, stamping, and impressing
IV. Decorative patterns:
  A. Rim bands or horizontal rows
  B. Angular or curvilinear zones bounded by incised lines and either empty or filled with some decorative unit
V. Shape:
  A. Lips rounded, narrowed and rounded, rounded and flattened, or flattened
  B. Rims straight, straight to slightly flaring, and flaring
  C. Upper shoulders somewhat constricted, slightly constricted, and very slightly constricted
  D. Shoulders rounded
  E. Shoulder diameter slightly greater than mouth diameter
  F. Bodies short, distance from base to shoulder being about the same as shoulder diameter
  G. Vessels often quadrilohate
  H. Bottoms rounded, rounded and flattened, semiconoidal, and conoidal

TABLE I

COMPARISON OF POTTERY TYPES AND TRAITS

Traits	Weight	Components							
		Brooks	McNeal	Norton	Converse	Gratten	Sumnerville	Scott	Goodall
Link traits by types									
Hopewellian zone-stamped or Norton crosshatched, Goodall dentate-stamped, Sumnerville incised, and Brooks plain, or all......	15	+	+	+	+	+	+	+	+
Norton crosshatched, Goodall dentate-stamped, Sumnerville incised, Brooks plain, or generalized Woodland, or all....................	4	+	..	+	+	..	+	+	+
Hopewellian zone-stamped or generalized Woodland, or both................	3	+	+	+	+	+	+	+	+
Any one, all, or any combination of Norton crosshatched, Goodall dentate-stamped, Sumnerville incised, and Brooks plain......	4	+	..	+	+	..	+	+	+
Diagnostic traits by types									
Hopewellian zone-stamped..................	11	..	+	+	+	+	+	..	+
Norton crosshatched.......................	3	+	..	+	..	..	..	..	..
Goodall dentate-stamped..................	6	..	..	+	..	..	+	..	+
Sumnerville incised........................	5	+	..	+	+	..	+	..	..
Brooks plain..............................	3	+	..	..	..	..	..	..	..
Generalized Woodland.....................	2	+	..	+	..	..	+	..	+

The previously mentioned sixth type of pottery has not been analyzed in any detail. It is generalized Woodland, and future synthesis may provide a type concept for it. For purposes of thr present study it has been classified entirely upon the basis of a cord-marked or malleated exterior surface, a characteristic of diagnostic value only with reference to the other types described here. An example of this pottery is illustrated in Plate I, Figure A.

Table I summarizes the data in a qualitative manner and weighs it in terms of the diagnostic and link traits of the pottery types.[5] All eight of the components share 18 of the 56 traits possible, six components share 37 traits, and four of the components have in common 44 of the 56 traits. Interpretation of this trait distribution is complicated by the uneven quality of the methods used to obtain and to preserve the collections. Had the excavation of all components measured up to modern archaeological standards and had the collections not been scattered, the number of traits common to all components probably would have been grater. I believe, however, that the distribution in Table I confirms the assumption that the pottery classified in this paper is representative of the Goodall focus.

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[1] Quimby, G. I., Jr., "The Goodall Focus, an Analysis of Hopewellian Components in Michigan and Indiana." (*In manuscript*.)

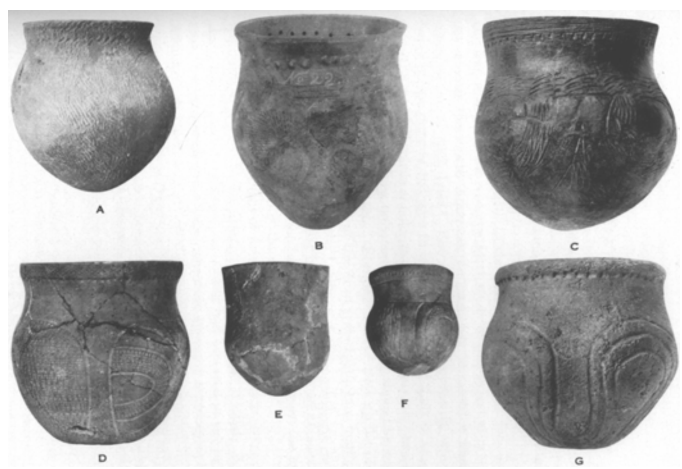
[2] The terminology and the system of classification have been described by W. C. MoKern, "Midwestern Taxonomic Method as an Aid to Archaeological Culture Study," *American Antiquity*, 4 : 301-313. 1939.

[3] Quimby, *op. cit*.

[4] The term "rocker incising" denotes a very narrow line cut into the semi-hardened clay by a technique related to plain rocker stamping such as is found on some pottery types in the Lower Mississippi Valley, e.g. "Tchefuncte stamped," "Troyville stamped," or "Chevalier stamped." The techniques are closely related, but the results can be clearly differentiated, and therefore I wish to make the distinction. Rocker incising has somewhat the appearance of freehand incising in simulation of plain rocker stamping, yet seems to have been the product of a sharp-edged tool which was rocked in the same way as a stamp.

[5] In the usual comparisons of components by pottery type there is no indication of the degree of relationship among the types. Comparison by individual ceramic traits, on the other hand, indicates the degree of relationship, but submerges the identity of the pottery type in the morass of trait elements. I believe the method employed here retains the virtues of both systems and at the same time eliminates the confusion resulting from the use of either alone.

QUIMBY PLATE I



Hopewellian pottery types

A, Generalized Woodland; B, Goodall dentate-stamped; C, Sumnerville incised; D, Hopewellian zone-stamped; E, Brooks plain; F, Norton crosshatched; G, Norton crosshatched. The scale is variable