STEEP

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SR 736 / April 1985

SOME WILLAMETTE HILLSLOPE EROSION RATES

The Problem

Erosion destroys land, increases fertilizer costs, decreases yields, and causes water pollution when sediment-laden runoff flows into streams and rivers. Rates of erosion are often estimated indirectly. Estimates depend on the method used and may vary by 200 tons/acre or more. Which numbers are correct for a given soil and management scheme? To answer this question, the Department of Soil Science at Oregon State University has been measuring erosion rates by various methods on selected soils in western Oregon for several years.

The Research

Erosion was measured by four different methods over a four-year period from October 1977 to June 1981. One method used standard erosion plots. These plots are 6 feet wide, 73 feet long, with a total area of 1/100 of an acre. All of the water and soil leaving the downslope end of the plot was collected in a large pan and measured. A second method used smaller erosion plots (called "mini" plots) with an area of 1/500 acre. A third method used H-flumes to measure the total soil loss from watersheds as large as one square mile. Runoff was collected at an outlet and measured; samples were taken to determine the content of suspended solids.

A fourth experimental method that has recently been used in Oregon involves estimating erosion rates by measuring the depletion of radioactive cesium in soils. Testing of atomic weapons from 1954 to 1965 deposited a measurable amount of radioactive cesium. As the cesium fell, it became tightly bound to the soil near the surface. When soil is lost from a landscape by soil erosion, the amount of cesium decreases. Therefore, by measuring cesium levels in soils, we can tell how much of the surface soil has eroded since the cesium fell, over 20 years ago. This technique is experimental and requires certain assumptions, but it is important because it estimates long-term rates of erosion as opposed to short-term estimates obtained from most erosion plot studies.

Results reported here are all from grass or winter wheat fields and all had appreciable cover by December 1. The average total September, October, and November rainfall is about 11 inches and pan evaporation is about 7 inches at the locations studied. Therefore, these soils are not likely to be extremely wet before December 1, which limits early runoff and erosion.

Erosion Plot Results

A summary of the available erosion plot data is shown in Table 1.

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Table 1. Erosion rates for five soil series in western Oregon. Measurements were made with erosion plots.

Soil Series[1]	Slope %	Crop	Range in total annual soil erosion[3] tons/acre/yr
Willakenzie	6-7	winter wheat[2]	0.7-1.5
Helmick	7-9	winter wheat	0.6-5.0
Dupee	7	winter wheat	3.8
Jory	7-12	winter wheat	0.1
	12	perennial grass	≅0
Nekia	7	perennial grass	0.1

[1]The plots on Jory and Nekia soils (2 years of data) were located in Marion County. The others (4 years of data) were located in southern Polk County.

[2]All plots under winter wheat cover were installed with the drill rows parallel to the long sides of the plot ("downhill"). Conventional tillage was used.

[3]T values, that is, the tolerable soil loss rates, calculated to equal the estimated soil formation rates for these soils are as follows: Willakenzie - 2 tons/acre/year, Helmick - 5, Dupee - 4, Jory - 3, and Nekia - 3.

Measured erosion rates ranged between 0 and 5 tons/acre/year. The highest losses (3-5 tons/acre) occurred on Helmick and Dupee soils in fields fall-planted to winter wheat. The lowest erosion rates (0-0.1 tons/acre/year) occurred under perennial grass cover on Jory and Nekia soils. The reduced erosion with perennial grass is well known and is one reason why grass waterways are so effective in controlling the formation of gullies The small measured losses under winter wheat cover on the Jory soils were surprising because the Silverton hills area has longer, steeper slopes and higher rainfall than the other sites. From observations made during the winter, the low erosion rates were attributed to the strong surface soil structure and to the large water holding capacity of the deep, well-drained profile.

Sediment Losses for 10 Watersheds: A summary of 25 watershed-years of data for ten locations in Polk and Benton counties is shown in Table 2. Measured sediment losses ranged between 0 and 20 tons/acre/year, and in all but two instances were less than 8 tons/acre/year. The largest annual loss was measured on Watershed 1, a 9-acre watershed on the Hazelair soil. Seventy percent of the 20 tons/acre annual total was lost during a single storm in November 1977. The fall-planted ryegrass had established a low amount of cover and the soils were frozen with a thin cover of snow. The warming rains which followed removed large amounts of sediment. The following year, the established ryegrass offered greater protection with sediment losses reduced to 0.2 tons/acre.

The lowest sediment losses were measured from Watershed 4, which has deep, well-drained soils. Adjacent areas of Willakenzie soils (Watersheds 5, 6, and 8) had higher losses because of poorer natural drainage resulting from a clay layer about 3 feet from the surface.

Comparing Tables 1 and 2, we see that erosion plots give somewhat lower erosion rates than watersheds but both types of data are generally in the range 0 to 10 tons/acre/year.

Table 2. Sediment losses from 10 watersheds in Polk and Benton Counties, Oregon.

Watershed	Size (acres)	Years of Data	Principal soil series, slopes and cropping	Range in total annual sediment yield[1]
				tons/acre
1	9	2	Hazelair, 12-20%, fall planted ryegrass	0.2-20.0
2	234	1	Willamette, Dupee, Hazelair, 7-20%, annual ryegrass, woodland	0.4-0.6
3	40	1	Dupee, Willamette, Hazelair, 3-15%, annual orchard grass	0.56
4	1	4	Willakenzie, 3-7%, winter wheat	0-0.3
5	4	4	Willakenzie, Helmick, 0-7%, winter wheat	1.1-7.5
6	15	4	Helmick, Willakenzie, 3-12%, winter wheat	2.3-9.6
7	704	4	Willakenzie, Helmick, Waldo, 0-20%, winter wheat pasture, orchard, woodland	0.2-1.3
8	6	1	Willakenzie, 3-7%, winter wheat	1.8
9	222	2	Steiwer, Helmick, Hazelair, 3-20%, winter wheat, woodland	0.4-1.0
10	148	2	Willakenzie, Bellpine, Hazelair, 3-20%, winter wheat, pasture, woodland	0.2-0.6

[1] T values, that is, the tolerable soil loss rates, calculated to equal the estimated soil formation rate for these soils are as follows: Hazelair - 2 tons per acre per year, Willamette - 5, Dupee - 4, Willakenzie - 2, Helmick - 5, Waldo - 5, Steiwer - 3, and Bellpine - 3.

The Cesium Tracer Study

Cesium distribution was measured on Watershed 6, to calculate long-term erosion rates. The results ranged from 1 to 12 tons/acre/year, which is consistent with short-term measurements made with erosion plots and flumes. The cesium data also show that toeslopes are active portions of the landscape, serving as both temporary storage sites of eroded sediment and source areas for active erosion. Sideslopes and stable ridgetops, however, show no detectable difference in erosion rates.

Significance of the Results

The four largest watersheds (2, 7, 9, and 10) had somewhat smaller sediment losses than the smaller watersheds. There are two possible reasons: (1) some redeposition of sediment occurred in the swales, and (2) the larger watersheds contained a greater proportion of woodland, which is resistant to erosion.

Redistribution of sediment within the watershed will not affect water quality in major streams, but can have a tremendous impact on land productivity. A slight decrease in depth of a shallow soil will decrease yields far more than a slight increase in the depth of a deep soil will increase yields. Under most circumstances, the consequences of an appreciable redistibution within a watershed will be a productivity decrease.

The average annual rate of soil loss that can occur without greatly decreasing productivity is called the soil loss tolerance, or T value. T values for each of the soils studied are shown in Table 2. In most cases erosion rates were below T. Watersheds 1, 5, and 6 exceeded T at least once; the 20 tons/acre loss for the Hazelair soil (watershed 1) was 10 times the T value for that soil.

Was the four-year study long enough to indicate what happens over the long run, say 20 or 30 years? We know that erosion is not a uniform process and that large erosion losses occur from a few storms. However, the climatic conditions (rainfall amount and intensity, temperature, etc.) during the study were fairly close to the long-term averages for this area. Also, the cesium tracer method verified the erosion plot and watershed results. We, therefore, have confidence in the measured rates of erosion.

What About Other Soils and Crops?

These measurements show the range of expected erosion losses on certain soils of the hilly uplands of the Willamette Valley. Obviously, ten watersheds and six sets of erosion plots do not represent the wide range of soils and cropping practices found in western Oregon. The rates of erosion measured using erosion plots, H-flumes, and a cesium tracer were fairly consistent. Because of many factors, including the natural variability of the soil and local climatic differences, we must be careful not to extrapolate the results of this study to other soil situations. The information presented here is applicable to the conditions of the measurements and should help guide conservation decision-making in this area.

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This publication was prepared by Jack Istok, biotechnician, and James A. Vomocil, extension specialist in soil science, Department of Soil Science, Oregon State University, Corvallis.

Publication was made possible by a grant from Extension Service, USDA, and contract funds from the Soil Conservation Service, USDA, for a special program to extend research results developed by a project entitled "Solutions to Environmental and Economic Problems (STEEP)." STEEP is a special research program conducted by USDA-ARS and the Agricultural Experiment Stations of Idaho, Oregon, and Washington.

Extension Service, Oregon State University, Corvallis, O. E. Smith, Director. This publication was produced and distributed in furtherance of the Acts of Congress of May 8 and June 30, 1914. Extension work is a cooperative program of Oregon State University, the U.S. Department of Agriculture, and Oregon counties.