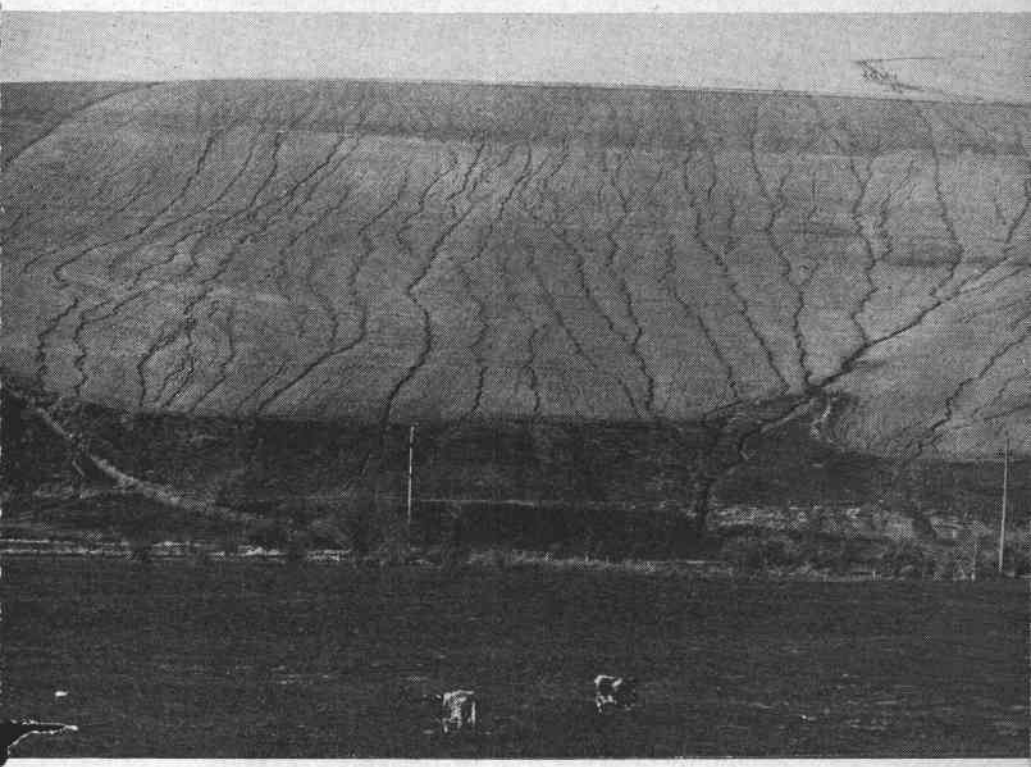
The Economic Effect of

SOIL EROSION ON WHEAT YIELDS IN EASTERN OREGON



United States Department of Agriculture
Soil Conservation Service
and
Oregon Agricultural Experiment Station
Cooperating

Oregon State System of Higher Education
Oregon State College
Corvallis

Station Circular 157 November 1943

FOREWORD

The wheat producing lands of eastern Oregon have suffered significant measurable losses of soil and productive capacity caused by erosion. The relation between soil depth, loss of surface soil, and wheat yields indicates that, should erosion be allowed to continue at its present rate, many fields soon will have their productivity reduced below the profit level.

Seriousness of the losses is not always fully appreciated even by the owners of land where they occur. Much erosion is caused by cultural practices which if modified can reduce erosion materially. This study indicates the extent to which erosion has already occurred and presents suggestions for control of the problem.

WM. A. SCHOENFELD
Dean and Director

Illustration on cover—
Soil erosion exacts a heavy toll.

SUMMARY

Size and location of sample

The results of this study are based on information obtained from 989 soil observations and wheat samples taken from the Wild Horse and Rock Creek Sample areas in 1939, 1940, and 1941.

Amount and rate of soil erosion

For the Wild Horse Area an average of 6.6 inches or 34.7 per cent of the topsoil has been removed by erosion during about 50 years of wheat cultivation. The rate of soil loss was 0.13 inch per year or 1 inch of topsoil every 8 years. At this rate it would require about 100 years to remove the topsoil that remains. In the Rock Creek Area 4 inches or 26.6 per cent of the topsoil has been removed by erosion. At the rate of 0.08 inch per year 1 inch of topsoil is removed every 12 or 13 years. If erosion continues at this rate the remainder of the topsoil will be lost in about 150 years.

The effect of depth of soil on wheat yields

The average yield of wheat on the Wild Horse Area was 46 bushels per acre on soils 48 inches or more in depth as compared with 22 bushels on soils less than 24 inches in depth. The yield was 43 bushels per acre where the *topsoil* was 14 inches or more in depth as compared with 13 bushels where the topsoil was less than 6 inches in depth.

The results on the Rock Creek Area show a difference in yield from 27 to 20 bushels with a change in *total soil depth* from more than 48 to less than 24 inches, and a reduction from 31 to 21 bushels with a change from 15 to less than 10 inches in the depth of *topsoil.*

The effect of soil erosion on wheat yields

The loss of an inch of topsoil caused a reduction of 0.9 bushel in the yield of wheat in the Wild Horse Area, and a reduction of 0.8 bushel in the Rock Creek Area. The change in yield due to erosion was the most pronounced on shallow soils or as much as 1.7 bushels per inch where the topsoil is less than 6 inches in depth.

The economic effects of soil erosion

At $0.70 per bushel the annual loss of income per acre is only $0.084 and $0.045, respectively, for the two sample areas. These annual losses may seem small to the average wheat farmer until they are applied on many acres of wheat land for a 10- or 20-year period. For example, the estimated loss of income on 284 acres of wheat on the Wild Horse Area is $24 for the first year. By the end of the tenth year the loss for the farm has increased to $241 per year. The cumulative loss in 10 years

for a typical wheat farm on the Wild Horse Area is $1,315 or an average loss of about $131 per year.

A comparable loss of income for a typical Rock Creek Area farm is about $33 the first year and $334 the tenth year. The cumulative loss of income on 745 acres for such a period is $1,825 or an average of $182 per year.

When the topsoil is removed by erosion the productive value of the land disappears. If nothing is done to prevent erosion, it is estimated that wheat land studied in the Wild Horse Area will be rendered marginal for wheat within 100 years. During that period the land would shrink from its present value for producing wheat to a future value as pasture, a difference of probably $100 or more per acre. A similar change would take place in the Rock Creek Area within 150 years.

The amount that farmers can invest to prevent erosion varies with the period of tenure or the time during which the individual farmers will receive benefits. Farmers on the Wild Horse Area could invest $5.42 and farmers on the Rock Creek Area $2.88 per acre to prevent the loss of income from erosion that would accrue over a 20-year period. An initial investment of $19 and $10 per acre for the two respective areas would be returned with interest at 4 per cent within 100 years. In lieu of these investments, at the beginning of the period, annual investments amounting to $0.80 per wheat acre on the Wild Horse and $0.42 per wheat acre on the Rock Creek Area could be made for a 20-year period or approximately double these amounts for a 100-year period.

Certain soil conservation practices are effective

Erosion can be reduced by the use of certain soil conservation practices such as trashy fallow, contour cultivation, and a grass-legume-wheat rotation. A combination of these soil conservation practices is much more effective than any one alone.

A complete soil conservation program

Recommendations for soil conservation vary with specific soil and slope situations. Erosion conditions are usually such as to require the use of several supplementary and complementary soil conservation practices for effective control. A complete soil conservation program should provide not only for the essential measures to prevent erosion, such as the retirement of wheat land to alfalfa or grass, but it also must provide for the most efficient use of these crops. This means that some alteration of the farm organization with reference to the livestock program will be necessary to utilize these products in such a way as to maintain or increase farm income under the soil conservation plan.

The Economic Effect of Soil Erosion on Wheat Yields in Eastern Oregon*

by

H. L. Thomas, R. E. Stephenson, Carl R. Freese, Ray W. Chapin, and W. W. Huggins†

INTRODUCTION

Soil erosion is a recognized problem on eastern Oregon wheat farms. Definite information has been lacking, however, as to its effect on wheat yields, farm income, and land values. Such information is needed to plan and sponsor an adequate soil conservation program. The object of this study is to attempt to measure the loss of soil by erosion, to determine the effect of soil erosion on wheat yields, and to evaluate the damages of soil erosion in terms of bushels of wheat and dollars and cents.

This study was made by the Soil Conservation Service and the Oregon Agricultural Experiment Station, during the years 1939, 1940, and 1941. The data were gathered directly from wheat fields located in two eastern Oregon wheat farming areas; namely, the Wild Horse Area, near Athena, Oregon, and the Rock Creek Area, near Condon, Oregon. (See Figure 1 for location of fields and areas sampled.)

The two sample areas were selected on the basis of uniformity as to soil and climatic conditions within the area, and because they were regarded as representative of a larger wheat farming region. Wheat fields sampled were selected on a basis of their uniformity as to slope, exposure, soil type, variety of wheat, and cultural practices, the objective being to hold constant or eliminate all factors affecting yield except those being sampled. Each sample consisted of a measurement of the depth of topsoil, the total depth of soil, the per cent slope, and a sample of wheat from which to compute the yield per acre.‡ The number of such samples taken from an indi-

* Acknowledgments: The authors acknowledge the assistance of Mr. Clarence Waldo and Mr. Bernard Otness, assistant and soil technologist in the Soil Conservation Service, in the field work in 1939 and 1940, and the assistance of Mr. H. R. Fortmann, student assistant in agronomy, Oregon State College, who participated in the statistical analysis in 1941. Special credit is due Professor D. Curtis Mumford, head of the Department of Farm Management, Oregon State College, who contributed valuable comments and suggestions in the preparation of the final manuscript.

† Agricultural Economist, Soil Conservation Service; Soil Scientist, Oregon Agricultural Experiment Station; Assistant Agronomist, Soil Conservation Service; Associate Soil Technologist, Soil Conservation Service; and Research Associate, Electrical Engineering Department, Oregon State College.

‡ A sample of wheat consisted of six drill rows one-half rod in length.

vidual field ranged from 15 to 50, depending on the size of field and variations in soil and erosion conditions.

As a basis for estimating soil erosion, the profiles of adjacent grassland were studied and measured to determine the depth of topsoil. The reduction in depth of topsoil on the wheat land was assumed to be due to erosion following cultivation.

The statistical method was used to determine the net effect of soil erosion on wheat yield. The results were expressed as sums, averages, and regression coefficients. In such a study, it must be recognized that whereas the average depth of topsoil is 12.8 inches for a given field or area, there is a great variation in depth of soil on different slopes within the same field and for different fields within the sample area. Again, whereas the average rate of soil erosion is found to be .132 inch per year, it is known that erosion varies greatly from year to year, and that most of the erosion measured may have occurred during a relatively few years of heavy rainfall. Likewise, in estimating the effect of erosion on yield through time, other factors are assumed to remain constant whereas in practice the loss in yield from soil erosion may have been partly offset by improvements in varieties of wheat and production methods.

DESCRIPTION OF AREAS SAMPLED

The Wild Horse Sample Area represents the Blue Mountain foothill region. The Rock Creek Sample Area represents the low rainfall portion of the Columbia Basin wheat region in Oregon. These areas are different from the standpoint of soil, topography, and climate, but the wheat-fallow system of farming is practiced in both areas. A brief description of the general physical conditions for each sample area follows.

The Wild Horse Sample Area

The Wild Horse Sample Area is located along the steep, west slopes of the Blue Mountains, south and east of Weston. This area is characterized by a steep and rolling topography that is representative of the Blue Mountain region, not only in Oregon, but also in Washington to the north.

At this elevation the precipitation is about 22 inches per year (Table 1), and the yield of wheat ranges from 30 to 50 bushels per acre, depending on specific soil conditions.* The cropping systems are: wheat and fallow; wheat and peas; or wheat, peas, and fallow.

* Table 1 shows the monthly and annual precipitation for the crop years in 1939, 1940, and 1941 at Weston and Condon.

Table 1. Monthly and Annual Precipitation in Inches at Weston and Condon, Oregon

Year	July	August	September	October	November	December	January	February	March	April	May	June	Total
Weston (Wild Horse Sample Area)													
1938	0.05	Trace	0.29	1.86	2.77	0.97	.....	.....	.....	.....	.....	.....	.....
1939	.....	.....	.....	.....	.....	.....	1.60	2.59	2.40	0.51	0.60	0.03	13.67
1939	0.56	0.03	0.28	1.18	0.12	3.37	.....	.....	.....	.....	.....	.....	.....
1940	.....	.....	.....	.....	.....	.....	2.13	6.15	3.20	2.02	0.66	0.24	19.94
1940	1.03	Trace	2.20	2.27	2.83	2.17	.....	.....	.....	.....	.....	.....	.....
1941	.....	.....	.....	.....	.....	.....	1.55	1.32	1.02	1.14	3.73	3.57	22.83
38-year average	0.50	0.60	1.31	1.74	2.75	2.37	2.48	2.27	2.46	2.03	2.07	1.31	21.89
Condon (Rock Creek Sample Area)													
1938	0.75	0.09	0.33	0.92	0.71	0.49	.....	.....	.....	.....	.....	.....	.....
1939	.....	.....	.....	.....	.....	.....	0.32	0.98	1.08	0.16	0.37	0.58	6.78
1939	0.41	Trace	0.04	0.50	0.04	1.53	.....	.....	.....	.....	.....	.....	.....
1940	.....	.....	.....	.....	.....	.....	2.33	2.19	1.91	2.37	0.40	0.07	11.79
1940	1.10	0.00	2.41	1.91	1.76	0.91	.....	.....	.....	.....	.....	.....	.....
1941	.....	.....	.....	.....	.....	.....	1.31	0.67	0.29	0.70	2.73	1.90	15.69
23-year average	0.40	0.36	0.98	1.05	1.70	1.31	1.34	1.00	0.85	1.00	1.22	0.99	12.20

The soils belong to the Waha and Palouse series. Waha soils, residual from basalt modified by wind action, range from 18 inches on shallow south exposures, to more than 6 feet in depth on steep north slopes. The Palouse soils are formed from wind-deposited materials. For the most part the fields sampled are located on west slope exposures.

The fields sampled in this area range in slope from 5 to 35 per cent with an average slope of 15 per cent. Under these soil conditions the rate of erosion is unusually high. During periods of heavy precipitation, the loss of soil from steep slopes results in serious damage to productive wheat land.*

The Rock Creek Sample Area

The Rock Creek Sample Area is located in the vicinity of Mayville, Oregon. The soils in this locality are classed as the Morrow and Condon series and range from 12 to 48 inches in depth. The soil profiles are reasonably well developed, making it possible to study the loss of soil by erosion.

As contrasted with the Wild Horse Sample Area, the rainfall in the Mayville section averages only about 12 inches and the yield of wheat is correspondingly low—between 15 and 30 bushels per acre for the period studied. The slope of fields sampled averaged 9 per cent as compared with 15 per cent for the Wild Horse Sample Area. Under these soil and climatic conditions, the rate of soil erosion is considerably less than in the Wild Horse Area.

THE SIZE OF THE SAMPLE

The data in Table 2 show the number of farms, fields, and samples taken during three years of field work. The field work was conducted on thirty-three fields on twenty-seven farms. (Some fields were sampled in both 1939 and 1941.) In all, 989 samples were taken during the three years of study. The fields were selected to represent adequately the soil and erosion conditions in the general vicinity. It is believed that the results apply to a much larger area than the one sampled.

Table 2. THE NUMBER OF FARMS, FIELDS, AND SAMPLES BY YEARS AND AREAS

Item	Wild Horse Sample Area			Rock Creek Sample Area			Total
	1939	1940	1941	1939	1940	1941	
Number of farms	3	4	5	9	3	3	27
Number of fields	4	4	5	9	6	5	33
Number of samples	51	246	162	76	250	204	989
Number of acres	281	184	366	992	484	657	2,964

* The results of this study apply in some measure to many soil and erosion conditions throughout the Columbia Basin wheat region, but more specifically to the soil and slope conditions sampled.

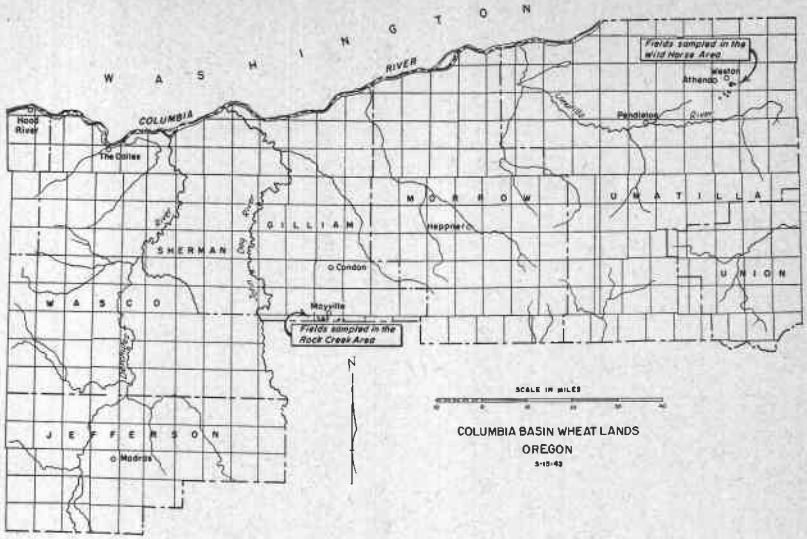


Figure 1. The location of fields sampled.

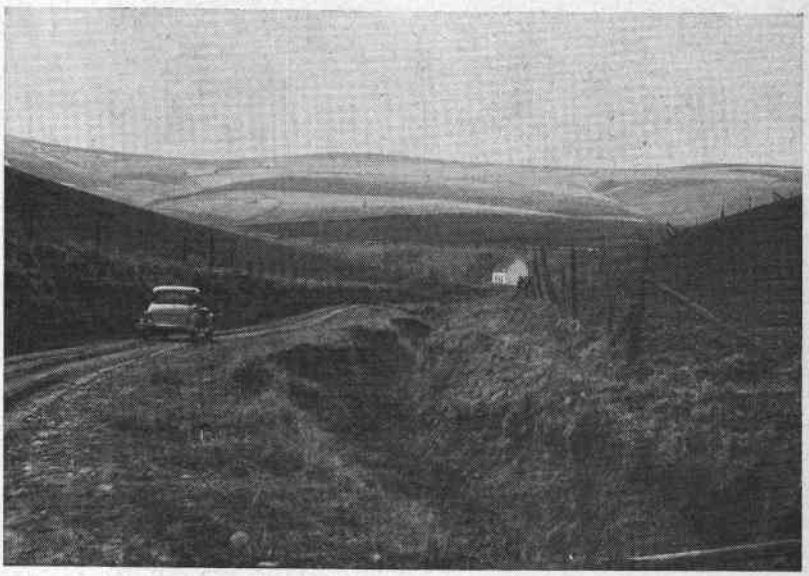


Figure 2. Topographic and soil erosion conditions in the Wild Horse Area. *Courtesy Soil Conservation Service*

Table 3. THE RATE OF SOIL EROSION

Year	Number of observations	Average slope	Average depth of soil profile	Average depth of topsoil*		Topsoil removed		Annual rate of soil erosion†	Years to remove remaining topsoil
				Original depth	Present depth				
		Per cent	*Inches*	*Inches*	*Inches*	*Inches*	*Per cent*	*Inches*	
Wild Horse Sample Area									
1939	51	18.5	29.8	12.3	5.9	6.4	52.0	.128	46
1940	246	16.5	38.2	21.3	13.8	7.4	34.7	.148	94
1941	162	13.9	31.1	18.8	13.3	5.4	28.7	.108	124
Average all samples	459	15.8	34.2	19.4	12.8	6.6	34.7	.132	97
Rock Creek Sample Area									
1939	76	7.9	33.1	14.3	10.6	3.7	25.8	.074	144
1940	250	9.9	28.1	15.9	11.6	4.3	27.0	.086	136
1941	204	8.2	23.6	14.5	10.8	3.6	24.8	.072	150
Average all samples	530	9.0	26.6	15.2	11.2	4.0	26.6	.080	141

* Topsoil is used in this study to refer to the entire "A" horizon.
† Based upon 50 years of cultivation.

THE RATE OF SOIL EROSION

The rate of soil erosion varies with the climate, the soil, the topography, and the farming practices. Erosion tends to increase at an accelerated rate through time, with the removal of the more resistant surface soil layers.

The data in Table 3 show the rate of soil loss from fields sampled in this study. For the Wild Horse Sample Area (average slope 15.8 per cent) the average loss of topsoil was 6.6 inches or 34.7 per cent of the original surface soil. The survey disclosed that sample fields had been under cultivation about 50 years. Based on this period the average loss of soil was about .13 inch per year or about 1 inch every 8 years. Assuming no acceleration in the rate of erosion it would require approximately 97 years for erosion to remove the remaining 12.8 inches of topsoil.

For the Rock Creek Sample Area (average 9 per cent slope) the average loss of surface soil (530 observations) is 4 inches or 26.6 per cent of the original depth of surface soil. The average loss of soil per year is .08 inch or 1 inch every 13 years. At this rate it will require 141 years to remove the remaining 11.2 inches of topsoil.

Table 4. THE EFFECT OF SLOPE ON THE RATE OF SOIL EROSION

Slope groups	Number of observations	Total depth of soil	Original depth of topsoil	Present depth of topsoil	Topsoil removed by erosion	Per cent of topsoil removed	Annual rate of soil removal*	Years to remove remaining topsoil
		Inches	*Inches*	*Inches*	*Inches*	*Per cent*	*Inches*	
Wild Horse Sample Area								
0- 4.9 per cent ..	.....	.....	.....	.....	.....	.....	.....	.....
5- 9.9 per cent ..	44	43	18.0	12.3	5.7	31.6	.114	108
10-14.9 per cent ..	159	34	17.2	10.7	6.5	37.8	.13	83
15-19.9 per cent ..	116	31	17.2	10.4	6.8	39.5	.136	77
20-24.9 per cent ..	87	33	17.4	11.0	6.4	36.8	.128	86
More than 25 per cent	53	33	18.8	11.5	7.3	38.8	.146	79
Rock Creek Sample Area								
0- 4.9 per cent ..	77	27	14.2	10.6	3.6	25.3	.072	148
5- 9.9 per cent ..	253	28	14.7	10.9	3.8	25.8	.076	144
10-14.9 per cent ..	132	31	15.9	10.9	5.0	31.4	.100	109
15-19.9 per cent ..	22	34	16.2	11.1	5.1	31.5	.102	109
20-24.9 per cent ..	7	30	16.0	10.2	5.8	36.3	.116	88
More than 25 per cent	.....	.....	.....	.....	....	.....	.....	.....
The Two Sample Areas								
0- 4.9 per cent ..	77	27	14.2	10.6	3.6	25.3	.072	148
5- 9.9 per cent ..	297	35	16.3	11.6	4.7	28.8	.094	124
10-14.9 per cent ..	297	33	16.5	10.8	5.7	34.5	.114	95
15-19.9 per cent ..	138	32	16.7	10.7	6.0	35.9	.120	89
20-24.9 per cent ..	94	32	16.7	10.6	6.1	36.5	.122	87
More than 25 per cent	53	33	18.8	11.5	7.3	38.8	.146	79

* Based on 50 years of wheat cultivation.

It is noted that the rate of soil erosion is apparently much less for the Rock Creek than for the Wild Horse Area. This is probably due to differences in the soil slope and the amount of rainfall. Factors such as soil texture and structure and farming practices are essentially the same for the two areas.

To test the effect of slope on the rate and amount of soil erosion the data have been grouped into six class intervals ranging from less than 5 to more than 25 per cent. The results of this analysis are presented in Table 4.

The results indicate a definite increase in the rate of erosion with each increase in slope. This relationship is most apparent in the third section of this table, showing the combined results for the two sample areas. It may be noted that as slope increases from less than 5 to more than 25 per cent, the average loss of surface soil increases from 3.6 to 7.3 inches or from 25.3 to 38.8 per cent of the topsoil.

THE EFFECT OF DEPTH OF SOIL ON WHEAT YIELDS

Crop yields are governed by three major factors: soil, climate, and management or cultural practices. In this study, as applied to wheat yields, the soil is the chief factor under consideration. The plant is related to the soil through a root system, the development and functioning of which provided necessary nutrients and water for growth. When there is inadequate root development, or the functions of the root are retarded because of an unfavorable root environment, yields are reduced. Shallow soils, whether caused by erosion or otherwise, limit root volume, and thereby lower the capacity of the plant to obtain what it needs from the soil. The soil made shallow by erosion probably holds less available nutrient and moisture, both because of a lack of depth and because of less favorable conditions in the area that is accessible to the roots. Effective soil depth as influenced by the degree of erosion therefore becomes an important crop yield factor.

Effect of total soil depth

The total depth of soil determines to a large extent the moisture storage capacity of the soil. In the Columbia Basin region, the fallow system of wheat farming is used to accumulate moisture and plant nutrients for 2 years to produce one crop of wheat. Any reduction in moisture penetration and storage caused by erosion has a detrimental effect on wheat yields. To show the effect of soil depth on the yield of wheat, the data have been grouped into four

intervals as follows: (1) soils under 24 inches; (2) soils 24 to 36 inches; (3) soils 36 to 48 inches; and (4) soils 48 inches and deeper. The summary of results is shown in Table 5.

Table 5. THE RELATION BETWEEN THE TOTAL DEPTH OF SOIL AND YIELD OF WHEAT BY YEARS AND SAMPLE AREAS

Year	Total depth of soil							
	Soils under 24"		Soils 24"-36"		Soils 36"-48"		Soils 48" and deeper	
	Number of observations	Average yield	Number of observations	Average yield	Number of observations	Average yield	Number of observations	Average yield
		Bushels		*Bushels*		*Bushels*		*Bushels*
Wild Horse Sample Area								
1939	21	14.2	15	23.4	4	31.3	11	42.3
1940	47	20.7	58	30.1	49	36.3	95	47.4
1941	56	30.9	63	37.3	21	41.6	22	49.6
Average all samples	124	21.9	136	30.3	74	36.4	128	46.4
Rock Creek Sample Area								
1939	4	11.8	32	15.4	14	21.5	26	25.5
1940	83	17.7	113	22.3	44	24.6	10	22.6
1941	113	29.2	67	31.7	18	33.2	7	33.2
Average all samples	200	19.6	212	23.1	76	26.4	43	27.1

For the Wild Horse Area the yield of wheat is reduced from 46 to 22 bushels per acre with the decrease in depth from more than 48 to less than 24 inches. The decrease for the Rock Creek Area is from 27 to less than 20 bushels for depths ranging from more than 48 to less than 24 inches.

Effect of depth of topsoil

Topsoil is probably more important to plant growth than a similar amount of subsoil. The surface soil contains the plant nutrients vital to plant growth and crop production. When the topsoil is removed by erosion the soil loses most of its productive capacity. Over a period of years a continuous decline in wheat yield may reasonably be expected.

Table 6 shows the differences in the average yield of wheat associated with differences in the depth of topsoil for the areas under consideration.

The results show a consistent decline in yield with decrease in the depth of surface soil. In the Wild Horse Area, the decline in yield is from 43 bushels to 13 bushels per acre as the depth of topsoil decreases. The change, less pronounced in the Rock Creek

Area, is from 31 to 21 bushels per acre with a decrease from more than 15 inches to less than 10 inches of topsoil. Yields decline because erosion has removed the most fertile soil and reduced the moisture holding capacity.

Table 6. THE RELATION BETWEEN THE DEPTH OF TOPSOIL AND YIELD OF WHEAT

Year	Depth of topsoil							
	Under 6"		6"-10"		11"-15"		Over 15"	
	Number of cases	Yield	Number of cases	Yield	Number of cases	Yield	Number of cases	Yield
		Bushels		*Bushels*		*Bushels*		*Bushels*
Wild Horse Sample Area								
1939	21	15.2	23	29.5	7	33.9	.....	.....
1940	8	13.5	74	28.3	66	35.4	104	44.2
1941	3	10.8	39	35.8	66	35.0	54	42.7
3 year average	32	13.2	136	31.2	139	34.8	158	43.4
Rock Creek Sample Area								
1939	....	.....	50	16.2	24	27.5	2	34.0
1940	....	.....	93	17.9	144	22.8	13	25.6
1941	....	.....	93	30.0	92	31.3	14	32.7
3 year average	....	.....	236	21.4	260	27.2	29	30.8

THE EFFECT OF SOIL EROSION ON WHEAT YIELDS

The multiple correlation method was used to isolate and measure the effect of soil erosion on wheat yields.* The results, expressed as coefficients of net regression, show that loss of 1 inch of topsoil on the Wild Horse Area causes a reduction of 0.9 bushel in the yield of wheat.† Similar results for the Rock Creek Area show a decrease of 0.8 bushel in yield with the loss of 1 inch of topsoil.

The results just quoted are for an average topsoil depth of 12.8 inches for the Wild Horse Area, and 11.2 inches for the Rock Creek Area. The question might be raised as to whether or not the effect of soil erosion is the same for other soil depths. For example, does the loss of an inch of soil from a 20-inch topsoil reduce yields as much as the loss of an inch of soil from a 6-inch topsoil? To an-

* The correlation problem as set up was composed of four independent variables—present depth of topsoil, depth of subsoil, slope, and the original depth of topsoil; and one dependent variable, the yield of wheat. The present depth of topsoil (due to erosion) was used in the correlation to represent erosion. It should be explained that the present depth of topsoil is affected by both the original depth of topsoil and the amount that has been removed by erosion; in order to use present depth of topsoil as an index of erosion, it was necessary to eliminate the factor of original depth. This was accomplished by including the original depth of topsoil as one of the independent variables.

† The partial regression coefficient is an expression of the unit change in the dependent variable (in this case wheat yield in bushels) that accompanies a unit change in the independent variable (in this case 1 inch of topsoil). For example, the coefficient .9169 means that, on the average, the loss of 1 inch of topsoil from the Wild Horse Sample Area causes a reduction of .9169 bushel in the yield of wheat.

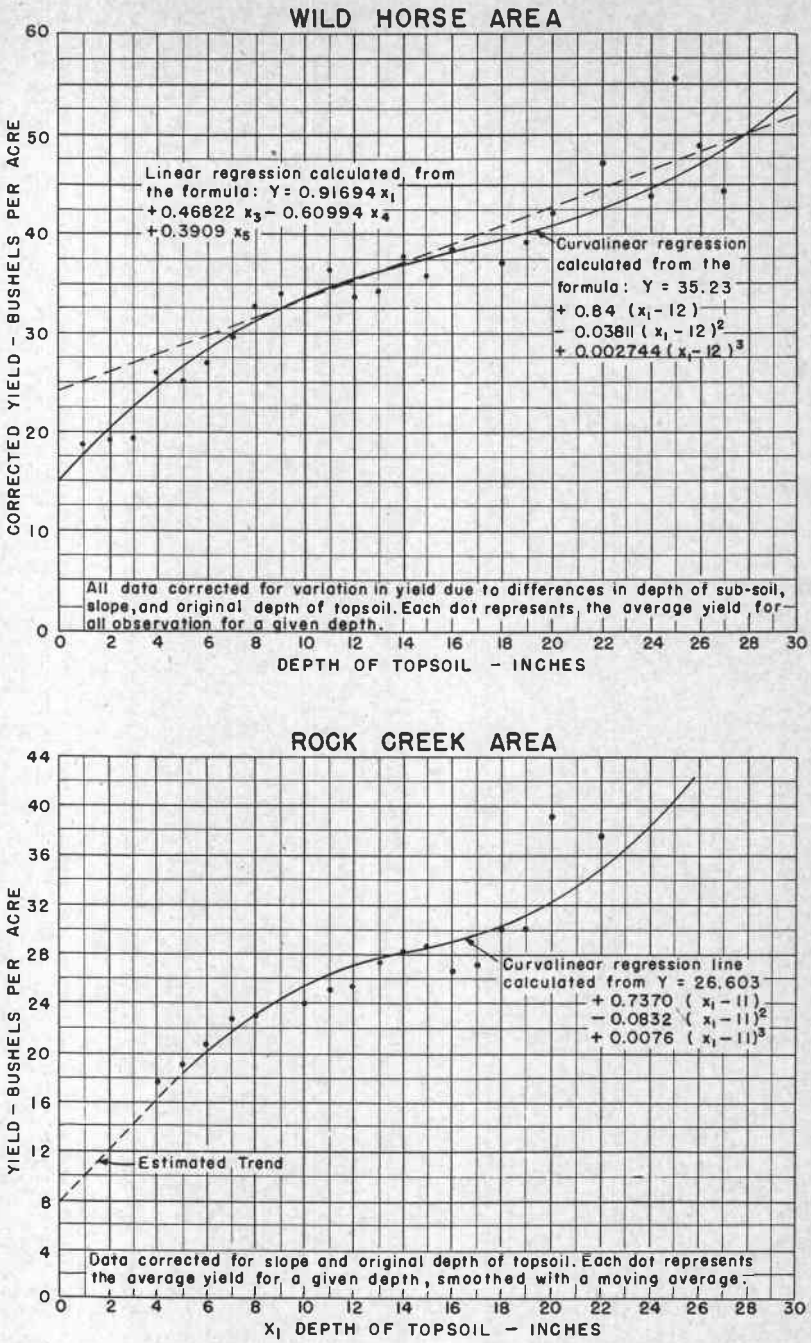


Figure 3. Effect of depth of topsoil on yield of wheat.

swer this question, the data were summarized to show the effect of soil erosion on yield for different depths of soil. The results are presented in Figure 3.

The results show for the Wild Horse Area that whereas the average reduction in yield for all soil depths is 0.9 bushel, the average for depths of about 20 inches is only 0.6 bushel as contrasted with 1.7 bushels for depths less than 6 inches. This means that soil erosion becomes more serious as it progresses, not only because the rate of erosion is accelerated, but also because its effect on crop yields increases with the loss of soil.

Most of the observations on the Rock Creek Sample Area were for soil ranging from 6 to 16 inches in depth. The effect of erosion on yield is about the same within this depth range but indications are that its effect increases rapidly for depths less than 6 inches. In other words, the loss in yield per inch of topsoil increases with time, and in making practical application of the results it is necessary to consider the future. If no measures are taken to prevent erosion, the average decrease in yield per inch of topsoil lost during the next 50 years will be 1.2 bushels for the Wild Horse and 1.1 bushels for the Rock Creek Area, instead of 0.9 and 0.8 bushel as indicated above.

THE ECONOMIC IMPORTANCE OF SOIL EROSION

The economic importance of soil erosion is measured by its adverse effect on wheat yields and farm income. The results in Table 7 indicate an average loss of 6.6 inches of topsoil from the Wild Horse Area during 50 years of wheat production. Loss of topsoil from the Rock Creek Area, where erosion is less rapid, was only 4.0 inches. At these rates 1 inch of topsoil has been lost every 8 and 13 years, respectively, for the two areas. It has been shown that the loss of an inch of topsoil causes an average decrease in yield of 0.9 and 0.8 bushel per acre for the two areas. At these rates the total reduction in yield over a 50-year period is 6.1 bushels for the Wild Horse and 3.2 bushels for the Rock Creek Area.

If it is assumed that the change in yield has been uniformly downward during the period of cultivation, the yield has declined at the rate of 0.12 bushel per year on the Wild Horse, and 0.064 bushel per year on the Rock Creek Area. At $0.70 per bushel the value of the annual decrease in wheat yield is $0.084 and $0.045 respectively.

Cumulative effect of erosion

The rate of erosion tends to accelerate with time and, more important, erosion losses, like compound interest, accumulate from

year to year. That is, the loss per acre is $0.084 the first year only and increases by that amount each year thereafter. Furthermore, the cost of erosion control increases through time.

Table 7. THE LOSS OF SOIL AND ITS EFFECT ON WHEAT YIELDS DURING 50 YEARS OF WHEAT CULTIVATION, 1890-1940

Item	Wild Horse Area	Rock Creek Area
Average depth of topsoil		
1890	19.4 inches	15.2 inches
1940	12.8 inches	11.2 inches
Loss of topsoil in 50 years	6.6 inches	4.0 inches
Average yield per acre of wheat		
1890	42.0 bushels*	29.9 bushels*
1940	35.9 bushels	26.7 bushels
Decrease in wheat yield per acre in 50 years	6.1 bushels	3.2 bushels
Annual loss of topsoil	0.132 inches	0.080 inches
Time required to remove 1 inch of topsoil	7.57 years	12.5 years
Decrease in wheat yield per inch of topsoil lost	0.917 bushels	0.802 bushels
Annual decrease in wheat yield per acre	0.121 bushels	0.064 bushels
Annual income loss per acre from decrease in wheat yield (@ 70¢ per bushel)	$0.084	$0.045

* Estimated from present yield based on the results of this study. All factors affecting wheat yield except erosion are assumed to remain constant.

The effect of soil erosion for a single acre for 1 year is usually not great. Wheat farmers may not be impressed by an annual loss of $0.08 per acre. The result is that positive action is delayed and irreparable erosion damages occur because farmers are unaware of small unit losses in income.

The reduction in yield for the Wild Horse Area is only one-eighth of a bushel per year but over a 10-year period the cumulative loss in yield is 6.7 bushels. (Table 8.) The average loss of income, computed at $0.70 a bushel, is only $0.08 per year on each acre, but the cumulative loss in 10 years is $4.63 per acre. Comparable though less striking results are shown for the Rock Creek Area.

Effect of erosion on the whole farm

Thus far erosion damages have been considered for only 1 acre of wheat land. The loss of income from erosion, however, may be more fully comprehended when applied to the whole farm.

In making application of the results in Table 8 to a farm, it is necessary to consider the wheat fallow system of farming, which permits a crop only every other year. The effects of erosion on yield go on every year as indicated. They are manifest, however, in terms of lower wheat production and income only when the land is in wheat. Table 9 shows the estimated change in production and income due to erosion for the whole farm for a 10-year period.

Table 8. THE CUMULATIVE EFFECT OF SOIL EROSION ON AN ACRE OF LAND IN WHEAT IN 10 YEARS

(Based on wheat planted after fallow)

Year	Depth of topsoil	Cumulative topsoil removed by erosion	Yield of wheat per acre	Cumulative decrease in yield due to erosion	Estimated decrease in income at assumed price of $0.70 per bushel*
Wild Horse Area	*Inches*	*Inches*	*Bushels*	*Bushels*	
1940	12.80	....	35.90	.....	.....
1941	12.67	.13	35.78	.12	$0.08
1942	12.53	.27	35.65	.25	.17
1943	12.40	.40	35.53	.37	.25
1944	12.27	.53	35.41	.49	.34
1945	12.14	.66	35.29	.61	.42
1946	12.00	.80	35.17	.73	.51
1947	11.87	.93	35.05	.85	.59
1948	11.74	1.06	34.93	.97	.67
1949	11.61	1.19	34.81	1.09	.76
1950	11.48	1.32	34.69	1.21	.84
Total 10 years	.....	1.32	.....	6.7	$4.63
Average per year	.....	.13	.....	0.67	$0.46
Rock Creek Area					
1940	11.20	.....	26.70	.....	.....
1941	11.12	.08	26.63	.07	$0.04
1942	11.04	.16	26.57	.13	.09
1943	10.96	.24	26.51	.20	.14
1944	10.88	.32	26.44	.26	.18
1945	10.80	.40	26.38	.32	.22
1946	10.72	.48	26.31	.39	.27
1947	10.64	.56	26.25	.45	.31
1948	10.56	.63	26.18	.52	.36
1949	10.48	.72	26.12	.58	.40
1950	10.40	.86	26.06	.64	.44
Total 10 years	.....	.86	.....	3.56	$2.45
Average per year	.....	.08	.....	.36	$0.25

* The data in this column represent an evaluation of yield losses on an acre of wheat land at $0.70 per bushel. Because of the wheat-fallow system of farming, loss of income on a single acre would occur only every other year when the land is in wheat. This means that the total loss per acre in 10 years is only $2.31 rather than $4.63. (See page 17 for further explanation and Table 9 for application of the results to a wheat farm.)

It should be explained that income losses from soil erosion are virtually net losses for a 10-year period; that whereas lower harvesting costs and handling charges will eventually become significant these changes are practically nil in a short-run period.

The results reflect the magnitude of erosion damages when the whole farm is considered over a period of 10 years instead of from year to year. For a representative wheat farm in the Wild Horse Area the loss in income amounts to $1,315 for the entire period, an average of $131 per year. Production the tenth year is 344 bushels less than the first year, a loss of $241 with wheat figured at $0.70 per bushel.

Similar results for the Rock Creek Area show a reduction of 477 bushels of wheat, valued at $334 by 1950, or an average loss of $182 per year for the period. This shows the effect on yield and

income for only 10 years, but it poses the question as to what the changes in production and income will probably be 30, 50, or 100 years hence.

The income losses as previously calculated are significant and should merit the careful consideration of every land user. The capital loss from erosion is considered in more detail in the section that follows.

Table 9. THE DECREASE IN INCOME FROM EROSION FOR TWO REPRESENTATIVE WHEAT FARMS OVER A 10-YEAR PERIOD

Item	1940	1950	Decrease
Wild Horse Sample Area			
Acres wheat land*	568	568	0
Acres in wheat	284	284	0
Bushels of wheat per acre	35.9	34.69	1.21
Bushels of wheat produced	10,196	9,852	344
Wheat at $0.70 per bushel	$7,137	$6,896	$241
Ten-year cumulative loss of income			$1,315
Average income loss per year			$ 131
Rock Creek Sample Area			
Acres wheat land*	1,490	1,490	0
Acres in wheat	745	745	0
Bushels of wheat per acre	26.70	26.06	0.64
Bushels of wheat produced	19,891	19,414	477
Wheat at $0.70 per bushel	$13,923	$13,589	$334
Ten-year cumulative loss of income			$1,825
Average income loss per year			$ 182

* The acreages used in this analysis are average for a large number of farms within the two areas.

THE LONG-TIME PHYSICAL AND ECONOMIC EFFECTS OF EROSION

At the present rate of erosion, it will require only about 100 years to remove the remaining topsoil on the Wild Horse Area and 150 years on the Rock Creek Area.* This estimate is based on the past 50 years; for that reason it is believed conservative. The approximate time period during which the remainder of the topsoil would be removed and the land rendered worthless for wheat production is presented graphically in Figure 4. In this chart the yield of wheat is estimated for different soil depths at 10-year intervals from data previously presented in Figure 3.

* Measurements of annual soil losses on the Wild Horse Soil Conservation Area have been made by resident soil conservation technicians. These studies indicate that a loss of from 15 to 35 tons per acre per year is not uncommon. At this rate it is estimated that shallow land will be abandoned within 50 years, and that some of the deeper, less erodable land will be abandoned within 100 years.

Soil, yield, and income loss

The data in Table 10 show the loss of topsoil, the decrease in yield, and the computed decrease in net income from the land over a long period of time as a result of erosion.*

Table 10. THE ESTIMATED LONG-TIME ECONOMIC CHANGES IN PRODUCTION AND INCOME FROM WHEAT DUE TO SOIL EROSION

(Based on wheat after fallow)

Year	Depth of topsoil	Yield of wheat	Value of crop at $0.70 per bushel	Cost of wheat production per acre*	Net return to land	
					Every other year	Average per year
	Inches	*Bushels*				
Wild Horse Area						
1940	12.80	35.9	$25.13	$15.45	$9.68	$4.84
1950	11.48	34.6	24.29	15.06	9.23	4.61
1960	10.16	33.4	23.38	14.72	8.66	4.33
1970	8.84	32.1	22.47	14.35	8.12	4.06
1980	7.52	30.4	21.28	13.86	7.42	3.71
1990	6.20	28.5	19.95	13.31	6.64	3.32
2000	4.88	26.3	18.41	12.67	5.74	2.87
2010	3.56	23.8	16.66	11.96	4.70	2.35
2020	2.24	20.8	14.56	11.10	3.46	1.73
2030	.92	17.6	12.32	10.17	2.15	1.08
2037	.0	14.9	10.43	9.41	1.02	.51
		Pasture	.43	.12	.....	.31
Rock Creek Area						
1940	11.2	26.7	18.69	12.01	6.68	3.34
1950	10.4	26.0	18.20	11.75	6.45	3.22
1960	9.6	25.3	17.71	11.47	6.24	3.12
1970	8.8	24.4	17.08	11.15	5.93	2.97
1980	8.0	23.4	16.38	10.77	5.61	2.80
1990	7.2	22.1	15.47	10.28	5.19	2.59
2000	6.4	20.7	14.49	9.75	4.74	2.37
2020	4.8	17.5	12.25	8.48	3.77	1.89
2040	3.2	14.4	10.08	7.40	2.68	1.34
2060	1.6	11.2	7.84	6.19	1.65	.82
2080	.0	8.0	5.60	4.98	.62	.31
		Pasture	.31	.12	.....	.19

* Total cost less interest on land. (See Oregon Agricultural Experiment Station Bulletin 373 for information on the cost of wheat production.) For the purpose of this analysis, it is assumed that the cost of wheat production on steep land is about 33 per cent higher than on level or gently rolling land. (See Oregon Agricultural Experiment Station Circular of Information 271 for information on the cost of wheat farming on different land slopes.)

The results show how yield and income diminish from their present level, with the loss of topsoil, to a point where the land is eventually rendered marginal for wheat production and is retired to pasture. For the Wild Horse Area, loss in "net return to land" per acre increases from $0.23 during the first decade to a total of $4.53 at the end of the period when the topsoil is gone. The loss in "net return to land" per acre on the Rock Creek Area, is only $0.12 during the first 10 years but increases to $3.15 in about 150 years.

* It is assumed that over a long period of time operating costs per acre will be lowered because of lower interest charges and taxes on depreciated land values, and from handling less wheat. For the purpose of this analysis, costs have been adjusted arbitrarily with changes in the yield of wheat for the entire period.

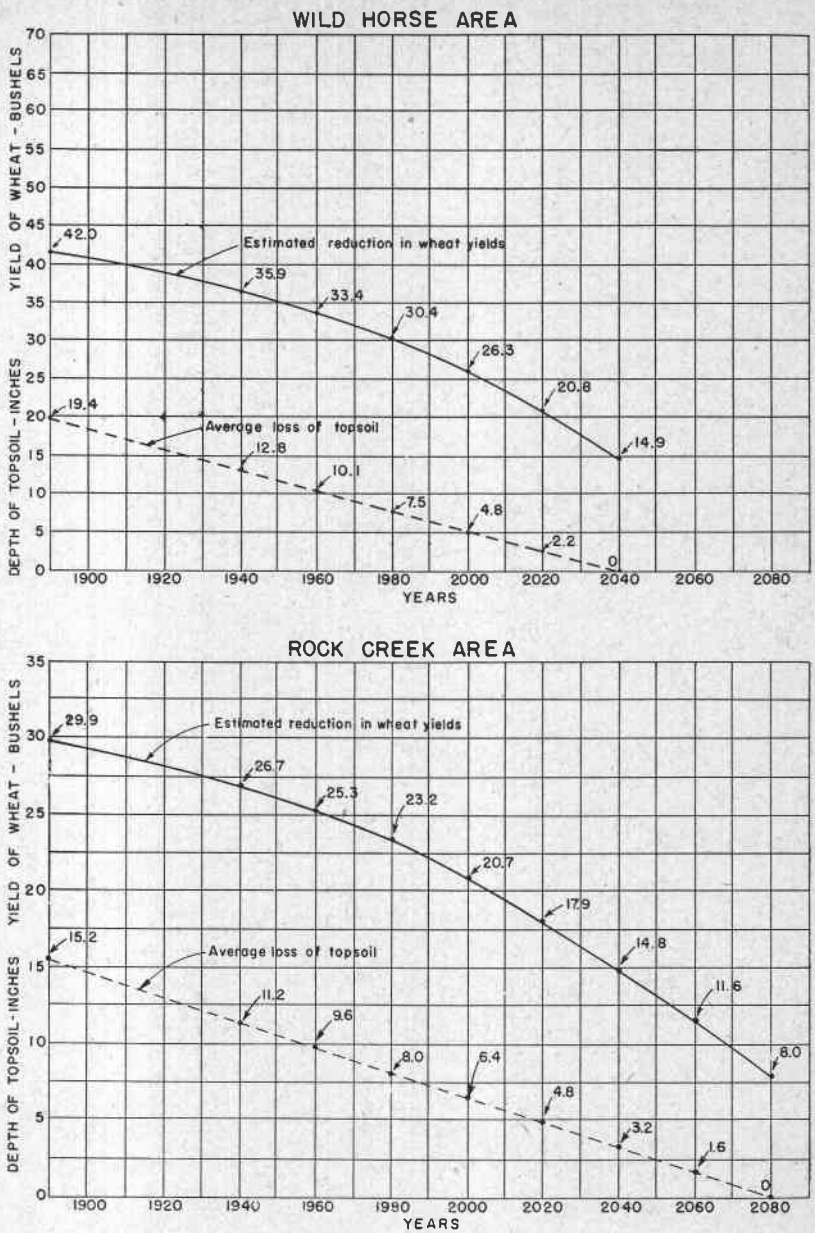


Figure 4. Long-time rate of soil erosion and its effect on wheat yields.

Capital loss

Land derives its value from production and income. When productivity is impaired by soil erosion, other things being equal, the capital value of the land diminishes. Capital losses may be of more immediate concern to the land owner than income losses.

The conventional method of determining land value is by dividing the net annual income by the interest rate. If there is a net income of $4.84 a year and the interest rate is 4 per cent, the value of the land is $121 per acre, since $4.84 is 4 per cent interest on $121. This figure, however, is the true value only if this income will continue forever at the present amount of $4.84.

Our studies of soil erosion indicate that with present methods of farming the income is steadily decreasing. Table 10 shows that the land, which is now producing an income of $4.84, will be used only for pasture by the year 2037 with an estimated annual income of $0.31. It is apparent therefore that, if this decrease in income is to continue, the land that now produces $4.84 net income is not worth $121 but is of lower value. In order to determine the true worth we must determine the present value of an income that is $4.84 the first

Table 11. THE VALUE OF WHEAT LAND ADJUSTED TO TAKE INTO ACCOUNT THE EFFECT OF SOIL EROSION

Year	Net return to land	Land value at 4 per cent	
		False value*	True value†
Wild Horse Area			
1940	$4.84	$121	$102
1950	4.61	115	94
1960	4.33	108	85
1970	4.06	102	76
1980	3.71	93	65
1990	3.32	83	54
2000	2.87	72	42
2010	2.35	59	30
2020	1.73	43	19
2030	1.08	27	11
2037	.51	13	8
After 2037	.31	8	8
Rock Creek Area			
1940	$3.34	$83	$73
1950	3.22	80	69
1960	3.12	78	64
1970	2.97	74	57
1980	2.80	70	50
1990	2.59	65	42
2000	2.37	59	34
2020	1.89	47	27
2040	1.34	33	16
2060	.82	20	8
2080	.31	8	5
After 2080	.19	5	5

* Based upon conventional method of capitalizing net return to land at 4 per cent, assuming the income continues forever at the present rate.

† Based upon a diminishing return to land due to soil erosion, with only a pasture value of $8.00 after 2037.

year only and that decreases until finally the income is for pasture alone. On this basis the true value of the land in 1940 is $102 instead of $121.

Likewise in 1950 when the net income is $4.61, it is found that $4.61 is 4 per cent interest on $115, but the land is really not worth this amount because next year the income will be less and still less the second year and so on down the scale. The difference between the false values and the true values is shown in Table 11.

On the other hand, if erosion and the decrease in income can be stopped now and prevented for the future, the land is worth $121 less the cost of stopping the erosion. This brings up the question of how much farmers can invest to prevent erosion.

HOW MUCH CAN FARMERS INVEST TO PREVENT EROSION?

The amount farmers can invest in soil conservation is contingent on the probable returns from such an investment. The returns from conservation accrue slowly over a long period of time. This means that the benefits that would accrue to the individual farmer would vary with his period of tenure. The tenant farmer who rents land for a single crop of wheat could spend only the probable benefits for 1 year or $0.08 per wheat acre on the Wild Horse and $0.04 per wheat acre on the Rock Creek Area to prevent erosion. The farmer who farms the land for 10, 20, or 50 years could obviously expend or otherwise invest much larger amounts, depending on the period of his tenure.

For the purpose of this study it is assumed that the average tenure for wheat farms is about 20 years. The cumulative loss of income from erosion on an acre of wheat land in 20 years is $11.87 on the Wild Horse, and $6.32 on the Rock Creek Area. The present value of the accumulated total loss indicates the amount that farmers may invest at 4 per cent interest to prevent erosion.* The results of this computation indicate that wheat farmers on the Wild Horse Area could invest $5.42, and Rock Creek Area farmers could invest $2.88 per acre of wheat land if by so doing the future loss of income from erosion could be prevented.†

* The total loss for 20 years was computed by accumulating the annual loss of $0.08 and $0.04, for the respective areas, plus interest at 4 per cent. The total was reduced by one-half to allow for the fact that wheat land produces an income only every other year. The latter value or $11.87 was in turn multiplied by .4563 (the present value of $1.00 20 years hence at 4 per cent compound interest) to obtain the present value of the future loss or the amount that could be invested now to prevent the loss.

In making this computation the slight saving in harvesting costs, from handling less wheat as a result of erosion, was ignored.

† The analysis assumes absolute control of erosion that is seldom if ever possible on sloping wheat land.

Using the data presented in Table 10, it is estimated that the present value of income losses from now until the topsoil is completely destroyed is about $19.00 on the Wild Horse Area and $10.00 on the Rock Creek Area. It will be noted that these amounts are the same as the difference between the present value of the land if protected from erosion and the value of the land if erosion is allowed to continue at its present rate. (Table 11.) These values may indicate the maximum per acre investments in conservation that are deemed feasible under the conditions assumed in this study.

Both the kind and amount of investment varies with the specific erosion conditions and the conservation measures required to effect its control. Such methods as terraces, contour furrows, drainageways, and similar structures require a heavy initial capital investment, while grass seedings, trashy fallow, and contour farming may require only a nominal increase in cash expenses for different or additional tillage or for seed. Or, instead of an increase in farming costs, the practice may reduce wheat yields from turning under heavy crop residue.* In either event, the farmer would like to know, also, how much he can spend annually to prevent erosion.

Here again the amount varies with the years over which dividends from conservation to the landowner will be forthcoming. It has already been shown that the loss of income from erosion or the benefits from conservation increase with time and the benefit for only 1 year is the same as the probable loss of $0.08 and $0.04 per acre, respectively. If, however, the farmer is concerned for a long period of time he would be able and willing to spend several times $0.08 and $0.04 per acre each year, knowing that the investment would be returned with interest later on. For example, the average annual equivalent of $5.42 on the Wild Horse Area for 20 years is $0.40, and the corresponding amount for the Rock Creek Area is $0.21. These amounts could be expended or otherwise sacrificed on each acre of wheat land each year and return the principal plus 4 per cent interest by the end of 20 years.

The annual investment per wheat acre for 20 years could be doubled or $0.80 and $0.42 per wheat acre, respectively, if the investment is concentrated on one-half the land area or the land planted to wheat as in the case of extra tillage or a reduction in yields and income from plowing under heavy crop residue. If the period is 97 years, the investment per wheat acre for conservation could be as high as $1.56 and $0.82 for the two respective areas. Whether for

* It should not be implied that conservation farming always results in an increase in the cost of farming or results in lower net income. Some of the practices may be as economical as conventional methods of farming and the new system of farming that includes more grass and legumes may, under certain conditions, be more profitable than the present wheat-fallow system.

20 or for 97 years the maximum annual investment is higher than the return from conservation during the first half but less than the return during the last half of the period. Thus, it may be necessary to consider a long period of time to justify an immediate expenditure that is necessary to effect satisfactory control of erosion. Where the period extends beyond the life expectancy of the present land user there may be justification for public assistance.

The next section of this circular considers the effectiveness of certain soil conservation practices being currently recommended on wheat lands.

THE EFFECTIVENESS OF SOIL CONSERVATION PRACTICES

This section of the report presents the results of several surveys and investigations showing the loss of soil with and without the use of certain erosion control practices under different soil and slope conditions. According to a reconnaissance survey of Palouse wheat farms, trashy fallow is about 75 per cent effective in controlling erosion and contour cultivation is 64 per cent effective (Table 12). Results from plot experiments on the Wild Horse

Table 12. THE EFFECTIVENESS OF TRASHY FALLOW AND CONTOUR CULTIVATION ON PALOUSE WHEAT FARMS*

Slope interval	Black fallow		Trashy fallow		
	Number of observations	Soil loss per acre	Number of observations	Soil loss per acre	Soil saved†
		Tons		*Tons*	*Per cent*
5.0- 9.9 per cent	4	30.37	4	7.97	74
10.0-14.9 per cent	4	34.43	3	1.13	97
15.0-19.9 per cent	2	44.25	8	12.06	73
20.0-24.9 per cent	1	52.80	1	26.78	50
25.0 per cent and over	4	78.71	2	30.24	62
Weighted average	15	47.69	18	12.17	75
	Up-down hill cultivation		Contour cultivation		
		Tons		*Tons*	*Per cent*
5.0- 9.9 per cent	6	22.99	1	15.39	33
10.0-14.9 per cent	5	27.54	2	1.70	94
15.0-19.9 per cent	4	30.83	6	10.28	67
20.0-24.9 per cent	1	52.80	1	26.78	50
25.0 per cent and over	4	78.71	2	30.24	62
Weighted average	20	38.33	12	13.98	64

* Compiled from data in a mimeographed report entitled, "Soil Erosion on Palouse Wheat Farms" by Leo L. Anderson and W. W. Hill, 1940. In this study the amount of soil removed by erosion was determined by the method of "rill measurements," wherein the area surveyed is cross-sectioned, and rills measured as to width and depth at regular intervals.

† Percentage saved in terms of black fallow or up- and down-hill cultivation base.

Area indicate that contour cultivation alone is about 60 per cent effective (Table 13). Stubble utilization with considerable crop residue on the surface was found to be very effective in controlling erosion. When the two practices are used in combination between 90 and 100 per cent of the soil loss can be saved. The results for 4 years indicate that these practices combined are about 80 per cent effective on slopes under 10 per cent.

Table 13. THE EFFECTIVENESS OF TRASHY FALLOW AND CONTOUR SEEDING ON THE ANNUAL RATE OF WATER RUNOFF AND SOIL EROSION

(Eight per cent slope in Wild Horse Area)*

Year and plot number	Direction of seeding	Surface trash per acre	Water runoff per acre	Water saved†	Loss of soil per acre	Soil saved†
		Pounds	*Inches*	*Per cent*	*Pounds*	*Per cent*
1937-38						
3	Down hill	105	1.14	....	6,552	....
4	Contour	37	.93	19	2,300	65
2	Contour	183	.33	71	380	94
1	Contour	267	.04	99	92	99
1938-39						
2	Down hill	31	2.00	....	21,640	....
1	Contour	1,008	.18	91	351	98
4	Down hill	224	.96	....	14,100	....
3	Contour	177	.91	5	2,830	80
1939-40						
1	Down hill	38	1.63	....	13,007	....
2	Down hill	1,100	.43	74‡	704	95‡
3	Contour	1,100	.11	94	132	99
1940-41						
1	Down hill	50	0.97	....	4,229	....
2	Contour	50	0.63	35	1,339	70
3	Down hill	458	3.96	....	11,405	....
4	Contour	458	3.53	11	8,827	23
4 year average	Down hill	286	1.58	....	10,234	....
	Contour	465	.83	48	2,031	80

* Data rearranged from Table 1 in the annual report of studies of the effect of different tillage practices on soil and water losses by erosion in the Blue Mountain Foot Hill Area of eastern Oregon. Typewritten report by Carl R. Freese and J. H. Parkins, Soil Conservation Service, Pendleton, Oregon, 1940. In this study plots were laid out on selected slope and soil sites, and the removal of soil by erosion was measured by collecting in a basin and weighing.

† The amount of soil and water saved with contour cultivation is expressed as a percentage of the amount lost with up- and down-hill cultivation.

‡ Due to trashy fallow only.

Experiments show that 94 per cent of the soil usually lost by seeding land to winter wheat can be saved by retiring it to alfalfa and grass (Table 14). They show also that an estimated 93 per cent of the soil lost by spike-tooth harrowing of fall plowed land can be saved by leaving rough or in the plowed condition. Seventy-three per cent of this soil can be saved by using a spring-tooth instead of a spike-tooth harrow.

Figure 5. Trashy fallow affords satisfactory protection against soil erosion on most wheat land. (Rock Creek Area.)

Courtesy Soil Conservation Service

Figure 6. A cloddy surface may serve as a good over-winter condition for some soils. (Wild Horse Area.)

Courtesy Soil Conservation Service

Table 14. THE EFFECTIVENESS OF LAND USE AND METHOD OF TILLAGE ON THE WILD HORSE AREA NEAR ATHENA, OREGON*

Method of land use or tillage	Number of plots	Annual loss of soil per acre by erosion	Soil saved by soil per acre by conservation method	Per cent effective
		Tons	*Tons*	*Per cent*
Land Use				
Alfalfa and grass	51	.61	10.51	94†
Fall wheat	186	11.12	0	0
Method of tillage				
Fall plowed (moldboard)	255	1.86	24.96	93
Fall plowed (moldboard) spring-tooth harrow	82	7.21	19.61	73
Fall plowed (moldboard) spike-tooth harrow	16	26.82	0	0

* Data rearranged from a typewritten report entitled, "A Plot Method of Sampling Over-winter Soil Losses on Wheat Fields Adjacent to the Blue Mountains in Oregon," by Carl R. Freese, 1941. The method of rill measurements was used to determine the loss of soil by erosion. (See footnote 1, Table 12, page 25 or the report cited for statement of method and procedure.)

† The amount of soil saved by the soil conserving method expressed in percentage of the soil lost by the depleting method.

These results apply generally to slopes of less than 10 per cent. Farmers should be especially interested in the damaging effect of smooth tillage or to soil condition left by a harrow or drill.

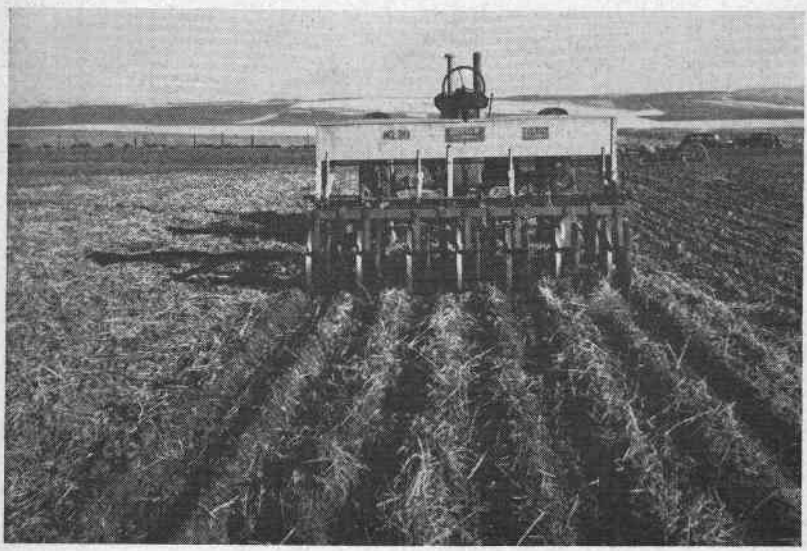


Figure 7. Special farm implements may be used to control erosion. (Wild Horse Area.)

Courtesy Soil Conservation Service

Sweet clover may save as much as 50 per cent of the soil otherwise lost by erosion and, at the same time, cause a 35 per cent increase in the yield of wheat (Table 15).

Table 15. THE EFFECT OF A SWEET CLOVER ROTATION ON THE RATE OF WATER RUNOFF AND SOIL EROSION*

Year	Crop yield per acre	Amount of water runoff	Amount of soil loss per acre
	Bushels	*Inches*	*Tons*
Winter wheat after summer fallow			
1938	34.9	.329	.118
1939	39.3	.645	.802
1940	19.5	.868	6.909
Average	31.2	.613	2.610
Winter wheat after summer clover			
1938	54.6	.131	.013
1939	42.0	.268	.008
1940	52.7	.504	3.574
Average	49.8	.301	1.198
Increase in wheat yield	18.6	.....	.....
Per cent soil and water saved	.....	50.9†	54.1†

* Data contributed by Soil Conservation Experiment Station, Pullman, Washington. The plot method was used in which the soil and water runoff were collected in a basin and weighed to determine the removal of soil by erosion.

† Per cent of wheat-summer fallow base.

The foregoing data show that the effectiveness of soil conservation practices varies with specific soil and erosion conditions, and the manner in which they are applied. These practices indicate also that a large part of the soil now being lost by erosion can be saved by the use of certain soil conservation practices. A much higher percentage can be saved by adopting a complete soil conservation program.

A RECOMMENDED SOIL CONSERVATION PROGRAM

Many soil losses from erosion can be avoided by adopting an adequate soil conservation program. Such a program will almost inevitably affect the production and general management of the farm as a whole. It is therefore essential in formulating plans for the new program to recognize the necessity for including a comprehensive farm management plan of procedure along with the more strictly soil conservation measures.

The specific recommendations for the soil conservation aspect of farming in the Wild Horse Area fall into three categories on the basis of slope.

On slopes under 10 per cent, (1) a portion of the stubble should be left on or near the surface to serve as a trashy fallow mulch; (2) cultivation should follow the contour to the extent

that slope and fields will permit without extreme inconvenience or excessive cost; and (3) a rough, cloddy surface mulch should replace the smooth, friable condition commonly left by spike-tooth harrowing.

On slopes from 10 to 25 per cent, (1) a crop rotation, such as wheat-peas-sweet clover, alternating on land properly laid out for strip cropping on the approximate contour, should be adopted with such auxiliary permanent seeded strips, terraces, and diversion ditches as conditions require; and (2) stubble utilization, rough tillage, and contour cultivation should be made part of the cropping technique.

On slopes greater than 25 per cent the land use should be shifted from wheat to alfalfa and grasses. The same applies also to shallow lands and all drainageways in cultivation.

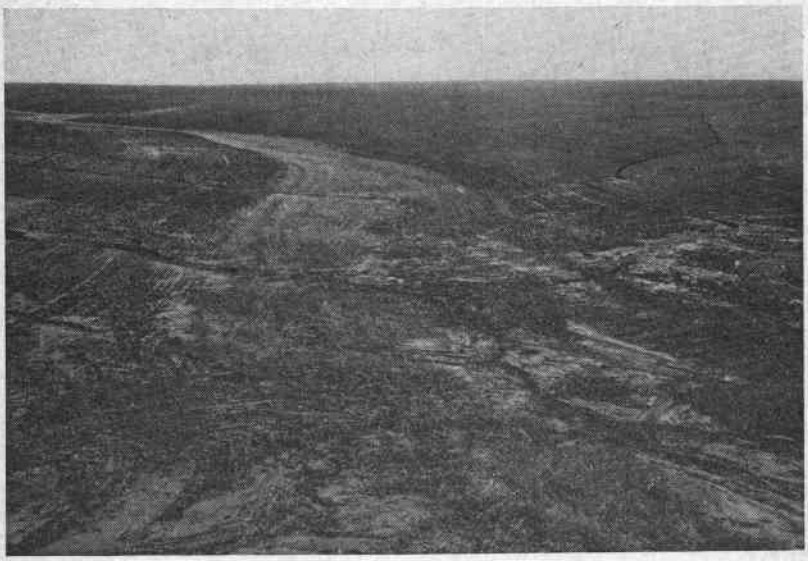


Figure 8. The drainageway has been filled in and seeded to grass, but this measure does not protect the adjacent wheat land. Several complementary practices are usually necessary to effect complete control on a given field. (Wild Horse Area.)

Courtesy Soil Conservation Service

Comparable measures would apply to the respective slopes in the Rock Creek Area except that, owing to lower rainfall and more gently sloping land, less emphasis is placed on strip cropping and rotations. The recommendations for this area include: (1) the re-

tirement of steep, erosive land to grass, and (2) the practice of trashy fallow and contour cultivation on wheat land.

While it is not within the province of this report to make specific recommendations for land use and livestock production, stress should be laid on the fact that adoption of soil conservation measures is only a step on the way to better farming methods. Obviously a wheat farmer can ill afford to reduce his wheat acreage, substitute hay or pasture, increase cash expenses, and add to the burden of farm labor unless these changes improve the farm income. Such improvement in part must subsequently result from the utilization by livestock of land taken out of wheat production. Cattle and sheep are particularly adapted for making profitable use of permanent grazing areas, legume soil-building crops, hay, and straw; all of which would have been considered byproducts of farming if not actually waste.

To the extent that the soil conservation program calls for the retirement of cash grain land to hay and pasture, it involves a change in the system of farming. This may mean only relatively more emphasis on livestock on most wheat farms, but along the foothills of the Blue Mountains the change should probably be more pronounced. The present wheat-peas-fallow rotation system would be changed to a long-time rotation including wheat, peas, and alfalfa or sweet clover, omitting the fallow.

This system of land use would naturally include livestock either produced on the farm or purchased and fattened depending on specific farm conditions. It is probable that such a system of conservation farming could be made as profitable over a period of years as the present exploitive wheat-peas-fallow system. The idle fallow year would be replaced with a crop, thus reducing erosion, and the productive qualities of the soil would be maintained or increased. The turning under of green manure crops would increase the fertility of the land.

Some of the factors that should be considered in attempting to implement a well rounded conservation program are as follows:

1. Budget the essential shifts in land use showing just how much grain, hay, and pasture probably should be grown and fed on the farm, and how much grain, grass seed, etc., likely would be sold.
2. Consider the operator's aptitude for handling a specific class of livestock.
3. Evaluate the adaptation of different kinds of livestock with regard to the available pasture, buildings, fences, and water

facilities, and the cost and practicability of providing these items.

4. Select the livestock enterprise or enterprises with a view to maintaining conservative numbers in proportion to feed and pasture resources. Conservation is as applicable to livestock management as it is to soil management, and moreover, nothing is gained for land conservation if pastures are overgrazed with livestock.

CONCLUSIONS

Soil erosion is definitely a factor affecting wheat yields in eastern Oregon. The effect varies from place to place with specific soil and climatic conditions. This study shows that an average loss of 25 to 33 per cent of the topsoil causes a reduction of 3 to 6 bushels per acre in wheat yield. Where all the topsoil has been removed, as on a few relatively steep slopes, the land is rendered marginal for wheat production. The present rate of soil erosion and its effect on wheat yields indicates that most of the land will be rendered marginal for wheat production within 100 to 150 years unless effective means of erosion control are put into operation.

Soil losses and reduced wheat yields from erosion cause material loss of income from the land. The loss accelerates with time because it accumulates from year to year. Thus the loss in income of $0.084 per acre in the Wild Horse Area, and $0.045 per acre in the Rock Creek Area increases by these amounts each year until the land is rendered marginal for wheat production, and the value of the land is reduced to that of pasture. The results of this study show that wheat farmers can afford to make substantial annual investments in the land to prevent erosion losses.

Data now available show that most of the topsoil can be saved from erosion by the careful application of simple soil conservation practices. Through careful planning such a program can be made to fit into the farm organization without any loss of income from higher operating costs or from reduced income through changes in land use. Wheat farmers may receive help from the nearest soil conservation office in developing a complete farm plan.