SOIL ERODIBILITY FACTOR DETERMINATION FOR SOME SELECTED OKLAHOMA MOLLISOLS

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CHAPTER I

INTRODUCTION

Rainfall erosion is a serious problem on farmland over a large part of the world, particularly on gently to steeply sloping land of both humid and semiarid areas. But agricultural lands are not the only type threatened by rainfall erosion since urban and suburban construction sites frequently leave the subsoil exposed by extensive bulldozing. According to Meyer et al. (6) more than 1 million acres in the United States are being reshaped annually as a result of roadway and reservoir construction, housing and business development, surface mining, and similar operations. In these cases the problem is more drastic because the rate of sediment production from such areas is very high.

As is well known, not all soils erode at the same rate, even different horizons within a profile possess different erodibility rates. Why soils differ in erodibility is not yet well established but it seems to be determined by differences in their natural properties. Due to basic soil differences sediment yields may vary more than 30-fold. Despite its importance however, the erodibility factor has been experimentally derived for only a few benchmark soils. A major obstacle has been that direct measurements of the K factor in the field or in the laboratory is both time-consuming and costly.

In Oklahoma, according to the Oklahoma Conservation Needs Inventory

(17), erosion is the dominant hazard limiting land use in 60.5 percent of the total acreage. At the same time, 32.1 percent of the land has dominant erosion problems which make it very expensive to keep under production. Most soil series in Oklahoma lack the soil erodibility determination which is essential for completion of the soil-loss prediction equation. If this data were available it would be easier to plan sound conservation practices to keep soil losses within tolerable limits.

The primary objective of this study is to determine the soil erodibility factor for some selected soils based upon specific soil characteristics. Since farm fields are a major sediment source in agricultural areas this study will also provide data for; estimating total sediment from watersheds, making sound conservation plans for clean water supplies, determining longevity of storage reservoirs, and preventing other sediment damages.

It is hoped that this study will bring about a wider used of the soil erosion equation for agricultural and nonagricultural purposes as well as add to the growing knowledge of soil science.

CHAPTER II

LITERATURE REVIEW

Rainfall Erosion

Erosion research in the United States began early in the twentieth century, after the problem had become serious in many parts of the country (14). Musgrave (9) pointed out that in the development of any body of new information, early investigations provide a basis for a qualitative evaluation. Only at a much later stage is sufficient information available to formulate a quantitative expression of the factors responsible for the final results. He concluded that this situation is perfectly applicable to the studies dealing with rainfall erosion.

According to Musgrave (9), and Smith and Wischmeier (15), four factors and their interrelations have long been considered the chief determiners of the rate of rainfall erosion. They are: (1) climate, mainly rainfall intensity and temperature; (2) soil, its inherent resistance to erosion and its infiltration and permeability rates; (3) topography, particularly length and degree of slope; and (4) vegetal cover, both living and dead material which provide protective effects. They concluded that any one of these factors can assume values which, alone, may create a rainfall erosion hazard.

Erosion research has been largely of an applied nature, conducted on field plots of different sizes. The early plots were generally 0.01

acre with a slope length of 72.6 feet and slope degree ranging from 3 to 22 percent (15, 28).

According to Rosenberry and Moldenhauer (12), sediment is the major water pollutant in the United States in terms of volume. They pointed out that more than 40 years of public policy has encouraged farmers to practice soil conservation but many obstacles, mainly of economic nature, still remain. Some states, like Iowa, (4) established a conservation policy imposing soil loss limits for agricultural and nonagricultural lands varying from 1 to 5 tons per acre per year depending upon soil type.

The Soil Erosion Equation

The first attempt to develop an equation for calculating field soil loss was made about 1940 in the Corn Belt States. The procedure developed there has been generally referred to as the slope-practice method (22). Zingg (30) published an equation in 1940 relating soil-loss rate to length and degree of slope. In the following years Smith (13) added crop and conservation practice factors and set up a graphical method for determining conservation practices needed on selected soils of the Midwest.

In 1947 Browning et al. (3) added soil erodibility and management factors and worked out a series of tables to simplify the use of the equation. Almost at the same time Musgrave (9) reappraised the equation and added another factor, the rainfall factor. The equation came to be known as the Musgrave equation and has been widely used for estimating gross erosion from cultivated watersheds.

The equations were widely used for many years but it was not until the late 1950's that an improved soil-loss equation was produced which overcame many of the limitations of the pioneer equations (22, 26). The improved equation was developed in 1956 at the Runoff and Soil-Loss Data Center of the Agricultural Research Service, Purdue University, based upon basic runoff and soil loss data from 48 stations in 26 states. The new equation is of general applicability and is widely known as the "universal" soil-loss equation (10, 15, 18, 22, 26, 27). This equation may be stated as follows:

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

where, A is the computed average annual soil loss in tons per acre,

R, the rainfall factor, is the number of erosion index units in a normal year's rain.

K, the soil-erodibility factor, is the erosion rate per unit of erosion index for a specific soil in cultivated continuous fallow, on a 9-percent slope 72.6 feet long.

L, the slope-length factor, is the ratio of soil loss from the field slope length to that from a 72.6 foot length on the same soil type and gradient.

S, the degree of slope factor, is the ratio of soil loss from the field gradient to that from a 9-percent slope.

C, the cropping-management factor, is the ratio of soil loss from a field with specified cropping and management to that from the fallow condition on which K is evaluated.

P, the erosion-control practice factor, is the ratio of soil loss with contouring, terracing, or strip cropping to that with straight row farming, up-and-down slope.

Numerical values for each of the six factors have been determined from research data and compiled in tables and figures presented by Wischmeier and Smith (27). Each one of the factors can be evaluated on a locational basis using the reference mentioned above as a helpful guide.

Wischmeier (24) stated that "more than a decade of widespread use has proved the universal erosion equation to be a very valuable soil and water conservation planning tool." He also explained how and why the equation is able to predict definite amounts of soil erosion and sediment production. Springer et al. (20) developed a calculator for quick application of the equation in the field. This useful device avoids long calculations and table-readings, and allows the conservationist to predict the soil loss for any specific field in less than a minute.

Soil Loss Tolerance

"Soil-loss tolerance" as defined by Wischmeier and Smith (28) denotes "the maximum rate of soil erosion that will permit a high level of crop production to be sustained economically and indefinitely." In the Midwest, the concept was established as limiting soil loss to an average rate capable of maintaining the organic matter at a desirable level (15).

Although establishment of tolerance values has been largely a matter of collective judgement, Smith and Stamey (16) presented some assumptions which have to be made prior to the adoption of any erosion tolerance standard:

(a) Soil is to be preserved or improved,

(b) various soil properties are subject to both wearing away by erosion and adding by renewal,

(c) all kinds of erosion and renewal are involved,

(d) fractional use-up of reserves is tolerable, and

(e) economic influences determine options within tolerance, but not the tolerance itself.

Almost at the same time, Stamey and Smith (21) published a mathematical expression that expresses the concepts involved in soil loss tolerance and soil renewal.

The soil-loss tolerance values, T, must be selected before the soil-loss equation can be used. Both physical and economic factors should be considered. According to many investigators (15, 18, 22, 27) the T values are estimates which may vary between 1 and 5 tons per acre per year, depending upon the type, depth, topography, and prior erosion of the soil. The most desirable soils from the standpoint of resistance to the erosion hazard are those that have a low K value and a high T value (18).

Soil Erodibility Factor

Browning et al. (3) were the first to introduce the soil erodibility factor into the earlier soil erosion equations. Van Doren and Bartelli (23) stated that soils erode at different rates, depending upon their physical characteristics and amount of past erosion.

Soil effects were usually confounded with the effects of differences in rainfall occurring in the different geographic regions. Wischmeier et al. (28) segregated the rainfall and soil effects and computed independent numerical values for each of them. This greatly enhanced the utility of plot data in geographic regions where the field studies were not conducted.

The soil-erodibility factor, K, in the soil-loss equation is a quantitative value experimentally determined. "Soil erodibility" as defined by Wischmeier and Smith (26) is "the average soil loss in tons per acre per unit of erosion index, from a particular soil in cultivated continuous fallow and with length and percent slope at unity or an arbitrarily selected base value." According to Wischmeier and Smith (27), values of K were only determined for 23 major soils on which erosion plot studies had been conducted since 1930. They stated that soil-erodibility values for numerous other soils have been approximated by comparison with those values experimentally obtained.

The soil erodibility factor reflects the fact that different types of soils erode at different rates. For example, sandy soils are generally more susceptible to erosion than clayey soils if runoff is equal (22). Some attempts have been made in the past to classify soils according to their relative erodibility (7, 15). Edwards (18) set up some ground rules and assumptions to clarify the interrelations of the soil characteristics affecting erodibility:

(1) Erodibility decreases with increase of grade and size of structure.

(2) Erodibility decreases with coarseness of texture.

(3) Erodibility decreases with amount and size of coarse fragments.

(4) Erodibility decreases with increase of content of organic matter.

(5) Erodibility decreases with increase in ability of the underlying material to take on water from the soil.

In another attempt to classify the soil properties that influence soil erodibility, Smith and Wischmeier (15) grouped them into two types: (1) properties affecting the infiltration rate and permeability; and (2) properties that resist the dispersion, splashing, abrasion, and transporting forces of the rainfall and runoff. The relation of soil properties to its erodibility was also presented by Wischmeier and Mannering (25). They stated that long-time average soil losses may vary more than 30-fold just due to basic soil differences. They presented a complicated mathematical equation based upon 15 soil properties and their interactions. They said the equation was of considerable practical value.

The soil erodibility evaluations were always estimated based principally upon field measurements. This had two major problems: (1) they could only be made in relation to a few benchmark soils, and (2) they required too many years of observations. By rearranging the universal soil-loss prediction equation and using data collected for many years from a series of erosion experiment stations, Olson and Wischmeier (10) computed the K values for many soils in 11 states. They concluded that evaluations of K from empirical data taken from experiments designed for other purposes were subjected to inaccuracies, but the average results obtained met the minimum requirements until more elaborated data became available.

Olson et al. (11) and Barnett et al. (1) measured the erodibility of some selected soils by means of a rainfall simulator. This equipment allows a faster K value determination. A problem is the limitation of use at only one location at a time. Barnett and Dooley (2) concluded that the rainulator designed by Meyers and McCune produces an average rainfall energy equal to 75 percent that of natural rain. This implies a downward bias in erosion data from tests using this device.

Meyer et al. (6) measured erosion and runoff rates for different treatments representing typical construction-site conditions that result from major land reshaping. They reported that sediment loads and runoff from such disturbed sites were much greater than from topsoil under similar conditions. Moldenhauer and Long (8) also determined the erodibility of disturbed soil samples in the laboratory by using a laboratory rain simulator. They established the order of erodibility for different textural classes at equivalent amounts of runoff. The order was fine sand > silty clay > silty clay loam > loam > silt.

In a recent paper, Wischmeier et al. (29) presented a new soil erodibility model based upon five soil parameters which they translated into a simple nomograph. This procedure seems to offer some hope of determining the soil erodibility factor for numerous soils since it requires only five soil parameters which are available from routine laboratory determinations and standard soil profile descriptions.

CHAPTER III

MATERIALS AND METHODS

The purpose of this study was to determine the soil erodibility factor, K, for some selected Mollisols. The soils studied were selected on the basis of their agricultural importance and their wide range of characteristics representative of soils within the Central Reddish Prairies and Rolling Red Plains resource areas of Oklahoma (4). Another important factor in selecting these soils was the availability of basic laboratory data and field profile descriptions.

The approximate location and the classification of the 16 soil profiles in this study is shown in Figure 1 and Table 1, respectively. The soils include 1 fine sandy loam, 2 loams, 12 silt loams, and a silty clay loam. Since all these soils receive an average annual rainfall ranging from 26 to 36" (Figure 1) and have some phase on gently sloping areas, some degree of water erosion could be expected in most years.

Five soil parameters are required for predicting the erodibility factor according to Wischmeier et. al. (29). They are as follows:

1. Percent silt plus very fine sand.
2. Percent sand coarser than 0.1 millimeter.
3. Percent organic matter.
4. Structure, size and type.
5. Profile permeability, determined by the less permeable horizon.

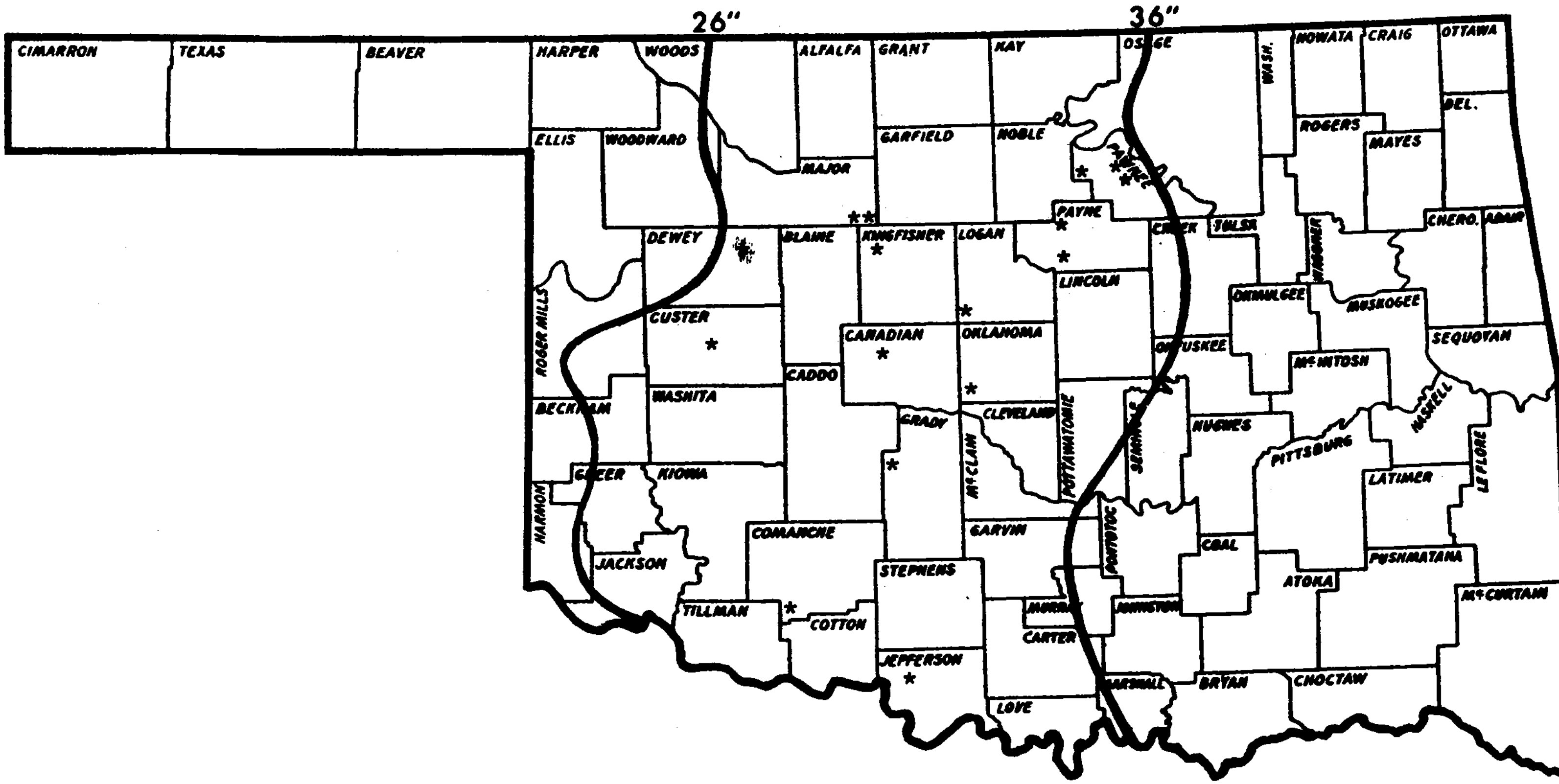


Figure 1. Locations of the Soils in This Study Within a 26-36" Average Annual Rainfall Belt.

TABLE I

SOIL SERIES USED IN THIS STUDY: CLASSIFICATION AND LOCATION BY COUNTIES

Soil Series	Classification		County
Bethany[5]	Fine, mixed, thermic	Pachic Paleustolls	Oklahoma, S28, T11N, R4W
Carey[5]	Fine-silty, mixed, thermic	Typic Argiustolls	Custer, S13, T14N, R17N
Foard[5]	Fine, montmorillonitic, thermic	Typic Natrustolls	Comanche, S23, T1S, R14W
Grant[4]	Fine-silty, mixed, thermic	Udic Argiustolls	Major, S13, T22N, R9W
Kingfisher[2]	Fine-silty, mixed, thermic	Udic Argiustolls	Canadian, S36, T13N, R8W
Kirkland[2]	Fine, mixed, thermic	Udertic Paleustolls	Logan, S36, T16N, R4W
Norge[5]	Fine-silty, mixed, thermic	Udic Paleustolls	Pawnee, S9, T22N, R6E
Pond Creek[4]	Fine-silty, mixed, thermic	Pachic Argiustolls	Major, S13, T22N, R9W
Reinach[3]	Coarse-silty, mixed, thermic	Pachic Haplustolls	Grady, S33, T8N, R8W
Renfrow[5]	Fine, mixed, thermic	Udertic Paleustolls	Pawnee, S8, T22N, R3E
Shellabarger[5]	Fine-loamy, mixed, thermic	Udic Argiustolls	Kingfisher, S5, T18N, R8W
St. Paul[5]	Fine-silty, mixed, thermic	Pachic Argiustolls	Dewey, S15, T19N, R16W
Teller[1]	Fine-loamy, mixed, thermic	Udic Argiustolls	Payne, S36, T18N, R2E
Vanoss[5]	Fine-silty, mixed, thermic	Udic Argiustolls	Pawnee, S3, T22N, R6E
Waurika[5]	Fine, montmorillonitic, thermic	Aeric Argialbolls	Jefferson, S33, T4S, R7W
Zaneis[2]	Fine-loamy, mixed, thermic	Udic Argiustolls	Payne, S8, T19N, R2E

The superscripts are shown in Appendix A.

The relationships were combined in a nomograph shown in Figure 2 which computes the value of K for any soil horizon in just four movements. The dotted line and arrows representing the surface horizon of Kirkland silt loam illustrates the procedure. When the entry data do no coincide with plotted percent-sand or percent-organic matter curves, linear interpolation should be considered. The selected physical and chemical data required for reading the nomograph are shown in Tables VI through XXI, in Appendix B. Table II gives an idea of the variability in the five parameters considering only the uppermost horizon of each soil.

TABLE II

VARIABILITY IN SOIL PROPERTIES
OF THE 16 SOILS STUDIED

Variable	Range in Values: Least	Range in Values: Greatest	Mean Value
Sand content (>.1 mm.), percent	0.9	50.7	10.6
Silt + v.f. sand (.1-.002 mm), percent	36.9	86.2	72.6
Organic Matter, percent	1.0	2.9	1.8
Soil Structure, coded*	1	4	2.4
Profile permeability, coded*	3	6	4.3

*Codification is shown in Figure 2.

When considering the permeability of horizons below the limiting horizon, for instance some B_3 or C horizon, their permeability is

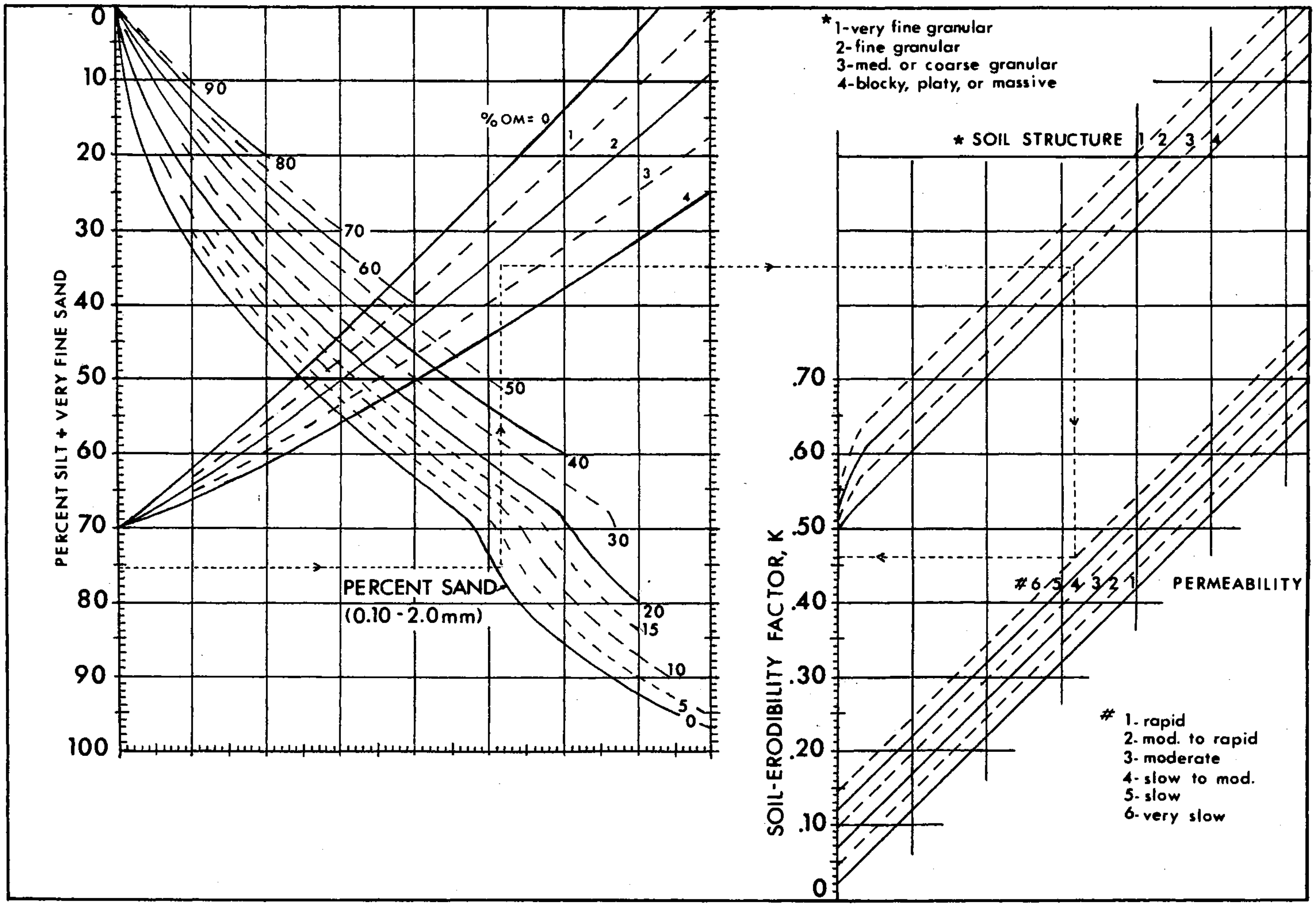


Figure 2. Soil Erodibility Nomograph.

considered to be that of the less permeable remaining horizon.

In this study erodibility factors were determined for every horizon in each profile in an attempt to extend its usefulness to potential nonagricultural users. Of course soil-losses can be predicted for all the underlying horizons which are exposed to an erosion hazard in construction sites and other disturbed areas in the same way that they can be estimated for surface horizons on agricultural lands. For practical reasons the K factors were determined for every horizon up to a maximum depth of 180 cm.

CHAPTER IV

RESULTS AND DISCUSSION

Erodibility Differences Related to the Whole Profile

The soil erodibility factor, K, for every horizon of each of the 16 soils studied are shown in Figures 3 to 18. The two-dimensional diagrams give a realistic idea of the relative depth of the solum, the sequence of horizons, and the type of structure which accounts for some of the variation in erodibility. Each horizon is characterized by a numerical erodibility factor which range from a maximum of 0.60 in the Cca horizon of Carey silt loam to a minimum of 0.11 in the C1 horizon of Shellabarger fine sandy loam. This more than five-fold ratio points out that the soil erodibility factor is primarily affected by differences in inherent soil properties.

Soil profiles were grouped according to erodibility variation with depth. One group of soils which includes Carey, Grant, Norge, Reinach, and Zaneis shows a consistent increase in erodibility with depth. Since the silt plus very fine sand fraction remains almost constant throughout the profile, and even decreases somewhat, the higher K values are considered the result of a decrease in organic matter and a less stable structure.

Another group, on the other hand, is characterized by a decrease in erodibility with depth, showing a quite stable subsoil and parent

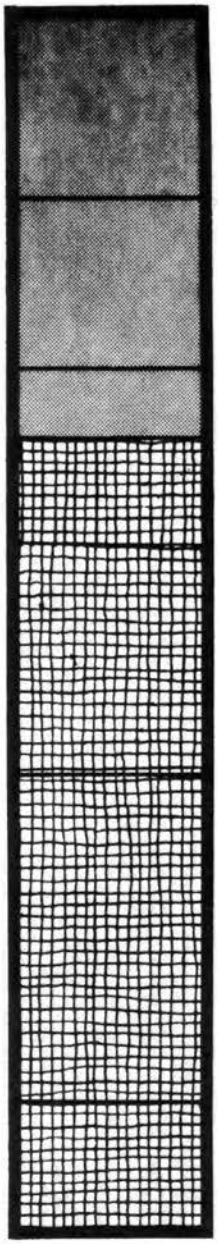
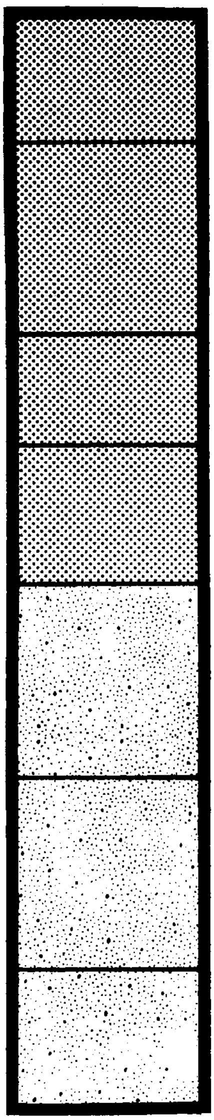
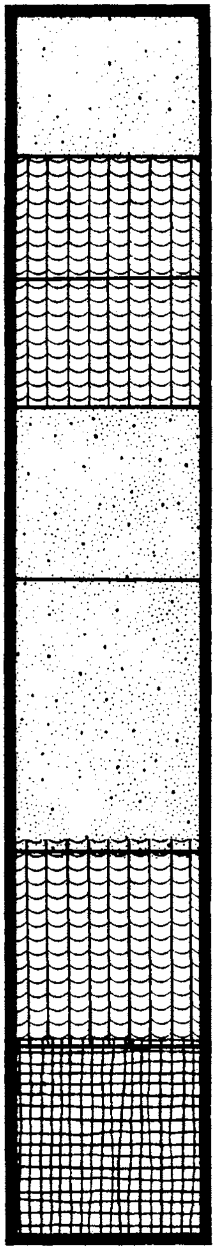


Figure 3. Erodibility Differences in a Slowly Permeable Bethany Silt Loam Profile.



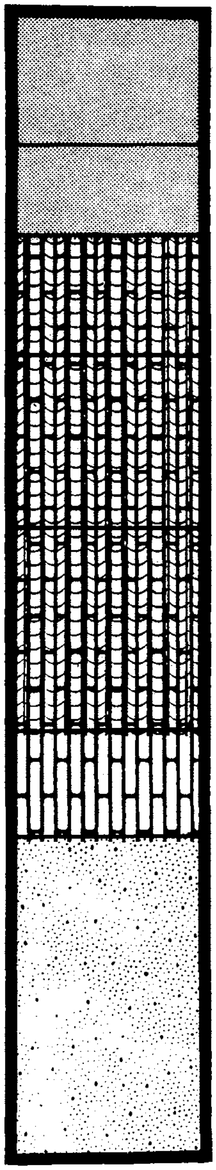
K	
.45	0 to 18 cm. Reddish brown silt loam; fine granular structure; 1.1% O.M.
.45	18 to 43 cm. Reddish brown light clay loam; medium and fine granular structure; 1.1% O.M.
.47	43 to 58 cm. Reddish brown light clay loam; medium granular structure; 0.7% O.M.
.46	58 to 76 cm. Red heavy loam; fine granular structure; 0.5% O.M.
.57	76 to 102 cm. Red loam; massive structure; 0.2% O.M.
.57	102 to 127 cm. Red loam; massive structure; 0.1% O.M.
.60	127 to 145 cm. Red loam, highly calcareous with many large lime concretions; 0.1% O.M.

Figure 4. Erodibility Differences in a Moderately Permeable Carey Silt Loam Profile.



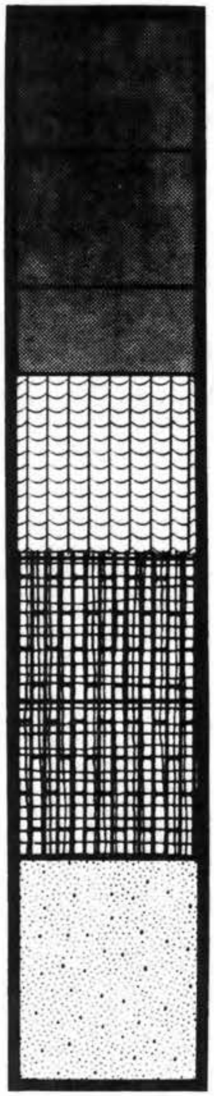
K	
.57	0 to 20 cm. Grayish brown light silty clay loam; structureless or puddled; 1.0% O.M.
.37	20 to 36 cm. Dark grayish brown clay; medium and fine subangular blocky; 1.2% O.M.
.47	36 to 53 cm. Dark grayish brown clay; medium subangular blocky structure; 0.6% O.M.
.47	53 to 76 cm. Dark grayish brown silty clay; massive structure; 0.4% O.M.
.45	76 to 112 cm. Dark grayish brown silty clay; massive structure; 0.2% O.M.
.47	112 to 137 cm. Light brown silty clay loam; medium subangular blocky structure; 0.1% O.M.
.48	137 to 163 cm. Light brown clay loam; coarse blocky structure; 0.1% O.M.

Figure 5. Erodibility Differences in a Very Slowly Permeable Foard Silty Clay Loam Profile.



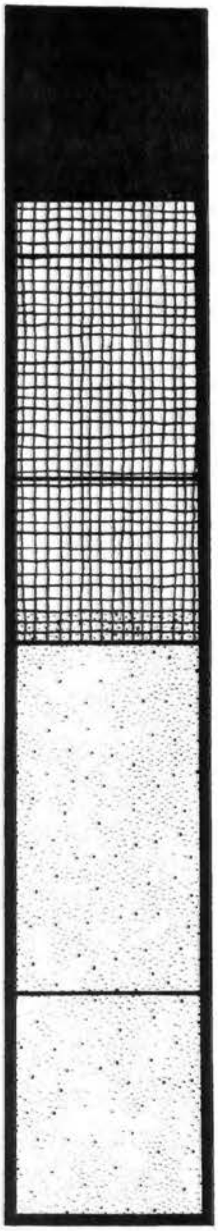
K	
.45	0 to 18 cm. Brown silt loam; fine granular structure; 1.3% O.M.
.42	18 to 30 cm. Dark brown silt loam, fine granular structure; 1.2% O.M.
.47	30 to 46 cm. Reddish brown heavy silt loam; coarse prismatic parting to fine subangular blocky; 1.1% O.M.
.49	46 to 69 cm. Reddish brown silty clay loam; coarse prismatic parting to fine subangular blocky; 0.9% O.M.
.56	69 to 94 cm. Reddish brown silty clay loam; coarse prismatic parting to fine subangular blocky; 0.5% O.M.
.56	94 to 109 cm. Red silt loam; coarse prismatic structure; 0.5% O.M.
.22	109 to 153 cm. Red weakly cemented sandstone; massive structure; 0.1% O.M.

Figure 6. Erodibility Differences in a Moderately Permeable Grant Silt Loam Profile.



K	
.51	0 to 18 cm. Reddish brown silt loam; medium granular structure; 2.0% O.M.
.50	18 to 36 cm. Same as layer above; 1.5% O.M.
.49	36 to 48 cm. Reddish brown silt loam; medium granular structure; 1.3% O.M.
.49	48 to 72 cm. Reddish brown silty clay loam; medium subangular blocky; 1.0% O.M.
.48	72 to 91 cm. Reddish brown silty clay loam; coarse prismatic and medium blocky; 0.9% O.M.
.53	91 to 112 cm. Red silt loam; coarse prismatic and medium blocky structure; 0.5% O.M.
.53	112 to 142 cm. Red heavy loam; massive structure; 0.4% O.M.

Figure 7. Erodibility Differences in a Moderately Slow Permeable Kingfisher Silt Loam Profile.



K	
.46	0 to 25 cm. Dark brown silt loam; medium granular structure; 2.3% O.M.
.45	25 to 31 cm. Dark brown silty clay loam; medium blocky structure; 1.5% O.M.
.37	31 to 62 cm. Dark brown clay; medium blocky structure; 1.1% O.M.
.39	62 to 84 cm. Clay similar to layer above with less distinctly blocky, nearly massive structure; 0.8% O.M.
.37	84 to 130 cm. Reddish brown clay; nearly massive structure; 0.4% O.M.
.36	130 to 160(+) cm. Light red silty clay; massive structure; 0.3% O.M.

Figure 8. Erodibility Differences in a Very Slowly Permeable Kirkland Silt Loam Profile.

K

.39 — 0 to 23 cm. Dark brown silt loam; medium and fine granular structure; 2.9% O.M.

.42 — 23 to 36 cm. Brown light silty clay loam; medium granular structure; 2.4% O.M.

.45 — 36 to 56 cm. Reddish brown silty clay loam; medium subangular blocky; 1.2% O.M.

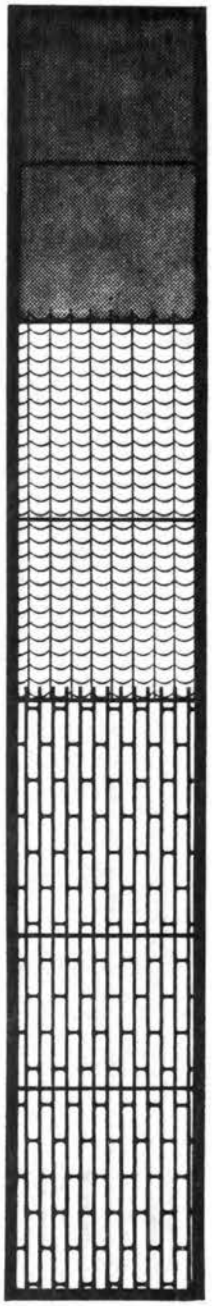
.47 — 56 to 81 cm. Reddish brown silty clay; coarse prismatic and medium subangular blocky; 0.6% O.M.

.51 — 81 to 102 cm. Reddish brown silty clay; coarse prismatic and medium subangular blocky structure; 0.4% O.M.

.53 — 102 to 122 cm. Reddish yellow silty clay; medium blocky structure; 0.2% O.M.

.53 — 122 to 168 cm. Yellowish red silty clay loam; subangular blocky and medium granular structure; 0.1% O.M.

Figure 9. Erodibility Differences in a Slowly Permeable Norge Silt Loam Profile.



K

.43 0 to 20 cm. Dark brown silt loam; fine granular structure; 2.0% O.M.

.36 20 to 41 cm. Dark brown heavy silt loam; fine granular structure; 2.0% O.M.

.33 41 to 67 cm. Dark brown silty clay loam; fine and medium subangular blocky structure; 1.5% O.M.

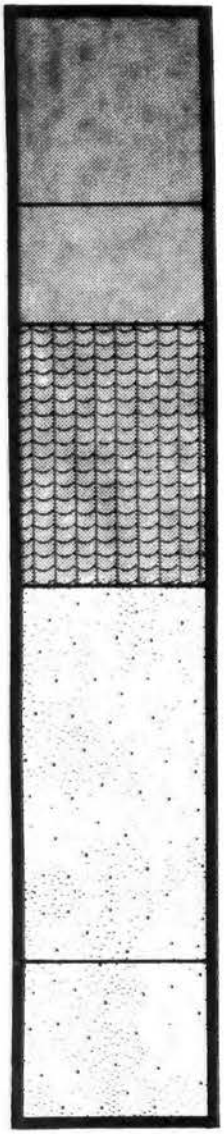
.37 67 to 91 cm. Very dark brown silty clay loam; fine and medium subangular blocky structure; 1.2% O.M.

.42 91 to 122 cm. Reddish brown silty clay loam; coarse prismatic structure; 1.0% O.M.

.47 122 to 142 cm. Red silty clay loam; coarse prismatic structure; 1.0% O.M.

.57 142 to 170 cm. Yellowish red light silty clay loam; coarse prismatic structure; 0.2% O.M.

Figure 10. Erodibility Differences in a Moderately Slow Permeable Pond Creek Silt Loam Profile.



K

.43 — 0 to 25 cm. Reddish brown silty loam; fine granular structure; 1.6% O.M.

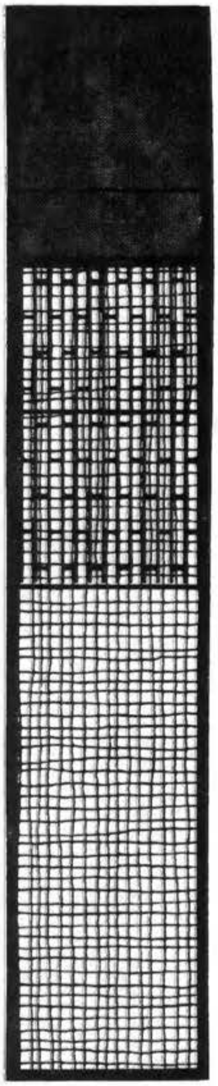
.42 — 25 to 41 cm. Reddish brown silty loam; fine granular structure; 1.3% O.M.

.47 — 41 to 76 cm. Reddish brown silty loam; medium subangular blocky and fine granular structure; 1.1% O.M.

.45 — 76 to 125 cm. Red silty loam; massive structure; 0.5% O.M.

.52 — 125 to 147 cm. Light red silty loam; massive structure; 0% O.M.

Figure 11. Erodibility Differences in a Moderately Permeable Reinach Silt Loam Profile.



K

.43 0 to 28 cm. Dark reddish brown silt loam; medium granular structure; 2.6% O.M.

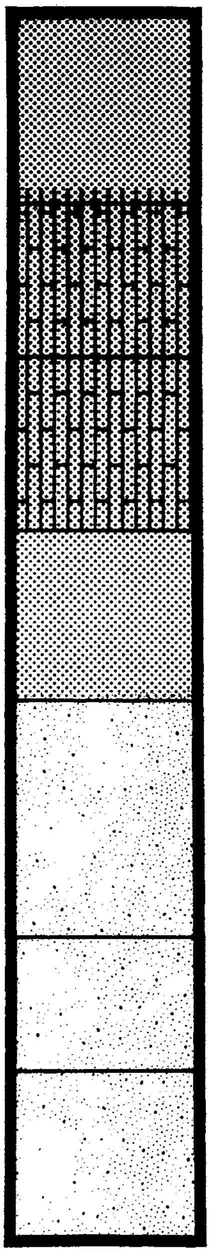
.36 28 to 33 cm. Dark reddish brown light clay loam; medium and fine granular structure; 2.0% O.M.

.33 33 to 53 cm. Dark reddish brown clay; prismatic and medium blocky structure; 1.2% O.M.

.36 53 to 76 cm. Dark reddish brown clay; prismatic and coarse blocky structure; 0.7% O.M.

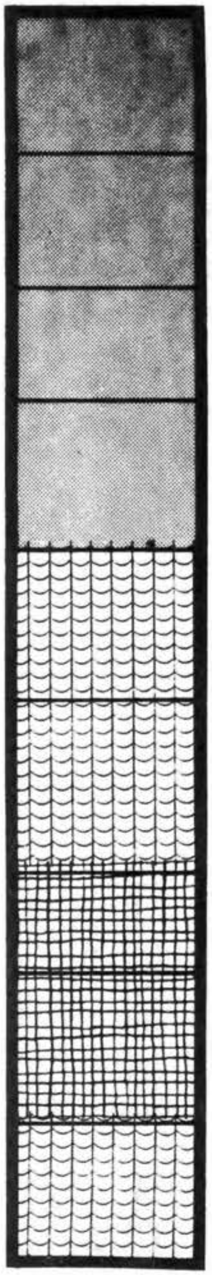
.37 76 to 140 cm. Reddish brown clay; medium blocky structure; 0.2% O.M.

Figure 12. Erodibility Differences in a Very Slowly Permeable Renfrow Silt Loam Profile.



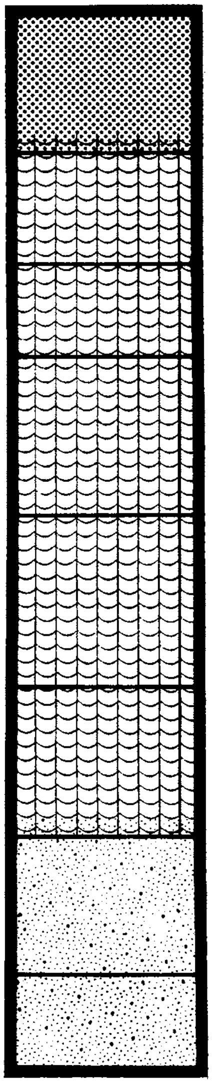
K	
.19	0 to 25 cm. Dark brown fine sandy loam; very fine granular structure; 1.8% O.M.
.21	25 to 46 cm. Dark reddish brown light clay loam; prismatic breaking to fine and medium granular structure; 1.2% O.M.
.23	46 to 69 cm. Yellowish red clay loam; prismatic breaking to fine and medium granular structure; 0.7% O.M.
.20	69 to 91 cm. Yellowish red sandy clay loam; medium granular structure; 0.4% O.M.
.11	91 to 122 cm. Reddish yellow loamy sand; structureless; 0.1% O.M.
.16	122 to 140 cm. Reddish yellow sandy clay loam; structureless; 0.2% O.M.
.18	140 to 163 cm. Mottled gray, yellow orange, and red dense sandy clay; structureless; 0.1% O.M.

Figure 13. Erodibility Differences in a Moderately Permeable Shellabarger Fine Sandy Loam Profile.



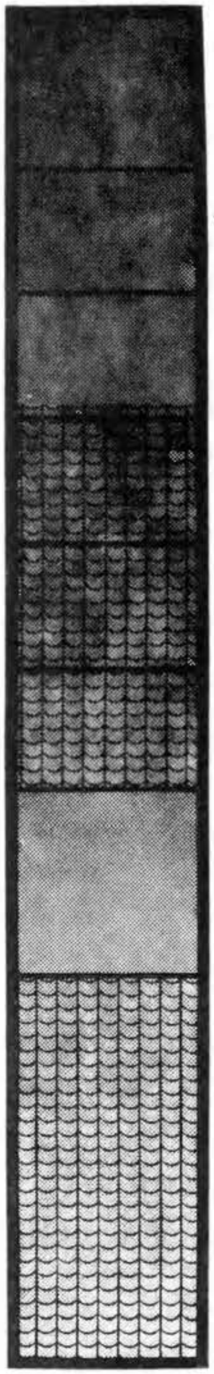
K	
.49	0 to 18 cm. Dark brown silt loam; fine granular structure; 1.3% O.M.
.43	18 to 36 cm. Dark grayish brown silt loam; fine granular structure; 1.4% O.M.
.45	36 to 51 cm. Dark grayish brown heavy silt loam; fine granular structure; 1.2% O.M.
.45	51 to 71 cm. Brown light silty clay loam; fine granular structure; 0.9% O.M.
.51	71 to 91 cm. Brown silty clay loam; fine subangular blocky structure; 0.8% O.M.
.46	91 to 114 cm. Dark brown heavy silty clay loam; medium to fine subangular blocky structure; 0.8% O.M.
.38	114 to 127 cm. Reddish brown silty clay; fine and medium blocky structure; 0.7% O.M.
.45	127 to 147 cm. Reddish brown clay loam; medium blocky structure; 0.4% O.M.
.49	147 to 165 cm. Yellowish red light clay loam; medium and fine subangular blocky structure; 0.4% O.M.

Figure 14. Erodibility Differences in a Moderately Slow Permeable St. Paul Silt Loam Profile.



K	
.41	0 to 18 cm. Dark brown fine sandy loam; medium granular structure; 1.1% O.M.
.37	18 to 33 cm. Brownish black fine sandy loam; medium subangular blocky; 1.4% O.M.
.37	33 to 45 cm. Dark brown light sandy clay loam; medium subangular blocky; 1.2% O.M.
.35	45 to 66 cm. Brown sandy clay loam; medium subangular blocky structure; 1.1% O.M.
.28	66 to 89 cm. Brown sandy clay loam; medium subangular blocky structure; 0.8% O.M.
.29	89 to 109 cm. Brown light sandy clay loam; medium subangular blocky structure; 0.5% O.M.
.27	109 to 127 cm. Yellowish brown sandy loam; structureless, single grain; 0.4% O.M.
.28	127 to 140 cm. Yellowish brown sandy loam; single grain; 0.4% O.M.

Figure 15. Erodibility Differences in a Moderately Permeable Teller Loam Profile.



K

.39 0 to 20 cm. Dark grayish brown silt loam; medium granular structure; 2.5% O.M.

.43 20 to 36 cm. Dark grayish brown silt loam; medium granular structure; 2.0% O.M.

.42 36 to 53 cm. Dark grayish brown light silty clay loam; medium granular; 1.8% O.M.

.42 53 to 69 cm. Dark brown silty clay loam; medium subangular blocky and medium granular; 1.3% O.M.

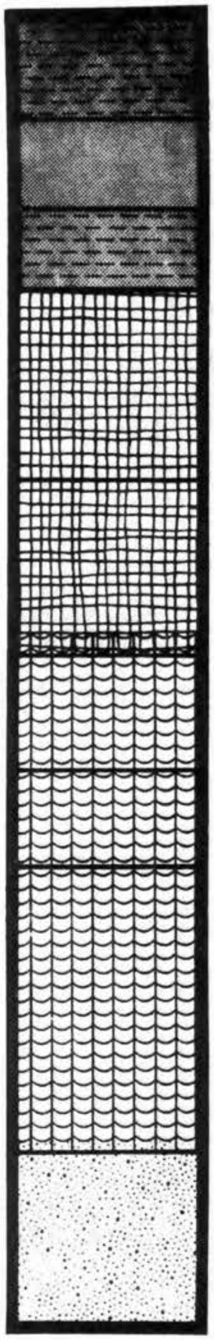
.40 69 to 86 cm. Much like the layer above; 1.0% O.M.

.36 86 to 102 cm. Reddish brown silty clay loam; medium subangular blocky and medium granular; 0.6% O.M.

.40 102 to 127 cm. Similar to layer above; 0.5% O.M.

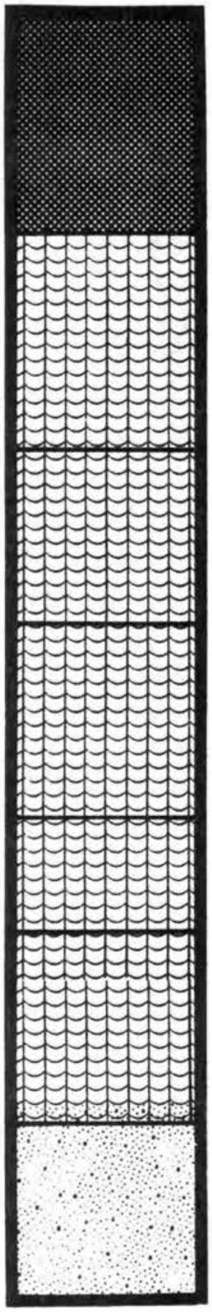
.44 127 to 178 cm. Yellowish red silty clay loam; medium granular and fine subangular blocky structure; 0.3% O.M.

Figure 16. Erodibility Differences in a Moderately Permeable Vanoss Silt Loam Profile.



K	
.53	0 to 13 cm. Grayish brown silt loam; fine granular, nearly structureless with thin plates; 1.5% O.M.
.52	13 to 25 cm. Dark grayish brown silt loam; fine granular; 1.2% O.M.
.55	25 to 36 cm. Light brownish gray silt loam; fine granular to platy; 0.7% O.M.
.36	36 to 61 cm. Dark grayish brown clay; medium blocky structure; 0.8% O.M.
.38	61 to 84 cm. Dark brown clay; medium blocky structure; 0.8% O.M.
.39	84 to 99 cm. Dark brown silty clay loam; medium subangular blocky structure; 0.6% O.M.
.43	99 to 112 cm. Brown clay loam; medium subangular blocky structure; 0.3% O.M.
.50	112 to 150 cm. Reddish brown clay loam; medium subangular blocky structure; 0.1% O.M.
.53	150 to 173 cm. Yellowish red clay loam; massive structure; 0% O.M.

Figure 17. Erodibility Differences in a Very Slowly Permeable Waurika Silt Loam Profile.



K

.39 — 0 to 28 cm. Very dark reddish gray loam; medium granular structure; 2.5% O.M.

.36 — 28 to 58 cm. Yellowish red clay loam; fine subangular blocky structure; 1.5% O.M.

.36 — 58 to 81 cm. Yellowish red clay loam; fine subangular blocky structure; 1.2% O.M.

.42 — 81 to 107 cm. Yellowish red clay loam; fine subangular blocky structure; 0.7% O.M.

.44 — 107 to 122 cm. Yellowish red clay loam; medium subangular blocky structure; 0.4% O.M.

.46 — 122 to 147 cm. Dark red loam; subangular blocky; 0.2% O.M.

.51 — 147 to 170(+) cm. Dark reddish brown weathered sandstone and shale; 0.1% O.M.

Figure 18. Erodibility Differences in a Moderately Slow Permeable Zaneis Loam Profile.

material. This trend is related to a sharp decrease in the silt plus very fine sand fraction, the other characteristics follow tendencies similar to the first group. Bethany, Kirkland, Renfrow, and Teller follow this pattern.

Still another group of soils show almost no variation in erodibility throughout their profiles. Although some slight variations occur, no identifiable pattern is evident. Soils of this class are Shellabarger, St. Paul and Vanoss.

The Foard, Kingfisher, Pond Creek, and Waurika soils have a high degree of erodibility at the surface which decreases at the B_1 and/or B_2 horizon before it increases again at the B_3 and/or C horizon. This variation closely follows the percent silt plus very fine sand which is high at the surface, decreases in the middle horizons where the clay fraction increases, and is high again at the bottom of these profiles.

How the Equation Works at Construction Sites

An example is presented here to explain better the use of the K factor in the soil-loss equation to predict sediment yields in construction sites and other disturbed areas. The equation is $A = R\ L\ S\ K\ C\ P$. It expresses soil loss in tons per acre per year (A) as the product of factors for rainfall (R), slope length (L), slope steepness (S), soil erodibility (K), cropping and management (C), and conservation practices (P).

It is assumed that Mr. Smith is planning a residential development in Payne County, Oklahoma. The site is on a normal erosional upland phase of Zaneis loam with a slope of three percent and averaging about 800 feet in length.

The first step is to locate Payne County on the map in Figure 19 in order to determine the R value which for this particular site is 250. Then it is necessary to enter Figure 20 with the 800-foot slope length, move vertically to the 3-percent slope curve, and read the proper LS value, 0.9 in this case, at the left margin. The total erosive potential of the expected rainfall and runoff is, therefore, 250 X 0.9 = 225 RLS units. Next, the expected soil loss per unit of RLS, which is the K factor, must be taken into calculation. First, the value for the A_1 horizon, K = 0.39, is considered. If the construction site were completely denuded and smoothed by bulldozers, its condition would approach that of continuous fallow. In such condition the product of the factors C and P is equal to 1.0. The final step in calculating the potential sediment yield of the A_1 horizon in an average-rainfall year is to multiply the K and CP values times the number of RLS units, or 0.39 x 1.0 x 225 = 88 T/A.

The B or C horizon of a soil is often more erodible than its topsoil. This is true for Carey, Grant, Norge, Reinach, and Zaneis as was pointed out before (above). The profile description of Zaneis loam (Figure 18) shows that removal of 18 cm. would increase K from 0.39 to 0.42, and that the removal of the top 147 cm would expose the highly erodible C horizon with a K factor of 0.51. In these cases the expected sediment yields would amount to 95 and 115 T/A, respectively.

In some situations, sediment yield can be reduced considerably by introducing some type of topographic modification in such a manner as to minimize the exposure of the more erodible layers. The use of protective mulches, for instance, during the exposure period will greatly enhance the reduction of sediment yield and also provide aid

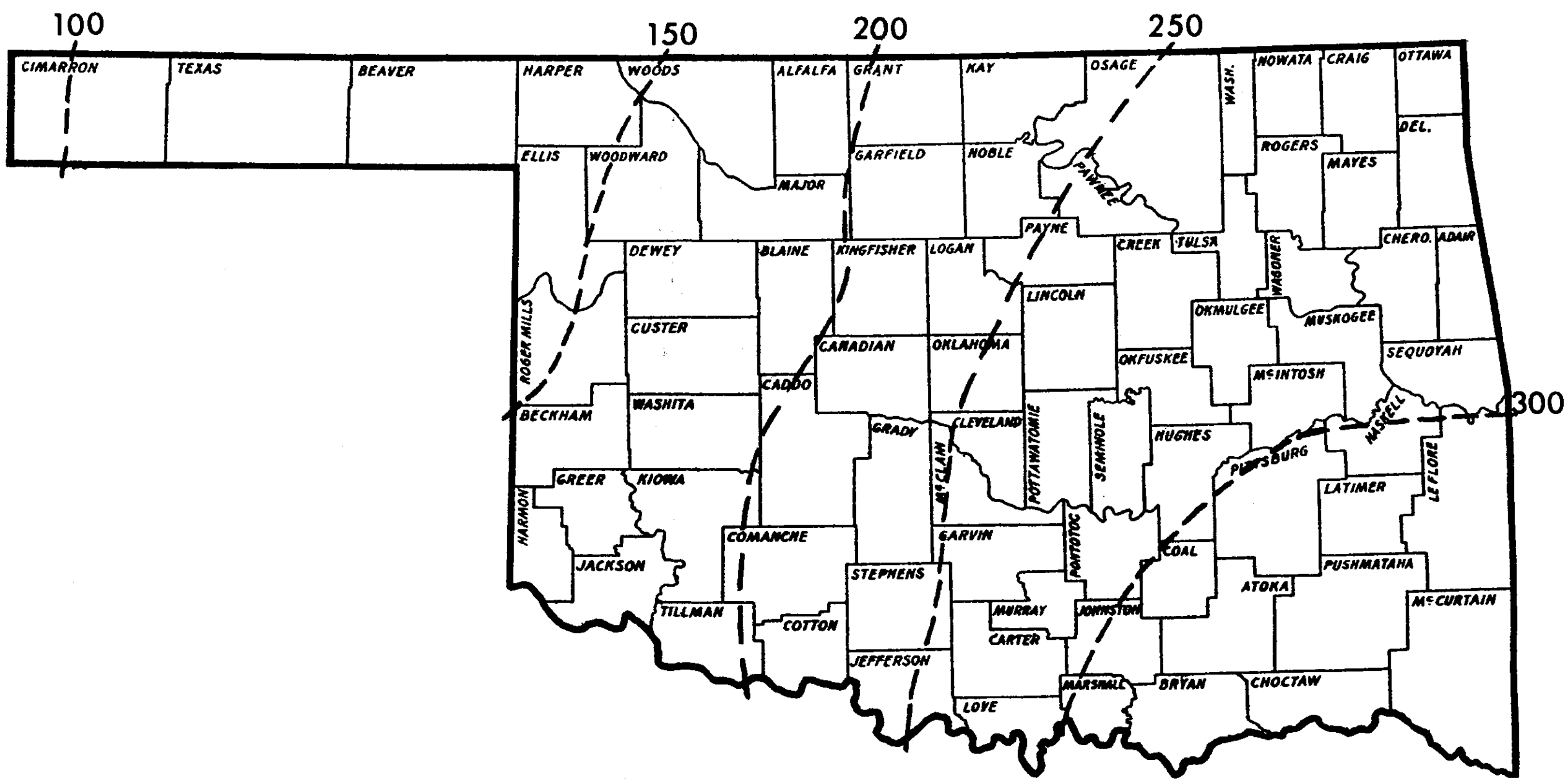


Figure 19. Iso-erodent Map of Oklahoma. (R Values for the erosion equation)

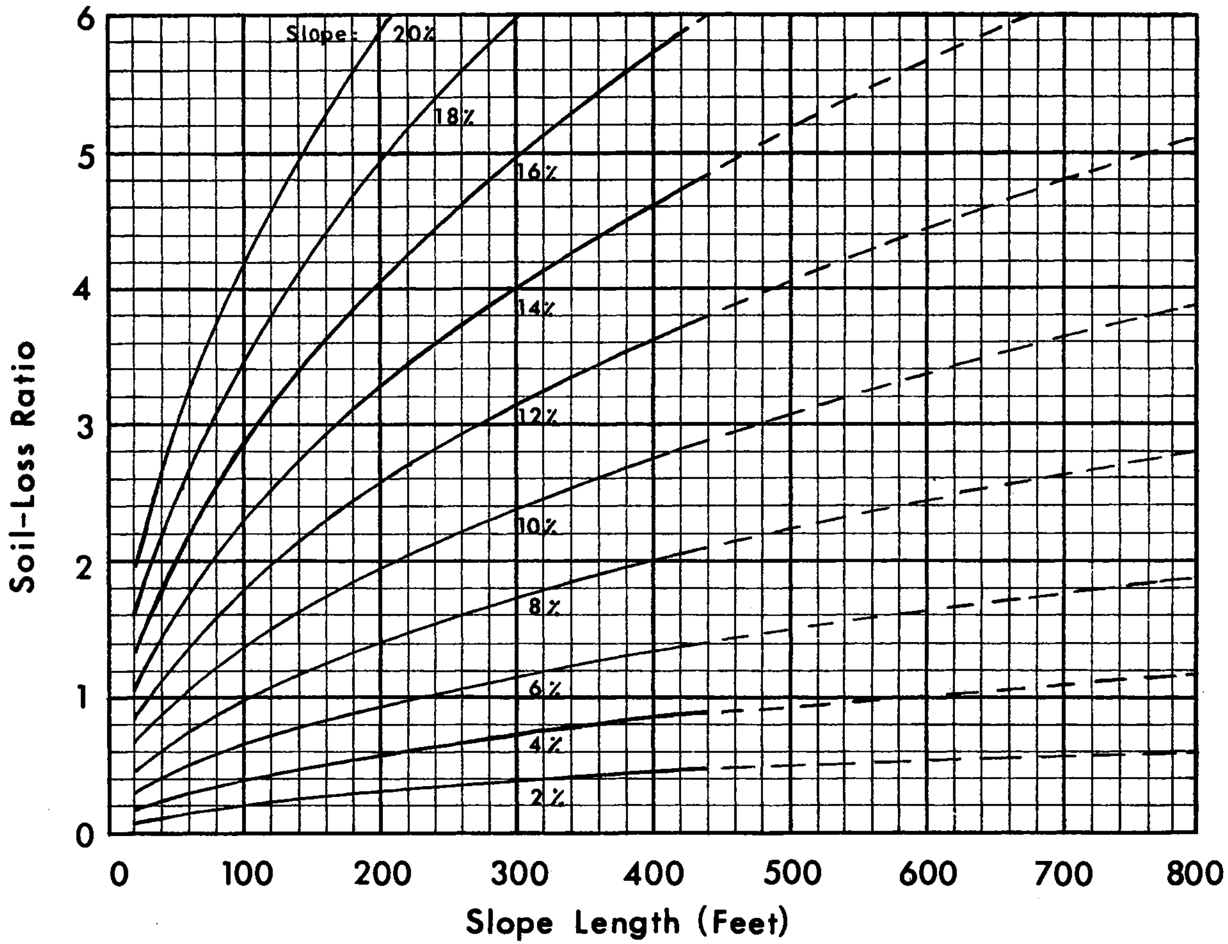


Figure 20. Slope-Effect Chart.
(LS values for the erosion equation)

for a faster revegetation. Results reported by Meyer et al. (5) show that straw mulch reduces the soil loss more than 5 times when compared with scalped and scarified soils. In other situations the return of the topsoil would be highly desirable. This is particularly true for those soils like Carey and Grant whose subsoils and parent materials are more erodible than their respective topsoils.

Soil Erosion on Agricultural Lands

Erosion on cropland refers almost exclusively to the topsoil since it is the surface horizon which is primarily affected by erosion. Table III gives the erodibility factors for the surface horizons of every soil studied. The values obtained by reading the nomograph are shown under the heading "Predicted K" and are compared with the established values in current use by by the Soil Conservation Service. Most of the estimated values currently in use were obtained by extrapolation from the experimental values of a few benchmark soils, therefore, they do not allow a statistical comparison.

The predicted K values are consistently higher than the estimated K values. The upward bias is probably caused by the use of specific profile descriptions. These descriptions probably do not agree completely with the central concept of the series as used in the estimation procedure.

The method used in this study seems to be more accurate in reflecting local soil differences, and is more adapted to small scale studies. For example, an increase in the organic matter content of the A_1 horizon of Kingfisher silt loam from 2 to 3 percent will decrease the K factor from 0.51 to 0.44. This is perfectly possible by means of an

TABLE III

COMPARISON BETWEEN PREDICTED AND ESTIMATED K VALUES AND ERODIBILITY CLASSIFICATION

Soil Series	Predicted K	Estimated K[1]	T Factor[1]	Erodibility Class
Bethany silt loam	.49	.37	5	Highly erodible
Carey silt loam	.45	.32	5	Highly erodible
Foard silty clay loam	.57	.43	5	Very highly erodible
Grant silt loam	.45	.37	5	Highly erodible
Kingfisher silt loam	.51	.32	4	Very highly erodible
Kirkland silt loam	.46	.43	5	Highly erodible
Norge silt loam	.39	.32	5	Moderately high erodible
Pond Creek silt loam	.43	.32	5	Highly erodible
Reinach silt loam	.43	.28	5	Highly erodible
Renfrow silt loam	.43	.37	5	Highly erodible
Shellabarger fine sandy loam	.19	-	5	Slightly erodible
St Paul silt loam	.49	.32	5	Highly erodible
Teller loam	.41	.28	5	Highly erodible
Vanoss silt loam	.39	.32	5	Moderately high erodible
Waurika silt loam	.53	.43	5	Very highly erodible
Zaneis loam	.39	.28	4	Moderately high erodible

[1] Estimated K values and T factors obtained from South Regional Technical Service Center (16).

adequate residue-management.

Almost intuitively, particle-size distribution is related to soil erodibility. Generally speaking, soils that are high in silt plus very fine sand, low in clay, and low in organic matter are the most erodible. Usually, erodibility decreases with decrease in the silt fraction, regardless of whether the corresponding increase is in the sand fraction or in the clay fraction. The order of erodibility according to texture is found to be the following: silty clay loam > silt loam > loam > fine sandy loam. In other words, erodibility decreases with coarseness of texture. Table IV gives the variability of the K values related to soil texture.

TABLE IV

VARIABILITY OF K RELATED TO TEXTURE

Soil Texture	Number of Soils	Range in Values Greatest	Range in Values Least	Mean Value
Silty clay loam	1	.57	.57	.57
Silt loam	12	.53	.39	.45
Loam	2	.41	.39	.40
Fine sandy loam	1	.19	.19	.19

The results in Table III show that Mollisols in Oklahoma do vary greatly with respect to inherent erodibilities. The 16 soils were tentatively classified according to their degree of erodibility. Sets of relative classes of soil erodibility are as follows:

	Range in K Values
Very highly erodible	> .50
Highly erodible	.40- .50
Moderately high erodible	.30- .40
Moderately erodible	.20- .30
Slightly erodible	< .20

The placement of soil series according to erodibility classes is also shown in Table III.

Some Erosion-Control Alternatives on Cropland

The accurate determination of the K factor by this simple procedure allows use of the erosion equation on hundreds of agricultural soils throughout the state. The policy of the Soil Conservation Service has always been to keep average soil losses from cultivated fields below five tons per acre per year, representing less than 1 millimeter of soil. The maximum permissible soil loss is defined as "T value" and is also listed in Table III for each soil series. It is also advisable to provide the farmer with many options for selecting cropping-system and management combinations in order that he can select the one which is best suited to his particular enterprise.

To present some of the possible alternatives as referred above, the soil-loss prediction equation is developed here for Grant silt loam which is located at the North Central Oklahoma Agronomy Research Station, Lahoma, Major County. This soil is highly erodible and its K factor for the plow layer is 0.45. From Figure 19, R = 200 at that location. Grant has a dominant 3-percent slope, with an average length of 600 feet. For this combination Figure 20 gives an LS value of 0.78. These values predict a basic soil-loss potential of 200 x 0.78 x 0.45 = 70 tons per acre per year.

Table III gives a soil-loss tolerance value of 5 tons per acre per year. To keep erosion under the tolerable limit it is necessary to use a CP factor no larger than 5/70 or 0.071. A table of CP values applicable to western Oklahoma was obtained from the local Soil Conservation Service. Table V lists some of these values. It shows that the only alternative is continuous small grain, 500-1000# residue on the surface at planting time with terraces and contour farming.

The terraces, which were already constructed, shortened the slope length to 300 feet thereby reducing the LS factor to 0.55. The product RLSK would now be 200 x 0.55 x 0.45 = 50 T/A, giving a maximum CP of 5/50 or 0.10. From Table V some other alternatives could now be used. They are: (1) continuous small grain, heavy residue under, with contour farming; or (2) continuous small grain, 500-1000# residue on surface at planting time, with field boundary farming; or even (3) two years small grain, 500-1000# residue on surface, two years cotton with winter cover, and contour farming. With this last alternative the annual soil-loss would be 8 T/A.

The soil-loss equation is used to predict the average annual soil loss that might be expected over a period of years. Nevertheless, it is important to note here that gross erosion in any one particular year may be as much as three or four times this average rate. In other years it might be less.

TABLE V

TYPICAL CROPPING-MANAGEMENT FACTORS FOR WESTERN OKLAHOMA

Cropping System	C P Factor W/O Terraces or Contour Farming	W/Terraces & Field Boundary Farming	W/Terraces & Contour Farming
Continuous Small Grain, M.R.U. 6/20	.29	.21	.15
Continuous Small Grain, H.R.U. 6/20	.22	.16	.11
Continuous Small Grain, M.R.U. 8/1	.22	.16	.11
Continuous Small Grain, H.R.U. 8/1	.18	.13	.09
Continuous Small Grain, 500-1000# R.O.S.	.12	.09	.06
Continuous Cotton, Moderate Fertility, No W/C	.59	.42	.30
Continuous Cotton, Moderate Fertility, With W/C	.50	.35	.25
2 Yrs. S. Gr., M.R.U. 8/1; 2 Yrs. Cotton, No W/C	.40	.28	.20
2 Yrs. S. Gr., 500-1000# R.O.S.; 2 Yrs. Cotton, No. W/C	.35	.25	.18
2 Yrs. S. Gr., 500-1000# R.O.S.; 2 Yrs. Cotton, With W/C	.31	.22	.16
Row Crop, Continuous Grain Sorghum, 25-30 bu/A.	.48	.34	.24
Row Crop, Continuous Grain Sorghum, 35-45 bu/A.	.42	.30	.21
Continuous Peanuts, with W/C	.43	.30	.22
Continuous Peanuts, no W/C	.54	.38	.27

M.R.U. = Moderate residue under

H.R.U. = Heavy residue under

R.O.S. = Residue on surface at seeding time

W/C = Winter cover

Since cultivated fields are a major sediment source in a general agricultural area, the equation may be used effectively to make sediment predictions over broad regions. In such cases sedimentation from gullies, roadside areas and residential sites also must be taken into consideration in making estimates of the total sediment loads.

CHAPTER V

SUMMARY AND CONCLUSION

Direct measurements of the erodibility factor is both costly and time-consuming and has been only feasible for a few major soil types. Based upon this premise the major objective of this study was to obtain soil erodibility values by a theoretical procedure. The study was conducted for 16 selected soils of order Mollisol. Criteria of selection were: (1) availability of laboratory data and soil profile descriptions, (2) agricultural importance, and (3) geographical location on the Central Reddish Prairies and Rolling Red Plains resource areas of Oklahoma. The soils included 1 fine sandy loam, 2 loams, 12 silt loams, and a silty clay loam.

The procedure for determining the erodibility factor was based upon five soil parameters which were translated into a simple nomograph (29). The parameters required were; silt plus very fine sand, sand coarser than very fine sand, organic matter, soil structure, and profile permeability. The reading of the nomograph is fast and accurate requiring only four movements. This procedure seems to bring some hope of easily determining the K factor for a broad number of soils, even at the soil phase level. This will allow further use of the soil-loss prediction equation for better conservation planning.

The soil erodibility factor, K, was determined for every horizon of each profile. Erodibility differences in each profile were related to depth. In some soils erodibility increased with depth, in others it decreased, while in still other soils it showed almost no variation through their profiles.

Mollisols in Oklahoma vary greatly with respect to inherent erodibilities when considering the plow layer. The extreme values were found to be 0.57 and 0.19, a three-fold variation. The erodibility was highly correlated with texture. The order of erodibility according to texture was: silty clay loam > silt loam > loam > fine sandy loam. Therefore, erodibility decreased with coarseness of texture. The soils were tentatively grouped in erodibility classes. This classification may be found in Chapter IV (i.e., Results and Discussion).

Examples of how the K values fit into the equation to predict soil losses were developed to encourage farmers, contractors, land developers, and others to use the equation as a valuable tool in conservation of one of our most valuable resources, our soils.

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APPENDIX A

SOURCES OF DATA

Sources of Data

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APPENDIX B

PHYSICAL AND CHEMICAL DATA (TABLES)

TABLE VI

SELECTED PHYSICAL AND CHEMICAL DATA OF BETHANY SILT LOAM

Horizon	Depth	Sand 2.0-0.1mm.	V.f. sand + Silt 0.1-0.002 mm.	Clay <0.002 mm.	Textural Class	Structure	Organic Matter
	cm.	%	%	%			%
Ap	0-25	1.5	84.0	14.5	sil	fgr	1.7
A12	25-48	1.1	78.4	20.5	sil	mgr	1.5
B1	48-56	1.5	67.5	31.0	sicl	mgr	1.0
B2t	56-102	1.5	59.3	39.2	sicl	mbk	0.8
B3	102-145	3.3	58.2	38.5	sicl	mbk	0.3
C1	145-163	2.1	58.2	39.7	sicl	mbk	0.2
C2	163-193	2.0	58.6	39.4	sicl	m	0.1

TABLE VII

SELECTED PHYSICAL AND CHEMICAL DATA OF CAREY SILT LOAM

Horizon	Depth	Sand 2.0-0.1 mm.	V.f. sand + silt 0.1-0.002 mm	Clay <0.002 mm.	Textural Class	Structure	Organic Matter
	cm	%	%	%			%
Ap	0-18	7.3	73.9	18.8	1	fgr	1.1
B21	18-43	6.4	70.7	22.9	1	fmgr	1.1
B22	43-58	8.7	68.6	22.7	1	mgr	0.7
B3	58-76	8.4	70.6	21.0	1	fgr	0.5
C1	76-102	8.5	74.6	16.9	1	m	0.2
C2	102-127	7.3	77.7	15.0	1	m	0.1
Cca	127-145	11.6	74.0	14.4	1	m	0.1

TABLE VIII

SELECTED PHYSICAL AND CHEMICAL DATA OF FOARD SILTY CLAY LOAM

Horizon	Depth	Sand 2.0-0.1 mm.	V.f. sand + silt 0.1 - 0.002 mm.	Clay <0.002 mm.	Textural Class	Structure	Organic Matter
	cm.	%	%	%			%
Ap	0-20	4.3	74.1	21.6	sil	m	1.0
B21t	20-36	2.8	54.8	42.4	sic	fmsbk	1.2
B22t	36-53	5.9	60.5	33.6	sicl	msbk	0.6
Bca1	53-76	6.9	59.4	33.7	sicl	m	0.4
Bca2	76-112	6.5	58.3	35.2	sicl	m	0.2
B3	112-137	6.6	59.0	34.4	sicl	msbk	0.1
C1	137-163	6.5	60.4	33.1	sicl	cbk	0.1
C2	163-178	7.5	61.3	31.2	cl	cbk	0.1

TABLE IX

SELECTED PHYSICAL AND CHEMICAL DATA OF GRANT SILT LOAM

Horizon	Depth	Sand 2.0-0.1 mm.	V.f. sand + silt 0.1-0.002 mm.	Clay <0.002 mm.	Textural Class	Structure	Organic Matter
	cm.	%	%	%			%
Ap	0-18	2.7	80.1	17.2	sil	fgr	1.3
A12	18-30	1.8	77.0	21.2	sil	fgr	1.2
B1	30-46	1.6	75.2	23.2	sil	cpr-fsbk	1.1
B21t	46-69	2.2	75.6	22.2	sil	cpr-fsbk	0.9
B22t	69-94	0.8	84.0	15.2	sil	cpr-fsbk	0.5
B3	94-109	0.9	83.9	15.2	sil	cpr	0.5
R	109-152	0.3	93.0	6.7	sl	m	0.1

TABLE X

SELECTED PHYSICAL AND CHEMICAL DATA OF KINGFISHER SILT LOAM

Horizon	Depth	Sand 2.0-0.1 mm.	V.f. sand + silt 0.1-0.002 mm.	Clay <0.002 mm.	Textural Class	Structure	Organic Matter
	cm	%	%	%			%
A11	0-18	0.9	86.2	12.9	sil	mgr	2.0
A12	18-36	0.7	81.9	17.4	sil	mgr	1.5
A3	36-48	1.1	79.5	19.4	sil	mgr	1.3
B21t	48-72	0.8	71.4	27.8	sicl	msbk	1.0
B22t	72-91	0.7	71.4	27.9	sicl	cpr-mbk	0.9
B3	91-112	0.8	75.8	23.4	sil	cpr-mbk	0.5
C1	112-142	0.8	82.5	16.7	sil	m	0.4
C2	142-173	1.6	78.7	19.7	sil	m	0.2

TABLE XI

SELECTED PHYSICAL AND CHEMICAL DATA OF KIRKLAND SILT LOAM

Horizon	Depth	Sand 2.0- 0.1 mm.	V.f. sand + silt 0.1- 0.002 mm.	Clay <0.002 mm.	Textural Class	Structure	Organic Matter
	cm	%	%	%			%
A1	0-25	1.9	75.6	22.5	sil	mgr	2.3
B1	25-31	1.6	63.6	34.8	sicl	mbk	1.5
B21t	31-62	1.1	56.4	42.5	sic	mbk	1.1
B22t	62-84	1.0	56.9	42.1	sic	bk-m	0.8
B3	84-130	0.9	53.4	45.7	sic	m	0.4
Cca	130-213	0.6	53.4	46.0	sic	m	0.3
C	213-254	2.1	71.7	26.2	sil	m	-

TABLE XII

SELECTED PHYSICAL AND CHEMICAL DATA OF NORGE SILT LOAM

Horizon	Depth	Sand 2.0-0.1 mm.	V.f. sand + silt 0.1-0.002 mm.	Clay <0.002 mm.	Textural Class	Structure	Organic Matter
	cm	%	%	%			%
A11	0-23	5.4	76.0	18.6	sil	fmgr	2.9
A12	23-36	2.7	72.7	24.6	sil	mgr	2.4
B1	36-56	2.9	64.9	32.2	sicl	msbk	1.2
B21t	56-81	2.1	65.5	32.4	sicl	cpr-msbk	0.6
B22t	81-102	1.9	68.0	30.1	sicl	cpr-msbk	0.4
B3	102-122	1.9	68.8	29.3	sicl	mbk	0.2
C1	122-168	2.0	69.8	28.2	sicl	sbk-mgr	0.1
C2	168-239	2.5	68.4	29.1	sicl	sbk-mgr	-

TABLE XIII

SELECTED PHYSICAL AND CHEMICAL DATA OF POND CREEK SILT LOAM

Horizon	Depth	Sand 2.0-0.1 mm.	V.f. sand + silt 0.1-0.002 mm.	Clay <0.002 mm.	Textural Class	Structure	Organic Matter
	cm	%	%	%			%
Ap	0-20	6.1	77.6	16.3	sil	fgr	2.0
B1	20-41	4.3	66.9	28.8	sicl	fgr	2.0
B21t	41-67	9.1	54.0	36.9	sicl	fmsbk	1.5
B22t	67-91	11.9	55.6	32.5	cl	fmsbk	1.2
B23t	91-122	18.3	55.5	26.2	1	cpr	1.0
B24t	122-142	13.3	63.0	23.7	1	cpr	1.0
B3	142-170	6.7	72.1	21.2	sil	cpr	0.2
C1	170-218	2.4	79.4	18.2	sil	m	0.4

TABLE XIV

SELECTED PHYSICAL AND CHEMICAL DATA OF REINACH SILT LOAM

Horizon	Depth	Sand 2.0-0.1 mm.	V.f. sand + silt 0.1-0.002 mm.	Clay <0.002 mm.	Textural Class	Structure	Organic Matter
	cm	%	%	%			%
Ap	0-25	8.0	76.9	15.1	sil	fgr	1.6
A12	25-41	5.7	75.4	18.9	1	fgr	1.3
B2	41-76	12.3	70.1	17.6	1	msbk-fpr	1.1
C1	76-125	7.9	71.9	20.2	1	m	0.5
C2	125-147	4.9	78.7	16.4	sil	m	-

TABLE XV

SELECTED PHYSICAL AND CHEMICAL DATA OF RENFROW SILT LOAM

Horizon	Depth	Sand 2.0-0.1 mm.	V.f. sand + silt 0.1-0.002 mm.	Clay <0.002 mm.	Textural Class	Structure	Organic Matter
	cm	%	%	%			%
A1	0-28	10.5	66.1	23.4	sil	mgr	2.6
A3	28-33	7.4	58.4	34.2	cl	mfgr	2.0
B2t	33-53	6.0	49.1	44.9	sic	cpr-mbk	1.2
B3	53-76	6.3	50.1	43.6	sic	vcpr-cbk	0.7
C	76-140	5.7	52.2	42.1	sic	mbk	0.2

TABLE XVI

SELECTED PHYSICAL AND CHEMICAL DATA OF SHELLABARGER FINE SANDY LOAM

Horizon	Depth	Sand 2.0-0.1 mm.	V.f.sand + silt 0.1-0.002 mm.	Clay <0.002 mm.	Textural Class	Structure	Organic Matter
	cm	%	%	%			%
A	0-25	50.7	36.9	12.4	fsl	vfgr	1.8
B11	25-46	42.8	32.6	24.6	scl	mpr-fmgr	1.2
B12	46-69	39.8	35.2	25.0	scl	mpr-fmgr	0.7
B2	69-91	60.8	22.6	16.6	fsl	mgr	0.4
C1	91-122	78.3	12.6	9.1	ls	sg	0.1
C2	122-140	61.9	22.4	15.7	fsl	sg	0.2
C3	140-163	58.9	24.3	16.8	fsl	sg	0.1
C4	163-198	65.2	21.8	13.0	fsl	sg	0.1

TABLE XVII

SELECTED PHYSICAL AND CHEMICAL DATA OF ST. PAUL SILT LOAM

Horizon	Depth	Sand 2.0-0.1 mm.	V.f. sand + silt 0.1-0.002 mm.	Clay <0.002 mm.	Textural Class	Structure	Organic Matter
	cm	%	%	%			%
Ap	0-18	2.6	82.7	14.7	sil	fgr	1.3
A12	18-36	2.2	77.4	20.4	sil	fgr	1.4
A13	36-51	2.2	75.5	22.3	sil	fgr	1.2
B11	51-71	2.2	74.0	23.8	sil	fgr	0.9
B12	71-91	2.3	73.3	24.4	sil	fsbk	0.8
B21t	91-114	3.2	65.7	31.1	sicl	mfsbk	0.8
B22t	114-127	4.0	58.6	37.4	cl	fmbk	0.7
B3	127-147	6.2	62.4	31.4	cl	mbk	0.4
C	147-165	7.1	65.1	27.8	cl	mfsbk	0.4

TABLE XVIII

SELECTED PHYSICAL AND CHEMICAL DATA OF TELLER LOAM

Horizon	Depth	Sand 2.0–0.1 mm.	V.f. sand + silt 0.1–0.002 mm.	Clay <0.002 mm.	Textural Class	Structure	Organic Matter
	cm	%	%	%			%
Ap	0–18	31.2	55.6	13.2	l	mgr	1.1
A12	18–33	28.1	51.9	20.0	l	msbk	1.4
B1	33–45	27.8	50.9	21.3	l	msbk	1.2
B21t	45–66	31.3	46.8	21.9	l	msbk	1.0
B22t	66–89	41.3	36.2	22.5	scl	msbk	0.8
B3	89–109	52.4	32.6	15.0	sl	msbk	0.5
C1	109–127	56.1	30.1	13.8	sl	sg	0.4
C2	127–140	49.7	32.8	17.5	sl	sg	0.4

TABLE XIX

SELECTED PHYSICAL AND CHEMICAL DATA OF VANOSS SILT LOAM

Horizon	Depth	Sand 2.0–0.1 mm.	V.f. sand + silt 0.1–0.002 mm.	Clay <0.002 mm.	Textural Class	Structure	Organic Matter
	cm	%	%	%			%
A11	0–20	3.1	77.0	19.9	sil	mgr	2.5
A12	20–36	3.7	75.8	20.5	sil	mgr	2.0
A3	36–53	4.6	73.8	21.6	sil	mgr	1.8
B1	53–69	3.0	70.4	26.6	sil	msbk-mgr	1.3
B21t	69–86	3.0	65.6	31.4	sicl	msbk-mgr	1.0
B22t	86–102	3.0	62.2	34.8	sicl	msbk-mgr	0.6
B3C	102–127	3.9	64.0	32.1	cl	msbk-mgr	0.5
C1	127–178	4.9	66.9	28.2	cl	mgr-fsbk	0.3
C2	178–244	5.4	68.5	26.1	l	mgr-fsbk	0.1

TABLE XX

SELECTED PHYSICAL AND CHEMICAL DATA OF WAURIKA SILT LOAM

Horizon	Depth	Sand 2.0- 0.1 mm.	V.f. sand + silt 0.1- 0.002 mm.	Clay <0.002 mm.	Textural Class	Structure	Organic Matter
	cm.	%	%	%			%
Ap	0-13	13.1	76.7	10.2	sil	fgr-pl	1.5
A12	13-25	10.6	72.8	16.6	sil	fgr	1.2
A2	25-36	10.9	70.8	18.3	sil	fgr	0.7
B21t	36-61	9.2	48.8	42.0	c	mbk	0.8
B22t	61-84	11.1	50.5	38.4	cl	mbk	0.8
B3	84-99	11.6	51.0	37.4	cl	msbk	0.6
B3ca	99-112	13.6	54.1	32.3	cl	msbk	0.3
C1	112-150	16.5	54.5	29.0	cl	msbk	0.1
C2	150-173	6.3	63.6	30.1	cl	m	-
C3	173-198	12.8	60.7	26.5	cl	m	-

TABLE XXI

SELECTED PHYSICAL AND CHEMICAL DATA OF ZANEIS LOAM

Horizon	Depth	Sand 2.0–0.1 mm.	V.f. sand + silt 0.1–0.002 mm.	Clay <0.002 mm.	Textural Class	Structure	Organic Matter
	cm	%	%	%			%
A1	0–28	20.2	62.3	17.5	1	mgr	2.5
B1	28–58	16.3	53.2	30.5	cl	fsbk	1.5
B21t	58–81	14.5	52.8	32.7	cl	fsbk	1.2
B22t	81–107	15.4	56.4	27.8	cl	fsbk	0.7
B31	107–122	16.4	56.9	26.7	1	msbk	0.4
B32	122–147	18.3	56.6	25.1	1	msbk	0.2
C	147–198	18.7	59.7	21.6	1	sg	0.1

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VITA

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