Soil Erosion

Soil erosion is the detachment and movement of soil material. The process may be natural or accelerated by human activity. Depending on the local landscape and weather conditions, erosion may be very slow or very rapid.

Natural erosion has sculptured landforms on the uplands and built landforms on the lowlands. Its rate and distribution in time controls the age of land surfaces and many of the internal properties of soils on the surfaces. The formation of Channel Scablands in the state of Washington is an example of extremely rapid natural, or geologic, erosion. The broad, nearly level interstream divides on the Coastal Plain of the Southeastern United States are examples of areas with very slow or no natural erosion.

Accelerated erosion is largely the consequence of human activity. The primary causes are tillage, grazing, and cutting of timber.

The rate of erosion can be increased by activities other than those of humans. Fire that destroys vegetation and triggers erosion has the same effect. The spectacular episodes of erosion, such as the soil blowing on the Great Plains of the Central United States in the 1930s, have not all been due to human habitation. Frequent dust storms were recorded on the Great Plains before the region became a grain-producing area. "Natural" erosion is not easily distinguished from "accelerated" erosion on every soil. A distinction can be made by studying and understanding the sequence of sediments and surfaces on the local landscape, as well as by studying soil properties.

Water Erosion

Water erosion results from the removal of soil material by flowing water. A part of the process is the detachment of soil material by the impact of raindrops. The soil material is suspended in runoff water and carried away. Four kinds of accelerated water erosion are commonly recognized: sheet, rill, gully, and tunnel (piping).

Sheet erosion is the more or less uniform removal of soil from an area without the development of conspicuous water channels. The channels are tiny or tortuous, exceedingly numerous, and unstable; they enlarge and straighten as the volume of runoff increases. Sheet erosion is less apparent, particularly in its early stages, than other types of erosion. It can be serious on soils that have a slope gradient of only 1 or 2 percent; however, it is generally more serious as slope gradient increases.

Rill erosion is the removal of soil through the cutting of many small, but conspicuous, channels where runoff concentrates. Rill erosion is intermediate between sheet and gully erosion. The channels are shallow enough that they are easily obliterated by tillage; thus, after an eroded field has been cultivated, determining whether the soil losses resulted from sheet or rill erosion is generally impossible.

Gully erosion is the consequence of water that cuts down into the soil along the line of flow. Gullies form in exposed natural drainage-ways, in plow furrows, in animal trails, in vehicle ruts, between rows of crop plants, and below broken man-made terraces. In contrast to rills, they cannot be obliterated by ordinary tillage. Deep gullies cannot be crossed with common types of farm equipment.

FIGURE 3-4

V-shaped gullies in a material relatively high in clay.

FIGURE 3-5

U-shaped gullies in a soil underlain by more erodible material.

Deposition of sediment carried by water is likely anywhere that the velocity of running water is reduced—at the mouth of gullies, at the base of slopes, along stream banks, on alluvial plains, in reservoirs, and at the mouth of streams. Rapidly moving water, when slowed, drops stones, then cobbles, pebbles, sand, and finally silt and clay. Sediment transport slope length has been defined as the distance from the highest point on the slope where runoff may start to where the sediment in the runoff would be deposited.

Classes of Accelerated Erosion

The classes of accelerated erosion that follow apply to both water and wind erosion. They are not applicable to landslip or tunnel erosion. The classes pertain to the proportion of upper horizons that have been removed. These horizons may range widely in thickness; therefore, the absolute amount of erosion is not specified.

FIGURE 3-6

Sheet erosion. Rills formed as water accumulated in small channels part way down slope. Sediment was deposited at the foot of the slope.

Class 1. This class consists of soils that have lost some, but on the average less than 25 percent surface. Throughout most of the area, the thickness of the surface layer is within the normal range of variability of the uneroded soil.

Evidence for class 1 erosion includes (1) a few rills, (2) an accumulation of sediment at the base of slopes or in depressions, (3) scattered small areas where the plow layer contains material from below, and (4) evidence of the formation of widely spaced, deep rills or shallow gullies without consistently measurable reduction in thickness or other change in properties between the rills or gullies. Figure 3-6 is an example of class 1 erosion.

Class 2. This class consists of soils that have lost, on the average, 25 to 75 percent of the original surface. Throughout most cultivated areas of class 2 erosion, the surface layer consists of a mixture of the original surface and material from below. Figure 3-7 is an example of class 2 erosion.

FIGURE 3-7

Class 2 erosion. The plowed layer of the light-colored areas is made up mainly of the original surface soil, whereas the plowed layer of the dark-colored areas is a mixture of the original surface soil and an underlying horizon.

Class 3. This class consists of soils that have lost, on the average, 75 percent or more of the Original survace. Even where the original A and/or E horizons were very thick, at least some mixing with underlying material generally took place. Figure 3-8 is an example of class 3 erosion.

FIGURE 3-8

Class 3 erosion. Gullies at the left require a gully symbol. The rills would be obliterated by tillage. Most of the original surface soil between rills has been lost.

Class 4. This class consists of soils that have lost all of the original surface. Class 4 includes loss of some or all of the deeper horizons throughout most of the area. The original soil can be identified only in small areas. Some areas may be smooth, but most have an intricate pattern of gullies. Figure 3-9 is an example of class 4 erosion.

FIGURE 3-9

Class 4 erosion intermingled with class 3 erosion. The areas in the middle and left have lost almost all diagnostic horizons. The areas in the foreground and far background have class 3 erosion.

USLE

About the Universal Soil Loss Equation

The Universal Soil Loss Equation (USLE) is hailed as one of the most significant developments in soil and water conservation in the 20 thcentury. It is an empirical technology that has been applied around the world to estimate soil **erosion by raindrop impact and surface runoff**. The development of the USLE was the culmination of decades of soil erosion experimentation conducted by university faculty and federal scientists across the United States.

Universal Soil Loss Equation **A = R K L S C P**

The USLE was developed at the USDA National Runoff and Soil Loss Data Center at Purdue University in a national effort led by Walter H. Wischmeier and Dwight D. Smith. The USLE is based on extensive erosion data from studies throughtout the USA, and provides a quick approach to estimating long-term average annual soil loss (A). The equation is comprised of six factors:

A - the tons of soil lost per acre each year. The value 'A' is usually compared to a value 'T'. T is the amount of soil loss that is considered 'tolerable'. Each soil series has a value T listed in the soil survey. Common values range from 1 to 5 tons/acre/year. When A is less than T, soil erosion losses from that land are not considered significant.

R - Rainfall and runoff factor. R is based on the total erosive power of storms during an average year and depends on local weather conditions.
K - Soil erodibility factor. Depends on texture, structure, and organic matter.
LS – L factor and S factor are combined into one factor.

L - Length is the distance between the beginning of water runoff on the land and location of sediment deposition on the land or runoff enters a well-defined channel. The slope length factor computes the effect of slope length on erosion. Slope length longer than 1000 ft are not used in this interactive calculator because the calculation may not be reliable.
S - Slope steepness. The slope steepness factor S computes the effect of slope steepness on erosion.

C - Management factor. Compares cropping practices, residue management, and soil cover to the standard clean fallow plot. C-factors for different management practices are developed based on their observed deviation from the standard, which is clean-till with continuous-fallow conditions.
P - Conservation practices implemented into the management system. It is the soil loss with contouring and/or strip cropping, or terracing to that with straight row cropping/planting up-and-down slope (*i.e.*, parallel to the slope).

USLE was the first empirical erosion equation that was not tied to a specific region of the United States, thus the title "Universal" Soil Loss Equation.
The USLE has been used in more than 100 countries to guide conservation planning, assess soil erosion for conservation policy development, and estimate sediment yield. It has helped to save millions of tons of soil, thus helping to the feed the world's population, and to protect the environment from sediment produced by soil erosion.

Wind Erosion [1]

Wind Erosion in regions of low rainfall, can be widespread, especially during periods of drought. Unlike water erosion, wind erosion is generally not related to slope gradient. The hazard of wind erosion is increased by removing or reducing the vegetation.

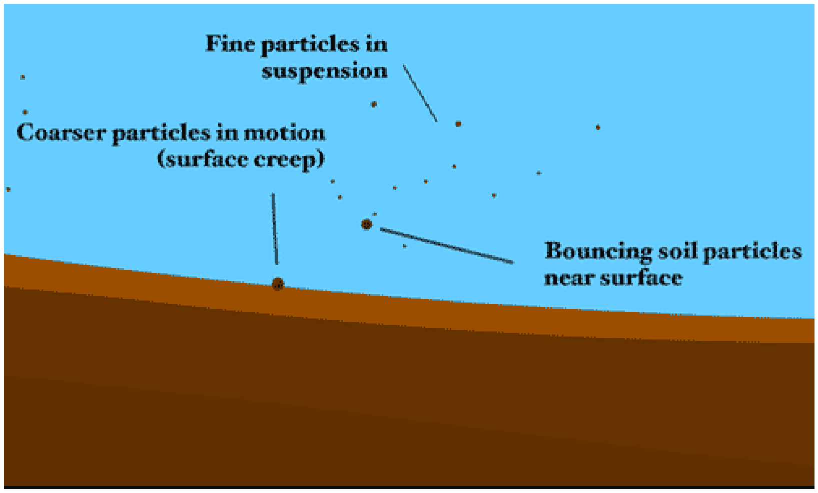
When winds are strong, coarser particles are rolled or swept along on or near the soil surface, kicking finer particles into the air. The particles are deposited in places sheltered from the wind. When wind erosion is severe, the sand particles may drift back and forth locally with changes in wind direction while the silt and clay are carried away. Small areas from which the surface layer has blown away may be associated with areas of deposition in such an intricate pattern that the two cannot be identified separately on soil maps.

Types of Wind Erosion

1. SUSPENSION: Fine particles less than 0.1 mm in size are moved parallel to the surface and upward into the atmosphere by strong winds. The most spectacular of erosive processes, these particles can be carried high into the atmosphere, returning to earth only when the wind subsides or they are carried downward with precipitation. Suspended particles can travel hundreds of miles.

2. SALTATION: Movement of particles by a series of short bounces along the surface of the ground, and dislodging additional particles with each impact. The bouncing particles ranging in size from 0.1 to 0.5 mm usually remain within 30 cm of the surface. Depending on conditions, this process accounts for 50 to 90% of the total movement of soil by wind.

3. SOIL CREEP: The rolling and sliding of larger soil particles along the ground surface. The movement of these particles is aided by the bouncing impacts of the saltating particles described above. Soil creep can move particles ranging from 0.5 to 1 mm in diameter, and accounts for 5 to 25% of total soil movement by wind.



The impact of bouncing soil particles dislodges finer particles into suspension and sets coarser particles into motion as surface creep. *Image by UNL*

WEPS INTRODUCTION: OVERVIEW OF WEPS 1.1

An Overview of the Wind Erosion Prediction System Introduction

Soil erosion by wind is a serious problem in the United States and the world. Wind erosion is a threat to agriculture and the earth's natural resources. It renders soil less productive by removing the most fertile part of the soil, namely, the clays and organic matter. This removal of clays and organic matter also damages soil structure. In addition to the soil, wind erosion can damage plants, primarily by the abrasive action of saltating particles on seedlings and fruits. Eroded soil can also be deposited into waterways where it impacts water quality and emitted into the air where it degrades the air resources. By affecting these resources, wind erosion can also become a health hazard to humans and other animals. The ability to accurately simulate soil loss by wind is essential for, among other things, environmental and conservation planning, natural resource inventories, and reducing air and water pollution from wind blown sources.

The Wind Erosion Equation (WEQ) was published in 1965 by Woodruff and Siddoway (1965). For years, WEQ has represented the most comprehensive and widely used model in the world for estimating soil loss by wind from agricultural fields. The functional form of WEQ is:

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

where,
E is the average soil loss (tons/acre/year),
I is the soil erodibility,
K is the soil ridge roughness,
C is the climatic factor,
L is the field length along the prevailing wind erosion direction, and
V is the vegetative factor.

WEQ is largely empirical in nature and was derived from nearly 20 years of field and laboratory studies by scientists at the USDA-Agricultural Research Service (ARS), Wind Erosion Research Unit (Chepil, 1958, 1959, 1960; Chepil and Woodruff, 1959). Many improvements were made to WEQ over the next 30 years.

(Hagen,1991).