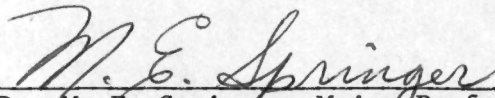


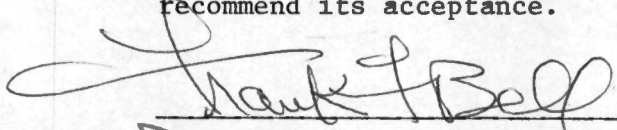
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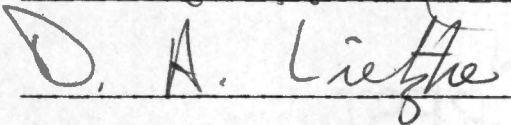
I am submitting herewith a thesis written by Mohd Safiai Saad entitled "Adaptation Of The Universal Soil Loss Equation To Complex Slopes As A Guide For Soil Conservation." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Plant and Soil Science.



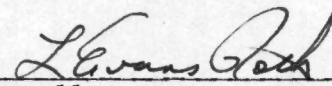
Dr. M. E. Springer, Major Professor

We have read this thesis and
recommend its acceptance.





Accepted for the Council:



Vice Chancellor
Graduate Studies and Research

ADAPTATION OF THE UNIVERSAL SOIL LOSS EQUATION
TO COMPLEX SLOPES AS A GUIDE FOR SOIL
CONSERVATION

A Thesis

Presented for the

Master of Science

Degree

The University of Tennessee, Knoxville

Mohd Safiai Saad

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ABSTRACT

Milan Field Station, Ames Plantation, and Knoxville Plant and Soil Science Farm were chosen for comparison of different methods of predicting the effect of length and steepness of slope on soil erosion.

Methods used to predict soil loss from a sample two segment slope were: old, addition, average LS, average slope, Fort Worth, substitute, and Wischmeier method. Predicted soil losses differed among methods because of the way length and steepness of slope were considered. The Wischmeier method is probably the most accurate because of the way it handles complex slopes. The substitute method is next best. Average slope, average LS and Fort Worth methods seem to predict close to Wischmeier method only on some situations. The old and addition method exaggerate the amount of soil loss.

Necessary cropping management systems and support practices (NCP) to keep soil loss within tolerance were used to estimate susceptibility of each piece of land to erosion. A set of NCP values of >0.32 , $0.16-0.32$, $0.08-0.16$, $0.08-0.4$, $0.02-0.04$, and <0.02 were chosen as breaks between isoerodent classes. On slopes of average length, these values compared favorably with land subclasses I, II ℓ , III ℓ , IV ℓ , VI ℓ and VII ℓ respectively.

Isoerodent maps by the old, average LS, and Wischmeier methods were drawn on a sample portion of Milan Field Station. Points of equal NCP were joined together to form isoerodent lines as a means of estimating erosion hazard. High NCP values suggest lower soil loss and low NCP values predict higher soil loss. Results showed that the old method predicted

higher soil loss and average LS predicted lower soil loss than the Wischmeier method. For the first segment of the slope, all methods gave identical results. Differences occurred because of the way the second segment of the slope was handled.

Nomographs were developed for each location. The function of these nomographs was to quickly determine NCP for a given length of slope, and also to find length of a simple slope for a given NCP. Thus they duplicate one function of a slide rule calculator.

For comparison with land capability subclasses 2 map (LCC2), the Wischmeier method was chosen to draw isoerodent maps for the three areas. These isoerodent maps are useful, because on complex slopes they predict erosion more accurately than either the LCC2 map or the slide rule calculator. Both isoerodent maps and slide rule calculator predict erosion more accurately than LCC2 maps except on simple slopes of average length. Since the maps are based on NCP, they are useful for designing conservation plans.

The Wischmeier method of predicting soil erosion on complex slopes and NCP isoerodent maps based on this method certainly are useful tools for planning soil conservation. For complex slopes the predictions are more precise than either LCC2 maps or the various methods which use the slide rule calculator.

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CHAPTER I

INTRODUCTION

Soil is a basic resource that can be lost through erosion. Soil erosion occurs wherever rainfall strikes bare soil or runoff water flows over erodible and insufficiently protected soil. Conservationists have appreciated the importance of protecting surface soil and have searched for ways to reduce erosion of soil by water. Estimating the susceptibility of each piece of land to erosion is one part of any plan to control erosion.

Land capability 2 subclasses have been used for planning erosion control measures, but they give too little emphasis to length of slope on either simple or complex slopes. A Universal Soil Loss Equation (USLE) has been used widely to evaluate erosion. Length and steepness of slope are considered important elements in the equation. Foster and Wischmeier (7) introduced the effect of shape and irregularity of slope on erosion.

The objectives of this thesis were to:

1. Compare the predicted losses by the USLE on complex slopes by (a) old method, (b) average LS method, and (c) Wischmeier method.
2. Prepare maps showing lines of equal necessary cropping management systems and support practices on parts of Knoxville Plant and Soil Science Farm, Milan Field Station, and Ames Plantation.

3. Evaluate these maps as simple guides for planning erosion control.

CHAPTER II

SELECTED LITERATURE REVIEW

Erosion of soil by water is a major problem because it reduces productivity of cropland, degrades water quality and reduces the quality of aquatic life (4, 13). Row crop farming practices, particularly on steep slopes, have caused severe erosion (2, 4). The loss of surface soil by erosion has gained attention from various authors (1, 12, 26, 28). They reported that yields on uneroded soil are much higher than on eroded soil.

Soil scientists and other conservationists publish soil survey reports that aim to explain the nature of soils and how to improve the art of using soil (3, 6, 20, 24). Kellogg (14) reported that interpretations are made about the capabilities of soil for crop adaptation, and soil limitations such as slope, degree of erosion, and drainage conditions. Devasigamoney (5) listed the natural characteristics of soils, their limitations, and used the Universal Soil Loss Equation (USLE) to suggest improved soil management.

A Soil Loss Equation was started in 1940 in the corn belt states. This equation was simply known as a slope practice method. It dealt specifically with soil loss rates in relation to length and steepness of slope (19, 41). In later years various factors were added to this equation which was later called the Universal Soil Loss Equation (USLE) (31). It is stated as $A=RKLSCP$, where A is annual soil loss in tons per acre per year, R is the rainfall and runoff factor (32, 34, 35), K is

the erodibility factor (38), L is the slope-length factor (39, 41), S is the slope-steepness factor (39, 41), C is the cover and management factor (31, 33, 37), and P is the support practice factor (31, 36). Other factors are occasionally added to improve the accuracy of the equation (8, 9).

The Universal Soil Loss Equation was designed primarily to predict soil loss from sheet and rill erosion. This equation has its limitations and should not be misused to predict other soil loss (40). Mayer et al. (17) used the equation to find sediment yield from roadside banks. Springer et al. (25) made use of this equation to find necessary cropping management systems for farm situations. Devasigamoney (5) used this equation to find necessary cropping management systems and support practices to keep soil loss within tolerance on simple slopes. Both authors (5, 25) tried to relate necessary cropping management systems and support practices with the length and steepness of simple slopes.

The length of the slope and its steepness are indeed important aspects to consider when determining soil loss (18, 31, 39, 41). Zingg (42) in his study of the effect of length of slope on soil loss concluded that soil loss per unit area varies as the 0.6th power of slope length. Musgrave (19) proposed 0.35 as the average value for slope length exponent for soil loss per unit area. Maddy and Thorenson (16) reported that if length of slope is doubled the erosion increases 1.5 times; if the slope steepness is doubled the erosion increases 2.5 times. Zingg also concluded in his study that soil loss varies as the 1.4 power of percent slope. Wischmeier (31) related soil loss and slope percentage by the equation $A = 0.43 + 0.30S + 0.04S^2$ (S is the slope percentage).

Slope length and slope steepness when tied together are known as topographic factor (LS). Wischmeier (36) proposed the equation $LS = \sqrt{\lambda} (0.0076 + 0.0053S + 0.00076S^2)$ (S is the slope percentage, λ is the slope length in feet) to relate the length and steepness of slope. In a later paper (41) he proposed $LS = (\lambda/72.6)^m (65.41 \sin^2 \theta + 4.56 \sin \theta + 0.065)$ where λ = slope length in feet, θ = angle of slope; and $m = 0.5$ if percent slope is 5 or more, 0.4 on slopes of 3.5 to 4.5%, 0.3 on slopes of 1 to 3%. Determination of LS is important for evaluating erosion. Williams (29) stated that LS is one of the most important factors in the Universal Soil Loss Equation because it accounts for more variation in gross erosion than any other factor except possibly the cropping management factor. He further stated that LS is particularly sensitive to error in measuring average slope when slope is above 3%. Roose (22) argued that this topographic factor LS is surely a weak point of Universal Soil Loss Equation because "the influence of slope is not independent of vegetal cover, cultural technique, soil, and probably climate."

For slopes that have uniform gradient, LS value for a given combination of length and steepness are given by published slope effect charts (41). When the slope is complex, its overall average gradient and length do not correctly give the LS of the slopes. Wischmeier (39) suggested two methods for determining LS to solve soil loss for complex slopes. For the first method, he proposed that when certain assumptions are made, complex slopes can be divided into a small number of equal length segments such that gradient within each segment could be considered uniform. He listed

adjustment factors to be multiplied with LS from the slope-effect chart to give LS for the entire slope. He then proposed another method (7) of dealing with irregular slopes by modifying LS in the Universal Soil Loss Equation where:

$$LS = \left[\frac{\sum_{j=1}^n (S_j \lambda_j^{1.5} - S_j \lambda_{j-1}^{1.5})}{\lambda (72.6)^{0.5}} \right].$$

He published a chart which gave solutions to this equation for various slope lengths and steepness.

Mapping of erosion hazard is one way to improve soil management. Grose (11) mapped erosion hazard of an area by making measurements of the A horizon thickness. Richter (21) discussed a morphometric map which showed inclination of the area, and calculated erosion by assigning grades that took into account the main factors which influenced soil erosion. Williams et al. (30) used aerial photographs to map soil erosion hazard. He compared a direct stereoscopic image with ground survey to evaluate erosion. Grant et al. (10) mapped erosion hazard by calculating soil loss using the Universal Soil Loss Equation and dividing average annual soil loss into five classes, 0-3 tons, 3-10 tons, 10-25 tons, 25-50 tons, 50-100 tons per acre per year. Each of these classes is colored for easy recognition.

The soil Conservation Service (SCS) of the USDA has developed a land classification system by which lands have been categorized according to their potential or hazard (6, 15). The land capability classification is divided into eight land classes. Each class has its own limitation or hazard of about the same degree, but of different kind as shown by

subclasses. Limitations increase from class I to class VIII. There are four subclasses: e-erosion, w-water, s-root-zone limitation, c-climate. In this study only subclass c is emphasized. Usually an average length of slope is assumed in assigning land capability subclass c to given soils.

CHAPTER III

MATERIALS AND METHODS

Three methods of evaluating erosion were compared, namely the old method, average LS method, and Wischmeier method. The Wischmeier method was then used to draw isoerodent maps showing lines of equal necessary cropping management systems and support practices values as a contour map shows elevation. The maps were compared with maps of land capability subclasses *c*.

Field Work

Three areas were selected: two in West Tennessee (parts of Milan Field Station and Ames Plantation) and one in East Tennessee (parts of Knoxville Plant and Soil Science Farm). The soil map for Ames Plantation was obtained from the soil survey of Fayette County (6). Detailed soil surveys of the Milan Field Station and Knoxville Plant and Soil Science Farm were used for soil information. These soil maps furnished necessary information such as soil mapping units, soil series, slope classes and erosion classes. Erodibility factors (*K*) and soil loss tolerance (*T*) of the soils, were obtained from a report of the Soil Conservation Service (23). In two cases exceptions to the values listed in (23) were made. For Memphis silt loam, *K* of 0.43 was used to give a *T/K* of 12. For Loring silt loam, *T* of 4 was used to give a *T/K* of 9. Thus for Memphis and Loring *T/K* values of 12 and 9 were used rather than 14 and 7.

As a first step in predicting erosion, the top of each ridge had to be determined. A ridge is defined as the line of high points from

which water will flow in both directions when it rains. To show direction of water flow, arrows were drawn from the top of the ridge to the area of deposition at the foot of the slope. Length of slope was measured from beginning of overland flow (high point) to the point where any sediment the water carried reached a defined drainageway (low point). Observations were made to determine if there was a change in gradient. Where there was a change in gradient, one slope gradient was determined from the beginning of first segment to the beginning of the second segment. Gradients of other segments were measured between the lower end of the segment above to either the upper end of the segment below or to the point where runoff is concentrated in a watercourse. The gradient was determined with a hand-held Abney level.

One method of predicting soil loss is calculating the amount of soil loss per acre per year for each combination of management systems and practices. A second is selecting a value for cropping management systems and practices necessary to keep soil loss within tolerance. Such a necessary CP (NCP) predicts the susceptibility of each piece of land to erosion.

Method of Calculating Necessary CP (NCP)

The Universal Soil Loss Equation is expressed as:

$$A = R K L S C P \text{ ----- (i)}$$

when erosion is to be limited within a predetermined tolerance T, the term A in the equation is replaced by T, the equation becomes:

$$T = R K L S C P \text{ ----- (ii)}$$

Dividing both sides by R K L S

$$\frac{T}{R K L S} = C P \text{ ----- (iii)}$$

Rearranging the equation (iii) it becomes:

$$T/K \times 1/R \times 1/LS = CP \text{ ----- (iv)}$$

Therefore, knowing T/K and R, from equation (iv) NCP could be found for any given LS. In other words, if length and steepness of slope were known, LS could be read from the slope effect chart published in Predicting Rainfall Erosion Losses - A Guide to Conservation Planning (41). Nomographs were developed for matching NCP and LS for several R values. Each consisted of a slope effect chart and NCP at various T/K values as shown in Figure 1. It related NCP to soil loss ratio LS, for specific R. This nomograph helps a farmer to determine alternative cropping systems for a slope or field. When steepness is known, this nomograph is also used to find length of slope for a given NCP.

NCP's of 0.32, 0.16, 0.08, 0.04, and 0.02 were arbitrarily chosen as breaks between NCP classes. These NCP classes were chosen for comparison with the land capability subclasses 2. Points of equal NCP may be connected just like a contour line is drawn to show equal elevations.

Methods of Determining NCP by Old Method, Average LS Method, and Wischmeier Method

Old Method

Select a certain two segment slope, for example, first segment 340 feet at 2%, second segment 300 feet at 5%, and T/K of 12.

1. To determine the length of slope for NCP of 0.32 place a ruler on the chart at NCP of 0.32 and read length of slope where the ruler intersects the known steepness of slope.
(Read 30).

Fig. 1. Nomograph for determining NCP for use in selecting conservation practices and management levels.

Instruction for determining NCP using the nomograph in Fig. 1.

1. Determine the percent slope of the mapping unit.
2. Determine the length of slope.
3. Look up T/K for the mapping unit in appropriate table.
4. Read the LS where length of slope crosses the percent slope.
5. Place the ruler at that LS and read NCP opposite it. This is CP necessary to keep soil loss within tolerance T.
6. The cropping systems that appear above the line of a given T/K are the alternative cropping systems acceptable with that practice.
7. Select one that is suited to your farm.

Instructions for determining the length of slope when NCP is fixed.

1. Determine the slope steepness.
2. Look up T/K for the mapping unit in appropriate table.
3. Find the desired NCP on the right hand side.
4. Place a ruler on the desired NCP under T/K for the unit and read the length of slope at a point where slope percentage is crossed.

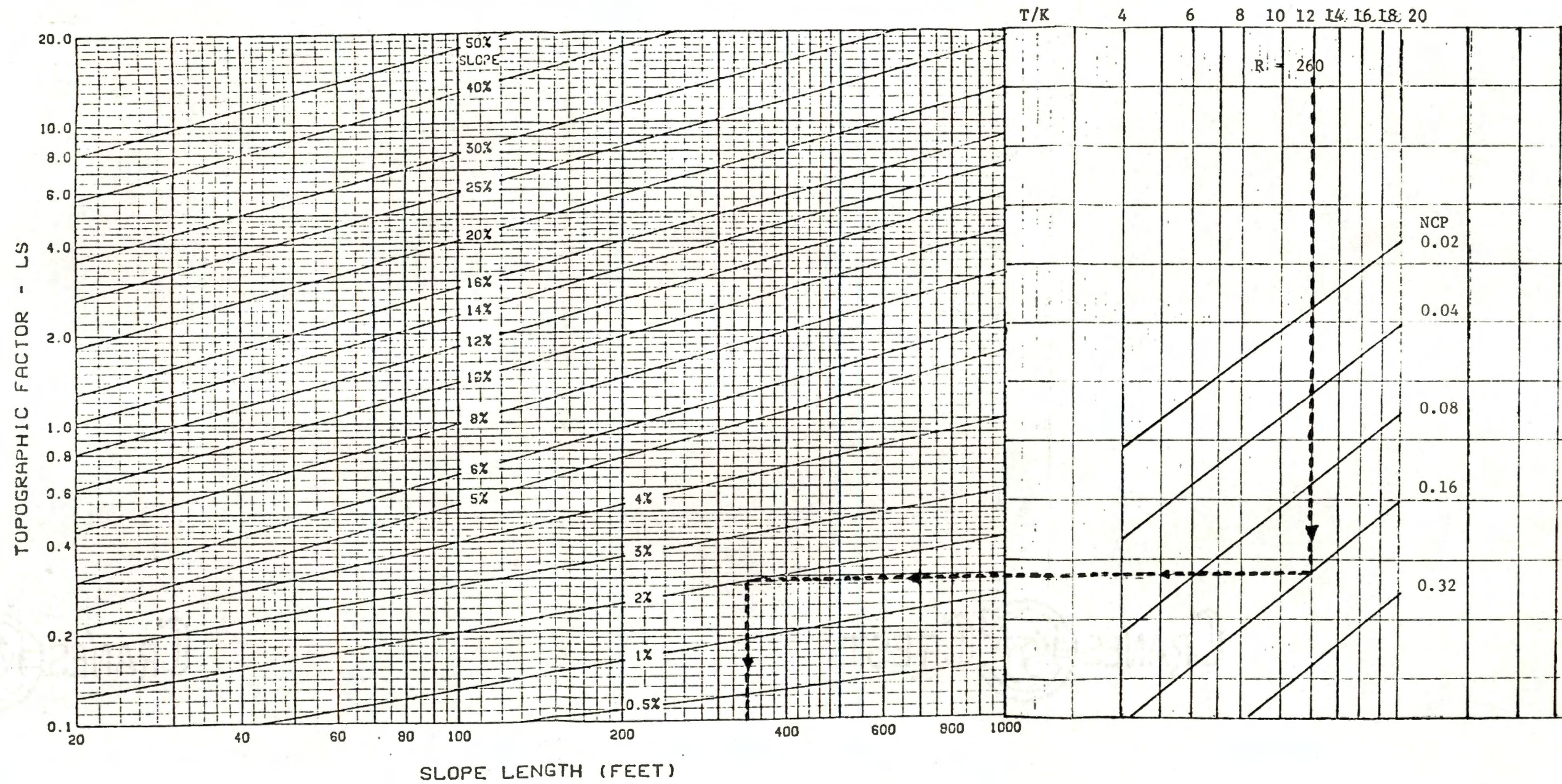


Figure 1.

2. Begin at the ridge and locate this point on the slope arrow.
3. Then locate the point for NCP of 0.16 by placing ruler on the nomograph at 0.16 and the given slope gradient. Read the length of slope as stated in Step 1. (Read 340)
4. If segment one length has been covered, then locate total length for NCP of 0.08 using slope percentage of segment two. (For complex slope only)
5. For NCP of 0.04, locate the total length on the slope by using percentage of segment two. (Read 460)
6. Proceed with other isoerodent classes until the entire slope has been covered.

Average LS Method

1. Determine lengths and slope percentages of the first and second segments.
2. Use formula given:

$$\frac{(L1 \times LS1) + (L2 \times LS2)}{L1 + L2} = LS$$

where,

L1 = length of first segment

LS1 = topographic factor for first segment length

L2 = length of second segment

LS2 = topographic factor for second segment length

LS = average topographic factor

3. Use the slope effect chart (Fig. 1) to find LS1 and LS2 and fill the table below:

L1	LS1	L2	LS2	L1LS1	L2LS2	LS
340	0.29	300	0.925	89.6	277.5	0.59

4. Locate LS for one of the NCP classes by placing a ruler under the appropriate T/K on Fig. 1. (Example: for NCP of 0.16, LS is 0.29).
5. From formula at Step 2, L2 could be found by letting the equation equal LS for each of the NCP classes obtained in Step 4.
6.
$$\frac{(L1 \times LS1)}{L1} + \frac{(L2 \times LS2)}{L2} = LS \text{ for each of the NCP classes.}$$
 Since L1, LS1, and LS2 are known, L2 could be found by solving the equation.
7. L2 obtained by the equation is then plotted on the slope at segment two.
8. Then proceed with other NCP classes.

Wischmeier Method

1. Determine the length and steepness of the first and second segments of the slope.

2. Use Foster and Wischmeier chart (7) (Appendix A) to find necessary values to fill the table below:

segment	λ_j	λ_{j-1}	U2	U1	U2-U1	segment L	LS
1	340	0	110	0	110	340	0.31
2	640	340	800	300	500	300	1.67
Entire slope					610	640	0.95

where:

λ_j = length of first segment

λ_{j-1} = length of segment above λ_j

U2 = vertical axis of Foster and Wischmeier chart λ_j

U1 = vertical axis of Foster and Wischmeier chart λ_{j-1}

segment L = length of segment

$$LS = \frac{U2 - U1}{L}$$

3. Locate LS for each NCP class by placing a ruler at the NCP under the appropriate T/K on Fig. 1 and reading LS.
4. When the LS for each NCP class has been determined, again use Foster and Wischmeier chart to estimate the length of the slope to correspond to required LS for each NCP class.
5. Locate the length obtained with a point on the slope arrow, since this is the length of slope within NCP class desired.

Drawing of Isoerodent Map Using Wischmeier Method

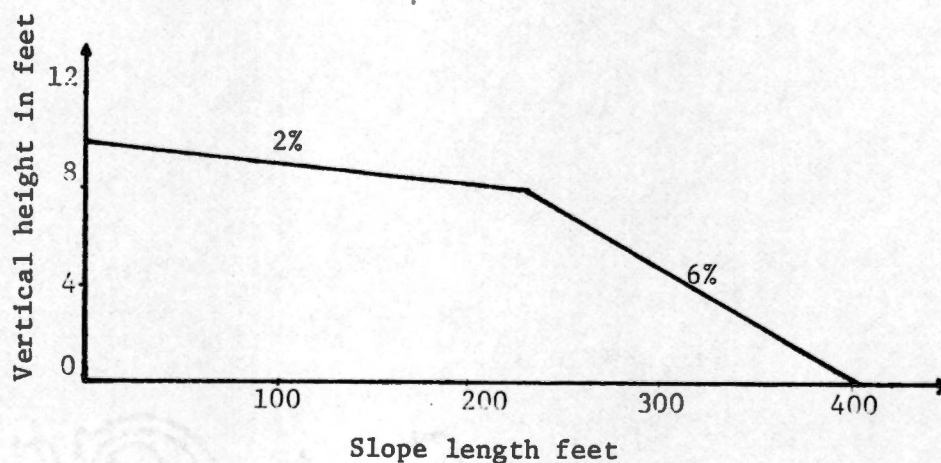
1. For all slopes having same ridge line, use the Wischmeier method to locate points between NCP classes on each slope arrow.
2. Connect points of equal NCP values.
3. Proceed for other ridge lines.
4. The result is an isoerodent map.

CHAPTER IV

RESULTS AND DISCUSSION

I. PREDICTING SOIL LOSS FROM A COMPLEX SLOPE BY THE OLD, ADDITION, AVERAGE LS, FORT WORTH, AVERAGE SLOPE, SUBSTITUTE, AND WISCHMEIER METHOD

A simple example shows how each method is used to find soil loss from Milan Field Station in West Tennessee under given cropping systems and practices.



CP	0.16
Length of first segment	231 ft.
Length of second segment	182 ft.
Slope steepness of first segment	2%
Slope steepness of second segment	6%
R for Madison County	260
K of Memphis silt loam	0.43

Old Method

In the old method, use 413 ft for length and for steepness 6%. Refer to Fig. 1 for LS:

$$\begin{aligned}
 A &= R K LS CP \\
 &= 260 \times 0.43 \times 1.35 \times 0.16 \times 1 \\
 &= 24.1 \text{ tons/acre/yr}
 \end{aligned}$$

Addition Method

Find the soil loss from first segment. Then find soil loss from second segment by using steepness of second segment and total length of both segments. Add them together:

First segment:

$$\begin{aligned}
 A &= R K LS CP \\
 &= 260 \times 0.43 \times 0.25 \times 0.16 \times 1 \\
 &= 4.47 \text{ tons/acre/yr}
 \end{aligned}$$

Second segment:

$$\begin{aligned}
 A &= R K LS CP \\
 &= 260 \times 0.43 \times 1.35 \times 0.16 \times 1 \\
 &= 24.1 \text{ tons/acre/yr}
 \end{aligned}$$

Average soil loss from the entire slope:

$$\begin{aligned}
 &= 4.47 + 24.1 \\
 &= 28.6 \text{ tons/acre/yr}
 \end{aligned}$$

Average LS Method

$$\text{Average LS} = \frac{(L1 \times LS1) + (L2 \times LS2)}{L1 + L2}$$

$$= \frac{(231 \times 0.25) + (182 \times 0.92)}{231 + 182}$$

$$= \frac{57.8 + 167.4}{413}$$

$$= 0.55$$

$$A = R K L S C P$$

$$= 260 \times 0.43 \times 0.55 \times 0.16 \times 1$$

$$= 9.8 \text{ tons/acre/yr}$$

Fort Worth Method

$$\text{Average soil loss from entire slope} = \frac{(A1 \times L1) + (A2 \times L2)}{L1 + L2}$$

where;

A1 = average soil loss from first segment

L1 = length of first segment

A2 = average soil loss from second segment based on steepness
and length of second segment

L2 = length of second segment

$$= \frac{(4.47 \times 231) + (16.5 \times 182)}{413}$$

$$= \frac{(1033) + (3003)}{413}$$

$$= 9.8 \text{ tons/acre/yr}$$

Average Slope Method

$$\text{Average slope} = \frac{(231 \times 2) + (182 \times 6)}{231 + 182}$$

$$= 3.8\%$$

LS for 413 ft at 3.8% = 0.62

$$A = R K LS CP$$

$$= 260 \times 0.43 \times 0.62 \times 0.16 \times 1$$

$$= 11.1 \text{ tons/acre/yr}$$

Substitute Method

Average soil loss from the entire slope:

$$= \frac{(A1 \times L1) + (A2 \times L2)}{L1 + L2}$$

where;

A1 = average soil loss from first segment

L1 = length of first segment

A2 = average soil loss of second segment based on
steepness of second segment and total length (L1 + L2)

L2 = length of second segment

$$= \frac{(4.47 \times 231) + (24.1 \times 182)}{413}$$

$$= \frac{1033 + 4386}{413}$$

$$= 13.1 \text{ tons/acre/yr}$$

Wischmeier Method

Segment	λ_j	λ_{j-1}	U2	U1	U2-U1	segment L	segment LS
1	231	0	72	0	72	231	0.30
2	413	231	520	215	305	182	1.67
Entire slope					377	413	0.91

$$\begin{aligned}
 A &= R K LS CP \\
 &= 260 \times 0.43 \times 0.91 \times 0.16 \times 1 \\
 &= 16.3 \text{ tons/acre/yr}
 \end{aligned}$$

These examples show how each method is used to examine soil loss on the whole slope. The old method used the length of the entire slope and steepness of the second segment to calculate soil loss. Addition of soil losses from both slope segments as done by some workers was also presented. The average LS method used the entire slope length and an average of LS from each segment. Average soil loss by the Fort Worth method (27) was obtained by dividing the sum of soil loss from the first segment plus soil loss from the second segment, based only on length of the second segment, by total length of both segments. The Wischmeier method used calculations based on length and steepness of both slope segments. Predicted amounts of soil loss from the same slope varied, depending on the method used. Soil loss from the sample slope is 24.1 tons/acre/yr by the old method, 28.6 tons/acre/yr by the addition method, 9.8 tons/acre/yr by both average LS and Fort Worth method, 11.1 tons/acre/yr by average slope method, 13.1 tons/acre/yr by substitute method and 16.3 tons/acre/yr by the Wischmeier method. Addition of soil losses from both slope segments exaggerates soil loss and was not used in this study. Since the Wischmeier method is based on the best available information, it is probably most accurate. The substitute method is next best in order of accuracy and may be adequate for many situations.

II. COMPARISON OF THE OLD METHOD, AVERAGE LS METHOD, THE WISCHMEIER METHOD, AND LAND CAPABILITY SUBCLASSES *e*

A sample slope of Milan Field Station Fig. 2 was chosen, in which the first segment was 2%, 231 feet long, and the second segment was 6%, 182 feet long on Memphis silt loam, having T/K of 12. These curves, based on NCP values, show that prediction of erodibility will vary if length and steepness of both segments of the slope are considered by different methods of evaluation.

NCP values are inversely related to soil loss from continuous fallow. The higher NCP values predict less soil loss from the given field. The lower NCP values predict more soil loss. It can also be interpreted that as NCP values increase, more choices of cropping systems are available to keep soil loss within tolerance. Fewer conservation measures are needed to protect the soil from loss.

For comparison of NCP with land capability subclasses *e*, breaks between NCP classes were arbitrarily chosen as given:

<u>NCP classes</u>	<u>Land capability subclasses <i>e</i></u>
>0.32	I
0.16 - 0.32	II <i>e</i>
0.08 - 0.16	III <i>e</i>
0.04 - 0.08	IV <i>e</i>
0.02 - 0.04	VI <i>e</i>
<0.02	VII <i>e</i>

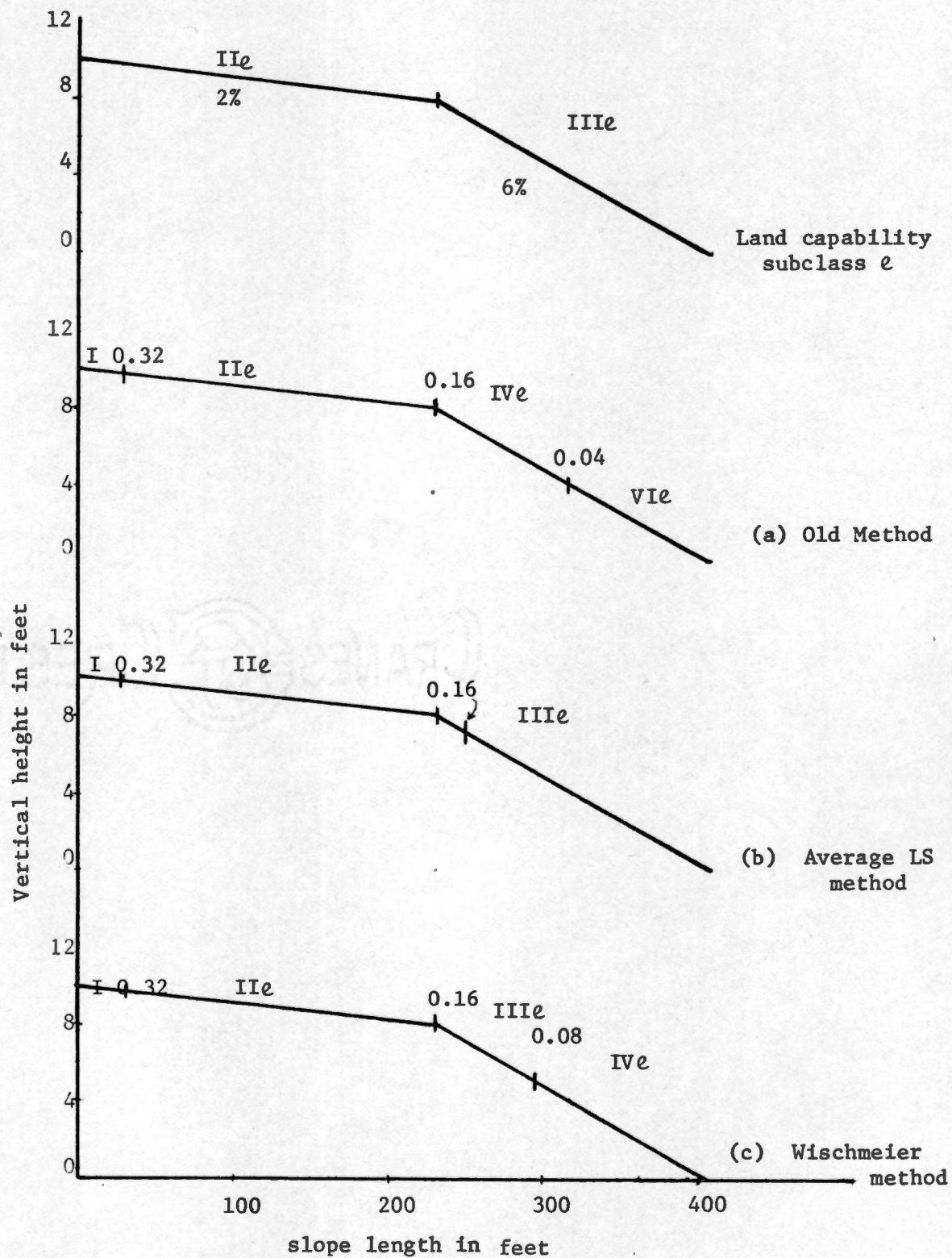


Fig. 2. Comparison of land capability subclasses *e* to NCP values by the (a) old, (b) the average LS, and (c) the Wischmeier methods.

For the entire slope, Fig. 2(a), the old method showed NCP of >0.32 , $0.16-0.32$, $0.04-0.08$, and $0.02-0.04$ which if expressed as land subclasses become I, II, IV, and VI. The average LS method Fig. 2(b) had NCP of >0.32 , $0.16-0.32$, and $0.08-0.16$, depending on distance from the ridge, which if expressed as land subclasses are I, II and III. The Wischmeier method Fig. 2(c) gave NCP of >0.32 , $0.16-0.32$, $0.08-0.16$ and $0.04-0.08$. When converted to land subclasses, these were I, II, III and IV. The standard land capability subclasses e showed subclasses II and III. For these slopes, standard land capability subclasses e pictured a less serious erosion hazard than the Wischmeier method and the old method, but more than the average method.

All methods except land capability subclass e showed a small part of NCP of >0.32 and mainly $0.16-0.32$ for the first segment. They differed considerably for the second segment. The old method showed NCP of $0.04-0.08$ (IV) and $0.02-0.04$ (VI). The average LS method showed the second segment to have a little NCP of $0.16-0.32$ (II) and much $0.08-0.16$ (III). The Wischmeier method showed NCP of $0.08-0.16$ (III) and $0.04-0.08$ (IV). The standard land capability subclasses e indicated subclass III.

Thus these examples show how combination of complexity with length of slope brings out differences in prediction of erosion. For the first segment of slope, the three methods produced identical results. For the second segment the old method showed NCP of $0.04-0.08$ (IV) and $0.02-0.04$ (VI). Thus, these low NCP values suggest more soil loss than the Wischmeier method. The NCP values of $0.16-0.32$ (II) and $0.08-0.16$

(111e) for average LS method suggest less soil loss than the Wischmeier method which showed NCP of 0.08-0.16 (111e) and 0.04-0.08 (1Ve). This shows that the Wischmeier method predicted soil loss between the old and the average LS methods. This agrees with calculation of soil loss in Part One. The Wischmeier method probably predicted erosion hazard more precisely than the other two methods since it effectively dealt with second slope segment. Both the old and average LS method recognized the importance of slope length but these methods are less precise than the Wischmeier in solving complex slope situations. Land capability subclasses e also did not recognize the specific length of slope in any soil mapping unit delineation.

The Wischmeier method recognizes that slopes are concave, or convex or a series of concave-convex. The LS factor of such slope situations cannot be determined accurately by the average LS method. Each segment of irregular slope should not be treated as an independent slope when water flows from one segment to another. The old method does not consider the steepness of the first segment when evaluating erosion of the second segment of slope. Nevertheless, the entire slope length is considered.

The old method could be used to determine erosion easily and quickly with the use of Universal Soil Loss Equation Slide Rule Calculators, developed by Springer, et al. (25), and modified in 1978 by the Soil Conservation Service. These calculators can be used to find annual soil loss and NCP for any given slope. They can also be used to find slope length and steepness at a desired NCP. The slide rule calculator developed by Springer et al. (25) was based on an old LS chart, while the new

slide rule calculator was based on new LS chart (41). They gave similar results when used in simple slope situations, but neither was able to deal with complex slopes.

The average LS method recognizes that length and steepness of slope of two segments are important in predicting the overall effect of the entire slope on erosion. The main advantage of the average LS method is the ease of predicting erosion on the field. Its danger lies in minimizing the erosion problem. Both slide rule calculators can be used for the average slope method after average slope is calculated. The Wischmeier method could be used quickly and easily if a simple way could be found to read LS for complex slope. The slide rule calculator cannot do that.

III. COMPARISON OF ISOERODENT MAPS BY THE OLD, THE AVERAGE LS, AND THE WISCHMEIER METHOD TO LAND CAPABILITY SUBCLASS e MAP

In earlier discussion, curves were used to show differences among old method, average LS method and the Wischmeier method on one slope transect. In this part of the discussion, isoerodent maps of Milan Field Station were drawn by the three methods to demonstrate the field differences among the methods.

Figure 3(a) shows that standard land capability subclasses e (LCC e) map placed Memphis silt loam (11 B2) and Loring silt loam (12 B2) in land subclass II e , while Memphis silt loam (11 C3) was placed in subclass III e . Slope measurements found slope segments of 2% and 6% on

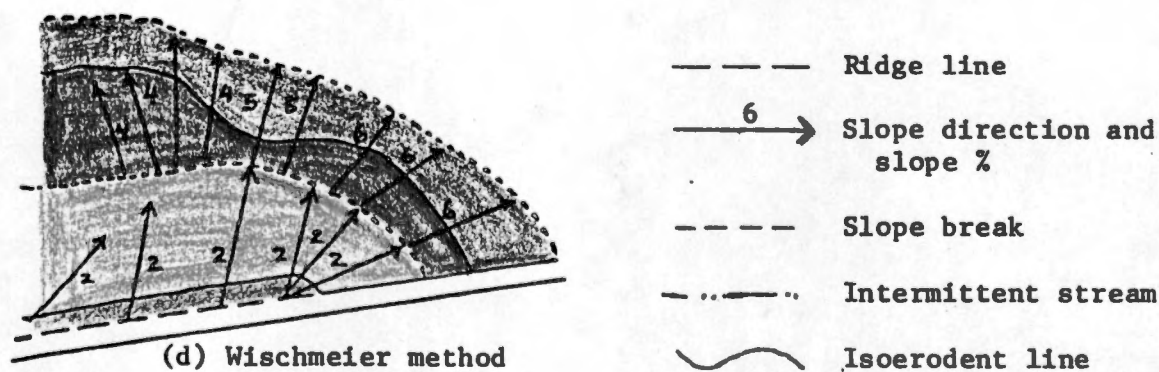
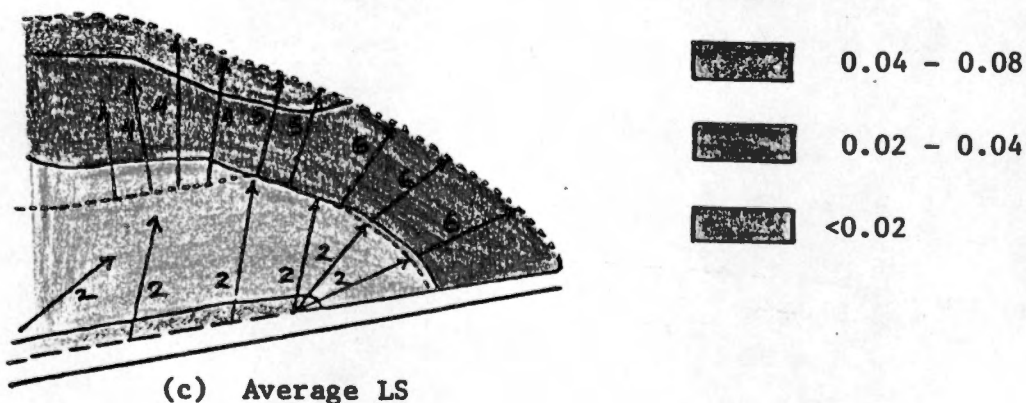
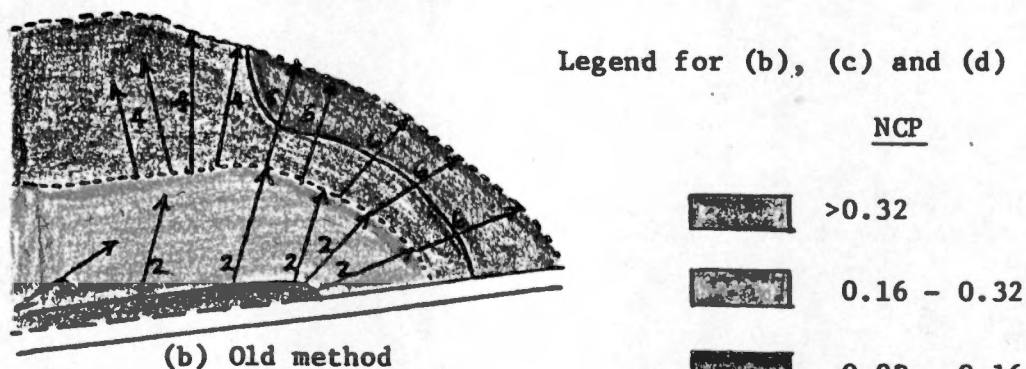
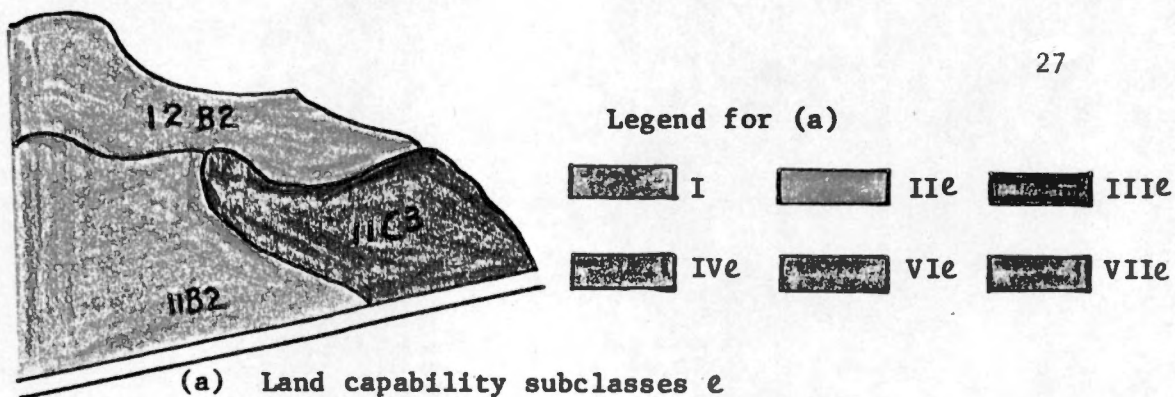


Fig. 3. Comparison of (a) land capability subclasses e to isoerodent maps based on NCP by the (b) old method, (c) average LS method and (d) Wischmeier method.

Memphis silt loam. The second segment on Loring silt loam was 5%.

On the first segment the three methods had NCP of >0.32 (I) and $0.16 - 0.32$ (II₂).

When slope steepness and length were measured, the three methods gave a different picture of erosion hazard. The differences occurred on the second segment of the slope. Results by the three methods differ from the LCC₂ map and also differ from each other. On the second segment, the old method Figure 3(b) indicated much of NCP class $0.04 - 0.08$ (IV₂) and NCP of $0.02 - 0.04$ (VI₂) but showed no NCP of $0.08 - 0.16$ (III₂). The average LS method Figure 3(c) classified a little of the second segment into NCP of $0.16 - 0.32$ (II₂) and much into NCP of $0.08 - 0.16$ (III₂). A small part was $0.04 - 0.08$ (IV₂). In contrast to the other two methods, the Wischmeier method Figure 3(d) placed the second segment in NCP of $0.08 - 0.16$ (III₂) and $0.04 - 0.08$ (IV₂).

The old method exaggerated the amount of soil loss, and the average LS method predicted lower soil loss than the Wischmeier method which probably predicted erosion most precisely. The Wischmeier method is useful in predicting erosion on complex slopes.

IV. COMPARISON OF WISCHMEIER METHOD AND STANDARD LAND CAPABILITY SUBCLASSES 2

The Wischmeier method was chosen over the old and average methods for drawing isoerodent maps. These maps look like contour maps but show lines connecting equal NCP values. Isoerodent maps were then compared with land capability subclass 2 maps.

The Wischmeier method was chosen because it probably represents the best prediction of soil loss. It deals more effectively with complex slopes since it takes into account various factors involving LS calculation of the entire slope (7). The land capability subclass map (LCC_e) is a standard land classification based on steepness of slopes with average lengths (6, 13, 15).

Figure 4, transect a, on the LCC_e map of Knoxville Plant and Soil Science farm, shows a simple C slope (5-12%) on Holston silt loam with a T/K of 16 (Table 1). LCC_e shows only subclass III_e. The Wischmeier method, Figure 5, transect a, shows NCP's of 0.16 - 0.32, 0.08 - 0.16, and 0.04 - 0.08 on 8% slope, depending on the distance from the ridge. These values if expressed as land subclasses would become II_e, III_e, and IV_e. On the same farm, Fig. 4, transect b, is a three segment slope having a top segment of B slope (2-5%), a middle segment of C slope (5-12%), and a lower segment D slope (12-20%) on Sequoia silt loam, T/K of 8 (Table 1). LCC_e shows the slope to have subclasses II_e, III_e, and IV_e. The Wischmeier method, Fig. 5, transect b, with measured slopes of 2%, 7%, 13% shows NCP's of >0.32 (I), 0.16 - 0.32 (II_e), 0.08 - 0.16 (III_e) 0.04 - 0.08 (IV_e), and 0.02 - 0.04 (VI_e). NCP values are expressed as subclasses _e on page 22 for easy comparison. On the Knoxville Farm, Fig. 4, transect c, has a B slope (2-5%) and D slope (12-20%) on Sequoia silt loam, T/K of 8. LCC_e shows subclasses II_e, and IV_e, but with measured slopes of 3% and 13% the Wischmeier method Fig. 5, transect C shows NCP's of 0.16 - 0.32 (II_e), 0.08 - 0.16 (III_e), 0.04 - 0.08 (IV_e) and 0.02 - 0.04 (VI_e). This clearly indicates that consideration of length and complexity of slope changed the prediction of erosion hazard. Evaluating erosion hazard by the Wischmeier method was responsible for changes in predicted erosion hazard.

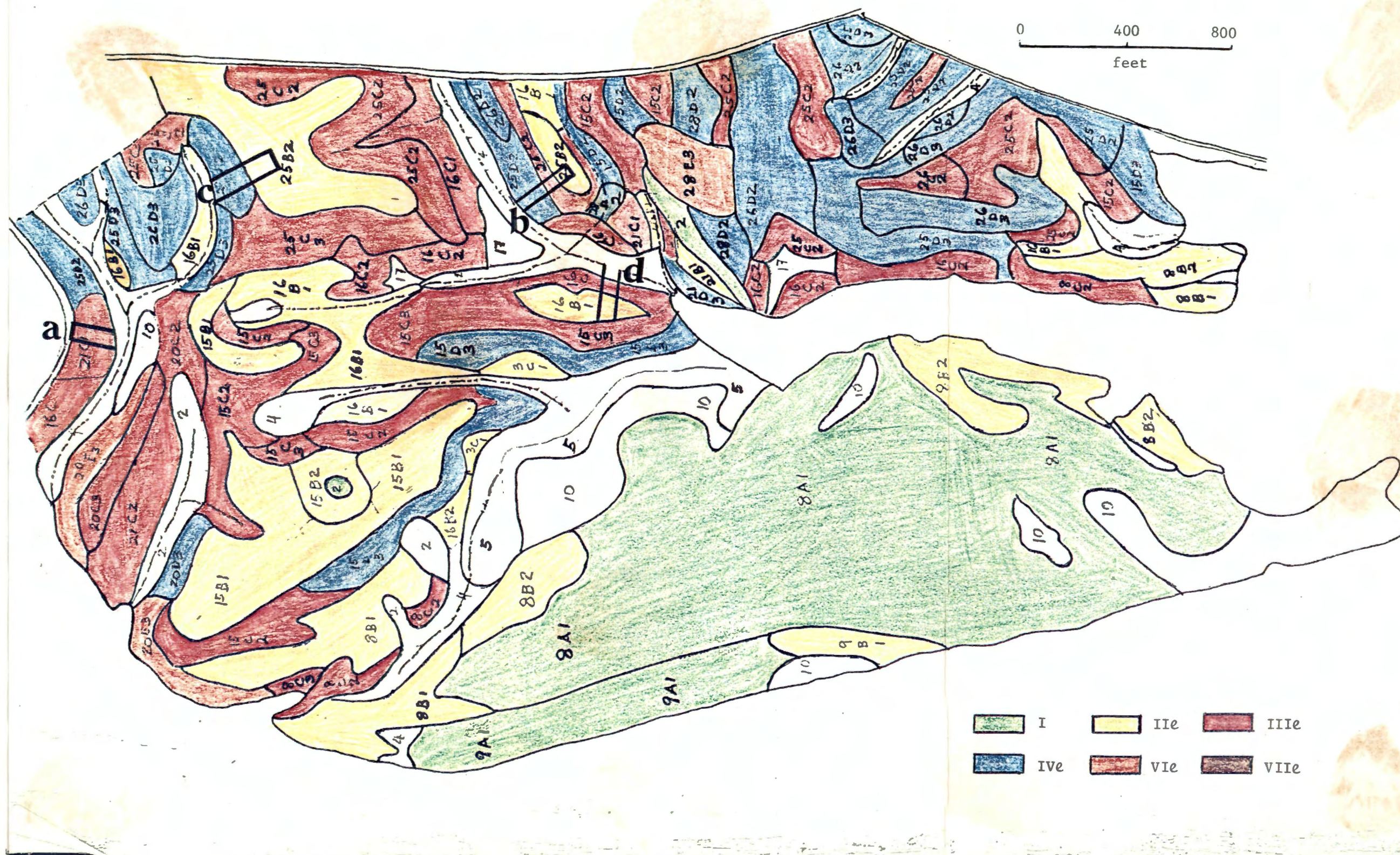


Figure 4. Transects a, b, c and d on LCC2 map of Knoxville Plant and Soil Science Farm.

Table 1. Soil mapping units and T/K's for the Knoxville Plant and Soil Science Farm

Map Symbol	Soil mapping unit	Soil Series T/K	Land Capability Subclass
2	Huntington loam	14	I
3C1	Huntington clay loam, 5-8% slopes	14	IIe
4	Lindside loam	14	IIw
5	Melvin silt loam	12	IIIw
8AI	Sequatchie loam, 0-2% slopes	21	IIe
8BI	Sequatchie loam, 2-5% slopes	21	IIe
8B2	Sequatchie loam, 2-5% slopes, eroded	21	IIe
8CI	Sequatchie loam, 5-12% slopes	21	IIIe
8C2	Sequatchie loam, 5-12% slopes, eroded	21	IIIe
8C3	Sequatchie loam, 5-12% slopes, eroded	21	IIIe
9AI	Sequatchie fine sandy loam, 0-2% slopes	21	I
9BI	Sequatchie fine sandy loam, 2-5% slopes	21	IIe
10	Whitwell loam	13	IIw
15BI	Etowah silt loam, 2-5% slopes	14	IIe
15B2	Etowah silt loam, 2-5% slopes, eroded	14	IIe
15C2	Etowah silt loam, 5-12% slopes, eroded	14	IIIe
15C3	Etowah clay loam, 5-12% slopes, severely eroded	14	IIIe
15D2	Etowah silt loam, 12-20% slopes, eroded	14	IVe
15D3	Etowah clay loam, 12-20% slopes, severely eroded	14	IVe
16B1	Captina silt loam, 2-5% slopes	7	IIe
16B2	Captina silt loam, 2-5% slopes, eroded	7	IIe

Table 1 (cont'd).

Map Symbol	Soil mapping unit	Soil Series T/K	Land Capability Subclass
16CI	Captina silt loam, 5-12% slopes	7	IIIe
16C2	Captina silt loam, 5-12% slopes, eroded	7	IVe
17	Taft silt loam	7	IVw
20C2	Waynesboro loam, 5-12% slopes, eroded	21	IIIe
20C3	Waynesboro clay loam 5-12% slopes, severely eroded	21	IIIe
20D3	Waynesboro clay loam 12-20% slopes, severely eroded	21	IVe
20E3	Waynesboro clay loam 20-30% slopes, severely eroded	21	IVe
21BI	Holston silt loam, 2-5% slopes	16	IIe
21CI	Holston silt loam, 5-12% slopes	16	IIIe
21C2	Holston silt loam, 5-12% slopes, eroded	16	IIIe
21D2	Holston silt loam, 12-20% slopes, eroded	16	IVe
21D3	Holston silt loam, 12-20% slopes, severely eroded	16	IVe
25B2	Sequoia silt loam, 2-5% slopes	8	IIe
25C2	Sequoia silt loam, 2-5% slopes	8	IIIe
25C3	Sequoia silty clay loam, 5-12% slopes, severely eroded	8	IIIe
25D2	Sequoia silty clay loam, 12-20% slopes, eroded	8	IVe
26C2	Dandridge silt loam, 5-12% slopes, eroded	6	IIIs
26D2	Dandridge silt loam, 12-20% slopes, eroded	6	IVs
26D3	Dandridge shaly silty clay loam, 12-20% slopes, severely eroded	6	IVs
28D2	Tellico loam, 12-20% slopes, eroded	13	IVe
28E3	Tellico clay loam, 20-30% slopes, severely eroded	13	VIe

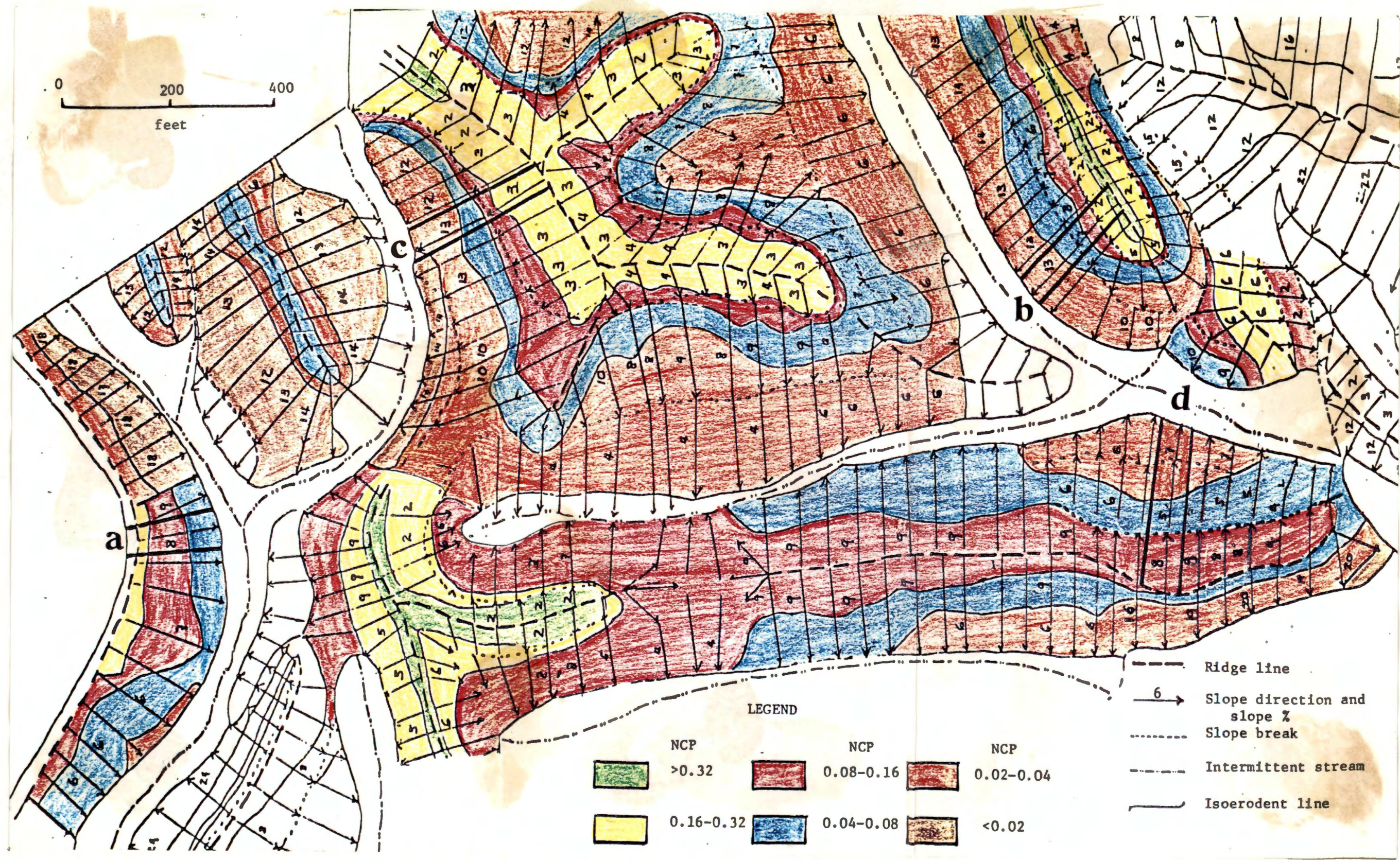


Figure 5. Transects a, b, c and d on isoerodent map of Knoxville Plant and Soil Science Farm. (Remainder of the map is in Appendixes B and C).

At Milan Field Station, Fig. 6 transect a, shows a simple slope segment, having B slope (2-5%) on Loring silt loam with T/K of 9 (Table 2). LCC₂ shows subclass II₂ while the Wischmeier method with a slope of 2%, Fig. 7 transect a, shows NCP's of >0.32 (I), 0.16-0.32 (II₂) and 0.08-0.16 (III₂) depending on length of slope. A short segment near the top of the slope has NCP equivalent to class I. As length increases the erodibility becomes worse. LCC₂ did not indicate any class I nor class III₂. This shows that even with simple slopes, consideration of length changes the prediction of the erosion hazard. At Milan Field Station, Fig. 6 transect b, shows Memphis silt loam soil, T/K of 12 (Table 2), having a B slope (2-5%) and C slope (5-8%). LCC₂ indicated subclasses II₂ and III₂, but the Wischmeier method, Fig. 7 transect b, indicated NCP's of >0.32 (I), 0.16-0.32 (II₂), 0.08-0.16 (III₂), and 0.04-0.08 (IV₂) on the 2% and 6% slopes. LCC₂ overlooked the presence of the narrow strip of class I on top of the ridge. The big difference was that the Wischmeier method showed the NCP's of 0.04-0.08 (IV₂) at the lower end that indicated a more serious erosion hazard.

Figure 6 transect c, of Milan Field Station with a B slope (2-5%) of Memphis silt loam, T/K of 12, and D slope (8-12%) Lexington silt loam having T/K of 7 shows subclasses II₂ and VI₂. The Wischmeier method, Fig. 7 transect c, shows NCP's of >0.32 (I), 0.16-0.32 (II₂), 0.08-0.16 (III₂), 0.04-0.08 (IV₂), and 0.02-0.04 (VI₂).

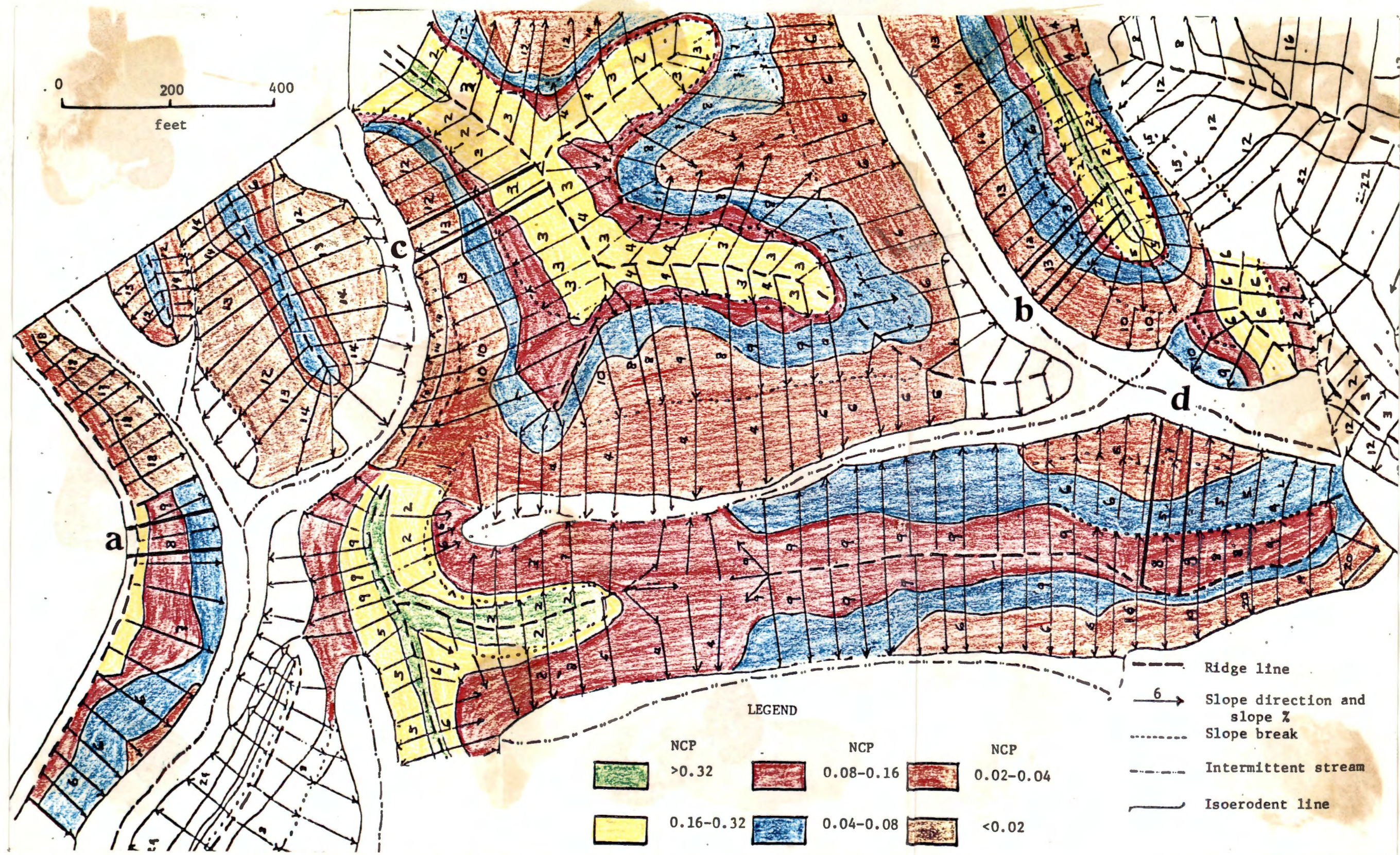


Figure 5. Transects a, b, c and d on isoerodent map of Knoxville Plant and Soil Science Farm. (Remainder of the map is in Appendixes B and C).

Table 2. Soil mapping units and T/K's for the Milan Field Station.

Map symbol	Soil mapping unit	T/K used for calculations	Land capability subclass
2	Collins silt loam	12	IIw
3	Falaya silt loam	12	IIIw
4	Waverly silt loam	7	IVw
IIAI	Memphis silt loam, 0 to 2% slopes	12	I
IIBI	Memphis silt loam, 2 to 5% slopes	12	IIE
IIB2	Memphis silt loam, 2 to 5%, slopes, eroded	12	IIE
IIB3	Memphis silt loam, 2 to 5%, slopes, severely eroded	12	IIE
IIC3	Memphis silt loam, 5 to 8%, slopes, severely eroded	12	IIIE
12AI	Loring silt loam, 0 to 2% slopes, severely eroded	9	I
12BI	Loring silt loam, 2 to 5% slopes	9	IIE
12B2	Loring silt loam, 2 to 5% slopes, eroded	9	IIE
12C3	Loring silt loam, 5 to 8% slopes, severely eroded	9	IIIE
13AI	Grenada silt loam, 0 to 2% slopes	7	IIw
13A2	Grenada silt loam, 0 to 2% slopes, eroded	7	IIw
13B1	Grenada silt loam, 2 to 5% slopes	7	IIE
13C3	Grenada silt loam, 5 to 8% slopes, severely eroded	7	IVE
13C4	Grenada silt loam, 5 to 8% slopes, severely eroded	7	IVE
14	Calloway silt loam	12	IIIw
15	Henry silt loam	7	IIIw
16B2	Lexington silt loam, 2 to 5% slopes, eroded	7	IIE
16C2	Lexington silt loam, 5 to 8% slopes, eroded	7	IIIE
16C3	Lexington silt loam, 5 to 8% slopes, severely eroded	7	IVE
16D4	Lexington silt loam, 8 to 12% slopes, severely eroded	7	VIE

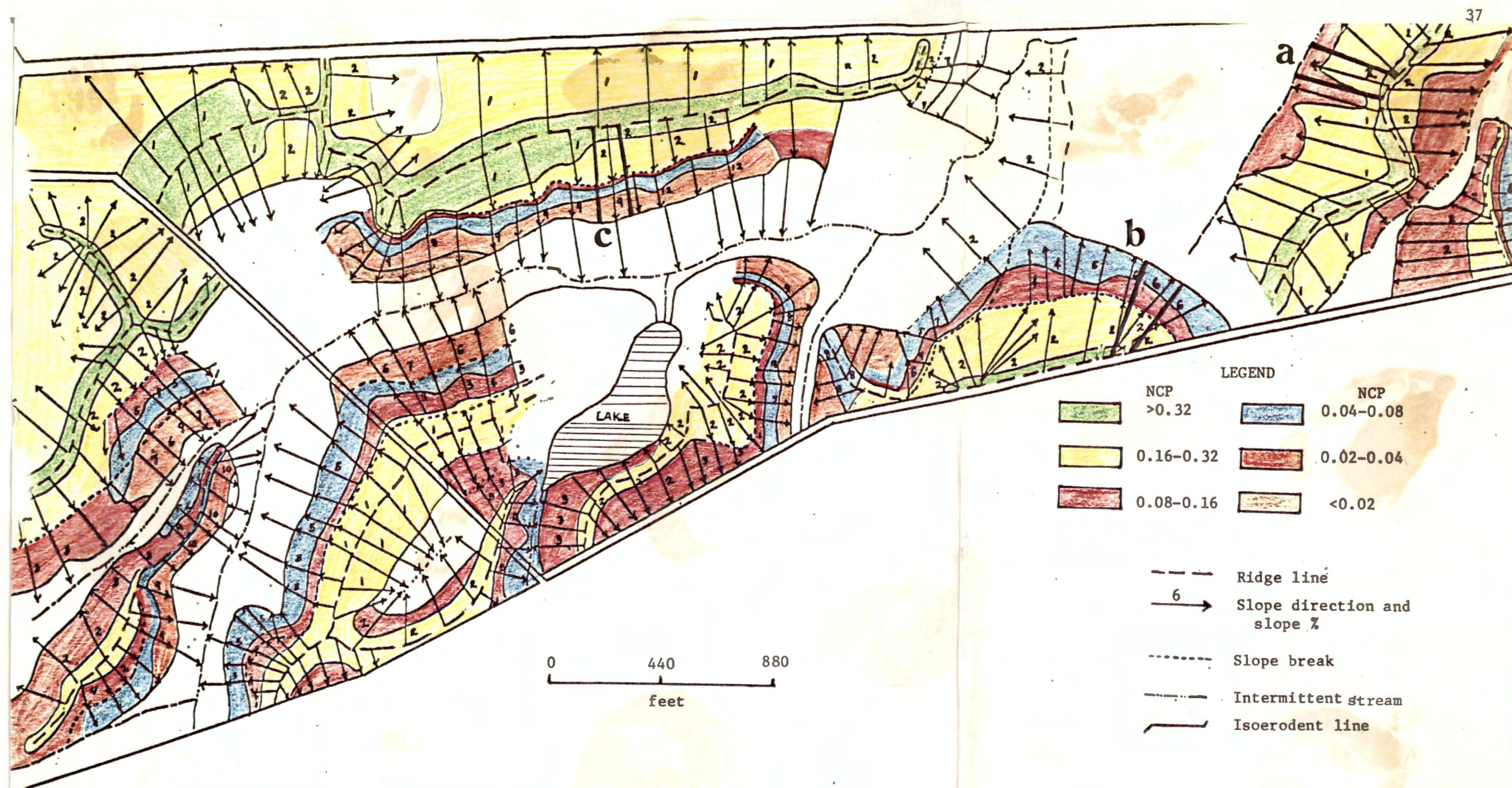


Figure 7. Transects a, b, and c on isoerodent map of Milan Field Station.

In this complex slope situation, LCC2 showed only subclass VI₂ land in the second segment, but the Wischmeier method with measured slopes of 2% and 9% indicated that the second segment had NCP's of 0.08-0.16 (III₂), 0.04-0.08 (IV₂) and 0.02-0.04 (VI₂). Thus when slope is short in length, the Wischmeier method recognizes that erosion is less serious than predicted by LCC2.

Soils on Ames Plantation are more seriously affected by erosion than the other locations because the rainfall and runoff factor (R) is the highest of the three areas studied. Figure 8 transect a, shows a two segment slope on Lexington silt loam C slope (5-8%), T/K of 7 (Table 3), and a second segment on Lexington-Ruston complex F slope (20-30%) T/K of 12. LCC2 shows subclasses III₂ and VII₂, but the Wischmeier method, Fig. 9 transect a, shows NCP's of 0.08-0.16 (III₂), 0.08-0.04 (IV₂), 0.02-0.04 (VI₂), and <0.02 (VII₂). In other words, the Wischmeier method recognizes that within the second segment are subclass VI₂ at the short lengths before reaching subclasses VII₂. The main advantage of the Wischmeier method is its ability to evaluate erosion along the second segment slope.

Use of Isoerodent Maps for Soil Management

Comparison of isoerodent maps with the LCC2 maps clearly indicate that length and complexity of slopes change the prediction of erosion. The Wischmeier method demonstrated the importance of segment length and steepness in a complex slope situation in evaluating erosion. Without considering slope complexity, the erosion hazard would have been miscalculated. The isoerodent maps produced by the Wischmeier method are

Table 3. Soil mapping units and T/K's for the Ames Plantation.

Map symbol	Soil mapping unit	T/K	Land capability subclasses e
LbB	Lexington silt loam, 2-5%	7	IIe
LbC	Lexington silt loam, 5-8%	7	IIIe
LbD	Lexington silt loam, 8-12%	7	IVe
LcC3	Lexington silty clay loam, 5-8%, severely eroded	7	IVe
LcD3	Lexington silty clay loam, 8-12%, severely eroded	7	VIe
LeD	Lexington-Ruston complex, 8-12%	12	IVe
LeF	Lexington-Ruston complex, 12-30%	12	VIIe
LfD	Lexington-Ruston gullied complex, 8-12%	11	VIe
LoB	Loring silt loam, 2-5%	9	IIe
LoC3	Loring silt loam, 5-8%, severely eroded	9	IIIe
MeB	Memphis silt loam, 2-5%	12	IIe
MfC3	Memphis silty clay loam, 5-8%, severely eroded	12	IIIe
Gs	Gullied land silty, (Lexington), severely eroded	9	VIIe
Gn	Gullied land sandy, (Ruston), severely eroded	11	VIIe
Cm	Collins fine sandy loam	12	I
CaB2	Calloway silt loam	12	IIIw

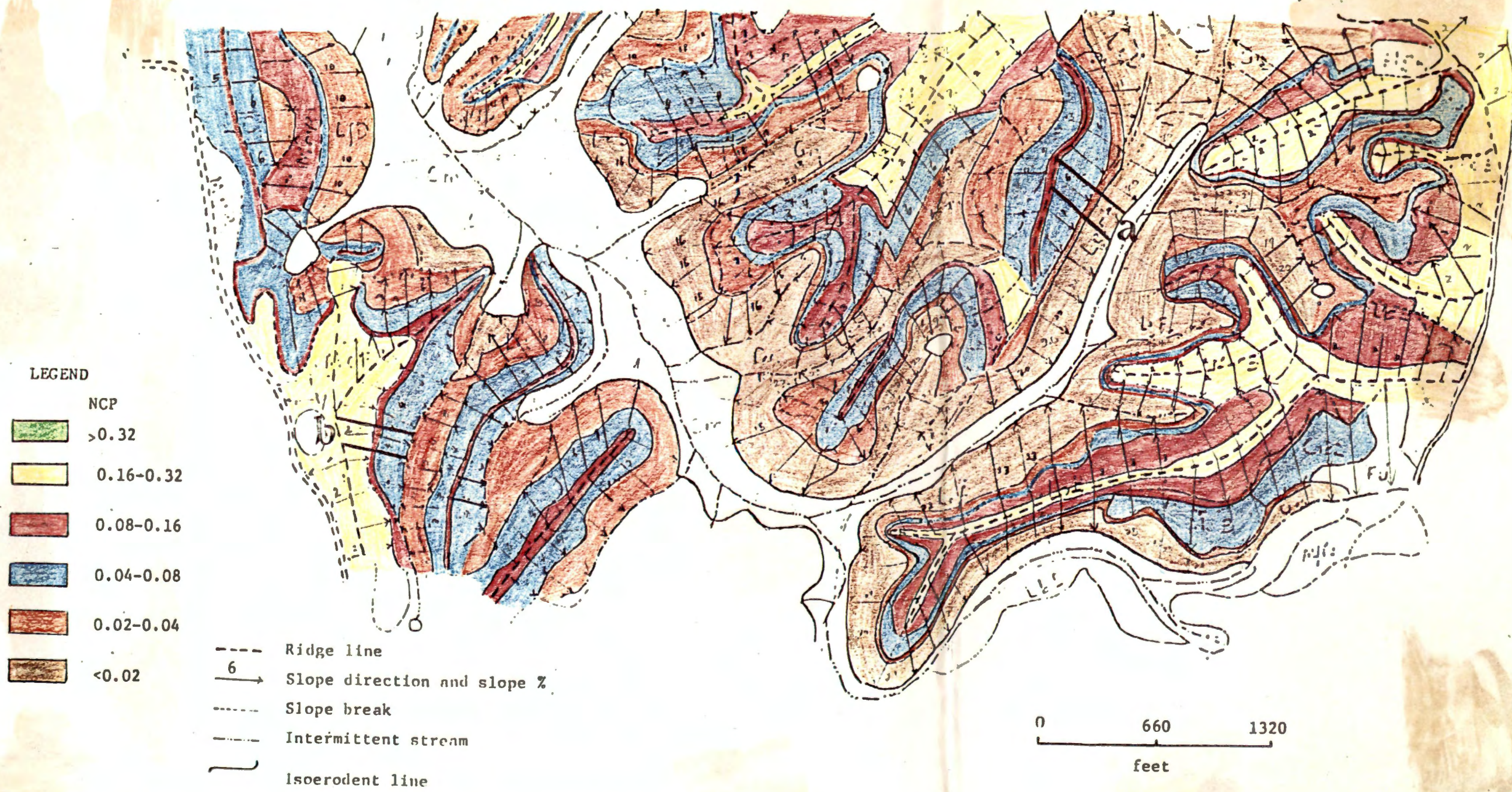


Figure 9. Transects a and b on isoerodent map of Ames Plantation.

more precise estimates of soil loss from a field or farm than LCC₂ maps. Isoerodent maps are useful for selecting the range of cropping systems and erosion control practices for a field or farm that will keep soil loss within tolerance. They can also predict soil loss under given C and P. On land having NCP of >0.32 means that a farmer could practice any cropping system with a CP of less than 0.32 and keep soil loss within tolerance. More selections are available for land that has NCP of >0.32 than for classes with lower NCP. For land that has NCP of <0.02 few selections are available to keep soil loss within tolerance. Such a value also means that more conservation measures are needed to protect against soil loss. A table showing C values of some of the cropping systems are available from conservationists of the area (13a, 25, 41). When the isoerodent map indicates that land has NCP of 0.08-0.16 all CPs less than 0.08 are acceptable. When land has NCP of 0.04-0.08, all CPs less than 0.04 are acceptable. Similar reasoning is true for other NCP classes.

Isoerodent maps by the Wischmeier method will tell the users of soils that all areas with the same isoerodent value have the same relative degree of erosion hazard or limitations for cropping systems and practices. The risk of soil damage by erosion or limitation in use becomes progressively greater as NCP values decrease. A farmer can practice similar cropping systems and management in the areas that have the same NCP values. An isoerodent map when superimposed on a soil map will tell a great deal about the physical condition of each mapping unit delineation. Thus, isoerodent maps can also be used as a single purpose map to predict erosion.

The aim of soil conservation is to obtain a maximum sustained level of production from a given area of land while maintaining soil loss below a tolerance level. The maps produced by the Wischmeier method are tools which may help achieve these objectives. A farmer can use these maps showing areas of equal NCP value to choose cropping systems for his farm. If he decides to use a more intensive cropping system than allowable then he has to put some conservation practices into effect. These maps are based on NCP. Thus when a farmer decides to construct a terrace on a slope of 5%, P become 0.5. His choice of cropping systems is greater, even though he operates within the same soil loss tolerance.

When the isoerodent map indicates NCP's of 0.32-0.16 (IIe), 0.08-0.16 (IIIe), and 0.04-0.08 (IVe) on a slope of 5%, 300 ft. length, and T/K of 12, a farmer could locate a terrace at 100 feet from the top of the ridge. He could farm the top part as subclass IIe and all the land below the terrace as subclass IIIe. Reducing slope length also decreases the amount of soil loss. Thus the lower part of the slope could be utilized more intensively without exceeding soil tolerance. Land that has NCP 0.08-0.16 (IIIe), 0.04-0.08 (IVe), and 0.02-0.04 (VIe) on the slope of 400 ft., 6% steepness, T/K of 7, might be used as C of 0.08-0.16 by practicing contour stripcropping, or used as C of 0.04-0.08 by practicing contour farming, whichever is applicable. Thus isoerodent maps are useful to a farmer for his conservation plan. A slide rule calculator is useful for evaluating erosion hazard on simple slopes, but isoerodent maps are better on complex slope situations.

A simple nomograph was developed for evaluating erosion. It consists of a slope effect chart (LS) and NCPs at various T/K for specific R. This nomograph, Fig. 1, page 12 can be used to determine NCP for various soils on simple slopes after R is given. Where steepness of a simple slope is known, it can also be used to determine length of slope for a given NCP. Instructions for use precede Fig. 1. This nomograph helps to select alternative systems of cropping and practices for a slope or field. Thus it has a function similar to the slide rule calculator. It can be designed for any R or any county.

An isoerodent map is more precise than an LCC₂ map or a slide rule calculator because it deals with complex slopes effectively. For simple slopes a slide rule calculator is an adequate tool for estimating erosion hazard. LCC₂ maps are less precise than the slide rule calculator or isoerodent maps for long simple slopes. Both isoerodent maps and the slide rule calculator indicated that with simple slopes of equal steepness, a long simple slope is more hazardous to erosion than a short one. This agrees with other researchers (13, 18, 25, 40) and the slide rule calculator that soil loss increases with slope length. For complex slopes, isoerodent maps by the Wischmeier method evaluate erosion more accurately than either LCC₂ maps or the slide rule calculator. For instance Fig. 4 transect d, page 30, shows a three segment slope on Etowah silt loam, T/K 14 and Captina silt loam T/K 7 (Table 2, page 36). LCC₂ indicated subclasses III₂, II₂ and III₂. The Wischmeier method Fig. 5, transect d, page 33, showed it to have NCPs of 0.08-0.16 (III₂), 0.04-0.08 (IV₂) and 0.02-0.04 (VI₂) on the measured slopes of 8%, 5% and 7%. This is probably true since water moved from one segment to another erodes more soil from the lower

segment of slope. Thus isoerodent maps by the Wischmeier method are useful for predicting erosion in this situation. Conservation plans could be based on the isoerodent maps. An LCC₂ map is useful for predicting erosion on simple slopes of average length. The slide rule calculator is a quick way to estimate soil loss for a simple slope but is less precise in dealing with a complex slope.

NCP values were chosen for comparison with land capability subclasses 2 but other values could also be chosen for NCP classes when drawing isoerodent maps. In this study NCP of 0.16-0.32 seemed to approximate LCC₂ subclass II₂ as shown in Fig. 5 transect b, page 33, of Knoxville Plant and Soil Science Farm. NCP of 0.02-0.04 also correlates well with LCC₂ subclass VI₂ as indicated in Figure 7 transect c, page 37, of Milan Field Station. NCP of <0.02 corresponds with LCC₂ subclass VII₂ as reflected in Fig. 9¹ transect a, page 41. Thus these NCP values correspond fairly well with LCC₂ subclasses 2.

Both isoerodent maps and LCC₂ maps indicate the single limitation of erosion, but an isoerodent map by the Wischmeier method is much more precise, especially in an area that has complex slopes. The effectiveness of the Wischmeier method is reduced when dealing with miscellaneous land types such as gullied land as shown in Fig. 8 transect b, page 39, of Ames Plantation. Isoerodent maps lose some of their usefulness when other soil limitations are greater than erodibility.

CHAPTER V

SUMMARY AND CONCLUSION

The effect of length and steepness on erosion of soil was studied for both simple and complex slopes in three areas of Tennessee: Milan Field Station, Ames Plantation, and Knoxville Plant and Soil Science Farm.

Various methods were used to predict erosion for complex slopes, namely, the old, the addition, the average LS, the average slope, the Fort Worth, the substitute, and the Wischmeier method. Erosion hazard was determined by these methods on a sample two segment slope with measured slopes of 2% and 6% on Memphis silt loam from Milan Field Station. Since the Wischmeier method is the most precise, results indicate that the substitute method is probably next best.

Erosion hazard based on the USLE and measured as necessary CP (NCP) was predicted by old, average LS, and Wischmeier methods. Classes of NCP predicted by these methods were then compared with standard land capability subclasses ℓ (LCC ℓ). The high NCP values suggest low soil loss and low NCP values suggest a high soil loss. For the simple part of the slope, the three methods produced identical results with NCP's of >0.32 (I) and $0.16-0.32$ (II ℓ). When the second segment was included to give a complex slope, the results differed. The old method had NCP's of $0.04-0.08$ (IV ℓ) and $0.02-0.04$ (VI ℓ) on the second segment. The average method showed the second segment to have a little NCP of $0.06-0.32$ (II ℓ) and much of $0.08-0.16$ (III ℓ). The Wischmeier method probably was the most precise

method for evaluating soil loss for complex slopes. The old method predicted greater soil loss and the average LS method predicted less soil loss than the Wischmeier method. Studies suggest that some workers have misused the old method and as a result exaggerated the amount of soil loss. Both old and new slide rule calculators can also be used to determine erosion hazard for simple slopes, but for complex slopes they are not precise.

This study developed a simple nomograph consisting of a slope effect chart (LS) and NCP of various T/K values. It related NCP to soil loss ratio LS for specific R. This device helps to find NCP at a given length and steepness of a simple slope. Thus, the function is similar to a slide rule calculator. When LS of a complex slope has been determined by the Wischmeier method, the nomograph can be used to find NCP for the entire slope.

Isoerodent maps based on NCP values were drawn for parts of the three studied areas. Values of >0.32 , $0.16-0.32$, $0.08-0.16$, $0.04-0.08$, $0.02-0.04$, and <0.02 were compared with LCC₂ I, II₂, III₂, IV₂, VI₂ and VII₂ respectively. These values were chosen for easy comparison but other values could also be used. NCP of $0.16-0.32$, $0.02-0.04$ and <0.02 correlated fairly well with LCC₂, II₂, VI₂ and VII₂. Perhaps future studies could adjust NCP values to fit better with LCC₂ classes. These isoerodent maps are more precise than LCC₂ maps and slide rule calculators in predicting erosion for complex slopes. For simple slopes, a slide rule calculator is sufficient to determine erosion hazard. Both the isoerodent map and slide rule calculator predict erosion more accurately than LCC₂ maps for long simple slopes. The effectiveness of an isoerodent map is reduced when

dealing with miscellaneous land types such as gullied land because other soil limitations are greater than erodibility.

The isoerodent maps were designed as single purpose maps for predicting erosion. They are better than LCC₂ maps and calculators in predicting erosion, especially in complex slope situations. By using these maps a farmer could choose among various cropping systems and kind of conservation measures available to him to fit his farm plans.

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APPENDIXES

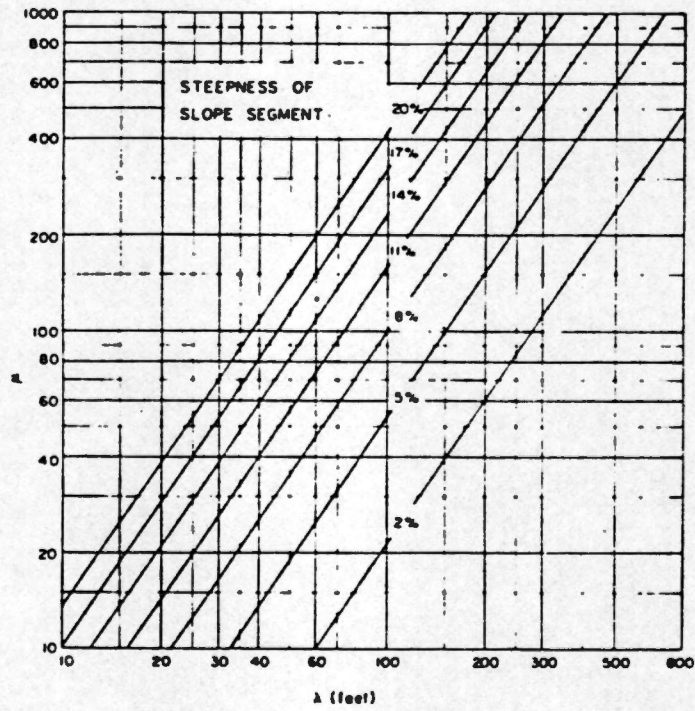


APPENDIX A



APPENDIX A

Foster and Wischmeier Chart



SOURCE: (Trans. Agric. Eng. 1974).

APPENDIX B

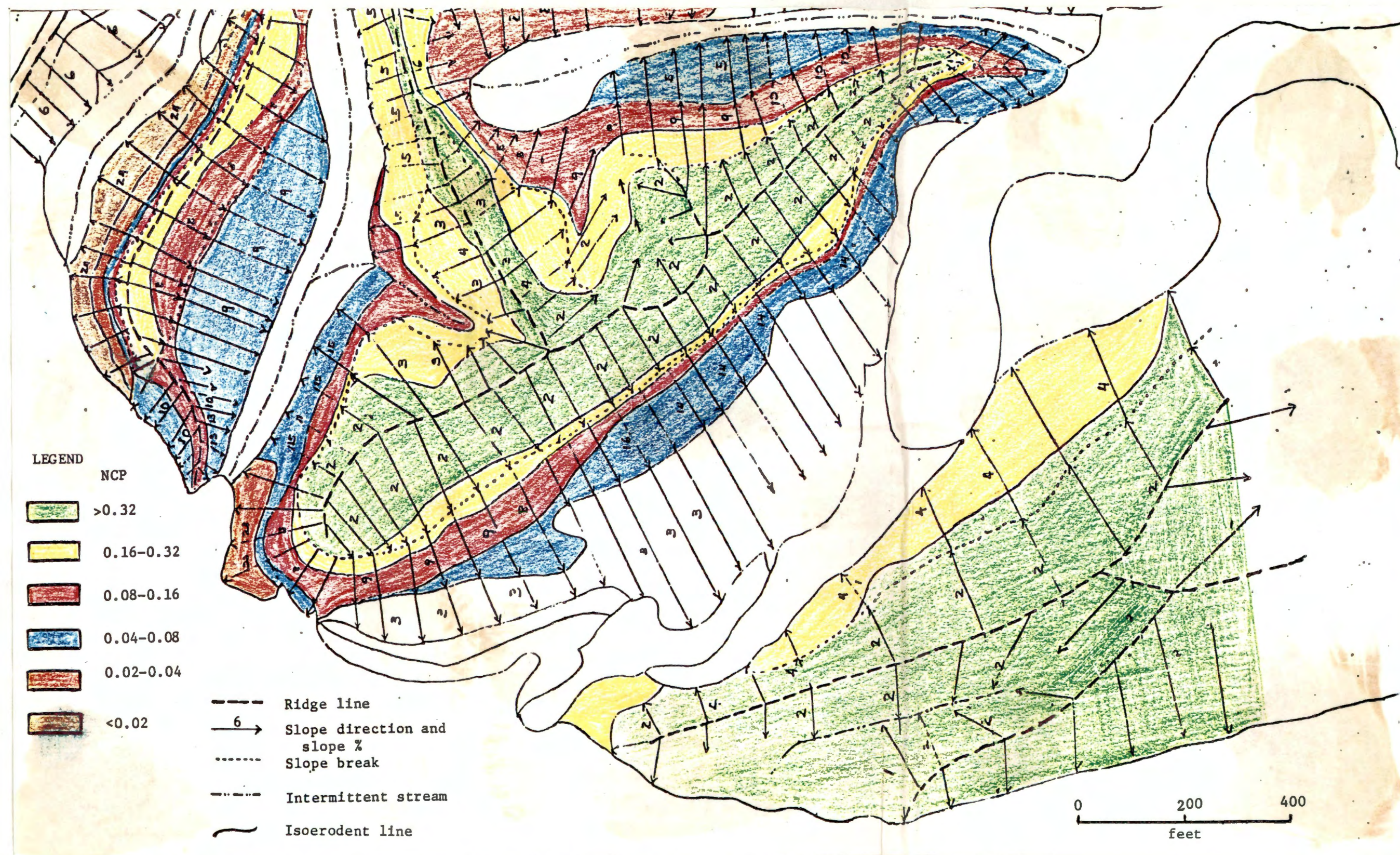


Figure 10. West part of isoerodent map of Knoxville Plant and Soil Science Farm.

APPENDIX C

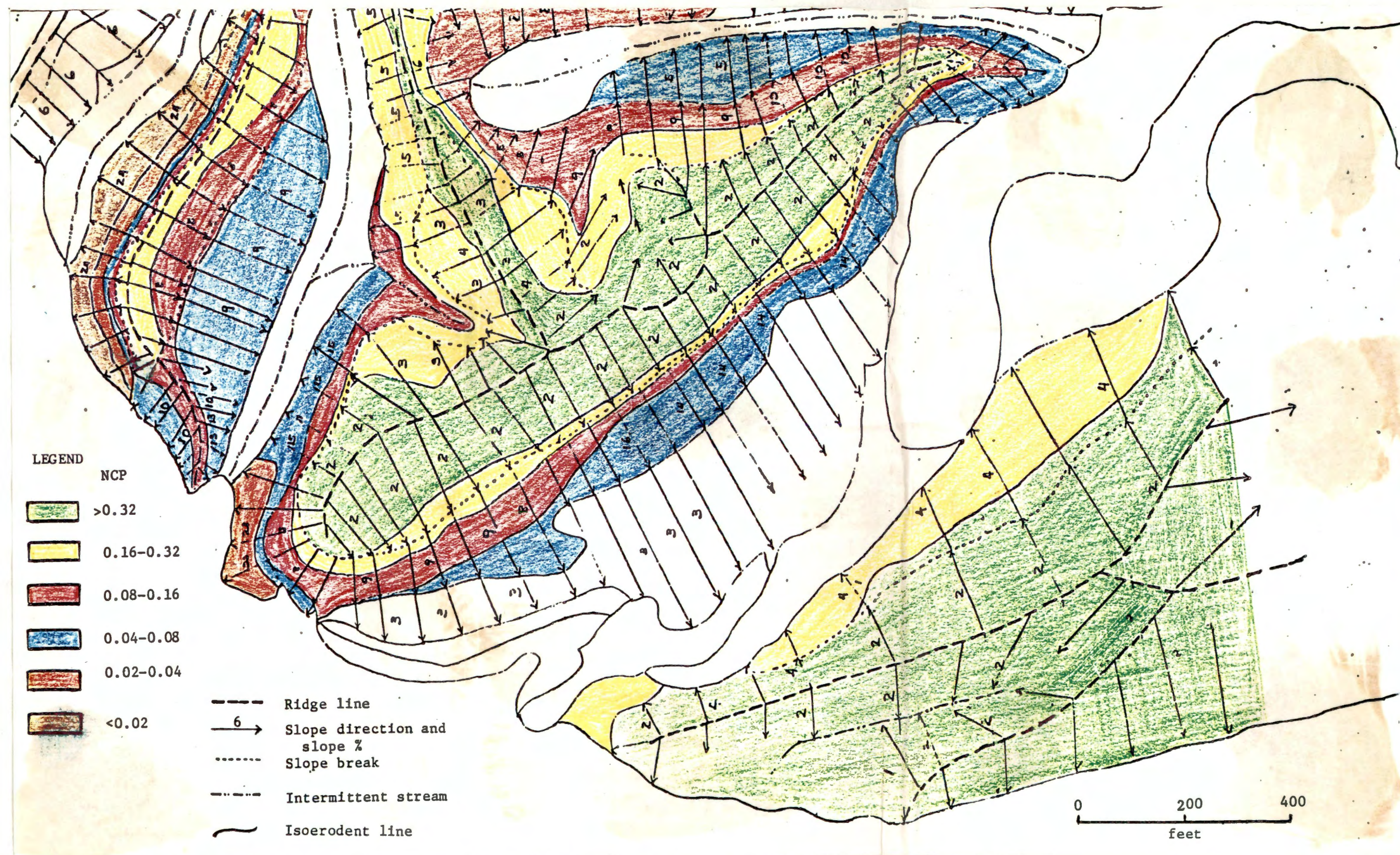


Figure 10. West part of isoerodent map of Knoxville Plant and Soil Science Farm.

VITA

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