# ESTIMATING SOIL LOSS BY WATER EROSION

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## Universal Soil Loss Equation (USLE):

A = R K L S C P
A = annual average soil loss (Mg/ha)
R = rainfall and erosivity index for geographic location
K = soil erodibility factor
L = slope length factor
S = slope steepness factor
C = cropping factor
P = conservation practice factor

**Rainfall and runoff Erosivity Index (R):** based on the kinetic energy of a storm and its maximum 30-minute intensity. For Lafayette, R ~ 3000 (MJ-mm/ha-h-y) ~ (170 for English unit table). See Figure 5.5

### Soil Erodibility Factor (K):

$$K = 2.8x10^{-7}M^{1.14}(12-a) + 4.3x10^{-3}(b-2) + 3.3x10^{-3}(c-3)$$

M =particle size parameter (% silt + % very fine sand) x (100 - % clay)

a =% organic matter
b =soil structure code
c =profile permeability

Parameter

Value

| | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| **b** | Very fine granular | Fine granular | Medium to coarse granular | Blocky, platy, massive | ----- | ----- |
| **c** | Rapid | Moderate to rapid | Moderate | Slow to moderate | Slow | Very slow |

*Note: All references to equations, figures, and tables refer to the Soil and Water Conservation Engineering 4th edition reference book by Schwab et al.*

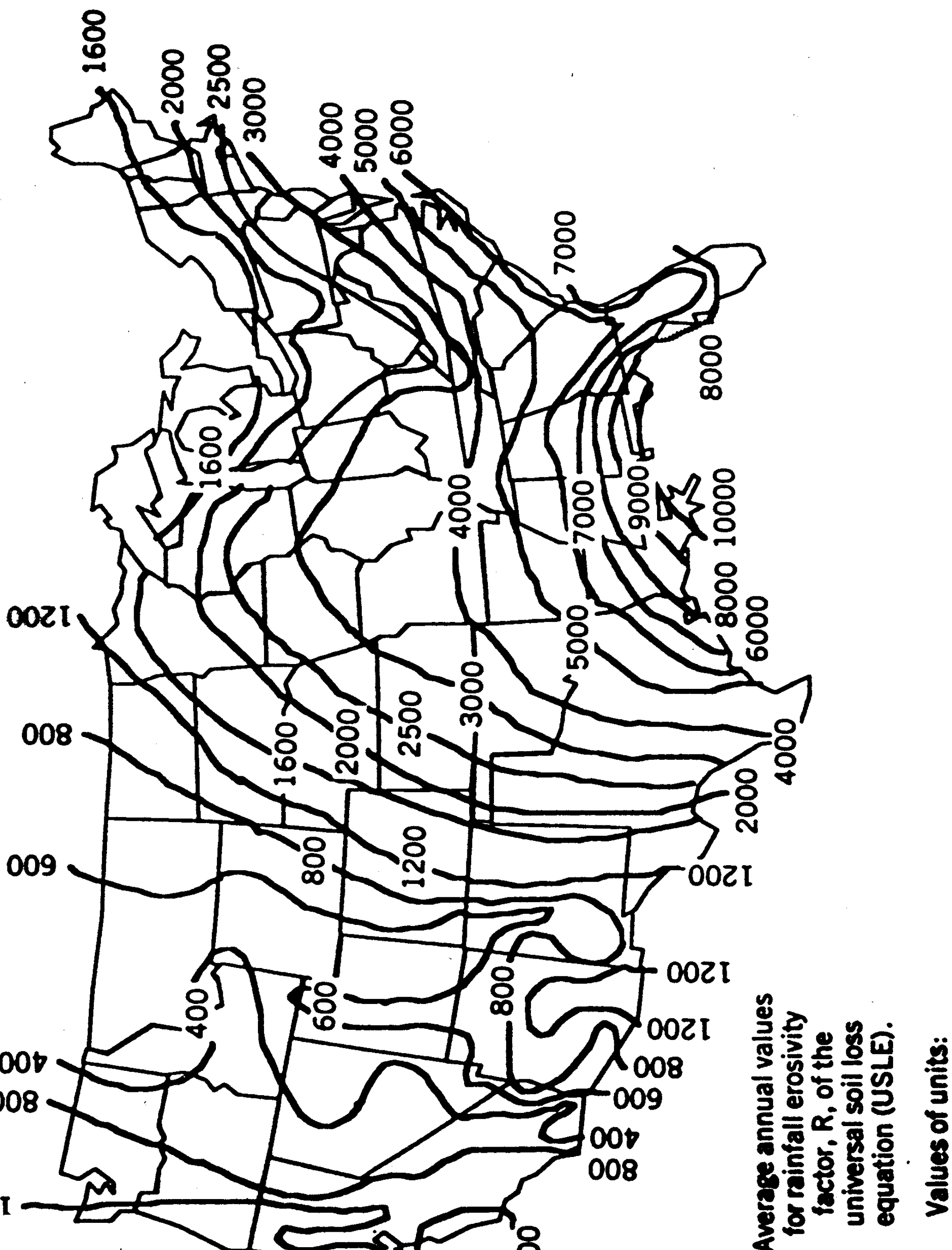


**Fig. 5.5** **Rainfall and runoff erosivity index *R* by geographic location.** (Adapted from Foster et al., 1981.)

*Note: All references to equations, figures, and tables refer to the Soil and Water Conservation Engineering 4th edition reference book by Schwab et al.*

**Slope Length Factor (L)**: $L = \left(\frac{l}{22}\right)^m$

L =slope length factor
l =slope length (m)
m =dimensionless exponent

$$m = \frac{\sin\theta}{\sin\theta + 0.269(\sin\theta)^{0.8} + 0.05}$$

$\theta$ =field slope steepness in degrees =

$$arc\tan\left(\frac{s}{100}\right)$$

s = slope (%)

If rill erosion > interrill erosion, then "m" should be increased up to 75%.
If rill erosion < Interrill erosion, then "m" should be decreased down to 50%.

**Conservation Practice Factor (P):**

$$P = P_c \times P_S \times P_t \text{(equation 5.11)}$$

$P_c$ =contouring factor based on slope (Table 5.3)

$P_s$ = strip cropping factor for crop strip widths recommended in table 5.3 (1.0 for contouring only or for alternating strips of corn with small grain; 0.75 for 4-year rotation with 2 years of row crop; 0.50 for 4-year rotation with 1 year of row crop)
$P_t$ = terrace sedimentation factor (1.0 for no terraces; 0.2 for terraces with graded channel sod outlets; 0.1 for terraces with underground outlets)

*Note: All references to equations, figures, and tables refer to the Soil and Water Conservation Engineering 4th edition reference book by Schwab et al.*

**Table 5.3** Contouring Factor $P_{c+}$ Maximum slope Lengths, and Maximum Strip Crop Widths for Different Slopes.[a]

| *Land slope (%)* | *$P_c$ value* | *Maximum Slope Length[b] (m)* | *Maximum Strip-Crop width (m)* |
|---|---|---|---|
| 1-2 | 0.6 | 120 | 40 |
| 3-5 | 0.5 | 90 | 30 |
| 6-8 | 0.5 | 60 | 30 |
| 9-12 | 0.6 | 36 | 24 |
| 13-16 | 0.7 | 24 | 24 |
| 17-20 | 0.8 | 18 | 18 |
| 21-25 | 0.9 | 15 | 15 |

[a]Factor for farming upslope and downslope is 1.0
[b]Maximum slope length for strip cropping can be twice that for contouring only.
*Source: Wischmeier and Smith (1978)*

**Slope Steepness Factor (S):**

For slopes < 4 m long

$$S = 3.0(\sin\theta)^{0.8} + 0.56$$

For slopes > 4 m long, s < 9%

$$S = 10.8(\sin\theta) + 0.03$$

For slopes > 4 m long, s > 9%

$$S = 16.8(\sin\theta) - 0.50$$

Slope length is measured from the point where surface flow originates (usually the top of the ridge) to the outlet channel or a point downstream where deposition begins.

*Note: All references to equations, figures, and tables refer to the Soil and Water Conservation Engineering 4th edition reference book by Schwab et al.*

**Cover Management Factor (C):**

This factor includes the effects of cover, crop sequence, productivity level, length of growing season, tillage practices, residue management, and expected time distribution of erosive events. Table 5.2 gives values as a percentage of soil loss expected for continuous fallow.

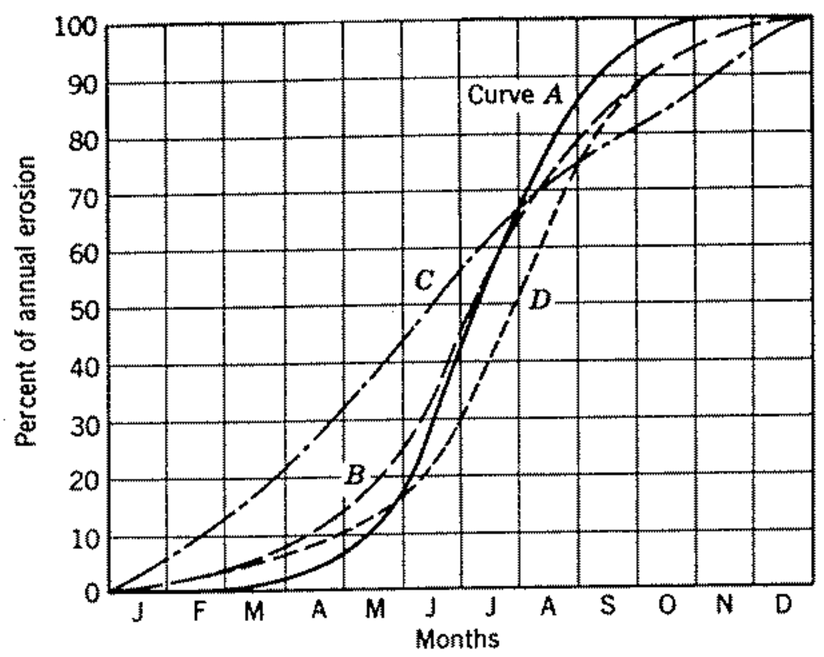


Fig. 5.7 Monthly distribution of the rainfall and runoff erosivity index. Curve A: northwestern Iowa, northern Nebraska, and southeastern South Dakota. Curve B: northern Missouri, central Illinois, Indiana, and Ohio. Curve C: Louisiana, Mississippi, western Tennessee, and eastern Arkansas. Curve D: Atlantic Coastal Plains of Georgia and the Carolinas. (Redrawn from Smith and Wischmeier, 1962.)

Table 5.2 gives values as a percentage of soil loss expected for continuous fallow.

*Note: All references to equations, figures, and tables refer to the Soil and Water Conservation Engineering 4th edition reference book by Schwab et al.*

## To calculate soil loss for a given crop rotation:

(1) Prepare stages of growth for each crop in the crop rotation.
(2) Determine dates for stages and determine % of soil exposed for X amount of time (Table below Table 5.2)
(3) Multiply the soil loss ratios for each growth period in a crop rotation by the percentage of annual erosion expected during each period.
(4) Read the soil loss ratios for each growth period from Table 5.2.
(5) Determine the percentage of annual erosion expected in each growth period from Figure 5.7.
(6) Sum products and express the total as a decimal value. Use this as the C factor value.
(7) Divide C value by the number of years in the rotation to determine annual C value

*Note: All references to equations, figures, and tables refer to the Soil and Water Conservation Engineering 4th edition reference book by Schwab et al.*

Table 5.2 Percentage of Soil Loss from Crops to Corresponding Loss from Continuous Fallow

| *Cover, Sequence, and Management*[a] | *Spring Planting* | | *Soil Loss Ratio (%)*[d] *for Crop Stage Period and Canopy Cover*[e] | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Residue**[b] **(kg)** | **Cover**[c] **(%)** | **F** | **SB** | **1** | **2** | **3:80** | **3:90** | **3:96** | **4L** |
| ***Continuous*** | | | | | | | | | | |
| ***Corn, RdL, sprg, TP*** | 5000 | -- | 36 | 60 | 52 | 41 | -- | 24 | 20 | 30 |
| ***Small grain*** | 5000 | 6 | -- | 16 | 14 | 12 | 7 | 4 | 2 | -- |
| ***Meadow*** | | | | | | | 1 | | | |
| ***Rotation*** | | | | | | | | | | |
| ***Rowcrop after meadow*** | | | 12 | 27 | 23 | 20 | -- | 14 | 12 | 21 |
| ***Corn after beans, sprg,*** | | | 47 | 78 | 65 | 51 | -- | 30 | 25 | 37 |
| ***Beans after corn, sprg, TP*** | | | 39 | 64 | 56 | 41 | -- | 21 | 18 | |
| ***Conservation tillage*** | | | | | | | | | | |
| ***Beans or corn after corn*** | 5000 | 60 | -- | 13 | 11 | 10 | -- | 10 | 8 | 20 |
| ***Corn after beans*** | | 3 | -- | 33 | 29 | 25 | 22 | 18 | 14 | 33 |
| ***Small grain after corn*** | 5000 | 60 | -- | 16 | 14 | 13 | 7 | 4 | 2 | |

[a]RdL, crop residue left in field; sprg, spring tillage; TP, plowed with moldboard.
[b]Dry mass per hectare, after winter loss and reductions by grazing or partial removal, 5000 kg/ha represents a yield of 6 to 8 Mg/ha.
[c]Percentage of soil surface covered by plant residue mulch after crop seeding. The difference between spring residue and that on the surface after crop seeding is reflected in the soil loss ratios as residues mixed with the topsoil.
[d]The soil loss ratios assume that the indicated crop sequence and practices are followed consistently. One-year crop deviations from normal practices do not have the effect of a permanent change.
[e]Crop stage periods: F, rough fallow; SB, seedbed until 10% canopy cover; 3, maturing until harvest for three different levels of canopy cover; 4L, residue or stubble.
*Source: Wischmeier and Smith (1978).*

*Note: All references to equations, figures, and tables refer to the Soil and Water Conservation Engineering 4th edition reference book by Schwab et al.*

Example for calculating C factor:

| Crop | Months | Soil Loss in % of Continuous Fallow (Table 5.2) | Percentage of Annual Erosion (Fig. 5.7) | C Factor |
|---|---|---|---|---|
| ***Corn, first year*** | Jan.-Apr. | 1 | 32 | 0.0032 |
| | May | 60 | 12 | 0.0720 |
| | June | 52 | 12 | 0.0624 |
| | July | 41 | 12 | 0.0492 |
| | Aug.-Sept. | 24 | 22 | 0.0528 |
| | Oct.-Dec. | 30 | 10 | 0.0300 |
| ***Small grain*** | Jan.-Mar. | 30 | 22 | 0.0660 |
| ***With meadow*** | Apr. | 16 | 10 | 0.0160 |
| ***Seeding*** | May | 14 | 12 | 0.0168 |
| | June | 13 | 12 | 0.0156 |
| | July-Aug. | 4 | 20 | 0.0080 |
| | Sept.-Dec. | 1 | 24 | 0.0024 |
| ***Meadow*** | Jan.-Dec. | 1 | 100 | 0.0100 |
| ***Meadow*** | Jan.-Dec. | 1 | 100 | 0.0100 |
| | | Total | | 0.4144 |
| | | Average C for four years | | 0.104 |

*Note: All references to equations, figures, and tables refer to the Soil and Water Conservation Engineering 4th edition reference book by Schwab et al.*