LAND USE PLANS FOR MECOSTA AND OSCEOLA COUNTIES BASED ON SOIL AND ECONOMIC CONSIDERATIONS

Thesis for the Degree of M. S.

MICHIGAN STATE UNIVERSITY

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1961

ABSTRACT

LAND USE PLANS FOR MECOSTA AND OSCEOLA COUNTIES
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by Clyde A. Black

There is a need for land use planning based on economic considerations. That is, planning which will maximize the net income for each farm. The purpose of this study was to meet this need for economic land use planning in a two county area of Michigan. The two counties chosen were Mecosta and Osceola counties.

An analysis was made of the current land use by soil management units in the two county area. This analysis was made from data that were taken for the National Inventory of Soil and Water Conservation Needs. This analysis demonstrated that the proportion of land in crops, forest, permanent pasture, and left idle was related to three characteristics of the soil: 1) texture of the primary material; 2) natural drainage; and 3) slope.

The expected gross income for four crops, corn, wheat, oats, and alfalfa, was calculated for each soil management unit under common and improved management. The expected cost of production was also calculated for each soil management unit under the two levels of management and subtracted from the expected gross income to calculate the expected net income. The expected gross income correlated very well with the expected net income. In every case the improved level of management produced a higher expected net income than the common level of management. As in the analysis of the present land use, the same three soil

characteristics had an effect on the expected net income.

Three crops, corn, wheat, and alfalfa, were combined in various sequences to determine what sequences would be the most profitable under the two levels of management.

The level of management had an effect of making more sequences acceptable in certain instances. In some cases certain sequences were acceptable under one level of management while unacceptable under another. In most cases the longer land use sequences were more acceptable than the shorter sequences. The sequences using less corn and more alfalfa were more acceptable than the sequences that had more corn and less alfalfa. This result is partially overcome by the improved level of management. The three soil characteristics had an effect on the acceptability of the sequences also.

Assuming that each of the acceptable sequences would be used on each of the soil management units, an analysis was made of the percentages of each unit that would be devoted to each of the three crops.

These data were combined for the total cropland of the two county area to show the changes that would result if an economic plan of land use were adopted. It was shown that less corn would be grown, and more wheat would be grown under common management. Under improved management more corn and wheat would be grown.

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A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE

Department of Soil Science

1961

AKNOWLEDGMENTS

The writer wishes to express his appreciation to his major professor and advisor, Dr. Eugene P. Whiteside. Dr. Whiteside has given many suggestions for carrying out this research and has been very helpful in his review and criticism of this thesis. The writer is also indebted to Mr. William Heneberry, of the U. S. D. A. Agricultural Research Service, and Mr. Stephen Shetron, of the U. S. D. A. Soil Conservation Service, for their helpful suggestions and to Mr. Clarence Engberg and Mr. Gilbert Landtiser, of the U. S. D. A. Soil Conservation Service for making available the Conservation Needs Survey Data. The writer also appreciates the helpful criticism that his committee has given.

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INTRODUCTION

Need for a Study of this Nature

There are many methods of planning the land use of a certain soil, field, farm, or area. Some of these methods are quite rational while others are less rational. The planning of land use quite often follows a particular need that is felt by the farm operator or his advisors concerning land use and soil management. If the need is primarily for an adequate livestock feeding program, the land will be used to provide the amounts of grain, roughage, and other feed constituents needed for feed. If the need is primarily for a program which will conserve the soil or the supply of moisture, without regard to income, the land may simply be held under grass or forest cover. However, if the need is primarily for a program which will maximize the returns from a given area, land use will be planned to provide the greatest net income from the soil, field, farm or area. In most cases these three goals are not in opposition. That is, most operators want to follow practices which will minimize the soil and water losses (or hold them within limits that permit permanent use of these resources), provide adequate feed for a livestock program, and at the same time maximize their net income.

It is with the need of maximizing the net income that this study is primarily concerned; namely, the planning of land use using both technologic and economic considerations as the criteria.

Purpose of this Study

The general purpose of this study is to meet this need for land use planning according to economic as well as technologic considerations. This need will be met within the allowable limits of soil and water loss that will assure a permanent agriculture. There were practical considerations in determining the scope and extent of this project. One of these practical limitations is the determination of the size of the area to be studied. Ideally, the North Central Region of the United States, Michigan, the Podzol Region, or other large areas might have been selected for this study. These areas were all eliminated, however, because of practical limitations. Since a smaller area had to be chosen, the writer first considered Osceola County because he had worked in that area for two summers on the National Cooperative Soil Survey. Later, the idea of using one county was dropped in favor of a two county area.

Another practical limitation also served to restrict the scope and extent of this study. The study was launched with the object in mind that all the potential uses of the land would be investigated: cropland, permanent pasture, forestry, idle, residential, and urban. These uses were studied in determining the present use of the land in the two county area. For practical reasons, however, only some the individual crops that are grown in the area were evaluated in determining the use of the cropland.

The chief purpose of the study is: 1) to demonstrate the need for the use of economic tools in planning land use; 2) to demonstrate land use planning methods using economic considerations; and 3) to consider the results of such a plan on land use and the probable consequences of its adoption.

PERTINENT LITERATURE

Charles E. Kellogg, Assistant Chief of the Soil Conservation Service in Charge of Soil Surveys, has written of the importance of economic considerations in land use planning as follows:

> "Successful farmers choose the practices for their fields according to two primary considerations: What practices do I need to come near the ideal (arable soil)? How will the costs and returns fit into my farm budget?" (12)

Earl O. Heady, professor of agricultural economics at Iowa State College, has shown that the best system of crops or rotations cannot be selected with just the knowledge of physical relationships or with just the knowledge of economic considerations, but with both (12). He also demonstrated in the same article the importance of the economic considerations in the crop-yield relationships when crops are competitive as well as complimentary.

Earl R. Swanson, associate professor of agricultural economics at the University of Illinois, published a bulletin which reports an economic analysis of the Drummer-Flanagan soils, found primarily in east-central Illinois (11). He used linear programing to determine the highest return farming systems on these soils. The bulletin lists three types of farming systems that were selected in order to maximize: 1) the labor income per acre of land farmed; 2) the labor income per hour of labor used; and 3) the cash balance per dollar of money spent. He also showed the effect of price changes on these farming systems.

EXPLANATION OF TERMS

The term "land use sequence" was chosen to denote the order in which crops are grown in the cropping system. In ordinary discourse this would be referred to as a crop rotation. However, it was necessary in this study to refer to this as a land use sequence, because rotation connotes the idea of crops rotating from field to field and is not the best term to use in considering the duration or order of crops on a certain soil or field. Also, the idea of a rotation does not necessarily connote the idea of a certain plan of land use for a certain field or soil, but of a group of fields or soils.

The two terms "common management" and "improved management" need explanation. It is realized that no manager or system of management will fit the exact description of common or improved. However, there was need for the consideration of levels of management. The improved level of management is defined as a system which includes the following management practices (8):

1. Has soil tested and applies recommended amounts of lime and fertilizer.
2. Uses recommended fertilizer placement.
3. Uses minimum tillage.
4. Provides adequate drainage.
5. Uses top quality seed.
6. Uses recommended seeding rates.
7. Controls weeds, insects, and diseases.
8. Uses good soil and water conservation practices.
9. Harvests carefully to save the crop.

10. Stores properly to preserve the quality.

11. Performs management operations at the proper time.

The average management is defined as a system which follows some, but not all of the above management practices. The common manager, in this study, incurs the median cost of fertilizing per acre per year of the farm account book study of this area. The average manager also followed the plow, disc, drag, and plant method of seedbed preparation for corn and oats. In a recent survey of farming practices 50 per cent of the farmers that were interviewed used this method of seedbed preparation (9).

The "soil management group" and "soil management unit" are terms that are used frequently through this paper. The "soil management group" refers to a group of soils with similarities in the texture of the primary material and the natural drainage. "Soil management unit" refers to a sub-division of a soil management group on the basis of similarities in slope. The texture, natural drainage, and slope groupings and the numbers and letters used to designate each are listed in Table 1. In many cases the 5.5 texture class has been dropped from consideration because of lack of sufficient data or for reasons of practicality. In many cases the A and B slope classes have been combined because of similarities in their management.

The decision was made to use the terms "expected gross income", "expected production costs", and "expected net income." These terms were used to indicate the anticipated situations when the manager is making a decision.

TABLE 1. THE CLASSIFICATION OF SOIL MANAGEMENT UNITS AND THEIR NUMBER AND LETTER DESIGNATIONS

		Drainage and Topograpy							
		a. Well-drained				b. Imperfectly-drained		c. Poorly-drained	
	Texture of the Primary Material	A 0-2% Slope	B 2-6% Slope	C 6-12% Slope	D 12-18% Slope	A 0-2% Slope	B 2-6% Slope	A 0-2% Slope	B 2-6% Slope
2.	Loam to silty clay loam	2aA	2aB	2aC	2aD	2bA	2bB	2cA	2cB
3.	Sandy loam	3aA	3aB	3aC	3aD	3bA	3bB	3cA	3cB
4.	Loamy sand	4aA	4aB	4aC	4aD	4bA	4bB	4cA	4cB
5.0	Sand with a well-developed subsoil	5aA	5aB	5aC	5aD	5bA	5bB	5cA	5cB
5.5	Sand with a weakly-developed subsoil	5.5aA	5.5aB	5.5aC	5.5aD				

CURRENT LAND USE IN MECOSTA AND OSCEOLA COUNTIES

In order to properly analyze the present land use in the two county area it was thought that an analysis of land use by soil management units would lead to a much better understanding than an analysis of land use ignoring the soil. By studying a sample of the land in this area which had been classified and mapped according to soil type, slope, erosion, and present land use, a comparison could be made indicating the differences in land use by differences in soils.

The United States Department of Agriculture, in cooperation with State agencies, has recently completed a National Inventory of Soil and Water Conservation Needs. The classification and mapping phase of this inventory was completed in Mecosta and Osceola Counties in 1958 as part of the National Cooperative Soil Survey. This inventory provided data which was acceptable for studying land use according to soil management groups.[1]

The sample that was taken was a stratified, random sample. This was taken by dividing the townships into three two-section tiers and selecting at random one quarter-section plot in each tier or three per township. This was slightly more than a two per cent sample. The soils in each sample were classified by methods used

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[1]The soil survey maps were measured by the United States Soil Conservation Service as part of the National Conservation Needs Inventory. The sample data was analyzed by the Iowa State Statistical Laboratory which furnished the basic data of soil groups and land use.

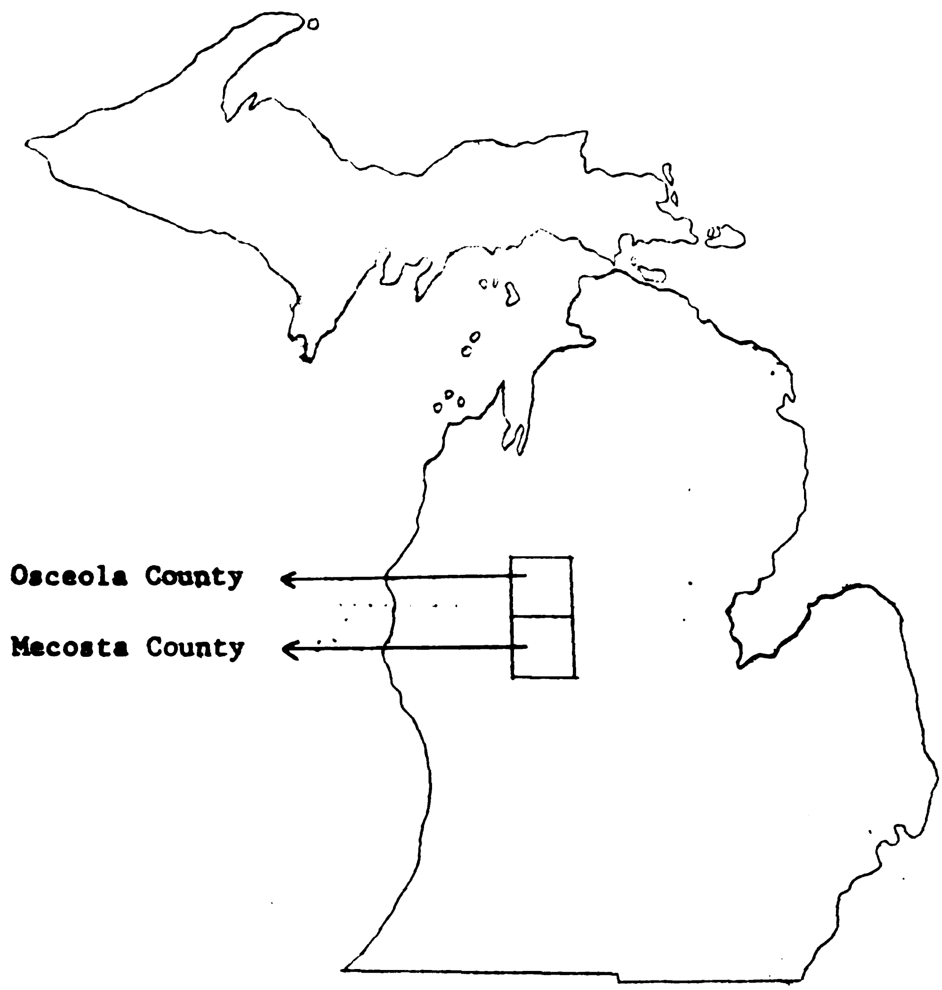

Figure 1. The location of Mecosta and Osceola Counties.

in the National Cooperative Soil Survey carried on by the Michigan Agricultural Experiment Station and the Soil Conservation Service of the United States Department of Agriculture.

The current use of the land had been divided into four broad classes: L = cropland, which included land currently in crops as well as land which had been in crops in the past three years or will probably return to crops during the next three years; P = pasture, which included permanent and not rotational pasture; F = forest; and I = idle or other uses, which included not only land that is idle, but land used for buildings, farmsteads, golf course, parks and cemeteries.

The results of the Conservation Needs Survey of Mecosta and Osceola Counties were processed so that the acreage of each soil management unit, in four land use categories was determined. One hundred sixty acres was considered a lower limit for any soil managment unit that might be representative of the observed land use. The results of this study are summarized in Table 2. The data have been tabulated so that the percentage of the soil management units that are in each of the four major land uses are arranged in a square as follows: $\begin{array}{c|c} L & P \\ \hline F & I \end{array}$.

Some conclusions that can be drawn from Table 2 are:

The percentage of land in crops (L) is greater:

1) on the soils that are developed from the finer textured primary materials as compared with the soils that are as illustrated in Figure 2;
2) on the gentler slopes as compared with the steeper slopes in each well-drained soil management group as illustrated in Figure 3; and

TABLE 2. THE PROPORTION OF EACH SOIL MANAGEMENT UNIT THAT IS CROPLAND, PASTURE, FOREST, OR IDLE (L, P / F, I).

	Texture of the Primary Material	Drainage and Topography: a. Well-drained A+B 0-6% Slope	a. Well-drained C 6-12% Slope	a. Well-drained D 12-18% Slope	b. Imperfectly A+B 0-6% Slope	c. Poorly A+B 0-6% Slope
2.	Loam to silty clay loam	74, 12 9, 5	63, 12 14, 12	42, 19 31, 8	60, 30 6, 3	27, 17 36, 19
3.	Sandy loam	69, 6 11, 14	62, 21 11, 7	27, 15 54, 5	[1]	[1]
4.	Loamy sand	47, 19 19, 16	38, 11 35, 12	36, 14 33, 17	39, 29 18, 14	28, 32 32, 9
5.0	Sand with a well-developed subsoil	29, 11 37, 23	19, 22 31, 28	12, 13 47, 28	[1]	5, 10 61, 24
5.5	Sand with a weakly-developed subsoil	9, 2 29, 60	15, 8 39, 38	[1]	[2]	[2]

[1] Sample was not large enough to be significant.

[2] These management units were combined with the 5.0 b and 5.0 c.

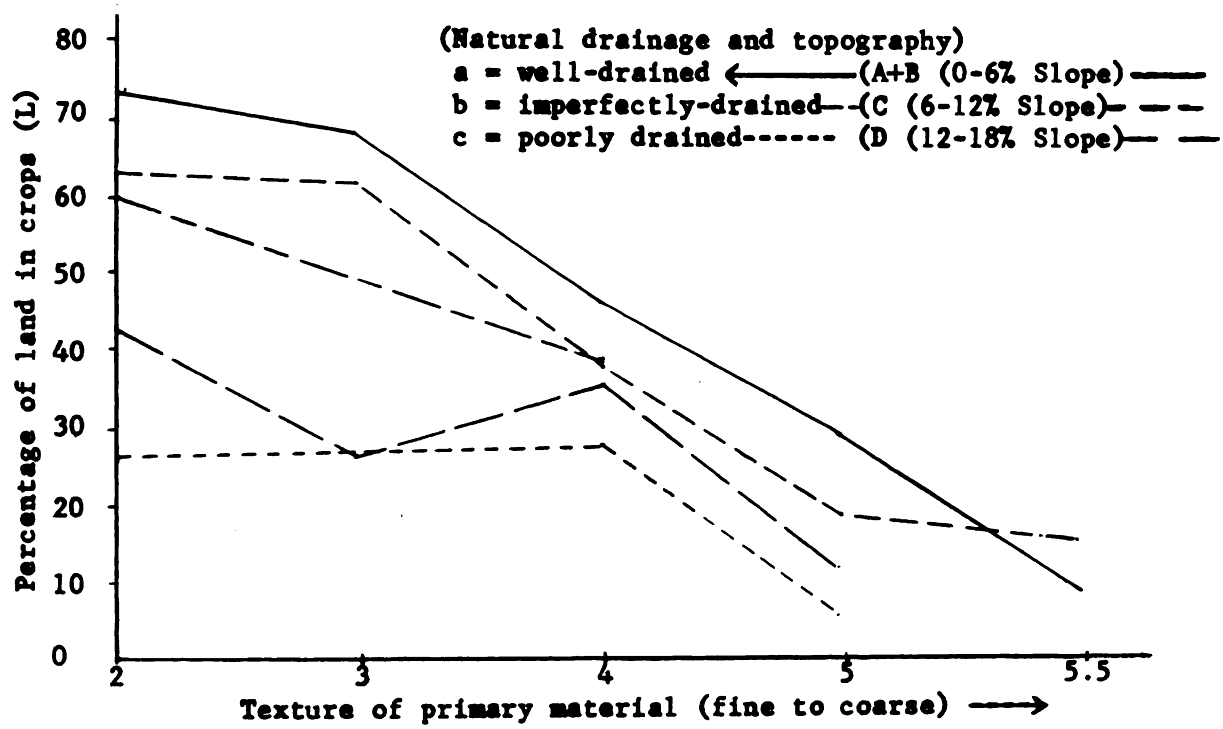

Figure 2. The percentage of land in crops (L) in relation to the texture of the primary material by soil management units.

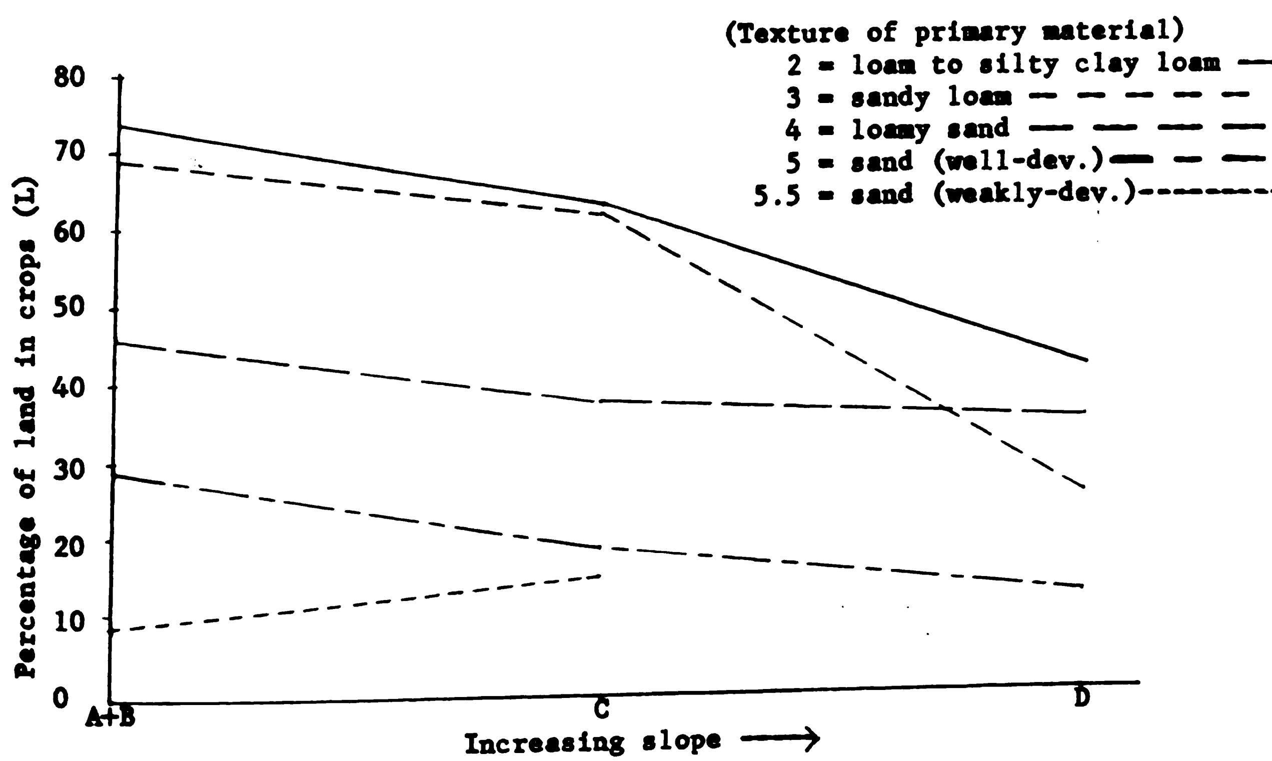

Figure 3. The percentage of land in crops (L) in relation to the slope of the land by soil management units.

3) on the naturally better-drained soils as compared with the naturally poorly-drained soils on gentle slopes as illustrated in Figure 4.

The proportion of land used for forest (F) varies inversely with the proportion of land used for crops (L). The percentage of land in forest (F) is less:

1) on the soils that are developed from the finer textured primary materials as compared with the soils that are developed from the coarser textured primary materials as illustrated in Figure 5;

2) on the gentler slopes as compared with the steeper slopes in each well-drained soil management group as illustrated in Figure 6; and

3) on the naturally better-drained soils as compared with the naturally poorly-drained soils on gentle slopes as illustrated in Figure 7.

The soils that are developed from finer textured primary materials have lesser amounts of idle land as illustrated in Figure 8. However, this seems to be the only influence on amounts of idle land. There seems to be no existent relationship between these soil properties and the use of the land for pasture.

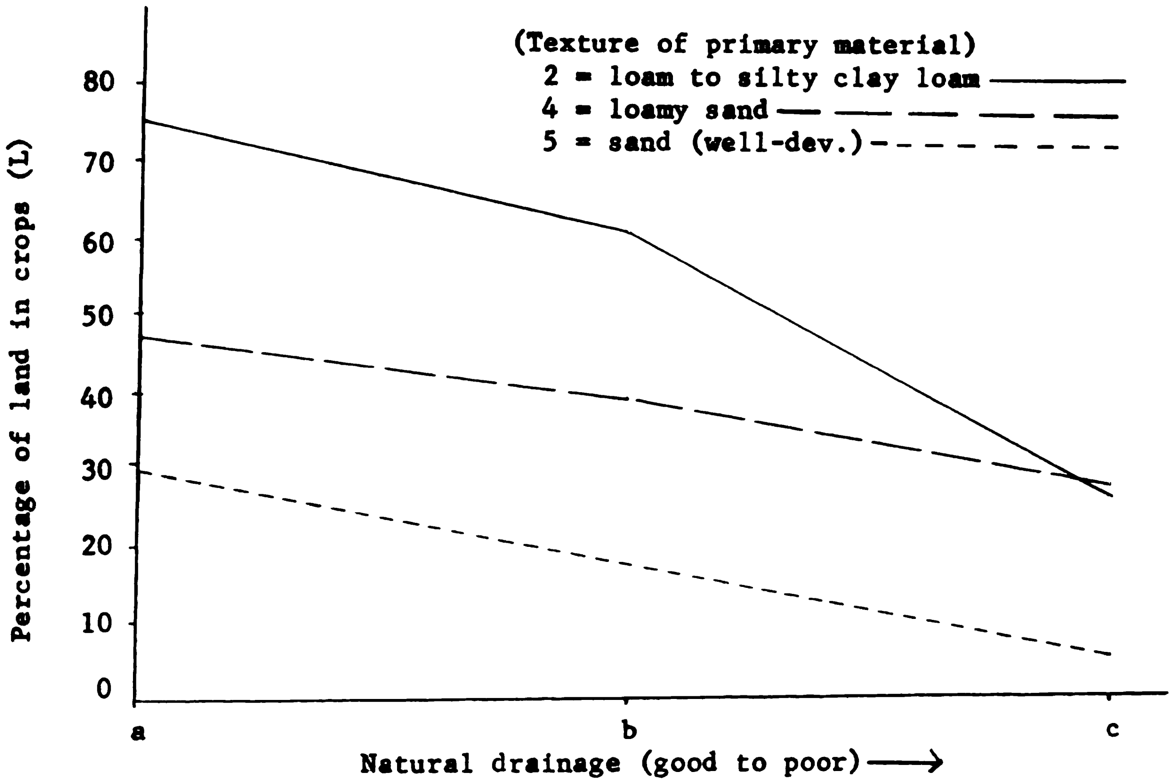

Figure 4. The percentage of land in crops (L) in relation to the natural drainage on level to gently sloping areas by soil management units.

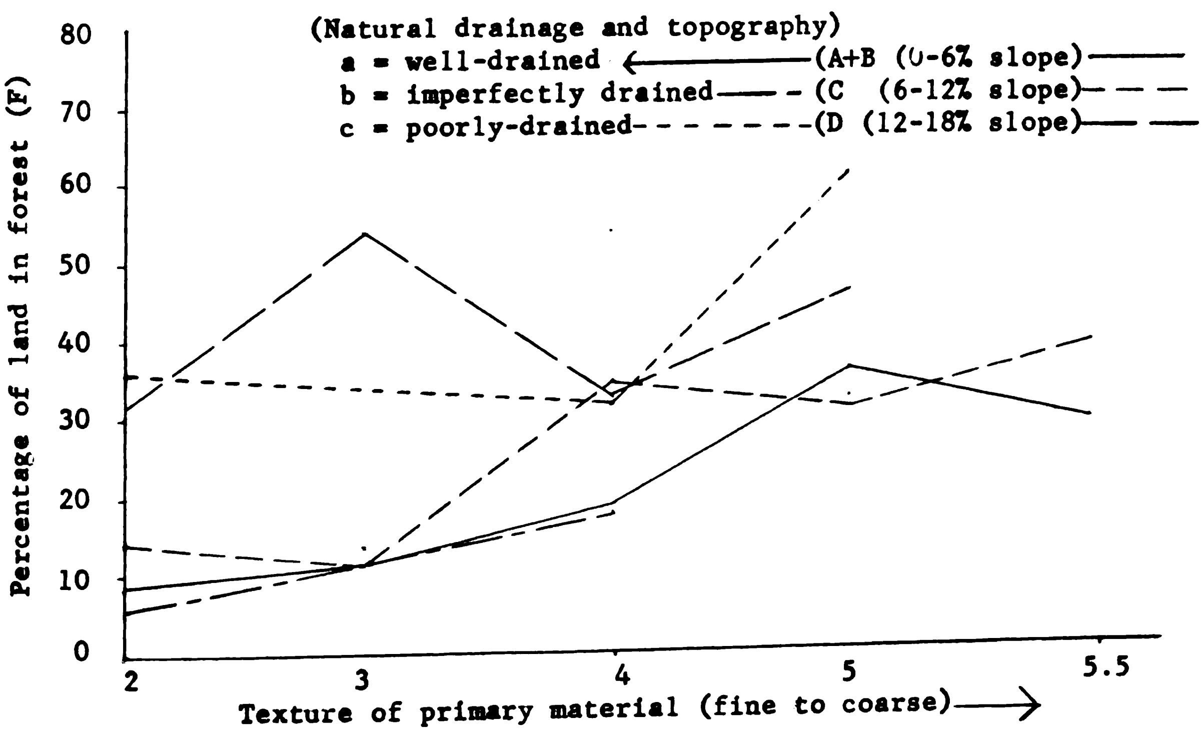

Figure 5. The percentage of land in forest (F) in relation to the texture of the primary material by soil management units.

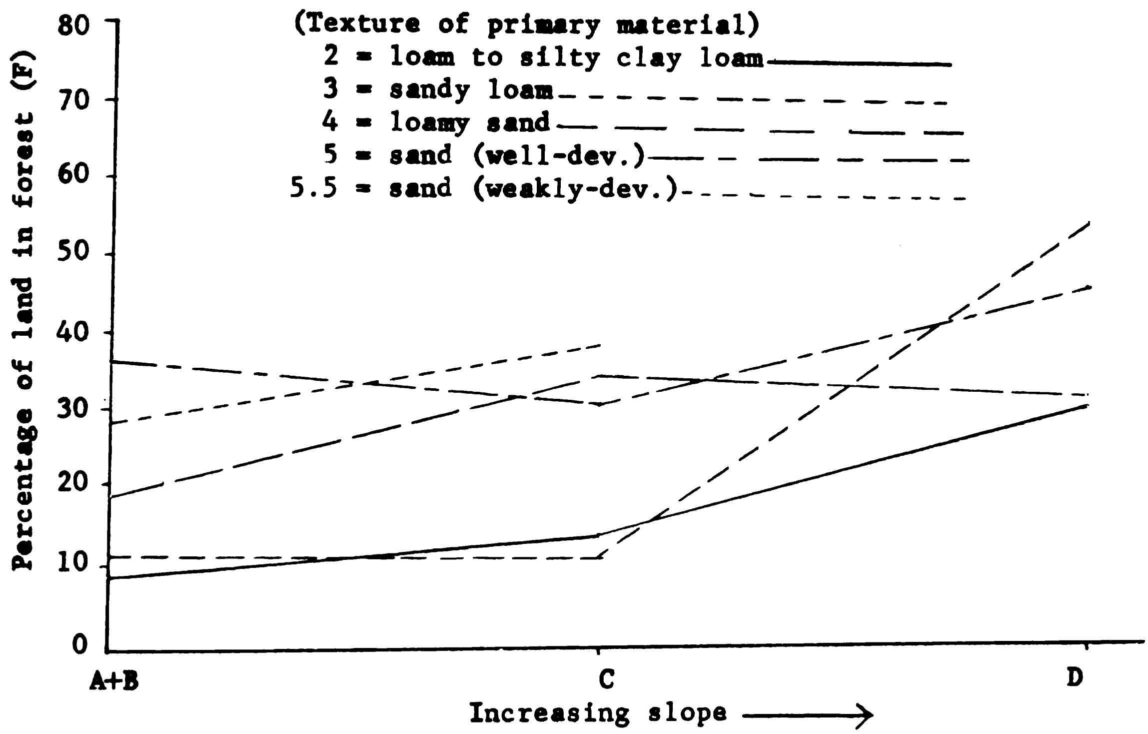

Figure 6. The percentage of land in forest (F) in relation to the slope of the land by soil management units.

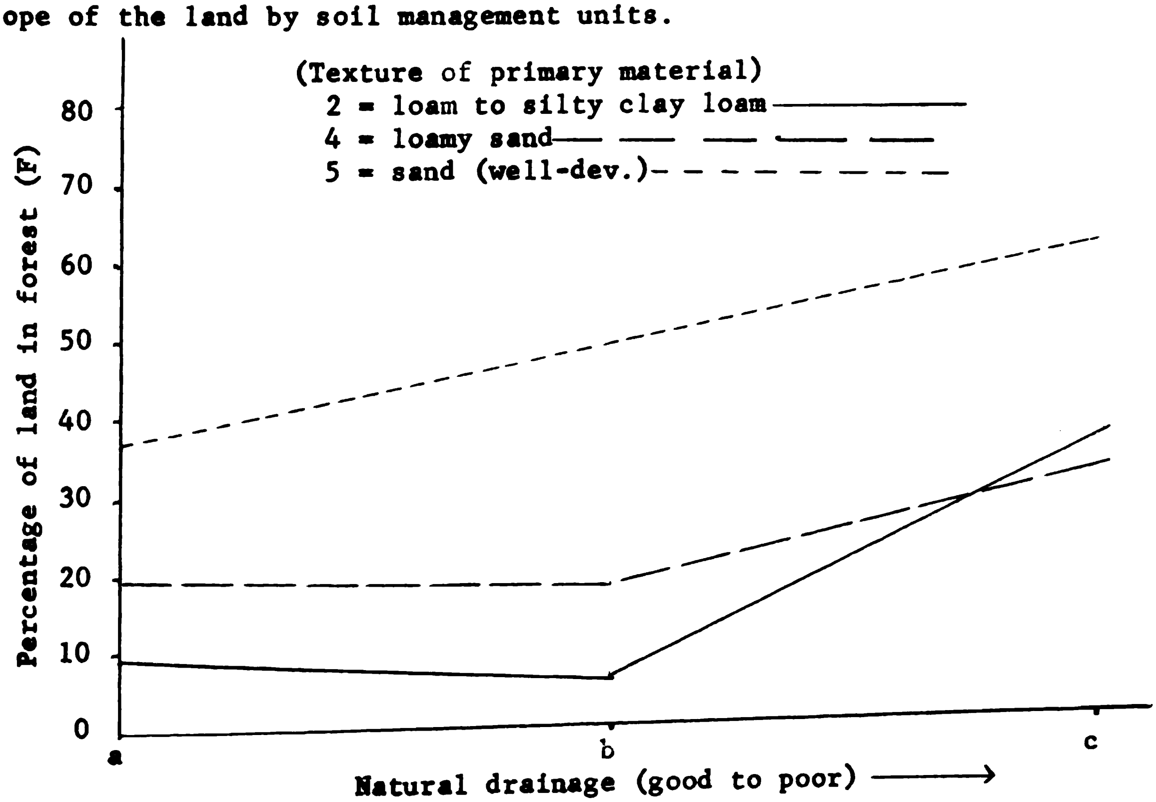

Figure 7. The percentage of land in forest (F) in relation to the natural drainage on level to gently sloping areas by soil management units.

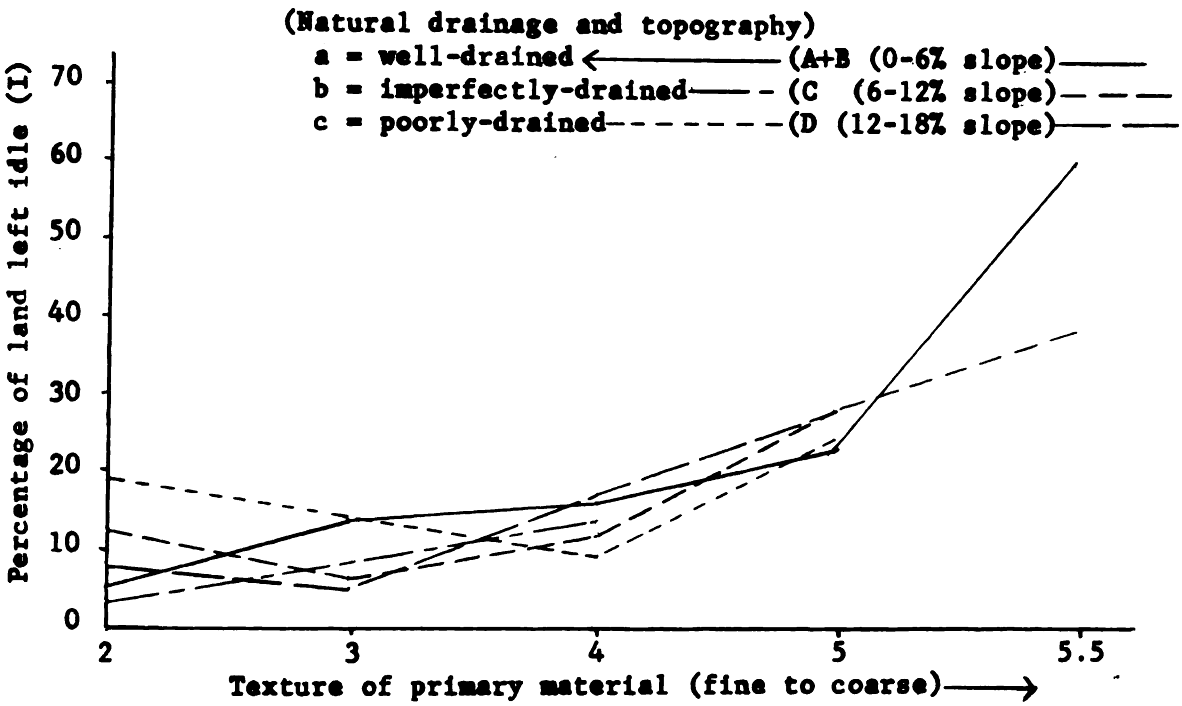

Figure 8. The percentage of the land left idle (I) in relation to the texture of the primary material by soil management units.

ASSUMPTIONS

Certain assumptions in a study of this type are necessary to properly analyze the data. The conclusions are only valid if the assumptions are met. If the assumptions are not correct, an adjustment would have to be made with the incorporation of the new assumptions. The assumptions used in this study follow:

1. The simple average of monthly prices received by Michigan farmers for the ten year period from 1949 to 1958 will be the expected prices for farm products. The ten year period, 1949 to 1958, should be a good base for expected prices. The conditions that have produced the prices during the ten years (supply and demand, international tensions, and governmental policy) will probably not change enough to drastically affect prices.
2. The average rates for custom work paid in Michigan indicate the expected costs in producing crops. Some discrepancy exists between the rates for custom work and the costs of producing crops since the custom rates are slightly lower. This may be explained by analyzing ownership of farm machinery as a form of insurance against not having the machinery available at the time needed for a particular farm operation. The use of custom rates in calcuating production costs is justified since they represent the best information available on costs of using farm machinery.

3. The manager of the land will wish to maximize the net return per acre per year within the acceptable limits of soil and and water loss and select his program of land use accordingly.
4. The practices outlined under the two management systems will be followed. The calculated yields are based on the following of these practices.
5. Adequate drainage will be provided for the naturally imperfectly-drained and naturally poorly-drained soils. The yields were calculated with adequate drainage assumed.
6. Managers following common and improved management systems will receive the same prices.

THE CALCULATION OF THE EXPECTED NET INCOME

The Calculation of the Expected Gross Income

The expected net income from each crop for each soil management unit under the two management levels was calculated. Next, these expected net incomes of the crops were combined into expected net incomes for land use sequences. Then the most profitable sequences were chosen by comparison.

In calculating the expected net income that a certain crop will produce on a certain soil management unit, a definite procedure was followed. First, the expected gross income that will accrue for each crop on each soil management unit was calculated. Second, the expected cost of producing each crop on each soil management unit was calculated. Third, the expected net income from each crop on each soil management unit was calculated by subtracting the expected production cost from the expected gross income. This procedure was carried out for both common and improved levels of management in order to compare differences in the expected net income due to level of management. Finally, the expected net incomes of the various crops in land use sequences were calculated and compared as to their relative advantage in securing a return from the land.

The methods and results of calculating the expected gross income follow: The expected yields for the two management systems were taken from the folder entitled, "Michigan Checklist for Areas 3 and 4" (8).[1]

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[1]The yields from the Michigan Checklist were for slopes less than 6 per cent. Another study had been made in Michigan that reported yields

This was an estimation of the yields in an area which contained Mecosta and Osceola Counties as shown in Figure 9. These yields are listed in Table 3.

The expected price was determined by taking a simple average of the monthly price data for the ten year period, 1949 to 1958, of prices received by Michigan farmers. These prices were:

Corn --------------	\$ 1.34 per bu.
Wheat -------------	2.00 per bu.
Oats --------------	0.72 per bu.
Alfalfa hay -------	22.13 per ton (2)

The expected prices and the expected crop yields were multiplied for each soil management unit in order to calculate the expected gross income:

Expected Price X Expected Yield = Expected Gross Income

The expected gross income under a system of common management is given below in Table 4. The data has been tabulated so that the expected gross income in dollars per acre for four different crops are arranged in

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on slopes less than 6 per cent and over 6 per cent. Yields on slopes greater than 6 per cent were calculated by employing the following simple proportion:

$$\frac{Y_{fm}}{Y_{cm}} = \frac{Y_{fs}}{Y_{cs}}$$

where Y_{fm} = yield on slopes less than 6 per cent from the Michigan Checklist

Y_{fs} = yield on slopes less than 6 per cent from the Sanilac report

Y_{cm} = yield on 6 to 12 per cent slopes in the two county area (unknown)

Y_{cs} = yield on 6 to 12 per cent slopes from the Sanilac report.

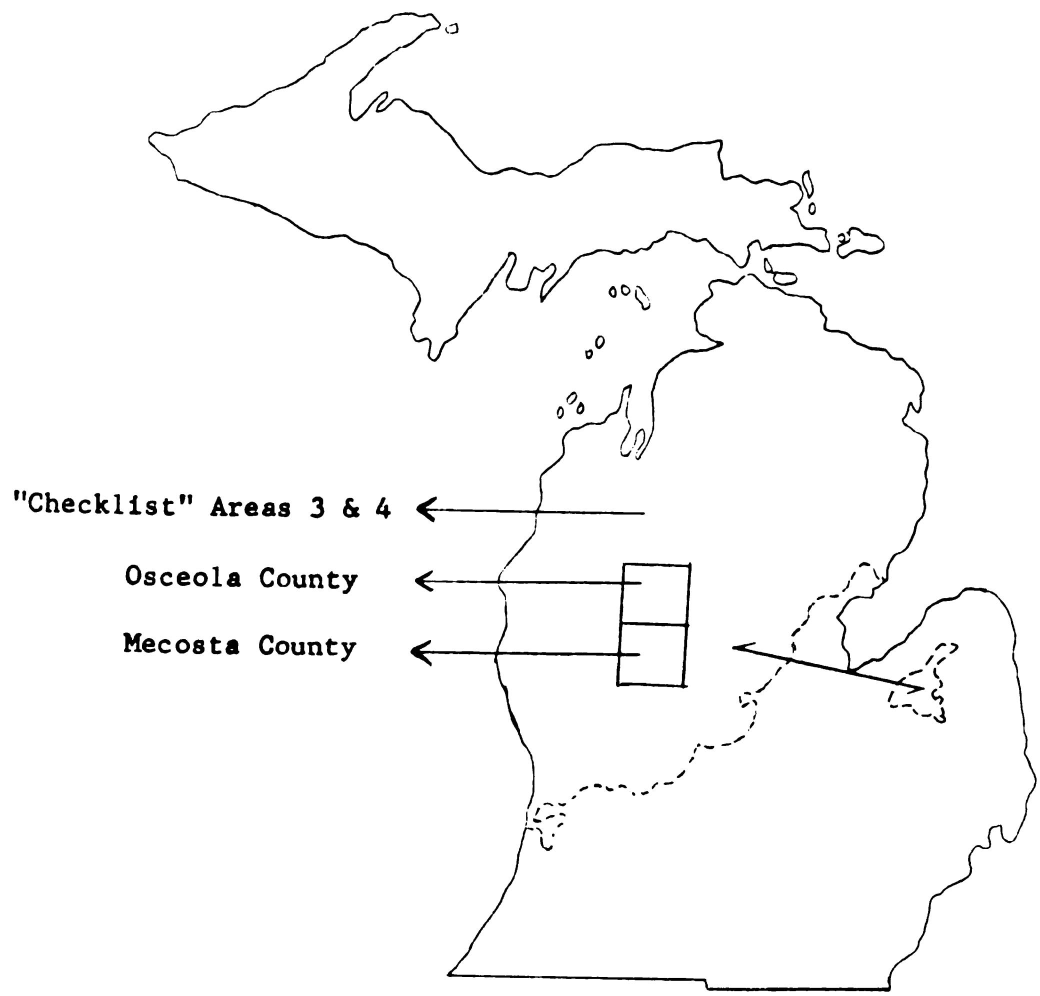

Figure 9. The location of Mecosta and Osceola Counties within "Checklist" Areas 3 and 4.

TABLE 3. THE EXPECTED YIELDS ON EACH SOIL MANAGEMENT UNIT FROM COMMON AND IMPROVED MANAGEMENT, C / O
W / A

	COMMON MANAGEMENT					
		Drainage and Topography				
		a. Well-drained			b. Imperfectly-drained	c. Poorly-drained
	Texture of the Primary Material	A+B 0-6% Slope	C 6-12% Slope	D 12-18% Slope	A+B 0-6% Slope	A+B 0-6% Slope
2.	Loam to silty clay loam	40 / 40* 25 / 2.3	30 / 33 21 / 1.7	30 / 33 21 / 1.7	45 / 40 25 / 2.5	50 / 43 27 / 2.6
3.	Sandy loam	35 / 30 20 / 1.9	30 / 27 18 / 1.6	30 / 26 18 / 1.6	41 / 40 25 / 2.4	43 / 40 25 / 2.4
4.	Loamy sand	25 / 25 15 / 1.5	22 / 23 14 / 1.4	/ 19 11 / 1.3	27 / 27 16 / 1.7	32 / 30 18 / 1.7
5.	Sand	15 / 17 11 / 0.9	10 / 15 10 / 0.9		18 / 20 12 / 1.0	22 / 22 13 / 1.2

*These yields are based on the experience of workers in Soil Science. They are the mean yield that can be expected over a period of a few years. These yields have not been adjusted to differences in the preceding crop.

TABLE 3. - Continued

Texture of the Primary Material	IMPROVED MANAGEMENT — Drainage and Topography: a. Well-drained A+B 0-6% Slope	a. Well-drained C 6-12% Slope	a. Well-drained D 12-18% Slope	b. Imperfectly-drained A+B 0-6% Slope	c. Poorly-drained A+B 0-6% Slope
2. Loam to silty clay loam	65, 65 / 40, 3.4	57, 59 / 36, 3.4	57, 59 / 36, 3.4	70, 70 / 40, 3.5	75, 77 / 44, 3.8
3. Sandy loam	55, 55 / 35, 3.1	48, 51 / 31, 3.1	44, 49 / 31, 3.1	66, 67 / 40, 3.4	68, 67 / 40, 3.4
4. Loamy sand	45, 45 / 25, 2.5	42, 42 / 24, 2.5	—, 34 / 20, 2.3	47, 47 / 27, 2.7	50, 50 / 32, 2.9
5. Sand	40, 40 / 22, 2.3	35, 36 / 20, 2.3		42, 42 / 23, 2.3	42, 42 / 23, 2.4

TABLE 4. THE EXPECTED GROSS INCOME WITH COMMON MANAGEMENT FROM CORN, OATS, WHEAT, AND ALFALFA, C | O / W | A, ON EACH SOIL MANAGEMENT UNIT

	Texture of the Primary Material	Drainage and Topography: a. Well-drained, A+B 0-6% Slope	a. Well-drained, C 6-12% Slope	a. Well-drained, D 12-18% Slope	b. Imperfectly-drained A+B 0-6% Slope	c. Poorly-drained A+B 0-6% Slope
2.	Loam to silty clay loam	54 29 / 50 51	40 24 / 42 37	40 24 / 42 37	60 29 / 50 55	67 31 / 54 58
3.	Sandy loam	47 22 / 40 42	40 20 / 36 35	40 19 / 36 35	55 29 / 50 53	58 29 / 50 53
4.	Loamy sand	34 18 / 30 33	27 17 / 28 31	— 14 / 22 29	36 19 / 32 38	43 22 / 36 40
5.0	Sand	20 12 / 22 20	13 11 / 20 20		24 14 / 24 22	29 16 / 26 27

a square: $\begin{array}{c|c} C & O \\ \hline W & A \end{array}$. Thus, $\begin{array}{c|c} 60 & 32 \\ \hline 50 & 55 \end{array}$ denotes that $60.00 is the expected gross income for corn per acre, $32.00 for oats, $50.00 for wheat, and $55.00 for alfalfa.

The expected gross income under a system of improved management is given in Table 5. The data was tabulated in the same manner as in Table 4.

The Calculation of the Expected Cost of Production

The expected costs of production were calculated for the common management level as follows: The cost of fertilizer per acre was taken from the median fertilizer cost per acre in the Farm Account Book Study of the area during the year 1958 (2). The amount of seed was taken from a recommendation of the Farm Crops Department of Michigan State University (1). This was multiplied by the seed cost (obtained from local sources) to determine the cost of seed per acre. Land preparation, seeding, and harvesting costs were all determined in the following manner: The cost of custom plowing, discing, dragging, and planting in addition to the custom cost of cultivating three times, picking and shelling were totalled as the cost of land preparation, seeding, and harvesting of corn. For wheat and oats the custom costs of plowing, discing, dragging, drilling, and combining were totalled for the expected cost of land preparation, seeding, and harvesting of wheat and oats. For alfalfa the custom costs of mowing twice, and the cost of baling were totalled for the cost of harvesting.[1] The costs of these operations were

[1]There was no charge made for land preparation and seeding in the case of alfalfa because this is usually done with the small grain which precedes the alfalfa in many of the land use sequences. In the case of some land use sequences in which alfalfa follows a row crop, a charge for plowing, discing, dragging, and drilling was added.

TABLE 5. THE EXPECTED GROSS INCOME WITH IMPROVED MANAGEMENT OF CORN, OATS, WHEAT, AND ALFALFA, $\frac{C \mid O}{W \mid A}$, ON EACH SOIL MANAGEMENT UNIT

	Texture of the Primary Material	Drainage and Topography a. Well-drained A+B 0-6% Slope	 C 6-12% Slope	 D 12-18% Slope	 b. Imperfectly-drained A+B 0-6% Slope	 c. Poorly-drained A+B 0-6% Slope
2.	Loam to silty clay loam	87 | 47 80 | 75	71 | 42 68 | 75	71 | 42 68 | 75	94 | 50 80 | 77	100 | 55 88 | 84
3.	Sandy loam	74 | 40 70 | 69	64 | 36 62 | 69	59 | 35 62 | 69	88 | 48 80 | 75	91 | 48 80 | 75
4.	Loamy sand	60 | 32 50 | 55	58 | 31 48 | 55	| 24 40 | 51	63 | 34 54 | 60	67 | 36 64 | 64
5.	Sand	54 | 29 44 | 51	47 | 26 40 | 51		56 | 30 46 | 51	56 | 30 46 | 53

taken from the Michigan Custom Work Bulletin (3).

A land use charge (the normal return of money if investing in something other than land) was determined by multiplying the value of the land by 0.05 (5% interest rate). The land values were taken from the average valuation of soil management groups and units in Arenac County (6).

All of these costs were totalled and ten per cent of the sum was added to the sum to cover taxes and miscellaneous costs. This latter amount (the sum plus ten per cent) was the expected cost of production. The expected costs of production are listed in Table 6.

The expected cost of production was calculated for an improved level of management as follows: The amount of fertilizer was taken from the Michigan fertilizer recommendation bulletin using in each case the maximum fertilizer recommendation for the soil management group (5). This amount of fertilizer was multiplied by an arbitrary price of fertilizer ($70.00 per ton) to determine the cost of fertilizer per acre. The amount of seed per acre was taken from a recommendation by the Farm Crops Department of Michigan State University as in the case of common management (1). This was multiplied by the seed cost (from local sources) to determine the cost of seed per acre. Land preparation, seeding, and harvesting costs were determined in the following manner: Minimum tillage was assumed to cost sixty per cent of the cost of custom plowing, discing, dragging, and planting. Full cost was assigned to cultivating twice, picking, and shelling the corn. These were totalled for the production cost of corn. For wheat and oats sixty per cent of the custom costs of plowing, discing, dragging, and drilling were added to the full cost of combining for the expected cost of land preparation, seeding, and harvesting. For alfalfa the full custom cost of mowing twice, raking twice,

TABLE 6. THE EXPECTED COST OF PRODUCTION WITH COMMON MANAGEMENT OF CORN, OATS, WHEAT, AND ALFALFA $\frac{C \mid O}{W \mid A}$ ON EACH SOIL MANAGEMENT UNIT

	Texture of the Primary Material	Drainage and Topography: a. Well-drained A+B 0-6% Slope	a. Well-drained C 6-12% Slope	a. Well-drained D 12-18% Slope	b. Imperfectly-drained A+B 0-6% Slope	c. Poorly-drained A+B 0-6% Slope
2.	Loam to silty clay loam	37 | 34 / 34 | 32	37 | 35 / 34 | 29	37 | 35 / 34 | 29	39 | 36 / 35 | 34	40 | 37 / 36 | 35
3.	Sandy loam	36 | 33 / 32 | 29	36 | 33 / 32 | 27	36 | 33 / 32 | 27	36 | 36 / 33 | 31	36 | 36 / 33 | 31
4.	Loamy sand	33 | 30 / 30 | 24	33 | 30 / 30 | 24	33 | 30 / 30 | 23	33 | 31 / 30 | 25	33 | 31 / 30 | 26
5.	Sand	31 | 29 / 28 | 20	31 | 29 / 28 | 20	31 | 29 / 28 |	31 | 29 / 28 | 21	31 | 29 / 28 | 22

and the cost of baling determined the cost of harvesting. The costs of these operations were taken from the Michigan Custom Work Bulletin. The land use charge and taxes and miscellaneous charges were assessed in the same manner as the average level of management. The expected costs of production for corn, wheat, oats, and alfalfa under improved management are found in Table 7.

The Calculation of the Expected Net Income

The expected production cost was subtracted from the expected gross income to determine the expected net income. This subtraction was carried out for both common and improved management systems and the results are given in Tables 8 and 9, respectively. The results are again arranged according to crops $\frac{C \mid O}{W \mid A}$.

Results and Discussion

There are several obvious results which should be noted. First, the improved level of management in all soil management units produces a higher expected net income than the common level of management. This is due to the magnitude of the increase in net income with the improved management level and the small resultant increase in production cost. This would indicate that the improved management level is not the optimum level.

Second, there is a close association between the expected gross income and the expected net income as shown in Figure 10. This close association is due for the most part to the cost data which does not take into account differences in the natural drainage and slope of

TABLE 7. THE EXPECTED COST OF PRODUCTION WITH IMPROVED MANAGEMENT OF CORN, OATS, WHEAT, AND ALFALFA, C | O / W | A, ON EACH SOIL MANAGEMENT UNIT

	Texture of the Primary Material	Drainage and Topography: a. Well-drained, A+B 0-6% Slope	a. Well-drained, C 6-12% Slope	a. Well-drained, D 12-18% Slope	b. Imperfectly-drained A+B 0-6% Slope	c. Poorly-drained A+B 0-6% Slope
2.	Loam to silty clay loam	41	32 / 40	46	41	32 / 40	49	41	32 / 40	46	43	34 / 42	47	44	35 / 43	49
3.	Sandy loam	40	31 / 35	43	40	31 / 35	43	40	31 / 35	43	41	31 / 35	44	41	31 / 35	45
4.	Loamy sand	34	28 / 30	34	34	28 / 30	34	34	28 / 30	33	34	28 / 30	35	34	28 / 30	36
5.	Sand	33	27 / 29	32	33	27 / 29	32	33	27 / 29		33	27 / 29	32	33	27 / 29	33

TABLE 8. THE EXPECTED NET INCOME WITH COMMON MANAGEMENT OF CORN, OATS, WHEAT, AND ALFALFA, C | O / W | A, ON EACH SOIL MANAGEMENT UNIT

Texture of the Primary Material	Drainage and Topography: a. Well-drained A+B 0-6% Slope	a. Well-drained C 6-12% Slope	a. Well-drained D 12-18% Slope	b. Imperfectly-drained A+B 0-6% Slope	c. Poorly-drained A+B 0-6% Slope
2. Loam to silty clay loam	16, -6 16, 19	3, -11 8, 8	3, -11 8, 8	22, -7 15, 22	27, -6 18, 22
3. Sandy loam	11, -11 8, 14	4, -13 4, 8	4, -14 4, 8	19, -5 17, 22	21, -5 17, 22
4. Loamy sand to sand	0, -12 1, 9	-6, -14 -2, 7	--, -16 -8, 5	3, -12 2, 12	10, -9 6, 14
5. Sand	-11, -17 - 7, -1	-18, -18 - 8, -1		-7, -15 -4, 1	-2, -13 -2, 5

TABLE 9. THE EXPECTED NET INCOME WITH IMPROVED MANAGEMENT OF CORN, OATS, WHEAT, AND ALFALFA, C | O / W | A, ON EACH SOIL MANAGEMENT UNIT

	Texture of the Primary Material	Drainage and Topography a. Well-drained A+B 0-6% Slope	C 6-12% Slope	D 12-18% Slope	b. Imperfectly-drained A+B 0-6% Slope	c. Poorly-drained A+B 0-6% Slope
2.	Loam to silty clay loam	46 14 40 30	30 9 28 30	30 9 28 30	50 17 38 31	56 21 45 35
3.	Sandy loam	33 9 35 26	24 5 27 26	19 5 27 26	47 17 45 31	50 17 45 31
4.	Loamy sand	4 20 21	24 3 18 21	-4 10 18	29 6 24 25	33 8 34 28
5.	Sand	21 2 15 19	14 -1 11 19		24 3 17 19	24 3 17 20

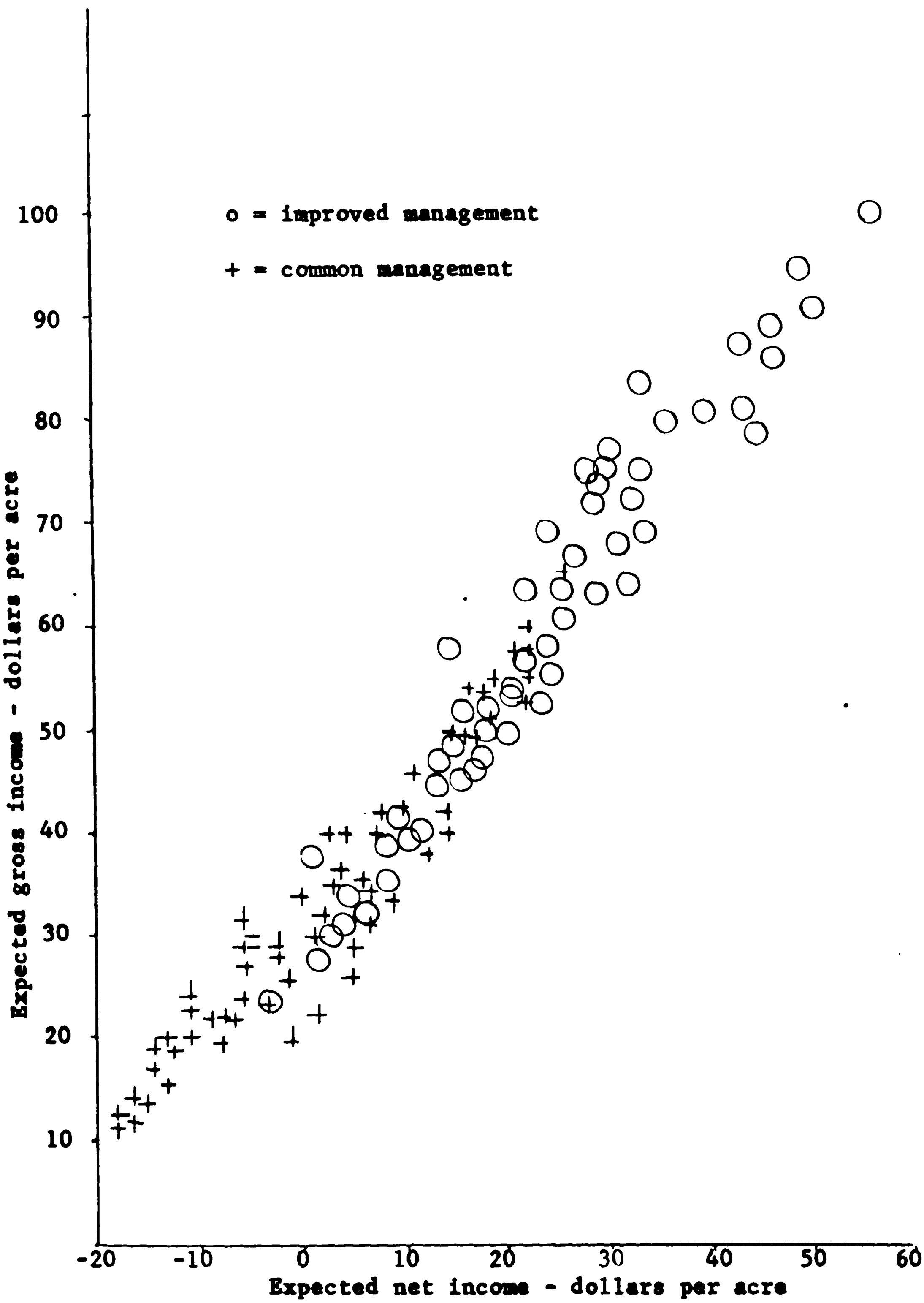

Figure 10. The relationship of expected gross income to expected net income.

the soil management group and unit. The production costs (fixed costs) vary directly with the coarseness of the primary material because of the increased interest charged on the higher valued, fine textured soils. This means that the expected gross income may be used as a criterion for choosing management levels.

Some of the characteristics of the soils, such as slope, natural drainage, and texture of the primary material, influence the expected net income from cropland on the soil group: 1) The steeper slopes have a lower expected net income than the more gentle slopes. This is shown in Figure 11 which is a graph of expected net incomes with variation in slope for soil management group 4a (well-drained loamy sands). This higher expected net income is primarily due to the increased yields on soils with gentler slopes. 2) The naturally poorly-drained soils have higher expected net incomes than the naturally imperfectly-drained soils which in turn have higher expected net incomes than the naturally well-drained soils. It must be remembered that there was an assumption made that there was adequate drainage on the poorly and imperfectly-drained soils in calculating the yields. This increase is probably due to the influence of the better moisture conditions on yields in the poorly and imperfectly-drained soils, particularly during the summer when moisture content may be critical. This relationship may be noted in Figure 12 which is a graph of the expected net incomes of soil management groups

4a, 4b, and 4c (well-drained, imperfectly-drained, and poorly-drained loamy sands) all on 0-6% slopes. 3) The soils developed on the finer

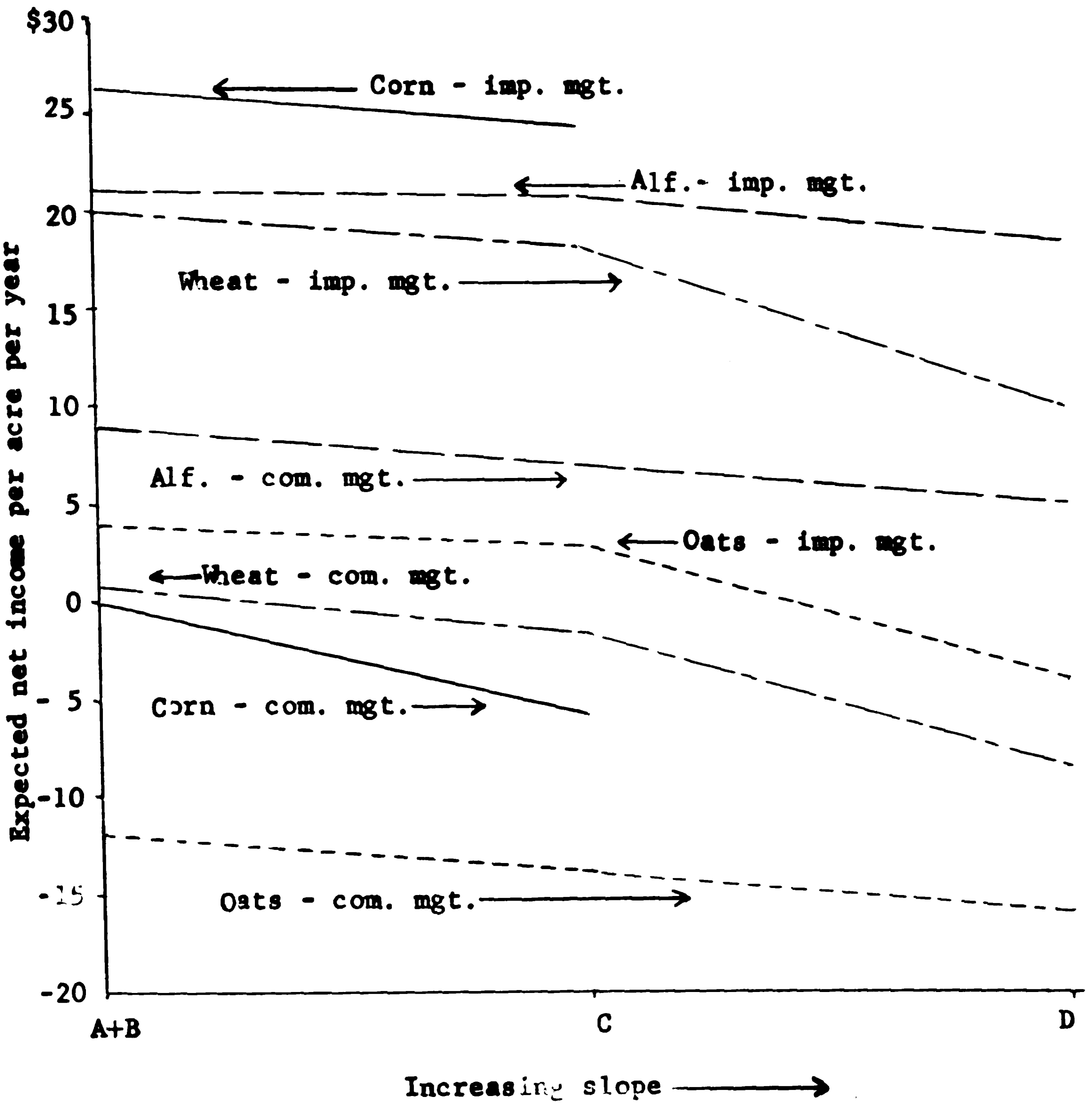

Figure 11. The effect of slope classes and management on the expected net income from various crops on soil management unit 4a (well-drained loamy sands to sands).

textured primary material have a higher expected net income than the soils that are developed on coarser textured primary material. The moisture holding capacity of the soil has an effect on the yields which in turn influences the expected net income. This relationship may be noted in Figure 13 which is a graph of the expected net incomes on soil management groups 2a, 3a, 4a, and 5a (well-drained loams to silty clay loams, sandy loams, loamy sands, and sands, respectively).

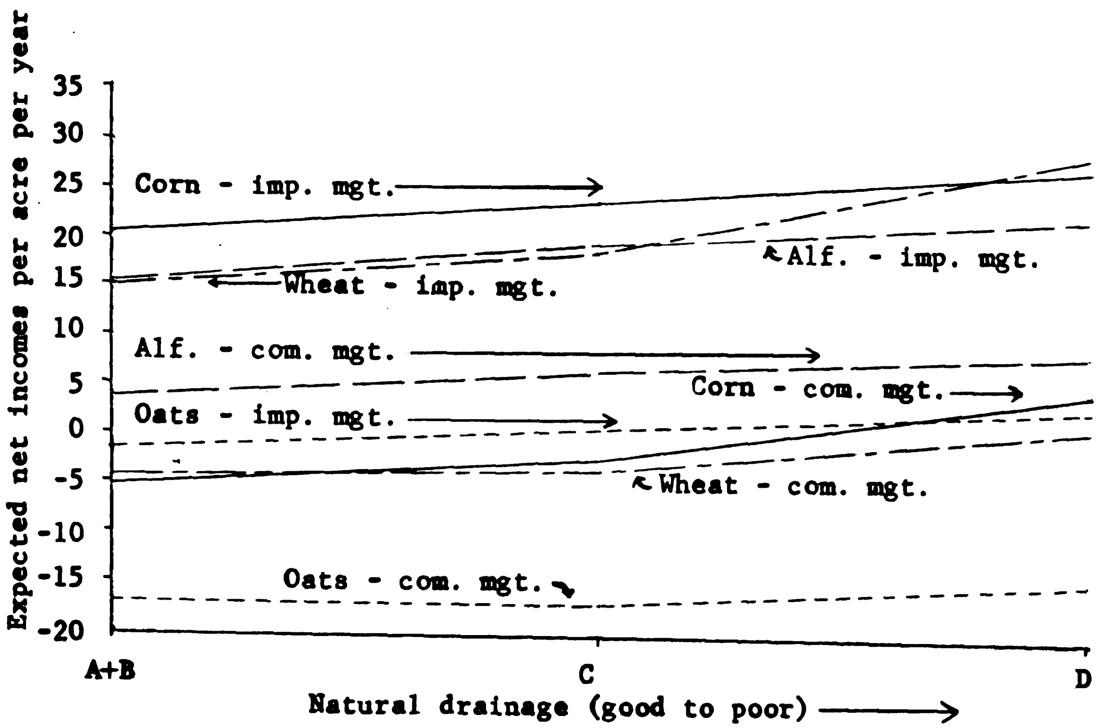

Figure 12. The effect of natural drainage and management on the expected net income from various crops on soil management units 4a, 4b, and 4c, all on 0-6% slopes.

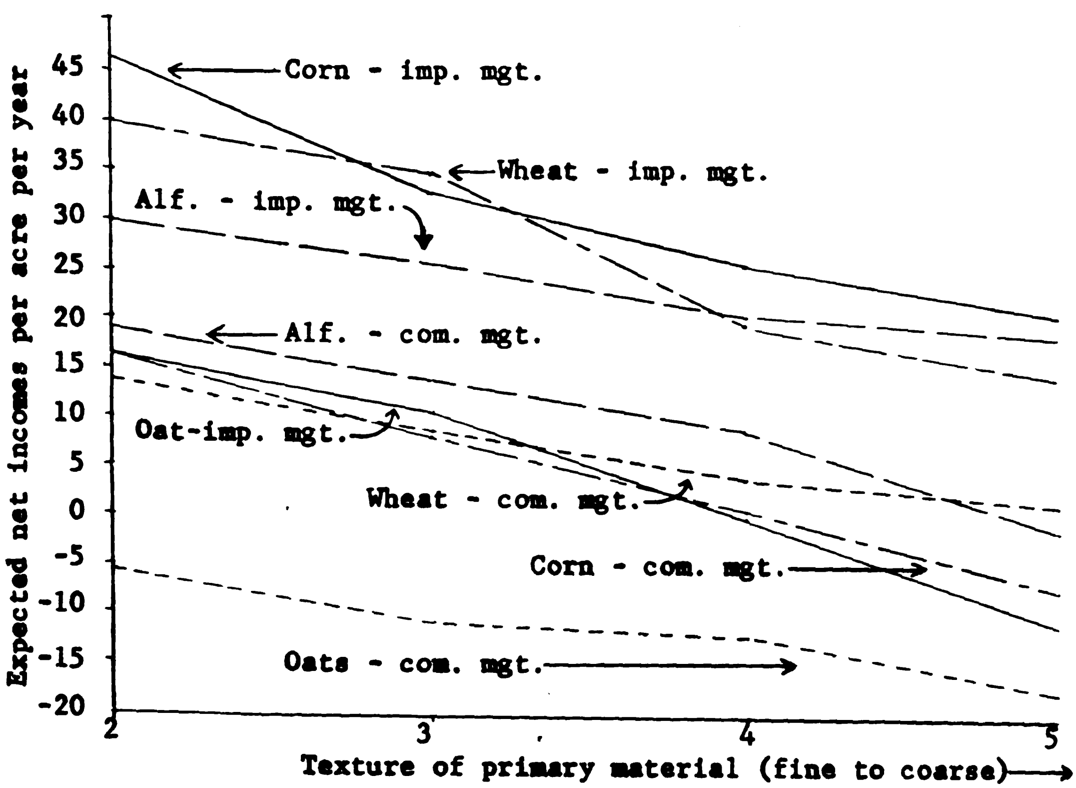

Figure 13. The effect of the texture of the primary material and management on the expected net income from various crops on soil management units 2a, 3a, 4a, and 5a, on A and B slopes.

PLANNING LAND USE USING EXPECTED NET INCOME PER ACRE AS THE CRITERIA

It has been one of the prime goals of the present study to show the effect of using the expected net income per acre in land use planning. It was decided that, in selecting land use sequences on the various soil management groups, only the sequences that would not permit an excessive amount of soil erosion would be considered.[1] The first step in selecting the most profitable land use sequence is to take the alternative sequences and calculate the expected net income per acre per year for each sequence. This expected net income per acre per year was calculated by adding the expected net incomes of the individual crops and dividing by the total number of years in the sequence. Then the sequences may be compared as to their relative profitability. In some of the soil management groups a problem arose as to how to select the right number of the most profitable sequences. This occurred in some cases where there was a large number of sequences producing a similar expected net income per acre and in other cases where there was a certain sequence that produced an expected net income per acre in excess of the other sequences. The problem, in short, was where to draw the line. It was decided to set the arbitrary acceptability line at ninety per cent of the highest expected net income producing sequence. The acceptable sequences would then

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[1]The procedure for determining sequences that would not permit an excess soil loss was as follows: A rotation index number was selected for each soil management unit from Tables 12 through 15 of the management guide (2). 200 feet length of slope was assumed. Then the sequences (rotations) that had index numbers equal to or greater than the index number for the soil management unit were considered acceptable. The rotation index number is based on a 3 ton per acre permissible annual soil loss on soil management groups 2a, 2b, 2c, 3a, 3b, and 3c and a 4 ton per acre permissible annual soil loss on soil management groups 4a, 4b, 4c, 5a, 5b, and 5c.

include all the sequences that would produce an expected net income within ten per cent of the most profitable sequence. The expected net incomes per acre for each of the sequences in each soil management unit are listed in Tables 10 and 11 for common management and improved management, respectively.

TABLE 10. THE EXPECTED NET INCOMES FROM VARIOUS LAND USE SEQUENCES ON VARIOUS SOIL MANAGEMENT UNITS WITH COMMON MANAGEMENT

2aA		2aB		2aC		2aD		2bA		2bB		2cA		2cB	
WAAAA	$20.59	WAAAA	$20.59	WAAAA	$10.59	WAAAA	$10.59	WAAAA	$22.63	WAAAA	$22.63	CWAAAA	$24.17	CWAAAA	$24.17
WAAA	20.00	WAAA	20.00	WAAA	10.18			CWAAAA	22.47	CWAAAA	22.47	CCWAA	24.03	CWAAA	23.80
CWAAAA	19.85	CWAAAA	19.85	WAA	9.51			WAAA	21.90	WAAA	21.50	CWAAA	23.80	WAAAA	23.56
CWAAA	19.23	CWAAA	19.23					CWAAA	21.85	CWAAA	21.85	WAAAA	23.56	WAAA	22.95
WAA	19.01	WAA	19.01					CCAAA	21.25	CAAA	21.15	CCAAA	23.33	CAAA	22.87
CCWAA	18.07	CAAA	17.82					CAAA	21.15	WAA	20.68	CWAA	23.25	WAA	21.93
CWAA	18.05							CCWAA	21.07			CCAA	23.16		
CAAA	17.82							CWAA	20.90			WAAA	22.95		
WA	17.54							WAA	20.68			CAAA	22.87		
CCAAA	17.48							CWA	20.68			CWA	22.32		
CWA	17.08							CCAA	20.17			WAA	21.93		
CCAA	16.12							CAA	19.87			CAA	21.82		
CAA	16.10							WA	18.24			WA	19.89		
CA	12.68							CA	16.73			CA	19.73		

3aA		3aB		3aC		3aD		3bA		3bB		3cA		3cB	
WAAAA	$14.78	WAAAA	$14.78	WAAAA	$ 9.64	WAAAA	$ 9.64	WAAAA	$23.46	WAAAA	$23.46	WAAAA	$23.47	WAAAA	$23.47
CWAAAA	14.17	CWAAAA	14.17	WAAA	9.02			WAAA	22.83	WAAA	22.83	CWAAAA	23.11	CWAAAA	23.11
WAAA	14.10	WAAA	14.10	WAA	7.99			CWAAAA	22.66	CWAAAA	22.66	WAAA	22.83	WAAA	22.83
CWAAA	13.49	CWAAA	13.49					CWAAA	21.99	CWAAA	21.99	CWAAA	22.53	CWAAA	22.53
WAA	12.95	WAA	12.95					WAA	21.76	WAA	21.76	CAA	21.77	CAAA	21.41
CAAA	12.49	CAAA	12.49					CWAA	20.98	CAAA	20.78	CWAA	21.65		
CWAA	12.48							CAAA	20.78			CCWAA	21.58		
CCAAA	12.21							CCWAA	20.51			CAAA	21.41		
CCWAA	12.20							CCAAA	20.33			CCAAA	21.39		
CCAA	10.87							WA	19.63			CCAA	20.23		
CAA	10.80							CWA	19.29			CWA	20.19		
CWA	10.79							CAA	18.97			CAA	19.87		
WA	10.65							CCAA	18.91			WA	19.64		
CA	7.44							CA	15.45			CA	16.79		

TABLE 10. - Continued

4aA		4aB		4aC		4aD		4bA		4bB		4cA		4cB	
WAAAA	$ 9.70	WAAAA	$ 9.70	WAAAA	$ 7.82	WAAAA	$ 6.54	WAAAA	$12.76	WAAAA	$12.76	WAAAA	$15.06	WAAAA	$15.06
WAAA	8.88	WAAA	8.88	WAAA	6.98	WAAA	5.58	WAAA	11.85	WAAA	11.85	WAAA	14.26	WAAA	14.26
CWAAAA	8.15	CWAAAA	8.15	WAA	5.59	WAA	3.66	CWAAAA	11.11	CWAAAA	11.11	CWAAAA	14.15	CWAAAA	14.15
WAA	7.50	WAA	7.50	CWAAAA	5.46			WAA	10.35	WAA	10.35	CWAAA	13.33	CWAAA	13.33
CWAAA	7.18	CWAAA	7.18	WA	2.82			CWAAA	10.06	CWAAA	10.06	WAA	12.93	WAA	12.93
CWAA	5.73	CWAA	5.73					CAAA	9.57	CAAA	9.57	CAAA	12.65	CAAA	12.65
WA	4.75	WA	4.75					CWAA	8.59	CWAA	8.59	CWAA	12.11	CWAA	12.11
CWA	3.31	CWA	3.31					WA	7.34	WA	7.34	CAA	10.79	CAA	10.79
CAAA	0.13	CAAA	0.13					CAA	7.30	CAA	7.30	WA	10.28	WA	10.28
CAA	0.03	CAA	0.03					CWA	5.86	CWA	5.86	CWA	10.06	CWA	10.06

5aA		5aB		5aC				5bA		5bB		5cA		5cB	
WAAAA	$ 0.55	WAAAA	$ 0.55	WAAAA	$ 0.32			WAAAA	$ 2.58	WAAAA	$ 2.58	WAAAA	$ 5.53	WAAAA	$ 5.53
WAAA	-0.17	WAAA	-0.17	WAAA	-0.46			WAAA	1.90	WAAA	1.90	WAAA	4.72	WAAA	4.72
CWAAAA	-1.37	CWAAAA	-1.37	WAA	-1.76			CWAAAA	0.98	CWAAAA	0.98	CWAAAA	4.32	CWAAAA	4.32
WAA	-1.38	WAA	-1.38	WA	-4.37			WAA	0.77	WAA	0.77	CWAAA	3.43	CWAAA	3.43
CWAAA	-2.34	CWAAA	-2.34					CWAAA	0.11	CWAAA	0.11	WAA	3.35	WAA	3.35
WA	-3.79	WA	-3.79					CWAA	-1.18	CWAA	-1.18	CAAA	2.73	CAAA	2.73
CWAA	-3.79	CWAA	-3.79					CAAA	-1.24	CAAA	-1.24	CWAA	2.09	CWAA	2.09
CAAA	-6.10	CAAA	-6.10					WA	-1.44	WA	-1.44	WA	1.26	WA	1.26
CAA	-9.29	CAA	-9.29					CAA	-3.41	CAA	-3.41	CAA	0.71	CAA	0.71

TABLE 11. THE EXPECTED NET INCOMES FROM VARIOUS LAND USE SEQUENCES ON VARIOUS SOIL MANAGEMENT UNITS WITH IMPROVED MANAGEMENT

2aA		2aB		2aC		2aD		2bA		2bB		2cA		2cB	
CWCWA	$40.18	CWAA	$37.20	WAAAA	$31.58	WAAAA	$31.58	CCA	$41.99	CWAA	$38.53	CWCWA	$47.62	CWAA	$43.83
CCWAA	38.97	CWAAA	36.47	WAAA	31.08			CWCWA	41.70	CWAAA	37.73	CCA	47.22	CWAAA	42 83
CCA	38.60	CWAAAA	35.99	WAA	30.25			CCWAA	40.93	CWAAAA	37.21	CCWAA	46.33	CWAAAA	42.16
CWA	38.41	WA	34.60	WA	28.60			CCAA	40.09	CAA	36.61	CWA	45.49	CAA	41.39
CCAA	37.34	CAA	34.44					CWA	39.84	CAAA	36.10	CCAA	45.13	CAAA	40.75
CWAA	37.20	WAA	34.25					CCAAA	38.98	WAAAA	34.54	CCAAA	43.87	WA	40.06
CCAAA	36.58	CAAA	34.22					CWAA	38.53	WAAA	34.54	CWAA	43.83	WAA	39.65
CWAAA	36.47	WAAA	34.08					CWAAA	37.73	WAA	34.52	CWAAA	42.83	WAAA	39.45
CWAAAA	35.99	WAAAA	34.00					CA	37.63	WA	34.50	CA	42.67	WAAAA	39.33
CA	34.88							CWAAAA	37.21			CWAAAA	42.16		
WA	34.60							CAA	36.61			CAA	41.39		
CAA	34.44							CAAA	36.10			CAAA	40.75		
WAA	34.25							WAAAA	34.54			WA	40.06		
CAAA	34.22							WAAA	34.54			WAA	39.65		
WAAA	34.06							WAA	34.52			WAAA	39.45		
WAAAA	34.00							WA	34.50			WAAAA	39.33		

3aA		3aB		3aC		3aD		3bA		3bB		3cA		3cB	
CWCWA	$32.37	CWAA	$30.65	WAAAA	$27.90	WAAAA	$28.43	CWCWA	$43.06	CWAA	$39.59	CWCWA	$44.05	CWAA	$40.04
CCWAA	31.17	CWAAA	30.34	WAAA	27.61			CCWAA	41.17	CWAAA	38.70	CCWAA	42.07	CWAAA	38.97
CWA	31.16	CWAAAA	30.13	WAA	27.11			CWA	41.08	CWAAAA	38.11	CWA	41.82	CWAAAA	38.25
CWAA	30.65	WA	30.11	WA	26.11			CCA	40.09	WA	37.87	CCA	41.73	WA	37.65
CWAAA	30.34	WAA	29.77	CAAA	25.33			CWAA	39.59	WAA	36.96	CWAA	40.04	CA	37.50
CWAAAA	30.13	WAAA	39.61					CCAA	38.85	WAAA	36.51	CCAA	39.94	WAA	36.66
WA	30.11	WAAAA	29.50					CWAAA	38.70	CA	36.39	CWAAA	38.97	CAA	36.53
WAA	29.77	CAAA	27.68					CWAAAA	38.11	WAAAA	36.23	CCAAA	38.89	WAAA	36.16
WAAA	29.61	CAA	27.20					CCAAA	38.11	CAA	35.97	CWAAAA	38.25	CAAA	36.07
WAAAA	29.50							WA	37.87	CAAA	35.77	WA	37.65	WAAAA	35.87
CCAAA	28.79							WAA	36.96			CA	37.50		
CCAA	28.72							WAAA	36.51			WAA	36.66		
CCA	28.59							CA	36.39			CAA	36.53		
CAAA	27.68							WAAAA	36.23			WAAA	36.16		
CAA	27.20							CAA	35.97			CAAA	36.07		
CA	26.26							CAAA	35.77			WAAAA	35.87		

TABLE 11. - Continued

4aA		4aB		4aC		4aD		4bA		4bB		4cA		4cB	
CWAAAA	$24.03	CWAAAA	$24.03	CWAAAA	$23.25	WAAAA	$18.59	CWAAAA	$27.33	CWAAAA	$27.33	CWAAAA	$32.08	CWAAAA	$32.08
CCWAA	23.93	CCWAA	23.93	WAAAA	23.15	WAAA	17.79	CCWAA	27.04	CCWAA	27.04	CWAAA	32.00	CWAAA	32.00
CCAAA	23.90	CCAAA	23.90	CWAAA	22.80	WAA	16.45	CWAAA	27.03	CWAAA	27.03	WAAAA	31.90	WAAAA	31.90
CWAAA	23.74	CWAAA	23.74	CAAA	22.60	WA	13.79	WAAAA	27.01	WAAAA	27.01	CWAA	31.88	CWAA	31.88
WAAAA	23.55	WAAAA	23.55	WAAA	22.56			CCAAA	26.92	CCAAA	26.92	WAAA	31.76	WAAA	31.76
CCAA	23.51	CCAA	23.51	CAA	21.63			CWAA	26.56	CWAA	26.56	CCWAA	31.70	CCWAA	31.70
CWAA	23.30	CWAA	23.30	WAA	21.59			WAAA	26.55	WAAA	26.55	CWA	31.69	CWA	31.69
CAAA	23.27	CAAA	23.27	WA	19.64			CCAA	26.44	CCAA	26.44	WAA	31.52	WAA	31.52
WAAA	23.06	WAAA	23.06					CAAA	26.42	CAAA	26.42	CCAAA	31.50	CCAAA	31.50
CWA	22.57	CWA	22.57					CWA	25.79	CWA	25.79	CAAA	31.14	CAAA	31.14
CAA	22.53	CAA	22.53					WAA	25.77	WAA	25.77	WA	31.04	WA	31.04
WAA	22.25	WAA	22.25					CAA	25.61	CAA	25.61	CAA	30.69	CAA	30.69
CA	21.05	CA	21.05					WA	24.23	WA	24.23	CCAA	29.76	CCAA	29.76
WA	20.64	WA	20.64					CA	23.98	CA	23.98	CA	27.60	CA	27.60

5aA		5aB		5aC		5bA		5bB		5cA		5cB	
CWAAAA	$21.61	CWAAAA	$21.61	WAAAA	$19.90	CWAAAA	$21.61	CWAAAA	$21.61	CWAAAA	$22.10	CWAAAA	$22.10
CCAAA	21.35	CCAAA	21.35	WAAA	19.10	CCAAA	21.35	CCAAA	21.35	CCAAA	21.88	CCAAA	21.88
CWAAA	21.19	CWAAA	21.19	CWAAAA	18.98	CWAAA	21.19	CWAAA	21.19	WAAAA	21.79	WAAAA	21.79
WAAAA	21.06	WAAAA	21.06	CAAA	18.45	WAAAA	21.06	WAAAA	21.06	CWAAA	21.72	CWAAA	21.72
CAAA	20.76	CAAA	20.76	CWAAA	18.15	CAAA	20.76	CAAA	20.76	CAAA	21.44	CAAA	21.44
CWAA	20.72	CWAA	20.72	WAA	17.76	CWAA	20.72	CWAA	20.72	WAAA	21.24	WAAA	21.24
WAAA	20.56	WAAA	20.56	WA	15.10	WAAA	20.56	WAAA	20.56	CWAA	21.16	CWAA	21.16
CAA	19.99	CAA	19.99			CAA	19.99	CAA	19.99	CAA	20.59	CAA	20.56
WAA	19.10	WAA	19.10			WAA	19.72	WAA	19.72	WAA	20.32	WAA	20.32
CA	17.16	CA	17.16			CA	18.46	CA	18.46	CA	18.90	CA	18.90
WA	17.09	WA	17.09			WA	18.06	WA	18.06	WA	18.52	WA	18.52

LAND USE IN CROPS BY SOIL MANAGEMENT UNITS

In order to calculate the expected use of the land if these recommendations were followed, the following procedure was used: Each of the land use sequences that was acceptable for each soil management unit was assumed to be equally acceptable to the managers involved. The average percentages of the land in corn, wheat, and alfalfa were then calculated. These percentages are listed in Table 12 for common management and in Table 13 for improved management.

TABLE 12. THE EXPECTED PERCENTAGE OF EACH SOIL MANAGEMENT UNIT IN CORN, WHEAT, AND ALFALFA IF LAND USE SEQUENCES RECOMMENDED WITH COMMON MANAGEMENT ARE USED

	2aA-%	2aB-%	2aC-%	2aD-%	2bA-%	2bB-%	2cA-%	2cB-%
Corn	7	7	0	0	20	10	24	10
Wheat	23	23	22	20	19	19	16	19
Alfalfa	70	70	78	80	61	71	60	71
	3aA-%	3aB-%	3aC-%	3aD-%	3bA-%	3bB-%	3cA-%	3cB-%
Corn	9	9	0	0	7	7	19	10
Wheat	21	21	22	20	23	23	18	19
Alfalfa	70	70	78	80	70	70	63	71
	4aA-%	4aB-%	4aC-%	4aD-%	4bA-%	4bB-%	4cA-%	4cB-%
Corn	0	0	0	0	0	0	5	5
Wheat	22	22	20	20	22	22	20	20
Alfalfa	78	78	80	80	78	78	75	75
	5aA-%	5aB-%	5aC-%	5aD-%	5bA-%	5bB-%	5cA-%	5cB-%
Corn	0	0	0		0	0	0	0
Wheat	20	20	20		20	20	20	20
Alfalfa	80	80	80		80	80	80	80

TABLE 13. THE EXPECTED PERCENTAGE OF EACH SOIL MANAGEMENT UNIT IN CORN, WHEAT, AND ALFALFA IF LAND USE SEQUENCES RECOMMENDED WITH IMPROVED MANAGEMENT ARE USED

	2aA-%	2aB-%	2aC-%	2aD-%	2bA-%	2bB-%	2cA-%	2cB-%
Corn	39	21	0	0	42	21	42	21
Wheat	19	21	32	20	17	21	17	21
Alfalfa	42	58	68	80	41	58	41	58
	3aA-%	3aB-%	3aC-%	3aD-%	3bA-%	3bB-%	3cA-%	3cB-%
Corn	18	9	5	0	43	16	43	21
Wheat	28	27	26	20	20	28	20	21
Alfalfa	54	64	69	80	37	56	37	58
	4aA-%	4aB-%	4aC-%	4aD-%	4bA-%	4bB-%	4cA-%	4cB-%
Corn	24	24	14	0	24	24	22	22
Wheat	16	16	16	22	16	16	17	17
Alfalfa	60	60	70	78	60	60	61	61
	5aA-%	5aB-%	5aC-%	5aD-%	5bA-%	5bB-%	5cA-%	5cB-%
Corn	18	18	12		18	18	18	18
Wheat	16	16	16		16	16	16	16
Alfalfa	66	66	72		66	66	66	66

RESULTS AND DISCUSSION

Some important limitations ought to be considered in attempting to analyze the results listed in Tables 10 and 11. These limitations deal with the original assumptions made in this study.

Firstly, the results are very dependent upon the expected prices. It should be recalled that these prices were simple monthly averages from a ten year period, 1949 - 1958, and probably are a good estimate of what prices will continue to be over the long run. If a war or some other catastrophe occurs, these prices would no longer be the expected prices, and the results and recommendations would no longer be valid. If the price of one of the crops should be increased or decreased considerably by government action, technology, or other means, the results and recommendations based on that price would no longer be valid. It should also be remembered that in making specific decisions the manager must consider his own abilities, feed requirements, and the need of a certain land use program. Extension personnel in farm management and land utilization must also remember this in making specific recommendations to farm managers. For instance, a certain manager may have a superior yield in a certain crop, but only average yields in other crops. This must be taken into consideration when he plans his land use program. Therefore, the results given in this paper should be taken only as a guide to planning land use in this area. They are valid when the assumptions made are true.

Secondly, one of the most obvious and important observations from the results which are listed in Tables 10 and 11 is the difference in acceptability of land use sequences due to the management level. This is most obvious in soil management unit 5aC (well-drained sands, 6 to 12 per cent slope). If this soil management unit is under common management, there is only one land use sequence which will bring a profit and that is WAAAA. The profit amounts to only 32¢ per acre per year. This same soil management unit, if under improved management, has five acceptable alternative land use sequences. Each of these five sequences will net a profit of over $18.00 per acre per year and two of these sequences use corn.

There are many less obvious instances of the differences due to the levels of management. In many of the soil management groups certain land use sequences are acceptable under one level of management, and unacceptable or less acceptable under a different management level. Also, in many of the soil management groups, the effect of improved management is to give more alternatives in land use sequences than under the common level of management.

A third important effect of improved management over common management is to nullify some of the effects that soil properties have on net income and the consequent acceptability of certain land use sequences. This effect will be noted more specifically in the paragraphs below.

A fourth important and obvious conclusion from the results listed in Tables 10 and 11 is that the longer land use sequences tend to be more acceptable than the shorter land use sequences. This fact is especially noted in the soil management groups where the sequences CA and CCAA may be compared. The net effect of these two sequences on land use is the same: fifty per cent of the time the land is in corn and the other fifty per cent of the time the land is in alfalfa. However, the CCAA land use sequence is consistently more profitable than the CA sequence. This is due to the efficiency derived in keeping the field in alfalfa for two years and the resulting savings in the cost of seeding and land preparation. This is one of the effects that is partially overcome by an improved level of management, however. This may be seen in the soil management groups 2a, 2b, 2c, 3a, 3b, and 3c (well-drained, imperfectly-drained, and poorly-drained loams to silty clay loams and well-drained, imperfectly-drained, and poorly-drained sandy loams). In these soil management groups under improved management many of the shorter land use sequences are equally as acceptable and in certain cases more acceptable than the longer land use sequences. This is important to the manager also for in considering the alternative land uses, he must realize that in general the longer sequences are the more profitable, however they do not apply equally to all soils or management conditions. Students of farm management, land utilization or extension personnel, will have to take into account this effect in their studies and recommendations.

A fifth important conclusion from the results listed in Tables 10 and 11 is that the sequences using more corn and less alfalfa tend to be less acceptable and less profitable than the sequences using less corn and more alfalfa. This is a result that was totally unexpected. It was thought by this writer that the land uses which used more corn and less alfalfa would produce a higher income. This was not true under the price and cost conditions that were assumed. However, the improved level of management had an effect of nullifying this condition. This relationship does not hold in soil management groups 2a, 2b, 2c, 3a, 3b, 3c (well-drained, imperfectly-drained, and poorly-drained loams to silty clay loams and well-drained, imperfectly-drained, and poorly-drained sandy loams) under improved management. This result is of special importance to the manager, student of farm management in land utilization, and extension personnel in these fields. It has commonly been taken for granted that the sequences which use more corn and less alfalfa produce the greater return. He must investigate first and then conclude whether or not this is true for the particular circumstances.

There are several soil characteristics that influence the choice of alternative land use sequences. These are the texture of the primary material, the slope, and the natural drainage of the soil. 1) In the coarser textured soils the longer land use sequences are relatively more acceptable than in the finer textured soils having the same natural drainage and slope. Also in the coarse textured soils the land use sequences which leave the soil for a greater percentage of the time in alfalfa are relatively more acceptable than in the finer textured soils having the same natural drainage and slope.

This condition is slightly altered in the good level of management, but is still evident. These relationships are illustrated in Figures 14 and 15. This effect is important to the farm manager, the student of farm management or land utilization, and the extension personnel because it means that in the coarser textured soils longer sequences and sequences using longer periods of alfalfa should be used not just for conservation purposes, but for economic reasons also.

2) One would expect that a relationship would exist between the steepness of a slope and the acceptability of the length of land use sequences and the duration of the land in alfalfa in the land use sequence. The expected relationship was that on the steeper slopes, the longer land use sequences and the sequences employing the land longer in alfalfa would be the more acceptable. On the steeper slopes the percent-

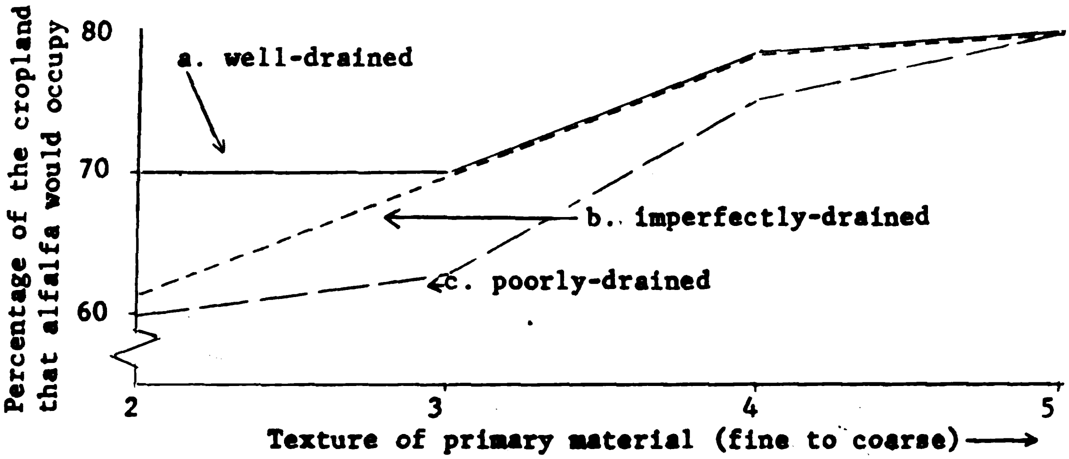

Figure 14. The effect of the texture of the primary material and natural drainage on the percentage of the cropland that alfalfa would occupy if recommended land use sequences were followed under common management on level land (0-2% slope).

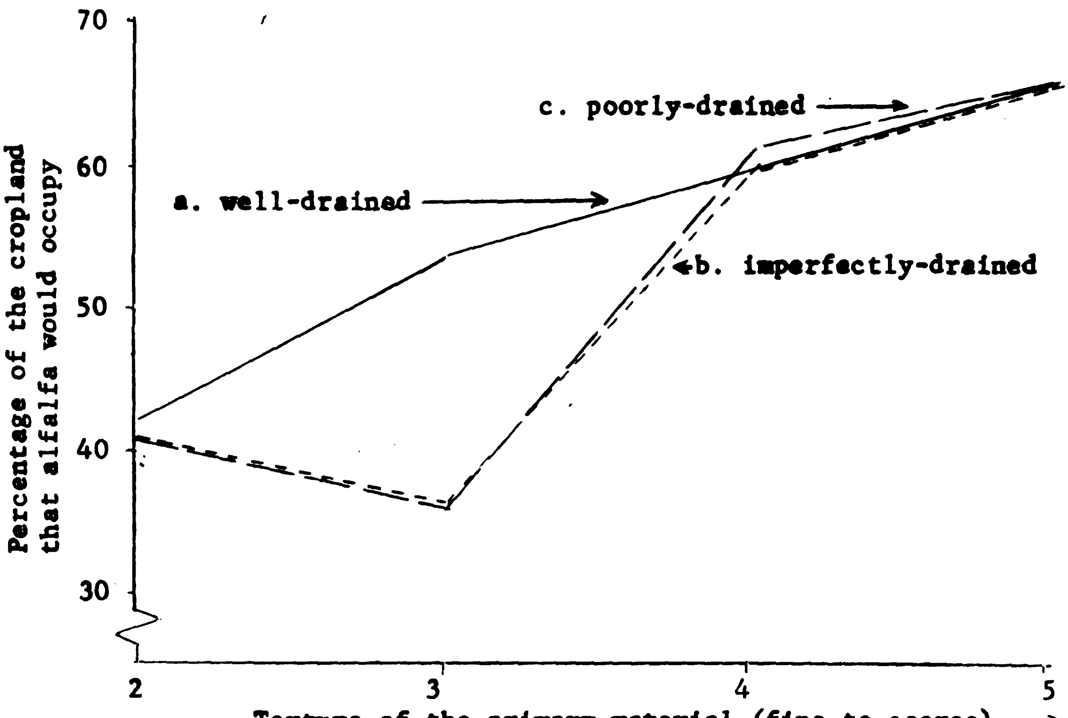

Figure 15. The effect of the texture of the primary material and natural drainage on the minimum percentage of the cropland that alfalfa would occupy if recommended land use sequences were followed under improved management level land (0-2% slope).

age of land in corn was less than on the more gradual slopes as illustrated in Figures 16 and 17. However, on the gentler slopes the longer land use sequences were just as acceptable as on the steeper slopes. In soil management groups 2a, 3a, and 4a (well-drained loams to silty clay loams, sandy loams, and loamy sands) under common management, the sequences WAAAA, WAAA, and where applicable CWAAAA are the most acceptable independent of the slope. On soil management group 5a (well-drained sands) WAAAA is the only acceptable land use sequence under common management. Under improved management of soil management groups 2a and 3a (well-drained loams to silty clay loams and sandy loams) there is a relationship whereby on the steeper slopes, the longer sequence and those sequences which have a longer duration of alfalfa are the more acceptable. On soil management groups 4a and 5a (well-drained loamy sands to sands) under good management the situation is much the same as for the common management: There is no relationship present between slope and length of land use sequence. However, the potentially useful number of sequences is greatly increased with improved management as shown by Figures 18 and 19. It would appear that, under the assumption of prices and costs that were used, the improved management of soil management group 2a (well-drained loams to silty clay loams) tend to make differences in slope more critical. This is due to the possibility of more intensive use of the flatter lands in this soil groups. This fact is important to the farm manager, student of farm management and land utilization, and the extension personnel in these fields because it demonstrates again the need for an economic analyses to plan land use. One would suspect that longer sequences would be more favorable for the steeper slopes. This suspicion is not borne out by an economic analysis and must be disregarded

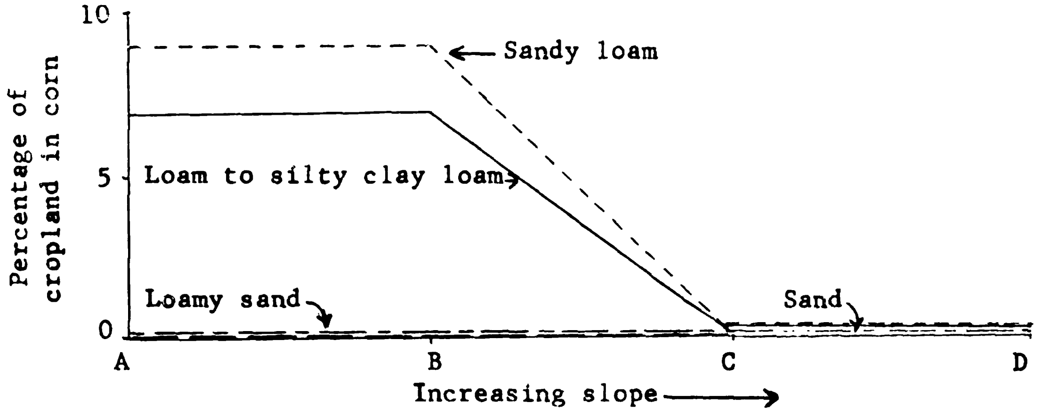

Figure 16. The effect of slope on the maximum percentage of the cropland that corn would occupy under common management.

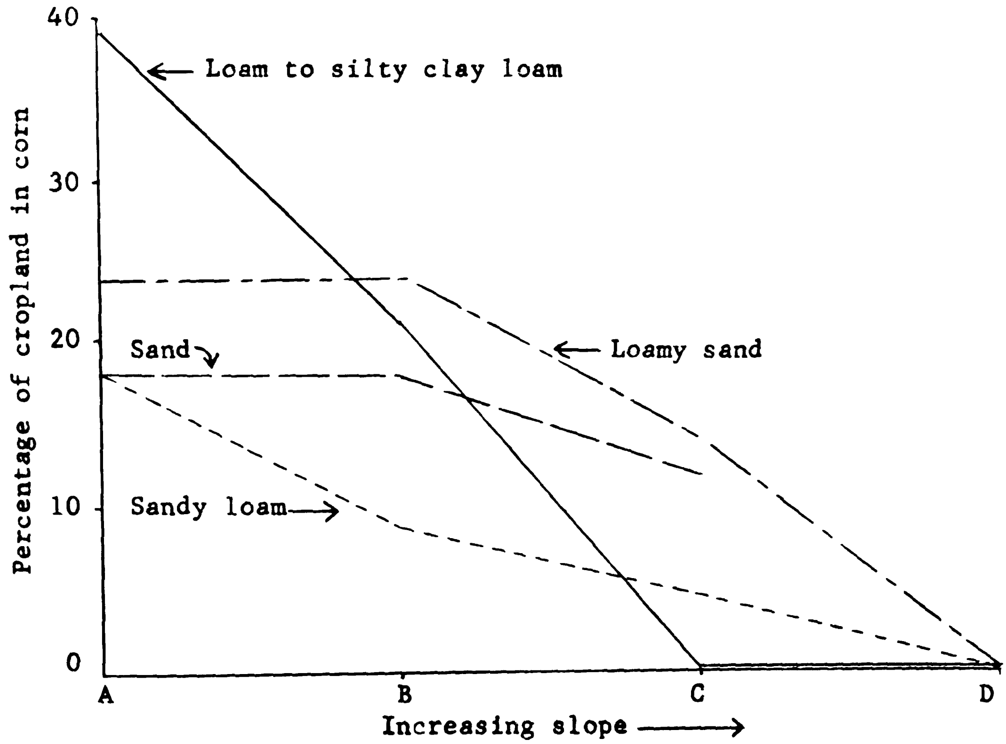

Figure 17. The effect of slope on the maximum percentage of the cropland that corn would occupy under improved management.

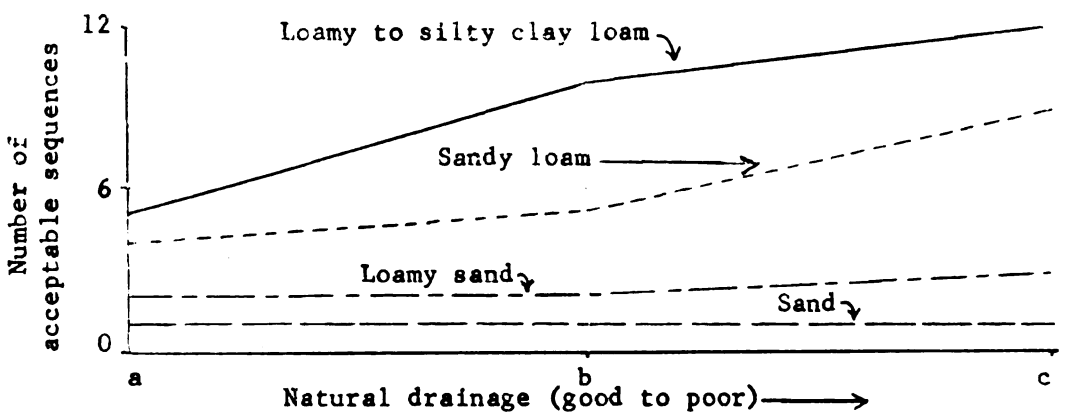

Figure 18. The effect of the natural drainage on the number of acceptable land use sequences under common management.

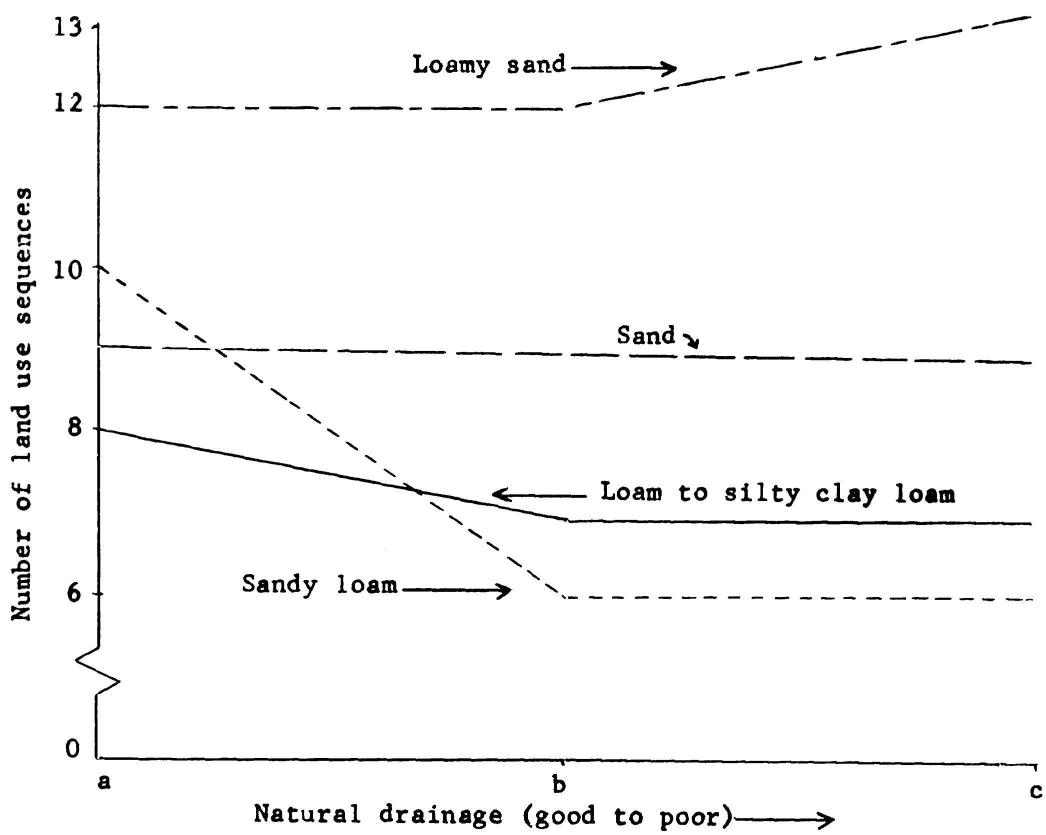

Figure 19. The effect of the natural drainage on the number of acceptable land use sequences under improved management.

for the present price and cost situation. 3) Natural drainage of the soil has an effect on the acceptability of land use sequences. One of the main relationships seems to be that in the more poorly drained soils, there are more acceptable sequences than in the naturally better drained soils of the same texture class under common management as shown in Figures 18 and 19. The most probable reason for this is that in the naturally more well drained soils there is a critical need for moisture at certain times in the growing season: thereby limiting certain land use sequences especially short sequences with a longer duration of corn and wheat. This relationship is not evident in soil management group 5a (sands) under common management and not very evident in any of the soil management units under improved management as shown in Figures 20 and 21.

Oats were eliminated early in this study of cropping sequences because they tended to make any sequence less profitable. This is very important also because it demonstrates that a certain crop if unprofitable, should be removed from the sequence and other suitable crops substituted.

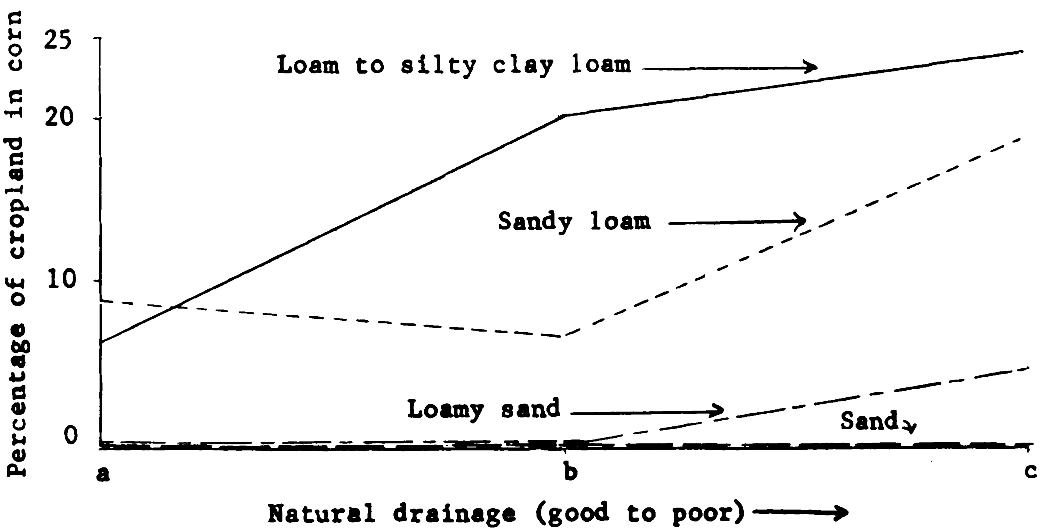

Figure 20. The effect of the natural drainage on the percentage of cropland in corn under common management.

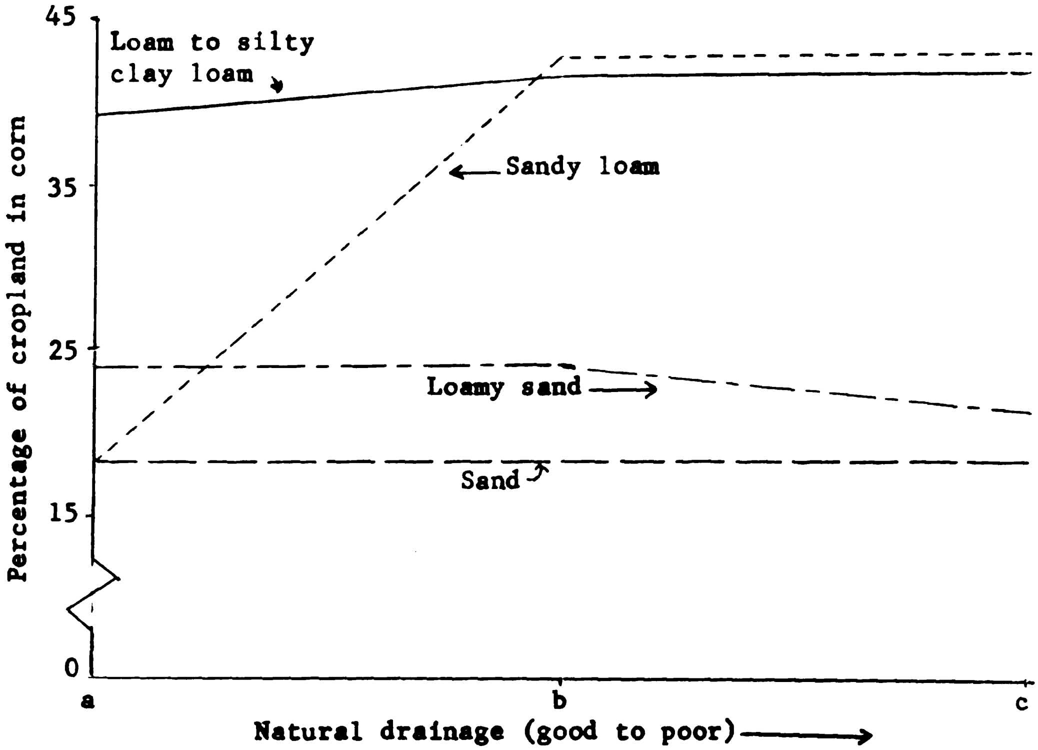

Figure 21. The effect of the natural drainage on the percentage of cropland in corn under improved management.

THE EXPECTED USE OF CROPLAND AND CROP PRODUCTION

It was decided to compare the expected use of cropland, the expected crop production, and the expected crop yields with the current use of cropland, current crop production, and current crop yields. In order to accomplish this, the following procedure was adopted: 1) The percentage of each crop on each soil management group or unit was multiplied by the cropland (L) acreage in that soil management group or unit. The percentages were taken from Tables 10 and 11 and the acreages of cropland (L) in each soil management unit or group were taken from the Conservation Needs Survey. These acreages were then totalled for each crop. 2) These calculated and expected acreages for each soil management unit were multiplied by the expected crop yields for each soil management unit, respectively. These expected yields are identical to the expected yields used earlier to calculate expected gross income. These crop production figures were then totalled for each crop. The cropland (L) in the soil groups under study amounted to 194,863 acres. The total cropland (L) in the two county area was 222,422 acres according to the Conservation Needs Study. Therefore, the acreage totals for each crop and the crop production totals for each crop were multiplied by the factor, $\frac{222,422}{194,863}$, in order to calculate the expected acreages and production of each crop for the two county area. The calculated crop production figures were divided by the calculated acreages to determine average crop yields. Then, the calculated crop acreages, crop production estimates, and average yields for both common and improved management were compared to the current acreage of these crops, the amount of crops produced, and current average yields as reported in the 1954 Census of Agriculture for the two county area (13). These values are listed in Table 14.

It should be noted from Table 14 that under common management less than one-half as much land would be planted to corn for grain and that about one-half as much corn would be produced for grain as is currently produced for grain. Also under common management nearly five times as much land would be seeded to wheat producing three and one-half times as much wheat as the current amount. This, of course, assumes no governmental restriction on acreages. Over twice as much cropland would be in hay under common management as is currently in hay.

Under improved management more than twice as much land would be devoted to corn for grain, with nearly four times as much corn produced for grain as is currently produced. Over four times as much land would be seeded to wheat, under improved management, producing over five times the current amount of wheat. Approximately twice as much land would be in hay under improved management as is currently used for that purpose.

TABLE 14. THE EXPECTED ACREAGES, PRODUCTION AND YIELDS OF CORN, WHEAT, AND ALFALFA UNDER COMMON AND IMPROVED MANAGEMENT COMPARED TO THE CURRENT ACREAGE, PRODUCTION AND YIELDS OF CORN, WHEAT, ALFALFA AND OTHER CROPS

	Corn (grain)			Wheat			Alfalfa	Oats	Corn (silage)	Annual Legumes	Misc.[1]
	Acreage	Production (bushels)	Yield (bu/A)	Acreage	Production (bushels)	Yield (bu/A)	Acreage	Acreage	Acreage	Acreage	Acreage
Common Economic Management	6,246	258,234	41.3	47,026	837,250	17.8	169,149	0	0	0	0
Improved Economic Management	36,156	1,907,150	52.7	44,806	1,395,375	31.1	141,460	0	0	0	0
1954 Census of Agriculture	15,385	505,852	32.9	10,493	274,637	26.2	73,645	21,978	8,944	5,558	3,488

[1]Misc. includes rye, barley, buckwheat, other grains, and grains grown together and thrashed together.

SUMMARY

It was one of the purposes of this study to calculate the expected net incomes from certain crops grown on each soil management unit under two levels of management. Expected net incomes from certain land use sequences were also calculated under the two management levels. The expected net incomes from the crops and land use sequences were compared to determine the most economic use of the land. The improved level of management in all cases produced a higher expected net income than the common level of management. The expected gross income correlated very closely with the expected net income because of the constancy of the expected production costs. The characteristics of the soil were shown to influence the expected net income. Thus, those on the steeper slopes had lower expected net incomes than those on the gentler slopes. The naturally more poorly-drained soils brought about higher expected net incomes than their better drained counterparts. Likewise the expected net incomes on the soils developed from the finer-textured primary materials were higher than those obtained on soils developed from coarser-textured primary materials.

The effects of the level of management were again noted in the results of the sequences which were found to be economically acceptable. The effect of the improved level of management was to nullify some of the effects of soil properties on economic acceptability of certain crop sequences. The longer land use sequences (which most generally includes those sequences containing a larger proportion of small grain and alfalfa) are usually the more economically acceptable.

The characteristics of the soil have an effect on the acceptability of a land use sequence. On the soils that were developed in finer textured primary material, the shorter land use sequences and sequences using less alfalfa are more acceptable than on coarser-textured primary materials. On the steeper slopes the sequences using more alfalfa are more acceptable. In the naturally more poorly-drained soils there are more acceptable land use sequences to choose from and corn occupies the land a greater part of the time.

RECOMMENDATIONS

Several conclusions may be drawn from the results of this study. First, the importance of making an economic analysis in order to plan land use has been shown. Second, the importance of determining the level of management has been clearly demonstrated to be significant in determining the land use program. The importance of knowing the soil management units has also been demonstrated.

NEEDS FOR FURTHER RESEARCH

Throughout the course of this study a number of research needs have been apparent to the writer. These needs are listed here as:

1. Comparisons of economic considerations should not only be cropping but forestry, idle, permanent pasture, and industrial or urban land uses on the various soil management groups or units.
2. Effects of different expected costs and prices on the most economic and technologically acceptable land use on the various soil management groups or units.
3. More accurate yield, production cost and management data on the soil management groups or units.
4. Comparisons of alternative land uses by an economic consideration of the alternative livestock enterprises and their feed requirements in conjunction with various soil groups or units.
5. Determination of the minimum or optimum size of farm on the various soil management groups or units from the above economic consideration of alternative uses.

LITERATURE CITED

1. CLANAHAN, D. L., and HILDEBRAND, S. C. Fact Sheet for Michigan Agriculture Seeding Rates and Weight per Bushel of Field Crops. (Michigan State University, Cooperative Extension Service, Department of Farm Crops) East Lansing, Michigan.

2. ELWOOD, E. M., et al. Farming Today, (Michigan State University, Cooperative Extension Service, Department of Agricultural Economics, A. Ec. 755, Area 10) East Lansing, Michigan, 1959.

3. ELWOOD, E. M., and QUENEMOEN, M. E. Rates for Custom Work in Michigan. (Michigan State University, Cooperative Extension Service, Department of Agricultural Economics, Extension Folder F-161 Rev.) East Lansing, Michigan, 1957.

4. A Guide for the Management of Soils Farm Crops and Pastures in Michigan. (Michigan State University, Departments of Soils, Farm Crops, and Horticulture; Michigan Agricultural Experiment Station; and the Soil Conservation Service, United States Department of Agriculture) East Lansing, Michigan, 1959.

5. Fertilizer Recommendations for Michigan Crops. (Michigan State University, Cooperative Extension Service, Departments of Soil Science and Horticulture, Extension Bulletin E-159 11th Revision) East Lansing, Michigan, 1959.

6. HENEBERRY, W., SCHAIRER, D., and WHITESIDE, E. P. Appraisal of Farm Real Estate in Arenac County for Property Tax Assessment.

7. HILL, E. B., and MAWBY, R. G. Types of Farming in Michigan. (Michigan State University, Agricultural Experiment Station, Department of Agricultural Economics, Special Bulletin 206, 2nd Revision) East Lansing, Michigan, 1954.

8. Michigan Checklist for Areas 3 and 4. (National Plant Food Institute, Midwest Regional Office in Cooperation with Michigan State University).

9. NIELSON, J., and BITTNER, R. F. Farm Practice Adoption in Michigan. (Michigan State University, Agricultural Experiment Station, Department of Agricultural Economics, Technical Bulletin 263) East Lansing, Michigan, 1958.

10. SCHNEIDER, I. F., et al. Soils and Their Management Needs Sanilac County, Michigan. (Michigan State University, Soil Science Department and the Soil Conservation Service, United States Department of Agriculture) East Lansing, Michigan.

11. SWANSON, E. R. Highest Return Farming Systems for Drummer-Flanagan Soils. (University of Illinois, Agricultural Experiment Station Bulletin 629) Urbana, Illinois, 1958.

12. UNITED STATES DEPARTMENT OF AGRICULTURE, Soil The Yearbook of Agriculture 1957. (85th Congress, 1st session; House Document No. 30.) Washington, D. C.: Government Printing Office, 1957.

13. UNITED STATES BUREAU OF THE CENSUS, United States Census of Agriculture 1954, Vol. 1 Counties and State Economic Areas, Part 6 Michigan, U. S. Government Printing Office, Washington, D. C., 1956.

APPENDIX

An example of the budget method used in this study is given below for both management levels. The example is for corn planted on management unit 26A.

Common Management

Expected gross income (45 bu. x $1.34)		$60.30
Plowing	$ 5.00	
Discing	1.50	
Dragging	1.25	
Planting	1.75	
Fertilizer	5.35	
Seed	2.00	
Cultivation (3X)	4.50	
Picking and shelling	7.50	
5% interest on land	6.29	
Sub-total	35.14	
10% misc.	3.51	
Total Expected Production Cost		$38.65
Expected Net Income		$21.65

Improved Management

Expected gross income (70 bu. x $1.34)		$90.30
Plowing	$ 5.00	
Discing	1.50	
Dragging	1.25	
Planting	1.75	
Total	9.50	
60% of 9.50	5.70	
Fertilizer	15.05	
Seed	2.00	
Cultivation (2X)	3.00	
Picking and shelling	7.50	
5% interest on land	6.29	
Sub-total	39.54	
10% misc.	3.95	
Total Expected Production Cost		$43.49
Expected Net Income		$50.31