

CROP YIELD, SOIL AND MANAGEMENT STUDIES
IN OSCEOLA COUNTY MICHIGAN

Thesis for the Degree of M. S.
MICHIGAN STATE UNIVERSITY

Wesley K. Mettert
1961



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ABSTRACT

CROP YIELD, SOIL, AND MANAGEMENT STUDIES

IN OSCEOLA COUNTY

MICHIGAN

By Wesley K. Mottert

This study was conducted to determine the average yields of major crops grown on the common agricultural soils under different levels of management. The yield and management information was collected through the use of questionnaires and personal interviews given to selected farmers. The local agricultural agencies provided lists of farmers who keep farm records. The soil information was obtained from the recently completed soil survey.

Farm crop yields for different kinds of soil have been estimated on the basis of common experiences. These estimates may be adequate for general use. However, the soil productivity ratings for different crops are more accurately ascertained by collecting actual yield measurements and evaluating them according to the factors influencing crop yields. These factors are kinds of soil, hereditary crop traits, climate and human activities.

To apply the above principles to the area studied, a general soil map was prepared showing the extent and distribution of associated soils in the county. For each of the major crops grown in the county, during the past 12 years, the average annual yield percentages were plotted to determine the yearly effects of variations in climate. The pH (acidity), available phosphorus and potassium were determined for 3 profiles of Nester, McBride and Kalkaska soils, as a clue to the fertility of these soils.

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An attempt to evaluate the net effect of human factors on crop yields has been made in this study by ascertaining the level of management at which each crop was grown. The evaluation of the soil information involved the use of soil management units. Through the use of these management units it was possible to array crop yields systematically by kinds of soils and management levels.

The results show that:

1. The methods used for obtaining and analyzing soil, crop yield and management information was inexpensive and rapid.
2. With qualifications, the results from this study can be used in developing yield tables for the major crops grown on the common agricultural soils by management units and different management levels.
3. Management levels affect crop yields in nearly every soil management unit. In some cases crop yields obtained under high levels of management were double those obtained under low levels of management.
4. The effects of soil slope on crop yields varied to some extent by soil management units and management levels.
5. Moderately eroded 2a, moderately fine textured, soils have higher hay yields than have the slightly eroded 2a soils. The effects of eroded 2a soil on corn crops are evident.
6. The poorly and imperfectly drained soils are not used extensively for cropland in Osceola County.
7. Wheat yields have increased during the last 12 years. This increase in yield is not entirely due to better management.

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Wesley K. Mettert

It is primarily due to the shifting of acreage from less suitable to more suitable soils. Wheat acreage controls have reduced wheat acreage and farmers are growing wheat on the more productive portions of their fields.

CROP YIELD, SOIL
AND MANAGEMENT STUDIES IN
OSCEOLA COUNTY MICHIGAN

By

Wesley K. Mattert

A THESIS

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in partial fulfillment of the requirements
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Approved: W. P. White

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I. INTRODUCTION

A. Objectives

The objectives of this study were to apply a procedure of obtaining soil, crop and management information to determine crop yields on the common kinds of soils and soil management practices in Osceola County, Michigan.

B. Importance

Reliable information on soils and crop yields can be useful in many ways. Farm operators can compare their yields with yields obtained on similar soils. If needed, adjustments of soil management practices can then be made with assurance. The most suitable kind and size of farm enterprise (dairying, cash crop, beef, swine, etc.) can be more accurately determined for a particular tract of land. The dollar value of farmland (its market price, value as collateral for loans or tax carrying capacity) can be more correctly assessed. Local agricultural agencies can use crop yield and soil information when planning educational programs in soil management, developing financial assistance programs, preparing alternative land use plans, establishing surplus crop controls, and advising urban and rural planning boards. This information can also be used in testing interpretive classifications of soils.

II. LITERATURE REVIEW

A review of the literature was made to become familiar with the several factors that control or influence crop yields, and to study methods and procedures that might be useful to determine crop yields for the kinds of soil found in Osceola County, Michigan.

A. General Principles

Crops are grown for many reasons but primarily they are grown for the yield of useful food or fiber they produce. This essential production is controlled or determined by such factors as crop heredity, climate, soil, and human activity. In the discussion that follows these factors are considered, primarily to show the relationships to one another and the part each plays in determining crop yields.

1. Hereditary crop traits

The capacity of plants to grow well in different soil and climatic conditions is dependent upon the germ plasm- the substance by which hereditary characteristics are transmitted in all crops.

Wadleigh (1957) describes the importance of this factor and its relationship to environmental conditions. He states that growth, vigor, disease resistance, sensitivity to length of day, and drought resistance are some inherited characteristics

of plants. It is paramount that the combination of these traits be adapted to the climate and soil in order to fully reap the benefits of ideal soil management.

Odell (1947) made a detailed analysis of crop yield records in relation to kinds of soils in central Illinois. These yield records covered a period of 45 years. Close examination of these data reveals that corn yields were rather stable prior to 1936. During 1937 and subsequent years corn yields were substantially higher even though similar management was used. This increase in yield was due primarily to the introduction of hybrid seed in 1937. This study exemplifies the fact that potential optimum is controlled in part by crop inheritance.

Rather (1942) has shown that soil and soil management cannot alone accomplish effective production. Crops must be adapted to the soil and climate. This adaptability of crops is not only a species consideration but one of crop varieties. Stiffness of stem in small grains is much more essential on a fertile soil with abundant moisture than on an infertile one. Where the growing season is limited, earlier maturing corns are required on low lying poorly drained soils than on locally higher lying well drained soils.

Roberts and Jones (1940) report that in the case of corn the narrowly bred hybrids are more restricted in their adaptation than open pollinated varieties, when grown for silage. Thus, the selection of species and particularly the specific varieties of

crops to grow is essential to high acre yields and profitable crop production.

2. Climate

The growth of plants, the final yield, and its quality depend very materially on weather. The three most important factors in climate from a standpoint of plant response are temperature, water supply and light. Precipitation or water supply is the most important factor in determining the distribution of plants and crops within broad areas having similar temperatures. Fluctuations in temperature and rainfall are important agriculturally as they beget wet, dry, cold or hot periods that greatly affect crop yields. Hail storms, tornadoes and strong winds may destroy crops locally. Hildreth and Magness (1941) have shown that both light intensity and the length of the daily illumination period profoundly affect plant behavior.

All of these elements of climate are interrelated in their effect on green plants; temperature and light affect the water requirements. Available moisture supply greatly influences the effects of high temperature and light intensities. In addition to these relationships, living plants are complex organisms affected by nutritive as well as climatic factors in their environment.

Went (1950) made a study to determine the influence of environmental conditions on the biological variability in plants, or the plant's response to climate. The study was conducted in greenhouses where the environmental factors were controlled rigidly. The influence of the most important environmental factors was

studied simultaneously. When the climatic responses of a number of plants were investigated in detail, marked differences were found that have a significant bearing on the distribution of these plants over the earth. He concluded that it is necessary to revise present ideas about the temperature limits within which a plant can exist. The distribution of plants is not just a question of frost damage or heat coagulation, but it is correlated with very specific temperature requirements, which are met only in certain climates. The adaptation of a plant to its physical environment goes much farther than merely a general relationship between type of climate and optimal growing conditions. In any breeding program it is only by consideration of the climatic requirements of plants that a proper array of plant characteristics can be combined to produce a desired species for a given location.

Bates (1955) calculated the correlation coefficients between several climatic factors and corn yields during 41 years, 1913-53. He found that mean maximum temperature, mean relative humidity and evaporation in June (the month in which corn usually pollinates) were very closely correlated with corn yields. These three factors were closely correlated with each other, and since evaporation is dependent on temperature and humidity, the latter two factors appear to be those affecting corn yields. Each of these factors was more closely correlated with corn yields than was rainfall at any period of the year. The number of rains in June showed a higher correlation with yield than total rainfall during any other period. If rainfall during more than one month was considered, October 1 to August 1 showed the highest correlation with yield.

Number of cloudy days in June was not closely correlated with corn yields and the correlation that existed was probably due to effects of rainfall, humidity and temperature.

Humphery (1941) relates the effects of climate and diseases. It is well known that disease can wipe out entire crops. Potato blight, red rust in wheat, curly top in sugar beets are typical diseases affected by weather in one way or another. Some diseases require moist, humid conditions for infection and development; others are more serious when it is relatively dry. Some are favored by cool temperatures; others require warm weather. In some cases the principal effect is not on the disease producing organism itself but on the host plant, or even on an insect carrier of the disease.

The late blight of potatoes is favored by excessive humidity and moderate temperatures, conditions necessary for the spread of the parasite. Scab of wheat and other small grains is always more prevalent when warm moist weather occurs during the period from heading to maturity. The cereal rusts, one of the most important plant diseases affected by weather, are more prevalent during seasons characterized by high temperatures and rainfall.

The prevalence of destructive insects is one of the important factors determining success or failure in crop production.

Hyslop (1941) describes the influence that climatic conditions have in controlling insect populations. He suggests that the various factors of climate, such as temperature, moisture and rate of evaporation, affect different insects in varying degrees at different times. Each insect at each stage of development has a

definite tolerance to these factors. Below or above this tolerance the insect dies or becomes less of a problem. Usually moisture and temperature are not independent; the optimum growth and the extreme range of tolerance of insects are at certain combinations of moisture and temperature. For example; cool, delayed springs are favorable for the development of many species of outworms and seed corn maggots. Grasshopper populations increase during a series of dry years. Late dry fall weather which retards the germination of wheat seed beyond a certain date will practically eliminate the hessian fly.

Very often the effect of climate on insects is a complicated one. The climate may not directly affect a certain insect but may affect others that prey on it, reducing or increasing their numbers. The introduction of parasites as a means of control has been successful only where the insects and parasites have developed in similar climatic conditions.

3. Soil

The soil is a natural body composed of admixtures of broken and weathered minerals and decaying organic matter, which covers the earth in thin layers that differ from each other and the underlying materials in their properties. They may supply, when containing the proper amounts of air and water, sustenance for plants as well as mechanical support.

Russell (1937) and Lyon and Buckman (1943) point out that growth and development of higher plants depend on two sets of factors, namely internal and external. The latter factors, of

special interest from the soil standpoint, may be enumerated as follows; (1) light, (2) mechanical support, (3) heat, (4) air, (5) water and (6) nutrients. With the exception of light, the soil is an agent in supplying, either wholly or in part, these essential conditions.

Mechanical support is a function entirely of the soil. The comparatively loose and friable condition of most soils presents ample space for the growing roots. In some cases, however, the presence of a compact layer or a lack of adequate drainage may interfere with root distribution. Although temperature depends almost wholly on weather conditions, the transfer of heat through the soil is of vital importance to activities of all kinds. The addition of water increases the heat capacity of a soil to a marked degree. Hence, the removal of excess water permits the soil to warm up earlier in the spring. Because of differences in water holding capacity a coarse textured soil with low water-holding capacity warms earlier than a moderately fine textured soil with greater water holding capacity.

Air and water are usually supplied rather easily because of the open conditions found in soils of good structure.

Oxygen and carbon dioxide function as chemical and biochemical agents. Water is a source of hydrogen and oxygen as well as an efficient solvent. By its circulation, water promotes an interchange and interaction of constituents and not only brings nutrients in contact with the absorbing and adsorbing surfaces of roots and microorganisms but also facilitates their penetration. The two prime functions of the soil are thus realized through the

coordination of the functions mentioned above - mechanical support and favorable conditions for use of sufficient supply of certain essential elements.

All of the known elements have been found in soils. At least sixteen of these are considered necessary for the growth of green plants. The essential elements are carbon, hydrogen, oxygen, nitrogen, phosphorus, sulfur, potassium, calcium, magnesium, iron, manganese, zinc, copper, molybdenum, boron, and chlorine. According to Dean (1957) the presence, abundance, and availability of these essential elements determine the nutrient supplying power and reserve of soils.

Overall chemical analyses indicate that the total supply of nutrients in soils is usually high in comparison with the requirements of crop plants. Much of this potential nutrient supply, however, is tightly bound in forms that are not released fast enough to produce satisfactory plant growth. Thus, measurements of available nutrients are more valuable than those of total nutrients when considering crop nutrient needs.

Russell (1957) has discussed the physical properties of soils. He points out that the size, shape, arrangements, and mineral composition of soil particles and the volume and form of pores affect the flow and storage of water, the movement of air and the ability of the soil to supply nutrients to growing plants.

The physical properties and the chemical composition of the large and small particles differ greatly. The coarse separates - the stones, gravel, and sand - act as individual particles. These particles have low surface area per unit mass, but since the most

important physical-chemical reactions take place on the surface of soil particles and the total area of such surfaces strongly affects the ability of soils to react chemically, the coarse particles have limited physical-chemical activity. The silt particles have greater chemical activity than coarse separates because of their higher specific surface. Silts exhibit some plasticity and cohesion. The amount of surface activity in the silts, however, is not enough to give desirable physical-chemical behavior to soils that contain large amounts of such particles but little or no clay.

The clay portion controls many of the important properties of soil. The clay particles are extremely small and are usually negatively charged. They react with positive ions in the soil solution. The attraction between the negatively charged clay and such positive ions as hydrogen, calcium, magnesium, and potassium results in a dynamic equilibrium with these ions in the soil solution. These ions can be replaced or exchanged from the soil particles in response to changes in concentration in the soil solution. This process of ionic exchange is one of fundamental importance in soil management and plant nutrition.

The charged clay surfaces together with their associated exchangeable ions also react with water molecules, which become oriented when they are present in the electric field near the charged surfaces. The resulting layers of oriented water molecules give the characteristic properties of plasticity, cohesion, and expansion to clays. Moist soil horizons that contain large amounts of clay may have these same properties.

In soils that contain substantial amounts of silt and clay,

many of these fine particles are formed into secondary structural units called aggregates. The size, shape, and arrangement of soil aggregates largely determine the porosity and pore size distribution of soil horizons. This soil structure greatly influences the infiltration and movement of water and air and the penetration of plant roots. Soil aggregates are not permanent structural units, particularly in the surface horizon of a cultivated soil. They are dependent on the texture, organic matter content, climatic conditions, and soil management practices.

All of the above physical properties of soils affect plant growth through their relation to the quality of the root environment.

4. Human factors

Human factors influence the ultimate yields of farm crops in many ways. The people, their desires, ambitions, and abilities, determine the type of farm enterprise, the kind of crops grown, the management practices followed, and the efficiency of farm operations. Cook ¹ points out that even though ideal management is followed, high yields cannot be expected unless farm operations are timely and efficient.

Economic conditions, such as market demands, price received, cost of production, and governmental controls, may materially

¹Cook, R. L., Chairman of Soil Science Department, College of Agriculture, Michigan State University, personal conversation.

affect land use and crop production. When market demands increase and the price goes upward, the cost of production can be increased, especially the cost of items which enhance acre yields. In reality, however, increased market demand usually has a depressing effect on acre yields. Low acre yields become profitable under these conditions. Consequently, the crop in question may be grown on the soils where it is not particularly adapted, fertility programs may be spread over larger acreage resulting in lower fertility levels, and farmers who lack an understanding of the techniques for obtaining high acre yields and who normally do not produce the crop may be motivated to do so.

The effects of economics can be illustrated in another way. If the cost of production can be lowered, by minimum tillage for example, the net returns may be increased and the acreage operated by a farmer could be increased or more intensive fertilization could be used thus increasing total production of acre yields. Government controls restricting the acreage of certain crops have commonly resulted in a gradual increase of acre yields. This increase may be due to either improved management on the remaining acres or the use of more suitable soils or both.

B. Application of Principles to Osceola County

Crop yields in Osceola County are the function of the yield factors mentioned above. In the following discussion these factors are considered primarily to show their effect on crop yields within the county.

1. Plants

Plant breeders have improved crop varieties through the years. Many of the commonly grown crops are adapted to the climate and some of the soils of Osceola County. Eighty-five day hybrid corn, soft winter wheat, leaf rust and stem rust resistant oats, and long term alfalfa are well adapted to conditions in the county. Thus, the effect of seed quality on high yield expectancy is favorable.

2. Climate

Although the growing season ranges from 110 to 130 days and there is an average of 30 inches of rainfall annually; seasonal, daily, and locality variations in climate occur. The growing season may be wet or dry, hot or cold. Any one or all of these conditions may prevail during a particular growing season. Day to night temperatures fluctuate widely. For example, during the month of June daily temperatures range to 80°F while night temperatures range to 50°F and below. Occasionally, freezing temperatures occur during the summer months particularly in depressional areas in the landscape. The growing season is 2 to 3 weeks longer in the southwestern part of the country than it is in the northeastern part. Areas of good air drainage and some local variation in elevation tend to be less susceptible to frost during the growing season. Most of the natural forests have been clear cut in the past creating large open areas which allow good air movement. Today reforestation is limiting air movement and tends to make some fields more susceptible to frost. Many of the poorly to very poorly drained soils are used for woodland or pasture because

the frost hazard limits their use for row crops and small grains. The seasonal variations in climate usually prevent severe insect problems.

The climatic conditions materially affect crop yields in Osceola County. Records from the Michigan Agricultural Statistics (1949-1961) show that during the past 12 years, average corn yields have fluctuated 33 percent, average oat yields 38 percent, average wheat yields 40 percent, and average hay yields 31 percent. When these fluctuations of average yields for the county occur from year to year it is evident that climatic factors are affecting yields. The annual percentage yield fluctuations of major crops in Osceola County are shown in figure 1. These fluctuations are conservative when individual kinds of soil and local areas are considered. Crop yields are adversely affected on fine textured soils during wet years and on coarse textured soils during dry seasons. Thus yields fluctuate more for individual soils than figure 1 indicates. Figure 1 also indicates that crop yields tend to fluctuate in a cyclic manner. Over a five year period corn, oats, wheat, and hay yields fluctuate from high to low. The wheat and hay cycles correspond while the corn and oat cycles are independent and do not correspond with any other cycle. These differences between individual crop cycles can easily be explained. Wheat is a biannual and hay is either a biannual or perennial. Growth of these two crops takes place over many seasons and is less affected by short term, adverse climatic conditions. On the other hand, summer grown corn and spring grown oats are materially affected by prevailing summer or spring climatic conditions, respectively.

3. Soils

The soils of Osceola County affect yields substantially. They vary in texture from clays to sands and in drainage from well to very poorly drained, as summarized in Table 1. A wide range of slope and erosion conditions exist on the well and imperfectly drained soils. A general soil map of Osceola County is shown in Figure 2. This map was especially prepared for this report by the author. It shows the extent and distribution of 11 soil associations in the County. Each soil survey field sheet was scrutinized and the broad areas of similarly associated soils were noted and delineated on a county road map. This general soil map is useful for preparing problem area maps, land resource area maps, and developing broad land use plans. The map provided a guide for evaluating the distribution of farms selected for this study. However, it is not suitable for making fertilizer, liming, drainage, or other recommendations that require detailed soil information.

Some 500 different mapping units were used in making the detailed soil survey for the county. Rather than discuss each of these units separately, it is feasible to assemble them into interpretative groups of soils having similar profile characteristics, similar management requirements, and similar potential productivities. In Michigan these groups are referred to as soil management groups and soil management units or soil capability units, (Michigan State University, 1959).

The grouping of soils into soil management groups are based upon an understanding of the soil formation factors associated with

Figure 1. Annual percentage yield fluctuation of major crops in
Osceola County, Michigan

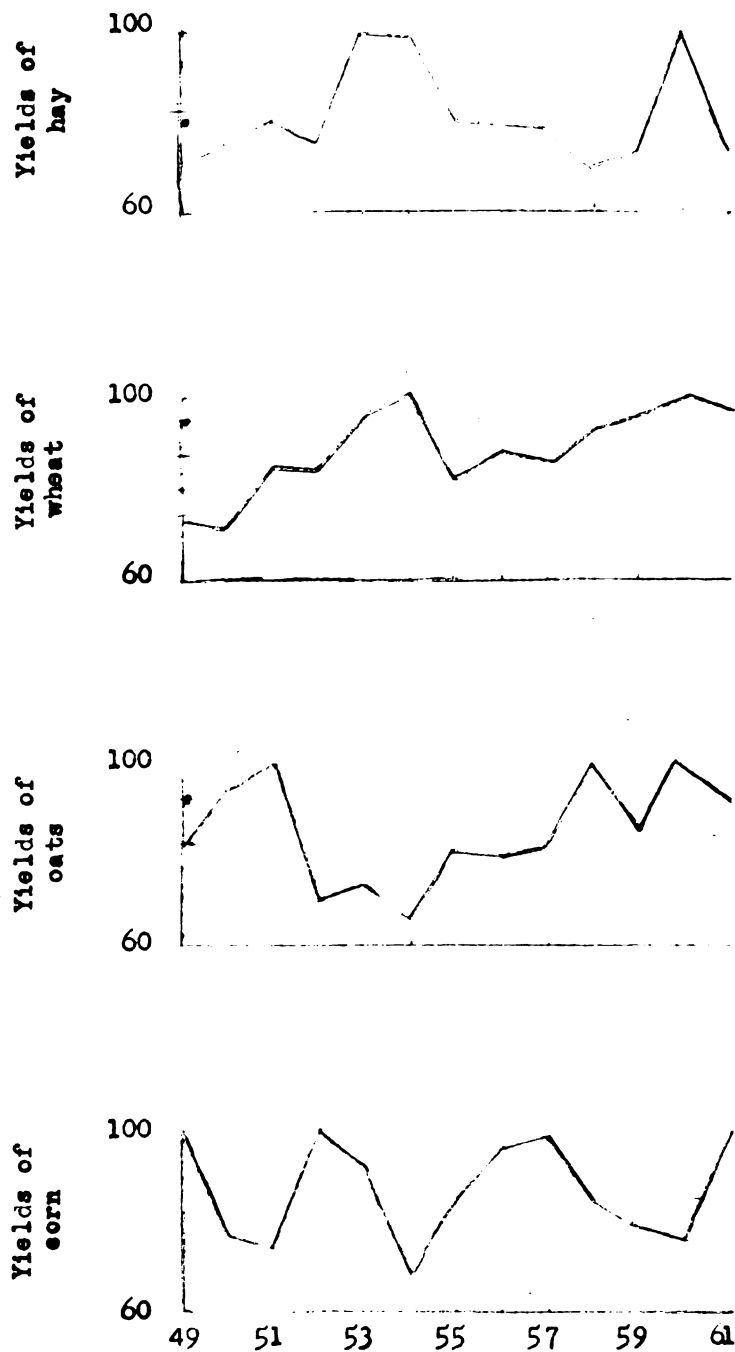
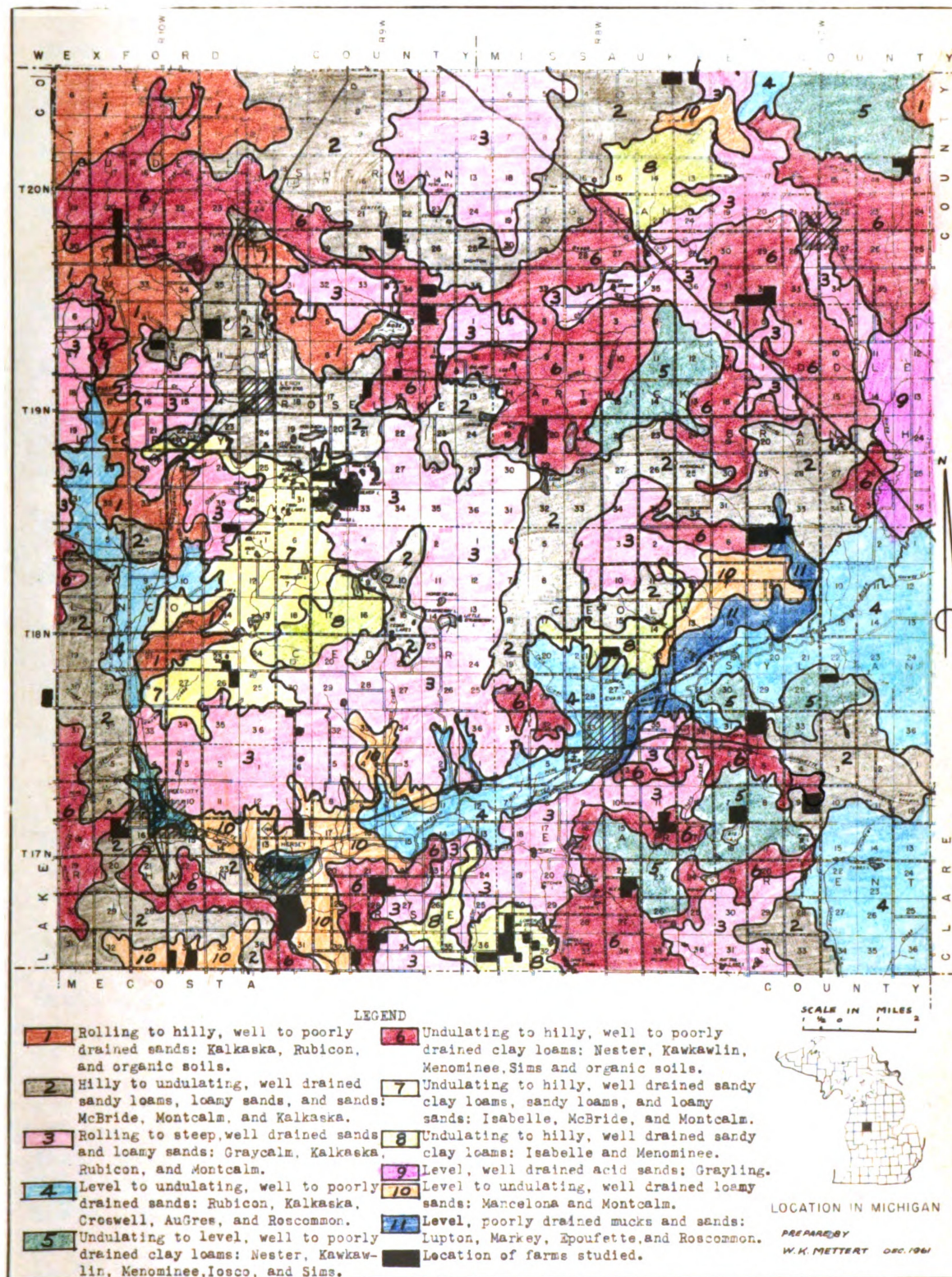


Figure 2.

GENERAL SOIL MAP
OSCEOLA COUNTY, MICHIGAN



the differences in the soils. These factors are usually cited as four groups; parent material, topography, organisms, and climate; plus a fifth factor, time. These factors not only relate the soils to one another and to the landscape in which they occur but some of them such as climate and topography are also directly related to plant growth and land use.

The two soil formation factors most commonly associated with local soil differences in Osceola County are the parent materials and topography or natural drainage. The inter-relationships of a number of common soils series in the county are shown in table 1, arranged systematically according to these two factors. In the chart, each horizontal line is given a number from the finest textured materials, clay and silty clay, as 1 at the top to the coarsest textured materials, sands, as 5 at the bottom. Each column is given a letter from "a" for the naturally well drained at the left side to "c" for the most poorly drained at the right. Thus, each compartment or group of soil series has a number and a letter designation that places it in relation to each of the other soil management groups. The management groups designated with fractional numbers indicate soils developing in material of one texture overlying material of another texture. The soils in each of these groups have been shown to be similar in their readily available moisture holding capacities to a depth of 60 inches and their base exchange capacity to 40 inches. The variability of these properties among management groups is shown in Tables 2 and 3, as averages of figures available for the soils in each group. The sandy and clayey mineral soils hold less readily available

water for plant growth than those developed from loamy materials. The clays have the highest basic exchange capacity, the sands the lowest.

The distribution of available phosphorus, potassium, and pH (acidity) in profiles of members of three of these groups are shown graphically in Figure 3. These data are based on soil tests made by the Osceola County Soil Testing Laboratory. The soil samples were carefully collected from three representative profiles of each soil studied by the author. Composite soil descriptions of these soils are shown in appendix C. Close examination of Figure 3 reveals that the coarse textured well drained soil, Kalkaska, is more acid than the moderately coarse, McBride, and moderately fine textured, Nester, soils.

The moderately fine textured soil is high in available P and K, while the coarse textured soil is low in these constituents. The moderately coarse textured soil exhibits more variability between horizons than either the coarse or moderately fine textured profiles. The bulge in the available P content of the Podzol B horizons of both the McBride and the Kalkaska soils is probable due to phosphoric compounds affiliated with the humus in these horizons.

4. Human factors

Crop yields per acre are materially affected in Osceola County by human activities. The kind of crops grown, the management practices used and the timeliness and efficiency of farm operations are determined by the desires, ambitions, and abilities of the people who farm the land.

Economic conditions, such as market demands, prices received,

Table 1. Relationships among some common Osceola County Soils from limy mineral or organic materials

Texture of mineral parent material	Mineral soils			Organic soils	
	Podzols		Humic Gleys		
	Natural Drainage				
	Well drained	Imperfectly drained	Poorly drained	Very poorly drained Shallow, less than 42" thick	Deep, over 42" thick
	(a)	(b)	(c)	(c)	(c)
(1) Clays and silty clays	1a Kent ¹	1b Selkirk ¹	1c Pickford	M/1c over clays Willette	Mo-c limy, Lupton
(2) Clay loams	2a Nester ¹ Isabella ²	2b Kawkawlin ¹ Twining ²	2c Sims Butternut	M/3c over loams, Linwood.	Mo slightly acid to neutral, woody, Carbon-dale; medium acid to neutral fibrous, Houghton.
(3/2) Sandy loams over clay loams	3/2a Uby ²	3/2b Belding ²	3/2c Breckenridge	(M/mc over marl, Edwards)	Mo-a extremely acid, disintegrated, Loxley;
(3) Sandy loams	3a McBride ² Newago ²	3b Coral ²	3c Ensley		
(4/2) Sand and loamy sand over loams to clay loams	4/2a Monominee ²	4/2b Tosco ²	4/2c Brevort	M/4c over sands; limy, Markey; slightly acid, Tawas. M/4ca	
(4) Loamy sands	4a Montcalm ² Mancelona ² Blue Lake ²	4b Otisco ² Gladwin ²	4c Edmore	extremely acid,	extremely acid, fibrous, Greenwood.
(5) Sands	5a Croswell Kalkaska East Lake Rubicon Grayling	5b AuGres Saugatuok*	5c Roscommon (extremely acid, Kinross)	Dawson	

1. These soils have profiles typical of the Gray Wooded soils.
 2. These soils have profiles typical of the bissequa soils with Podzol upper sequence and Gray Wooded lower sequence of horizons.
- * The subsoil horizon of this soil is cemented by iron oxides and humic substances.

Table 2. Average readily available moisture in inches of water for the upper 60 inches of some Michigan soils. (Michigan State University, 1959)

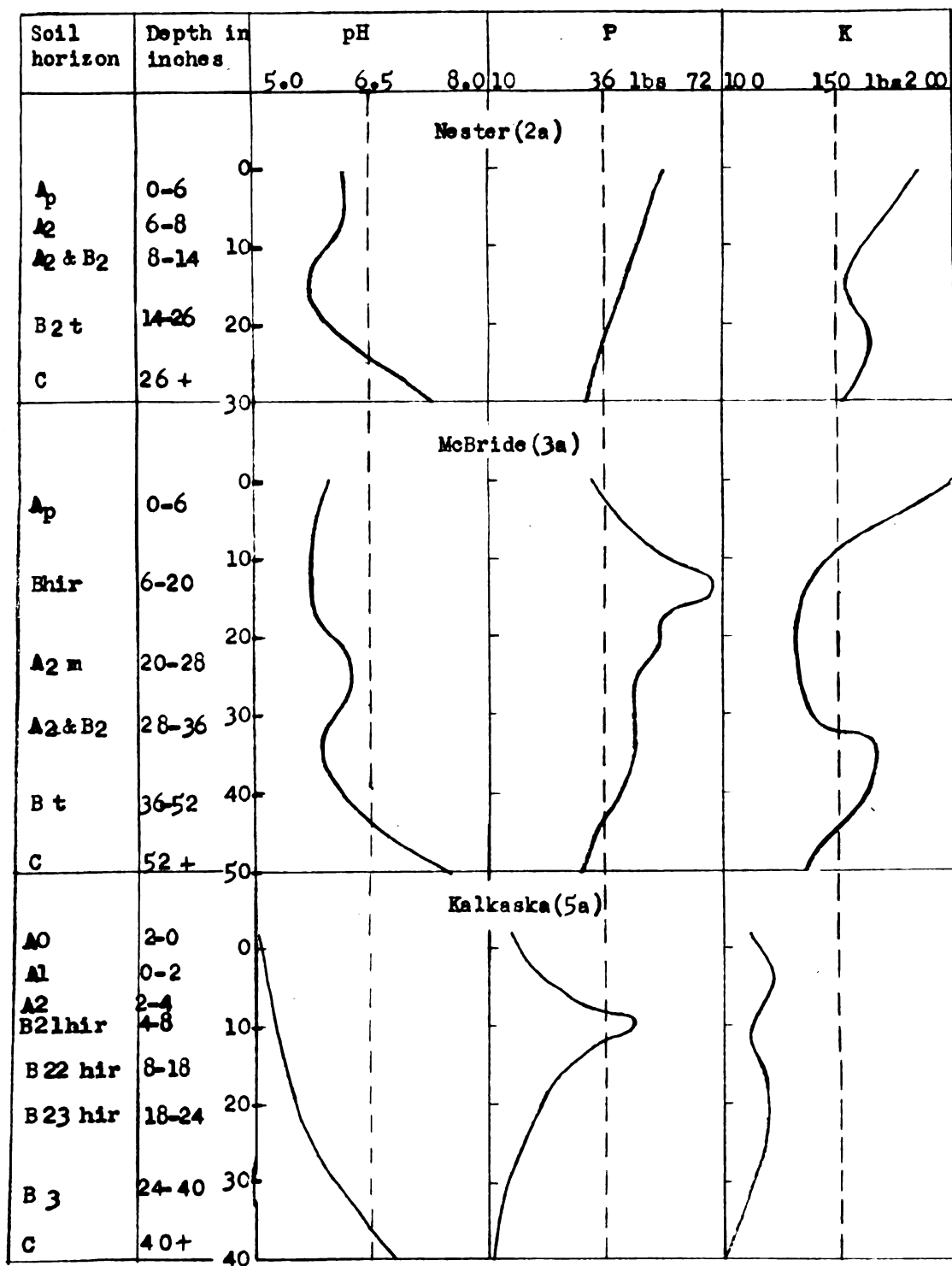
Texture of mineral parent material		Well drained (a)	Imperfectly drained (b)	Poorly drained (c)
	Group No.			
Clays	(1)	6.4	3.8	6.6
Clay loams	(2)	8.2	-	5.5
Loams	(2)	9.7	8.7	8.2
Sandy loams	(3)	11.3	8.8	11.1
Loamy sands	(4)	10.0	-	-
Sands	(5)	4.5	9.0	6.9

Table 3. Base exchange capacities in tons of CaCO_3 per acre to a depth of 40 inches. (Data of A.E. Erickson et al, summarized by L.W. Tobin, Michigan State University).

Texture of primary material		Well drained (a)	Imperfectly drained (b)	Poorly drained (c)
Clays	(1)	58.T	42.T	60.T
Loams	(2)	35.T	34.T	39.T
Sandy loams	(3)	(35T)*20.T	18.T	28.T
Loamy sands	(4)	12.T	--	--
Sands	(5)	6.T	16.T	12.T

() * Dark colored soils formed under grass vegetation. The other soils were formed under timber vegetation.

Figure 3. pH (acidity), available P, and available K in profiles of Nester, McBride, and Kalkaska soils in Oosola County.



pH (acidity) determined by the Beckman pH meter.

Available K determined by the Spurway Reserve method.

Available P determined by the Bray method.

The dashed vertical lines indicate adequate amounts of the lime, P and K.

cost of production, and governmental controls, have affected land use and crop production in Osceola County. For example, the production of potatoes in this area has been reduced considerably by the loss of market demand. At one time this area was one of the greatest potato producing areas in Michigan. Potato production has become very competitive and the few farmers who continue to grow potatoes use high fertility programs, irrigation, high quality seed, and adequate pest and weed controls to insure a profitable potato crop. With the use of these management practices, farmers can commonly expect from 400 to 600 bushels per acre.

Government controls restricting wheat acreage in the county have had a similar effect on wheat yields. Wheat yields have increased considerably. It is generally believed that this increase in yield is due to farmers use of improved management.

To insure good hay seedings when seeded with oats farmers have reduced seeding rates of oats. This practice prevents the oat crop from competing with the new hay seedings, but it has lowered oat yields considerably. This example exemplifies that farmers desires do affect crop yield.

Undoubtedly human factors have affected the yields of all the major crops grown. These factors should be considered when determining crop yields for different kinds of soil. An attempt to value the net effect of these human factors has been made in this study by ascertaining the level of management at which each crop was grown. The method used to determine management levels for the major crops grown in the county is discussed in the procedure section of this report.

C. Methods of Collecting Yield Data

The Soil Survey Staff (1951) has suggested several methods for collecting crop, yield, and management data. The methods vary in ease of collection and degree of validity of the data. The recognized methods of collection and the advantages and disadvantages of each are discussed below:

1. Recording field observations of results of crop growth on different soils and under different sets of management practices. This is done during the course of a soil survey. Such observations are not precise yield estimates but can be an aid in classifying the soils from highest to lowest in productivity for a given crop.
2. Assembling data on crop yields from experimental plots where fertility, variety and other research trials are being made. These are accurate yields. The management conditions, however, may not be generally similar to those on most farms.
3. Harvesting small plots from different soils within the same field on various farms. Such data are especially useful in arranging the soils relative to one another and evaluating current crop yields with common management practices. This method is time consuming and requires considerable effort.
4. Studying yield records kept by farmers on fields or farms in connection with Cooperative Extension Service farm accounts, Farmers Home Administration clients and other farm account keepers. These may be long time records involving many crops and management practices. However, the yields may or may not be by individual fields and often times the soils are variable

even within a field.

5. Selecting fields largely of one soil unit and having the farmers furnish information annually regarding yields and other factors. This method requires a number of years before accurate and usable data can be obtained.
6. Sending questionnaires to and visiting with farmers who have kept records. This usually results in reliable estimates of recent yields. Representative fields of the important soils can be selected and the farm operators asked to cooperate in the work of estimating the production of certain soils with crop varieties and practices he has used.

III PROCEDURE

A. Selection of the farms

This study was conducted in Osceola County, Michigan, which lies within the north central portion of the lower peninsula. This glaciated area with its many land forms and drift textures contains numerous soil types, slope and erosion conditions.

Recently, the National Cooperative Soil Survey completed a detailed soil survey for Osceola County. This area, being completely mapped, provided an excellent opportunity to correlate crop yields with kinds of soil.

In order to acquire the most reliable crop and management information, the local agricultural agencies were asked to submit a list of farmers who keep crop yield records. A total of 46 farmers were suggested in this manner. Nine of these have kept farm account records in cooperation with the Cooperative Extension Service, 26 others have kept records for 3 to 5 years in conjunction with the Farmers Home Administration, and all 46 have developed or are in the process of developing farm conservation plans with the assistance of the Soil Conservation Service. This selection of farms was ideal. Not only were crop yield records available in one form or another, but the location of the farms was such as to give a fair representation of all parts of the county and include the common agricultural soils. The map in figure 1 shows the location of the farms in the county as well as in accordance with the general soil areas. The results of past experiences the various agencies have had with these farmers indicate a high degree of cooperation could be expected.

B. Collection of yield, management, and soil data

Questionnaires and personal interviews with farmers coupled with soil survey information provided the data for this preliminary study.

1. Questionnaire

A questionnaire was sent to each of the 46 farmers. The questionnaire was designed to cover all phases of crop production. Specific questions were asked relative to seed quality, soil management practices, fertility programs, crop stands, growing seasons and yields obtained. In addition, the farmers were asked to make a sketch showing field size and location, and to list kind and number of livestock kept on the farm. An explanatory letter accompanied the questionnaire. An example of the letter and forms used in this study is given in appendix 1. The questionnaires were sent September 19, 1961 and 31 of them were completed and returned by the farmers.

2. Personal interviews

Two weeks following the date questionnaires were sent, personal visits were made to each farm. During the interview the farmers received help in completing questionnaires. Additional information on crop rotations and soil drainage was also recorded and the accuracy of the completed questionnaires, soil surveys, and methods of crop yield measurement was discussed. In addition, the selection of fields of one kind of soil was emphasized. All of the farmers and their families were helpful and accommodating. Fifteen of these farmers were not able to complete the forms because of pressing farm work at this time of year. They suggested that any future

questionnaires be sent during the winter months when farm work is less pressing.

3. Soil Survey

Each field, for which yield and management data were obtained, was located on the appropriate soil survey field sheet. The Osceola County Farm Platbook (Osceola 4H Club Council, 1958) and the sketches drawn by the farmers were used in locating farms and fields. The soil type, slope and erosion conditions were readily obtained for each field in this manner. In fields that possessed more than one soil type, slope or erosion condition, the proportion of each condition was determined by measurement with a small plastic grid. The scale of the grid and soil survey field sheets were 4 inches to a mile. For each field the mapping unit symbols and the proportion of each were recorded on the appropriate questionnaire form.

C. Analyses of Yield, Management and Soil Data

Before the crop yields obtained from the questionnaires and personal interviews could be correlated by kinds of soil and management for each field, their suitability for use in this study had to be determined. This suitability was based on the validity of the yield and management information and the complexity of the soil in each field.

Yields recorded on questionnaires were measured by several methods. Corn and oat yields from research trials were precisely measured. Corn grain and oat yields, other than those from research trails, were based on crib and bin measurements. Wheat yields were based on weight slips from sales. Corn silage and hay yields were estimates based on sile capacity and bale weight and count. All the

farmers who completed questionnaires had records on which to base their answers. Some questions in the forms were answered from memory. These questions dealt with climatic conditions, harvesting losses, and insect problems. In as much as the questionnaires covered a period of only 3 years, most farmers, while studying their records, were able to remember fairly well all the management details. The crop yields and management information thus obtained was considered suitable for use in this study.

Although the soil survey was found to be very accurate by the farmers, and 50 percent of the fields contained only one soil, the number of contrasting soils within some fields created a problem when correlating crop yield with soils in these fields. The solution of this problem was partially overcome by grouping similar soil conditions into soil management units. Since the soils in some fields were so complex, their use in this study was abandoned.

The useable information was analyzed by a threefold method as discussed below. First, the soils occurring in every field were listed, by soil management units. Second, the levels of management used in every field were ascertained. Third, the suitable crop yields were arrayed systematically in a table according to soil management units and three levels of management.

1. Classifying soils as soil management units

The soils in every field were classified into soil management units. The soil management units can be defined as slope and eroded phases of the soil management groups described in section II B 3 of this report.

The complexity of soil patterns in some parts of the county resulted in numerous combinations of soil management units in some fields. The number, proportions and yield study suitability ratings of the soil management units occurring in the fields are summarized below:

No. of mgt. units present	Proportion of mgt. units present	Yield study suitability rating
1	1	excellent
2	1 : 1	good
2	2 : 1	fair
3	1 : 1 : 1	questionable
3	2 : 1 : 1	poor
4 or more	-	poor

The fields having poor suitability ratings were not used. If the proportion 1:1, 2:1 and 1:1:1 of soil management units were the result of similar soil drainage, profile texture, slope or erosion characteristics that could be reasonably grouped, they were used. Fields classified into one management unit presented an excellent source of yield and management data. A summary of the mapping units in each field used and their proportions are shown in appendix C

2. Determining management levels

The management levels used in Osceola are numerous. However, for practical purposes all levels of management were grouped into three major levels, high, medium, and low. The determination of the actual level of management used in each field was based on the soil management practices important for the particular soil group and crop, the fertility program and the efficiency of farm operations.

The fertility programs were determined from the ratio of cropland acres to livestock numbers and the amounts of commercial fertilizer used. The plant nutrients returned per acre of farmland were based on the number of animal units per acre and the nutrients

contained in farm manure (Tisdale and Nelson, 1956); are shown in table 4. The values from this table plus the amount of commercial fertilizer gave a picture of the fertility practices on the farm.

For each of the major crops, the management practices were rated in the following manner. (The most important practices are listed first for each crop):

Corn	Oats	Wheat	Hay
1. stand density	planting date	planting date	liming
2. seed variety	seeding rates	fertility level	fertility level
3. fertility level	fertility level	seed variety	harvesting dates
4. crop rotation	seed variety	seeding rates	seed variety
5. planting date	weed control	harvesting date	weed control

In addition to these practices, soil amendments, such as drainage, erosion control measures, and irrigation systems required on certain soil management units, were considered. The management of a particular field was rated high if all the management practices and required soil amendments were ideal. If the first 2 management practices or soil amendments plus any one of the other practices were not ideal the management of the field was rated medium. When 4 or more of the practices and amendments were not ideal, the management of the field was rated low. Each field and crop was rated in this fashion. The actual management ratings by fields are shown in appendix C.

Table 4. Plant nutrients returned per acre of farmland based on number of animal units¹ per acre. (Tisdale and Nelson, 1956)

No. of acres per animal unit	Tons of manure	lbs. N	lbs. P ₂ O ₅	lbs. K ₂ O
1	13.	156.	39.	117.
2	6.5	78.	19.	59.
3	4.3	51.	13.	39.
4	3.2	39.	10.	30.
5	2.6	31.	8.	23.
6	2.1	25.	6.	19.
7	1.8	21.	5.	16.
10	1.3	15.	4.	12.
15	.8	10.	2.4	7.

¹An animal unit equals 1 cow, 5 sheep or 1 horse. 95 percent of all animals on farms studied were dairy cows. Hence the pounds of N, P₂O₅, and K₂O, are based on cow manure which contains an average of .60 percent nitrogen, .15 percent P₂O₅ and .45 percent K₂O.

3. Arraying yield data

After the soils were classified into management units and the levels of management were determined for each field, all the suitable yields were arranged in tabular form for each of the major crops. The form of these tables was similar to table 1 described in section II B 3 of this report. The form was changed to accomodate four slope phases (units) of the well drained soil groups and three management levels in each management unit. The yields were recorded in the appropriate compartments according to soil profile texture, natural drainage, slope class, and management level. The actual crop yields per acre obtained on fields of different soil management units under high, medium and low levels of management are shown in tables 5 through 8.

Table 5 - Actual corn yields per acre obtained on fields of different soil management units under high, medium, and low levels of management: (99 farm yields 1959 to 1961, inclusive)

Parent material texture	Manage-system value	Natural drainage											
		a								b		c	
		Slope											
		12-18%		6-12%		2-6%		0-2%		0-6%		0-2%	
		ton*	bus.	ton	bus.	ton	bus.	ton	bus.	ton	bus.	ton	bus.
1	High Medium Low			18									
2	High		60	17	75	15	90			17	90	17	80
					50	11	90			12			
				15	65	10	75			9			
			50	12	60	9							
				12	60								
	Medium	10		9	75	18	43			9	50		
		7.6			55	16							
		7		8	50	5	55			9			
		6		6		7			8				
		6		6	45								
Low	5	58		30	8								
		50			7								
3	High				50	18	90						
					50	16							
	Medium					10	60						
	Low			6.3									
4/2	Medium			12									
				12									
4	High	17	80	12		18	85	12	75				
		15	25	11			42	10	70				
		12		14				9	65				
							7						
							17						
	Medium	6				12	40	5					
	10					80							
Low				20									
5	High			7	40		76			6			
	Medium					10							
						2							

* Ton represents tons of silage

Table 6. Actual oat yields in bushels per acre obtained on fields of different soil management units under high, medium and low levels of management:
(68 farm yields 1959 to 1961 inclusive)

Parent material texture	Management system value	Natural drainage				
		a			b	
		12-18%	6-12%	Slope		0-6%
				2-6%	0-2%	
1	High					74.4
2	High	52	80	70 50		
			70	65		
	Medium	75	66 50	50		
		50	65 45			
		40	62 25			
	Low		60			
		25	32 20	50 35		
		20	30	40 35		
			23	40 10		
3	High		45	60, 20		
	Medium		40	60		
	Low		38	40, 39, 35		
4/2			80 50			
	High		70 50			
	Medium		50			
4	High	52	75		70, 40, 30	
		20	35		60, 40, 30	
			37		50, 40, 30	
	Medium	55		30		
	Low	25	30 20	20	20	
5	High			54		
	Medium			20		

Table 7. Actual wheat yields, in bushels per acre, obtained on fields of different soil management units under high, medium, and low levels of management:
(47 farm yields 1959 to 1961 inclusive)

Parent material texture	Management system value	Natural drainage				
		a			b	
		Slope				
		12-18%	6-12%	2-6%	0-2%	0-5%
2	High	40	43	43		45
	Medium	30	60,55,30 60,40,20 59,33,35	48 29	1	43 42 25
		Low	35	30,26,35	5	
3	Medium	35 25 15				
4 1/2	Medium		20			
4	High				50 40	
	Medium	30 20	20 17	50,30,10,39	38	
	Low	15	15	17.5		
5	Medium		35			

Table 8. Actual alfalfa-bromegrass hay yields, in tons per acre, obtained on fields of different soil management units under high, medium, and low levels of management: (101 farm yields in Osceola County, 1959 to 1961 inclusive)

Parent material texture	Management system value	Natural drainage				
		a			b	
		Slope				
		12-18%	6-12%	2-6%	0-2%	0-6%
2	High		4.5,2.7 3.5	5.5,5 5, 3	4 2	
	Medium	3	4,2.5,1.6	5, 2.7	4.3	4.0
		2.7	4,2.2,4.5	4, 2	3.5	3.9
		2	3,2	3.5,1.5		
	Low	1.7	2.5,1.7	3		
			3.5,2.5	2.7,1.5	2	2.5
			3, 2	2.5,1.5		2
			2.5,2	2.5,1		
			2.5,2	2, 1		
	2.5,1.8	2,2.2,1				
3	Medium		3 1	4.3,3.5 3.5,2		
	Low		1.8,1.4,1.2			
4/2	High		6.4,2.5 2.7,1.5			
	Low			2.2,1.5		
4	High	3 2	1	3 2.5	4,1 2.5	
	Medium	2.5,2 2,1.5	2.5,1.8 2.0	4 2 2	1.8,.6 .8	
	Low	1.5	1,.5			
5	Medium			2,1.7,.9		

IV RESULTS

From the 31 completed questionnaires, 96 yields of corn, 68 yields of oats, 46 yields of wheat and 101 yields of hay were obtained for use. Additional yields were also obtained but were discarded, because the soils were too complex. Considering the time and expense it took to collect these yields, the method of using questionnaires and personal interview with selected farmers is very efficient and effective as indicated by the results above.

In the study, average crop yields for the kinds of soil that occur in Osceola County under various management levels were sought. These average yields were found for the management unit groupings of the common agricultural soils. The average yields are shown in Table 9. 2 to 10 individual yields were used in determining averages.

In addition some individual yields were entered in Table 9 and are shown in parentheses. These yields were either accurately obtained from research trials or seemed to be reasonably model for the particular management unit and level of management when compared to nearby units or levels in the Table. Even though reasonably accurate, extremely high or low individual yields were not entered in Table 9, as they detracted from the trends in average yields. They are entered in Tables 5 through 8 as actual yields.

Table 9. Average crop yields per acre obtained by different soil management units under high, medium, and low levels of management: (296 farm yields, 1959 to 1961 inclusive)

Soil area (see Fig.2)	Management group & soil series	Slope gradient	Soil mgt. system	Average acre yields				
				Corn silage	Corn grain	Oats	Wheat	Alfalfa brome hay
				tons	bu.	bu.	bu.	tons
6,7,8		12-18%	High Med. Low	7.6	55 54	50 23	(40) (30)	2.5
6,7	2a	6-12%	High Med. Low	11.2 7.5	61 55 43	75 53 26	44 30	3.6 2.7 2.4
5,6	Nester Isabella	2-6%	High Med. Low	12.6 11.2 7.5	85 49	62 (50) 36	44 38.5	4.6 3.1 1.8
5		0-2%	Med. Low					3.9 (2)
5,6	2b Kawkawlin	0-6%	High Med.	14.5 9.	90 (50)		(45) (37)	4.0 2.3
5,6,7	2c, Sims	0-2%	High	(17)	(80)			
		12-18%	Med.				25	
2,7	3a	6-12%	High Med. Low	6.2	50	(45) (40) (30)		2 1.5
	McBride Newaygo	2-6%	High Med. Low	17 (10)	(90) (60) (40)	40		3.3
5,6	4/2a Menominee	6-12%	High Med.	12		62 (50)		3.3
		2-6%	Med.					1.8
2,3,7	4a	12-18%	High Med. Low	14 8	53	34 (25)	25 (15)	2.5 2 (1.5)
2,3,7	Montcalm Mancelona Blue Lake	6-12%	High Med. Low	12.3		49 25	18.5 (15)	2.1 .75
2,7,10		2-6%	High Med. Low	(18) (12)	63 60	(30) (20)	29 (17.5)	2.8 2.6
10		0-2%	High Med. Low	11 (5)	70 (40)	43 (20)	45 (38)	2.5 1.1
1		12-18%	Med.					(1.5)
1,2,3	5a Kelkaska Graycalm	6-12%	High Med.	(7)	(40)		(35)	
2,4		2-6%	High Med.		(76)	(54) (20)		1.5
4	5b Au Gres	0-6%	High	(6)				

() Single yields

V DISCUSSION

The influence of different soil management units, soil erosion classes, slope classes, and management levels on crop yields can be evaluated by close examination of table 9 and the four preceding tables.

Table 9 shows that management levels affect crop yields on every management unit. The use of high management levels in many cases increased yields and in some instances more than doubled crop yields over the use of low management levels. For example, corn silage yields on the 2a soils with 2-6 percent slopes under high, medium, and low management levels are 12.6, 11.2, and 7.5 tons, respectively. Hay yields on these same soils and management levels are 4.6, 3.1, and 1.8 tons per acre, respectively. Several other examples showing the effects of different management levels on crop yields are easily observed in table 9.

The influence of different levels of management on crop yields tend to vary by soil profile texture, slope classes and crop. On the 6-12 percent slopes of the 2a, 3a, and 4a, the use of high management levels over that of low management levels gave increases of oat yields per acre of 49, 7, and 24 bushels, respectively. The 7 bushel yield differential maybe dubious as it represents only 2 single yields. In comparison to the 49 bushel differential in oats yield above, corn yield differentials on these same 2a soils were only 18 bushels per acre. This exemplifies that different crops vary in their response to high management levels, or that the range of management applied to oash crop is narrower and higher

The influence of texture of parent material and natural soil

drainage on yields as reflected by the soil management units is apparent. When corn silage yields on the 3a soils with 2-6 slopes with medium and high management levels were averaged, they were 1.6 tons higher than those on the 2a soil, with similar slope and management. Corn grain yield differences were similar. The 3a soils out yielded the 2a soils by 8 bushels per acre. Corn yields on the 4a soils with similar slope and management were 6 bushel per acre less than those on the 2a and 14 bushels less than on the 3a soils. Corn yields on the 2b soils were almost cut in half where adequate drainage was lacking. Oat yields follow a similar trend. However, the 2a soils are the most productive. By averaging the yields for all 3 management levels for the 2a, 3a, 4a, and 5a soils on 6-12 percent slopes, the following average yields in bushels per acre were obtained; 51, 41, 37, and 35, respectively. These differences can be attributed largely to the different parent material textures.

The influence of all the different soils on wheat yields could not be observed in the table as most of the yields were obtained on the 2a soils. A comparison can be made between the 2a and 4a soils on 2-6 percent slopes with medium management, the 2a soils have yields of 38.5 bushels per acre while the 4a soils have 29. On 6-12 percent slopes on these soils the wheat yields with medium management levels were 44. and 18.5 bushels, respectively. The 2a soils are more productive than the 4a soils.

The influence of erosion on hay yields is apparent as shown in the following tabulation.

Crop	mtg. level	erosion	
		slight	moderate
corn	high	58 bu.	50 bu.
	medium	7.5 tons	7.0 tons
hay	high	3.5 tons	---
	medium	2.1 tons	3.5 tons
	low	2.2 tons	2.6 tons

On the moderately eroded 2a soils (6-12 percent slopes), hay yields obtained under medium levels of management were 1.4 tons per acre higher than those obtained on slightly eroded conditions on similar soils and management. Under low levels of management they were .4 tons higher. On these eroded soils the plow layer consists of a mixture of the surface (A) and subsoil (B) horizons. This mixing eliminates partly the acid condition of the B horizon as shown in Figure 3. Also A and B horizons are thinner. These conditions permit the alfalfa roots to easily and readily reach the calcareous parent material. Alfalfa responds favorably to these conditions and this response may account for the increased yields of hay on eroded soils. The effects of these moderately eroded soils compared to slightly eroded soils under high management levels decreased corn grain yields 8 bushels per acre and under medium management levels corn silage yields .5 ton.

The effects of soil slope on crop yields is shown in table 9. For corn grain, steeper slopes show lower yields with high level of management than on milder slopes with similar management. Since corn yields have been higher when correlated with thicker surface horizons, the generally thin surface horizons on these slopes may be limiting corn yields.

Some general relationships between soils, crops, and soil management can be observed in tables 5 through 8. First, the scant number of yields obtained in this study for the poorly and imperfectly drained soils show that these soils are not used extensively for cropland in the county.

Second, the concentration of wheat yields in the 2a group of soils indicates that wheat is particularly adapted to this soil group. Surplus crop controls have restricted acreage of wheat, consequently farmers are growing wheat only on their more productive lands. This practice has increased wheat yields probably more than has the use of better or other management practices.

Third, management levels used varied among the major crops grown in the county. By averaging the management levels ($h=1$, $m=2$, $l=3$) determined for each yield used in this study, the average management level for each of the major crops was obtained. The corn crops were grown with the highest average management, wheat ranked second with a medium management, hay ranked third, a low-medium management, and oats ranked last with a low management rating. Good management is essential for profitable corn production and many of the farmers are aware of and use management practices that insure high yields. Oat yields are low because legume grass seedings are made with oats and seeding rates of oats are reduced to insure good stands of hay crops.

Farmers who were successful in getting high crop yields were asked to rate the value of the soil amendments and management practices in accordance to the soils on their farms. A summary of these ratings by soil groups follow. The highest rated practices are

listed first:

1a,2a,3a	2b,2c	4a,5a
1. Liming	1. draining	1. irrigation (potatoes, strawberries)
2. Fertilizing	2. fertilizing	2. liming
3. Proper timing of operations	3. proper timing	3. fertilizing
4. Planting adapted crop varieties	4. planting adapted crop varieties	4. proper timing of operations
5. Rotating crops	5. rotating crops	5. planting adapted crop varieties
		6. rotating crops

Seeding rates affected corn and oat yields especially where the above practices were used. Stands of 10,000 or less plants per acre of corn gave only average or low yields. Whereas stands of 14,000 plants per acre gave average to high yields and stands of 18,000 plants per acre generally gave the highest yields. In order to get 18,000 plants per acre, one farmer had to set his corn planter at 22,000 kernels per acre and lubricate his seed corn with powdered graphite to prevent the planter from cracking the kernels. Altho theoretically, 12,000 plants per acre should give a 70 bushel yield, farmers who obtained stands of 14,000 to 16,000 plants per acre come closer to 70 bushel yields than those who obtained stands of 10,000 to 12,000 plants per acre. Oat yields were highest where 2 to 2½ bushels of seed were sown per acre. Seeding rates of 4 to 6 pecks per acre usually reduced yields considerably. All these results are based on the use of certified seed.

VI CONCLUSION

A. Conclusions concerning the methods used for collecting soil, crop yield and management information follow :

1. The method used in selecting farms for study was ideal. Counselling with the local agricultural agencies was especially useful. Farmers who have kept records and would cooperate can be readily selected in this manner.
2. Soil survey information is easily obtained in areas that have recently completed surveys.
3. The use of questionnaires when accompanied with personal visits provides an excellent means for collecting crop yields and management information. The number of questionnaires returned is high and the accuracy of yield and management information can be validated. The farmers suggested that future questionnaires be sent during times when farm work is less pressing.
4. The use of soil management units was useful when assembling management and yield information into usable form.
5. The method used to determine the management levels for the different crop yields was unique. Not only were the desirable management practices on each crop and needed soil amendments on each soil taken into consideration but but the ratio of livestock numbers to cropland acres was determined as a measure of plant nutrients returned to the soil annually.

B. Conclusions concerning the yields obtained from this study follow:

1. Management levels affect crop yields on nearly every soil management unit.
2. The influence of different levels of management on crop yields tends to vary by soil profile texture, surface slope, drainage, and kind of crop.
3. The influence of texture of parent material on yields is apparent. The 3a group gave maximum yield of corn with good management but the 2a group was most productive for other crops studied.
4. The effects of soil slope on crop yields varied to some extent by soil management groups and management levels. In many cases, corn and small grain yields were lowered on the steeper slopes.
5. The poorly and imperfectly drained soils are not used extensively for cropland in Osceola County.
6. The increase in wheat yields from 1949 to 1960 is due to the growing of more wheat on the 2a soils. Wheat is well adapted to this group.
7. Moderately eroded 2a soils show an increase of 1.4 tons of hay over slightly eroded 2a soils with similar slopes and management levels.
8. The foregoing conclusions are based on the observations made in this study. Further study may substantiate or change the results of these observations. As it is crop yield differences of less than 10 percent cannot be

considered significant.

9. The expected crop yields for the management units under high, medium, and low levels of management, as shown in table 10, are based on the above observations.

C. Conclusions concerning further research needs follow:

1. It was assumed that climatic conditions affected all parts of the county equally. Further research is needed to determine the actual effects of climate on crop yields by different soil textures, natural drainage, slopes, and location of soils in respect to woodland.
2. Further research is needed to evaluate the effects of different combinations of management practices on crop yields. Even though individual management practices have great value, it is apparent that certain combinations of management practices enhance the value of some individual practices.
3. Crop yields fluctuate cyclically over a period of 3 to 7 years in Osceola County as shown in figure 1. With further study, it might be possible to collect yield and management information for only one year and compute average yields by taking into consideration that portion of the crop yield cycle that varies from the actual period observed.
4. A follow up on the farms and fields used in this study would enhance the value of the results.

Table 10. Estimated crop yields per acre obtainable on different soil management units of the common agricultural soils under high, medium and low management:

Soil mgt.group & soil series	slope gradient	soil management system	average acre yields				
			corn silage	corn grain	oats	wheat	alfalfa brome hay
			tons	bu.	bu.	bu.	tons
2a Nester Isabella	12-18%	high	10.5	55	60	40	3.8
		med.	9.4	47	50	30	2.5
		low	8.0	40	23	18	1.5
	6-12%	high	11.0	61	63	48	4.0
		med.	9.5	55	53	44	2.7
		low	8.6	43	36	30	2.5
	2-6%	high	13.0	85	62	44	4.4
		med.	11.2	49	50	38	3.0
		low	9.6	36	36	30	1.8
	0-2%	high					4.5
		med.			-		4.0
		low					2.0
2b Kawkawlin	0-6%	high	15	90	-	45	4.0
		med.	9.0	45		33.5	2.3
		low	-	-			1.0
2c Sims	0-2%	high	16	80	-	35	4.0
		med.	10	50	-	15	2.5
		low	10	50	-	-	1.0
3a McBride Newaygo	12-18%	high	12	60	45		3.2
		med.	8	40	40	25	1.5
		low	5	25	35		1.0
	6-12%	high	14	70	58		3.5
		med.	10	50	40		2.0
		low	6.2	35	38		1.5
	2-6%	high	17	90	65		4.5
		med.	12	60	60		3.5
		low	8	40	40		2.0
	0-2%	high	17	90	65		4.5
		med.	12	60	60		3.5
		low	8	40	40		2.0
4/2a Menominee	6-12%	high	14	70	57		3.5
		med.	12	60	50		2.0
		low	7.5	35	33		1.5
	2-6%	high	15	75	60		3.3
		med.	12	60	48		2.0
		low	7.5	30	34		1.5
	0-2%	high	16	80	62		2.7
		med.	13	60	50		1.8
		low	8.	35	35		1.0

(continued on next page)

Table 10. Estimated crop yields (continued)

soil mgt.group & soil series	slope gradient	soil mgt. system	average acre yields				
			corn silage	corn grain	oats	wheat	alfalfa brome hay
			tons	bu.	bu.	bu.	tons
4a Montcalm Mancelona Blue Lake	12-18%	high	11	50	35	30	2.5
		med.	8	40	30	25	2
		low	4	20	25	15	1.5
	6-12%	high	12	60	45	32	2.5
		med.	9	45	37	20	2.
		low	5	25	25	15	1.
	2-6%	high	14	65	40	35	3
		med.	10	50	30	29	2.5
		low	6	30	20	18	2.0
	0-2%	high	11	70	43	40	2.5
		med.	6	40	32	35	1.5
		low	5	25	20	25	.5
5a Kalkaska Graycalm	12-18%	high	-	-	-	25	2.0
		med.	-	-	-	20	1.5
		low	-	-	-	10	.7
	6-12%	high	7	40	50	30	2.0
		med.	6	30	20	25	1.5
		low	4	20	10	15	.7
	2-6%	high	8	45	50	30	2.0
		med.	7	40	25	25	1.5
		low	4	20	10	15	.5
	0-2%	high	7	45	45	25	2.0
		med.	6	30	20	20	1.0
		low	4	10	10	10	-

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Appendix A

Sample letter and questionnaire forms with which yield and management data were collected.

Soil Conservation Service
Box 37
Gladwin, Michigan
December, 1961

Dear Sir:

The National Cooperative Soil Survey is preparing to publish the Completed soil survey of your county. We need your help in compiling crop yield information for the different soils that are in your county.

Your farm was suggested as a possible source of this information by your County Director of Agriculture, Farmers Home Administration Supervisor and the Soil Conservation Service Technician.

By filling in the attached forms and dropping them in the mail, you will materially help to establish realistic crop yields for the soils in the county.

Please use the following plan when filling out forms.

1. Write your name, address, township and section at the top of page 2. Also draw a sketch of farm and enter livestock numbers.
2. Use pages 3 and 4 for corn crops, 5 and 6 for oats, 7 and 8 for hay and 9 and 10 for wheat, potatoes or any other major crop grown on the farm.
3. Record your 1961 corn crop for only one field in the first column on pages 3 and 4, then record 1960 corn crop for only one field in second column, finally record 1959 corn crop in last column.
4. Use the same procedure as in 3 above for other major crops grown on your farm.

The information you provide will be treated confidentially. It will be used in developing yield tables for the agricultural soils in Osceola County. The information will be useful to farmers like yourself in planning their cropping rotations, fertility programs and management practices.

If you need help in filling out forms, please call.

Thank you for your time and effort. We would appreciate hearing from you soon.

Sincerely yours,

Ken Mattert

Name

Address

Township

Section

Total acres on farm

Acres cropland

Draw a sketch of your farm. Number the fields and indicate the number of acres in each field. Show which direction is north. The maps or sketches in your Farm Conservation Plan, F.H.A. Record or A.S.C. Farm Folder can be used as a guide.

In the following blanks fill in the average number of animals kept on your farm.

Dairy cows

Heifers 2 yr.

Heifers 1 yr.

Beef cows

Steers

Ewes

Pigs

Hens

Please record _____ (i.e. corn, oats, wheat, hay, etc.)
crop for the past three years. Use back for additional
comments and records.

	<u>Sample Answer</u>	<u>Your Record</u>
Year	1961	1959 1960 1961
Field No.	1 from sketch	
Acres in field	10 acres	
Previous crop	Alfalfa	
Time of plowing	Fall 1960	
Moisture conditions when plowed	Wet	
How was field fitted?	Plow plant	
Erosion control	Contouring	
Date planted	May 10	
Variety of seed	Certified	
Condition of stand	Peer	
Bushels of manure applied per acre	90	
Tons of lime applied per acre	3 tons	
Fertilizer analysis and amount used	5-20-20 200 lbs.	
How applied?	Plow down	

1959

1960

1961

Was field tested?	Yes or no
Kinds and number of cultivations	3 Harrow
Kind and amount of weed control sprays	2,4D 1/16 per ac.
Growing seasons	Normal
(a) Temperature	above, below
(b) Rainfall	Normal above, below
(c) Percent & cause of crop damage	3% Hail
Date harvested	Nov. 15
Yield per acre	60 bu.
How was yield measured?	Wagon loads
Harvesting losses	In %
Was this a good yield for this field?	Yes or no
Number of inches of irrigation water applied	None
Is drainage needed?	Yes or no
Crop rotation followed	C-C-H-H

Appendix B

Summary of soil, crop yield and management data available by fields.

Identification of soil numbers, slope letters, and erosion numbers in each soil symbol are shown in Appendix C. Soil symbols are listed in the first soil number.

The crop, yield and management levels used are indicated by a three part symbol. The first letter represents the kind of crop, the numbers represent the yield, and the last letter represents the level of management as follows:

<u>Crop</u>	<u>Yield</u>	<u>Management</u>
C = Corn	Given in	h = high
O = Oats	bushels. except	m = medium
W = Wheat	numbers	L = low
H = Alfalfa-brome	followed by "T"	
P = Potatoes	indicate tens	
	of silage and	
	hay yields (H) are	
	in tons.	

Field No.	Soils and proportions	Cropland ac. per. animal unit	Crops, yields and manage- ment by years.		
			1959	1960	1961
1	442B1-904A0. 9-1	.8		C15Th	C90h
2	443B1	.8			W29m
3	443B1	.8			W5L
4	443B1-642B1. 8-1	.8			H1L
5	652B1-217B1. 4-1	2.2	H3.9h		C17Th
6	112B1-238B1. 8-1-1	2.2	H3.9h	C76h	O54h
	740B1				
7	652B1-710B1. 9-1	2.2	C15Th	O74h	
		2.2	C90Th		
8	215C1-480B1. 3-1	2.2	O50h	H6.4h	
9	446C1-236B1. 19-1	2.1	H2m	C65m	O20m
10	446B1-446C1. 1-1	2.1	C55h	O50m	H3.5h
11	446B1-446C1. 2-1	2.1	H5m	H5.5m	C75m
12	236B1-236C1. 4-1	3.			C85h
13	G236B1-846A0. 9-1	3.			C18Th
14	G236B1-236A1. 9-1	3.			C18Th
15	520B1-520C2. 9-1	3.			C18Th
16	G236A1-G236B1. 1-1	3.			O40h
17	G236A1-G236B1. 1-1	3.			O40h
18	236A1	3.			O30h
19	480C2-780A-				
	260B1. 1-1-1	5.			C45m
20	260B1	5.		C75h	

Appendix B (continued)

Field No.	Soils and proportions	Cropland ac. per. animal unit	Crops, yields and manage- ment by years.		
			1959	1960	1961
21	480B1-480C3- 116C2. 2-1-1	5.	C10Th	H1.6L	H1.7L
22	480C2-480B1. 1-1	5.	H2.2m		
23	365B1	7.		C14Th	C11Th
24	260A1	7.	C5Tm		O20L
25	236C1	7.		O75h	
26	G236A1-G236B1. 2-1	7.	O-m	H4m	
27	365B1-260B1. 4-1	7.			H2.5h
28	272B1-480D0. 9-1	7.			H4.5m
29	263A1	10			C10Th
30	263A1	10		C9Th	
31	263A1	10	C7Th	O50h	H2.5h
32	263A1-260B1. 3-1	10			O1Th
33	263A1	10	H1h	H2.5h	
34	221A1	4.5			C7.5Tm
35	484D2-710B1. 1-1	4.5		C8Tm	
36	484B1-653B1. 1-1	4.5	C5Tm		
37	112B2	4.5		C2Tm	
38	236C1-480C1. 2-1	4.5			O18m
39	443B1-236D2. 4-1	4.5		O43m	
40	653B1-484B1. 3-1	4.5		H4m	H2.5L
41	484B1-484C2. 1-1	4.5	H4m		
42	112B1-236C1. 4-1	2.3	H2m		C10Tm
43	236D1-236C1. 1-1	2.3		C6Tm	W15L
44	260D1-260B1. 2-1	2.3	C10Tm		
45	260D1-221E1. 1-1	2.		O55m	
46	260D1-260B1. 1-1	2.		O75h	
47	260D1-702B1- 221C1. 2-1-1	2.	O50m		
48	343C1-260D1- 112B1. 2-1-1	2.		H31	
49	236C1-465B1. 1-1	6.2	H.5L		C50h
50	236B1.	6.2	W10m	C40h	O30h
51	236C1-116D2. 4-1	6.2	C42h	O37h	H1h
52	465B1-236B1. 4-1	6.2	O20h		
53	236C2	6.2			W17m
54	465C1-444C1. 4-1	6.2		H1.4L	
55	465C2	6.2		C6.3Tm	
56	480D3-465B2. 2-1	6.2	C7.6Tm		
57	482C2-480A1- 465C2. 1-1-1	6.2			O62m
58	465B2	6.2	O39L		
59	465C2	6.2	O38L		H1.2L
60	465B2-480A1. 1-1	6.2	H3.5m	H4.3m	
61	482B1-654B1. 2-1	4.			C10Th
62	480B1-217B1. 1-1	4.		C40h	
63	654B1-480C1. 1-1	4.	C9Th		W43m
64	480B1	4.		W48m	

Appendix B (Continued)

Field No.	Soils and proportions	Cropland ac. per. animal unit	Crops, yields and manage- ment by years		
			1959	1960	1961
65	480C2	4.			H2m
66	480B1-480C2. 1-1	4.		H3.5m	
67	480C2-480B2. 2-1	4.	H2.5m		
68	480C1	2.	H3m	C6Tm	C90h
69	480C1	2.			C17Th
70	482C2-482D2. 1-1	2.	C5TL	O65m	
71	480D1	2.			O75h
72	480C1	2.	O25m		H2.7h
73	480D1	2.		H1.7m	
74	480C1	5.	O45m		
75	482B1-482C1- 1-1-1 653B1.	5.			W45h
76	654B1-482B1. 1-1	5.		W23m	
77	482B1	5.	W43h	H4h	H2h
78	482B1-482C2- 1-1-1 653B1.	5.	H2L		
79	480C2	4.			C15Th
80	741B1	4.			C10Th
81	482C2-236C2. 2-1	4.	W30L	C15Th	O50m
82	236C1	4.		C12Th	O20L
83	480C1	4.	C12h	O66m	H2.5m
84	480C1	4.	C60h		H2.5m
85	480C2	4.			C75h
86	480C1	4.	O50L		
87	482C2-236C2. 4-1	4.		H4h	
88	482C2-236C2. 2-1	4.			H2.5L
89	482C2	4.			W35m
90	482C2	4.		W30L	
91	904A0-213C1 2-1	3.			C80h C17Th
92	482B1-465B1- 654B0. 2-1-1	3.	C18Tm	C16Tm	O70m
93	217B1-217C1. 1-1	3.		C12Tm	O50m
94	482B1-654B1. 1-1	3.	O10L	H5m	H4m
95	482B1-904A0- 2-1-1 217B1.	3.	H3L		
96	480B1	3.8	H1.5L		C90h
97	480D2	3.8		C58L	
98	482B1-335B1. 1-1	3.8	C16Tm		O50L
99	480D2	3.8	O20L		
100	480D2-480B1. 1-1	3.8	O40m		
101	480D2-480B1. 1-1	3.8			H2.7m
102	480B1	3.8		H2L	
103	446C2-446E2- 1-1-1 446C1.			C6Tm	C10Tm
104	446D1-446C1 1-1		O40m		
105	443C1-443D2- 1-1-1 236B1.		H3m	H4m	H5m

Appendix B (Continued)

Field No.	Soils and proportions	Cropland ac. per. animal unit	Crops, yields and manage- ment by years		
			1959	1960	1961
106	482B2	2.7		H2.5L	C11Th
107	480D2-480E2- 1-1-1 120D2.	2.7		C3.4TL	
108	480B1-120C1. 1-1	2.7	C3.6L		035m
109	480B1-120C1. 1-1	2.7		035m	
110	480B2-480D2. 2-1	2.7			H1L
111	217B1-653B0. 3-1	2.7	H2.L		
112	443D1	6.6			C9Th
113	443D1-443C1. 1-1	6.6		C7Th	050m
114	443B1-443C1. 1-1	6.6	C7TL		
115	443D3-443C2 1-1	6.6		025L	
116	444C1-648B1. 4-1	6.6	030L		
117	446B1-443D2. 1-1	6.6			W25m
118	444C1	6.6		W40m	
119	446D3-444E2. 2-1	6.6	W40m	H2m	
120	444C1	6.6			H2.5L
121	446D2-446B1- 1-1-1 648B1	6.6	H2.m		
122	465B1-663B1- 859A0. 1-1-1	6.6			C85m
123	465B1	6.6		C60m	060m
124	465B1-112B1- 1-1-1 236B1.	6.6	C80m	035L	
125	236D2-465D2. 4-1	6.6	025L		
126	482C1-482B1- 482D2. 2-1-1	6.6			W35L
127	482D2-465E2 2-1	6.6			W35L
128	482C1-	6.6	W26L		
129	465C1-465B1- 663B1. 2-1-1	6.6			H1.8L
130	482C1-480B1- 482D2. 3-1-1	6.6		H2.5L	
131	236C1-482D1 1-1	6.6	H2L		
132	260A1	6.6			C70H
133	260B1	6.6	W38m	C12Th	060H
134	263A1		C17Th	070H	
135	260A1-260B1 1-1		030m		H.75m
136	260B1-112C1 1-1	6.6			W50m
137	263A1	6.6		W40H	
138	260B1-260A1 2-1	6.6		H3h	
139	260B1	6.6	126 cow days per. acre		
140	160A1-236B1 4-1	15	GMh	seeded	H1.5h
141	480B2	2.2	C9Th	040M	
142	100B2	2.2	020m		
143	480B2-480C3- 236C2 4-1	2.2			H2L
144	480B2	2.2		H1.2L	

Appendix B (Continued)

Field No.	Soils and proportions	Cropland ac. per. unit	Crops, yields and manage- ment by years		
			1959	1960	1961
145	100B1-920A0 4-1	2.2	H.9m		
146	480C1	4.			C30L
147	465C2-480D2 4-1	4.		C50H	
148	480D2-482B1 2-1	4.	C50h	052H	H3m
149	465C2-480D2 100D2 1-1-1	4.			040m
150	116C2-480D2 4-1	4.	020L		
151	116C2	4.		H2.5m	H2m
152	236B1-443B1 2-1	4.			W20m
153	480C2			W20m	
154	480D1-116C2 1-1	4.	W15m		
155	217C1-236D1- 236B1-465D1- 443D1. 4-2-2-2	1.6	H2.7h	H2.3h	H1.5h
156	482C2-236D2- 111D2-223D1. 1-1-1-1	6.4			H2.5m
157	223D1-236C2- 236D2-111D2. 2-1-1-1	6.4		H2m	
158	426B1-271B1- 380D1. 2-1-1	6.4			C10Th
159	112C2-223D2 1-1	6.4		C40h	
160	482C2-426B1- 380D1-271B1. 6-2-2-1	6.4	C60h		
161	223D2-380D1- 223C1. 5-4-1	6.4			040m
162	380D1-426B1- 271B1. 2-1-1	6.4		060h	
163	236C2-111D2- 111C2. 2-1-1	6.4	035h		
164	380D1-426B1- 223C1-271B1. 5-2-2-1	6.4			W25m H2.5L
165	443B0-443C2 1-1			H21	
166	480C2-443C1 3-1				
167	465B2-710B0- 653A0 3-1-2		H2L	C25m	P200m
168	465B1		P200m	032L	070m
169	446C2				
170	446C3				
171	443C2-443B0 1-1		023L		
172	446C2			C55h	
173	480C2-443C1 4-1				C50h P400h
174	112B1	4.5			
175	112C2-236B1 1-1	4.5		P500h	
176	112B2	4.5	P350h		
177	642B0-465C2 1-1	4.5		H2L	W42m
178	112C2	4.5		W35m	
179	236D2-112D2. 1-1	4.5			H1.5L
180	214E2-112C2. 2-1	4.5		H1.5L	

Appendix B (Continued)

Field No.	Soils and proportions	Cropland ac. per. unit	Crops, yields and manage- ment by years		
			1959	1960	1961
181	236D2-217D2- 6-2-1 217C2	4.4	H1.8m		C15Tm
182	236D2	4.4		C12Th	
183	236D2	4.4	C25h		
184	236C1-482C1- 111C1. 5-3-2	4.4		O30L	
185	236D2-480D2 1-1	4.4			W35L
186	236C1-236D2 1-1	4.4	W20L		
187	236D2	4.4			H2m
188	236D2			H3h	
189	480C1-654B1- 908A0. 1-1-1	3.8		C9Tm	C9Tm
190	480C1-654B1 1-1	3.8	C50m		
191	480B2-653B1 8-1	3.8			O65h
192	480C1-653B1 1-1	3.8		O60m	
193	217C1-482C2- 480D1 18-2-1	3.8	O70h		
194	480C1-480D1- 654B1-217C1 6-2-1-1	3.8			H1.7L
195	482C1-907A0- 236C1. 7-2-1	3.8			W59m
196	236C1-426B1- 465C1 5-4-1	2.3		C12Th	C70m
197	446B1-236C1 3-1	2.3	C15Th C90h	O45m	C12Tm H2.2m
198	217C1-100C1- 120D1-480C2. 4-3-2-1		W20m		O50m
199	236B1-426B1- 443B1. 5-3-2		O20L	H2m	
200	46502-443B1 4-1		H1m		
201	215C1-482B1 3-1	4		C17Th	C11Th
202	442B1-442D1- 236D1. 4-5-1		C60h	O80h	
203	443B1-442C1 1-1	4			O50h
204	442B1-442C1 1-1	4	O70m		
205	442B2	4			H5m
206	442C2-442D1- 442B1. 1-1-1	4		H4.5h	
207	465B1	4	H3.5m		
208	442C2	4			W60m
209	442C2	4		W60m	
210	442C2	4	W55m		

Appendix C

Soil identification legend for soil symbols in fields studied

<u>Field number</u>	<u>Field name</u>	<u>Field number</u>	<u>Field name</u>
100,110	Kalkaska sand	486	Dighton sandy loam
102	East Lake loamy sand	517	Kent sandy loam
105	Wallace sand	518	Kent loam
111,112	Kalkaska loamy sand	520	Kent silt loam
116,221	Grayoalm sand and loamy sand	530	Kent silty clay loam
118	Grayling sand	607	Otisco loamy sand
114,115	Rubicon sand	608	Otisco sandy loam
120		642	Twining loam
202	Ocqueoc loamy sand	647	Selkirk silt loam
213	Manistee loamy sand	648	Twining fine sandy loam
214	Melita sand	649	Twining loamy fine sand
215	Melita loamy sand	652	Kawkawlin silt loam
216	Menominee sand	653	Kawkawlin loam
217	Menominee loamy sand	651,654	Kawkawlin sandy loam
223	Blue Lake loamy sand	657	Selkirk loam
236	Montcalm loamy sand	658	Selkirk fine sandy loam
S236	Montcalm stony loamy sand	663	Coral loam
G236	Montcalm gravelly loamy sand	664	Coral sandy loam
238	Creswell loamy sand	670	Richter sandy loam
239	Creswell sand	706	Iosco sand
260	Mancelona loamy sand	707	Iosco fine sand
262	Bentley loamy sand	708	Iosco loamy fine sand
263	Mancelona sandy loam	709	Iosco loamy sand
270,271	Rousseau loamy fine sand	710	Iosco sandy loam
320	Newaygo sandy loam	718	Arenac sand
325	Alcona sandy loam	719	Arenac fine sand
335	Udly sandy loam	720	Arenac loamy sand
365	Montcalm sandy loam	740	Augres sand
380	Dryburg sandy loam	741	Augres loamy sand
418	Newaygo loam	758	Allendale loamy sand
442	Isabella loamy sand	760	Allendale sandy loam
443,444	Isabella sandy loam	770	Ingalls loamy sand
446	Isabella loam	771	Ingalls fine sandy loam
465	McBride sandy loam	790	Dafter sandy loam
466	McBride loamy sand	804	Ogemaw sand
479	Nester loamy sand	805	Ogemaw loamy sand
480,485	Nester loam	808	Pickford silty clay loam
482,484	Nester sandy loam	8085	Pickford clay loam
		809	Pickford silty clay
		810	Ogemaw sandy loam

Appendix C (Continued)

<u>Field number</u>	<u>Field name</u>	<u>Field number</u>	<u>Field name</u>
821	Epoufette loamy sand	847	Brevort loamy sand
815, 822	Epoufette sandy loam	848	Brevort fine sandy loam
826	Breckenridge sandy loam	850	Munuscong fine sandy loam
830	Saugatuck sand	851	Pinconning loamy sand
832	Saugatuck loamy sand	859	Ensley lean
833	Roscommon sand	875	Bergland silt loam
834	Roscommon loamy sand	897	Butternut loam
8331	Roscommon mucky sand	900	Butternut sandy loam
837	Brevort sand	901	Butternut clay loam
P840	Kinross peaty sand	904	Sims silt loam
840	Kinross sand	903, 906	Sims sandy loam
8405	Kinross loamy sand	907	Sims loam
845	Edmore sandy loam	920	Washtenaw loam (Lake Co.)
846	Edmore fine sandy loam		

Slope legend

Slope class	Slope gradient	Description
A	0-2%	nearly level
B	2-6%	gently sloping
C	6-12%	moderately sloping
D	12-18%	strongly sloping
E	18-25%	steep
F	25-45%	very steep
G	45% plus	extremely steep

Erosion legend

0	uneroded
1	slightly
2	moderately eroded
3	severely eroded
4	gullied land
T&U	deep blowouts

Each soil symbol is composed of three components: soil number, slope class, and erosion class. Thus, 236D3 equals Montcalm loamy sand with a slope of 12-18% and eroded class 3.

Appendix D
Some representative soil series descriptions from Osceola, County.

NESTER SERIES

The Nester series consists of Gray-Wooded soils developed in reddish clay loam or silty clay loam calcareous till. The Nester soils are the well to moderately well drained member of the soil catena that includes the imperfectly drained Kawkawlin and the poorly to very poorly drained Sims soils. Kent soils have finer textured B horizons than Nester, and C horizons of silty clay or clay, instead of clay loam or silty clay loam, as do the Nester soils. Isabella soils have a Podzol upper sequum, a weakly to moderately developed fragipan in the lower A2 and upper Bt, are developed in sandy clay loam to coarse sandy clay till, and have thicker sola than Nester. The Nester soils occupy undulating to strongly sloping areas in till plains and moraines. These soils are well to moderately well drained. Runoff is medium on the milder slopes and rapid on the steeper ones. Permeability is moderate. Native vegetation consisted of northern hardwoods, including sugar maple, elm, beech, ash, and basswood, with some hemlock and white pine. The greater proportion has been cleared and is under cultivation. Crops include wheat, oats, rye, and hay crops, with corn grown for both grain and silage. A small proportion, especially the steeper areas, are in forest or permanent pasture. Nester soils are very extensive and widely distributed in Osceola County.

Soil Profile Nester loam.

Ap 0-6" Loam; dark grayish yellowish brown * (10YR3/2) or
 grayish yellowish brown (10YR4/2); weak, fine to

* ISCC-NBS color names are used through out this manuscript.

Appendix D (Continued)

NESTER SERIES -2

Soil Profile -con't.

medium, granular structure; friable when moist;
slightly acid to neutral; abrupt smooth boundary.
5 to 8 inches thick.

A2 6-8" Loam; grayish yellowish brown (10YR5/2), weak, coarse, granular or weak, fine, subangular blocky structure; friable when moist; slightly acid to neutral; gradual irregular boundary. 2 to 5 inches thick.

A2&B2 8-14" Loam; grayish yellowish brown (10YR5/2) representing A2, and silty clay loam; moderate brown (7.5YR4/4) or moderate yellowish brown (10YR5/4) B1; the B1 often occurs as isolated peds, surrounded or nearly surrounded by A2; moderate, coarse, granular to massive (A2), and moderate, fine angular blocky (B2) structure; friable to slightly firm; medium to slightly acid; clear wavy boundary. 4 to 8 inches thick.

B2t 14-26" Clay loam, silty clay loam, or clay; dark brown (7.5YR4/4), or moderate brown (7.5YR5/4) to (5YR4/4); light gray or pale brown loamy material occurs as coatings and crack fillings in upper 3 or 4 inches; a few thin reddish brown (5YR5/3) and yellowish red (5YR5/6) clay coatings on ped faces; moderate to strong, medium, angular blocky structure; firm; medium to slightly acid; clear irregular boundary. 8 to 24 inches thick.

Appendix D (Continued)

NESTER SERIES -3

Soil Profile -cont'd

C 26"+ Clay loam or silty clay loam till; light brown (7.5YR5/4) or moderate brown (5YR4/4); weak to moderate, medium, angular blocky structure; firm; calcareous.

Range in Characteristics

Undisturbed areas have a thin A0 horizon and a dark grayish yellowish brown (10YR2/2) or brownish gray (10YR3/1) A1 horizon, one to 3 inches thick. Under cultivation the A1 and upper part of the A2 horizons have been mixed. The thickness and character of the A2&B2 horizon are variable, with the A1 comprising up to 90 percent of the horizon in some areas and only about one-half in others. The acidity of the B2 horizon varies from slightly to strongly acid. Pockets and thin discontinuous strata of coarser textured material occur in the B and C horizons in some areas. Grayish and yellowish mottlings occurs in the lower part of the B2 horizon in the moderately well drained areas. Depth to the C horizon ranges from 20 to about 40 inches. Loam, sandy loam, and loamy sand types have been mapped. The coarser textured types, especially loamy sand, represent a thin deposit of sandy material on the surface. Colors refer to moist conditions. Consistencies refer to moist conditions unless otherwise specified.

Type Location

A representative profile in the county can be found in the NE $\frac{1}{4}$ of NE $\frac{1}{4}$, Sec. 30, T18N, R7W.

Appendix D (Continued)

McBRIDE SERIES

The McBride series consists of soils with a Poszol upper sequum and a Gray-Wooded lower sequum, with a fragipan horizon, developed in sandy loam till. The depth to the calcareous till ranges from 42 to about 60 inches. The fragipan occurs in the lower part of the A2 horizon of the Gray-Wooded sequum. McBride soils are the well to moderately well drained member of the toposequence that includes the imperfectly drained Coral and the poorly to vary poorly drained Ensley soils. Montcalm soils have coarser textured sola than McBride, lack a well developed fragipan horizon, and have sandy C horizons. Isabella soils have finer textured sola than McBride, and are developed in sandy clay loam to clay loam C horizons. The Dryburg and Ubly soils are formed in 18 to 42 inches of loamy fine sand to fine sandy loam overlying clay to silty clay and loam to silty clay loam, respectively. The McBride soils occupy nearly level to steep areas on moraines and till plains. These soils have medium runoff on the milder slopes and rapid runoff on the steeper slopes; permeability is moderate. The native vegetation consisted of sugar maple, beech, and oaks, with lesser quantities of hickory and basswood. The greater proportion of these soils is used for general and dairy farming, with a large part of the steep slopes in forest. Corn, oats, wheat, and hay are the principal field crops, and a considerable acreage is devoted to Irish potatoes. McBride soils are extensive and widely distributed in the county.

Soil Profile: McBride sandy loam

Appendix D (Continued)

McBRIDE SERIES -2

Soil Profile: McBride sandy loam (con't)

- Ap 0-6" Sandy loam; dark grayish yellowish brown (10YR3/2); weak to moderate, fine, granular structure; very friable; slightly to medium acid; abrupt smooth boundary. 5 to 9 inches thick.
- Bhr 6-20" Sandy loam; moderate yellowish brown (10YR4/4); moderate, medium, granular to weak, fine, subangular blocky structure; very friable; slightly to strongly acid; clear wavy boundary. 3 to 15 inches thick.
- A2m 20-28" Loamy sand to sandy loam; grayish yellowish brown (10YR5/2) to light grayish yellowish brown (10YR6/2) or moderate yellowish brown (10YR5/3); massive to very weak, medium, platy structure; brittle and hard when dry, friable when moist; medium to strongly acid; abrupt irregular boundary. 5 to 20 inches thick.
- B2t 36-52" Sandy clay loam; moderate brown (7.5YR4/4) moderate to strong, medium, subangular blocky structure; firm; medium acid; clear wavy boundary. 10 to 25 inches thick.
- C 52"+ Sandy loam; light brown (7.5YR5/4); weak, coarse, subangular blocky structure; friable; neutral to calcareous.

Range in Characteristics:

Undisturbed areas have a very dark grayish yellowish brown (10YR2/2) A1 horizon, 1 to 3 inches thick, and a light grayish

Appendix D (Continued)

McBRIDE SERIES -3

Range in Characteristics: (con't)

yellowish brown (10YR6/2) or light grayish brown (7.5YR6/2) A2 horizon, 2 to 4 inches thick. The Bh horizon is moderate brown (7.5YR4/4) in some areas. The entire A2 horizon of the Gray-Wooded sequum is a fragipan horizon in some places. The degree of development of the fragipan ranges from weak to strong. The B2t horizon is light brown (5YR5/4) in some areas, and the texture ranges from fine loam to fine sandy clay loam. The B2t horizon has clay films on some peds in a few places. Lenses, pockets, and layers of loamy sand occur in the C horizon in numerous areas. Also, the C horizon may have numerous calcium-carbonate concretions. Sandy loam, loamy sand, and loam types have been mapped. Colors refer to moist conditions. Consistencies refer to moist conditions, unless otherwise specified.

Type Location:

A representative profile can be found in the county in the SE1/4 of NE1/4, Section 31, T19N-R9W.

KALKASKA SERIES

The Kalkaska series consists of Podzols developed in sand glacial drift that contains little or no calcareous material. Kalkaska soils are associated with the well drained Rubicon, Grayling, Graycald, and Wallace soils, and the moderately well drained Croswell soils, imperfectly drained Au Gres, imperfectly to poorly drained Saugatuck, and the poorly to very poorly drained Roscommon and Kimross soils. Kalkaska soils have thicker and lighter colored A2 horizons, and thicker and darker colored Bh horizons than Rubicon soils. Grayling

Appendix D (Continued)

KALKASKA SERIES -2

soils have much thinner A2 horizons and thinner and lighter colored B horizons than Kalkaska. Graycalm soils have a weakly developed Gray-Wooded lower sequum, with thin and often discontinuous Bt horizons below a depth of 42 inches, which the Kalkaska lack. Wallace soils have cemented (ortstein) B horizons. East Lake soils have calcareous sands and gravel at depth of less than 42 inches, and the sola are less acid than in Kalkaska soils. The Croswell soils are less well drained than Kalkaska, with mottling occurring at depths of from about 16 to 36 inches. Blue Lake soils are developed in loamy sands and have weak textural B horizons. The Kalkaska soils occupy nearly level to steep areas on outwash plains, till plains, valley trains, and moraines. These soils are well drained, with a slow rate of runoff; their permeability is rapid to very rapid. The original vegetation was principally sugar maple, beech, yellow birch, elm, ironwood, and hemlock, with some white pine. Nearly all areas have been cut over, with the cleared areas now being cropped to oats, hay, and potatoes, and a considerable part in idle land. A considerable proportion is in second-growth forest, permanent pasture, or reforested to conifers. Kalkaska soils occur extensively throughout Osceola County.

Soil Profile: Kalkaska sand

- | | | |
|----|------|--|
| AO | 2-0" | Partially decomposed leaves and raw organic matter.
1 to 4 inches thick. |
| A1 | 0-2" | Loamy sand; grayish brown (10YR3/1) humus, mixed with gray (10YR6/1); numerous fine roots; weak, fine, |

Appendix D (Continued)

KALKASKA SERIES -3

Soil Profile: Kalkaska sand (con't.)

- granular structure; very friable; strongly acid; abrupt smooth boundary. 1 to 3 inches thick
- A2 2-4" Sand; brownish ping (7.5YR7/2) to grayish yellowish brown (10YR4/2); single grain, structureless; loose; medium to strongly acid; abrupt wavy boundary. 3 to 12 inches thick.
- B21h 4-8" Loamy sand or sand; dark grayish brown (5YR2/2), becoming grayish brown (7.5YR3/2) or moderate brown (5YR3/4) in lower part; weak, medium, granular structure; very friable; medium to strongly acid; clear irregular boundary. 2 to 8 inches thick.
- B22ir 8-18" Sand; moderate brown (7.5YR4/4); very weak, medium, subangular blocky structure to single grain; very friable to loose; strongly to slightly acid; gradual irregular boundary. 6 to 12 inches thick.
- B23ir 18-24" Sand; light brown (7.5YR5/6) or moderate brown (7.5YR4/4); single grain, structureless; loose; medium to slightly acid; gradual irregular boundary. 5 to 12 inches thick.
- B3 24-40" Sand; dark orange yellow (10YR6/6) or moderate yellowish brown (10YR5/4); single grain, structureless; loose; medium to slightly acid; gradual wavy boundary. 8 to 18 inches thick.
- C 40"+ Sand; light grayish yellowish brown (10YR6/3) or

Appendix D (Continued)

KALKASKA SERIES -4

Soil Profile: Kalkaska sand (con't)

light yellowish brown (10YR6/4); single grain, structureless; loose; slightly acid to mildly alkaline.

Range in Characteristics:

In cultivated areas the A1 and a considerable part of the A2 are mixed, to form the Ap horizon. The A2 is thin or is absent in some areas, especially where the Ap is 9 or 10 inches thick. In some areas, the B21h horizon consists of dark grayish brown (5YR2/2-3/2) loamy sand or sand 2 to 4 inches thick grading abruptly into the moderate brown (7.5YR4/4) sand B221r horizon. The reaction of the solum is slightly acid in some areas. The thickness of the solum ranges from 20 to about 45 inches or more. The upper B horizons are weakly cemented in some areas. Where Kalkaska grades toward Wallace soils, there are irregular-shaped and sized chunks of cemented (ortstein) material in the upper B horizons. Where Kalkaska soils grade toward Grayoalm soils, there are thin discontinuous bands of textural B horizons below a depth of 66 inches. Where Kalkaska soils grade toward Rubicon soils, the B21h horizon approaches the minimum thickness given. Loamy sand, and sand types have been mapped. Colors refer to moist conditions. Consistences refer to moist conditions unless otherwise specified.

Type Location:

A representative profile in the County can be found in the SW1/4 of NW1/4, Section 9, T18N, R10W.

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