A REVIEW OF NATURAL RESOURCE INFORMATION AND INTERPRETATION OF REMOTE SENSING IMAGERY AS AIDS IN IMPROVING A SOIL SURVEY IN INGHAM COUNTY, MICHIGAN

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ABSTRACT

A REVIEW OF NATURAL RESOURCE INFORMATION AND INTERPRETATION OF REMOTE SENSING IMAGERY AS AIDS IN IMPROVING A SOIL SURVEY IN INGHAM COUNTY, MICHIGAN.

By

Saiid Mahjoory

The study area of approximately 1020 hectares (2,050 acres) is located in Southern Michigan (Leroy Township, Ingham County). A soil map was made by using 1/12,000 scale, black and white aerial photography (taken in April 1964) as a base map.

Soil profile properties were determined through observations made with a bucket soil auger and examination of recent road cuts. The soils were classified based on soil Taxonomy, 1975.

Relationship between the map units, and the soil formation factors (topography, parent materials, organisms, climate and time) were determined by observations of the soils in the natural landscape. The glacial materials recognized in the study area (based on a 5 foot depth) include: till, outwash, lacustrine, alluvial, outwash over till, and organic materials.

Other natural resources data available were, aerial photography (older and more recent black and white: April 1964, August 1972; color infrared: May 1975), a topographic

map, a surface geology map, and a published soil map of the area. These were interpretive maps made from the new soil map. The interpretive maps included: a surface formation map, a soil drainage class map and a soil management group map of the study area, made by the author. The new soil map was also compared with the published soil map.

The published soil map (1933) can help soil surveyors to understand the kind of soils present in the study area, and where they are located. The use of other available natural resource data in soil surveying can also help soil surveyors to make more precise soil maps more rapidly.

Recent, good quality, black and white aerial photography (with stereoscopic coverage) and also color infrared imagery can help soil surveyors make more accurate soil maps. Time of year is very important in taking of aerial photography. Early in the year (spring) is best in Michigan. The location of natural and man-made features on the soil map, help the mapmaker and user to find their locations, in the field.

Familiarity of the soil scientist with the available natural resource data in an area, and their relationships to differences in the soils present plus the soils significance to use or management for various purposes, can help him make soil maps more accurately and more rapidly.

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A THESIS

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TO

My Wife, Hosny

for her love, understanding, and encouragement.

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I. INTRODUCTION

To make a modern soil survey in southern Michigan, the soil scientist needs to have a basic understanding of glacial materials and their relationships to landforms and soil genesis. The information he gathers is recorded on aerial photographs that serve as base maps and that completely cover the survey area.

Use of aerial photographs as the base map for soil surveys started about 40 to 50 years ago. These, with the use of stereoscopes greatly increased the accuracy of many soil boundaries, and made the work of the soil surveyor easier.

The initial purpose of making soil surveys was to provide for the nation's agricultural future. We need to protect and improve the soil resources for a permanent agriculture and a healthy enjoyable environment. Protecting the soil is possible only with detailed information about it. Soil surveys provide much of the basic information for this work.

Land is needed for homes, businesses (including factories), parks, playgrounds, roads, forestry, wildlife and especially food and fibre production. When we have food to eat, clothes to wear, a house to live in, and a healthy environment to enjoy, it may be because we have made good use of the available lands for all these purposes. By understanding the soils, other land features, and their interrelationships, perhaps we can make more accurate soil maps with soil surveys to assist in wiser land use and management.

The objectives of this study are,to determine how soil surveys can be improved in quality, utility and efficiency:

1. By choice of the most suitable available remote sensing imagery, adequately interpreted.
2. By better understanding the relationships of soil properties to soil formation factors, including:
   (a) The parent materials,
   (b) The associated landforms and topography,
   (c) The relative ages of the land surfaces
   (d) The influence of organisms and
   (e) The climate of the study area.
3. By understanding the significance of soil properties to their use and management for various purposes.

II LITERATURE REVIEW

A. Definitions:

Whiteside in the course, "Origin and Classification of Soils" in January, 1973; defined: soil, a pedon, a polypedon, a soil body and a soil map unit as follows:

Soil: as used here refers to the upper portion of the earth's crust, that has been altered *in situ* into layers that differ from each other, and the underlying unaltered materials. It has width, breadth, and depth.

A Pedon: is the smallest observable, and measurable entity of a soil. Generally, it is roughly hexagonal or cylindrical in shape, a meter or more in horizontal cross section and extending from the land surface to: a depth beyond which alteration *in situ* by weathering and other soil formation processes does not extend, plus a representative sample of the underlying materials; or, to an arbitrary depth defined by the length of the tools used in observing the properties of the soil profiles.

A Polypedon: is a collection of contiguous pedons having properties that fall within the defined range of a kind of soil.

A Soil Body: is a single delineation on a soil map. In very detailed soil mapping, it would probably correspond to a landscape unit that could properly be referred to by the name of a class in the lowest category (series) of the current soil classification system in the United States, Soil Taxonomy, plus a phase of such a series.

A Soil Map Unit: All the similar soil bodies in a given survey area, or in all similar soil surveys using the same legend, can be referred to as a soil mapping unit.

Definitions of other common terms used herein, are as follows:

A Soil Series: The soil series is a collection of soil individuals, essentially uniform in differentiating characteristics and in arrangement of horizons; or if genetic horizons are thin or absent, a collection of soil individuals that, within defined depth limits, are uniform in all soil properties diagnostic for a soil series. (Soil survey staff, 1960).

<u>Soil Type</u>: Soil types have been distinguished within series on the basis of plow layer texture (Soil Survey Staff, 1960), but in the current classification in the United States, they are one of the kinds of phases of the soil series.

<u>Soil Management Groups and Units</u>: Soil series may be grouped according to dominant textures of the profile and natural drainage conditions in Michigan for practical purposes. These groups are called soil management groups, and are designated systematically by numbers and letters (Mokma, et al 1974). For more detailed uses, soil management groups must be subdivided into phases. The slope phases and gravelly, stoney or rocky phases are the most common subdivisions in Michigan. These subdivisions are called soil management units.

<u>A Soil Map</u>: is a map designed to show the distribution of soil types or other soil mapping units in relation to other prominent physical and cultural features on the earth's surface (Soil

Survey Manual, 1951).

Soil Surveying: Consists of the examination, classification, and mapping of soil in the field. (Soil Survey Staff, 1960).

Landscape: All the natural features such as fields, hills, forests, water, etc., which distinguish one part of the earth's surface from another part. (Glossary, SSSA 1975).

B. Factors of Soil Formation

The soil forming factors are the independent variables (properties) that define the soil system (Jenny, 1941).

1. Parent material: Parent material is the initial state of the soil system. It determines chemical and mineralogical composition, texture, and fabric of the young soils. The glacial drift materials in Michigan are very complex even within small areas (Zobeck, 1976). The texture of the mineral parent materials range from sand to silt and clay. These differences in texture are long apparent in the soils formed from these materials. "In areas where soils have formed from consolidated rocks, the soils are shallow because time has not permitted deeper weathering, and outcrops of

bedrock as knobs or ledges are found." (Whiteside et al 1968).

The dominant parent materials in the study area were deposited as glacial till, outwash deposits, lacustrine deposits, alluvium and organic materials, or combinations of these.

2. Climate: The climate in the study area is cool and humid, (Engberg, 1974) so the evaporation and transpiration are smaller than precipitation. The soils in this area therefore, differ from the soils in arid areas. Climate is one of the most important factors in soil formation and development. It determines the amount of water available for weathering the minerals and transporting of soil constituents. So the humid climate of the study area has resulted in removal of the soluble materials from the surface to the subsurface horizons or out of the profile. Climate also effects the kind of plant and animal life on and in the soil. The influence of climate is important in large areas with little relief with differences in latitude and longitude. But the climate in this particular area does not present

any very marked differences evident in local soil differences.

3. Organisms (plants and animals): The native vegetation in southern Michigan was principally deciduous forest. The dominant forest trees on the till plains of Southern Michigan are oak, hickory, maple, beech, elm, ash, sycamore and walnut, according to Gordon (1967). The dominant forest of the lake plain was elm-ash. Some isolated wetland areas in the lake plain were covered by sedges, wiregrass, bluejoint, cattails and other water tolerant species.

   "In the southern part of the state the early settlers found small areas of prairie grass in which only scattered burr oak trees were growing." These areas became known as "oak opening" or "prairies". The soils of these areas have darker colored and deeper surface (A_1) horizons than the soils in the adjoining timbered areas (Whiteside, et al 1968).

   The chief contribution of vegetation and animal life is the addition of organic matter and nitrogen to the soil. The kind of organic

Table 1. Relationships Between Soil Types and Original Vegetation*

Soil Types	Probable original cover on the larger bodies of land
Hillsdale sandy loam	Oaks and hickory dominant; sugar maple, beech, elm and cherry, few to abundant; medium size trees; small amount of undergrowth.
Brookston loam and Brady sandy loam	Dense stand of tall and large individual trees, mainly elm, silver maple, ash, basswood, shagbark hickory, and swamp white oak; vines, few shrubs, very little herbaceous undergrowth.
Conover loam	Elm, ash, basswood, oaks, hickory; fewer beech, sugar maple, walnut, and butternut.
Granby sandy loam	Elm, ash, swamp white oak, sycamore, cottonwood, aspen, red maple; considerable shrub and herbaceous growth; grasses; *Carex*; *Juncus*; and other vegetation.
Houghton muck	Marsh type of vegetation; grasses and sedges dominant; shrubs, such as *Potentillas*, *Cornus*, black birch, scattered tamarack, and willows.

*This information was obtained from the Soil Survey Ingham County, Michigan (Veatch et al 1941).

materials on and in the soil depend largely on the kind of plants that grew in the soil. The remains of these plants accumulate on or beneath the surface and after decomposing with time they become soil organic matter.

The local relationship between soil types and original vegetation are shown in Table 1.

4. Topography and natural drainage: Topography or relief has had a marked influence on the soil of the county, through its influence on natural drainage, erosion and plant cover. Natural drainage differs from well-drained on the convex ridge tops to poorly-drained in the concave depressions. The most obvious relationships of soil properties to relief probably occur in humid regions where soils on nearly level relief tend to have thicker sola than those on slopes (Buol, et al 1973). Also, variation of aspect and elevation influences the distribution of energy, plant nutrients and vegetation. Relief is sometimes related to differences in initial materials. For example, in broad river flood plains, crests of natural levees near the stream channels commonly have coarser material than the areas far back from the

levees that are very nearly level, and have the finer textured initial material (Russell, 1967).

5. <u>Time:</u> All Michigan soils are geologically relatively young, and some of the glacial materials in the southern part of the state may have been deposited over 30,000 years ago (Martin, 1955). The parent material of the soils of the study area were deposited by glaciers or by melt waters from the glaciers which covered the county about 10,000 to 14,000 years ago. All soil properties that differ from the parent materials are related to the time of soil formation. It is necessary to have the other soil formation factors equal or quite similar to study the significance of one such as time, as a soil forming factor. Many factors will change through time, such as the vegetation, depth of leaching, acidity, organic matter content, etc. The soils of this humid temperate area will weather faster, and hence mature, faster than in arid regions. Often, glaciation was a part of the geologic history, and the number of years since the glacier retreated may be used as a starting point of many soil's

development, if no more recent erosion or deposition was involved.

In the areas where soils developed from similar parent material with similar topography, climate and organisms, time may be a significant soil formation factor. For example, Chandler (1937) studied forest soils on glacial moraines in Alaska and found a litter layer well developed in fifteen years, a brownish A horizon in silt loam by 250 years, and a Podzol (Spodozol) profile 10 inches (25 centimeters) thick in 1,000 years.

C. Genesis of the Soils

The processes responsible for the development of the soil profiles from the parent material are referred to as soil genesis. Several processes were involved in the formation of soil layers in the study area. Accumulation of the organic matter, leaching of calcium carbonate, formation and translocation of clay (resulting in clay skins or argillans, on the ped faces in the subsoil) can be important parts of the major soil forming processes.

Accumulations of the organic matter in the surface horizon range from high to low. The soils in level or depressional areas with high water tables are commonly high in organic matter, whereas the soils on high lands, with low water tables, and on steep slopes are low in organic matter. The Colwood and Marlette soil series can be examples of these, respectively.

Leaching of the carbonates and other bases have occured in most of the soils. This can be a loss of soluble minerals or exchangeable bases. Leaching of carbonate in Marlette, a well-drained series, is to a depth of 20 - 40 inches (50 - 100 centimeters)but the Owosso-Marlette soils are leached to a depth of 10 - 36 inches (25 - 90 cm). The differences in the depth of leaching, where erosion has not been active, are a result of the effect of time as a soil forming factor, when other soil formation factors are constant.

Reduction and transformation of Fe is the result of the processes associated with gleying in more poorly-drained soils. In somewhat poorly and poorly-drained soils the gray colors in the subsoil horizons and bright mottles indicate the loss and segregation of the Fe compounds. Capac (somewhat poorly-drained) and Colwood (poorly-drained) soils show evidence of gleying in their subsoils and subsurfaces, respectively.

In some soils,the translocation of clay minerals has contributed to horizon development. The eluviation (leaching and elutriation) of the A_2 horizon, above the illuviation (accumulation) in the B horizon, is evident by light color and bare mineral grains (skeletans) in the A_2 horizon and a lower clay content. The B horizon normally has an accumulation of clay (clay skins or argillans) on the surface of peds (structure particles). The Hillsdale, Marlette and Capac soils are examples of soils that have translocated silicate clay accumulations in the B horizon in the form of clay films.

D. Classification of the Soils

The purpose of soil classification is to organize our knowledge and draw generalizations from the experiences with the soil system for recall and use with similar soils elsewhere. We might be able to describe the phenomena that occur with reasonable certainty to explain similar properties with associated other kinds of soils. Classification also gives a definition of and provides names for soils which communicate information important for technical grouping of soils for various purposes (Whiteside, 1976 personal communication).

The current system of classification has six categories that include, from most general to most specific: orders suborders, great groups, sub-groups, families and series (Soil Survey Staff, 1975). Ten soil orders are recognized. They are:

Entisols, Vertisols, Inceptisols, Aridisols, Mollisols, Spodosols, Alfisols, Ultisols, Oxisols, and Histosols.

Only five of these soil orders are found in the study area. They are:

Alfisols, Inceptisols, Mollisols, Entisols and Histosols.

E. Geology and Landforms

Four separate periods of glaciations have been recognized by geologists during the pleistocene in the United States. The last glacial period called the Wisconsin Glaciation, began about 70,000 years ago, and ended about 10,000 years ago (Haney, 1971).

In moving southward during the cold substages, the glaciers, bearing huge boulders in their undersides, flowed more readily into the lowlands now occupied by the Great Lakes, forming thickened ice lobes in them and scouring them deeper. Although the main body of the lobes moved southward, they also expanded laterally, so that ice also flowed eastward, and westward out of the basins. Consolidated and cemented sedimentary rocks underlie the Wisconsinan deposits in much of Michigan (Leverett and Taylor, 1915).

The surface configuration features on local landscapes depend on deposition of the glacial materials. Land features resulting from the erosional action of ice sheets, postglacial stream dissection, formation of alluvial plains, and lake shore wave cutting, are minor in total area; although they may be locally determinate in differentiation of land surfaces into minor soil and land types.

The major glacial formation and landscape features of Michigan were differentiated on a genetic basis by Frank Leverett (1917). The features recognized by him are recessional and interlobate moraines, till plains, or ground morains, outwash plains or river terraces, beach ridges, and old shorelines.

By studying geology and landforms, the soil scientist will be able to understand how the soils are related to them. Due to variation in glacial materials deposited and their associated topography, with retreat of the ice sheets, the distribution of the soils are very complex. Consequently, within a mapping unit the uniformity of the soils present depend largely on the deposits of glacial materials, whether they are homogeneous or heterogeneous in nature (Mahjoory, 1967). Where the sediments are homogeneous the point observations in a mapping unit are more uniform than in heterogeneous glacial drifts.

In this study glacial landforms that have been recognized due to their different underlying materials are:

1. Till materials
2. Outwash materials
3. Lacustrine materials
4. Alluvial materials
5. Outwash over till materials
6. Organic materials

F. Reported Use of Remote Sensing Imagery

Remotely sensed imagery, and interpretation techniques are very helpful in recognition of soil characteristics. Various types of imagery can be used. They include black and white panchromatic, color, color IR or black and white IR photography. Multispectral imagery and even RADAR imagery are less conventional products which have made possible the study of spectral properties of soils beyond the visible portion of the spectrum (Myers, 1975). This imagery has increased the accuracy of the interpretation of soil and terrain conditions and decreased the amount of field verification required.

In the early 1900's, plane tables were used to draw both a base map and a soil map (Soil Survey Manual, 1960). Aerial photographs were first used for soil mapping by

T. M. Bushnell, and his co-workers in 1929. In recent years, aerial photographs have almost entirely replaced other types of field base maps (Lourke and Austin, 1951). Interpretation of black and white photography has been the basic remote sensing method used for various soil investigations in the past.

Several investigators, among them Colwell (1960), Smith (1968), Parry (1969), Anson (1970) and Kuhl (1970), have reported that for many types of natural resource inventories, color and color-infrared film are superior to black and white panchromatic film. Differences in color allow certain geologic features to be traced more easily on color photographs than on black and white (Anson, 1970). Determining differences in organic matter, soil texture, soil color and soil type by color-infrared photography is much easier when the soils are seasonally non-vegetated (Myers, 1975). Examples of the value of color aerial photography for soil delineations have been demonstrated by Mollard (1968), Mintzer (1968), Rib and Miles (1969), and Parry etal. (1969).

The major conclusion reached by a majority of investigators evaluating various film types and sensor systems was that natural color aerial photography, is the best single sensor for interpreting soils (Rib, 1975). Color-infrared photography was noted to be of special value in determining important terrain features such as drainage, land use, and vegetation conditions, particularly, early in the year (spring).

The use of multispectral imagery and automatic data processing techniques in soil studies have been reported by Baumgardner (1970) and Kristof (1971). Computer analysis of multispectral imagery shows promise for reducing preparation time, and increasing accuracy of soil surveys (Mathews, 1973). Mathews found that soils derived from limestone, shale, sandstone, and local colluvium were identifiable with a high degree of accuracy.

Myers', etal (1974) in work at the Michigan Agricultural Experiment Station, indicates that only in bare fields can soil drainage classes be satisfactorily determined. Using ERTS data on an experimental basis a high percentage of well-drained mineral soil areas were correctly classified in the bare field, particularly in the center of the fields. Misclassification (as somewhat poorly-drained, and poorly-drained soils) were common near the edges of the fields. This misclassification is probably the result of the nominal resolution elements of an ERTS-scan covering a portion of vegetation in adjacent areas. Also, bare organic

soil areas were successfully separated from bare mineral soil areas.

G. <u>Improvement of Accuracy in Soil Mapping with Remotely Sensed Imagery</u>.

Kinds of soil can be interpreted in part from aerial photographs (panchromatic, black and white) by the study of the pattern created by the nature of the parent rock or the mode of deposition of the parent material, and the physiographic environment (Frost, 1950). The use of aerial photographic prints for base maps considerably improved soil survey accuracy and efficiency (Myers, 1975). Mapping of soils on aerial photography requires experience in field observation, as well as knowledge of soil genesis and classification (Bomberger, 1960).

"To take full advantage of remote sensing techniques in identifying soil characteristics, one must be able to recognize tonal patterns, textures (photographic), cultural conditions, and surface conditions wherever possible." (Myers, 1969).

The stereoscope greatly increased the accuracy of soil mapping, and made the work of the soil surveyor faster (Odenyo, etal, 1975). Landforms, relief, slope, etc., can be readily seen and delineated on stereoscopic pairs of aerial photographs (Frost, 1960).

Color-infrared film has been found to be especially useful for separating different vegetation species. Differences in density, and vigor of vegetation are also related to soil differences (Goudey, 1970 and Parry et al 1969). According to a National Technical Work-Planning Conference Committee of the Cooperative Soil Survey in February, 1977, (report in process of preparation), color-infrared imagery is of limited value for soil surveys in areas that are irrigated. Apparently, the added complexity due to irrigation complicates the interpretations.

A conclusion reached in the Hildage County, Texas project (reported to Work-Planning Conference, above), that evaluated various kinds of imagery for soil mapping use, was that color-infrared and color photography were both valuable tools for mapping soils.

An experiment was also done recently (1974 - 1976), in evaluation of IR photography in the course of the soil survey of Clay County, Minnesota. The color-infrared photography allows accurate separation of significant soil conditions where panchromatic photos give little or no indication of where to draw lines separating these conditions. According to that evaluation, although IR photos aid any soil scientist in mapping, they are of particular aid to those with less experience, because black and white photography shows less distinct differences.

The soil surveyor himself can best delineate soil boundaries by: distinguishing the associated landscape features, through the combination of examination of soil profiles with experience and training regarding the relationship of soils to soil formation factors, and assistance through interpretation of remote sensing imagery.

III. MATERIALS AND METHODS

This study was made on an area of approximately, 1,020 hectares, located in southern Michigan. It is in sections 1, 2, 11 and 12 of Leroy Township, in Ingham County as shown in Figure 1.

The information about soil characteristics, and their relationships with the landscape, and parent materials was obtained in part, from the "Legend for the National Cooperative Soil Survey in progress in Ingham County." All soils are classified and name according to a national system, Soil Taxonomy, (Soil Survey Staff, 1975).

A. Making a Soil Map

1. Base map selection:

The soil survey was made, using an aerial photo as a base map that provided information about the cultural features and some information on the distribution of soil bodies on the landscape.

The stereo pairs of images were not available, so the dominant soil characteristics were determined by using photographic characteristics such as tone, pattern and texture. Later the stereo pairs of the images were supplied by the United States Department of Agriculture,

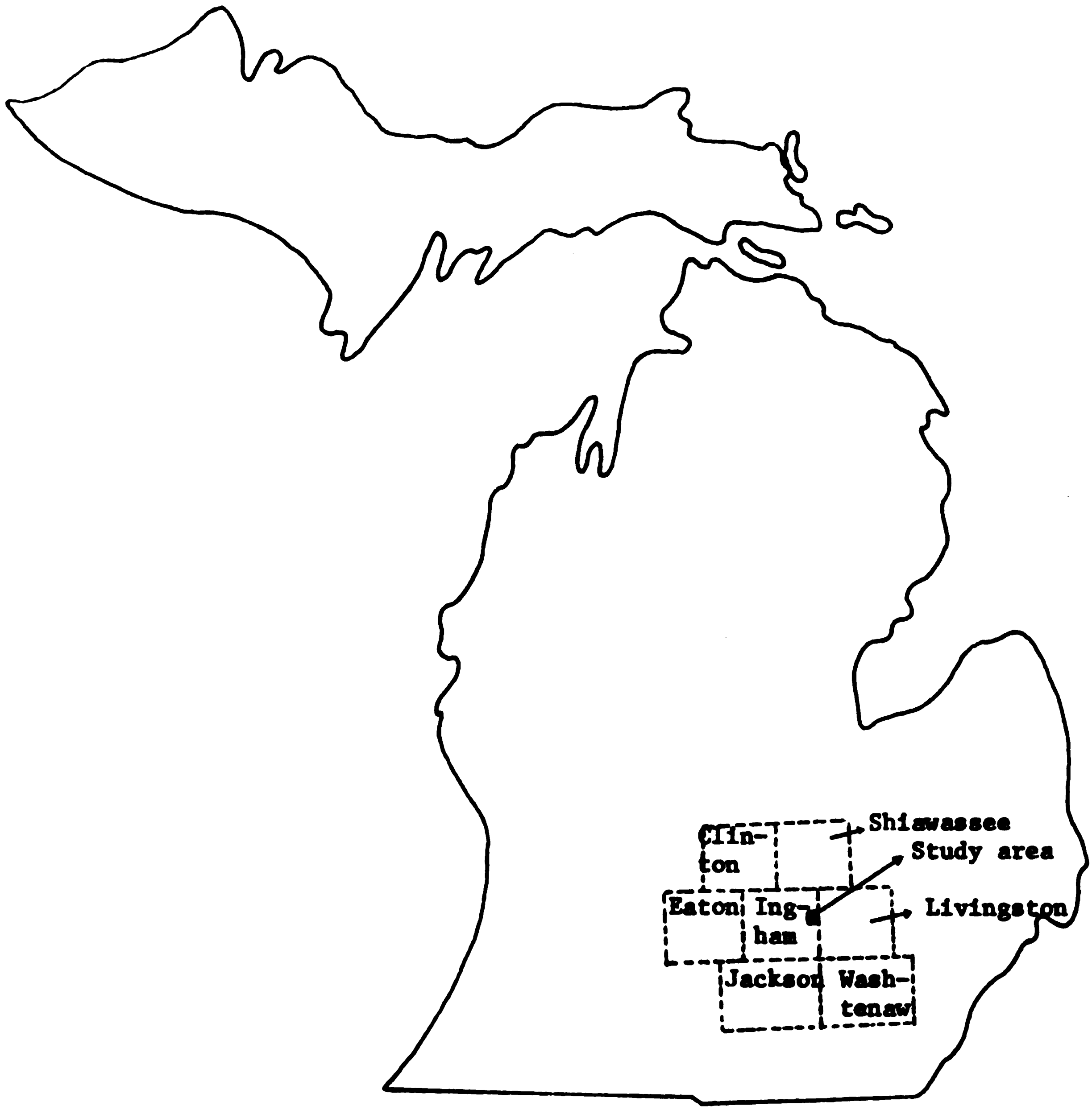


Figure 1: Location of Ingham County and the Study Area in Michigan.

and after interpretation, were compared with the base map of the area.

2. Field investigations:

Soil boundaries were determined through observations made by using a bucket soil auger. In addition, recent road cuts were observed. This had advantages in recognizing some soil characteristics such as structure, or color patterns on structure surfaces. For the determining of each soil series the following important features of each soil horizon were studied:

a) Color
b) Texture
c) Thickness of solum (depth to C horizon)
d) Drainage characteristics (presence or absence and depth of mottling)
e) Reaction
f) Parent material (C horizon)
g) Slope of land surface

Slopes were measured by an Abney level. The acidity or alkalinity of the soils reaction was measured by field pH techniques and 0.5 N, HCl.

The location of the natural land features, such as streams, ponds, marshes, and man-made features (roads, buildings, etc.) were marked on the aerial photo field sheet.

Drainage-ways and wet spot symbols conformed to the aerial photobase. These help the map reader to find his location in the field.

The soil boundaries were drawn on the field sheet by traversing the area, crossing from one soil to another. The results of the field investigations were recorded on the aerial photograph field sheet. Later the soils, roads, and streams were transferred to an acetate overlay as a line soil map.

3. Additional office works included:

- interpretation of available aerial photographs
- inking the fields sheets
- checking all the soil boundaries and symbols with coloring of the field sheet
- joining the field sheet with adjacent sheets and
- recording the individual mapper on the back of the field sheet.

B. Comparison with Other Natural Resource Data Sources:

1. More recent aerial photography of the area, black and white ASCS (1972) and color infrared, remote sensing project (1975).

2. Topographic map of the area (Michigan Department of Conservation; Geological Survey Division, with 20'(6m)

contour intervals, 1908.

3. Surface geology map of the area (Martin, 1958).

4. Published 1933 soil map of Ingham County, Michigan (Veatch et al, 1941).

IV. RESULTS AND DISCUSSION

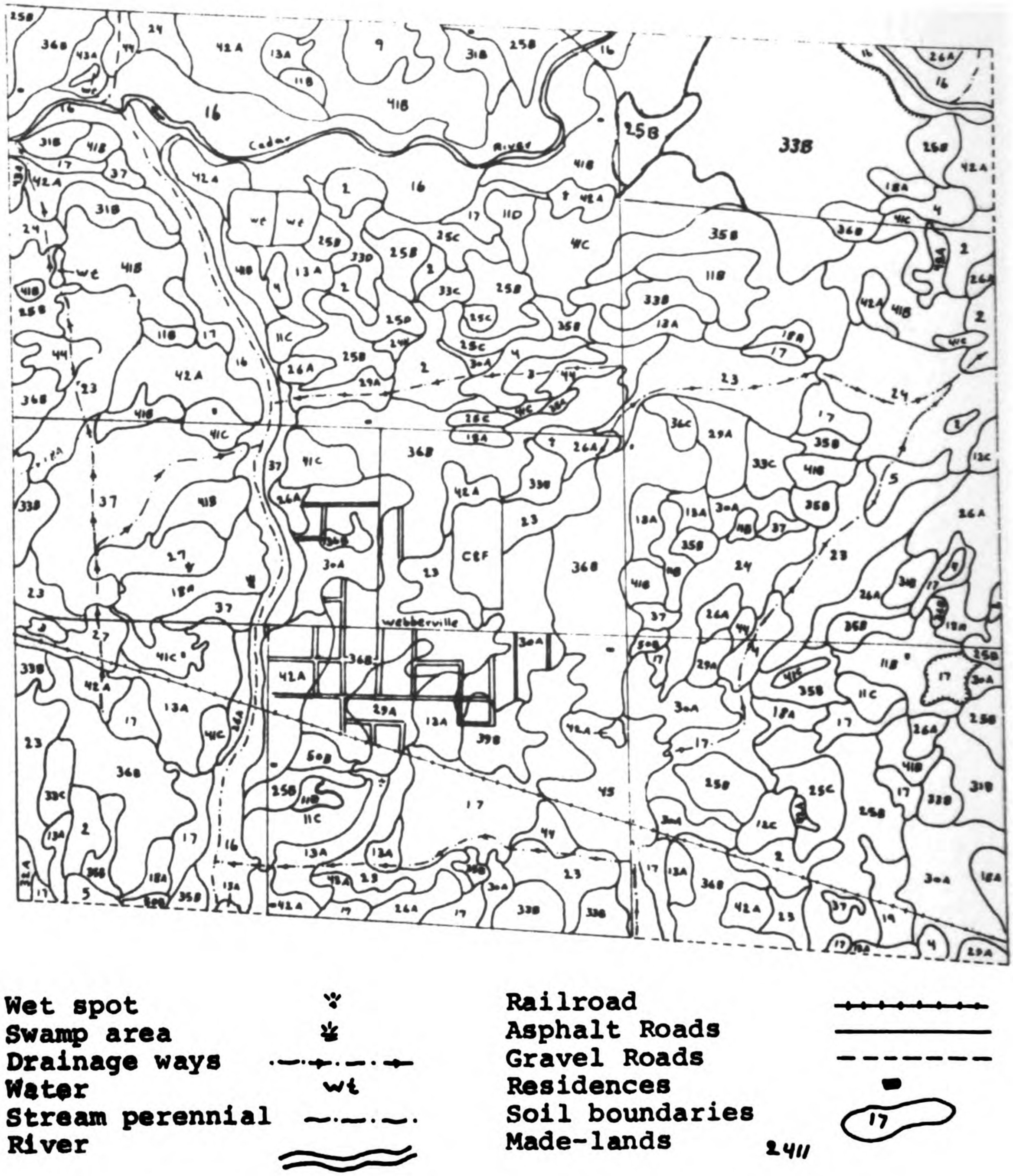
A. Soils From Different Kinds of Parent Materials with Different Drainage Classes:

The soil map of the study area, Figure 2, illustrates the delineations of the soil map units as done in the regular field investigation on an aerial photo base. The 42 map units are composed of 35 soil types. Their series classifications, 33, are shown in Table 2.

The soils of the area are developed mostly on land surfaces approximately 10,000 to 14,000 years of age. The soil profile characteristics differ chiefly with the texture of parent materials and the natural drainage conditions. The textural variations in the deposits of glacial drift (including fluvio-glacial materials, as well as till materials) resulted in different soil profile textures. The soils developed from lacustrine materials are mostly fine textured and somewhat poorly to poorly drained, whereas the soils developed from outwash are mostly coarse textured and well-drained to poorly-drained. The variability of the topography also influences the kinds of soils, their drainage or slope classes, and their distribution.

Soils in level or nearly level areas with water tables

Figure 2: Recent Soil Map of the Study Area, 1977



Map unit symbols	Soil Type
2	Houghton muck
3	Adrian muck
4	Palms muck
5	Edwards muck
9	Napoleon muck
11 B,C	Boyer-Spinks loamy sands
12 C	Boyer sandy loam
13 A	Brady sandy loam
16	Sloan-Cohoctah sandy loams
17	Colwood-Brookston loams
18 A	Capac loam
19	Corunna sandy loam
23	Gilford sandy loam
24	Granby loamy sand
25 B,C,D	Riddles-Hillsdale sandy loams
26 A	Kibbie loam
27	Lenawee silty clay
29 A	Matherton loam
30 A	Metamora-Capac sandy loams
31 B	Metea loamy sand
32 A	Selfridge loamy sand
33 B,C,D	Marlette loam
35 B,C	Oshtemo sandy loam
36 B,C	Owosso-Marlette sandy loams
37	Sebewa loam
39 B	Sisson loam
41 B,C	Spinks loamy sand
42 A	Thetford loamy sand
43 A	Wasepi sandy loam
45	Aurelius muck
50 B	Teasdale sandy loam

The letters of designated slope classes are given below, and appear after the above number symbols, unless the slopes are 0-2 percent only. The complete map unit name is the soil type name (above) plus the slope class (below) if a capital letter completes the map unit symbol, at left above.

A	0 - 2 percent slopes
B	2 - 6 percent slopes
C	6 - 12 percent slopes
D	12 - 18 percent slopes

Table 2: Classification of the Soil Series Used in The Study Area

Soil series	Family characteristics* (Texture, mineralogy, reaction, and/or temperature)	Sub-group	Order
Adrian	sandy, mixed,euic,mesic	Terric Medisprists	Histosol
Aurelius	loamy,mixed, mesic	Terric Limnaquents	Entisol
Boyer	coarse-loamy,mixed,mesic	Typic Hapludalfs	Alfisol
Brady	coarse-loamy,mixed,mesic	Aquollic Hapludalfs	Alfisol
Brookston	fine-loamy,mixed,mesic	Typic Argiaquolls	Mollisol
Capac	fine-loamy,mixed,mesic	Aeric Ochraqualfs	Alfisol
Cohoctah	coarse-loamy,mixed,mesic	Fluvaquentic Haplaquolls	Mollisol
Colwood	fine-loamy,mixed,mesic	Typic Haplaquolls	Mollisol
Corunna	fine-loamy,mixed,mesic	Typic Haplaquolls	Mollisol
Edwards	marly,euic,mesic	Limnic Medisaprists	Histosol
Gilford	coarse-loamy,mixed,mesic	Typic Haplaquolls	Mollisol
Granby	sandy,mixed,mesic	Typic Haplaquolls	Mollisol
Hillsdale	coarse-loamy,mixed,mesic	Typic Hapludalfs	Alfisol
Houghton	euic,mesic	Typic Medisaprists	Histosol
Kibbie	fine-loamy, mixed,mesic	Aquollic Hapludalfs	Alfisol
Lenawee	fine,mixed,nonacid,mesic	Mollic Haplaquept	Inceptisol
Marlette	fine-loamy,mixed,mesic	Glossoboric Hapludalfs	Alfisol

Table 2: Classification of the Soil Series Used in the Study Area (Continued)

Soil series	Family characteristics* (Texture, mineralogy reaction, and/or temperature	Sub-group	Order
Matherton	fine-loamy over sandy or sandy-skeletal,mixed,mesic	Udollic Ochraqualfs	Alfisol
Metamora	fine-loamy,mixed,mesic	Udollic Ochraqualfs	Alfisol
Metea	loamy,mixed,mesic	Arenic Hapludalfs	Alfisol
Napoleon	dysic,mesic	Typic Medihemists	Histosol
Oshtemo	coarse-loamy,mixed,mesic	Typic Hapludalfs	Alfisol
Owosso	fine-loamy, mixed,mesic	Typic Hapludalfs	Alfisol
Palms	loamy,mixed,euic,mesic	Terric Mediaprists	Histosol
Riddles	fine-loamy,mixed,mesic	Typic Hapludalfs	Alfisol
Sebewa	fine-loamy,mixed,mesic	Typic Argiaquolls	Mollisol
Selfridge	loamy,mixed,mesic	Aquic Arenic Hapludalfs-Alfisol	
Sisson	fine-loamy,mixed,mesic	Typic Hapludalfs	Alfisol
Sloan	fine-loamy,mixed,mesic	Fluvaquentic Haplaquolls-Mollisol	
Spinks	sandy,mixed,mesic	Psammentic Hapludalfs-Alfisol	
Teasdale	coarse-loamy,mixed,mesic	Aquollic Hapludalfs	Alfisol
Thetford	sandy,mixed,mesic	Psammaquentic Hapludalfs-Alfisol	
Wasepi	coarse-loamy,mixed,mesic	Aquollic Hapludalfs	Alfisol

*Family names include these terms and the sub-group name.

near the surface are somewhat poorly-drained to poorly-drained. The soils on high lands or on steeper slopes are well-drained or moderately well-drained.

Stereoscopic interpretation was useful in determining land features such as slopes, relief, and drainage characteristics. They can easily be separated on the stereo pairs by office interpretation. According to Myers (1975), field work in soil surveying can be reduced by office interpretation of the aerial photography.

In this study great soil variability was observed in the landscape due to different textures and fabrics of the glacial sediments. The glacial parent materials have been classified into the following groups based on their fabrics that reflect their modes of origin and landforms:

Glacial Parent Materials	Number of Toposequences
1. Till materials - moderately coarse to fine textured	3
2. Outwash materials - stratified: gravels, sands & sandy loams to loams.	4
3. Lacustrine materials - stratified: silts & clay	2
4. Alluvial materials - stratified: sandy to loamy	1
5. Organic materials	-
6. Outwash over till materials, 2 over 1 above	2
	12

1. Soils developed from glacial till and outwash over till:

These soils are found on till plains, and moraines. They are a mixture of materials of glacial origin and ranging in particle size from clay to boulders. They have been deposited directly from the ice without substantial water action. They are not stratified and the associated soil drainage classes are commonly poorly and somewhat poorly-drained on till plains and well-drained on moraines.

More soils are well-drained if the glacial till is coarse loamy to sandy, and the water table low.

As previously mentioned, it is important that the soil mapper understand the processes involved in the deposition of soil parent materials to relate his work to the natural landscape. In the glacial drift and outwash over till derived soils of this area (Table 3) about half of the soil series have been found to be derived from fluvioglacial materials (outwash) 10-40 inches (25-100cm) thick over till deposits. For example, Owosso-Marlette sandy loams and Metea loamy sand, include 10-36 inches (25-90cm) of sandy loam and 20-40 inches (50-100cm) of sand or loamy sand over loam till, respectively. However, the loamy till beneath increases the water holding capacity and decreases the permeability of these soil profiles, compared to their surface materials.

The sandier materials may have been deposited upon the loamy materials as outwash from other till areas or as water worked materials from within the ice. If the former is true these soils will commonly adjoin outwash areas on lower elevations, and till on higher elevations. Thus, the soil surveyor with his field experience, and knowledge about glacial materials can understand where the soils will likely differ in the landscape. This can

Table 3... Soil Series and Soil Mapping Units Associated With Glacial Till and Outwash Over Till

Soil name	Soil mapping units			Drainage classes
	Slope %		Surface texture	
Hillsdale	2-18	BCD	SL	well-drained
Metea*	2-6	B	LS	well-drained
Owosso-Marlette*	2-12	BC	SL	well-drained
Riddles-Hilldale	2-18	BCD	SL	well-drained
Marlette	2-18	BCD	L	well-drained
Capac	0-4	A	L	somewhat poorly-drained
Selfridge*	0-2	A	LS	somewhat poorly-drained
Colwood-Brookston	0-2		L	poorly-drained

* Associated with outwash materials over till

be checked by his borings as he traverse the area.

2. Soils developed from glacial outwash:

When the glacial ice melts, water becomes available, and tends to wash the finer materials away from the original heterogeneous mixture, thus segregating different particle sizes. The result is a general concentration of the coarser materials (sand and gravel), which also tend to become stratifed, along drainageways nearby. The finer silt and clay are deposited in more distant quieter water as stratified lacustrine materials.

Due to their relatively low water holding capacity, the coarse materials result in formation of soils that generally are better drained than soils developed from fine material on similar topography.

The soils that developed from glacial outwash in the study area are shown in Table 4.

3. Soils developed from lacustrine materials:

These soils formed from fine clay and silt deposited from the quiet water, as in glacial lakes, further from the sediment sources such as outwash plains or stream channels. These sediments are a variety of stratified drifts. Textures range from loam to clay. The soils that have been developed from lacustrine materials are normally poorly, and somewhat poorly-drained. Slopes are commonly level or

Table 4... Soil Series and Soil Mapping Units Associated with Glacial Outwash

Soil Names	Soil mapping unit		Drainage Classes
	Slope %	Surface texture	
Boyer	6-12 C	SL	well-drained
Oshtemo	0-12 B,C	SL	well-drained
Boyer-Spinks	0-12 BC	LS	well-drained
Spinks*	0-12 BC	LS	well-drained
Matherton	0-3 A	SL	somewhat poorly-drained
Wasepi	0-3 A	SL	somewhat poorly-drained
Brady	0-3 A	SL	somewhat poorly-drained
Thetford*	0-3 A	LS	somewhat poorly-drained
Sebewa	0-2	L	poorly-drained
Gilford	0-2	SL	poorly-drained
Granby*	0-2	ls	poorly-drained

* These soils may also be derived from sandy tills.

Table 5... Soil Series and Soil Mapping Units Associated with Lacustrine Materials

Soil name	Soil mapping units		Drainage classes
	Slope %	Surface Texture	
Sisson	2-6 B	L	well-drained
Kibbie	0-3 A	L	somewhat poorly-drained
Lenawee	0-2	sic	poorly-drained

or nearly level like the lake basins in which such sediments accumulated.

The soils that developed from lacustrine materials in the study area are shown in Table 5.

4. Soils developed from alluvial materials:

These soils formed on river flood plains. They are usually somewhat poorly-drained or poorly-drained except on levees along stream channels. Most of these areas have slopes less than 2 percent. Only one alluvial soil map unit (Sloan-Cohoctah) is found in the study area and extends from north to south beside Kalamink Creek and east to west along the Red Cedar River.

5. Soils developed from organic materials:

These soils formed from many different plant associations (e.g. Bog, marsh, forest peat, or swamp peat, and sedimentary peat) in depressional areas on lake plains, outwash plains, and till plains. They may be deep or shallow organic materials. Because of the wetness of the areas the plant remains did not completely decompose, and accumulated in these areas. These soils are naturally poorly-drained or very poorly-drained. But with special management and artificial drainage, these soils can be used for crop production. The soils that developed from organic materials in the study area are shown in Table 6.

Table 6... Soil Series and Soil Mapping Units Associated with Organic Deposits.

Soil name	Soil mapping units		Drainage classes
	Slope %	Surface texture	
Aurelius	0-2	muck	poorly-drained
Edwards	0-2	muck	poorly-drained
Houghton	0-2	muck	poorly-drained
Palms	0-2	muck	poorly-drained
Adrian	0-2	muck	very poorly-drained
Napoleon	0-2	muck	very poorly-drained

Excluding the organic soils - the materials of which were deposited in post glacial times - there are 12 toposequences of soils mapped in this four square mile study area from five different kinds of materials. These 12 different parent materials are each recognized as having one of the five modes of origin just tabulated, Tables 3 - 5. But the soils on these five kinds of geologic materials (modes of origin) - differ also in the texture of their parent materials, the natural drainages with which they are associated and the slopes of their surfaces.

In one of these parent materials (calcareous loam till) 3 different soil drainage classes are each associated with a different soil series in the area, and 3 slope classes of the well-drained member of this toposequence (Marlette) are recognized map units. In short, 5 different soil map units are differentiated on this one parent material. In all, there are 39 map units on these six kinds of non-organic materials in the study area.

B. Comparison with Other Natural Resource Data Sources.

1. Comparison of remote sensing alternatives for making soil maps.

a. Comparison of black and white imagery taken at different times.

(a) Topographic, natural drainage, and photographic relationships

These relationships are shown in the cropland area, within the rectangular solid lines in the southeast corner of the Figures 3 and 4. Three different soil drainage classes are present on Figure 3. They are: poorly-drained (2 areas of 17), somewhat poorly-drained (1 area of 18A), and well-drained (areas 11C, 25B, and 41B). Early in the year when the soil surface is exposed, poorly-drained soils appear very dark, somewhat poorly-drained soils appear lighter, and well-drained soils appear very light in tone (Figure 3). These differences are related to the surface soil colors associated with the natural drainage differences. These soil variations do not show up as clearly on Figure 4, taken in August. Later in the year foliage of trees, crops and all form of vegetation cover more ground, and little of the soil surface is exposed. So, natural soil drainage variations with differences in topographic features can more easily be interpreted early in the year (Figure 3) on black and white photography.

(b) Man-made features

Black and white imagery made in August 1972 (Figure 4), has a definite advantage, in keeping located, over black and white imagery made in April 1964 (Figure 3), because it is more representative of the land use and cover of the area today. The features that have been changed by man since 1964 (Figure 4) include: additional sub-roads (R), newer residences (H), a golf course (G), and a dumping ground (D). Such additional features can help a soil surveyor to cover more acreage with confidence in his location.

The preceding comparison shows how good quality,recent black and white aerial photographs are a useful tool in soil surveying if they are made early in the year. The accurate placement of the boundaries between soil mapping units and evaluation of the variations within a mapping unit must always be based on careful field investigation.

b. Comparison of infra-red with black and white imagery.

(a) Vegetation differences

Color IR photography Figure 5, has an advantage over black and white imagery, Figure 3, in identifying vegetation features, such as differences in species, stage of growth, plant vigor or stress, and land use differences. This is due to the fact that living green vegetation has high reflectance in the near IR-band. (.7-.9μ). This is evidenced by bright red or reddish on films (Figure 5) which are sensitive in this band (e.g. Kodak, 2445 and color IR film). Fields labeled with the letters B and D in the northeast one quarter of the study area are examples. These are called false colors, because the green color of chlorophyl appears red. Black and white imagery does not show such striking contrast in tone. The black and white image alone does not distinguish between dormant, or non-living, and living vegetation. The recent land use map of the study area based on 1972 remote sensing imagery compared with an earlier (1962) land use map at the Tri-County Planning Commission Office in Lansing, enabled the author to select comparable fields for the above studies of vegetation differences and subsequent studies of soil moisture and soil texture differences.

(b) Water and land differences

Color IR imagery also shows striking differences between land and water. For example, the ponds, P, in the northwest corner of the color IR photograph, Figure 5, shown with an arrow, are blue to dark blue. The adjoining lands are light to dark gray or pale blue and red to reddish if vegetated. On black and white imagery Figure 4, these differences are only tones of light gray to dark gray. In contrast, color IR imagery commonly shows a very clear boundary between water that absorbs radiation, and land which reflects much more radiation.

(c) Soil moisture differences

Color IR film has a definite advantage in the detection of soil moisture differences over panchromatic black and white film. Differences in soil organic matter and in water content, associated

Figure 3: Soil Map of study area as done on the regular field sheet (black and white photo, April 1964)

Figure 4: Black and White photo of the study area taken in August of 1972

Figure 5: Color Infrared Imagery of the Study Area taken in May, 1975.

with differences in natural drainage and topography, commonly show up better on color IR than black and white. In part, this is due to the inability of one's eyes to distinguish between tones of gray as well as one's ability to distinguish between color hues. In the southeast corner of the color IR film, Figure 5, the well-drained non-vegetated area (H) appears light gray (with a mixture of some pink due to vegetation), a somewhat poorly-drained area (G) appears darker bluish gray, and the poorly-drained area (F) appears very dark blue. These differences in natural drainage are also distinguished, however, on black and white photography, Figure 3, early in the year.

The differences in tone of the well-drained areas in Figure 5, just referred to, are lighter on the coarse textured areas, map units 11C and 41B, Figure 3, than on map units 25B and 25C which have more loamy, moderately coarse textures and greater moisture holding capacities.

(d) Soil texture differences

Color IR film has a great advantage over black and white film in recognition of soil texture differences. Fine textured or loamy soils have good water holding capacity and appear darker. This is very evident in the northeast corner of Figure 5, at point C, on loams, while coarse textured or sandy soils, at points A, have poor water holding capacity, and appear lighter. These soil differences were confirmed in April, 1975, when this entire area had been recently plowed. Thus, the boundary between these soils of different texture are clearer on color IR film than black and white and the soil map was revised to show the differences.

According to Kenneth, et al (1951) it is frequently difficult to establish whether tonal variations with color IR on bare soil areas are due to moisture or texture. For example, the well-drained gently rolling, fine-textured soils, on color IR films, Figure 5C, are dark enough to call somewhat poorly-drained soils, compared to the gently rolling, coarse textured soils Figure 5, A. Due to the good water holding capacity of the finer textured soils they appear darker blue. Field checking established that these aerial differences were due to texture, rather than soil color or topography, and the soils have been identified better than with black and white film. However, moisture differences may confuse the texture-moisture relationships in irrigated areas.

By these comparisons it is evident that using the color infra-red imagery helps soil surveyors in identifying natural soil drainage, soil textural variations and vegetation differences better than with black and white imagery. The time of year is very important in all kinds of aerial photography. The best time is early in the year (spring) before deciduous trees leaf-out in southern Michigan. The use of color IR imagery will also be helpful in improving accuracy, and decreasing the time to make a soil survey.

2. Comparison of the topographic map and drainage classes map:

Topographic maps are intended to depict the relief features of the land surface, and indicate the degree of slope of the ground (N. Strahler, 1960). The topographic map of the study area was made in 1908, by the Department of Conservation, Geological Survey Division, Figure 6, and shows 20 foot (6m) contour lines.

Natural soil drainage classes of the study area are shown by different soil series names on the soil map. Natural drainage classes of the soils in the study area are defined as follows, and shown with symbols (W, SWP, or P) on the drainage class map, Figure 7.

Well-drained soils (W): Water is removed from the soil readily, but not rapidly. Well-drained soils are free of gray mottles, and horizons are usually bright colored. The water table is generally at depths greater than 60 inches from the surface.

Somewhat poorly-drained soils (SWP): Water is removed from the soil slowly enough to keep it wet for significant periods, but not all of the time. They have gray mottling within 10-18 inches (25-45 cm) of the surface. The water table is quite high during the spring of the year. While these soils make productive agricultural lands, they offer moderate to severe restrictions without artificial drainage for dwellings and septic tank disposal fields.

Poorly-drained soils (P): Water moves away so slowly that the soil remains wet for a large part of the year. Poorly-

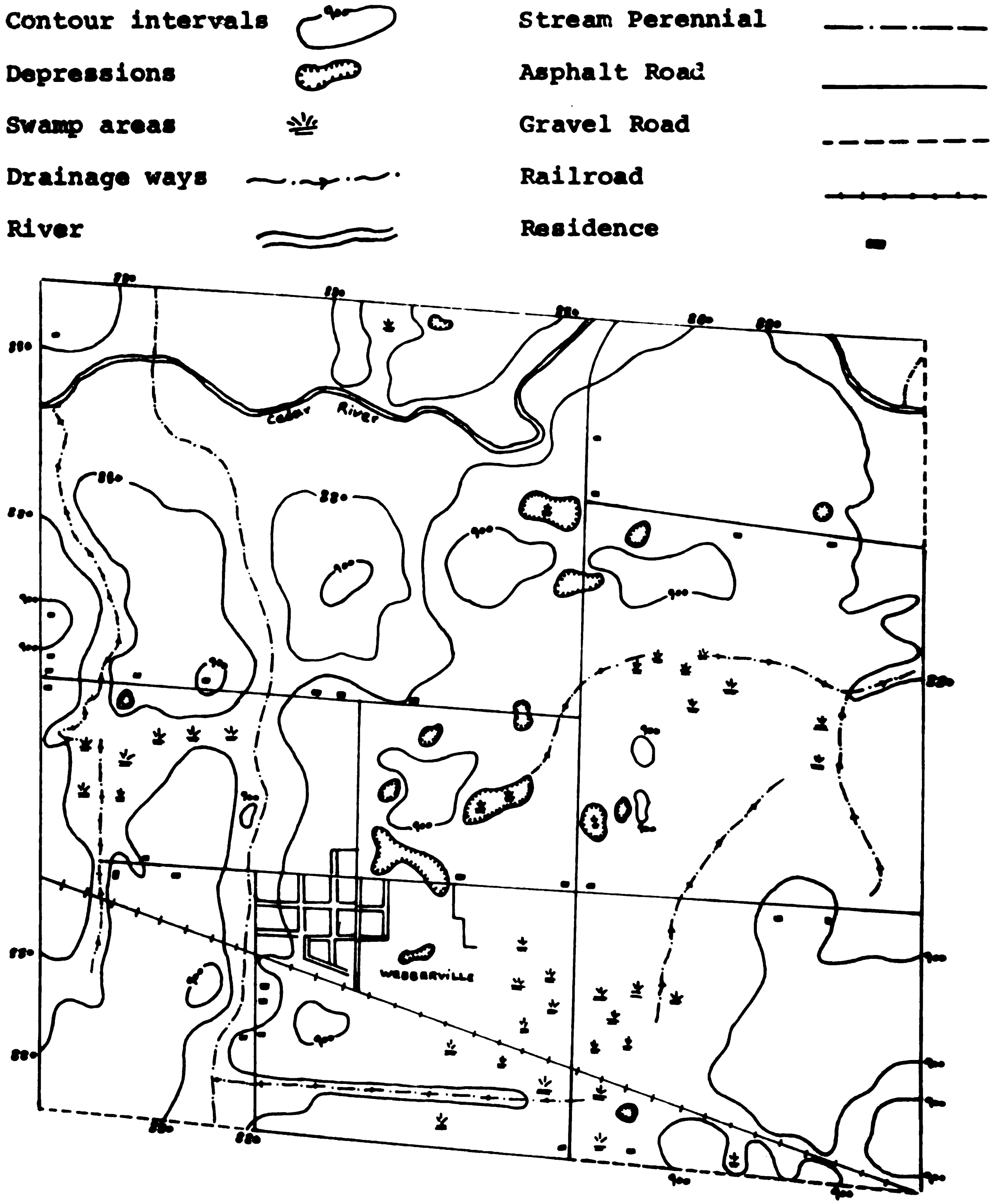


Figure 6: Topographic Map of the Study Area*

*Made in 1908 by Michigan Department of Conservation, Geological Survey Division, with 20 foot (6 m) contour intervals.

Well-drained	**W**
Somewhat poorly-drained	**SWP**
Poorly-drained	**P**

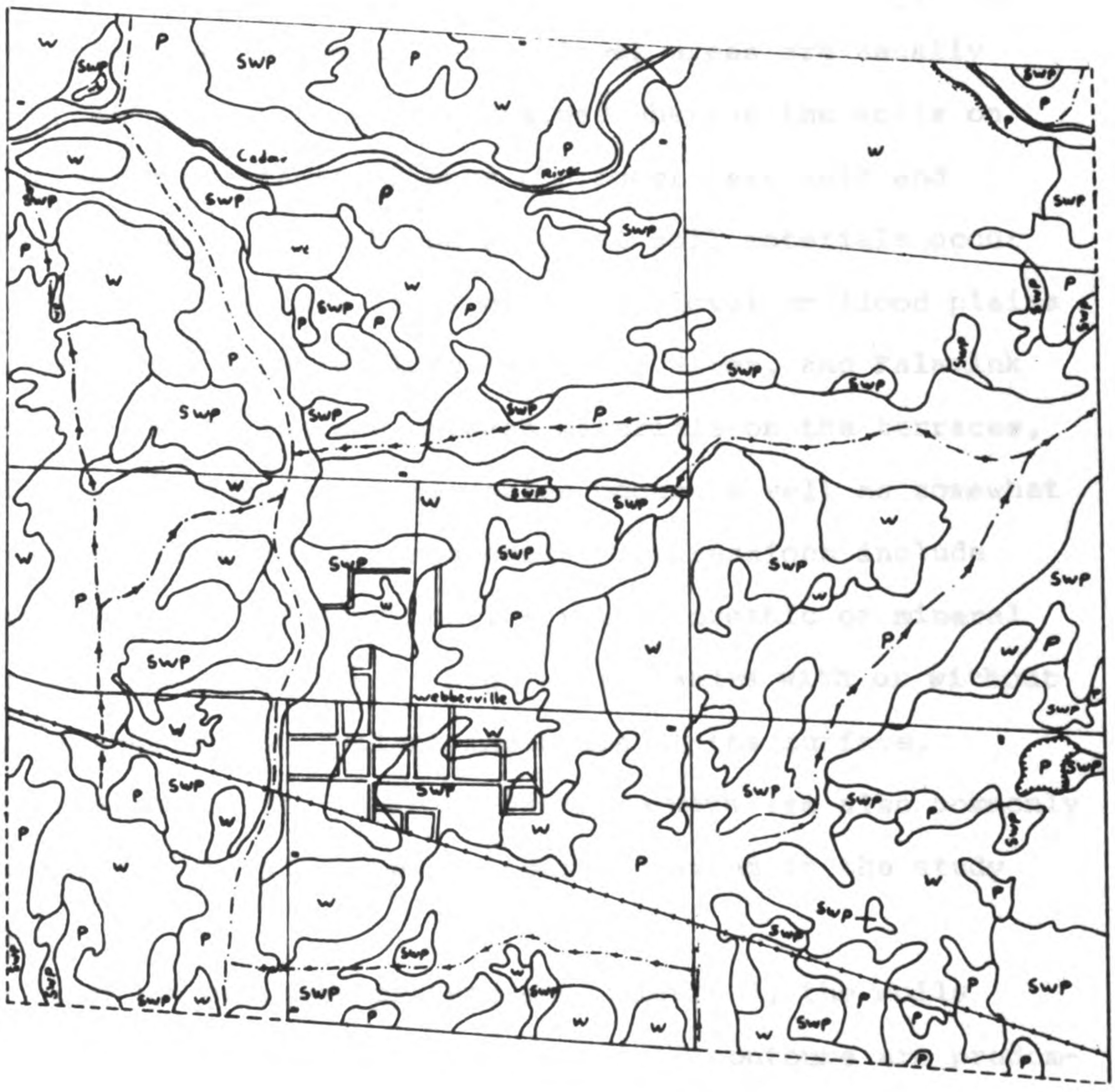


Figure 7: Drainage Classes Map of the Study Area

drained conditions are the result of a high water table a slowly permeable layer within the profile,or wet conditions through seepage, or to some combination of these conditions.

Due to natural drainage, and slope conditions, the soils located in low or nearly level areas are usually somewhat poorly- or poorly-drained whereas the soils on high areas or steeper slopes are moderately well and well-drained. Outwash and alluvial soil materials occur where the slopes are level or nearly level on flood plains or terraces, located along Red Cedar River, and Kalamink Creek. On the coarser outwash materials on the terraces, several well-drained soil series occur as well as somewhat poorly- and poorly-drained soils. Depressions include mostly poorly and very poorly-drained organic or mineral soils. These are due to high water tables with or without the accumulation of plant materials at the surface, respectively. The soils in drainage ways are also commonly poorly-drained and somewhat poorly-drained in the study area.

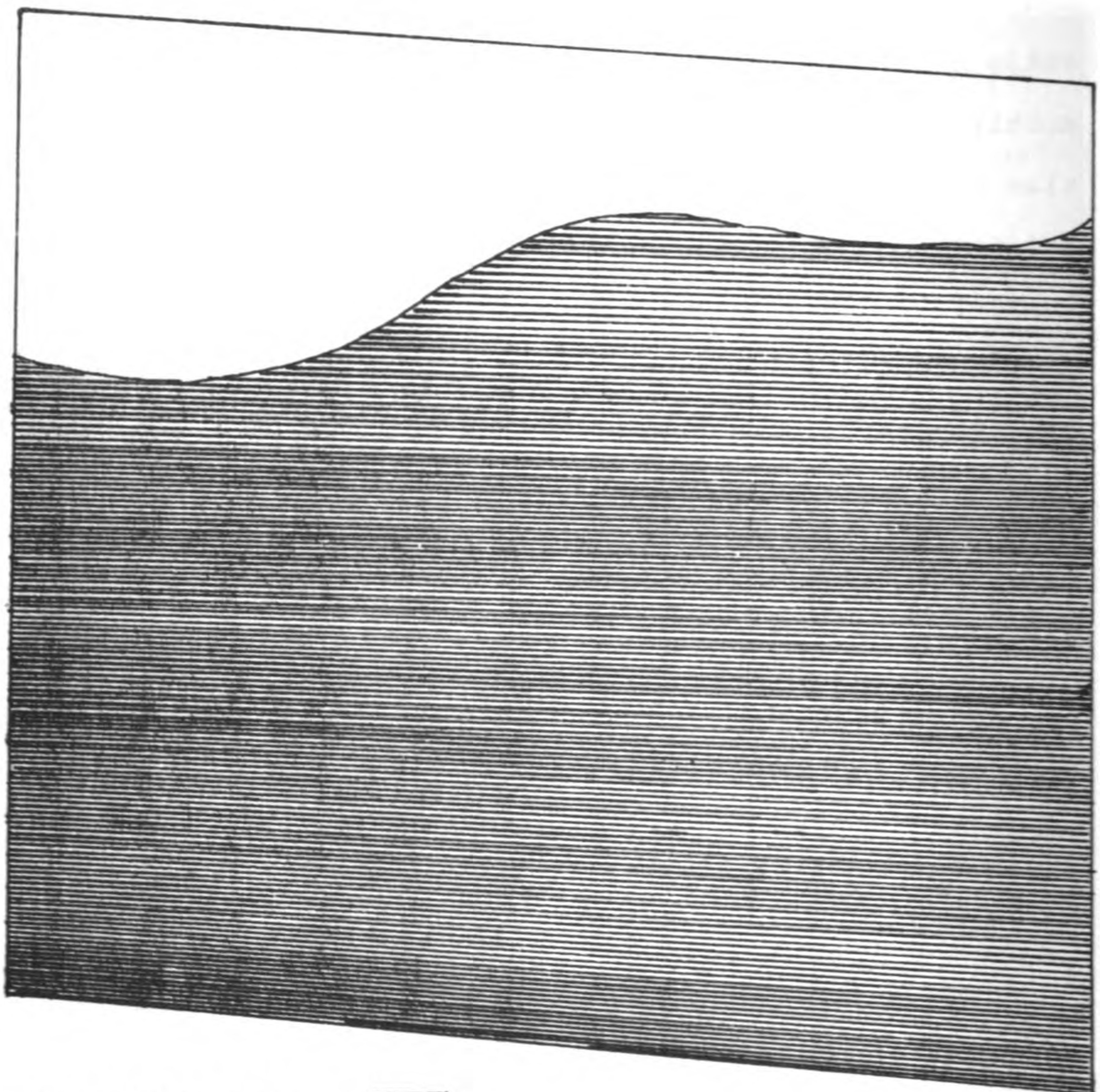
In the drainage classes map, Figure 7, the soils located above the 900 foot (270 meter) contours are predominantly well and moderately well-drained, but some, somewhat poorly- and poorly-drained soils also occur in these parts. The distance of contour intervals on this kind of topographic map (20 foot, or 6 meter contours) are not desirable for detailed soil surveying. However, the soils below the 880 foot (264 meter) contour intervals are mostly poorly and somewhat poorly-drained. In this part, also some well-drained soils occur. Soils between the 880 and 900 foot (270 and 264 meter) contours include well-drained, somewhat poorly-drained and poorly-drained areas.

Some drain lines show up in the recent drainage classes map, Figure 7, that do not show up in older topographic maps, Figure 6. The reason could be the owners have made these drain lines after the topographic map. Most of the marsh areas on the topographic map, include poorly-drained soils on the drainage classes map. Using the topographic maps in soil surveying and mapping projects or as a base map may help soil surveyors to make more correct soil maps. In detailed soil surveying detailed topographic maps (with less contour interval distances) will be more useful.

3. Surface geology of the study area:

The surface geology of the study area was reported by Martin in 1955, Figure 8. As the map shows, the horizontally hatched areas were called ground moraines (or till plains)and include 76 percent of the area, Table 7. The areas without hatching were believed to be outwash and glacial channels.

Figure 8: Surface Geology of the Study Area by Martin (1955).



Ground Moraines

Outwash and glacial channels

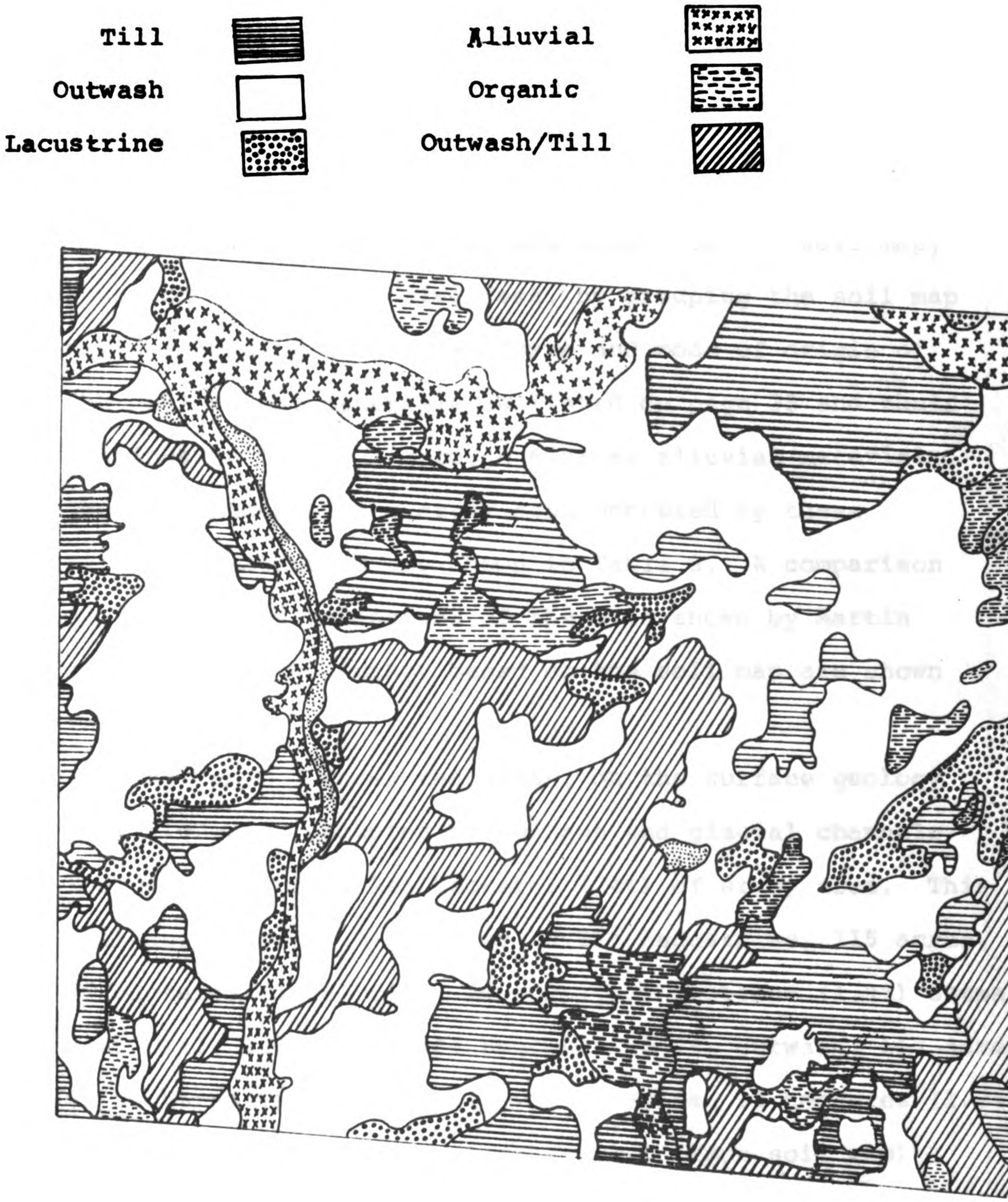


Figure 9: Surface Geology of the Study Area Based on Recent Soil Map, 1977

They include 24 percent of the area.

A surface formation map of the area has been made by the author, Figure 9. This was made from the soil map, based on the surface five feet, by grouping the soil map units according to the landforms and mode of origin of the soil parent materials as listed on page 35 and their listings in Tables 3 through 6 or as alluvial materials. The percentage of the study area occupied by these different materials are shown in Table 8. A comparison of the surface formations of the area shown by Martin and those by the author based on the soil map are shown in Table 7.

As Tabel 7 shows the areas, on the surface geology map, Figure 8, occupied by outwash and glacial channels include 615 acres, 246 hectares (24%) of study area. This includes 7 acres, 3 hectares (0.2%) lacustrine, 115 acres, 46 hectares (4.5%) till, 5o acres, 20 hectares (1.9%) outwash over till, 250 acres, 100 hectares (9.8%) outwash, 163 acres 65 hectares (6.4%) alluvial and 30 acres, 12 hectares (1.2%) of muck soils, on the surface geology (from soil map) Figure 9.

The areas occupied by ground moraine (or till plains), Figure 8 and Table 7, include 1,935 acres, 774 hectares (76%) of the study area. This includes 150 acres, 60 hectares (5.9%)

Table 7... Comparison of Surface Geology of the Study Area, As Shown in Figures 8 and 9

Figure 8 from Helen Martin Hectares	(acres)	%	Figure 9 from the soil map	Hectare	(acres)	%	% component
Outwash and glacial channels	246 (615)	24	Lacustrine	3	(7)	0.2	3
			Till	46	(115)	4.5	39
			Outwash over till	20	(50)	1.9	7
			Outwash	100	(250)	9.8	24
			Alluvial	65	(163)	6.4	70
			Muck	12	(30)	1.2	21
				246	(615)		
Ground moraine (or till plains)	774 (1935)	100	Lacustrine	60	(150)	5.9	97
			Till	70	(175)	6.9	61
			Outwash over till	257	(642)	25.2	93
			Outwash	315	(788)	30.9	76
			Alluvial	27	(68)	2.7	30
			Muck	45	(112)	4.4	79
				774	(1935)		
	1020 (2550)	100		1020	(2550)	100	

Table 8... Amount and Percentage of Surface Formations, in the Study Area, Figure 9

Surface materials	Hectares	(Acres)	% of map covered
Lacustrine	63	(157)	6.1
Till	116	(290)	11.4
Outwash/till	277	(695)	27.1
Outwash and water	415	(1035)	40.7
Alluvial	92	(230)	9.1
Muck	57	(143)	5.6
Total	1,020	(2,550)	100

lacustrine, 175 acres, 70 hectares (6.9%) till, 642 acres, 257 hectares (25.2%) outwash over till, 788 acres, 315 hectares (30.9%)outwash, 68 acres, 27 hectares (2.7%) alluvial and 112 acres, 45 hectares (4.4%) of muck soils in surface geology (from soil map), Figure 9.

To increase acreage and do a good job in soil surveying and mapping, a more detailed surface geology map would be helpful. But, using a very general geological map, Figure 8, in detailed soil surveying, cannot be very useful. It may even be confusing.

4. Comparison of published and recent soil maps as to natural drainage classes, soil management groups, and surface formations.

An approximate comparison of the drainage classes on the published soil map in 1933 (Veatch et al, 1941), Figure 10, and the recent soil map of the area, Figure 2, was made as follows: 64 point observations were selected (in the center of each 40 acres) on each soil map. The natural drainage classes, and the soil management groups found on each map were recorded. Of the total 64 observations: 48, (75%) of them on the new map agree, 14, (22%) are in adjoining, and 2, (3%) are in contrasting drainage classes compared to the published soil map. It is interesting that both maps show about 40% well-drained, 20% somewhat poorly-drained, and 40% poorly-drained soils in the study area.

Published soil map and soil management groups legend

Map symbol	Soil management groups	Map unit name
B	5/2a	Berrien loamy sand
Bs	3/5a-4a	Bellefontaine sandy loam
Br	2.5c	Brookston loam
By	4b	Brady sandy loam
Cl	2.5b	Conover loam
Cm	Mc	Carlisle muck
F	3/5a	Fox sandy loam
Gl	L-2c - L-4c	Griffin loam
Gp	Mc-a	Greenwood peat
Gs	5c	Granby sandy loam
Hs	3a	Hillsdale sandy loam
Km	L-Mc	Kerston muck
Mm	5c	Maumee loam
Mi	2.5a	Miami loam
Ol	4a	Oshtemo sandy loam
Wa	L-2c	Wallkill loam

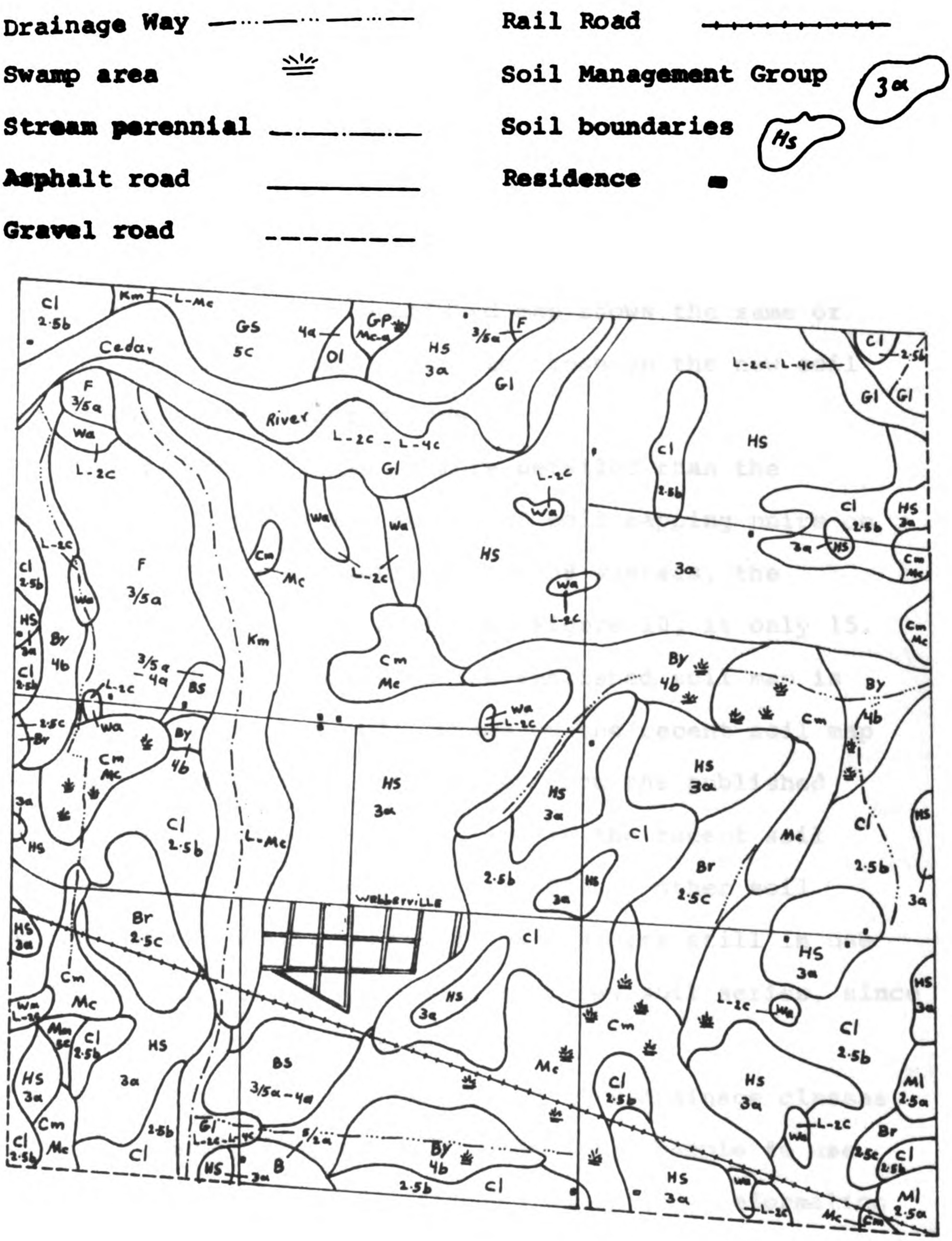


Figure 10: Published Soil Map and Soil Management Group Map of the Study Area, 1941

Comparison of soil management groups on the recent soil map and the published soil map from the 64 point observations, show that the published map groups agree in 17%, adjoin in 47%, and are contrasting in 36% of the observations. Or, the published map shows the same or similar soil management groups to those on the new soil map in 64% of the observations.

The recent soil map is more detailed than the published soil map. The number of soil mapping units on the recent soil map, Figure 2, are 39 whereas, the number on the published soil map, Figure 10, is only 15. The number of soil series on the published soil map is 16, and the number of soil series on the recent soil map are 33. The number of soil series from the published map, Figure 10, that are also used in the recent soil map, Figure 2, are only 3. Since 1933, 3 other soil series are now inactive, but 10 of them are still in use in the United States. The number of new soil series, since 1933, used in the study area are 30.

A detailed soil map-related to soil drainage classes, or soil management groups and units-helps people to use their land better, for various purposes. Any information available before field investigation may be helpful in making a more correct soil map. By using the published map, soil surveyors can better understand what kind of soils are present in the study area, and where they are located.

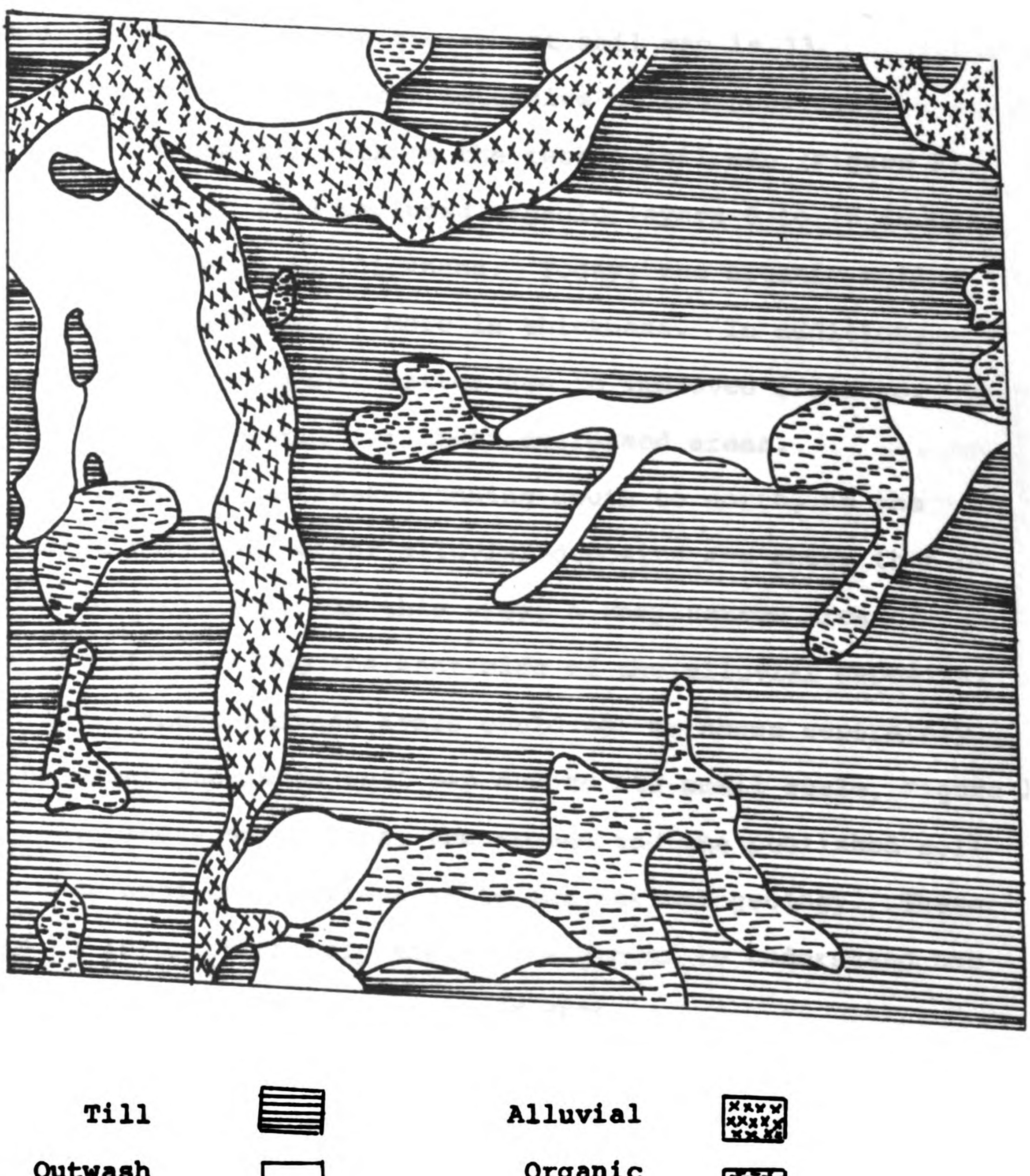
A comparison of surface geology as interpreted from the recent soil map (Figure 9) with the 1933 published soil map (Figure 11) has also yielded some interesting comparisons.

The published soil map did not recognize any soil formed in lacustrine deposits. On the recent soil map some small areas of lacustrine deposits are delineated (Figure 9).

The till area shown on the NE ¼ of Figure 11 includes considerable outwash on the NE ¼ of Figure 9. Spinks loamy sand (41B and 41C) is a major component of the outwash in this area (Figure 2). The Spinks series may be formed in either outwash or till (Table 4). Much of this area is shown as Hillsdale on the published soil map (Figure 10).

The large area of outwash/till near the center of Figure 9, is shown primarily as till in Figure 11. This area is mostly Owosso-Marlette sandy loams (36B) on the recent soil map (Figure 2), and is Hillsdale sandy loam(Hs) on the published soil map (Figure 10). Apparently, Hillsdale in 1933 included the Owosso sandy loam, now recognized as sandy loam outwash over loam till (Table 3) as well as some of the coarser Spinks soils as mentioned in the preceding paragraph.

Figure 11: Surface Geology of the Study Area Based on the Published Soil Map, 1941



Thus, the concept of the Hillsdale soil series has been narrowed since 1933. The number of soil series recognized on the published soil map is 16, whereas the number of soil series on the recent soil map is 33.

Organic areas are more extensive on the published soil map (figure 11) than on the recent soil map (Figure 9). Organic soils in 1933 included organic layers 6 to 16 inches (15-40 cm) or more in thickness. Today, the organic soils are 16 inches (40 cm) or more in thickness. In addition, decomposition of organic matter due to improved drainage, can be another reason, for their decreased areas.

Along Kalamink Creek, running south to north, on the published soil map, wider alluvial deposits are shown than on the recent soil map. In this area, a very narrow area of outwash extends along the east side of the alluvial deposits, Figure 9. These outwash areas could not be shown separately on the older published soil map due to its small scale, Figure 11.

With these exceptions, the recent and the published soil maps show good correlations as to the surface geology. These kinds of information help the soil surveyor to understand how the soils are related to the landscapes.

C. <u>Use and Management of the Soils</u>

Relating soil mapping units to soil management groups and soil management units is helpful to understand the problems and the limitations in the use of the soils. Michigan soils are rated on the basis of four classes of soil limitations for various uses. These limitations by series in the study area and their soil management groups, are listed in Table 9. The meanings of the four classes of limitations are shown at the bottom of Table 9.

Most of the study area has productive soils for farm crops, column 5, Table 9, with good management.* These include the mineral soils in the following soil management groups on slopes of less than 6%, last column, Table 9, they are: 1.5c, 2.5a, 2.5b, 2.5c, 3/2a, 3/2b, 3/2c, 3a, 3b, and 3c. A soil management group map of the study area is shown in Figure 12. These soils qualify, by definition of the United States Department of Agriculture, as prime agricultural lands, except where they are now urbanized. All of the soils in the study area have potentialities as soils of local significance for agricultural production. None of these are listed as having severe or very severe limitations for farm crops in Table 9.

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*L. S. Robertson, 1975: Good management is the product of a good manager. Problems accumulate with poor management and they sometimes seem to be unsolvable. "Management is a process which establishes goals, defines problems, inventories information relevant to the solution of the problems, analyzes the information, reaches decisions on how to solve the problem acts on those decisions, and bears the responsibility for the consequences of the acts"

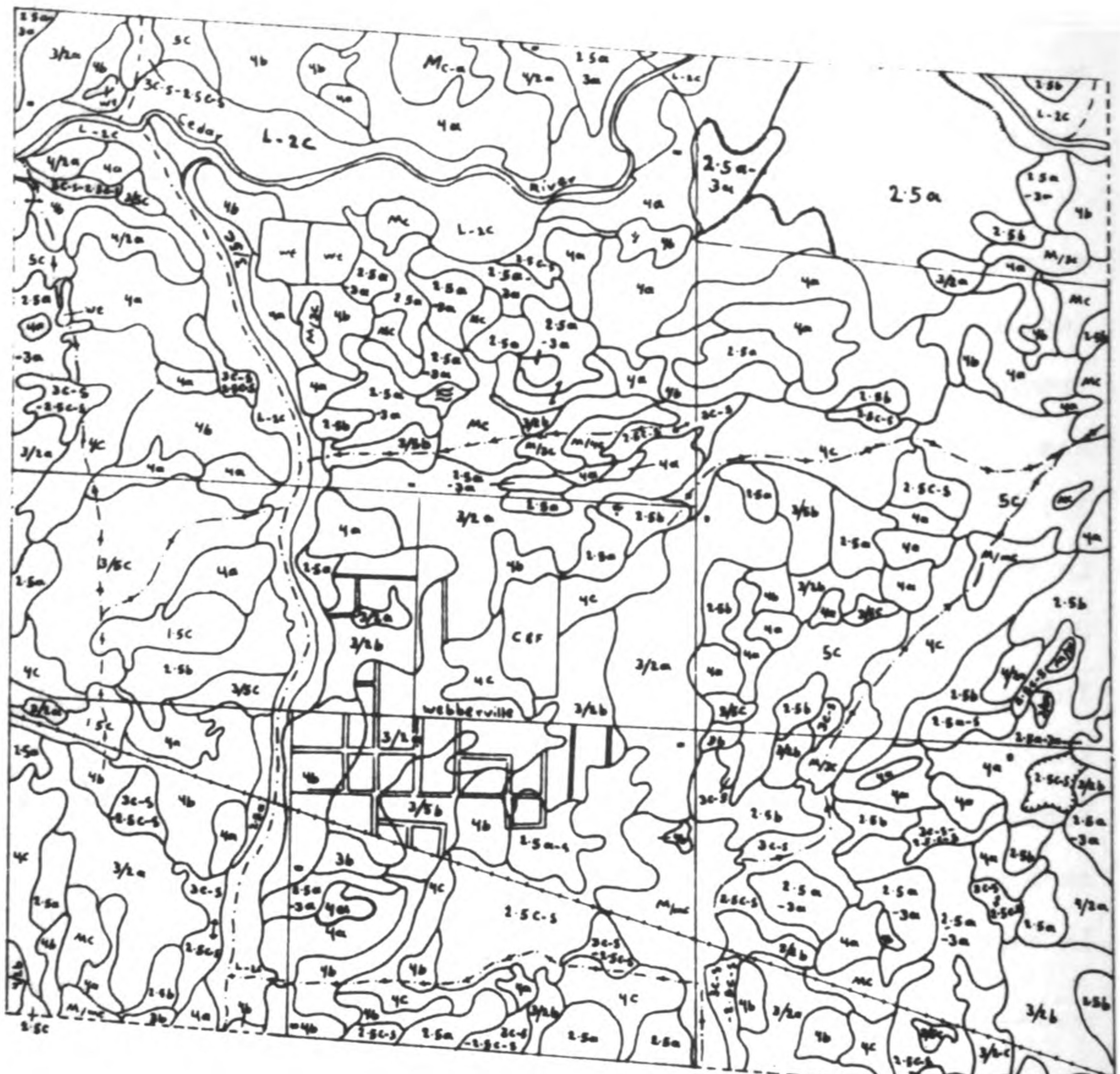

Figure 12: Soil Management Groups Map of the Study Area, 1977

TABLE 9...Degree of Limitation of Soil Series or Soil Management Groups for Various Uses[1]

Soil Series	Slope Classes	Residential Development Without Public Sewers	Highways & Streets	Farm Crops*	Trees	Soil Management Groups [2]
Adrian	A	very severe	very severe	moderate	severe	M/4c
Aurelius	A	very severe	very severe	slight	severe	M/mc
Boyer	B,C	slight	slight	moderate	moderate	4a
Brady	A	moderate	moderate	moderate	severe	4b
Brookston	A	severe	severe	slight	severe	2.5c
Capac	A	severe	severe	slight	moderate	2.5b
Cohoctah	A	severe	severe	moderate	severe	L-2c
Colwood	A	severe	severe	slight	severe	2.5c
Corunna	A	severe	severe	slight to moderate	severe	3/2c
Edwards	A	very severe	very severe	slight	severe	M/mc
Gilford	A	severe	severe	moderate	severe	4c
Granby	A	severe	severe	moderate	severe	5c
Hillsdale	B,C,D	slight	slight	slight	slight	3a
Houghton	A	very severe	very severe	moderate	severe	Mc
Kibbie	A	severe	severe	slight	severe	3b
Lenawee	A	severe	severe	slight	severe	1.5c
Marlette	B,C,D	moderate	moderate	slight	slight	2.5a
Matherton	A	moderate	moderate	slight	severe	3b

Table 9...Degree of Limitation of Soil Series of Soil Management Groups for Various Uses[1] (Continued)

Soil Series	Slope Classes	Residential Development without public sewers	Highways & Streets	Farm Crops*	Trees	Soil Management Groups[2]
Metamora	A	severe	moderate	slight	severe	3/2b
Metea	B	slight	moderate	slight	slight	4/2a
Napoleon	A	very severe	very severe	moderate	severe	Mc
Oshtemo	B,C	slight	slight	moderate	moderate	4a
Owosso	B	moderate	moderate	slight	slight	3/2a
Palms	A	very severe	very severe	slight	severe	M/3c
Riddles	B,C,D	moderate	moderate	slight	slight	2.5a
Sebewa	A	severe	severe	slight	severe	3c
Selfridge	A	severe	moderate	moderate	severe	4/2b
Sisson	B	slight	moderate	slight	slight	3a
Sloan	A	severe	severe	moderate	severe	L-2c
Spinks	B,C	slight	slight	moderate	moderate	4a
Teasdale	B	severe	moderate	slight	severe	3b
Thetford	A	severe	moderate	moderate	moderate	4b
Wasepi	A	moderate	moderate	moderate	severe	4b

Table 9.. Degree of Limitation of Soil Series or Soil Management Groups for Various Uses[1] (Continued)

1. The soils are evaluated only to a depth of 5 feet or less. Soils are rated on the basis of four classes of soil limitations, as follows:

<u>slight</u> - relatively free of limitations or limitations are easily overcome.
<u>moderate</u> - limitations need to be recognized, but can be overcome with good management and careful design.
<u>severe</u> - limitations are severe enough to make use questionable
<u>very severe</u> - extreme measures are needed to overcome the limitations and usage generally is unsound or not practical.

2. NOTE: Information in Table 9 is from engineering interpretation sheets of United States Department of Agriculture, Soil Conservation Service, in Cooperation with Michigan Agricultural Experiment Station.

* Limitations apply to slopes of less than 6%.

In addition to the limitations for farm crops discussed above, each soil series has limitations for different purposes. For example, the clayer to loamy, naturally poorly-drained Lenawee, Colwood, and Sebewa Soil Series, in the 1.5c, 2.5c, 3c Soil Management Groups, have only slight limitations for farm crops but have severe limitations for residential development without public sewers, highways and streets, or trees. However, the well-drained sandy Boyer, Spinks and Oshtemo soil series, in the 4a soil management group, have only slight limitations for residential development without public sewers or, highways and streets, but they have moderate limitations for farm crops or trees. This information can be obtained from soil maps with an understanding of the significance of soil properties, to their potential uses and management for various purposes (Figure 12 and Table 9).

Knowing the uses and management need for the soils information in a given area, the soil scientist can also design the survey to be sure that the essential information is part of the soil surveys. By thus avoiding spending time on properties of no utility, the efficiency and speed of the survey may also be increased.

CONCLUSIONS

1. In the study area (Sections 1, 2, 11 and 12 of Leroy Township in Ingham County) great soil variability was observed in the landscape due to different textures of the glacial sediments, and variations in the associated natural drainage.

2. The glacial landforms that have been recognized in the area, with their different underlying materials are: till, outwash, lacustrine, alluvium, outwash over till, and organic materials.

3. The use of detailed geologic maps in soil mapping projects would also be helpful in recognizing some approximate soil parent material boundaries, and different ages of land surfaces. However, the available surface geology map in the study area was too general to be helpful, it was even confusing.

4. A good soil map can help understand the surface geology of an area.

5. A topographic map may be useful in locating variations in the landscape. In the study area, the available topographic map, with 20'(6m) contour intervals, was

too general to be very helpful.

6. The soils on level or nearly level areas are usually somewhat poorly-drained, whereas, the soils on highlands or steeper slopes are usually well-drained.

7. A steroscope with aerial photos can help the soil surveyor in delineating physiographic land features and drainage characteristics of associated soils.

8. The use of available, good quality, recent aerial photography helps the soil surveyor to delineate soil characteristics, particularly drainage and slope features and to make more precise soil maps more rapidly.

9. Time of year is very important in taking of aerial photography. Early in the year (spring) is best in Michigan.

10. Color infrared imagery can be more helpful than black and white imagery in delineating natural drainage classes, soil texture, and different vegetations.

11. In bare fields, soil drainage classes can be determined much better than in vegetated areas on either color infrared or black and white imagery.

12. The published soil maps, already available, can help soil surveyors to understand what kinds of soils are present in the study area, and where they are located.

13. Familiarity of the soil scientist with the available natural resource data in an area and their relationships to differences in the soils present, and the soils' significance to use or management for various purposes can help him make soils maps more accurately and more rapidly.

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