

## Soil Erosion and Control

Erosion is by water and wind. Crudely, about 2/3 is by water and 1/3 by wind. The loss of topsoil means loss of soil fertility. Plant growth is reduced and the soil is even more subject to erosion. Erosion is a serious matter because arable land is finite and the population continues to increase. Not only is soil quality hurt where topsoil is lost but the eroded material is also transported to and deposited in low-lying positions causing problems with water quality and sedimentation in reservoirs, harbors and so forth.

### *Water Erosion*

Though total runoff is greater in humid regions, intense rainfall may cause high runoff and soil erosion in arid regions.

Erosion is a natural process but in the absence of site disturbance by construction or farming, the rate of soil loss is very small. Soil loss by geologic erosion is estimated to be  $< 0.5 \text{ Mg / ha-yr}$ . If  $\text{BD} = 1.3 \text{ g / cm}^3$ , then this represents an annual loss of about 0.04 mm.



Geologic erosion.

However, accelerated erosion occurs where the soil has been disturbed. Accelerated erosion degrades soil quality and agricultural sustainability. Soil conservation-ists have established an upper limit to

accelerated erosion below which agricultural sustainability may not be seriously affected. This rate of topsoil loss by erosion is  $11 \text{ Mg / ha-yr}$ . Using a  $\text{BD} = 1.3 \text{ g / cm}^3$ , this represents an annual loss of about 0.8 mm. Unfortunately, losses from 80 % of crop land in US exceed this amount. Average topsoil losses in countries that can even less afford a loss in agricultural sustainability, like China and India, are up to 3.3 mm annually.



Accelerated erosion.

It has been estimated that up to 38 million Mg (metric tons) N, P and K is lost annually in the US due to erosion. This is about equal to  $\frac{1}{2}$  of the fertilizer additions of these nutrients.



Accelerated erosion.

Nutrient and water losses and yield reduction cost about \$ 27 billion annually. Off-site costs due to water purification, sedimentation and so forth are about \$ 17 billion.

### Mechanics of Erosion

Soil erosion is initiated by detachment of soil particles. The detached particles are transported by runoff water. Raindrop splash tends to destroy surface aggregation and detach soil particles. To some degree splash can also transport particles downslope, especially when the wind is blowing. Runoff water laden with suspended particles also detaches more soil particles as it move across the surface.



Raindrop splash.

### Types of Water Erosion

*Sheet* soil is removed uniformly.



*Rill* soil moved along small channels down-slope.



*Gully* transport along much larger channels.



Sheet and rill erosion are responsible for most erosion.

### USLE

*Universal soil loss equation* includes the factors responsible for water erosion

$$A = RKLSCP$$

where

A = predicted soil loss

R = climatic erosivity (rainfall and runoff)

K = soil erodibility

L = slope length

S = slope gradient

C = crop and management effect

P = erosion control practice(s) used

Gives loss in ton / acre-yr

(x 2.24 = Mg / ha-yr)

Values for each of these factors are obtained from appropriate tables. This older equation has been modified as the Revised USLE (mathematical / computer model). Other models include CREAMS and AGNPS.

Though USLE has been supplanted by more refined models, it is instructive to examine the components of USLE and how these affect water erosion.

### ***R Rainfall and Runoff***

The rainfall erosion index based on kinetic energy of rainfall and maximum 30 min intensity. It is summed for all storms at a location and averaged over several years.



Map of R values.

### ***K Soil Erodibility***

Quantifies the susceptibility of a soil to erosion as affected by infiltration capacity and structural stability. Underlying factors include texture, mineralogy (shrink-swell clays), depth to impervious layer, soil depth, tendency to form a crust and organic matter content. K values run from 1.0 to 0.01 with the highest values for soils with high content of silt or very fine sand. Lowest values are for Oxisols which have very stable structural

aggregates. K values are given in county soil surveys.

### ***LS Topography***

Slope length and gradient combined. Values are relative to that for a standard erosion plot, 22.1 m long with 9 % grade. For example,

Length	Slope	LS
30 m	2 %	0.2
300	2	0.4
300	20	12.9

### ***C Cover and Management***

This factor depends on cropping system and management practices and is expressed as the ratio of soil loss under specific system to that from the same soil if bare. For a particular cropping sequence, surface residue and roughness and canopy cover are time-averaged. C values range from 1.0 to near 0. For example,

System	C
Continuous corn under conventional tillage	0.360
Continuous corn under no-till	0.100
Pasture	0.003
Forest	0.001

### ***P Erosion Control Practices***

Reflects reduction due to contour planting, strip cropping and terracing relative to cultivation parallel to slope.

*Contour planting* perpendicular to slope

*Strip cropping* alternate strips of tilled and untilled crops

Water velocity is slowed as it moves through untilled strips so that sediment from the tilled strips is deposited. Buffer strips at lower end of field serve similar purpose.



**Terracing** intended to break slope or reduce grade.

### Water Erosion Control

Reduce detachment of soil particles C  
Reduce transport of detached particles P

Decreasing C involves keeping some type of cover on the soil surface and involves

**Conservation tillage**, any of several tillage systems that leaves 30+ % of soil surface covered with crop residue. Conservation tillage, besides by protecting soil surface from raindrop splash, also increases infiltration (organic matter effect) and reduces runoff velocity.

**Cover crops**, grown during the off-season, provide soil cover especially following crops that do not produce much residue.

Decreasing P involves one or more of contouring, strip cropping and terracing.

### Wind Erosion

Most common in arid and semiarid regions where soil surface is dry. In humid regions, drained organic soils are prone to wind erosion. About 12 % of US is subject to wind erosion. Wind erosion may lead to **desertification** where the stand of vegetation is very sparse due to drought or over-grazing.

As with water erosion, soil particles must first be detached before these can be transported. Wind carrying suspended particles is an effective detachment agent.

Transport occurs as

**Saltation** medium size particles bounce along soil surface (50 - 70 % of wind erosion)

**Soil creep** larger particles move along soil surface (5 - 25 %)

**Suspension** fine sand and smaller in the air (15 - 40 %)

### Wind Erosion Equation WEQ

Factors contributing to wind erosion are accounted for by this predictive model

$$E = f(I, C, K, L, V)$$

where

E = tons / acre-yr

I = soil erodibility index

K = surface roughness factor

C = climate factor

L = unsheltered length of field

V = vegetative cover

### ***I Erodibility Index***

Values range from 0 (wet or stoney soil) to 310 (single grain, very fine sand).

### ***K Soil Roughness Factor***

Varies from 1.0 for a smooth surface to 0.5 for optimum configuration of low ridges.

### ***C Climate Factor***

Based on wind speed, rainfall and temperature relative to climate at Garden City, KS which is assigned  $C = 1.0$ . For example,

<i>Location</i>	<i>C</i>
Las Vegas	3.25
Garden City	1.00
Fort Worth	0.14

### ***L Length of Field Factor***

Distance of unsheltered area in direction of prevailing wind.

### ***V Vegetative Cover Factor***

Depends on the amount and type of cover as well as whether it is living, standing or flat. For example, standing wheat stubble is 6 times more effective in reducing wind erosion than an equal mass of flattened straw.

### **Control of Wind Erosion**

K, L and V factors can be controlled. K can be optimized by establishing ridges that reduce wind velocity and trap eroded particles. L can be reduced by installing windbreaks. V is the most important factor under control of the land manager.



Wind breaks.

### **Soil Loss Tolerance**

T-value is the maximum annual erosion loss that may occur without loss of long-term productivity. The highest is 5 ton / acre-yr (11.2 Mg / ha-yr). T values are given in county soil surveys.