

ANR-790-4.2.1

ALABAMA A & M AND AUBURN UNIVERSITIES

The Rural Environment And NPS Pollution

Understanding Agricultural Erosion, Sedimentation, And NPS Pollution

In rural environments, land-disturbing activities that destroy natural vegetation, remove topsoil, or transform terrain features contribute significantly to nonpoint source (NPS) pollution. Disturbed land is vulnerable to the beating action of raindrops and the energy of flowing water, which do the real damage. Raindrops dislodge most of the solid particles that are eroded from disturbed lands while stormwater runoff erodes channels and transports pollutant-laden sediment to lakes, streams, and waterways.

According to estimates by the U.S. Environmental Protection Agency, agricultural runoff is responsible for 50 to 70 percent of the nonpoint source pollution that impairs water quality nationwide. Urban runoff, the next largest source, contributes only 5 to 15 percent. In Alabama, agriculture causes about 40 percent of the surface NPS problems, resource extraction (mining) causes 19 percent, and urban runoff causes 7 percent.

Most sediment is eroded when the soil is bare. Soils are protected naturally by vegetation and vegetation residues, but under many crop production systems, farmers must remove or bury much of this protective cover. Once the cover is gone, bare soil is exposed to the erosive forces of wind, rain, and runoff.

Sediment is by far the greatest NPS pollutant in rural environments. Sediment impairs water quality and transports other pollutants.

What Is The Erosion-Sedimentation Process?

Erosion is the detachment and transport of soil particles by water or wind. **Sedimentation** occurs when water carrying eroded soil particles slows long enough to allow soil particles to settle out.

The erosion-sedimentation process consists of (1) detachment of soil particles; (2) transport of soil particles; and (3) sedimentation or settling out of soil particles. These three steps may occur several times between the original detachment and when the particle actually reaches a stream or lake.

In Alabama, high-intensity rainfall causes most of the soil erosion. These intense rains and the resultant erosion normally occur in the spring or summer.

Erosion caused by rainfall starts when soil particles are detached by the impact of raindrops striking the soil surface. The weight of water falling in 30 minutes of a moderate thunderstorm may exceed 200,000 pounds (100 tons) per acre. (Water has a density of 62.4 pounds per cubic foot. One inch of water per square foot weighs 5.2 pounds [62.4 pounds divided by 12]. Therefore, 1 inch of rain on an acre would weigh 226,512 pounds [5.2 pounds per square foot-inch times 43,560 square feet per acre].)

When raindrops strike bare soil at high velocity, they shatter soil granules and clods and detach particles from the soil mass. As the precipitation rate begins to exceed the intake capacity of the soil, runoff occurs, and soil particles may be transported.

Larger, heavier particles such as gravel and sand settle out sooner than smaller, lighter particles such as clay. Clay may stay in suspension for very long periods, travel long distances, and thereby contribute significantly to surface water turbidity.

Types Of Erosion

The erosion that occurs under natural environmental conditions of climate and vegetation, undisturbed by people, is called **geological, natural, or normal erosion**. These rates are relatively low and usually average less than one-half ton per acre per year in most of the United States.

The more rapid erosion that occurs when people clear the natural vegetation is called **accelerated erosion**. Accelerated erosion may be hundreds or thousands of times as great as geological erosion. Soil erosion on cropland can range from less than 1 to more than 100 tons per acre per year, depending on the crop system, management practices, rainfall, soil characteristics, and topographic features.

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Rates Of Sedimentation

Sediment concentrations in rivers of the United States range from 200 to 50,000 parts per million (ppm), with occasional concentrations as high as 600,000 ppm. The amount of sediment moved by flowing water has been reported to average at least 4 billion tons a year, with about 1 billion tons reaching major streams. Estimates attribute about 30 percent of this sediment to natural geologic erosion and about 50 percent to erosion from agricultural lands.

Sediment produced by accelerated erosion comes from many sources both urban and rural. But agricultural cropland produces more sediment than any other single source because of the large area involved.

Types Of Cropland Erosion

Four major types of cropland erosion which occur in Alabama are: sheet, rill, gully, and wind.

Sheet erosion removes a thin, rather uniform layer of surface soil. This soil movement is also called interrill erosion. Sheet erosion may go unnoticed until much of the productive topsoil has been removed. Six tons of dry soil over an acre of land is about the same thickness as ten sheets of standard grade typing paper (approximately 0.04 inch). Ten tons would be less than one-tenth of an inch (0.067 inch). Under such conditions, visual perception of soil losses from sheet erosion in the range of even 5 to 10 tons per acre per year would likely go unnoticed for many years unless a stable reference point was readily available for comparison. (These numerical values are based on the assumptions that 1 cubic foot of dry soil weighs approximately 83 pounds and that 1 inch of soil covering 1 acre of land [43,560 square feet] would contain approximately 150 tons.)

In **rill erosion**, numerous small channels are formed by water flowing over the soil surface. Water moving down a slope follows the path of least resistance and concentrates in tillage marks, eroded flow channels, and other depressions in the natural land surface, where it gains in depth and velocity. Rill erosion increases rapidly on steeper or longer slopes as runoff depth and turbulence increases. Most people do not realize that erosion is occurring until rills at least 1 inch deep become apparent. Tillage can easily remove rills up to 4 inches deep.

Gully erosion occurs when water accumulates in narrow channels and removes soil in these narrow channels to depths of 1 to 2 feet or more. Gully erosion can produce huge volumes of sediment but can usually be prevented on cropland.

Wind erosion is the detachment and transport of soil by wind. This problem is related to extensive drought periods, which seldom occur in the Southeast.

Effects Of Agricultural Runoff On Water Quality

As the largest single land-disturbing activity and the greatest producer of animal wastes, agricultural production is the greatest source of nonpoint pollution to the nation's waters. Stormwater runoff from cropland may contain soil, crop nutrients, pesticides, animal wastes, and other organic matter. Two pollutants of primary importance to surface water quality are sediment and phosphorus.

Sediment As A Pollutant. The major pollutant of surface water is sediment, the soil material eroded from land surfaces and transported to streams and lakes by runoff waters. On a total mass basis, cropland is the chief source of sediment. Nationally, agriculture is credited with half or more of the sediment deposited in inland waters. For Alabama, with about 15 percent of the land in cropland, this value is around 40 percent. Of course some counties have a much higher percentage of cropland and, thus, a much greater potential for sediment damage. See Figure 1.

Sediment affects the use of water in many ways. Suspended solids reduce the amount of sunlight available to aquatic plants and cover fish spawning areas and food supplies. This reduces fish, shellfish, and plant populations and decreases the overall productivity of lakes and streams.

Sediment fills drainage ditches, road ditches, culverts, and stream channels and shortens the economic life of reservoirs and farm ponds. It can clog water filters, erode power turbines, and damage pumping equipment.

Sediment not only impairs the quality of water resources in which it resides but often degrades the location where it is deposited. It may carry animal or industrial wastes, nutrients, heavy metals, and toxic chemicals adsorbed to the soil particles.

Because sediment is Alabama's single largest water quality contaminant and because the processes related to its generation and transport are associated with those of other pollutants, reducing the sediment loss to surface waters should help abate agricultural nonpoint pollution problems.

Fertilizers As Pollutants. Dramatic improvements in erosion control and reduced sedimentation can often be achieved through proper use of fertilizers. Vigorous crops protect the soil much more effectively than poor crops, and vigorous crops require a high level of soil fertility.

When agricultural soils are not adequately protected from erosion, however, plant nutrients—principally nitrogen and phosphorus—may be transported off fields by sediments in surface runoff. Nitrogen and phosphorus are found in fertilizers, but other

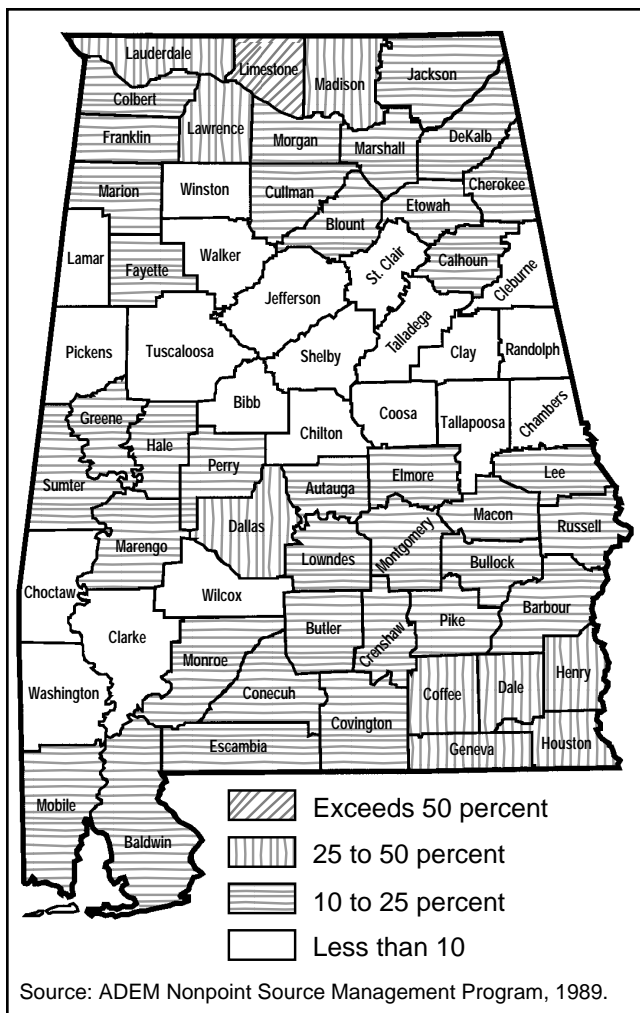


Figure 1. Percentage of cropland in Alabama.

sources include animal wastes, human wastes, plant residues, and some detergents.

Pollution from nutrients is of concern because some nutrients are potentially toxic to humans and animals and because they play a major role in accelerating eutrophication of lakes and streams. A natural process, eutrophication is the nutrient enrichment of waters and the ensuing growth of aquatic life. When the process is accelerated, excessive algae blooms and rapid growth of aquatic weeds occur. This excessive growth may lower dissolved oxygen content of the water as algae and weeds decompose. It may interfere with recreational use of the water, alter fish populations, clog water intake filters, and impair drinking water quality.

The most troublesome nutrient element in surface water is phosphorus. It stimulates the production of algae blooms that can choke out beneficial plants and smother aquatic animals. Excessive phosphorus may come from such sources as fertilizers, organic matter,

and animal manure. Because phosphorus is concentrated in the top few inches of soil, it is very susceptible to erosion and likely to be present in sediment.

Nitrogen may also contribute to nutrient enrichment of surface waters, but it is more of a public health concern when it finds its way into groundwater in the nitrate form. Nitrate contamination of groundwater will be covered in more detail in other articles in the water quality series.

Pesticides As Pollutants. Pesticides, which are widely used in crop production, can be a source of pollution when transported to water bodies by runoff, percolation, seepage, or careless application procedures. The impact of pesticides on water quality depends on persistence and formulation, rate and method of application, and mobility.

Pesticides may be dissolved in water (solution), suspended in water in solid or liquid phases (suspension or emulsion), or adsorbed to clay particles which are suspended in water. Water transport of pesticides from agricultural land includes their movement in the solution phase through surface runoff and subsurface flow and in the solid or adsorbed phases as suspensions in surface runoff.

Studies have shown that except when heavy rainfall occurs shortly after treatment, the total amount of pesticides that runs off the land is less than 5 percent of that applied. However, some chemicals are highly toxic to fish and other aquatic life and persist in the aquatic environment for a long time. Even very low levels of these pesticides in runoff or subsurface flow may be of environmental concern.

The varying chemical properties of pesticides—for example their solubility and chemical breakdown rate—help determine the damage they inflict on water quality. The toxicity of a pesticide does not necessarily decrease because of its adsorption to sediment, but its association with sediment will normally cause much of it to settle out in the receiving water.

Other Agricultural Pollutants. Pathogens, found in animal wastes, may make receiving water unsuitable for domestic uses, for contact recreation purposes, or as a habitat for game and shellfish.

Decomposing organic material from animal wastes and plant residues can reduce the oxygen level of water below that required for fish and other aquatic life.

In sufficient quantities, heavy metals such as cadmium, copper, chromium, lead, nickel, and mercury can be directly or indirectly harmful to human and animal health.

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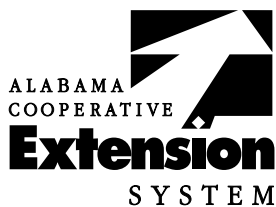
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ANR-790-4.2.1

This publication, supported in part by a grant from the Alabama Department of Environmental Management and the Tennessee Valley Authority, was prepared by James E. Hairston, *Extension Water Quality Scientist*, assisted by Leigh Stribling, *Technical Writer*.

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UPS, **New June 1995**, Water Quality 4.2.1