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Soil Erosion and Wheat Yields in Whitman County, Washington

Whitman County in southeastern Washington produces more wheat each year than any other county in the United States. It also has the dubious honor of being one of two most critically eroding areas of cropland in the nation. This paper documents the wheat production and soil-loss record during a 27-year period, 1939 through 1965.

General Description of the Area

In Whitman County, 1,041,000 of a total of 1,386,880 acres are cultivated. The cropland consists of very steep, dune-shaped hills. Slopes as steep as 50 per cent are cultivated, and an "average" slope for the area is in the 15-20 per cent range. The land lies at an elevation of 1500 to 2500 feet above sea level with the local relief in any quarter section about 50 to 250 feet. There are several to many hills in each square mile.

Annual precipitation varies from about 14 inches in the western part of the county to more than 21 inches in the eastern part. There is a high degree of correlation between total precipitation and elevation. Almost 60 per cent of the annual precipitation occurs during the five-month period—November through March—and less than 5 per cent comes in the two summer months—July and August (Washington Extension Service, 1965).

Most of the precipitation occurs in rains of moderate to low intensity, but snowfall in many years contributes substantially to the total moisture. The soil is often frozen as deep as 6 to 12 inches at the time of winter and early-spring storms.

The soils are silt loam texture and have formed in a very deep deposit of loess under a climax cover of bunchgrass, forbs, and scattered shrubs. The cultivated land was broken during the last decade of the 19th century.

Winter wheat is the most important crop, both in terms of acreage and dollars. It is alternated with summer fallow in the western half of the county, and in the eastern half, where rainfall is higher, it follows field peas, summer fallow, green manure, or grain in that order of importance. Whitman County also is the largest producer of dry edible field peas in the nation, and has sizable acreages of winter and spring barley.

Farms in the annual cropping area average 600 to 800 acres in size and twice that amount in the summer fallow area. They are about equally divided between tenant-operated and owner-operated types. Land sells for about $250 per acre in the lower

rainfall area and $350 to $400 per acre in the area of annual cropping. Average farm size, per cent of tenancy, and sale value of land have been increasing during the past three decades.

The farms are highly mechanized, and a farmer commonly has $50,000 to $75,000 invested in machinery. A crawler tractor and a self-propelled-leveling combine account for about $35,000 of this total.

Detailed Description of a Typical Palouse Hill

Although there are nine distinct types of topography recognized in the Palouse (Starr, Johnson, and Kaiser, 1950), the hills do possess similarity without uniformity. Figure 1 shows the profile of a typical hill through the central part of the county, and is representative of the areas where long-time research has been carried out by the Washington State Experiment Station and the Agricultural Research Service of USDA in the vicinity of Pullman, Washington.

Table 1 shows the physical characteristics of each site on the typical hill (Agricultural Research Service, 1961).

South- and west-facing slopes are generally longer and less steep than north and east exposures. The hilltops or ridgetops have lost nearly all the original topsoil by combined action of water and tillage erosion.

Table 2 shows the characteristics of erosion and microclimate for each site on the typical hill (Agricultural Research Service, 1961; Kaiser, 1961).

In addition to showing critical soil loss in total from the typical Palouse hill, the information in Table 2 (which is extrapolated and updated from a wide variety of sources) shows that there are many interrelating factors which determine soil erosion and crop yields.

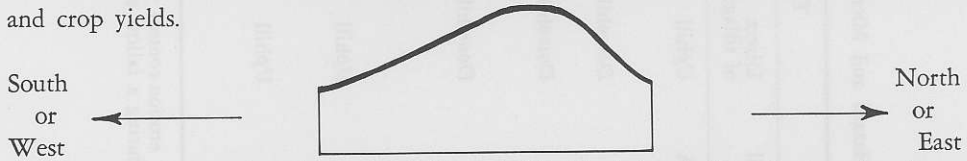

Figure 1. Cross-section of a typical "Palouse hill." Vertical scale 2.3 x horizontal scale.

Table 1. Characteristics of Soils and Slopes on the Typical Palouse Hill

Location on hill	Soil series	Average depth of topsoil	Average % soil O.M.	Steepness of slope	Land cap. class
Lower south slope	Palouse silt loam	24″	3.6	0-12%	II_e
Upper south slope	Naff silt loam	15″	3.0	12-30%	III_e
Ridge on hilltop	Garfield silty clay loam	4.5″	1.8	0-30%	IV_e
Steep north slope	Thatuna silt loam	20″	3.1	30-40%	IV_e
Lower north slope	Palouse silt loam	20″	3.8	12-30%	III_e
Foot slopes and bottoms	Snow and Caldwell silt loam	21″	4.0	0-12%	II_e

Table 2. Characteristics of Erosion Hazard and Microclimate for Different Areas on a Typical Palouse Hill

Location on hill	Water Erosion Hazard: Type and degree	Water Erosion Hazard: Ave. soil loss[a]	Tillage Erosion Hazard: Direct. of tillage	Tillage Erosion Hazard: Ave. soil loss[b]	Microclimate: Character	Microclimate: Eff. Prec. zone
Lower south slope	Area of silt deposition. Slight gully hazard.	0-10 T/A	*Up*hill	0 T/A	Receives excess moisture by runoff and seepage from higher slopes.	15-25″
Upper south slope	Area of moderate rill erosion.	7-15	*Down*hill	3-6	Loses moisture by runoff and seepage.	10-15″
Hilltop	Area of moderate to severe rill and sheet erosion.	10-20	*Down*hill	6-12	Moisture deficient because of severe runoff and snow removal.	7-10″
Steep north slope	Area of severe rill erosion. Shallow and deep soil slips.	25-50	*Down*hill	12-24	Excess moisture due to snowdrift accumulation and heavier rainfall. Thaws out slowly in spring because of shadow.	25-40″
Lower north slope	Area of moderate rill erosion and silt deposition.	10-20	*Up*hill	0	Excess moisture by runoff and seepage.	20-25″
Foot slopes and bottoms	Area of silt deposition. Subject to moderate gully hazard.	0-5	*Up*hill	0	Excess moisture by seepage and runoff.	20-30″

[a] Soil losses in a summer fallow treatment without special erosion-control practices.
[b] Rate at which soil is turned off the slope by all tillage during a fallow season with a moldboard plow.

Procedures Used in the Wheat Yield—Soil Loss Study

Wheat-yield data were secured from two sources. Those relating to total county yields were obtained from documented records of the Agricultural Marketing Service and Statistical Reporting Service of USDA. Yield data relating to specific areas on the typical Palouse hill came from an early study made in 1938-1940 by Anderson and Kaiser (Freeman and Martin, 1942) and from a later research project by the ARS and the State Agricultural Experiment Stations of Idaho, Oregon and Washington (Agricultural Research Service, 1961).

Soil-loss data were secured by means of an annual field appraisal made by the Soil Conservation Service, USDA, at the end of each winter erosion season. This study has been made in Whitman County annually since the runoff season of 1939-1940. In it, data are recorded each year for 500 to 1000 fields in the county showing the amount of soil erosion per acre on different land capability classes in fields under different conservation treatments. Soil losses are appraised by means of field observations backed by the Alutin rill erosion measurement system (USDA, 1961).

Numerous checks against data obtained from lysimeters on the Soil Conservation Experiment Station near Pullman, Washington, have indicated that the data thus obtained are accurate within 20 per cent $\pm$.

Comparison of Wheat Yields and Soil Losses in the County

The data on yields and erosion year by year during the 26-year period are shown in Table 3.

It is not the primary purpose of this paper to analyze yearly differences either in erosion or crop yields; however, both are greatly influenced by land treatment as well as climatic factors. For example, the extremely low soil loss in 1944-1945 and in 1947 is attributed in large degree to the fact that there were no extensive storms at the time of frozen ground during those years, while the extremely high loss in 1962-1963 resulted from heavy rainfall on deeply frozen soil.

The figures show a 26-year average erosion rate of 0.7 tons of soil for each bushel of wheat raised in the county. The high loss was 2.03 tons, and the low loss was 0.15 tons. During six of the 26 years of record, the loss exceeded one ton of soil per bushel of wheat.

It is important to remember that these erosion figures represent soil displaced from the slopes of the field, and do not indicate the amount of soil removed from the field or farm. Most of the displaced soil is deposited on lower slopes in the field from which it originated. The sediment load of streams flowing out of the field, the farm, or the county varies considerably from year to year, as evidenced both by ocular estimates and by limited stream gauging data obtained by the U.S. Geological Survey.

Methods of sediment damage appraisal used in this study are not precise. They do indicate that of the total soil displaced from the steeper slopes by water erosion, from 25 to 75 per cent is usually deposited on lower-lying slopes in the same field or on the same farm (USDA, 1939-1965).

Comparison of Wheat Yield and Soil Erosion on the Typical Palouse Hill

The data on wheat yield and soil erosion are summarized in Table 4. At first glance they would seem to indicate that soil erosion is not an important factor in wheat yield

Table 3. Comparison of Soil Erosion and Wheat Yields Whitman County, Washington

Year	Acres of harvested wheat[a]	Bushels of wheat produced[a] (thousands of bushels)	Tons of soil eroded water erosion[b] (millions of tons)	Tons of soil eroded per bushel of wheat (tons)
1939	362,000	11,041	no data	-----
1940	378,000	11,264	11.5	1.02
1941	371,000	12,058	8.0	0.66
1942	288,500	9,838	20.0	2.03
1943	286,000	9,552	12.0	1.25
1944	380,200	12,851	2.0	0.15
1945	391,800	12,773	2.0	0.16
1946	422,500	15,252	20.0	1.31
1947	445,000	13,261	1.0	0.07
1948	470,000	14,335	16.0	1.11
1949	493,000	13,853	5.0	0.36
1950	449,300	15,546	9.0	0.58
1951	451,000	15,469	10.0	0.65
1952	467,000	17,512	7.0	0.40
1953	531,200	17,954	7.5	0.42
1954	370,000	15,614	5.0	0.32
1955	339,900	12,814	6.0	0.47
1956	339,000	12,610	9.0	0.71
1957	318,600	14,496	5.0	0.34
1958	332,000	13,579	8.5	0.63
1959	340,100	17,141	9.5	0.55
1960	344,600	14,232	11.5	0.81
1961	347,000	11,069	8.5	0.77
1962	295,000	13,540	11.3	0.83
1963	349,800	16,160	21.9	1.35
1964	346,600	15,840	7.8	0.49
1965	386,900	20,247	15.9	0.78
			26-year average 1940-1965	0.70

[a] Data from Agricultural Marketing Service and Statistical Reporting Service, USDA.
[b] Data from field appraisals made by Soil Conservation Service, USDA.

in the Palouse, because yields have increased on eroded sites as well as on areas with little or no erosion. Closer inspection, however, shows that erosion is affecting wheat yields on the Palouse hill. While the overall field yields are increasing due to advanced technology, the increase comes primarily from uneroded portions of the hill. For example, on the lower south and north slopes where little or no erosion occurs and where topsoil high in organic matter still is found, wheat yields increased 60 and 70 bushels per acre in the past decade. During the same period under the same treatment, yields on the eroded hilltops increased only 20 bushels per acre. As the area of eroded land increases in each field, loss of topsoil will become a more and more important factor in total field yields.

Summary and Conclusions

1. Whitman County, Washington, is an important wheat-producing area which also is subject to critical soil loss by erosion.

2. During a 26-year period, 1939-1965, erosion moved an average of 0.7 tons of soil off the steep cultivated slopes for each bushel of wheat produced.

Table 4. A Comparison of Wheat Yield and Soil Erosion on Different Areas of the Typical Palouse Hill

Location on hill	Land capability	Wheat yields 1950-1960[a] (bu/ac)	Wheat yields 1960-1965[b] (bu/ac)	Erosion losses[c] (tons/ac)
Lower south slope	IIe	50	110	5
Upper south slope	IIIe	35	75	9
Hilltop	IVe	15	35	15
Steep north slope	IVe	25	40	30
Lower north slope	IIIe	40	80	12
Foot slopes and bottomland	IIe	50	120	3

Data from a variety of published and unpublished materials.
[a] Using common varieties of wheat in use prior to Gaines and with limited fertilization.
[b] Using Gaines wheat with optimum rates of commercial fertilizers.
[c] Soil-erosion losses are average for wheat-pea and wheat-fallow systems for the wheat production year.

3. The areas on a typical hill where erosion is the most critical also are the lowest wheat-yielding areas.

4. The cumulative effects of erosion over a period of years reduce the relative wheat-producing capacity of the soil. Eroded soil produces only 32 per cent as high yields as does noneroded soils in the Palouse.

Literature Cited

Agricultural Research Service. 1961. Economics of cropping systems and soil conservation in the Palouse. Bulletin No. 2 (August). In cooperation with the State Experiment Stations of Idaho, Oregon, and Washington.

Freeman, O. W., and H. H. Martin. 1942. The Pacific Northwest. John Wiley and Sons, New York, pp. 357-358.

Kaiser, V. G. 1961. Historical land use and erosion in the Palouse—a reappraisal. Northwest Sci., 35: No. 4.

Starr, W. A., S. G. Johnson, and V. G. Kaiser. 1950. Types of topography as related to land use in Whitman County, Washington. Paper presented at Northwest Scientific Association annual meeting.

USDA. 1939-1965. Unpublished data in annual erosion damage survey reports for Whitman County, Soil Conservation Service.

USDA. 1961. Methods of measuring soil erosion losses. Pocket handbook for Soil Conservation Service, p. G-1.

Washington Extension Service. 1965. Washington climate for Adams, Lincoln, Spokane and Whitman counties. Washington State University. EM 2545.

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