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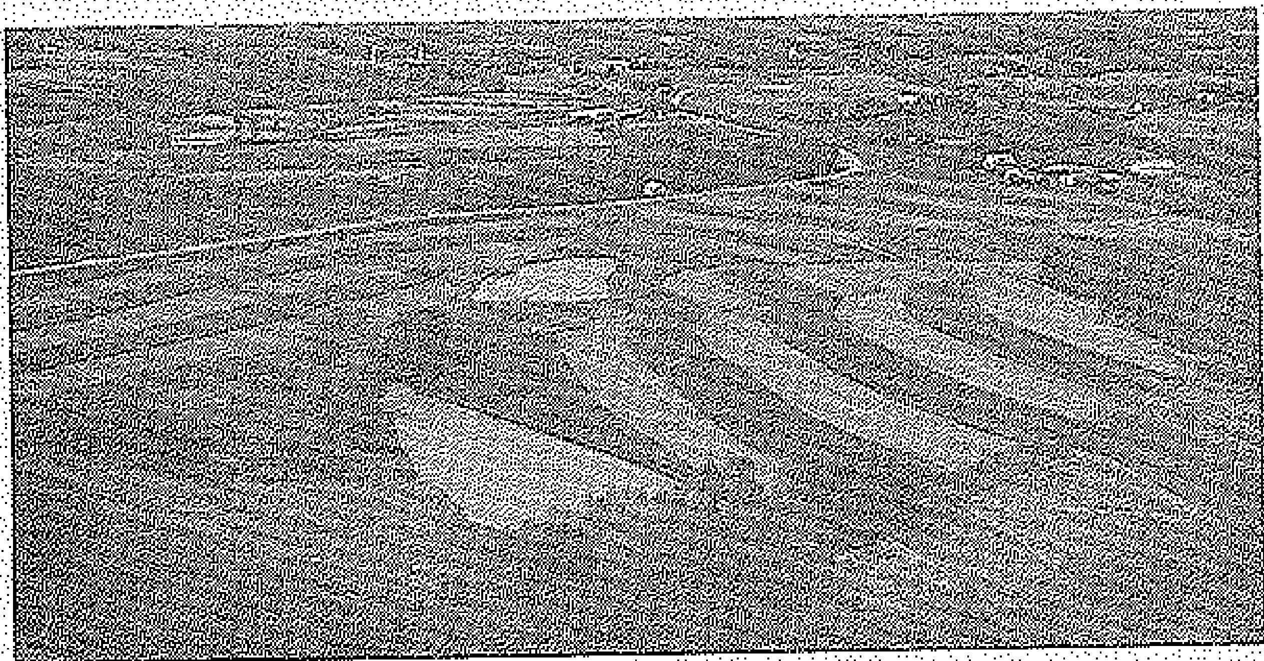
BENEFITS / COSTS OF SOIL AND WATER CONSERVATION PRACTICES FOR EROSION AND SEDIMENT CONTROL



UNITED STATES DEPARTMENT OF AGRICULTURE
Soil Conservation Service
Raleigh, N. C. 27611

June 1980

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June 1980

Note: Much of the information used in this document was taken from EPA Report 600/3-79-106, October 1979, "Effectiveness of Soil and Water Conservation Practices for Pollution Control."

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INTRODUCTION

Nonpoint sources account for most of the water pollution caused by agricultural activities in North Carolina. Since nonpoint sources are diffused, they are difficult to control and monitor. Their control can best be accomplished by applying proven soil and water conservation practices and good management.

Potential agricultural water pollutants can be divided into three broad categories - sediment, nutrients, and pesticides. This report addresses only erosion and sediment pollution control; however, soil and water conservation practices (SWCPs) will have additional benefits in terms of reducing losses of pesticides, especially those which are moderately or strongly absorbed and are persistent. SWCPs are beneficial in reducing edge-of-field losses of phosphorus but are less effective in reducing total losses of nonsorbed pollutants such as nitrate.

Only cropland soil and water conservation practices will be discussed in this document since cropland erosion accounts for about 90% of the agricultural erosion in North Carolina.

Some basic concepts about soil and water conservation practices need to be understood when using this report. First, practices should be planned and applied as a complete conservation system and not just single practices. Secondly, SWCPs are site specific and need to be planned and applied for specific fields depending on soils, crops, slopes, and proximity to water courses. Thirdly, erosion is variable depending on rainfall events, ground conditions, and the amount of cover. Erosion rates should be computed for the field as an average for the cropping system being used. Also SWCPs are designed to reduce soil erosion and/or to increase water retention. Soil and water move together so controlling the movement of one generally affects the movement of the other.

Sediment is the product of erosion and should not be confused with erosion. Erosion is the detachment and movement of soil or rock fragments by water, wind, ice or gravity (for purposes of this report, erosion refers only to that caused by water). Types of water erosion include: gully, sheet, rill, splash, and geologic.

Sediment, on the other hand, is any solid mineral or organic material that has been eroded, transported, and deposited on land or in water. Although systems of SWCPs are designed to reduce soil erosion, they generally achieve a reduction in sediment delivery roughly proportional to the reduction in erosion. There are exceptions to this rule. For example, on fields which have relatively low sediment delivery ratio (SDR), diversions may in some cases increase the SDR. On fields with high SDRs, practices such as tile outlet terraces may decrease sediment delivery due to sediment deposition within the terrace channels.

Soil erosion can be computed using the Universal Soil Loss Equation (USLE). The Soil Conservation Service uses the USLE to plan conservation systems to reduce soil loss on cropland to an acceptable tolerance. A tolerable level of erosion is that amount of annual soil loss in tons per acre that can be lost and still maintain the soil's natural productivity over time. This is generally considered about 5 tons per acre for North Carolina soils. The USLE is used to predict rates of erosion resulting from sheet and rill erosion. The USLE is:
A = RKLSCP,

Where A, is the computed soil loss (sheet and rill erosion) per unit of area; the product of the six other factors, in tons per acre per year. A is not the sediment yield.

R, the rainfall factor, is the average number of units of the rainfall erosivity index (EI) in a normal year's rain.

K, the soil erodibility factor, is the erosion rate per unit ot erosion index for a specific soil in cultivated continuous fallow.

L, the slope-length factor, accounts for the effects of the greater runoff that accumulates as the distance from the top of the slope increases.

S, the slope-gradient factor, accounts for the increased erosiveness of runoff as slope steepens. In application, L and S are combined into a topographic factor.

C, the cover-management factor, is the ratio of soil loss from a field with specified cropping and management to the fallow condition.

P, the factor for supporting practices, is the ratio of soil loss with certain practices to that with straight-row farming, up-and-down slope.

The first criteria of soil and water conservation practices should be to protect the soil resource (reduce loss of soil). Usually SWCPs will also improve water quality by reducing sediment delivery. Many of the SWCPs can be Best Management Practices; however, sometimes the most cost effective sediment control practices do not control erosion (e.g., sediment basins).

Some rules of thumb that can be used to equate tons of soil loss to inches of soil depleted are shown below:

-one ton of topsoil = one cubic yard
-one acre inch of topsoil = 150 tons

Rate of Erosion Tons/Acre/Year	Years to Lose 1 Inch Topsoil	Inches Per Year
30	5	.20
20	7.5	.135
15	10	.10
10	15	.066
5	30	.033

SECTION 1

ECONOMIC BENEFITS OF SOIL AND WATER CONSERVATION PRACTICES

The installation of cropland erosion control practices does not result in the dramatic increases in crop yields as compared to the installation of subsurface drainage in wet tobacco or corn land. Nevertheless, there are long term reductions in crop yields when erosion is allowed to go unchecked. Many farmers have offset the annual loss of crop yields by using improved varieties and increased fertilization; therefore, the farmer may not have experienced a "real" loss in crop yields. This sometimes makes it difficult for farmers to understand that their yields would have been greater had their land been properly cared for in the past. Also, they don't realize the potential loss in yields due to the fertilizer that is washed away during the erosion process. Neither farmers no society have always recognized the economic cost of reduced net incomes associated with increase inputs, such as fertilizer, and with reduced productivity. Too often the short-run solution of increased inputs masks both the short-run and long-run costs of erosion. Frequently the only economic analysis made is a comparison of the annual cost-return relationship in crop production "with and without erosion control." The important questions of what incremental inputs are necessary because of soil depletion by erosion or how long increased inputs can maintain soil productivity are not typically considered.

There are many costs other than reduced crop yields associated with cropland erosion. These include increased runoff, which increase flooding, increased increased production costs, and increased cost of municipal water treatment. Of course, there are the water quality costs such as removing sediment from lakes and reservoirs and the lowered aquatic habitat and intangible costs that are more difficult to quantify.

The following research documents the cost of erosion.

<u>Reduced Crop Yields</u>

1. In the 1940s, Adams (1) observed yield reductions of 34 to 40 percent for non-leguminous crops (cotton, corn, and oats) and 22 percent for a legume crop (vetch) on Southern Piedmont soils where water had eroded the top 15 centimeters (6 in. of surface soil). Soil erosion reduced corn yields 40 percent (2,697 vs. 1,631 kg/ha) on similar soils. Average production in 1940 was approximately 50% lower than today.

   He based his comparisons on Land Capability Class II (moderately eroded) and IV (severely eroded) plots in long-term rotation studies on a Cecil soil.

2. Buntley and Bell (2) estimated an average corn yield reduction of 32 percent with similar erosion classes on selected west Tennessee soils. Their crop yield reductions due to soil erosion for fescue, wheat, cotton, corn, and soybeans were 25, 28, 33, 42, and 50 percent, respectively, on several Grenada silt loam soil mapping units exhibiting minor to severe water erosion.

3. Modern fertilizers, herbicides, and improved varieties have increased corn yields more than 100 percent in the past 30 years (3). However, these technological advances apparently have not offset the yield reductions due to soil erosion on cultivated sloping lands of the Southern Piedmont.

4. In 1979, Langdale (4), et. al., reported the following:

At current production levels in the Southern Piedmont, each centimeter of soil eroded from Class II land costs the producer about 147 kilograms of grain per hectare (5.9 bu/ac for 1" soil loss). This loss exceeded 200 kilograms per hectare per centimeter during such years as 1974 and 1975, when rainfall distribution was moderate and good, respectively.

Although climatic variations may reduce corn yields on a short-term basis, soil erosion is the primary underlying long-term cause of low corn yields under conventional tillage in the Southern Piedmont. Even though non-irrigated corn yields in the region have more than doubled in the past 30 years, yield reductions due to the removal of 15 centimeters of soil by water erosion have remained constant near 40 percent.

Based on Langdale's work that loss in production is 5.9 bushels per acre for 1 inch soil loss means that production loss is about .79 bushel per acre per year when the annual erosion rate is 20 tons per acre. (5.9 bu/ac ÷ 7.5 yrs = .79 bu/ac/yr).

If the corn price is $3.00 per bushel, there is a loss of $2.37/ac/yr. ($3.00/bu x .79 bu/ac/yr = $2.37 ac/yr). At this rate of soil loss, the yield 50 years hence will be reduced 39.5 bu/ac. The present value of the loss is found by multiplying the factor for the present value of an increasing annuity for 50 years times the rate of loss. (The interest rate for the current year is 7-1/8%). The calculation is 181.78929 x 2.37 = $431 per acre present value of lost production. Average annual equivalent value would be $431/ac x .0736 = $32/ac. The value of potential production lost is $32/ac/yr ÷ 20 tons/ac/yr = $1.60/ton soil loss.

Work by Frye (5) at the University of Kentucky showed the following comparison of corn yields on eroded and uneroded Maury soils.

YIELD OF CORN ON ERODED AND UNERODED MAURY SOIL,
AVERAGE OF 3 YEARS, NO-TILLAGE

Plot Treatment Winter Cover	N, kh/ha	Yield, Bu/Acre Eroded	Uneroded	
Stalks	0	58	75	
	50	87	92	
	100	110	114	
Rye	0	65	69	
	50	88	101	
	100	117	126	
Crimson Clover	0	67	74	
	50	83	100	
	100	109	117	
B. F. Vetch	0	63	78	
	50	105	114	
	100	95	109	
Hairy Vetch	50	84	112	
AVERAGE		87	99	(14% increase)

Source: University of Kentucky, Lexington.

Loss of Water Storage Capacity

Another way erosion reduces crop yields is in the reduced potential to store water (6). A Grenada soil that holds .25 inch of available water per inch of soil material above a pan holds an acre inch (27,0000 gallons) for every 4 inches of soil material.

Therefore, a soil that has . . . .

Soil Material Above the Pan	Inches of Available H_2O Stored	Gallons of Available H_2O Stored/A
24"	6	162,000
20"	5	135,000
16"	4	108,000
12"	3	81,000
8"	2	54,000
4"	1	27,000

All available water stored in the soil at planting time is not utilized for producing corn or soybeans. Research in the Midwest indicates that under conventional tillage the evaporation from the soil surface during the growing season is 40 to 50 percent of the growing season precipitation under corn and 25 to 30 percent of the growing season precipitation under soybeans.

It is obvious from all of these figures that it is not possible, even on deep uneroded soils to produce 100 bushels of corn, or 40 bushels of soybeans, using only the water stored in the soil at planting time. If these yield levels are to be attained, the water stored in the soil at planting time must be replenished from rainfall during the growing season.

Soil erosion decreases the soil-water recharge potential. As the surface horizon along with its accumulation of organic matter is eroded away the less stable structure of the subsoil material is exposed. This less stable subsoil structure cannot take the abuse of cultivation and raindrop impact as well as the original surface soil, and as a consequence it breaks down and crusting of the surface occurs. Research has shown that this crusting can reduce the infiltration rate of the soil by as much as 80 percent. This significantly reduces the recharge potential and greatly increases the runoff of water that could have been stored in the soil for crop use.

TVA runoff data from the Beech River watershed in West Tennessee indicates that approximately 20-inches of the 50-inches of annual precipitation runs off each year. Runoff was obviously less before the soils in the watershed were severely eroded........and current research shows us that it would be less if all of the cropland in the watershed were under soil and water conservation practices and cropping systems.

Research has shown that it takes about 4,000 gallons of water to produce each bushel of corn in a 100 bushel per acre yield, and about 13,000 gallons of water to produce each bushel of soybeans in a 40 bushel per acre yield. (6)

Therefore, an uneroded Grenada soil that has . . .

Soil Material Above the Pan	Gallons of Available H_2O Stored /A	Bushels of Corn Per Acre	Dollar Value at $3.00 Per Bushel
24"	162,000	40.5	$121.50
20"	135,000	33.8	101.40
16"	108,000	27.0	81.00
12"	81,000	20.3	69.90
8"	54,000	13.0	39.00
4"	27,000	6.8	20.40

Decreasing Profit Potential